Final Report

Back Creek Watershed Action Plan

BACK CREEK Conservancy

CENTER FOR WATERSHED PROTECTION

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Chesapeake Bay Trust
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Executive Summary

The Back Creek watershed, located almost entirely within the City of Annapolis, Maryland, outlets to the Severn River. The City's largest marinas and yacht yards call Back Creek home, along with over 1,700 yachts of varying shapes and sizes. Residential land use makes up 67% of the watershed area, 20% is commercial, and the remaining area is divided among natural areas, roads, and industrial use. Like many urban watersheds, Back Creek is affected by sedimentation, degraded shoreline, and excess nutrients and toxins conveyed by stormwater runoff to the Creek.

This Back Creek Watershed Action Plan describes the watershed assessment conducted by the Center for Watershed Protection (the Center) and outlines a series of recommendations for watershed restoration, describes implementation strategies, and identifies priority projects for implementation. Information from the recently released AECOM "City of Annapolis Stormwater Management Inventory and Watershed Improvement Plan" (AECOM, 2016) has been incorporated into the recommended actions.

In the spring of 2016, the Center conducted field assessments throughout the Back Creek watershed to evaluate pollution management and watershed restoration opportunities. During these assessments, field crews visited 29 residential neighborhoods, 28 potential retrofit locations, and 5 potential hotspot locations. Outcomes from these assessments are described in Section 3, including describing positive actions that residents can take to engage in behaviors and activities that improve water quality, several hotspot locations discovered in the watershed, and 29 stormwater retrofits. These retrofits are summarized in Table 15 and prioritized by the amount of sediment removed each year.

Overall, five general recommendations were developed for the Back Creek Watershed, as follows and described further in Section 6:

1. Encourage pollution prevention practices as well as tree planting and landscape management in residential neighborhoods.
2. Encourage marinas and yacht yards to become certified Clean Marinas and encourage boaters to pledge to be Clean Boaters.
3. Implement stormwater retrofit practices.
4. Educate businesses on eliminating hotspots.
5. Implement a complete water quality monitoring plan.

Implementing these projects will help reduce sedimentation and improve the water quality of Back Creek. They will also help the City of Annapolis meet its Phase II Watershed Implementation Plan (WIP) requirements. For example, implementation of all of the stormwater retrofits (Recommendation 3) would yield 237 pounds of phosphorus, 1,758 pounds of nitrogen, and 121,644 pounds of sediment reduction from the Back Creek watershed.

Section 7 lists potential funding sources and describes how cost estimates were calculated for the proposed projects and retrofits in the plan. The cumulative estimate for implementing the five watershed recommendations is estimated to exceed three million dollars over the next five years.

Section 5 of the plan provides an overview of and multiple resources on creating a robust water quality monitoring program. Monitoring efforts can be beneficial for the watershed in several ways:

- They can help track water quality improvements from stormwater retrofit projects.
- They can detect pollution hotspots to help decrease or eliminate some sources of pollution.
- They can help determine the effects environmental or anthropogenic changes are having on water quality.

Section 1. Introduction

1.1 Plan Overview

The purpose of the Back Creek Watershed Action Plan is to characterize the Back Creek watershed and provide a series of recommendations for watershed restoration, describe implementation strategies, and identify priority projects for implementation. Planning level cost and pollutant removal estimates are provided. Financial and technical partners for plan implementation are suggested for various strategies and projects. This Plan is intended to assist the Back Creek Conservancy in their efforts to measurably improve water quality in the watershed.

1.2 U.S. EPA Watershed Planning 'a' through 'i' Criteria

In 2003, the U.S. Environmental Protection Agency (EPA) began to require that all watershed restoration projects funded under Section 319 of the federal Clean Water Act to be supported by a watershed plan that includes the following nine minimum elements, known as the "a-i criteria", as listed below:

a. Identification of the causes and sources that will need to be controlled to achieve the load reductions estimated in the watershed plan
b. Estimates of pollutant load reductions expected through implementation of proposed nonpoint source (NPS) management measures
c. A description of the NPS management measures that will need to be implemented
d. An estimate of the amount of technical and financial assistance needed to implement the plan
e. An information/education component that will be used to enhance public understanding and encourage participation
f. A schedule for implementing the NPS management measures
g. A description of interim, measurable milestones
h. A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards
i. A monitoring component to determine whether the watershed plan is being implemented

This Watershed Action Plan meets the a-i criteria. Table 1 shows where these criteria are addressed throughout this document.

Table 1. U.S. EPA Watershed Planning "a-i" Criteria									
Section of the Plan	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Section 1. Introduction									
Section 2. Watershed Overview and Baseline Conditions	X								
Section 3. Field Assessments and Findings	X		X						
Section 4. Pollutant Reduction Estimates		X							
Section 5. Monitoring Plan									X
Section 6. Recommended Watershed Management Actions and Implementation Plan	X		X		X	X	X	X	
Section 7. Cost Estimates and Funding				X					
Section 8. References									

1.3 Plan Organization

The Plan is organized as follows:

Section 1. Introduction – provides an introduction to the Back Creek Watershed Action Plan.

Section 2. Watershed Overview and Baseline Conditions – describes the land use, impervious cover and tree canopy percentage, the TMDLs assigned to the watershed, and existing best management practices (BMPs).

Section 3. Field Assessments and Findings – provides an overview of upland and retrofit assessment methodologies and key findings.

Section 4. Pollution Reduction Estimates – provides an overview of upland and retrofit assessment methodologies and key findings, along with the results of a green infrastructure analysis.

Section 5. Water Quality Monitoring – presents a literature review of an overview of creating a monitoring plan and components needed to successfully monitor the water quality of Back Creek.

Section 6. Recommended Watershed Management Actions and Implementation Plan – provides key recommendations for the watershed, resources for implementation, and project tracking information.

Section 7. Cost Estimates and Funding – provides information on how BMP costs were determined as well as funding sources for BMPs.

Section 8. References

Section 2. Watershed Overview and Baseline Conditions

2.1 Watershed Overview

Back Creek is a 6,000-foot long tidal estuary in the Annapolis Neck peninsula, draining to the Severn River, with a Maryland 8-digit watershed code of 02131002. Back Creek's 817-acre watershed is almost entirely located within the City of Annapolis, Maryland, with less than 5% of its area in Anne Arundel County. A map of Back Creek watershed is shown in Figure 1. Back Creek is the southeastern-most of the four Severn River creeks on which Annapolis has developed, and it is the most recently urbanized, after being annexed by the City in 1951. Back Creek begins near Georgetown East Elementary School, located off of Bay Ridge Avenue, and outfalls to the Severn River and subsequently into the Chesapeake Bay.

The Creek's water is severely impaired by sediment, nutrients, toxins, and hydrocarbons from poorly managed stormwater and, to an unknown extent, from recreational and tourist boats that travel and dock there. Back Creek may also be influenced from silt influx by the Severn River. Sedimentation is an ongoing problem throughout the upper third of the creek and particularly in the five small coves (outfalls) along the western side.

Since the 1960s, Back Creek has been the heart of the recreational boating industry in Annapolis. The waterfront holds all of the city's largest yacht yards and marinas, with a total of more than 60 maritime businesses employing more than 2,000 people. More than 1,700 yachts of all sizes are docked on the creek, creating the basis for Annapolis's designation as the nation's Sailing Capital.

Figure 1. Back Creek Watershed

2.2 Land Use

Residential development of the watershed, which is completely served by city sewer, occurred from the 1920s to the 1990s primarily through common ownership communities—homeowner and condominium associations and through large rental apartments. The entire watershed was "built out" by 1995, so future land development will be limited to infill development, building renovations, and redevelopment.

Land uses in the watershed consist of residential, commercial, marina, and recreation uses (see Table 2). Eastport, located on the peninsula between Spa and Back Creeks consists of a majority of 1/8 acre residential homes. The southern end of Bay Ridge Avenue consists of higher density residential development with mostly apartment complexes and smaller residential lots. It also includes commercial use and small businesses and the Eastport Shopping Center. The Tyler Heights area is mostly subdivision-style, small residential lots with high density residential apartments. On the east side of Back Creek, more diverse land uses are present with small lot residential, apartment complexes, an elementary school, a large commercial shopping center, and several marinas (McCrone and AEGIS, 2009). Figure 2 shows the land uses and areas of Back Creek. Table 3 shows the breakdown of residential lot sizes in the watershed, both as a percentage of the residential area total and as a percentage of the entire watershed.

Table 2. Land Use Area in Back Creek Watershed

Land Use	Area (acres)	Percentage of Watershed
Commercial	160.0	19.6%
Industrial	20.7	2.5%
Open Space	10.7	1.3%
Residential	543.8	66.6%
Transportation	31.6	3.9%
Water	1.1	0.1%
Woods	49.0	6.0%
Total	**816.8**	**100.0%**

Table 3. Residential Land Use Types and Area in Back Creek Watershed

Residential Land Use	Area (acres)	Percentage of Residential Areas	Percentage of Entire Watershed
Residential 1/2-acre	9.2	1.7%	1.1%
Residential 1/4-acre	383.3	70.5%	46.9%
Residential 1/8-acre	136.5	25.1%	16.7%
Residential 2-acre	14.8	2.7%	1.8%
Total	**543.8**	**100%**	**66.6%**

2.3 Impervious Cover

Currently, the total impervious cover for the Back Creek drainage area is 350.8 acres (42.9%). These numbers are based on the 2011 impervious cover GIS data provided by Anne Arundel County.

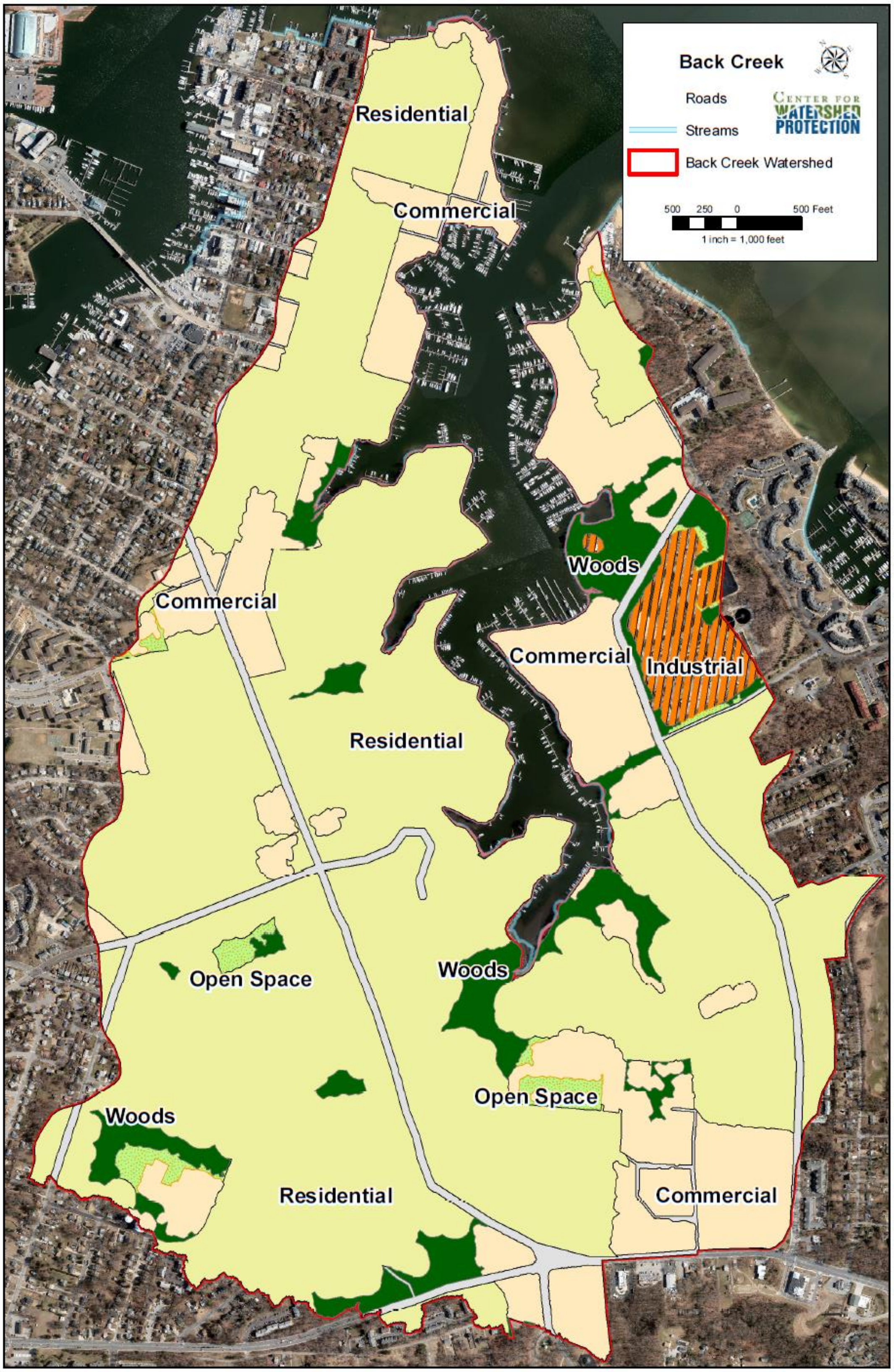


Figure 2. Land Use in Back Creek

2.4 Tree Canopy Cover

The tree canopy cover for the Back Creek watershed was calculated to be 31.4% (McCrone and AEGIS, 2009). See Figure 3.

2.5 TMDLs/NPDES MS4 Permit

The City of Annapolis's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit is soon to be updated by the Maryland Department of Environment (MDE) and will likely require that 20% of the City's existing untreated impervious cover be treated through stormwater retrofits. Retrofits identified in this watershed action plan will help the City meet its NPDES MS4 permit as well as the Chesapeake Bay TMDL load reductions.

Back Creek has four Total Maximum Daily Load (TMDL) requirements for bacteria, nitrogen, phosphorus, and sediment. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet applicable water quality standards (USEPA, 2010). The nitrogen, phosphorus, and sediment TMDLs are described in the 2010 *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment* (USEPA, 2010). The Chesapeake Bay TMDL discusses the Severn River, but not Back Creek specifically. The Severn River nitrogen, phosphorus, and total suspended sediment (TSS) TMDLs are listed in Table 4.

Table 4. Chesapeake Bay Annual Allocations for Severn River (USEPA 2010)

TMDL	Total Nitrogen	Total Phosphorus	Total Suspended Solid
Waste Load Allocation (WLA) (lb/yr)	244,630	23,149	2,991,739
Load Allocation (LA) (lb/yr)	114,992	3,499	935,655
TMDL (lb/yr)	359,621	26,647	3,927,294
2009 Existing (lb/yr)	445,316	50,568	3,716,445
Percent Reduction	19%	47%	-6%

A waste load allocation (WLA) is the portion of the TMDL allocated to existing and/or future point sources. A load allocation (LA) is the portion of the TMDL attributed to existing and/or future nonpoint sources and natural background (USEPA, 2010). Summing the WLA and the LA will give the TMDL for a waterbody.

The bacteria TMDL is described in the 2008 document, *Total Maximum Daily Loads of Fecal Coliform for the Restricted Shellfish Harvesting Areas in Whitehall and Meredith Creeks, Mill Creek, and the Severn River Mainstem of the Severn River Basin in Anne Arundel County, Maryland* (MDE, 2008). The bacterial TMDL is for the Severn River Mainstem, which includes Back Creek. The TMDL calculation results for the Back Creek subwatershed is shown in Table 5. The table shows that no reductions are needed from the Back Creek subwatershed to meet the TMDL goal for the Severn River Mainstem.

Table 5. Bacteria TMDL Calculation Results (MDE 2008)

	Median			90th Percentile		
	Allowable Load	Current Load	Percent Reduction	Allowable Load	Current Load	Percent Reduction
Subwatershed	Counts/day	Counts/day		Counts/day	Counts/day	
Back Creek	3.76E+11	3.76E+11	0.0%	4.56E+12	4.56E+12	0.0%

Figure 3. Tree Canopy in Back Creek

2.6 Summary of Existing BMPs

In 2015, AECOM developed a *Stormwater Management Inventory and Watershed Improvement Plan – Interim Submittal* for the City of Annapolis (AECOM, 2015). This project included identifying existing BMPs within the City limits from archived plan sets. Table 6 below lists the BMPs constructed within the Back Creek watershed. The table is organized by address; the BMP Label corresponds to BMP location on the map in Figure 4.

Table 6. AECOM Summary of Existing BMPs

BMP Label	Year Built	BMP Type	No. of BMPs	Address
516	1999	Infiltration Trench	6	1 Little Harbor Way
65, 236, 237, 238	2010	Rain Garden, Disconnection Roof Runoff, Disconnection Non-Roof Runoff	4	1019 Tyler Ave
30, 239, 240	2013	Rain Garden, Disconnection Roof Runoff, Permeable Pavement	3	1094 Hoover St
31, 241, 242, 243	2013	Rain Garden, Disconnection Roof Runoff, Permeable Pavement	4	1096 Hoover St
526	1999	Infiltration Trench	6	2 Little Harbor Way
739	1999	Detention Structure (Dry Pond)	1	2204 Bay Ridge Ave
527	1999	Infiltration Trench	6	3 Little Harbor Way
445	2006	Sand Filter	1	3764 Edgewood Rd
528	1999	Infiltration Trench	6	4 Little Harbor Way
384	2003	Underground Filter	1	403, 405, 407, 409 Chester Ave
5	2014	Rain Garden	1	433 Burnside St.
382	2007	Infiltration Trench	1	435 Burnside St
391, 421	2004	Dry Well	2	5 Eastern Ave
529	1999	Infiltration Trench	6	5 Little Harbor Way
454	2003	Infiltration Trench	3	502 State Rd
493	2003	Infiltration Trench	3	504 State Rd
494	2003	Infiltration Trench	3	508 State Rd
399	2004	Infiltration Trench	1	518 Fourth St
534, 540, 541	2002	Bioretention	3	660 American Dr
457	1994	Infiltration Trench	1	707 Glendon Ave
452, 546	1992	Infiltration Trench	2	707 Warren Dr
394	2001	Infiltration Trench	1	7074 Bembe Beach Rd
734	1998	Infiltration Trench	1	721 Chester Ave
532	1996	Infiltration Trench	1	7364 Edgewood Rd
442	2005	Infiltration Trench	1	7425 Edgewood Rd
471	2007	Dry Well	1	803 Park Wood Ave
699	2003	Dry Swale	1	811 Chester Rd
736	2009	Underground Filter	1	821 Chesapeake Ave
448	1986	Infiltration Trench	1	914 Bay Ridge Rd

Table 6. AECOM Summary of Existing BMPs				
BMP Label	**Year Built**	**BMP Type**	**No. of BMPs**	**Address**
562	1987	Detention Structure (Dry Pond)	1	929 939 Forest Hills Ave
105, 223	1993	Dry Well, Infiltration Trench	2	Annapolis Landing Marina
567	1995	Micro-bioretention	1	Bay Forest Ct
97	1993	Other	1	Bay Ridge Ave
85	1997	Infiltration Trench	1	Castle Rock Lot 5
98	1998	Dry Well	1	Glendon Ave- Lot 117
108, 745, 746	2003	Bioretention	3	Tributary Grill

The Center recommends that this list be used as a starting place when tallying BMPs in the Back Creek watershed. When out in the field, Center employees noticed that some of the BMPs had been removed, such as BMP numbers 108, 745, and 745, near the Giant in Bay Forest Center. Others, such as BMP numbers 534 and 540 located in Watergate Pointe Apartments were still in place. Many of the BMPs listed were likely the result of new home construction, and the BMPs installed to meet the Maryland stormwater performance standards.

In addition to the AECOM study, McCrone, Inc. and AEGIS prepared a *City of Annapolis Watershed Study and Action Plan*, released in January 2009 (McCrone and AEGIS, 2009). This report also identified existing BMPs in the Back Creek watershed, as listed in Table 7 below. These BMPs are also mapped in Figure 4.

Table 7. McCrone & AEGIS Existing BMPs	
BMP Label	**Description**
MC_1	Pervious Driveway
MC_2	Rain Garden
MC_3	Pervious Driveway
MC_4	Stone Trench
MC_5	Pervious Alley
MC_6	Bio-retention Area
MC_7	Bio-retention Area
MC_10	Shoreline Restoration
MC_11	Rain Barrels
MC_12	Rain Garden
MC_13	Gabion Lined Channel

Because the McCrone and AEGIS study is even older than the AECOM report, BMPs listed may also no longer be in place or functioning properly. For example, a visual assessment of MC_3 and MC_4 indicated that these BMPs have filled in with sediment, and are no longer providing their intended benefits. These BMP lists may be useful for future work in the watershed to prevent duplication of stormwater treatment efforts.

Figure 4. Existing BMPs Identified by AECOM and McCrone

Section 3. Field Assessments and Findings

The watershed assessment protocols used during this study are based on a series of manuals written by the Center to restore small urban watersheds and compiled into a format that can easily be accessed by watershed groups, municipal staff, environmental consultants, and other users. The manuals outline a practical, step-by-step approach to develop, adopt, and implement a subwatershed plan. The manuals provide specific guidance on how to identify, design, and construct the watershed restoration practices, describe the range of techniques used to implement each practice, and provide detailed guidance on subwatershed assessment methods to find, evaluate, and rank candidate sites.

3.1 Upland Subwatershed Site Reconnaissance (USSR)

The Center conducted the Unified Subwatershed and Site Reconnaissance (USSR) to evaluate pollution-producing behaviors and restoration potential in upland areas of the Back Creek watershed. The USSR is a “windshield survey” where field crews drive watershed roads to determine specific pollution sources and identify areas where pollution prevention possibilities exist. The USSR can be a powerful tool in shaping initial watershed restoration strategies and locating potential stormwater retrofit or restoration opportunities. The goal of the USSR is to quickly identify source areas that are contributing pollutants to the stream, and reduce these pollutant loads through source controls, outreach and change in current practice, and improved municipal maintenance operations. Additional information on the USSR is found in Wright et al. (2005). The USSR includes the Neighborhood Source Assessment (NSA) and the Hotspot Site Investigation (HSI).

3.1.1 Neighborhood Source Assessment (NSA)

Residents engage in behaviors and activities that can influence water quality. Some behaviors that negatively influence water quality include over-fertilizing lawns, using excessive amounts of pesticides, and poor housekeeping practices such as inappropriate trash disposal or storage. Alternatively, positive behaviors such as tree planting and using native plants, disconnecting rooftop downspouts, and picking up pet waste can help improve water quality.

The Neighborhood Source Assessment (NSA) was conducted to evaluate pollution source areas, stewardship behaviors, and restoration opportunities within individual residential areas. The assessments focus specifically on yards and lawns, rooftops, driveways and sidewalks, curbs, and common areas. Table 8 provides examples of the types of restoration opportunities that were evaluated for each site.

An NSA field form was used to assess neighborhoods in terms of age, lot size, tree cover, drainage, lawn size, general upkeep, evidence of pollution sources, and evidence of resident stewardship (i.e., storm drain stenciling, pet waste management signage, etc.). Each site was assigned a pollution severity rating of “severe,” “high,” “moderate,” or “low,” using a set of benchmarks set forth in Wright et al. (2005). Pollution severity is an index of the amount of non-point source pollution a neighborhood is likely generating based on easily observable features (i.e., lawn care practices, drainage patterns, oil stains, etc.). A restoration potential rating of “high,” “moderate,” or “low” was also assigned to each neighborhood. Restoration potential is a measure of how feasible onsite retrofits or behavior changes would be, based on space, number of opportunities, presence of a strong homeowner association (HOA), and other similar factors. Appendix A includes the NSA field forms that were completed during field work.

Table 8. Types of Projects Identified during Neighborhood Source Assessment

Type	Description	Examples
On-site Retrofits	Homeowners reduce stormwater runoff generated by their lots	• Rain gardens • Rain barrels • Rooftop disconnection
Lawn and Landscaping Practices	Better lawn and landscaping practices minimize the use of chemicals and encourage the use of native landscaping, particularly in neighborhoods where high input lawns and extensive turf cover are prevalent.	• Improved buffer protection • Native plantings • Turf reduction • Proper fertilizer and pesticide application
Open Space Management	Management of neighborhood common areas or courtyards	• Landscaping • Tree planting • Pet waste education • Trash removal
Education and Outreach	Providing homeowners with additional information to better manage pollution in their residential lots	• Lawn and nutrient management outreach • Rain barrel and rain garden education • Storm drain stenciling

A total of 29 neighborhoods were visited by the field crews as shown in Figure 5. A majority of the watershed is residential, and most homes are single-family, with some multi-family apartments and condos. Almost all neighborhoods had no visible stormwater management practices. There are only two stormwater ponds in the entire watershed. Maps of the neighborhoods corresponding to the NSA labels of Figure 5 are shown in Figure 6, Figure 7, and Figure 8.

The Back Creek neighborhoods assessed tended to rate as moderate in terms of pollution severity. One neighborhood rated as high for pollution severity, due to the amount of highly managed turf lawns, sediment/organic matter in the curb and gutter, and the percentage of homes with downspouts connected to the storm sewer or directed to impervious areas. Eleven neighborhoods (38%) did not have any pollution indicators.

Neighborhoods generally rated moderate for restoration potential, with ten rating low. Opportunities identified include installing rain barrels, tree planting, building rain gardens, providing nutrient and lawn management education, and disconnecting downspouts. Generally, the neighborhoods in the watershed were taken well care of; very little trash was evident and most neighborhoods had at least 40% tree canopy cover. Most open areas of apartment/condo complexes and HOAs had prominent pet waste signs and bags available for dog walkers.

The single family home neighborhoods in the watershed had limited opportunities for large scale retrofits. Approximately 50% of the homes had disconnected downspouts, which allows some stormwater runoff to infiltrate into the soil before reaching the storm sewer. There are opportunities to plant trees and construct rain gardens on individual homeowner's property within the watershed. A list of all the sites visited along with their ranked priority and planning level cost estimates is included in Table 9**.**

Implementing these types of retrofits is best accomplished by approaching the homeowners and working with them directly in order to find ones that are willing to construct and maintain these retrofits, and determine the suitability of installing certain retrofits on their property. For example, disconnecting a downspout requires that homes have a large enough pervious area or lawn with less than 5% average slope, and that the disconnection will cause no basement seepage.

The City of Annapolis charges a stormwater utility fee; they allow residents to apply for a 50% discount on this utility fee by installing stormwater management structures on their property. Stormwater management structure examples include rain barrels, rain gardens, green roofs, pervious pavers, etc. A maintenance plan is required in the application for the discount.
http://www.annapolis.gov/government/city-departments/mayors-office/office-of-environmental-policy/watershed-protection-and-restoration/stormwater-management/

The City of Annapolis no longer allows stormwater stenciling by volunteer groups, but does "encourage volunteer groups to identify which inlets they think should be priorities in the City marking program". None of the inlets inspected during the field assessment in Back Creek had a stormwater marker.
http://www.annapolis.gov/government/city-departments/mayors-office/office-of-environmental-policy/watershed-protection-and-restoration/storm-water-public-participation/ The Opportunity column of Table 9 has recommendations of the neighborhoods where stormwater inlet marking should be pursued.

Figure 5. Neighborhoods Visited

Figure 6. Neighborhoods of Back Creek-1

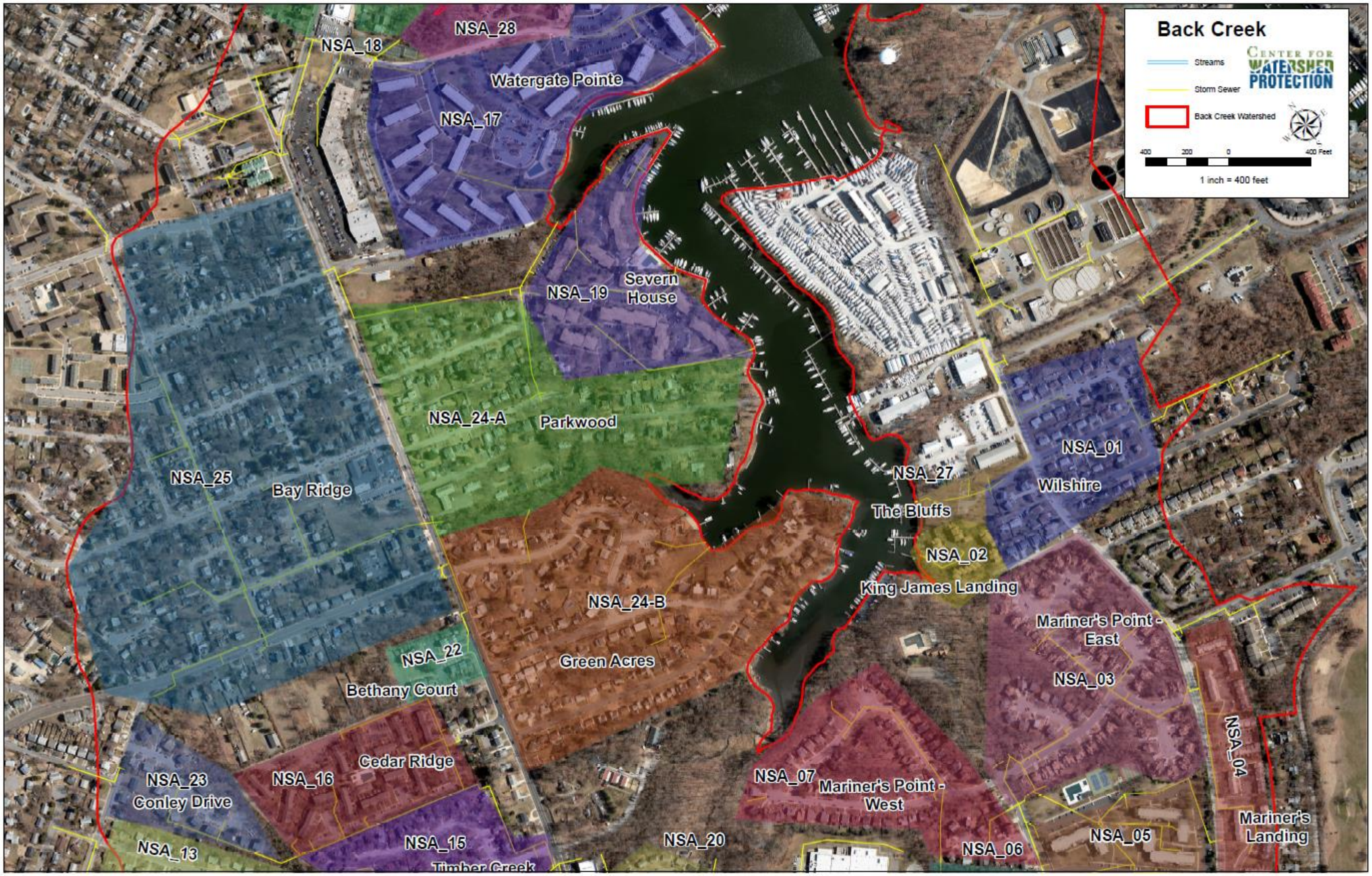


Figure 7. Neighborhoods of Back Creek-2

Figure 8. Neighborhoods of Back Creek-3

Table 9. Neighborhood Source Control Opportunities

Site_ID	Neighborhood	Pollution Severity	Restoration Potential	Opportunity	Priority	Assumptions on cost	Estimated Cost
NSA_18	Eastport	High	Moderate	rain barrels, lawn management advice, stormwater inlet markers	High	rain barrels for 10% of homes; lawn management advice	$3,627.00
NSA_24A	Parkwood	Moderate	Moderate	downspout disconnection, rain barrels, rain gardens	High	downspout disconnection for 10% of homes; rain barrels for 20% of homes; 1 rain garden	$2,906.00
NSA_24B	Green Acres	Moderate	Moderate	downspout disconnection, rain gardens, rain barrels, tree planting	High	downspout disconnection for 10% of homes; 2 rain gardens; rain barrels for 20% of homes; 10 trees	$6,154.00
NSA_01	Wilshire	Moderate	Moderate	rain barrels, downspout disconnection, rain gardens	Medium	rain barrels for 30% of homes; downspout disconnection for 25% of homes; 2 demonstration rain gardens	$4,830.00
NSA_04	Mariner's Landing	None	Moderate	rain barrels, stormwater inlet markers	Medium	rain barrels for 30% of homes;	$3,060.00
NSA_05	Fairwoods of Annapolis - East	Moderate	Moderate	tree planting, downspout disconnection, stormwater inlet markers	Medium	5 trees, 10 downspout disconnection	$675.00
NSA_07	Mariner's Point - West	Moderate	Moderate	lawn management advice	Medium	lawn management advice	$256.00
NSA_11	Reserve at Quiet Waters	Moderate	Moderate	downspout disconnection, bare soil management	Medium	downspout disconnection; 1 acre of grass seeding	$1,391.00

Table 9. Neighborhood Source Control Opportunities

Site_ID	Neighborhood	Pollution Severity	Restoration Potential	Opportunity	Priority	Assumptions on cost	Estimated Cost
NSA_12	Forest Hills Apartments	Moderate	Moderate	tree planting	Medium	20 trees	$1,900.00
NSA_13	Tyler Heights	None	Moderate	rain barrels, tree planting	Medium	rain barrels for 30% of homes; 8 trees	$3,004.00
NSA_14	Ambridge	Moderate	Moderate	downspout disconnection	Medium	downspout disconnection for 10% of homes	$106.00
NSA_17	Watergate Pointe	Moderate	Moderate	tree planting, stormwater inlet markers	Medium	30 trees	$2,850.00
NSA_19	Severn House	Moderate	Low	car wash containment, stormwater inlet markers	Medium	car wash containment, pump, storage container	$7,500.00
NSA_20	Victor Haven	Moderate	Moderate	rain gardens, stormwater inlet markers	Medium	2 rain gardens	$3,000.00
NSA_21	Bay Ridge Gardens	None	Moderate	tree planting	Medium	8 trees	$760.00
NSA_23	Conley Drive	None	Moderate	tree planting, rain barrels	Medium	15 trees; rain barrels for 10% of homes	$1,603.50
NSA_25	Bay Ridge	Moderate	Moderate	rain barrels, stormwater inlet markers	Medium	rain barrels for 20% of homes	$3,740.00
NSA_26	Bembe Beach	Moderate	Moderate	tree planting, downspout disconnection, rain gardens	Medium	14 trees; downspout disconnection for all homes; 1 rain garden	$3,330.00
NSA_27	The Bluffs	Moderate	Moderate	tree planting	Medium	15 trees	$1,425.00
NSA_02	King James Landing	Moderate	Low	stormwater inlet markers	Low		$0.00

Table 9. Neighborhood Source Control Opportunities							
Site_ID	**Neighborhood**	**Pollution Severity**	**Restoration Potential**	**Opportunity**	**Priority**	**Assumptions on cost**	**Estimated Cost**
NSA_03	Mariner's Point - East	None	Low	stormwater inlet markers	Low		$0.00
NSA_06	Georgetown East	None	Low	rain gardens	Low	2 rain gardens	$3,000.00
NSA_08	Fairwinds of Annapolis - West	None	Low	downspout disconnection, rain gardens	Low	4 downspout disconnections per building; 2 rain gardens	$3,320.00
NSA_09	Fairwinds of Annapolis - Georgetown Court	None	Low	better management of common space/replace paver area with grass or landscaping	Low	removal of excess pavers and replace with grass	$10,000.00
NSA_10	Beechwood Hill	Moderate	Low	stormwater inlet markers	Low		$0.00
NSA_15	Timber Creek	None	Moderate	downspout disconnection	Low	downspout disconnection for 40% of homes	$416.00
NSA_16	Cedar Ridge	None	Low	stormwater inlet markers	Low		$0.00
NSA_22	Bethany Court	None	Moderate	rain barrels	Low	rain barrels for 30% of homes	$510.00
NSA_28	Harbor View	Moderate	Low	None	Low		$0.00
NSA_29	Baywoods	Low	Low	None	Low		$0.00

Table 10 shows a representative photo of a home in each neighborhood.

Table 10. Typical Homes in each Neighborhood	
NSA_01 - Wilshire 	**NSA_02** – King James Landing 
NSA_03 – Mariner's Point - East 	**NSA_04** – Mariner's Landing 
NSA_05 – Fairwinds of Annapolis - East 	**NSA_06** – Georgetown East 

Table 10. Typical Homes in each Neighborhood	
NSA_07 – Mariner’s Point - West 	**NSA_08** – Fairwinds of Annapolis - West 
NSA_09 – Fairwinds of Annapolis – Georgetown Court  	**NSA_10** – Beechwood Hill 
NSA_11 – Reserve at Quiet Waters 	**NSA_12** – Forest Hills Apartments 

Table 10. Typical Homes in each Neighborhood

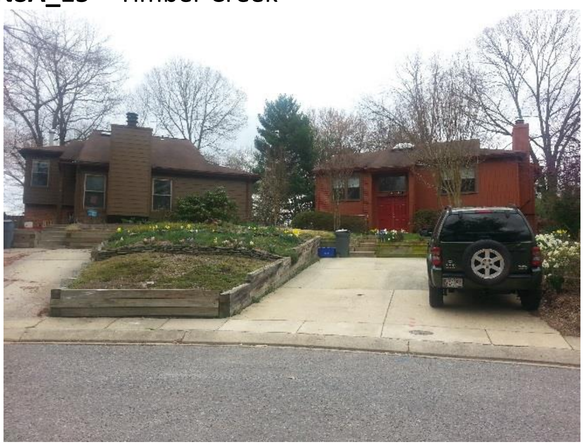
NSA_13 – Tyler Heights 	**NSA_14** – Ambridge 
NSA_15 – Timber Creek 	**NSA_16** – Cedar Ridge 
NSA_17 – Watergate Pointe 	**NSA_18** – Eastport 

Table 10. Typical Homes in each Neighborhood

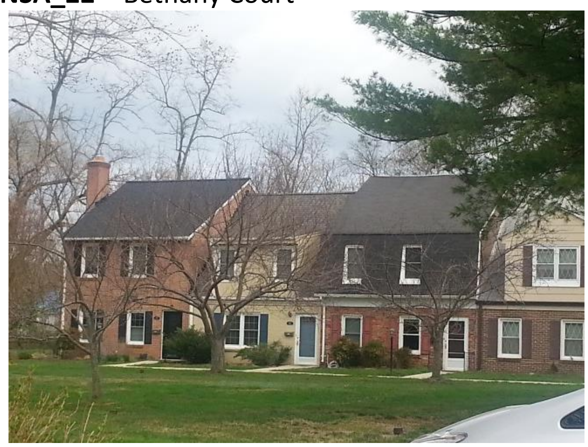
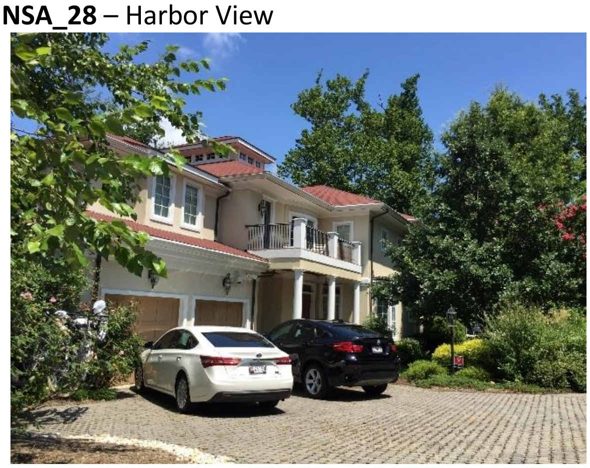
NSA_19 – Severn House 	**NSA_20** – Victor Haven 
NSA_21 – Bay Ridge Gardens 	**NSA_22** – Bethany Court 
NSA_23 – Conley Drive 	**NSA_24-A** – Parkwood 

Table 10. Typical Homes in each Neighborhood

NSA_24-B – Green Acres 	**NSA_25** – Bay Ridge 
NSA_26 – Bembe Beach 	**NSA_27** – The Bluffs 
NSA_28 – Harbor View 	**NSA_29** - Baywoods 

A few homes had rain barrels, such as the one in Figure 9, located in NSA_25. An additional opportunity for reducing soil erosion and runoff could occur in the backyards of a few single family homes in NSA_20. These backyards direct stormwater runoff into the headwaters of a stream near Georgetown Elementary. See Figure 10.

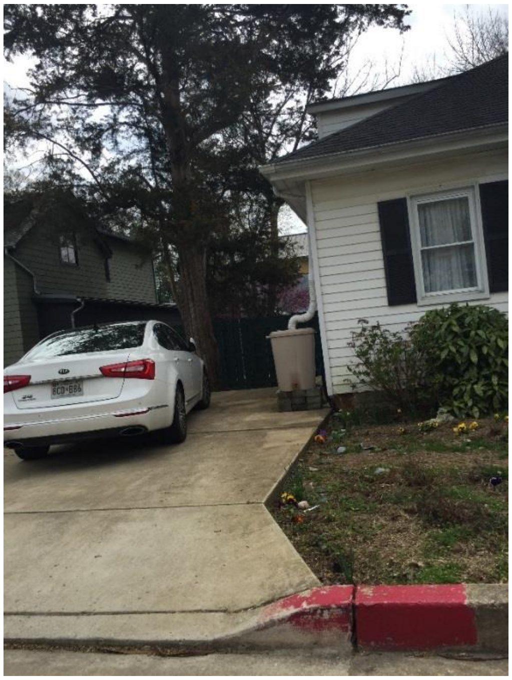


Figure 9. Rain Barrel in NSA_25

Figure 10. Backyard in NSA_20 near the school

3.1.2 Hotspot Investigations

Pollution source control includes the management of potential “hotspots” which are certain commercial, industrial, institutional, municipal, and transport-related operations in the watershed. These hotspots tend to produce higher concentrations of polluted stormwater runoff than other land uses and also have a higher risk for spills. They include auto repair shops, restaurants, etc. Specific on-site operations and maintenance combined with pollution prevention practices can significantly reduce the occurrence of “hotspot” pollution problems.

The Hotspot Site Investigation (HSI) is used to evaluate commercial, industrial, municipal or transport-related sites that have a high potential to contribute contaminated runoff to the storm drain system or directly to receiving waters. At hotspot sites, field crews look specifically at vehicle operations, outdoor materials storage, waste management, building conditions, turf and landscaping, and stormwater infrastructure to evaluate potential pollution sources (Table 11). Appendix A includes the HSI field forms that were completed during field work.

Based on observations at the site, field crews may recommend enforcement measures, follow-up inspections, illicit discharge investigations, retrofits, or pollution prevention control and education. The overall pollution prevention potential for each hotspot site is assessed based on observed sources of pollution and the potential of the site to generate pollutants that would likely enter the storm drain network. A hotspot designation criterion set forth in Wright et al. (2005) was used to determine the status of each site based on field crew observations.

Table 11. Potential Hotspot Pollution Sources		
Type	**Description**	**Examples**
Vehicle Operations	Routine vehicle maintenance and storage practices, as well as vehicle fueling and washing operations	• Vehicle storage and repair • Fueling areas • Vehicle washing practices
Outdoor Materials	Exposure of outdoor materials stored at the site	• Loading and unloading • Outdoor materials • Secondary containment
Waste Management	Housekeeping practices for waste materials generated at the site	• Dumpster practices
Stormwater Infrastructure	Practices used to convey or treat stormwater, including the curb and gutter, catch basins, and any stormwater treatment practices	• Catch basins • Stormwater treatment practices

All the non-marina commercial sites were assessed for potential hotspots and are shown in Figure 11. Two of those locations were confirmed as hotspots as pollution producing behaviors were witnessed, as described in Table 12. Figures 12, 13, 14, and 15 show photos taken during the field assessment of the confirmed hotspots.

Figure 11. Potential Hotspot Locations

Table 12. Confirmed Hotspot Sites

Site ID	Location	Type of Hotspot	Description	Recommended Actions
HSI-04	Hillsmere Center (110 Hillsmere Dr)	Dumpster Management	Overflowing dumpster, nearby trash, cover open	Outreach materials to target business groups
HSI-06a	Georgetown Plaza (914 Bay Ridge Road)	Outdoor Material Storage	Restaurant - grease storage	Outreach materials to target business groups, containment pallet
HSI-06b	Georgetown Plaza (914 Bay Ridge Road)	Storm drain Inlet Dumping	Catering company - washing carts and wash water draining to catch basin	Outreach materials to target business groups, containment mat and pump

Figure 12. HSI-04

Figure 13. HSI-06a - Grease Storage

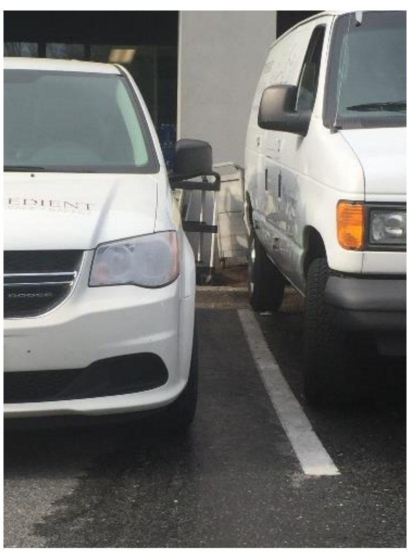


Figure 14. HSI-06b - Wash Water

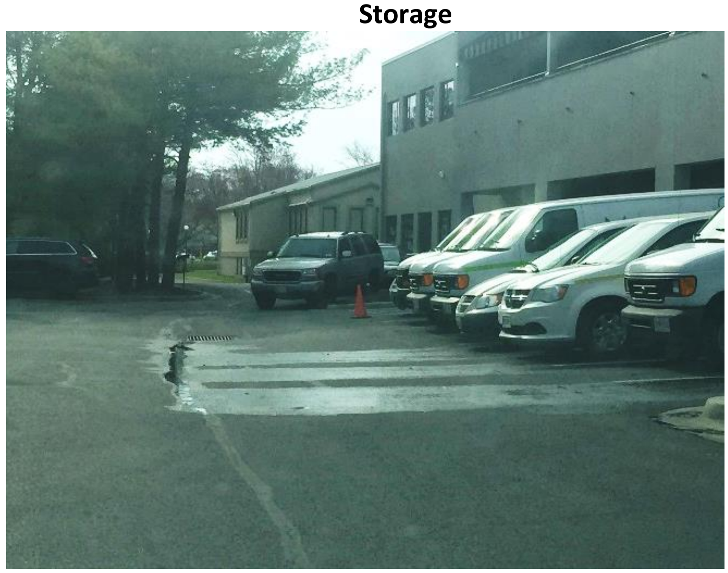


Figure 15. HSI-06b - Wash Water

When assessing the neighborhoods, a potential hotspot was observed in the Severn House neighborhood in the form of a hose available for washing vehicles. This is described in Table 13 and shown in Figure 16.

Table 13. Potential Hotspot Site				
Site ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**
HSI-NSA_19	Severn House	Vehicle Operations	Outdoor car wash that conveys wash water to the parking lot storm drain	Divert water from storm drain using containment mat and provide education

Figure 16. HSI-NSA_19

3.2 Stormwater Retrofit Inventory

Stormwater retrofits are structural stormwater management practices that can be used to address existing stormwater management problems within a watershed. These practices are installed in upland areas to capture and treat stormwater runoff before it is delivered to the storm drainage system, and ultimately, Back Creek. They are an essential element of a holistic watershed restoration program because they can help improve water quality, increase groundwater recharge, provide channel protection, and control overbank flooding. Without using stormwater retrofits to address existing problems and to help establish a stable, predictable hydrologic regime by regulating the volume, duration, frequency, and rate of stormwater runoff, the success of many other watershed restoration strategies -- such as stream stabilization and aquatic habitat enhancement -- will be threatened. In addition to the stormwater management benefits they offer, stormwater retrofits can be used as demonstration projects, forming visual centerpieces that can be used to help educate residents and build additional interest in watershed restoration.

Potential stormwater retrofit opportunities at a number of candidate project sites in the Back Creek watershed were assessed during the retrofit inventory. A Retrofit Reconnaissance Inventory (RRI) field form was used to evaluate retrofit opportunities at candidate sites. Field crews look specifically at drainage patterns, the amount of impervious cover, available space, and other site constraints when developing concepts for a site. Candidate retrofit sites identified for the assessment generally had one or more of the following characteristics:

- Located on commercial sites or apartment/condo complexes with large areas of impervious cover
- Could serve as a demonstration project; and
- Located at existing stormwater management facilities or near stormwater inlets

Marinas and yacht yards were not included in the retrofit assessment as many are already certified as Clean Marinas. Marinas and yacht yards that are not in this program should be encouraged to join.

The top retrofit opportunities identified by AECOM (AECOM, 2016) are also included.

3.2.1 Water Quality and Pollutant Removal Calculations

A water quality volume (WQv) was calculated for each retrofit drainage area. This volume captures high pollutant loads in the “first-flush” of stormwater runoff from all rainfall events. The WQv was calculated for each proposed retrofit as follows:

$$\mathrm{WQv} = \frac{\mathrm{P} \times \mathrm{Rv} \times \mathrm{A}}{12}$$

Where:

- WQv = water quality volume (cubic feet)
- P = design storm runoff depth (1 inch)
- Rv = 0.05 + 0.009(I), where (I) is the percent impervious cover of the site
- A = site drainage area (acres)

This volume reflects the water quality design volume defined in Chapter 2 of the Maryland Stormwater Design Manual (MDE, 2009), and is used to assess each retrofit’s sizing and pollutant removal potential. Nutrient load reductions for nitrogen, phosphorus, and total suspended solids (TSS), were calculated based upon several recommendations of the Chesapeake Bay Program Expert Panel on Stormwater Retrofits (Schuler and Lane, 2012):

- The nutrient and sediment removal rate for each individual retrofit project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides.

- Removal rates for new retrofits are derived from the adjuster curves based on the runoff depth captured by the practice and whether the BMP is defined as a "runoff reduction" or "stormwater treatment" practice.

3.2.2 Cost Estimates

Cost estimates (including design, construction, land acquisition, and 1 year of maintenance) were developed for each proposed retrofit using the Center's Clean Water Optimization Tool (CWOT) (http://www.cwp.org/clean-water-optimization-tool/). The primary source of cost data is from *Costs of Stormwater Management Practices in Maryland Counties* (King and Hagan, 2011), although information from the Center's *Urban Stormwater Retrofit Practices Manual* (Schueler et al., 2007) and professional judgment were utilized as well to refine the estimates for certain proposed retrofits. The CWOT User Manual has further information on cost data sources.

3.2.3 Desktop Assessment

In preparation for the field assessment, the Center first conducted a desktop analysis using ArcMap, which narrows down the locations to visit in the watershed. The Center used aerial imagery and the following GIS layers:

- Outline of the Back Creek watershed
- 2-foot contours
- Stormwater utilities such as pipes, inlets, and outfalls
- Sanitary sewer pipes
- Water pipes

The GIS data helps to identify likely locations for a retrofit. For example, sites with steep slopes or high concentrations of underground utilities are poor locations for stormwater retrofits. On the other hand, the GIS data can help identify likely locations for retrofits, such as areas with open space near stormwater inlets.

Overall, the Center identified 28 locations to visit to look for potential retrofits (see Figure 17).

Figure 17. Potential Retrofit Locations Visited During Field Assessment

3.2.4 Field Assessment

After visiting all 28 RRI locations identified in Figure 17, only 11 of these locations had areas that were suitable for retrofits. The other 17 locations were deemed unsuitable for retrofit construction due to topography, land use, shallow stormwater inlet depth, or other reasons that would make constructing a stormwater retrofit inherently difficult or expensive. Because some of the 11 suitable retrofit locations could accommodate multiple retrofits, there are a total of 23 retrofits proposed.

The recently released "City of Annapolis Stormwater Management Inventory and Watershed Improvement Plan" (AECOM, 2016) outlined five high priority BMPs in the Back Creek watershed. These AECOM BMPs are included in the analysis of this report, including an additional BMP at Baywoods off of Bembe Beach Road. Figure 18 shows all the Center and AECOM retrofit locations and their contributing drainage areas. The majority of retrofit opportunities proposed by the Center are for bioretention practices. In addition, opportunities for three impervious cover removal areas, one sand filter, one permeable paver practice, and one conversion of a dry pond to a wet pond were identified. Approximately 10% of the watershed (81 acres) and 8% (28 acres) of the impervious cover would be treated by the retrofits identified by the Center and as described in this report. The AECOM report proposed 5 bioretention retrofits and two regenerative stormwater conveyances (RSCs) at outfalls. If the AECOM outfall retrofits are constructed in addition to the Center-identified retrofits, then approximately 25% of the watershed (210 acres) and 12% (100 acres) of the impervious cover would be treated.

Figure 19 shows the hydrologic soil groups within the watershed and the Center and AECOM retrofit locations. Most of the watershed has C or D soils, with a very small section of B soils. Because these soils are unlikely to drain quickly, the retrofits discussed in this report assume an underdrain will be needed.

The retrofits identified by the Center are summarized and shown in Table 14. Table 15 lists the estimated pounds of phosphorus, nitrogen, and TSS the retrofits would remove each year, a planning level cost estimate to design and build the retrofit and maintain it for 1 year, and the cost effectiveness for all retrofits identified by the Center and the high priority BMPs identified by AECOM. The cost estimate for the AECOM BMPs comes from their report (AECOM, 2016). The pollutant removal values for the AECOM BMPs were found using the same process used for the Center retrofits, and therefore will not match the AECOM report. Appendix B shows the complete spreadsheet as well as corresponding explanations.

Appendix C includes the Retrofit Reconnaissance Inventory (RRI) field forms that were completed during field work. The forms show the conceptual sketches, constraints, and field notes for each retrofit. Appendix D is an excerpt of the AECOM report showing the BMP concepts for the Back Creek watershed (AECOM, 2016).

3.2.5 Prioritized Ranking of Recommended Actions

The retrofits listed in Table 15 are prioritized by total amount of sediment removed by the BMP each year. The BMP that would remove the most sediment is Out_04, the outfall just upstream of the SPCA.

If a regenerative stormwater conveyance is constructed at this outfall, approximately 26,600 lbs of sediment would be captured each year. The BMP with the second highest rate of removal is RRI-08-A, the stormwater pond in the Ambridge neighborhood, just upstream of Out_04. If this pond is converted from a dry pond to a wet pond, approximately 10,570 lbs of sediment would be captured each year. The City of Annapolis plans to modify the Ambridge pond so both of these retrofit locations would need to be evaluated again after the City work is complete to see if further restoration at Out_04 is needed.

Also, because RRI-11-A, RRI-11-B, and BMP_17 are within the drainage area of RRI-08-A, if the pond is retrofitted, RRI-11-A, RRI-11-B and BMP_17 may become a lower priority, as any runoff from those sites would be treated by the downstream pond retrofit at RRI-08-A. The same caveat is true for RRI-21-A, RRI-22-B, RRI-23-A, and RRI-23-B, which fall within the drainage area of Out_07, and RRI-08-B, which falls within the drainage area of Out-04. While these “upstream” retrofits may become lower priority due to the effect of downstream retrofits, they should not be considered redundant or eliminated from consideration. Constructing retrofits in series, or a “treatment train,” can increase the overall volume treatment, pollutant removal, and resiliency of the system.

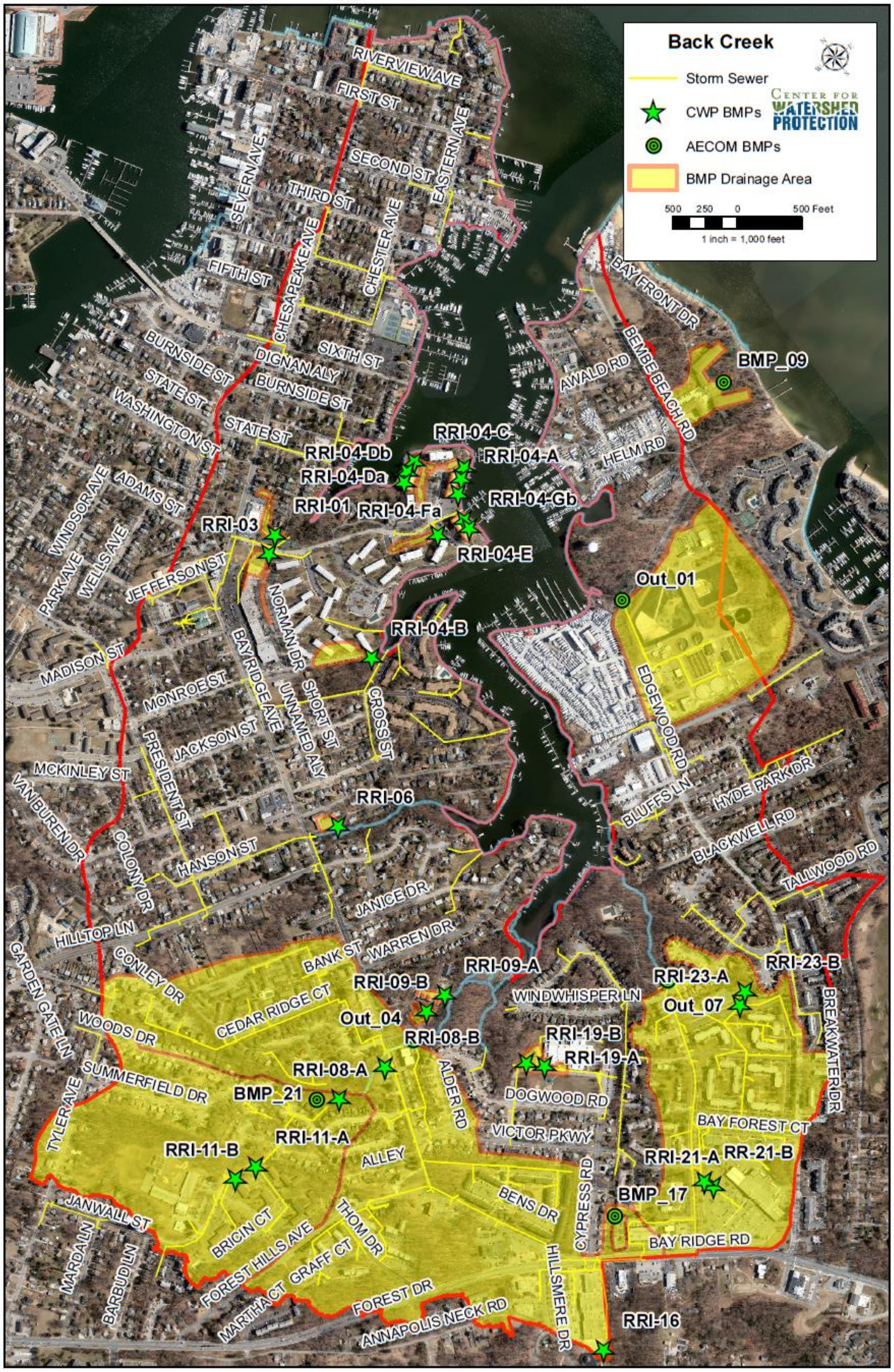


Figure 18. Retrofit Opportunities and their Contributing Drainage Areas (CDAs)

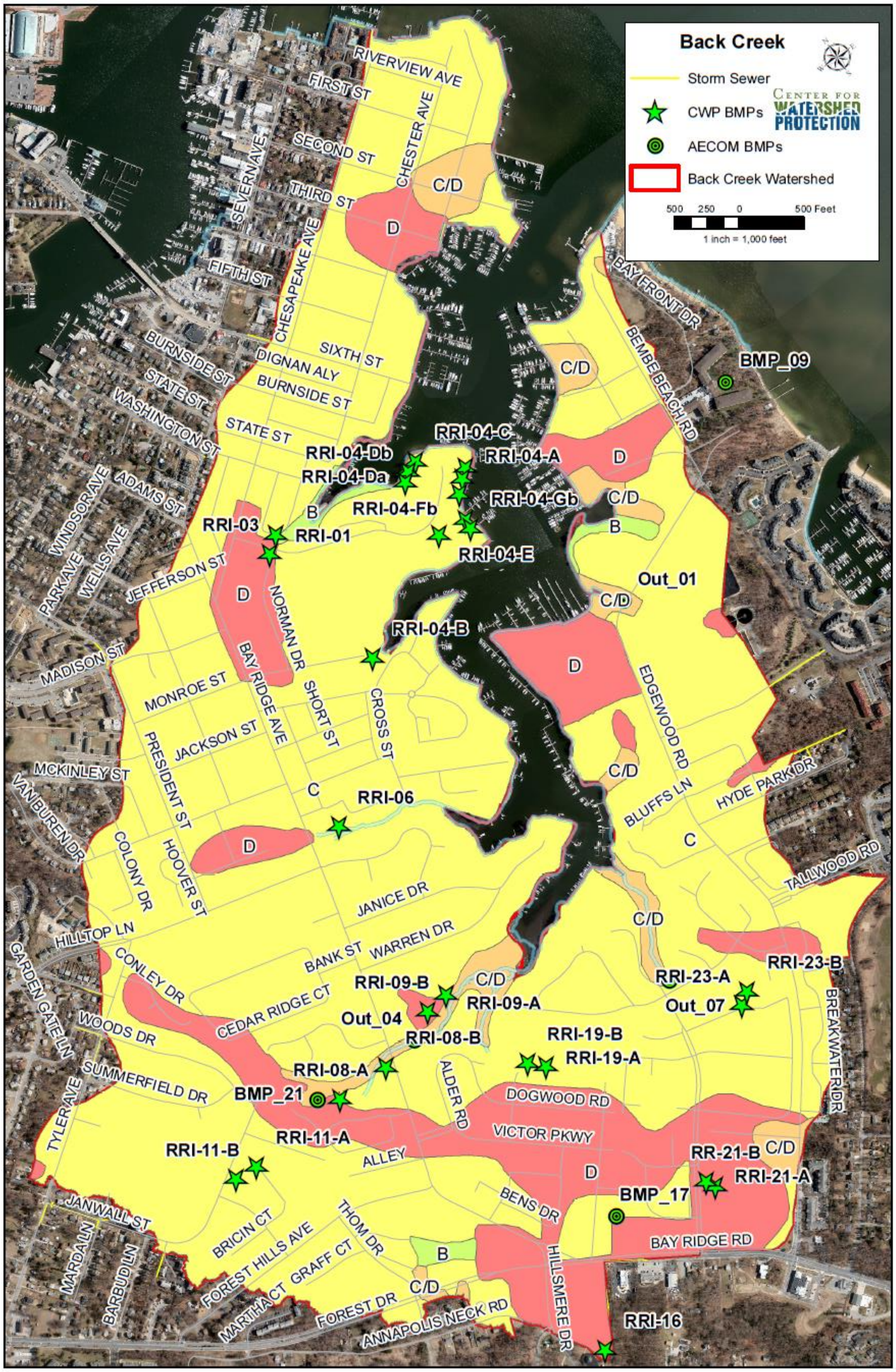


Figure 19. Hydrologic Soil Groups

Table 14. Center Identified Retrofit Locations

Retrofit	Photo Location
RRI-01 – Emory G Bowen Sr Alley A large amount of runoff currently is channeled down this alley and drains into ***Joan's Cove***, an easement area with erosion and sedimentation issues. The Center proposes constructing a permeable paver alley to promote infiltration and reduce runoff. This retrofit will also help reduce the degradation of Joan's Cove.	  **Permeable Pavement** (photos taken facing east and north)
RRI-03 – Norman Drive and Americana Drive A portion of the parking lot, some roof runoff from the ***Eastport Shopping Center***, and runoff from Norman Drive would be captured by the proposed bioretention at western corner of this location. The bioretention would require 3 parking spaces and use the grassy area between the parking lot and the sidewalk. A curb cut would be needed to bypass the existing catch basin inlet, which would also serve as the overflow.	 **Bioretention** (photo taken facing northwest)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-04-A – Near the parking lot of Watergate Pointe #700 There is a concrete channel that collects runoff from the parking lot near ***Watergate Pointe #700*** before discharging to a grate that pipes the runoff directly to Back Creek. The Center proposing constructing a bioretention in place of the concrete channel and the existing outlet pipe could be kept for overflow.	 **Bioretention** (photo taken facing north)
RRI-04-B – Parking lot at the end of Monroe Street The parking lot at the end of Monroe Street at ***Watergate Pointe*** has a concrete channel that captures stormwater runoff and channels it directly to Back Creek. The Center proposes removing the concrete channel and replacing with a bioretention. Because of the elevation change at that location, a berm would likely be needed to encourage ponding.	 **Bioretention** (photo taken facing west)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-04-C – Parking lot east of Watergate Pointe #705 Stormwater runoff from the parking lot east of ***Watergate Pointe #705*** is captured by a concrete channel that outlets directly to Back Creek. The Center proposes installing a sand filter at the end of the parking lot to improve the water quality of the runoff reaching Back Creek. The concrete channel would be removed and the BMP would not require any removal of parking spaces.	 **Sand Filter** (photo taken facing north)
RRI-04-D – Behind Watergate Pointe #705 The building downspouts conveying roof stormwater runoff from ***Watergate Pointe #705*** is directly connected to pipes that outlet into Back Creek. The Center proposes to build 2 bioretention areas (one for each downspout pipe) to capture the runoff water from the pipes. The existing buried pipes could be used as an underdrain connection and for overflow.	 **Bioretention** (photo taken facing north)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-04-E – Parking lot in front of Watergate Pointe #760 The parking lot in front of ***Watergate Pointe #760*** drains to a catch basin at the southeast corner. The Center proposes to construct a bioretention by removing 3 parking spaces. The existing catch basin would serve as an overflow. The bioretention underdrain would tie into that catch basin.	 **Bioretention** (photo taken facing south)
RRI-04-F – Behind Watergate Pointe #700 The building downspouts conveying roof stormwater runoff from ***Watergate Pointe #700*** is directly connected to pipes that outlet into Back Creek. The Center proposes to build 2 bioretention areas (one for each downspout pipe) to capture the runoff water from the pipes. The existing buried pipes could be used as an underdrain connection and for overflow.	 **Bioretention** (photo taken facing southwest)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-04-G – Behind Watergate Pointe #680 The building downspouts conveying roof stormwater runoff from ***Watergate Pointe #680*** is directly connected to pipes that outlet into Back Creek. The Center proposes to build 2 bioretention areas (one for each downspout pipe) to capture the runoff water from the pipes. The existing buried pipes could be used as an underdrain connection and for overflow.	 **Bioretention** (photo taken facing southeast)
RRI-06 – Parking lot of Church of Nazarene, 1309 Bay Ridge Avenue Stormwater from the ***Church of Nazarene*** parking lot, the adjacent home, and a portion of the church roof sheet flows to the adjacent stream that outlets into Back Creek. The Center proposes to construct a bioretention that would capture the runoff in the back corner of the parking lot. A curb would need to be constructed along the edge of the parking lot and entrance road to channel the water to the bioretention. An underdrain would outlet directly to the stream.	 **Bioretention** (photo taken facing north)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-08-A – Ambridge Neighborhood Pond Approximately 70 acres of the Back Creek watershed drains to this stormwater pond in the ***Ambridge*** neighborhood. The Center proposes to convert this existing dry pond to a wet pond by digging the pond deeper and modifying the outlet.	 **Dry Pond to Wet Pond Conversion** (photo taken facing northwest)
RRI-08-B – Overflow parking for 1819 Bay Ridge Ave The Center proposes removing a portion of the underutilized parking lot.	 **Impervious Cover Removal** (photo taken facing southeast)

Table 14. Center Identified Retrofit Locations

Retrofit	Photo Location
RRI-09-A – SPCA parking lot Stormwater runoff from the ***SPCA*** gravel parking lot is eroding the slope next to the parking area and creating a channel to the nearby stream. The Center proposes to construct a bioretention at the edge of the parking lot to reduce or eliminate the erosion to the stream. The bioretention could also capture water that currently ponds near the kennel if a valley gutter is constructed across the parking lot driveway.	 **Bioretention with valley gutter** (photos taken facing west)
RRI-09-B – Yard inlet at SPCA The Center proposes constructing a bioretention next to the yard inlet at the ***SPCA***. The yard inlet would serve as the overflow and where the underdrain would connect.	 **Bioretention** (photo taken facing southwest)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-11-A – Near parking lot of Reserve at Quiet Waters, 14 Melrob Court The Center proposes constructing a bioretention behind the north end of the parking lot at ***Reserve at Quiet Waters*** apartment complex. A curb cut would be needed to bypass the catch basin in the parking lot. A berm would be constructed to encourage ponding. An existing yard inlet west of the parking lot would serve as the overflow and where the underdrain would connect.	 **Bioretention** (photo taken facing north)
RRI-11-B – Near parking lot of Quiet Waters off of Bricin Street The Center proposes constructing a bioretention behind the east end of the parking lot at the ***Reserve at Quiet Waters*** apartment complex. Curb cuts would be needed on both sides of the existing catch basin to capture runoff. The catch basin would serve as an overflow and where the underdrain would connect.	 **Bioretention** (photo taken facing west)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-16 – Bay Ridge Plaza, 123 Hillsmere Drive The Center proposes removing the south end of the underutilized parking lot at ***Bay Ridge Plaza***.	 **Impervious cover removal** (photo taken facing southeast)
RRI-19-A – Georgetown East Elementary School The Center proposes a bioretention in front of ***Georgetown East Elementary School***. A curb cut and trench drain through the sidewalk would be needed to channel the water from the drive to the bioretention. The underdrain would directly connect to the nearby storm sewer.	 **Bioretention** (photo taken facing east)

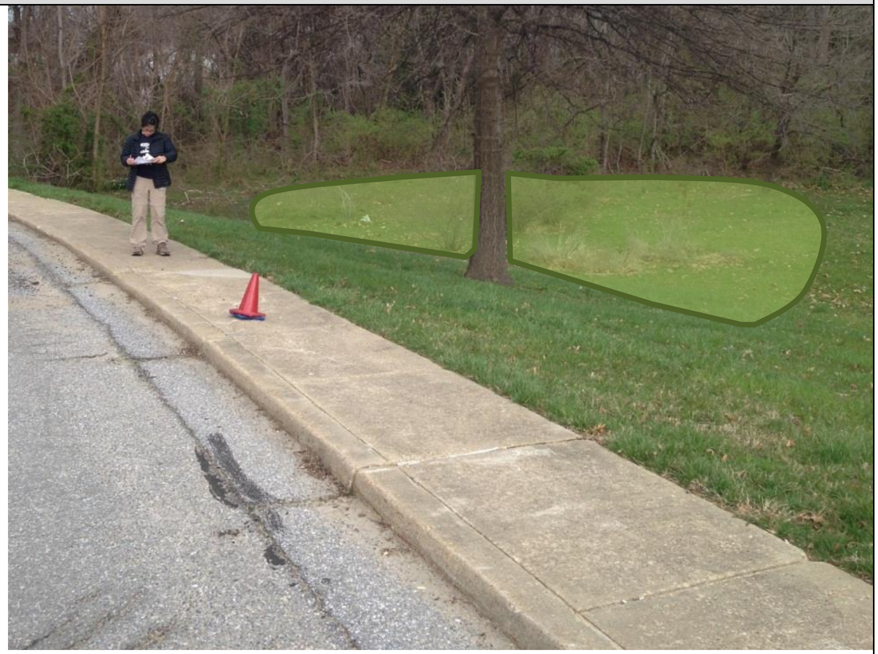
Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-19-B – Georgetown East Elementary School The Center proposes constructing a bioretention in the low area north of the ***Georgetown East Elementary School*** next to an existing yard inlet. New catch basins would need to be installed on either side of the entrance road to direct the water to the bioretention. The yard inlet would serve as the overflow and where the underdrain would tie into.	 **Bioretention** (photo taken facing north)
RRI-21-A – Giant parking lot, 948 Bay Ridge Road The Center proposes constructing a bioretention in the parking lot island of the Giant at the ***Bay Forest Shopping Center***. Curb cuts would be needed to bypass the existing catch basin. The catch basin would serve as the overflow and where the underdrain would connect.	 **Bioretention** (photo taken facing east)

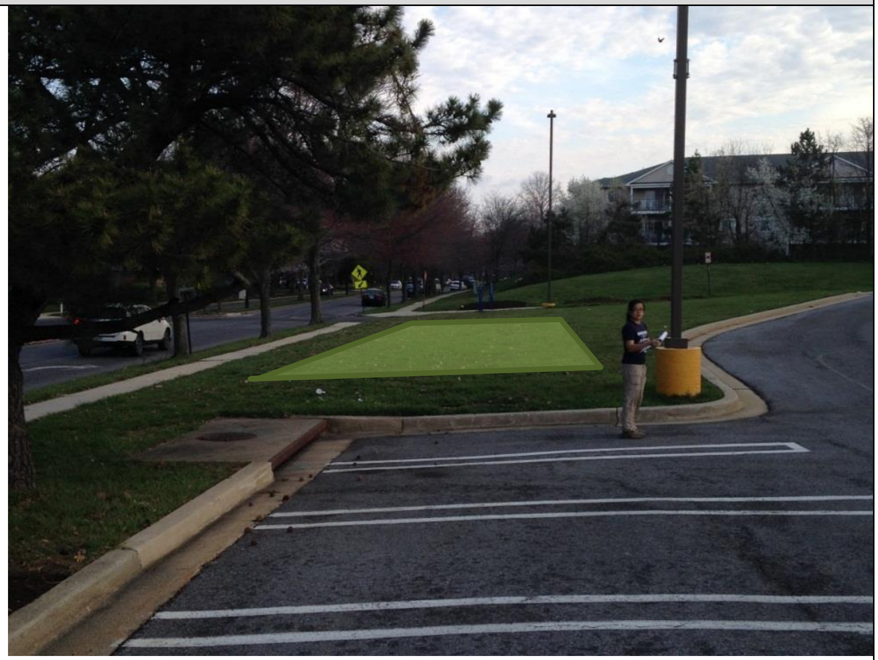
Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-21-B – Giant parking lot, 948 Bay Ridge Road The Center proposes constructing a bioretention near the parking lot entrance off of Georgetown Road of the Giant at ***Bay Forest Shopping Center***. A curb cut would be needed to bypass the existing catch basin. The catch basin would serve as the overflow and where the underdrain would connect.	 **Bioretention** (photo taken facing northeast)
RRI-23-A – Fairwinds of Annapolis – East, Silverwood Circle, near the tennis courts The Center proposes constructing a bioretention next to an existing catch basin adjacent to the parking area at ***Fairwinds of Annapolis – East***. Curb cuts would be needed to bypass the catch basin, which would serve as the overflow and where the underdrain would connect	 **Bioretention** (photo taken facing northeast)

Table 14. Center Identified Retrofit Locations	
Retrofit	**Photo Location**
RRI-23-B – Fairwinds of Annapolis – East, Silverwood Circle, near the tennis courts The Center proposes removing the old, unused tennis courts at ***Fairwinds of Annapolis – East***.	 **Impervious cover removal** (photo taken facing northeast)

Table 15. Stormwater Retrofits in Back Creek Watershed

Site ID	Site Description	Practice	Drainage Area (acre)	%IC	% Water Quality Volume	Total Phosphorus Removal (lbs/yr)	Total Nitrogen Removal (lbs/yr)	Total TSS Removal (lbs/yr)	Cost $ (Design, Construct., Land Acq., 1 Yr Maint.)	Cost Effectiveness ($/lb TP Removed)	Cost Effectiveness ($/lb TN Removed)	Cost Effectiveness ($/lb TSS Removed)
St. Luke's Church†	large restoration project	Regenerative Stormwater Conveyance	28.27	48%	84%	39.29	195.38	50,005.26				
Out_04*	outfall near SPCA	Regenerative Stormwater Conveyance	120.70	45%	100%	76.41	646.12	26,601.09	$ 845,797.00	$ 11,068.59	$ 1,309.03	$ 31.80
Out_07*	outfall at Mariner's Point	Regenerative Stormwater Conveyance	55.00	55%	100%	38.68	297.33	13,906.60	$ 668,361.00	$ 17,278.56	$ 2,247.88	$ 48.06
RRI-08-A†	Ambridge neighborhood pond	Conversion of Dry Pond to Wet Pond	67.78	32%	68%	27.25	201.07	10,570.31	$ 326,236.60	$ 11,970.13	$ 1,622.51	$ 30.86
BMP_21†*	*Ambridge neighborhood pond*	*Conversion of Dry Pond to Wet Pond*	*55.60*	*35%*	*101%*	*24.37*	*173.23*	*9,607.55*	*$ 220,291.00*	*$ 7,101.87*	*$ 743.92*	*$ 21.39*
Out_01*	outfall at Osprey Nature Center at Ellen O. Moyer Park	Regenerative Stormwater Conveyance	34.60	44%	100%	21.49	184.82	7,435.33	$ 354,975.00	$ 16,517.54	$ 1,920.67	$ 47.74
RRI-21-A	*Giant parking lot at Bay Forest Shopping Center*	*Bioretention*	*2.29*	*84%*	*27%*	*1.01*	*6.18*	*386.61*	*$ 50,075.92*	*$ 49,585.94*	*$ 8,097.28*	*$ 129.53*
RRI-11-A	*Reserve at Quiet Waters - near parking lot*	*Bioretention*	*1.94*	*54%*	*39%*	*0.87*	*6.76*	*309.94*	*$ 47,652.32*	*$ 55,049.54*	*$ 7,048.90*	*$ 153.75*
RRI-03	corner of parking lot at Eastport Shopping Center	Bioretention	0.81	95%	71%	0.72	4.08	278.76	$ 44,453.51	$ 62,057.28	$ 10,900.04	$ 159.47
BMP_09*	Baywoods	Wet Pond Upgrade	4.57	55%	114%	0.52	2.99	222.54	$ 194,523.00	$372,994.45	$ 65,057.32	$ 874.11
RRI-04-C	end of parking lot at Watergate Pointe	Filtering Practice	0.58	96%	106%	0.47	1.97	216.10	$ 36,590.53	$ 78,325.09	$ 18,575.01	$ 169.32
*BMP_17**	*Georgetown Plaza*	*Bioretention*	*0.69*	*68%*	*99%*	*0.55*	*3.78*	*204.57*	*$ 200,288.00*	*$363,933.14*	*$ 53,020.28*	*$ 979.08*

Table 15. Stormwater Retrofits in Back Creek Watershed

Site ID	Site Description	Practice	Drainage Area (acre)	%IC	% Water Quality Volume	Total Phosphorus Removal (lbs/yr)	Total Nitrogen Removal (lbs/yr)	Total TSS Removal (lbs/yr)	Cost $ (Design, Construct., Land Acq., 1 Yr Maint.)	Cost Effectiveness ($/lb TP Removed)	Cost Effectiveness ($/lb TN Removed)	Cost Effectiveness ($/lb TSS Removed)
RRI-04-B	end of Monroe St, Watergate Pointe	Bioretention	1.30	66%	22%	0.42	2.93	154.89	$ 15,461.23	$ 36,902.62	$ 5,271.58	$ 99.82
RRI-19-B	Georgetown Elementary School	Bioretention	0.47	72%	85%	0.37	2.48	139.66	$ 31,095.84	$ 83,439.83	$ 12,528.61	$ 222.65
RRI-01	alley at south end of Chester Ave next to Joan's Cove in Eastport	Permeable Pavers	0.64	49%	77%	0.39	3.18	137.80	$ 199,417.61	$510,651.95	$ 62,736.37	$ 1,447.10
RRI-16	Bay Ridge Plaza	Impervious Cover Removal	0.33	100%	105%	0.35	1.91	135.10	$ 50,979.55	$147,736.04	$ 26,726.69	$ 377.34
RRI-06	Church of Nazarene parking area	Bioretention	0.34	90%	111%	0.34	2.00	131.63	$ 18,835.66	$ 55,293.29	$ 9,415.00	$ 143.09
RRI-04-E	parking lot near catch basin at Watergate Pointe	Bioretention	0.46	99%	47%	0.34	1.87	131.03	$ 25,192.00	$ 75,188.54	$ 13,495.72	$ 192.26
RRI-21-B	*Giant parking lot at Bay Forest Shopping Center*	*Bioretention*	*0.46*	*78%*	*64%*	*0.34*	*2.15*	*127.58*	*$ 25,021.31*	*$ 74,321.31*	*$ 11,640.64*	*$ 196.12*
RRI-23-B	*old tennis court removal at Fairwinds of Annapolis - East*	*Impervious Cover Removal*	*0.29*	*100%*	*105%*	*0.31*	*1.69*	*119.42*	*$ 45,063.09*	*$147,736.04*	*$ 26,726.69*	*$ 377.34*
RRI-11-B	*Reserve at Quiet Waters - near parking lot*	*Bioretention*	*0.47*	*45%*	*112%*	*0.31*	*2.61*	*107.19*	*$ 25,913.20*	*$ 84,112.64*	*$ 9,930.39*	*$ 241.76*
RRI-23-A	*near tennis courts of Fairwinds of Annapolis - East*	*Bioretention*	*0.49*	*90%*	*33%*	*0.27*	*1.57*	*102.36*	*$ 13,441.50*	*$ 50,695.43*	*$ 8,576.05*	*$ 131.32*

Table 15. Stormwater Retrofits in Back Creek Watershed

Site ID	Site Description	Practice	Drainage Area (acre)	%IC	% Water Quality Volume	Total Phosphorus Removal (lbs/yr)	Total Nitrogen Removal (lbs/yr)	Total TSS Removal (lbs/yr)	Cost $ (Design, Construct., Land Acq., 1 Yr Maint.)	Cost Effectiveness ($/lb TP Removed)	Cost Effectiveness ($/lb TN Removed)	Cost Effectiveness ($/lb TSS Removed)
RRI-04-F	roof top disconnection at Watergate Pointe	Bioretention	0.29	76%	123%	0.26	1.68	98.17	$ 15,763.75	$ 60,634.44	$ 9,371.63	$ 160.58
RRI-04-G	roof top disconnection at Watergate Pointe	Bioretention	0.28	75%	107%	0.24	1.57	90.63	$ 15,210.12	$ 63,254.44	$ 9,708.88	$ 167.84
RRI-04-D	roof top disconnection at Watergate Pointe	Bioretention	0.26	75%	100%	0.22	1.44	83.42	$ 14,265.41	$ 64,450.04	$ 9,893.16	$ 171.01
RRI-09-B	SPCA parking lot	Bioretention	0.47	31%	106%	0.25	2.55	82.69	$ 25,913.20	$101,853.48	$ 10,170.54	$ 313.37
RRI-19-A	Georgetown Elementary School	Bioretention	0.28	65%	108%	0.22	1.54	80.22	$ 18,085.37	$ 83,133.20	$ 11,767.47	$ 225.45
RRI-04-A	concrete channel near parking lot at Watergate Pointe	Bioretention	0.20	85%	122%	0.19	1.18	74.08	$ 10,897.50	$ 56,394.16	$ 9,274.04	$ 147.10
RRI-09-A	SPCA parking lot	Bioretention	0.28	82%	35%	0.15	0.90	55.48	$ 15,071.14	$103,678.62	$ 16,698.13	$ 271.64
RRI-08-B	*Overflow parking for 1819 Bay Ridge Ave*	*Impervious Cover Removal*	*0.12*	*100%*	*105%*	*0.12*	*0.67*	*47.81*	*$ 18,040.11*	*$147,736.04*	*$ 26,726.69*	*$ 377.34*
Total			**380.27**			**243.35**	**1,880.51**	**122,332.9**	**$3,572,911.50**			
Total (italicized BMPs are not implemented)			**373.41**			**232.75**	**1,730.12**	**120,177.0**	**$3,292,970.26**			

***** BMPs proposed by AECOM 2016 report.

† BMPs funded for construction.

3.3 Additional Restoration

The field assessment included a visit to Joan's Cove. While a stormwater retrofit is not proposed for this outfall location, the cove could benefit from invasive plant removal, slope stabilization, and wetland restoration. See Figure 20.

Figure 20. Joan's Cove

Additionally, through the work of Ms. Betsy Love, a student at the Anne Arundel County Watershed Stewards Academy and parishioner at St. Luke's Church (1101 Bay Ridge Avenue), and with help from the Alliance for the Chesapeake Bay, funding was secured for the design and construction of a large restoration project on the church property. This project was originally proposed in the "City of Annapolis Watershed Study and Action Plan" (McCrone and AEGIS, 2009). The design by Underwood & Associates, Inc. is currently working its way through the permitting process. This project includes 1,400 linear feet of stream creation, 320 linear feet of living shoreline, approximately 500 linear feet of bioswale, 7 curb openings, and over 125,000 square feet of native plantings. As currently designed, this project has a drainage area of 28.27 acres, 48% which is impervious. It will treat 41,609 cubic feet of runoff and remove 195.38 lbs/yr of TN, 39.29 lbs/yr of TP, and 50,005.26 lb/yr of TSS.

Section 4. Pollutant Reduction Estimates

4.1 Overview of Pollutant Removal from the Chesapeake Bay Program Expert Panel on Stormwater Retrofits

Pollutant removal for stormwater retrofits included in the Tool were calculated based on the recommendations of the CBP Expert Panel on Stormwater Retrofits (Schueler and Lane, 2012). The panel classified retrofits into two broad project categories -- new retrofit facilities and retrofits of existing BMPs. Given the diversity of possible retrofit applications, the panel decided that assigning a single universal removal rate was not practical or scientifically defensible. Every retrofit is unique, depending on the drainage area it treats, the treatment mechanism employed, its volume or size and the antecedent degree of stormwater treatment, if any. Instead, the panel elected to develop a protocol whereby the removal rate for each individual retrofit project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The panel conducted an extensive review of recent BMP performance research and developed a series of retrofit removal adjustor curves to define sediment, nitrogen, and phosphorus removal rates. Removal rates for new retrofits are derived from the adjuster curves based on the runoff depth captured by the practice and whether the BMP is defined as a “runoff reduction” (RR) or “stormwater treatment” (ST) practice (see Table 16).

Table 16. Runoff Reduction and Stormwater Treatment Practices

BMP	Type of Practice
Permeable pavement	RR
Permeable pavers	RR
Downspout disconnection	RR
Bioretention	RR
Rain garden	RR
Regenerative Stormwater Conveyance	RR
Sand filter	ST
Wet ponds	ST

4.2 Existing Conditions and Load Reductions from Future BMPs

Table 17 shows the estimated annual pollutant load from the Back Creek watershed. These values were calculated from GIS data provided by the City of Annapolis and Anne Arundel County using 816.76 acres in the watershed with 42.88% imperviousness. If all the retrofits listed in Table 15 were implemented, the total pollutant removal would be 236.71 lbs/year, 1,757.62 lbs/year, and 121,643.83 lbs/year for TP, TN, and TSS, respectively. The percent reduction of pollutants within the subwatershed is shown below.

Table 17. Estimated Annual Back Creek Pollutant Load and Removal from Center Projects

	TP	TN	TSS
Back Creek Subwatershed Pollutant Load (lb/yr)	716.66	7,269.48	230,662.99
Total Retrofit Pollutant Removal (lbs/yr)	236.71	1,757.62	121,643.83
% Pollutant Reduction with Retrofit Implementation	33.0%	24.2%	52.74%

Table 18 shows the top retrofits that would remove the most nutrients and sediment. Eight retrofits are consistently within the top ten for TP, TN, and TSS removal. They are the project at St. Luke's Church, the RSC near the SPCA (Out_04), the RSC at Mariner's Point (Out_07), dry pond to wet pond conversion in the Ambridge neighborhood (RRI-08-A and BMP_21), the RSC at Ellen O. Moyer Park (Out_01), the bioretention at in the Giant parking lot (RRI-21-A), the bioretention at Quiet Waters (RRI-11-A), and the bioretention at the intersection of Norman Dr. and Americana Dr. (RRI-03).

Table 18. Top Pollutant Removal Retrofit Sites

Top 10 Retrofits	TP Removal		TN Removal		TSS Removal	
	Site	lbs/yr	Site	lbs/yr	Site	lbs/yr
#1	Out_04	76.41	Out_04	646.12	St. Luke's Church	50,005.26
#2	St. Luke's Church	39.29	Out_07	297.33	Out_04	26,601.09
#3	Out_07	38.68	RRI-08-A	201.07	Out_07	13,906.60
#4	RRI-08-A	27.25	St. Luke's Church	195.38	RRI-08-A	10,570.31
#5	BMP_21	24.37	Out_01	184.82	BMP_21	9,607.55
#6	Out_01	21.49	BMP_21	173.23	Out_01	7,435.33
#7	RRI-21-A	1.01	RRI-11-A	6.76	RRI-21-A	386.61
#8	RRI-11-A	0.87	RRI-21-A	6.18	RRI-11-A	309.94
#9	RRI-03	0.72	RRI-03	4.08	RRI-03	278.76
#10	BMP_17	0.55	BMP_17	3.78	BMP_09	222.54
Total		**230.64**		**1,718.75**		**119,323.99**

Section 5. Water Quality Monitoring

5.1 Role of Water Quality Monitoring

Water quality monitoring can help the Conservancy understand the hydrology and long term trends of Back Creek and track water quality improvements from stormwater retrofit projects by determining how much of an effect environmental (e.g. wind intensity, sunlight intensity, precipitation) or anthropogenic changes (e.g. increased impervious surface, stormwater retrofits, community cleanup events) can have on water quality. Monitoring can also detect pollution hotspots to help decrease or eliminate some sources of pollution.

There are three phases of water quality monitoring described in this section. Phase I describes how the Conservancy can first engage volunteers through community outreach and education while collecting basic information about Back Creek, such as pH and turbidity. Phase II introduces more resource intensive monitoring procedures, such as water column water quality sampling and macroinvertebrate sampling. Finally, Phase III of the monitoring plan briefly discusses long-term monitoring assessments needed to ensure that the water quality goals of Back Creek are being met.

5.2 Pollutants of Concern and Potential Sources

The two major concerns for Back Creek Conservancy are pathogens and sediment. Pathogens can enter the waterway through various methods, such as sewer leaks, pet and wildlife waste, or marine waste. Pathogens are an important pollutant to monitor due to their direct impact on public health. Secondary concerns include algal blooms and heavy metals.

The increasing amount of sediment in the Back Creek watershed may be due to the large areas of impervious surfaces in the watershed (although contributions from the main stem of the Severn River may be a factor as well). These impervious surfaces cause large amounts of stormwater runoff which contributes to erosion of the headwater streambanks. Sedimentation of the Creek decreases the water depth, thereby decreasing boat access. Dredging can mitigate sedimentation, but without decreasing or stopping upstream sediment from entering, it would be an expensive, short term solution.

Other issues in Back Creek include algal blooms caused by an increase of nutrients in stormwater. Increased nitrogen and phosphorus entering the Creek through runoff can cause eutrophication. This means the Creek turns into a buffet for naturally occurring algae, and they grow rapidly. Although algae do produce oxygen during the daytime while they are photosynthesizing, it is not enough to overcome the oxygen consumption by bacteria that decompose dead algae. This cycle of eutrophication decreases the amount of oxygen in the water column, creating a difficult habitat for marine life. This is prevalent during the summer months, and as algae propagate faster during the summer, dissolved oxygen (DO) saturation in the water decreases more rapidly causing stratification of the water column and impairing the survival of marine life.

With the abundance of boats in the Creek, there may be heavy metals in the sediment caused by antifouling paints, engine wear, or vessel scraping and sanding. Heavy metals can also enter the Creek through stormwater runoff and also from soil erosion, releasing naturally occur metals. Although the Back Creek watershed was never heavily industrialized, older farming methods did use some heavy metals, which could potentially be in the legacy sediment. Metals buried in sediment do not typically transport into the water without a large catalyst, but dredging can cause resuspension of the sediment carrying the heavy metals. Even though the heavy metals are unlikely to stay suspended for long, they can settle on the surface of the sediment, increasing the risk of bioaccumulation (Lee, J. et al., 2013; Hedge, L. et al., 2009).

5.3 Overview of Water Quality Monitoring

The essential elements of water quality monitoring include logistics, safety procedures, pre-monitoring preparation, sampling frequency, sampling location determination, data collection, and analysis and reporting. The *EPA Volunteer Estuary Monitoring, A Methods Manual* (2006) provides more details on these topics.

5.3.1 Monitoring Manager

Involving volunteers in monitoring has multiple benefits: the monitoring expenses decrease, outreach and education increases, and it strengthens the voices in the community advocating for the water quality improvements. If volunteers are used, a Monitoring Manager position would be important for the organization. This person would be the point of contact for all the volunteers and would troubleshoot issues that arise, as well as be responsible for collecting the information from the volunteers and ensuring that volunteers are trained for monitoring.

5.3.2 Training and Safety

Before a volunteer can help with monitoring, equipment and safety training is required. Table 19 lists guides for recruiting and training volunteers.

Table 19. Volunteer Training Resources

Topic	Title	Website Link
Orientation Manual	Volunteer Centre of Camrose and District, Creating an Orientation Manual for Volunteers, 2008	https://sustainingplaces.files.wordpress.com/2013/05/volunteer-orientation-manual.pdf
Recruiting, Training, and Retaining Volunteers	EPA Volunteer Estuary Monitoring: A Methods Manual- Chapter 4: Recruiting, Training, and Retaining Volunteers, 2006	https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/nonpoint-source-volunteer-monitoring
List of Protocols for Training	Canadian Council of Ministers or the Environment, Protocols Manual for Water Quality Sampling in Canada	http://www.ccme.ca/files/Resources/water/water_quality/protocols_document_e_final_101.pdf

Water monitoring has various safety risks, such as chemical handling, falling into a stream, or coming in contact with poison ivy. Liability forms should be completed by all volunteers after safety training. See Figure 21 for an example liability form. Below is a short list of safety considerations for monitoring:

- Always work with a partner

- Check the weather to make sure it is safe for monitoring
- Never wade in swift or high water
- Inform the Monitoring Manager of the monitoring location and when volunteers should return
- Keep a first aid kit available
- Do not monitor if the water appears to be severely polluted; contact the Monitoring Manager immediately
- Confirm permission is granted by the landowner before entering site
- Watch for and avoid poison ivy, poison oak, poison sumac, wildlife (particularly snakes), and insects such as ticks, hornets, and wasps

LIABILITY WAIVER

I the undersigned, being the volunteer involved in the Back Creek Conservancy Water Monitoring Program (hereinafter referred to as the Program) or being the parent or legal guardian of such a volunteer in the Program, in consideration of my or another's participation in the Program, I hereby, for myself and any volunteer for whom I am a parent or legal guardian release, discharge, hold harmless, and forever acquit the State of Maryland, the County, the City, the Back Creek Conservancy or other local sponsors, and their officers, agents, representatives and employees from any and all actions, causes of action, claims or any liabilities whatsoever, known or unknown now existing or which may arise in the future, on account of or in any way related to or arising out of my participation in the Program. Further, I assume all liability of any non-participants who accompany me.

I understand that I am a volunteer for all purposes, including worker's compensation, and am not an employee of the State of Maryland, the County, the City, the Back Creek Conservancy or other local sponsors, and their officers, agents, representatives and employees, and as such they are not responsible for injury or death of myself and any volunteer for whom I am a parent or legal guardian which may occur while acting as a volunteer.

Participant's name (please print):

Participant's signature:

Participant's age:

Signature of participant's parent or legal guardian (if under 18):

Date:

Figure 21. Sample Liability Form

Other safety considerations are noted in the guides in Table 20.

Table 20. Example Safety Guidelines	
Title	**Website Link**
Town of Westford Stormwater Sampling Manual, 2014, Page 11-15	http://westfordma.gov/Pages/Government/TownDepartments/WestfordMA_EngDept/DOCS/Westford%20SW%20Training%20Manual.pdf
Red River Basin Water Quality Monitoring Volunteer Manual, Page 45	http://www.iwinst.org/wp-content/uploads/2012/04/water_quality_manual_part1.pdf
EPA Volunteer Estuary Monitoring: A Methods Manual, 7-3 to 7-5, 2006	http://nepis.epa.gov/Exe/ZyPDF.cgi/P1007NHX.PDF?Dockey=P1007NHX.PDF

5.3.3 Pre-Monitoring Tasks

The following tasks should be completed before monitoring.

- Print field data sheets
- Check site location and parameters needed for monitoring
- Check the weather the day before and morning of to make sure it is safe to monitor
- Calibrate monitoring equipment, if needed
- Pack all monitoring equipment

5.3.4 Data Collection

When collecting data, all measurements should be written down on the field sheets and make sure all items in the field sheet are completed. Print out monitoring procedures to ensure that they are properly followed during monitoring. Once monitoring is finished, clean the materials and store for the next use.

5.3.5 Quality Assurance Project Plan (QAPP)

A Quality Assurance Project Plan (QAPP) has been developed for water quality monitoring on Back Creek. Consult the QAPP for more information on water quality sampling, the sampling locations, and data management.

5.3.6 Data Storage, Analysis, Reporting

Field sheet data must be aggregated and analyzed in order to track trends and be able to report on results. The data can be entered into a database, usually an Excel spreadsheet, by the volunteer, or if further quality control is needed, by the Monitoring Manager. Any questionable results or outliers should be reported to the Monitoring Manager. Data sheets should be entered into the database within 48 hours of sampling/analysis. A yearly water quality report can be created from this information and distributed via newsletter or posted online. Table 21 lists resources on analyzing monitoring data.

Table 21. Data Analyzing Resources		
Topic	**Title**	**Website Link**
Explanation of How to Analyze Data	Hoosier Riverwatch, Volunteer Stream Monitoring Training Manual, Chapter 8, 2015	http://www.in.gov/idem/riverwatch/files/volunteer_monitoring_manual.pdf
Example of How to Present Data	South River Federation, 2014 Sub-Report Card, Water Quality Analysis: Aberdeen Creek	http://www.southriverfederation.net/images/stories/pictures/WaterQuality/aberdeen%202014.pdf

5.4 Monitoring Components

Tables 22, 23, and 24 describe the components of the three phases of monitoring: basic, advanced, and the monitoring assessment.

Table 22. Phase I - Basic Monitoring	
Type of Monitoring	**Purpose**
Observational Monitoring	Engage volunteers to visually assess their neighborhood and be able to detect significant changes
Stormwater Outfall Assessment	Engage volunteers to visually assess their nearby outfalls and be able to detect significant changes
Multi-parameter Meter	Introduce water quality monitoring to volunteers, potentially to find abnormalities in the water, develop baseline water quality measurements, and identify trends based on pollutants of concern or indicators

Table 23. Phase II - Advanced Monitoring	
Type of Monitoring	**Purpose**
Quantitative Bacterial Analysis	Introduce advanced water quality monitoring to volunteers, potentially to find abnormalities in the water
Stream Bank Erosion Rate Calculations	Determine rate of erosion
Continuous Monitoring at Selection Locations	Determine water quality variations with time
Sediment Core Sampling	Determine composition of sediment
Macroinvertebrate Sampling	Determine biological health of the creek/streams
External Bacterial Monitoring	Identify potential public health issues
Alternative Bacteria Analysis Methods	Collect enhanced bacteria source tracking

Table 24. Phase III - Monitoring Assessment	
Assessment	**Purpose**
Determine trends and baseline water quality	Evaluate potential sources of pollution, determine scope of pollution issue, and prioritize resources
Increase bacteria analysis locations	Increase public health awareness
Based on creek water quality data, increase or decrease monitoring locations	Optimize resource usage
Evaluate land use changes	Ensure that monitoring plan is adequately assessing water quality based on land use
Evaluate technical changes and regulatory changes	Ensure that resources are used efficiently

5.4.1 Phase I

The goal of Phase I monitoring is to involve volunteers in basic water quality monitoring and to identify potential water quality problems. Detailed field sheets will be important in this type of monitoring, since specific measurements may not be taken. Phase I monitoring should help recruit and engage the citizens of Back Creek.

Observational Monitoring

Observational monitoring, such as stream walks observing individual locations, such as at an outfall, is an easy way to get volunteers involved with minimal training and equipment. Volunteers can have dedicated stream sections or outfalls to monitor at set intervals (e.g. every other month) or after large storm events. By having a dedicated stream or outfall, the volunteer will be able to better identify visual changes, which can be an indicator for pollution. Volunteers can take photos or videos of the stream or outfall to capture changes or abnormalities. Table 25 lists resources for conducting observational monitoring.

Table 25. Observational Monitoring Resources

Topic	Title	Website Link
Stream Walk Procedures	Wisconsin's Citizen-Based Water Monitoring Network, Stream Walk Survey	http://watermonitoring.uwex.edu/pdf/level1/Pubsstreamsurvey.pdf
Field Sheet	Wisconsin's Citizen-Based Water Monitoring Network, Stream Walk Worksheet	http://watermonitoring.uwex.edu/pdf/level1/Pubsstreamsurveyform.pdf
Stream Walk Survey Sheet	Riverkeeper Stream Walk Methods	http://www.riverkeeper.org/patrol/stream-walk-resources/
Stream Walk Survey	Visual Stream Survey	http://www.georgiaadoptastream.com/Manuals_etc/Visual/Visual.pdf

Volunteers should assess the streams during dry weather and after storms in order to compare conditions and note any changes. If there is evidence of illicit discharge (soapy water, sewage smell, trash, etc.), local officials should be notified. Volunteers can also perform a stream paddle, where they kayak or canoe in Back Creek and assess the shoreline. Recommended stream walk locations are listed:

- Site 1: Outfall South of SPCA, off Bay Ridge Ave
- Site 2: Outfall East of Mariner's Point Community Clubhouse
- Site 3: Outfall East of Georgetown East Elementary School
- Site 4: Outfall South of Church of Nazarene
- Site 5: Outfall at Joan's Cove

Stormwater Outfall Assessment

Similar to the stream walk, volunteers can visit stormwater outfalls and provide an assessment of the outfall conditions. Dry weather outfall assessments can be performed to find illicit discharges.

The guides listed in Table 26 are designed for municipalities, but the monitoring procedures are still applicable for a volunteer monitoring program. One major difference is that as a citizen, permission must be granted before accessing private properties. Chapter 11 in the Center for Watershed Protection's IDDE Manual provides details on how to perform an Outfall Reconnaissance Inventory, where outfalls are assessed for illegal discharges. The guides in Table 26 also provide some chemical analysis that can be performed at an outfall assessment to determine potential sources of illicit discharges.

Table 26. Stormwater Outfall Assessment Resources		
Topic	**Title**	**Website Link**
Outfall Assessment	Center for Watershed Protection, IDDE Manual, Chapter 11	https://www3.epa.gov/npdes/pubs/idde_manualwithappendices.pdf
Outfall Field Sheet	Center for Watershed Protection, IDDE Manual	http://www.wastormwatercenter.org/files/library/outfall-reconnaissance-inventory-collection-field-sheet.pdf
Field Guide	North Central Texas, Illicit Discharge Detection and Elimination Field Investigation Guide	http://www.in.gov/indot/files/NC_Texas_IDDE_FieldGuide.pdf

Monitoring during storms can also show how upstream pollution and erosion immediately affects water quality. Sampling during the beginning of the storm captures the first flush, which contains the highest amount of pollution during a rainstorm. Table 27 lists a resource on measuring first flush data.

Table 27. First Flush Resource		
Topic	**Title**	**Website Link**
First Flush	LaMoreaux, A.; Stream Surveys and Stormwater Sampling, 2002	http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/2002_special_topic_raineventsampling.pdf

Multi-parameter Meter Water Quality Monitoring

Collecting data throughout the water column adds another dimension to monitoring. A water column is a column of water that is measured from the surface of the water to the bottom sediments. A multi-parameter sonde can be used to measure pH, conductivity, salinity, dissolved oxygen, depth, chlorophyll-a, and temperature. Since tidal water tends to move in layers (the less dense runoff floats on top of the saltier, therefore denser estuarial water), water column monitoring provides some insight into the hydrology of the Creek. This type of stratification can occur naturally in waterways, but with higher nutrient, sediment, and temperature of runoff, it can exacerbate the layers. These more pronounced layers may be difficult to mix by wind, increasing the likelihood of a dead zone.

Equipment used for water column monitoring include a secchi disk and a sonde. A secchi disk is a simple device used to measure transparency in a water column. Sondes need to be calibrated before use and consistently maintained to ensure the probes will work correctly. Specific methods on how to use a sonde varies depending on the brand and model. Some sondes will automatically save the data, but others will require hand-writing the readings. Table 28 lists examples of a typical standard operating procedure for a secchi disk and a sonde. Also see the QAPP.

Table 28. Water Column Monitoring Resources		
Topic	**Title**	**Website Link**
Sampling and Analysis Protocol	Horsetooth Reservoir Water Quality	http://www.fcgov.com/utilities/img/site_specific/uploads/HT_Res_WQ_Monitoring_Program.pdf

Table 28. Water Column Monitoring Resources		
Topic	**Title**	**Website Link**
Standard Operating Procedure for Sonde	Maine Volunteer River Monitoring Program	http://www.maine.gov/dep/water/monitoring/rivers_and_streams/vrmp/qapp/sop08-do-temp-cond-sal-ysi85.pdf
How to Use Secchi Disk	Citizen Lake Monitoring Program Instruction Manual, Minnesota Pollution Control Agency	https://www.pca.state.mn.us/sites/default/files/wq-s1-13.pdf

5.4.2 Phase II

Phase II monitoring requires more time and resources.

Quantitative Chemical and Bacterial Analysis

Quantitative chemical and bacterial analysis requires more sophisticated equipment, typically by using an automated meter or analyzing a grab sample at a laboratory. Quantitative analyses in streams or stormwater outfalls can allow volunteers to understand the exact composition of chemicals in the water, such as ammonia. A grab sample is a discrete, non-continuous sample taken at a specific date, time, and location. Table 29 lists several resources describing quantitative sampling methods.

Table 29. Quantitative Sampling Resources		
Topic	**Title**	**Website Link**
Gallatin Stream Teams Citizen Monitoring Program	Standard Operating Procedures Field Manual for Water Quality Assessment Monitoring, Chapter 5: Protocol for Metal sampling	http://greatergallatin.org/wp-content/uploads/2013/06/SOP_GGWCVolMonProgram_FINALJuly08_REV07-2013.pdf
How to Collect Grab Samples	Maine DEP, Protocols for Collecting Water Grab Samples in Rivers, Streams, and Freshwater Wetlands, 2014	http://www.maine.gov/dep/water/monitoring/biomonitoring/materials/sop_watergrab.pdf
EPA Sampling Method	Volunteer Estuary Monitoring: A Methods Manual, page 7-15 to 7-17	http://nepis.epa.gov/Exe/ZyPDF.cgi/P1007NHX.PDF?Dockey=P1007NHX.PDF

The data from grab samples are limited in interpretation and represents only one distinct point in time. This is important because generalizations cannot be made unless sufficient data has been collected. One high result does not mean the entire Creek is contaminated. There could be other factors that can affect one sample, yet not be indicative of the whole Creek. A waterbody can naturally assimilate some pollution, but there is a maximum capacity for assimilation. If a pollutant frequently exceeds this threshold, then water quality will be adversely affected. Table 30 lists common chemicals or biological indicators that are typically monitored for water quality.

Table 30. Common Water Quality Parameters			
Algae	COD	Metals	Potassium
Ammonia	E. coli	Nitrate/Nitrite	Sodium
BOD/CBOD	enterococci	TKN	Total Organic Carbon
Chloride	Fecal Coliform	Phosphate	Transparency

Table 31 lists the typical monitoring equipment needed for measuring the listed parameters.

Table 31. Equipment List	
Parameter	**Equipment**
Temperature	Thermometer
Salinity	Salinity Refractometer
Electrical Conductivity	Conductivity Meter
pH	pH Meter
Multiple Parameters (e.g. nitrogen, phosphorus, etc.)	Spectrophotometer (multiple parameters measured)
Potassium	Potassium Meter
Turbidity	Turbidimeter
Bacteria, specifically *Escherichia coli* (*E. Coli*)	Coliscan Easygel
	3M Petrifilm
	IDEXX
	Membrane Filtration

Samples can be collected from the water flowing at the sites listed in Section 5.4.1. Popular swimming areas are also good places for sampling. These samples can be sent to a laboratory for analysis or analyzed with equipment listed in this section.

Stream Bank Erosion Rate Calculations

Since sediment is a concern for the Conservancy, measuring the erosion rate of the streambanks could help determine the portion of sediment added to the bottom of the Creek from streambank erosion. Permission from landowners is required before measuring, as it requires burying erosion pins or other measuring devices. Some locations that the Conservancy can monitor stream bank erosion include:

- Stream area south of SPCA
- Joan's Cove
- Any location downstream of a planned retrofit – comparing the erosion rate before and after installation would allow tracking of any sediment reduction

Table 32 lists resources for conducting stream bank measurements.

Table 32. Stream Bank Erosion Resources		
Topic	**Title**	**Website Link**
Guide for Stream Bank Measurements	USDA Stream Channel Reference Sites: AN Illustrated Guide to Field Techniques	http://www.stream.fs.fed.us/publications/PDFs/RM245E.PDF
Bank Pin Method	Contribution of In-Channel Processes to Sediment Yield of an Urbanizing Watershed	http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2009.00320.x/abstract

Continuous Monitoring at Select Location

Continuous monitoring shows water quality variations over time. It requires more advanced knowledge of hydrology and estuarine science, due to the nature of the data collected. Continuous monitoring is advantageous because it can collect data during unpredicted events such as algal blooms and during large storm events when it is unsafe to allow volunteers to sample. Storm events could also damage the equipment or detach it from the site. Theft and accessibility are also important concerns when choosing a location. With continuous monitoring, the hydrology can be more accurately modeled because data can be collected at different timescales (daily, hourly, monthly, etc.). Table 33 provides guidelines for conducting continuous monitoring locations.

Table 33. Continuous Monitoring Locations

Topic	Title	Website Link
Sampling Location Selection	Virginia Institute of Marine Science, Guidelines- Shallow Water Quality Monitoring, 2009	http://www.truecostofdata.com/cms/uploads/Guidelines-Water-Quality-Monitoring-Continuous-Monitoring-Stations.pdf
USGS Method for Continuous Monitoring	USGS Guidelines and Standard Procedures for Continuous Water Quality Monitors	http://pubs.usgs.gov/tm/2006/tm1D3/pdf/TM1D3.pdf

Sediment Core Sampling

Sediment core sampling should be performed by an external organization, due to the expertise and equipment needed to evaluate the sediment. Simple sediment samples can be collected by volunteers and sent to a lab to analyze for biological, chemical, physical, and toxicological parameters, similar to water samples. Interpreting the data is different since water is much more dynamic than sediment. One unique piece of data that a sediment core can provide is historical contamination, such as heavy metals and PCBs. Sediment loads from different eras could potentially be parsed out from core data and be used to calculate Back Creek's sediment loading rate. Table 34 lists a sediment sampling document.

Table 34. Sediment Sampling Resources

Topic	Title	Website Link
Sediment Sample Collection	Standard Operating Procedures Field Manual for Water Quality Assessment Monitoring, Page 17, 2013	http://greatergallatin.org/wp-content/uploads/2013/06/SOP_GGWCVolMonProgram_FINALJuly08_REV07-2013.pdf

Macroinvertebrate Sampling

Macroinvertebrates are small animals that do not have a backbone and can be seen with the naked eye, such as beetles, dragonflies, and stoneflies. These insects are used to assess the health of a waterway due to their sensitivity to environmental change. They also give a more localized assessment of a stream, since these insects have limited mobility. When certain insects, such as mayflies and caddisflies are found, it is likely that the water quality in that stream is good. Not finding these animals does not mean that the water is polluted as there are various other factors that could account for their absence.

The Maryland Department of Natural Resources (DNR) has a Maryland Stream Waders Volunteer program that allows volunteers to collect biological stream samples, with DNR performing the lab analysis and providing training and equipment. Additionally, they also offer training on how to perform benthic macroinvertebrate processing and subsampling, and identifying fish taxonomy. Samples can also be sent to a private lab for analysis. Additional information about benthic macroinvertebrate sampling can be found in Table 35.

Table 35. Macroinvertebrate Sampling Resources

Topic	Title	Website Link
Maryland Macroinvertebrate Program	Maryland Biological Stream Survey	http://dnr2.maryland.gov/streams/Pages/mbss.aspx
Field Guide	Water Quality Monitoring with Benthic Macroinvertebrate Field Manual, 2013	http://ecospark.ca/sites/default/files/currents/2013_CC_Manual.pdf
Sample Collection and Identification	Hoosier Riverwater Volunteer Stream Monitoring Training Manual Page 68-78, 2015	http://www.in.gov/idem/riverwatch/files/volunteer_monitoring_manual.pdf
Sample Collection for Lab Analysis	Gallatin Stream Team Program, Standard Operating Procedures Field Manual for Water Quality Assessment Monitoring Page 18, 2008	http://greatergallatin.org/wp-content/uploads/2013/06/SOP_GGWCVolMonProgram_FINALJuly08_REV07-2013.pdf

External Bacteria Monitoring

The bacteria monitoring for Back Creek is performed by Operations Clearwater Program at the Anne Arundel Community College (AACC). The Conservancy is working with AACC to collect samples for bacterial analysis. Additional locations can be added each year with increased resources. If volunteers are collecting samples in the future, they must be trained. Table 36 lists a resource for bacteria monitoring.

Table 36. Bacteria Monitoring Resources

Topic	Title	Website Link
EPA Sampling Method	Volunteer Estuary Monitoring: A Methods Manual, page 7-15 to 7-17	http://nepis.epa.gov/Exe/ZyPDF.cgi/P1007NHX.PDF?Dockey=P1007NHX.PDF
How to Create a Bacteria Monitoring Program	Safe Waters, Healthy Waters: A Guide for Citizen Groups on Bacteria Monitoring in Local Waterways.	http://www.cwp.org/wp-content/uploads/2016/06/SAFE-WATERS-Guide_Final.pdf

Bacterial Analysis Methods

There are various types of bacterial monitoring that can be performed to assess the health of a waterway. All bacteria monitoring methods have flaws, so some organizations will use multiple measurement parameters to help narrow down a potential source. Measuring for bacteria usually requires an incubator and a premade agar plate, such as 3M Petrifilm, or sending a water sample to a certified laboratory. There are alternative options to detect bacteria; however, most are not EPA-certified methods, but they can be used to refine potential source locations.

An alternative testing option to help identify bacteria sources is to measure for optical brighteners. These are used in laundry detergent, and, since wash water is generally directed to the sanitary sewer, tracking these chemicals could identify sanitary sewer discharges, which will also likely be significant bacteria sources. One issue with optical brighteners is that the method that is typically used to detect these chemicals also show a similar result from some organic matter in water, creating false positives. A new method for detecting sewage that has shown promise is sewage sniffing dogs. These dogs can detect human sewage at very low levels, making it much quicker to identify potential issues. The service can be hired to test at a site, or samples can be collected and sent to their facility. Table 37 lists resources for alternative methods to monitor for bacteria.

Table 37. Alternative Bacteria Monitoring Resources

Topic	Title	Website Link
Optical Brightener	Testing for Optical Brighteners and Fecal Bacteria to Detect Sewage Leaks in Tidal Creeks	http://people.uncw.edu/hillj/classes/EVS595/Optical%20brightener%20paper%20for%20NCAS.pdf
Optical Brightener	Optical Brightener Testing in Mill Creek, The Dalles, OR, 2013	http://www.deq.state.or.us/lab/wqm/OpticalBrightenerReport2013.pdf
Indicator Parameters	Center for Watershed Protection, IDDE Manual, page 122	http://www.wastormwatercenter.org/files/library/outfall-reconnaissance-inventory-collection-field-sheet.pdf
Sewage Sniffing Dogs	Environmental Canine Services	http://www.ecsk9s.com/

5.4.3 Phase III: Monitoring Assessment

Phase III occurs after data are collected and analyzed after several years. A monitoring assessment can help redirect the monitoring towards a more efficient use of resources. For example, if site A and B have had very similar results for the past 5 years, it maybe repetitive to continue to monitor at both sites. Then the resources for site B could be allocated to a different site, C. If data that are expected to show a trend does not, the frequency or timing of the data collection may need to be altered. For example, if high turbidity is expected after a storm, yet monitoring occurs 48 hours after a storm, too much time may have passed to observe high turbidity. These alterations can help refine the monitoring plan and show improvements or deterioration more accurately and broadly. Additional resources can allow for increased monitoring to look for other trends or to allow for increased bacterial and chemical analysis.

An assessment can also evaluate other changes, such as land use, resources, or regulations. If land use is altered significantly, such as if a park is turned into fertilizer factory, the monitored pollutant of focus may change. An increase or decrease in resources can increase or decrease the quality of monitoring. Regulatory changes, such as changes to the Chesapeake Bay Total Maximum Daily Load, can shift the focus to different nutrients or chemicals. All stakeholders should be involved in major monitoring changes to ensure transparency and leveraging of information and resources. It is vital to have a monitoring science expert review the data to find gaps in the monitoring program or improvements that can be made. The monitoring plan and QAPP should be updated accordingly.

Section 6. Recommended Watershed Management Actions and Implementation Plan

Watershed restoration is a major, long-term commitment that requires dozens of individual stormwater retrofit and green infrastructure projects along with targeted and focused community educational efforts to be implemented over a multi-year timeframe. The process can also be quite costly. As such, careful planning is needed to prioritize practices and actions that will result in an efficient and cost-effective protection strategy. This section details 5 key watershed recommendations and provides information on effective implementation of those recommendations.

A major focus of this Plan is to improve the internal capacity of the Back Creek stakeholders and community members to enact the watershed recommendations. Community member involvement and feedback is crucial to the ultimate success of these recommendations and should be sought during all stages of the Plan implementation.

The 5 recommendations are listed below and are discussed in more detail in the following section.

1. Encourage pollution prevention practices as well as tree planting and landscape management in residential neighborhoods.
2. Encourage marinas and yacht yards to become a certified Clean Marina and boaters to pledge to be Clean Boater.
3. Implement stormwater retrofit practices.
4. Educate businesses on eliminating hotspots.
5. Implement a complete water quality monitoring plan.

Each of these recommendations is discussed in more detail below. Table 38 outlines suggested partners and implementation milestones for each of the 5 watershed recommendations. It is important to note that implementation is by far the longest and most expensive step in the watershed management process. Land acquisition and construction of projects often account for a majority of these costs. Sustaining progress over time and adopting the plan as more experience is gained are vital aspects of implementation.

Table 38. Recommendations and Implementation Milestones

Recommendation	Suggested Partners	Implementation Milestones (5 years)
1. Encourage pollution prevention practices as well as tree planting and landscape management in residential neighborhoods.	• City of Annapolis • Eastport Civic Association • Severn River Association • Barrels by the Bay • Unity Gardens • Center for Watershed Protection	• 117 new trees planted (matches Table 9 total) • Discuss with 5 HOAs or apartment/condo associations about lawn care management

Table 38. Recommendations and Implementation Milestones		
Recommendation	**Suggested Partners**	**Implementation Milestones (5 years)**
2. Encourage marinas and yacht yards to become certified Clean Marinas and boaters to pledge to be Clean Boaters.	• Severn Riverkeeper • Eastport Civic Association	• All marinas are certified as Clean Marinas
3. Implement stormwater retrofit practices.	• City of Annapolis • Center for Watershed Protection • Severn Riverkeeper • Severn River Association	• Implementation of 5 stormwater retrofit practices
4. Educate businesses on eliminating hotspots.	• City of Annapolis • Center for Watershed Protection	• Elimination of hotspots identified in plan • Work with HOAs on implementing car wash BMPs
5. Implement a complete water quality monitoring plan.	• U.S. Naval Academy • Severn Riverkeeper • Severn River Association • Eastport Civic Association • Center for Watershed Protection	• Implement a water quality monitoring plan as described in Section 5.4 of this plan

6.1 Recommendations from Field Assessments

1. *Encourage pollution prevention practices as well as tree planting and landscape management in residential neighborhoods.*

Several opportunities for tree planting were identified in neighborhoods. Tree planting is a very cost effective restoration action that provides multiple benefits, including ecological, economic and quality of life benefits – protecting air and water quality, reducing energy costs, increasing property values and beautifying neighborhoods and highways. Altogether, approximately 6 acres of tree planting (117 trees) opportunities were identified in the watershed and are shown in Figure 22. Grant opportunities exist through the Chesapeake Bay Trust (see Section 7) and other funders.

Highly fertilized lawns were mainly identified in the multifamily neighborhoods; education should be provided to the maintenance company on proper lawn fertilization. The Conservancy should partner with the Anne Arundel County Watershed Stewards Academy on their Clean Lawn Care program.

Storm drain inlet marking or stenciling was noted as absent in the majority of neighborhoods. Neighborhoods with prominent catch basin locations, and unlikely to be hidden by parked vehicles, would be good candidates for stormwater inlet markers. The Conservancy should contact the City of Annapolis's Office of Environmental Policy on stormwater inlet marking. Inlet marking is a lower priority and can be done in the future.

Resources:

- Anne Arundel County Watershed Stewards Academy – The Anne Arundel County WSA trains Master Watershed Stewards that can work in communities to install green infrastructure, conservation landscaping, etc. http://www.aawsa.org/
- City of Annapolis – The City's Office of Environmental Policy has education programs for public participation in improving water quality. http://www.annapolis.gov/government/city-departments/mayors-office/office-of-environmental-policy
- Eastport Civic Association – The Eastport Civic Association awards grants to organizations that improve the quality of life for the residents of Eastport. http://www.eastportcivic.org/
- Severn River Association – The Severn River Association works to protect and improve the health of the Severn River. http://severnriver.org/
- Barrels by the Bay – Barrels by the Bay works to educate communities on water resources issues and provide rain barrels. http://www.barrelsbythebay.org/
- Unity Gardens – Unity Gardens is an organization that funds neighborhood greening projects in Anne Arundel County http://www.unitygardens.org/
- Center for Watershed Protection – The Center provides free manuals on restoring urban watersheds, and presents and trains on pollution prevention practices. http://www.cwp.org/

Figure 22. Tree Planting Opportunities

2. *Encourage marinas and yacht yards to become a certified Clean Marina and boaters to pledge to be Clean Boaters.*

Encourage all marinas within the watershed to participate in the Maryland Clean Marina Initiative, which promotes adopting pollution prevention practices to improve water quality. Start a marina outreach program to facilitate general education and coordinate enrolment of marinas in the Maryland Clean Marina Initiative, and encourage participants and go above and beyond the minimum practices associated with the Clean Marina Initiative. Work with marina owners to educate boaters on the importance of proper sewage handling and disposal; encourage boaters to lock or eliminate the use of the overboard discharge valves on their MSD systems while in Back Creek.

Resources:

- The Maryland Clean Marina Initiative and the Maryland Clean Boater Program are both sponsored by the Maryland Department of Natural Resources (DNR) http://dnr2.maryland.gov/Boating/Pages/cleanmarina/home.aspx
- Good Mate – Recreational Boating & Marina Manual http://www.oceanconservancy.org/do-your-part/green-boating/2014-good-mate-brochure.pdf

3. *Implement stormwater retrofit practices.*

The implementation of retrofit projects not only reduces impervious cover but is also extremely beneficial in terms of improving stormwater water quality, increasing groundwater recharge, and controlling flooding. Stormwater retrofits targeting sediment removal are priorities. High priority retrofit projects are identified in **Error! Reference source not found.**. It is important to develop long term maintenance plans for these projects to ensure long-term performance. Section 7 lists funders for these types of projects. Appendix E summarizes the neighborhood and retrofit projects for each neighborhood.

4. *Educate businesses on eliminating hotspots.*

A few confirmed hotspot locations were found in the watershed and those identified could easily be eliminated with proper education and cleanup. Confirmed hotspot locations are identified in Table 12. The Conservancy should work with the City of Annapolis's Office of Environmental Policy to conduct immediate follow-up inspections at all of the confirmed and potential hotspots.

Resources:

- Urban Subwatershed Restoration Manual Series Manual 8: Pollution Source Control Practices. (Schueler, et al., 2005). This manual contains detailed information on identification and management of pollution hotspots. http://owl.cwp.org/mdocs-posts/urban-subwatershed-restoration-manual-series-manual-8/

5. *Implement a Complete Water Quality Monitoring Plan.*

The Conservancy should continue their water quality monitoring to investigate water quality conditions and identify long term trends. Trend monitoring is the best way to determine if creek conditions are improving and watershed goals are being met.

Resources:

- Section 5 of this report
- QAPP
- Safe Waters, Healthy Waters: A Guide for Citizen Groups on Bacteria Monitoring in Local Waterways http://www.cwp.org/wp-content/uploads/2016/06/SAFE-WATERS-Guide_Final.pdf
- U.S. EPA Monitoring and Assessing Water Quality – Volunteer Monitoring https://archive.epa.gov/water/archive/web/html/index-18.html

6.2 Track and Monitor the Implementation Progress

Back Creek Conservancy should develop an approach to monitoring implementation activities that includes project monitoring and project tracking. Project monitoring should be geared towards quantitative measures of success for both structural and non-structural management and restoration practices (i.e., stormwater retrofits, tree planting, etc.). Monitoring methods will depend upon the project.

Managing the delivery of a large group of restoration projects within the watershed can be a complex enterprise. Creating a master project spreadsheet linked to a Geographical Information System (GIS) system can help track the status of individual projects through final design, permitting, construction, inspection, maintenance and any performance monitoring. For non-structural efforts, tracking systems will include measures such as number of trees planted, residents educated, or number of dedicated volunteers. By tracking the delivery of restoration projects, lessons learned can be identified and implementation progress over time can be assessed, which in turn, helps explain future changes in water resource quality.

By tracking the delivery of watershed projects, implementation progress can be assessed over time, which in turn, helps explain future changes in water quality. Project tracking can also improve the delivery of future projects, and creates reports that can document implementation progress for key funders and stakeholders. The tracking system should account for all restoration practices undertaken in the watershed regardless of their type or size.

Section 7. Cost Estimates and Funding

Costs for the Neighborhood Source Assessments (NSA) projects are shown in Table 39.

Table 39. Cost Estimates for NSA Projects

BMP	Cost	Source of Cost
Downspout disconnection	$20	Blue Water Baltimore http://www.bluewaterbaltimore.org/wp-content/uploads/2014/03/DD_BMP_Fact_Sheet_2014.pdf
Lawn management advice	$3.20 per household	Center for Watershed Protection Manual 8 http://owl.cwp.org/mdocs-posts/urban-subwatershed-restoration-manual-series-manual-8/
Rain barrel	$85	Arlington Echo http://www.arlingtonecho.org/restoration-projects/rain-barrels.html
Rain garden (10 ft by 10 ft; $15/ft^2)	$1,500	Rain Gardens Across Maryland http://www.mdcoastalbays.org/files/pdfs_pdf/rain_gardens.pdf
Tree planting (10 gallon)	$95	Blue Water Baltimore http://www.bluewaterbaltimore.org/herring-run-nursery/plant-availability/

Costs for the proposed stormwater retrofits were derived from the Center's Clean Water Optimization Tool (CWOT). The model relies on cost data from a University of Maryland study, which was adjusted for Anne Arundel County. Table 40 lists the source of cost data for each BMP included in the Tool and notes where any additional modifications were made.

Table 40. Sources of Cost Data in the Clean Water Optimization Tool

BMP	Source of Cost Data and Assumptions/Modifications
Permeable pavement	King and Hagan (2011), averaged the costs for permeable pavement w/o sand and permeable pavement w/ sand
Bioretention	King and Hagan (2011), used cost for bioretention (new/suburban)
Conversion of dry pond to wet pond	The median value for construction cost per impervious acre treated from Schueler et al (2007) was used and was converted to a cost per acre treated. It was assumed that design costs for pond retrofits would be similar to the design cost associated with installing a new wet pond or wetland as a retrofit, so the value of 50% from King and Hagan (2011) was used. The operation and maintenance and county implementation cost assumptions provided by King and Hagan (2011) for wet ponds and wetlands were assumed to be applicable to pond retrofits. Land values were set at zero since the BMP involves modification to an already-constructed practice for which land has already been acquired.
Urban tree planting	King and Hagan (2011), but converted costs from $/impervious acre to $/pervious acre treated
Impervious cover removal	King and Hagan (2011), impervious urban surface reduction

All construction costs were brought up to 2014 dollars using the Bureau of Labor Statistics inflation calculator http://data.bls.gov/cgi-bin/cipcalc.pl. Costs for the AECOM retrofits were taken from their report (AECOM, 2016).

Listed below are Federal and State funding sources that are available for BMP implementation and educational outreach.

Grants & Financial Assistance Opportunities at MDE (http://mde.maryland.gov/aboutmde/GrantsandFinancialAssistance/Pages/AboutMDE/grants/index.aspx)

- Nonpoint Source Program (319)
- Linked Deposit Program

DNR Grants and Loans Center (http://dnr.maryland.gov/land/grantsandloans/index.asp)

- Chesapeake and Atlantic Coastal Bays Trust Fund
  http://dnr2.maryland.gov/ccs/Pages/funding/trust-fund.aspx
- Habitat Restoration and Conservation
  http://dnr2.maryland.gov/ccs/Pages/restoration.aspx
- Watershed Assistance Collaborative
  http://dnr2.maryland.gov/ccs/Pages/healthy_waters/wac.aspx
- The Bill James Environmental Grants
  http://dnr2.maryland.gov/met/Pages/bill_james.aspx
- The Margaret Rosch Jones Award
  http://dnr2.maryland.gov/met/Pages/rosch.aspx
- Maryland's Wild Acres
  http://dnr2.maryland.gov/wildlife/Pages/habitat/wildacres.aspx

Chesapeake Bay Trust (http://www.cbtrust.org/)

- Anne Arundel Community Tree Planting Grant
  http://www.cbtrust.org/site/c.miJPKXPCJnH/b.7958753/k.3322/AA_Community_Tree_Planting_Mini.htm
- Restoration and Retrofits
  http://www.cbtrust.org/site/c.miJPKXPCJnH/b.8600083/k.7FB3/Restoration_and_Retrofits.htm
- Outreach
  http://www.cbtrust.org/site/c.miJPKXPCJnH/b.8600079/k.E0A8/Outreach.htm

Nation Fish and Wildlife Foundation (NFWF) (http://www.nfwf.org/Pages/default.aspx)

- Chesapeake Bay Stewardship Fund
  http://www.nfwf.org/chesapeake/Pages/home.aspx
- Technical Capacity Grants Program Stormwater Management
  http://www.nfwf.org/chesapeake/Pages/technical-capacity-stormwater.aspx
- Environmental Solutions for Communities
  http://www.nfwf.org/environmentalsolutions/Pages/home.aspx

U.S. Government Grant Finder (http://www.grants.gov/)

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