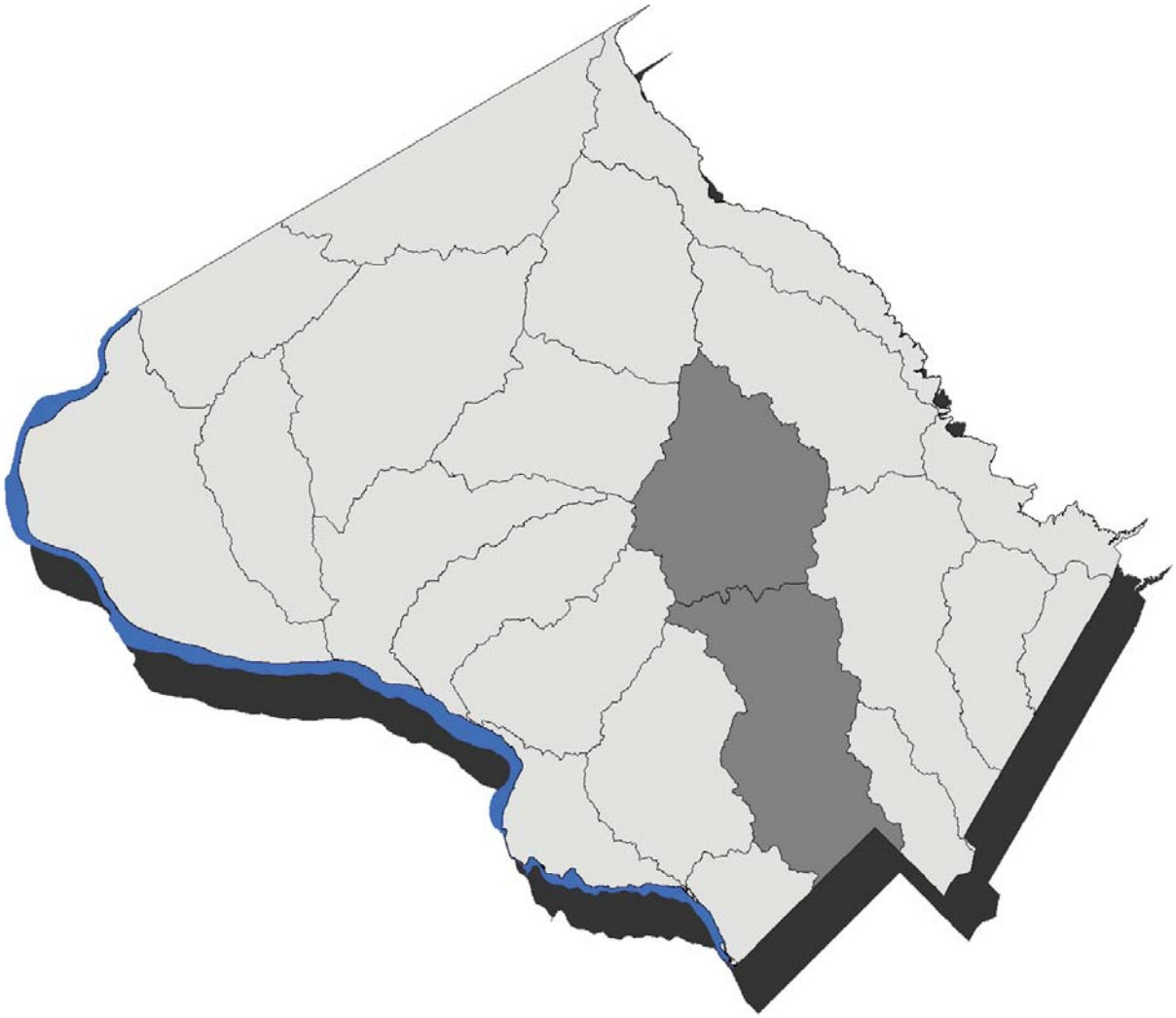
ROCK CREEK IMPLEMENTATION PLAN

PREPARED FOR:

MONTGOMERY COUNTY

DEPARTMENT OF ENVIRONMENTAL PROTECTION

255 Rockville Pike, Suite 120



January 2012

Rock Creek Implementation Plan

January, 2012

Prepared for:

Montgomery County Department of Environmental Protection
255 Rockville Pike, Suite 120
Rockville, MD 20850

Prepared by:

Biohabitats, Inc.
2081 Clipper Park Road
Baltimore, MD 21211

In collaboration with:

Versar
9200 Rumsey Rd
Columbia, MD 21045-1934

Horsley Witten Group
90 Route 6A
Sandwich, MA 02563

Capuco Consulting Services
914 Bay Ridge Road, Suite 206
Annapolis, MD 21403

Chesapeake Stormwater Network
117 Ingleside Avenue
Baltimore, MD 21228

RESOLVE
1255 23rd Street, NW, Suite 875
Washington, DC, 20037

Rock Creek Implementation Plan

Table of Contents

Acronym List 2
1 Goals and Existing Conditions 3
1.1 Introduction to the Implementation Plan and Watershed Goals 3
1.2 Existing Conditions in the Rock Creek Watershed 4
1.3 Problems Facing the Rock Creek Watershed 9
1.4 Existing Pollutant Loads and Impervious Surfaces 11
2 Inventory of Provisional Restoration Candidates 14
2.1 Types of Restoration Practices 14
2.2 Inventory of Previously Identified Projects 15
3 Evaluation of the Restoration Strategies to Meet MS4 Permit and TMDL Requirement 17
3.1 Bacteria and Pollutant Load Tracking 17
3.2 Desktop Review of BMP Coverage 17
3.3 Summary of Watershed Treatment Model Scenarios 18
3.4 Preliminary Results of the Bacteria Load Reduction Analysis 27
4 Evaluation of the Restoration Strategies to Meet MS4 Permit Trash Reduction Tracking ... 30
5 Nutrient and Sediment Reduction Tracking 33
6 Action Inventory Implementation Schedule 34
6.1 Rock Creek Watershed Implementation Schedule 34
7 References 37

Notes to Reader:

1. Throughout this Plan there are text boxes such as this that focus on public outreach and stewardship elements to consider for the Plan. In addition, there are references to Practice Sheets which have been developed that are general strategies that apply countywide but will require some customization on a watershed basis to reflect certain stakeholder demographics and priorities. These practice sheets are included as an appendix to the Countywide Coordinated Implementation Strategy.
2. Environmental Site Design (ESD) is defined within the 2010 Maryland Stormwater Design Manual as the use of small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic cycling of rainwater and minimize the impact of land development on water resources. The application of the term is focused on new and redevelopment projects, and does not explicitly address or consider retrofit applications where site constraints such as drainage area, utilities, and urban soil quality are significant factors. This watershed implementation plan uses the term ESD in a more flexible manner to include structural practices such as bioretention, vegetated filters, and infiltration that provide distributed runoff management using filtering, infiltration, and vegetative uptake processes to treat the water quality volume to the maximum extent practicable. These practices are also thought of as Low Impact Development (LID) practices.

Acronym List

BMPs – best management practices

DA – drainage area

DEP – Department of Environmental Protection

DF – discount factor

DU – dwelling unit

EPA – Environmental Protection Agency

ESD – environmental site design

GIS – geographic information systems

HOA – homeowners association

IA – impervious area

IC – impervious cover

LDR – low density residential

LID – low impact development

MDE – Maryland Department of the Environment

MEP – maximum extent practicable

MDP – Maryland Department of Planning

MNCPPC – Maryland National Capital Parks and Planning Commission

MPN – most probable number

MPR – maximum practicable reductions

MS4 – municipal separate storm sewer system

NPDES – National Pollutant Discharge Elimination System

RR – runoff reduction

SPA – Special Protection Area

TFPI – Trash Free Potomac Watershed Initiative

TMDLs – total maximum daily loads

TN – total nitrogen

TP – total phosphorus

TSS – total suspended solids

USACE – Army Corps of Engineers

WLAs – waste load allocations

WQPC – water quality protection charge

WRAP – watershed restoration action plan

WTM – watershed treatment model

1 Goals and Existing Conditions

1.1 Introduction to the Implementation Plan and Watershed Goals

This Implementation Plan for Rock Creek was developed in order to quantitatively demonstrate compliance with the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit. The Plan must meet the MS4 Permit's three major requirements:

- Assigned wasteload allocations (WLAs) for EPA-approved **Total Maximum Daily Loads (TMDLs)**
- Watershed restoration via **runoff management and impervious cover treatment**
- **Trash and litter management** to meet the commitments of the Potomac River Watershed Trash Treaty

Outreach and Stewardship Strategy
Primary messages for delivery in this watershed will focus on activities the County is undertaking to reduce bacteria, sediment, and nutrients, manage runoff, and to manage trash and litter.

The Plan outlines a comprehensive roadmap for watershed restoration that targets runoff management, bacteria reduction, and trash and litter management –including information pertinent to effectively include stakeholders in watershed restoration. The County MS4 Permit area comprises 69% of the total watershed area. The Plan focuses on the restoration effort within this MS4 Permit area. Areas not covered under the County's MS4 Permit include areas with rural zoning and federal and state properties, state roads, and municipalities that have separate MS4 permits. The County MS4 Permit area has approximately 24% impervious cover within the Rock Creek watershed.

Total Maximum Daily Loads (TMDLs)
Bacterial Reduction
The Maryland Department of the Environment (MDE) established a TMDL for bacteria in 2007. MDE submitted to EPA a TMDL for sediment in September, 2010 and is projecting a regulatory load limit for nitrogen and phosphorus by the end of 2011. The Plan addresses and documents bacteria loading to Rock Creek from the County MS4 Permit area. It also tracks potential reduction of bacteria loads through application of various stormwater management retrofits and other best management practices (BMP). This Plan focuses on achieving the maximum practicable reductions (MPR) as recommended by the state in the TMDL document. MDE indicated that the required reduction should be implemented in an iterative process that first addresses those sources with the largest impacts to water quality and risks to human health, with consideration given to the ease of implementation and cost of implementation. Going beyond MPR to achieve 100% of the County's WLA would require elimination of all wildlife sources of bacteria in the watershed, which represent approximately 40% of the County's WLA. Other MS4 permittees in the watershed include the City of Rockville, Maryland National Capital Parks and Planning Commission (MNCPPC), and Federal and State property.

Sediment and Nutrient Reduction
In 2010, MDE submitted a sediment TMDL to EPA for approval. During 2011, the MDE will be developing nutrient WLAs as part of the Bay-wide TMDL. There are no WLAs yet approved by EPA , but the full suite of BMPs proposed in the Plan are estimated to provide 52% load reductions for total nitrogen (TN), 53% for total phosphorus (TP), and 49% for total suspended solids (TSS).

Runoff Management and Impervious Cover Treatment
During the five-year Permit cycle, the County must add stormwater management for an additional 20% of impervious cover within the County's MS4 Permit area that is not currently managed to the maximum extent practicable (MEP). The baseline year for determining the 20% goal is 2009 since the Permit was issued on February 16, 2010. Full implementation of projects identified through this implementation plan can provide control of an additional 4,000 acres of impervious cover not treated to the MEP.

Trash and Litter Management
The third major permit element is that of trash and litter management to meet the commitments in the Potomac River Watershed Trash Treaty. The County must identify trash and litter reduction measures that are being implemented towards the goal of a Trash Free Potomac by the year 2013. This Plan also documents trash loading from the watershed and proposed reduction methods. An estimated 55% reduction of trash loads over baseline conditions is projected based on full implementation of BMPs identified in this plan.

1.2 Existing Conditions in the Rock Creek Watershed

Introduction to the Rock Creek Watershed

Rock Creek begins from several springs above Fieldcrest Road in the Laytonsville area, and flows approximately 21 miles before entering the District of Columbia. In the District, Rock Creek courses through Rock Creek Park before ending its journey by entering the Potomac River near Georgetown. The Rock Creek watershed in Montgomery County has a drainage area of approximately 61.5 square miles. A basic profile of the watershed is provided in Table 1, a map depicting existing conditions is presented in Figure 1, and a map depicting stream resource conditions is presented in Figure 2.

Above Route 28 the upper watershed still contains many miles of small headwater streams and streams are in good condition. The Upper Rock Creek Special Protection Area (SPA) includes the main stem above Muncaster Mill Road and the western side of the North Branch of Rock Creek above Muncaster Mill Road. New development is limited to eight percent new imperviousness in the SPA. Designation as an SPA requires use of enhanced plan review, sediment and erosion control, and stormwater management techniques for new development in order to provide additional stream resource and water quality protection.

Below Route 28, the watershed becomes highly developed and densely populated, with a mix of residential, commercial and industrial land uses. Prior development piped many headwater streams or developed homes too close to the stream, impacting aquatic habitat and stream systems. Much of the development in the lower portion of Rock Creek was completed by the 1960s, consequently little or no stormwater management was provided. Public gravity sewer

lines were also installed during this period and are now in need of replacement/repair. The high level of development and lack of stormwater BMPs in many areas of the lower watershed have led to unmitigated flows that have damaged Rock Creek and its tributaries.

There have also been incidences of acute water quality impacts in the lower reach that have damaged stream health. For example, a toxic pesticide entered the creek near East-West Highway in 2002 and killed thousands of fish as far down as Pierce Mill in the District of Columbia. The termaticide was spilled in a parking lot, and an employee washed the termaticide into a storm drain without realizing the storm drain discharged directly into Rock Creek.

Outreach and Stewardship Strategy
A more effective and wider-reaching outreach and education program may have prevented the environmental damage that the termaticide spill caused.

The County developed a Watershed Feasibility Study in April 2001 (URS, 2001) and Watershed Restoration Action Plan for Rock Creek in July 2001 (CWP and URS, 2001). Those Plans identified new stormwater management opportunities for 762 acres of drainage area and retrofits of existing stormwater management BMPs for an additional 512 acres of drainage area. The Plans also proposed restoration of more than 3.8 miles of stream channel. Lake management alternatives to Lakes Needwood and Frank were also proposed to extend life expectancy and improve sediment trapping. There were no TMDLs for Rock Creek when these earlier plans were completed, so their focus was on improving water quality through decreasing peak discharge and erosive velocities, stabilizing erosive stream banks, and improving instream habitat.

Table 1: Rock Creek Watershed Profile

Metric	***Acres***	***Percent of Watershed***
Watershed Drainage Area	39,300	100%
Impervious Cover	8,400	21%
Watershed Area Subject to County MS4 Permit[1]	27,300	69%
Impervious Cover Subject to County MS4 Permit[1]	6,600	24%
Pervious Cover (e.g., forest, turf, meadow, farm fields)[1]	20,643	76%

[1] Excluded areas include the City of Rockville, rural zoning, all MNCPPC lands, Federal and State property, and Federal and State roads.

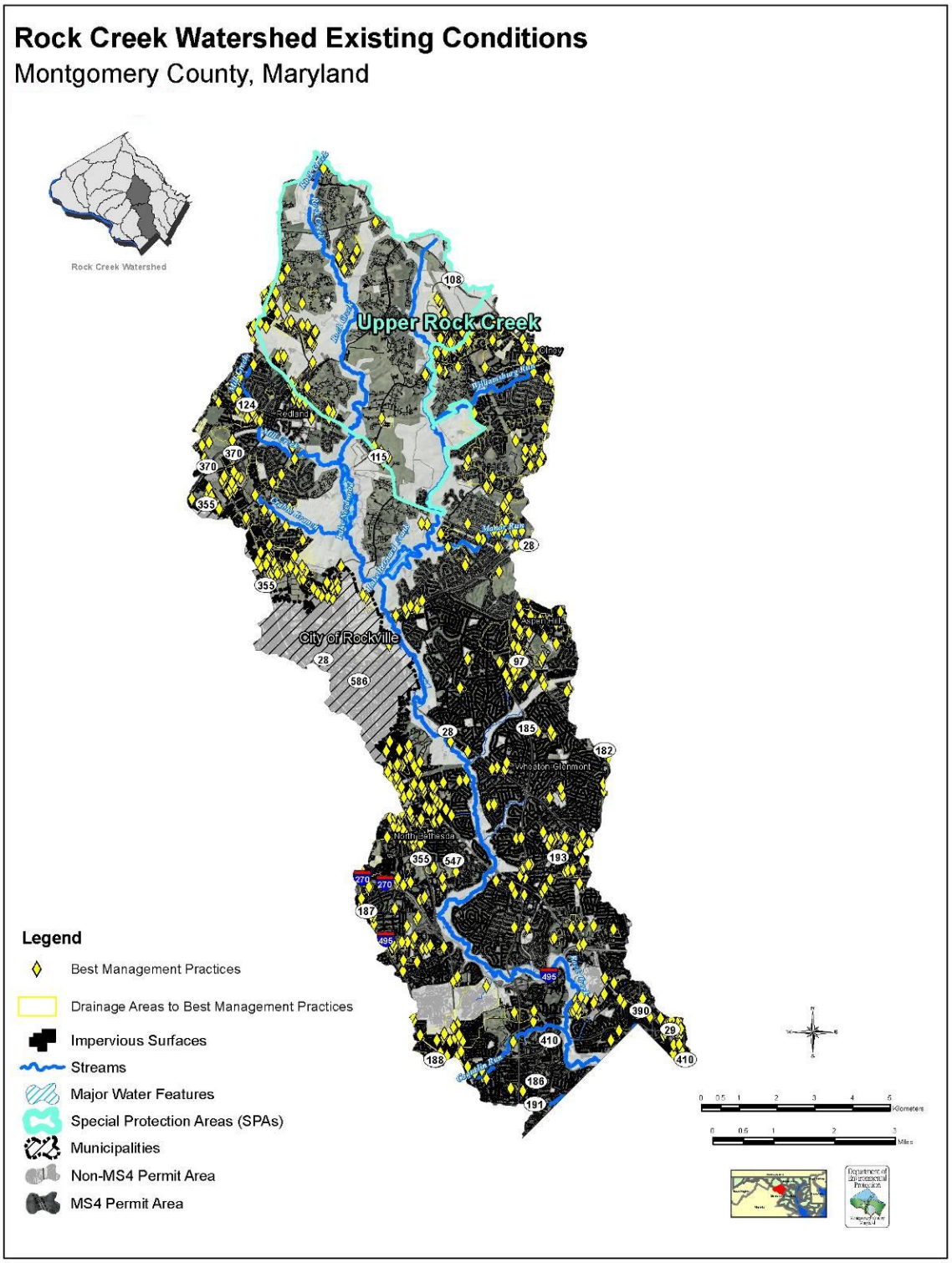


Figure 1: Existing Conditions and BMP Locations for the Rock Creek Watershed

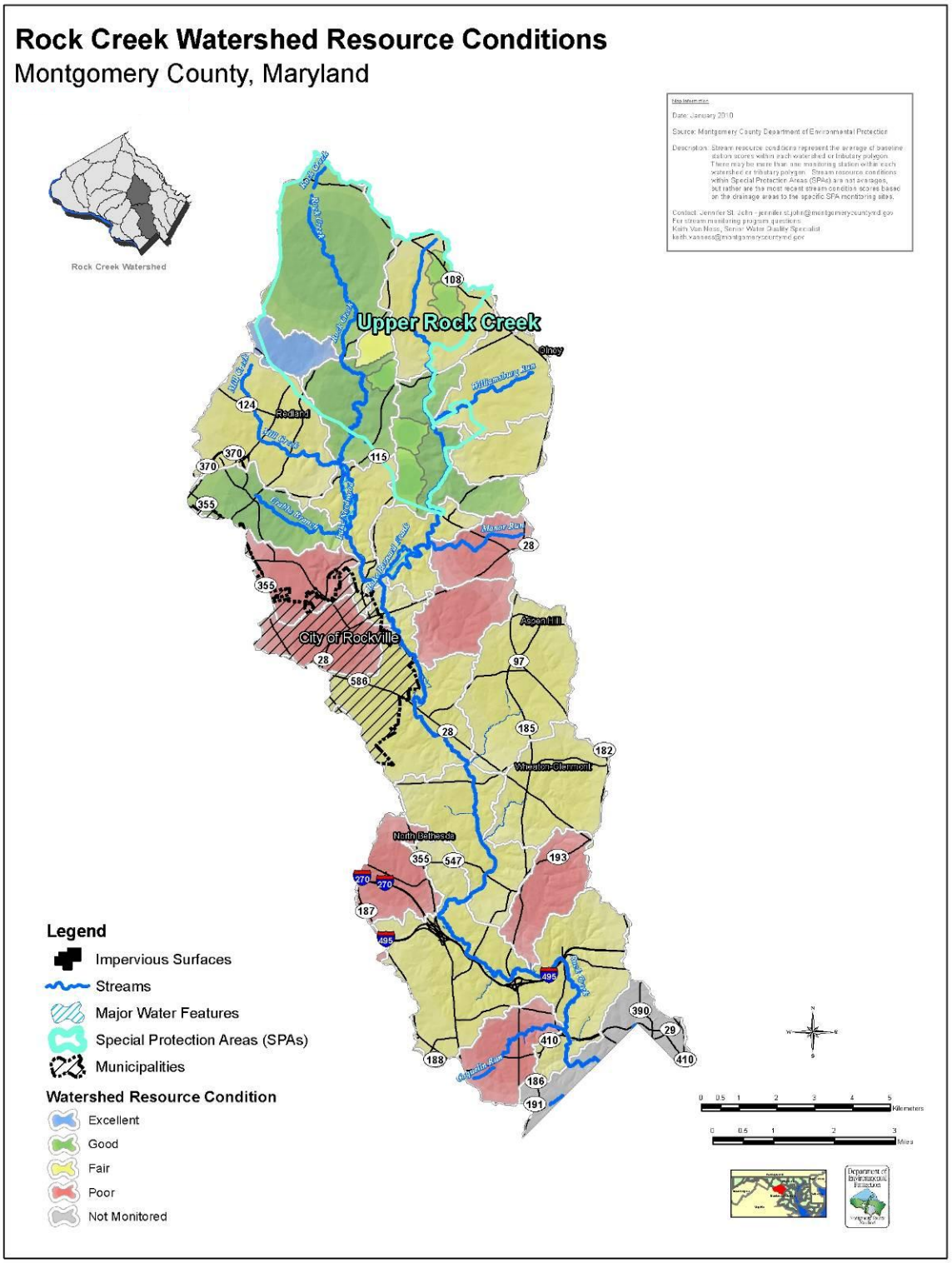


Figure 2: Stream Resource Conditions for the Rock Creek Watershed

Watershed Land Use

MS4 Permit area land use in the watershed is displayed in Table 2. Residential land use is the dominant land use in the watershed, covering about 65% of the watershed. This is followed by municipal/institutional at almost 10% and roadways at 8%. The watershed is largely built-out, with just over 6% identified as forest, open water, or bare ground.

Outreach and Stewardship Strategy Demographic Snapshot:
Traditionally, environmental behaviors have been targeted throughout the US to middle class and above middle class Caucasians. In portions of the Rock Creek watershed; however, Caucasians are a minority. As a result, outreach efforts in this watershed will need to target a different audience to effectively reach out to stakeholders for behavior change. Specifically, there are significant Asian and Latino populations to target in Rock Creek, which will necessitate going to the places where these stakeholder groups interact.

Table 2: County MS4 Permit Area Land Use

Maryland Department of Planning 2002 Land Cover/Land Use	*Watershed Acres*	*Percent of Total (%)*
Low Density Residential (<1 du/acre)	7,341	27%
Medium Density Residential (1-4 du/acre)	8,891	33%
High Density Residential (>4 du/acre)	1,373	5%
Commercial	988	4%
Industrial	942	4%
Municipal/Institutional- Intensive[1]	1,754	6%
Municipal/Institutional- Extensive[2]	891	3%
Roadway[3]	2,036	8%
Rural[4]	1,338	5%
Forest[5]	1,684	6%
Open Water	21	0.1%
Bare Ground	7	0.0%
Total Watershed	**27,265**	**100%**

[1] Institutional land use (churches, schools, municipal buildings)
[2] Open Urban Land and Bare Rock land use (parks, cemeteries, and golf courses)
[3] Combined County and private roads (excludes Federal and State roads)
[4] Orchards, Vineyards, Horticulture, Feeding Operations, Cropland, Pasture, and Agricultural Buildings land use
[5] 2002 Land Use Data.

Existing Stormwater Best Management Practices (BMPs)

There are 670 structural stormwater BMPs within the Rock Creek MS4 Permit area, each capturing drainage areas that vary from over 700 acres for regional pond BMPs to less than 0.01 acres for small, on-site BMPs. The current inventory of BMPs was categorized according to design era and historic performance criteria. Performance metrics were used to group the

BMPs into the five categories as shown in Table 3. The BMPs are classified according to their performance code as established in Appendix B of the Guidance Document.

Table 3: Existing Stormwater Management

BMP Performance Code[1]	*Count*	*Acres of Impervious Cover (IC) Treatment*	
		Drainage Area Treated	*Total IC in Drainage Area*
(4) ESD BMPs	81	183.5	65.7
(3) Effective BMPs	129	1832.5	580.1
(2) Under-performing BMPs	59	193.5	80.1
(1) Non-performing BMPs	151	1859.9	571.3
(0) Pretreatment & Unknown[2]	250	428.0	268.6
Total	670	4497.4	1565.8

[1]For drainage areas with more than one BMP, the maximum performance code was taken after deleting pretreatment BMPs (Code 0).
[2]Drainage area not associated with a specific BMP type

In addition to the structural stormwater BMPs listed above, there are 12 completed stream restoration sites within the County MS4 Permit area of Rock Creek. The completed projects have restored a total length of stream equal to almost 30,000 linear feet.

1.3 Problems Facing the Rock Creek Watershed

Biological and Habitat Conditions

The most recent countywide, five-year monitoring cycle was completed in 2010. In 2008, 24 tributaries in the Rock Creek watershed were sampled for benthic macroinvertebrates, fish species, and habitat metrics in order to assess the stream conditions. Results of the survey are in Table 4, summarized by both stream miles and drainage area. The survey data can be used to classify both instream conditions and overall water quality from the watershed. Therefore, the stream miles summary can be interpreted as an indicator of the current instream resource conditions. The drainage area summary can be used to indicate the condition of water quality draining from the watershed.

Currently, the majority of the stream resource conditions in Rock Creek were assessed as 'Fair', with similar percentages of 'Good' and 'Poor' streams, and very few 'Excellent' streams. The majority of the high quality streams were found in the Upper Rock Creek watershed, including Pope Farm Tributary which received the only 'Excellent' rating. In contrast, Lower and Middle Rock Creek received the majority of 'Poor' ratings, which can mostly be attributed to the increased development in the lower watershed.

Outreach and Stewardship Strategy Stakeholder Awareness of Watershed Issues:
Stakeholders in the Rock Creek watershed are already participating in several County-led and stakeholder-led restoration activities such as:

- Rainscapes
- Composting
- Grasscycling
- Picking up trash
- Planting trees

Stakeholders are aware that outreach support is needed to educate on dog waste disposal, trees regarding plantings and replacement of street trees, trash disposal, and impervious surface reduction.

Table 4: Rock Creek Stream Resource Condition Survey Results by Stream Miles and Drainage Area

Resource Condition	*Length (miles)*	*%*	*Area (Acres)*	*%*
Excellent	5.4	2%	550.9	1%
Good	38.4	18%	7,700.1	20%
Fair	115.8	53%	22,591.5	57%
Poor	47.6	22%	7,366.1	19%
Not Accessed	10.3	5%	1,125.2	3%
Total	217.4	100%	39,333.8	100%

Water Quality and Trash Issues

As part of its environmental enforcement program, the County tracks citizen complaints regarding water quality and illegal solid waste dumping. Table 5 summarizes the number and type of citizen complaints recorded for Rock Creek during the five year cycle from 2004 to 2009. The overwhelming majority of the complaints received were related to stormwater pollutant discharge. Table 6 includes the same complaints summarized by location and general zoning type. For some properties there were multiple complaints. The majority of complaints recorded were in residential, commercial, and industrial zoning. These locations were given 'hotspot' identification in the pollutant loading model, discussed further in Section 3.

Outreach and Stewardship Strategy Land Use Implications:
The primarily residential land use in the Rock Creek watershed necessitates outreach techniques that will resonate with residents. In addition, the intensive institutional land uses necessitate outreach partnerships with churches, schools and municipal building managers.

Table 5: Recorded Water Quality Complaints[1]

Number by Water Quality Complaint Type				
Total # of cases	*Stormwater-Pollutant Discharge*	*Surface Water-Chemical Discoloration/ Unknown*	*Surface Water-Sewage*	*Surface Water-Petroleum Product in Water*
203	177	14	8	4

[1] From WQCases2004_2009_Locations.shp

Table 6: Water Quality Complaint by Zoning[1]

General Zoning Type[2]	*Acres*	*Total # of Properties*
Apartments	8.7	2
Residential	86.3	98
Commercial	95.9	34
Industrial	85.5	22
Non-Conforming	17.1	1
Unzoned	172.3	13

[1] From WQCases2004_2009_locations.shp
[2] From County PROPERTIES.shp

Solid waste trash dumping sites were also logged by the County to identify trash hotspots. Table 7 includes a summary of the complaint database by complaint type. The majority of complaints were recorded as residential dumping or dumpster management. Table 8 identifies the general zoning type at the site of the complaint. As with Tables 5 and 6, for some properties there were multiple complaints noted in Tables 7 and 8.

Table 7: Solid Waste Trash Dumping Sites[1]

Number per Solid Waste Type				
Total# of cases	*Farm Land*	*Residential*	*Public Land*	*Dumpster*
421	1	231	62	127

[1] From SWCases2004_2009_locations.shp

Table 8: Solid Waste Trash Dumping Sites by Zoning[1]

General Zoning Type[2]	*Acres*	*Total # of Properties*
Apartments	68.6	9
Residential	131.9	238
Commercial	41.5	20
Industrial	21.2	10
Unzoned	70.8	10

[1] From SWCases2004_2009_locations.shp
[2] From County PROPERTIES.shp

1.4 Existing Pollutant Loads and Impervious Surfaces

TMDLs and Existing Bacteria Loads

MDE prepared the "Total Maximum Daily Loads of Fecal Bacteria for the Non-Tidal Rock Creek Basin in Montgomery County, Maryland" Final Report in June 2007. This document establishes a TMDL for the non-tidal Rock Creek watershed which is entirely within Montgomery County. The baseline load and WLA for the MS4 Permit area is displayed in Table 9.

Table 9: Bacteria Baseline Loading Estimates for Rock Creek Watershed and Comparison Values from MDE

Parameter	*Date*	*Baseline Montgomery County MS4 load*	*Montgomery County WLA Reduction*	*Target Montgomery County MS4 load*
Bacteria (Enterococci)	2007	453,669 Billion MPN/year	96.0%	18,195 Billion MPN/year

Impervious Surfaces

Impervious cover in the watershed, as derived from County geographical information system (GIS), is summarized in Table 10. The roofs of single family homes account for the largest percentage of impervious cover in the watershed at just over 26%. This is followed closely by County and private roads at just over 25%.

Table 10: County MS4 Permit Area Impervious Cover Breakdown

Impervious Cover Type	*Impervious Acres*	*Within Watershed*
1. Roads		
a. Low Density Residential[1]	368.0	5.6%
b. Other[2]	1,667.9	25.2%
2. Parking Lot		
a. County Small Lots (<1 acre) [3]	50.0	0.8%
b. County Large Lots (>=1 acre) [3]	112.0	1.7%
c. Private	1,390.5	21.0%
3. Roofs		
a. County[4]	124.6	1.9%
b. Single Family Homes[5]	1,735.8	26.2%
c. Other	863.4	13.0%
4. Sidewalks[6]	269.3	4.1%
5. Other		
a. Schools[7]	157.8	2.4%
b. Recreational[8]	40.2	0.6%
Total Impervious Acres from GIS[9]	**6,621.6**	**100%**

[1]All roads in RE2 or R200 property zoning.
[2]Includes County and private roads.
[3]Parking lots located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.
[4]Buildings located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.
[5]Buildings located on single family home parcels, derived using MDP_pnts from the County's PROPERTY geodatabase and selecting only single-family dwelling types.
[6]Sidewalks in jurisdiction. Does not include all residential sidewalks or driveways.
[7]Impervious cover located in public school parcels, derived using pubsch points from the County's LOCATIONS geodatabase. Some overlap with other impervious.
[8] Impervious cover identified as Recreational in geodatabase. Some overlap with other impervious.
[9] Sum of all GIS impervious. Excludes overlaps in schools and recreational.

Existing Trash Loads

The Potomac River Watershed Trash Treaty outlines the agreement between local and state elected officials to commit to a Trash Free Potomac by 2013. The agreement includes three major commitments:

- Support and implement regional strategies aimed at reducing trash and increasing recycling;
- Increase education and awareness of the trash issue throughout the Potomac Watershed; and
- Reconvene annually to discuss and evaluate measures and actions addressing trash reduction.

In general, trash reduction strategies fall into four categories: (1) Structural; (2) Educational; (3) Municipal; and (4) Enforcement. Structural stormwater BMPs will be assigned 95% removal credit for trash from the contributing drainage area. BMPs, while not specifically designed to capture trash, are also not very good at passing trash, and debris is prone to build up in forebays, around plants and interior elements, and around the outlet structures. This Plan estimates the percent reduction in trash from Rock Creek through structural BMPs.

In addition to trash removal by structural stormwater BMPs, programmatic practices from the other three categories (i.e., educational, municipal, and enforcement) provide trash prevention and control. These programmatic practices are specially aimed at reducing trash inputs to roads and streams, including educationally focused programs such as reduce, reuse and recycle campaigns; dumpster management and storm drain marking; and programs tied to operations such as littering and illegal dumping enforcement; stream cleanups; and street sweeping. These programmatic practices are further explored in the countywide strategy.

Other Pollutant Loads

In addition to bacteria and trash, there is a need for the County to track and understand other pollutants of interest such as nutrients and sediment. During 2010, the MDE submitted to EPA a TMDL for sediment in the Rock Creek Watershed. During 2011, it is expected that MDE will provide WLAs for nutrients to meet the Bay-wide nutrient TMDL. This Plan establishes some initial estimates for load reductions from baseline conditions for nutrients and sediment.

2 Inventory of Provisional Restoration Candidates

2.1 Types of Restoration Practices

Table 11 summarizes the 11 groups of watershed restoration practices evaluated for the Rock Creek watershed. The first four groups of restoration practices involve various forms of ESD. All restoration practices differ in the mode and manner by which they will be delivered in the watershed (capital budgets, operating budget, regulation, etc.). Multiple delivery mechanisms are needed to implement enough watershed restoration practices to meet the stringent watershed treatment and pollutant reduction targets set forth in the County's MS4 permit, the TMDL and the Potomac River Watershed Trash Treaty.

Table 11: Restoration Practices to be Evaluated in the Rock Creek Watershed Implementation Plan

Description of Practice	***Application in the Rock Creek Watershed***
ESD Practices	
New ESD Retrofit Practices - These include small scale ESD practices applied to County- owned or privately owned buildings, streets and parking lots and rights of way. Examples include rainwater harvesting, green roofs, upland reforestation, soil compost amendments, rooftop disconnection "green street" retrofits and converting swales to dry swales.	Public ESD Retrofits
ESD Upgrades - This category includes retrofit ESD practices within existing publicly-owned or privately-owned stormwater infrastructure, so that their hydrologic and pollutant reduction performance is upgraded.	Code 1 and 2 BMP Upgrades (see WTM 3.0)
Impervious Cover Reduction - This category involves cases where un-needed impervious cover is removed, soils amended and vegetation restored primarily on County schools, streets and parking lots.	Not applicable
Voluntary LID Implementation - ESD practices that are installed as a result of County education and incentive programs (e.g., Rainscapes incentives).	Private ESD Retrofits
Programmatic and Operational Practices	
MS4 Programmatic Practices – This category deals with reduced pollutants that can be attributed and quantified through MS4 stormwater education (e.g., lawn care), pollution prevention improvements at municipal hotspots, and better housekeeping on County land and facilities. Also includes any pollutant reductions due to product substitution, such as imposing restrictions on N or P content in fertilizer, increased pet waste enforcement, trash prevention and control.	Pet Waste Education
Hotspot Pollution Prevention – This category credits enhanced structural and non-structural practices employed at non-publicly owned stormwater hotspots that are identified through land use analysis.	Not applicable
Enhanced County Street Sweeping - This category includes any pollutant reduction that can be attributed to more intensive and targeted street sweeping in the watershed conducted by the County.	Not applicable

Description of Practice	*Application in the Rock Creek Watershed*
Trash Prevention and Control - This category includes a wide range of programs and practices specially aimed at reducing trash inputs to stream, including reduce, reuse and recycle campaigns, littering and illegal dumping enforcement, dumpster management, storm drain marking, storm drain inlet devices, stream cleanups, instream controls to trap and remove trash, etc. These measures are in addition to any trash trapped and removed by other restoration practices which are computed separately.	Not applicable
Structural Practices	
Traditional Retrofits - This is the traditional retrofit scale where large-scale, non-ESD retrofits are constructed on larger parcels of public or private land as discovered through analysis of MCDEP BMP inventory.	New Ponds
BMP Maintenance Upgrades - Credit for improvement in current permit cycle for major maintenance upgrades of failed stormwater practices that result in significant improvement in hydraulic function and increased treatment capacity using existing County maintenance budget. Credit can only be taken for increased load reduction due to upgrades that significantly rehabilitate BMP function from its installation baseline. (e.g., increase capacity, lengthen flow path, reduce short-circuiting, eliminate design failures) .	Code 1 and 2 BMP Upgrades (see WTM 3.0)
Habitat Restoration - This category includes any pollutant reduction or volume reduction that can be attributed to specific stream restoration or riparian reforestation projects planned for construction in the watershed for the permit cycle.	Riparian Reforestation

2.2 Inventory of Previously Identified Projects

Potential restoration strategies for the watershed set forth in the Plan were drawn from the Watershed Feasibility Study, the Watershed Restoration Action Plan, feedback received from watershed stakeholders, and the County's restoration sites inventory. Previously identified restoration projects identified are presented in Figure 3.

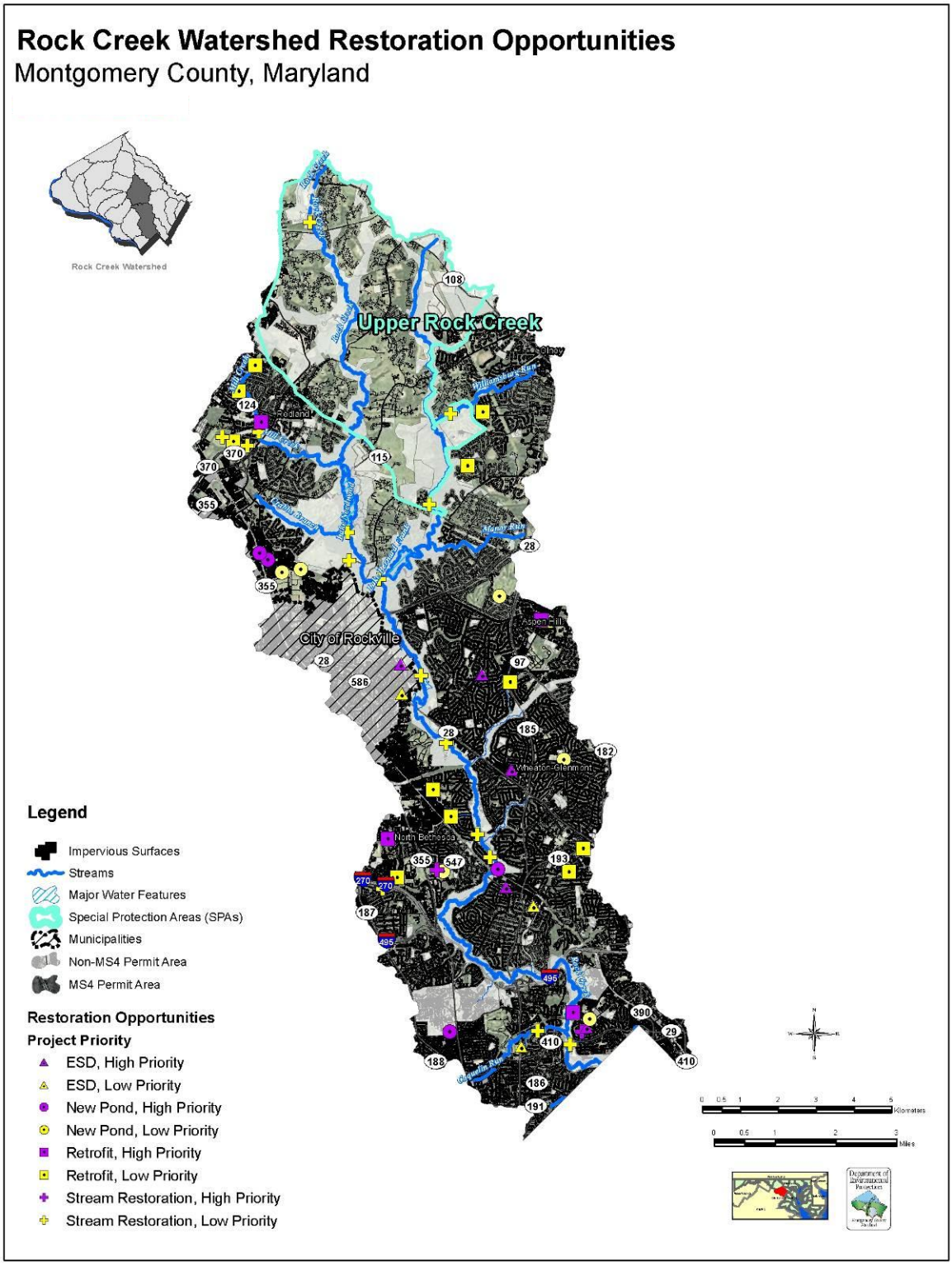


Figure 3: Identified Restoration Opportunity Locations for the Rock Creek Watershed

3 Evaluation of the Restoration Strategies to Meet MS4 Permit and TMDL Requirement

3.1 Bacteria and Pollutant Load Tracking

MDE established the TMDL for bacteria in Rock Creek using water quality samples taken from three monitoring stations at North Branch, Rock Creek south of Lake Needwood, and Rock Creek near East-West Highway during both wet and dry periods from October 2002 through October 2003. The point source WLA for the Montgomery County MS4 Permit area was determined using both bacterial source tracking and distributed land use. MDE used the Maryland Department of Planning (MDP) 2000 land use/land cover information. A similar land use-based model was used in this Plan to develop a primary source load of bacteria, sediment, nutrients, and trash to Rock Creek using 2002 MDP land use data for consistency with the countywide coordinated implementation strategy. Further information on land use loading rates can be found in the Plan Guidance Document, Section 2.

3.2 Desktop Review of BMP Coverage

A desktop review of BMP coverage was used to analyze the existing BMP coverage and proposed County restoration sites inventory of potential retrofit projects. The BMPs were classified according to their performance code as shown in Table 12. The relative performance of each practice type was based on comparative reviews of pollutant reduction and runoff reduction performances of practices from around the country (CWP, 2007; and CWP and CSN, 2008) or performance studies on individual practices (Schueler, 1998). The composite efficiencies were also compared to recent research values and assumptions used in local models (USACE, 2008; Chesapeake Bay Program, 2008; and MDE, 2009) to further justify the performance coding. A summary of the BMP modeling assumptions are in Table 12.

Table 12. Composite Runoff Reduction, Effectiveness Factor, and Pollutant Reduction by BMP Performance Code

Performance Code	*Description*	*TSS[1] (%)*	*TN[2] (%)*	*TP[3] (%)*	*FC[4] (%)*	*DF[5] (%)*
1	**Non-performing BMPs**	5	0	0	0	0.05
2	**Underperforming BMPs**	20	5	5	10	0.15
3	**Effective BMPs**	80	40	50	65	0.75
4	**ESD Practices**	90	65	65	75	1.0

[1] TSS: Sediment Removal rate
[2] TN: Total Nitrogen Removal Rate (Mass)
[3] TP: Total Phosphorus Removal Rate (Mass)
[4] FC: Fecal coliform reduction, see rationale in Guidance Document, Section 5.5 for why entercocci could not be used.
[5] DF: Discount Factor: Fraction of contributing impervious acres effectively treated to the Water Quality Volume, used to rate BMP treatability

The Watershed Treatment Model (WTM) was used to estimate pollutant sources and treatment options for Rock Creek. The spreadsheet used was an updated version of the publically available v3.1, which included an expanded runoff volume reduction component (personal correspondence, Deb Caraco, 2009). The WTM was used to track a progression of restoration

strategies across the watershed to illustrate the effectiveness of each strategy in reducing pollutant loads and ultimately meeting the TMDL load reduction targets. Targeted strategies range from specific restoration sites identified by the County to less well defined nonstructural strategies tied to stakeholder participation and involvement. The specific layers of analysis are presented below, following the nomenclature of WTM 1.0 – WTM 5.0.

3.3 Summary of Watershed Treatment Model Scenarios

A summary of the model scenarios evaluated using the Watershed Treatment Model are provided in Table 13 below and described in more detail in the following sections.

Table 13: Summary of WTM Scenarios

Implementation Phase	*Description*
WTM Baseline Conditions	The WTM was run under existing conditions approach with the MDP year 2002 land use/land cover data and existing BMPs. A correction procedure was conducted in order to correlate the model output with the MDE TMDL baseline load.
WTM 2.0 Completed as of 2009; High Priority; Low Priority and Other Potential Projects	The WTM was run with a series of future management practices, which were proposed projects from the County inventory of restoration sites. These practices cover new ponds, retrofits of existing facilities, and ESD practices from the proposed projects list determined in the Watershed Action Plan and Feasibility Study.
WTM 3.0 ESD Strategies and Other Structural BMPs	The remaining inventory of BMPs, which have reduced treatment efficiency, were reviewed for retrofit opportunities and potential increased pollutant removal efficiencies. In addition, the County's inventory for other project types that include public properties (e.g., libraries and parking lots), public schools, and open section roads available for ESD retrofits was reviewed. Finally, a neighborhood analysis was performed to summarize areas for private property ESD retrofits.
WTM 4.0 Habitat Restoration	Other projects on public lands and other practices that are identified in Appendix B of the Guidance Document were explored. For Rock Creek this focused on habitat restoration related to riparian buffer reforestation.
WTM 5.0 MS4 Programmatic Practices	Other MS4 programmatic practices that are identified in Appendix B of the Guidance Document were examined. For Rock Creek, this was limited to pet waste education, since the TMDL pollutant is bacteria

WTM 1.0– Baseline Conditions

The WTM was run under existing conditions approach with the MDP year 2002 land use/land cover data (Table 2) and existing BMPs coded under "Existing Management Practices" (Table 14). The baseline pollutant load was calculated and compared to the MDE-determined baseline

MS4 load for Enterococci (bacteria). Since the data used to establish the TMDL was collected by MDE from October 2002 through October 2003 (MDE 2007), any BMPs with "approved" dates after 2003 (Table 15) were not included in this baseline calculation. However, these BMPs approved after 2003 can be counted towards meeting the TMDL reduction target.

Table 14: Existing BMP Inventory for Rock Creek

BMP Performance Category	*Count*	*Total DA (Acres)*	*Total IA (Acres)*
ESD Practices (Code 4)	81	183.47	65.72
Effective BMPS (Code 3)	129	1832.45	580.06
Underperforming BMPs (Code 2)	59	193.48	80.06
Non-performing BMPs (Code 1)	151	1859.91	571.33
Pretreatment BMPs (Code 0)	250	428.04	268.62

DA: Drainage Area
IA: Impervious Area

Table 15: Existing BMPs approved after 2003, subtracted from Table 13 Inventory for Rock Creek prior to calculating baseline loading for TMDL tracking

BMP Performance Category	*Count*	*Total DA (Acres)*	*Total IA (Acres)*
ESD Practices (Code 4)	5	1.19	0.81
Effective BMPS (Code 3)	6	9.35	3.02
Underperforming BMPs (Code 2)	2	4.82	3.02
Non-performing BMPs (Code 1)	1	2.57	1.63
Pretreatment BMPs (Code 0)	2	1.42	0.89

DA: Drainage Area
IA: Impervious Area

WTM 2.0- Completed as of 2009, High Priority, Low Priority and Other Potential Retrofit Projects

The WTM was run with a series of future management practices, which were proposed projects from the County inventory of restoration sites. These practices cover new ponds, retrofits of existing BMPs, and ESD projects from the proposed projects list determined in the Watershed Action Plan and Feasibility Study, as summarized in Table 17. Drainage area (DA), impervious area (IA), total length, and total cost were all determined from engineering designs or estimated based on the running average per practice values from the County DEP Restoration Sites Database.

In general, the County used the information in Table 16 below to estimate proposed impervious

Outreach and Stewardship Strategy

To help watershed stakeholders understand why retrofits and other watershed restoration improvements are under construction, stakeholder outreach such as installing educational signage near all retrofit projects is recommended. This can be accomplished through partnerships with organizations such as the Friends of Rock Creek Environment (FORCE).

Messaging should focus on the ways that the treatment of stormwater on roads and public lands is changing. This is a demonstration of the new ways in which we manage stormwater. Implementation details on this stakeholder outreach are described in the Practice Sheet entitled Innovative Stormwater Management Outreach and Stewardship Campaign.

area and costs, where engineering costs were unavailable:

Table 16: Impervious Cover and Cost Estimates used in the Future Management Scenarios

• **38% imperviousness per drainage acre**
• **New Ponds, $6,000 per drainage acre**
• **Retrofit Pond, $4,000 per drainage acre**
• **ESD project, $200,000 per impervious acre**
• **Wetland, $50,000 per drainage acre**

The cumulative pollutant load reduction was computed and compared to the TMDL annual target for bacteria. The applicable target reduction in bacteria from the calculated MDE stormwater WLA is 96%. Thus, this step determined how far and at what cost the existing list of restoration projects goes toward meeting the TMDL, impervious cover, trash and other pollutant reduction goals. New Ponds were given effective BMP pollutant reduction efficiency, and ESD practices were given full ESD pollutant reduction efficiency.

Retrofits of existing BMPs were reconciled with the existing urban BMP database and given an incremental increase in pollutant reduction efficiency based on an assumed Code 4 BMP efficiency. The actual drainage area and impervious area from the existing practice was used to calculate pollutant and runoff reduction.

Table 17: Three levels of treatment: Complete as of 2009, High Priority, Low Priority and Other Potential Projects

Restoration Type	*Count*	*Total Cost*	*Total Length (mi)*	*Total DA (acres)*	*Total IA (acres)*
Completed Projects					
ESD	1	$560,000	-	4.0	2.8
New Pond	3	$2,188,282	-	367.3	120.6
Retrofit of Non-performing BMPs	2	$1,689,408	-	422.4	88.8
Stream Restoration	12	$4,376,856	5.6	-	-
High Priority Projects					
ESD	5	$1,199,368	-	7.8	5.4
New Pond	4	$7,127,120	-	642.7	302.0
Retrofit of Non-performing BMPs	5	$571,691	-	142.9	65.7
Stream Restoration	2	$1,420,000	1.1	-	-
Low Priority and Other Potential Projects[1]					
ESD	6	$654,000	-	5.7	3.9
New Pond	11	$8,011,709	-	1,536.1	737.3
Retrofit of Pretreatment BMPs	2	$36,947	-	9.2	7.7
Retrofit of Non-performing BMPs	4	$464,341	-	116.1	11.4
Retrofit of Underperforming BMPs	1	$21,681	-	5.4	4.9
Retrofit of Effective BMPs	4	$1,642,031	-	410.5	114.5
Stream Restoration	16	$14,272,500	10.8	-	-

[1]Includes Low Priority and Future Restoration Sites

WTM 3.0 – ESD Strategies and Other Structural BMPs Combined

The remaining inventory of Code 1 and 2 BMPs, which have reduced treatment efficiency, were reviewed for retrofit opportunities and potential increased pollutant reduction efficiencies. In addition, the County's GIS Property database was reviewed for other project types that include public properties (e.g., libraries), public schools, and open section roads available for ESD retrofits. Then the Guidance Document was followed for determining total potential reduction from assumed treatment areas from these four target areas.

a. Code 1 and 2 BMP ESD Retrofits- The remaining Code 1 and Code 2 BMP treatment area was calculated by subtracting the previously targeted retrofits from (WTM 2.0) from the total BMP area (summarized in Table 18). It was then assumed these areas were suitable for retrofits and incrementally increased the performance efficiency of Code 1 and 2 BMPs to the MEP within Future Management Practices. The cost per impervious acre estimate was based on typical County retrofits for large pond BMPs.

Table 18: Underperforming (Code 2) and Non-performing (Code 1) BMPs targeted for retrofit

Target	Count	Total DA (acres)	Total IA (acres)	Cost per IA	Total Cost
Total Code 2 BMPs	59	193.5	80.1		
-Previously Targeted for Retrofit	-1	-5.4	-4.9		
Remaining Code 2 for Retrofit	**58**	**188.1**	**75.2**	**$12,000**	**$901,920**
Total Code 1 BMPs	151	1,859.9	571.3		
-Previously Targeted for Retrofit	-11	-681.4	-166		
Remaining Code 1 for Retrofit	**140**	**1,178.5**	**405.3**	**$12,000**	**$4,863,960**
				Total	$5,765,880

Table 19 shows the following:

b. Public properties – Forty percent of the impervious cover from the aggregate area and associated imperviousness from untreated County-owned Large Parking Lots and Rooftops was assigned to future management practices as code 4 (see Table B.4 of Guidance Document, and summary in Table 19 below). The forty percent target for restoration was based on a judgment of the maximum extent practicable considering physical constraints to ESD/LID. The unit cost estimate was based on an equal mix of new ESD retrofits for larger parking lots and rooftops.

c. Public schools – Forty percent of the impervious cover from the aggregate area and associated imperviousness and from untreated Public Schools Parcels was assigned to future management practices as code 4 (see Table B.4 of Guidance Document, and summary in Table 19 below). The restoration target was set similarly to part (b) above.

d. LDR and Other County Roads – Seventy-five percent of the impervious cover from the aggregate area and associated imperviousness from RE2 and R200 roadways was assigned to future management practices as code 4 (see Table B.4 of Guidance Document, and summary in Table 19 below). The restoration target was set similarly to part (b) above. The unit cost estimation was based on an open-section road retrofit. Other County Roads were assigned a forty percent aggregate impervious cover restoration target, and the unit cost was based on a curbed road retrofit.

Outreach and Stewardship Strategy
To reduce imperviousness on private property, stakeholder outreach is recommended in partnership with chambers of commerce, and business associations to educate landowners on BMPs that can be implemented to reduce runoff from private lots. Recommended Practices include rainwater harvesting, green roofs, upland reforestation, soil compost amendments, rooftop disconnection "green street" retrofits and converting swales to dry swales along with other items listed in the Chapter 5 of the MDE Design Manual. Implementation details are included in the Practice Sheet entitled Parking Lot Runoff Water Quality Outreach and Stewardship Campaign.

e. Private Property ESD implementation - The County offers technical and financial assistance through the RainScapes Program to encourage property owners to implement ESD practices on their property. The RainScapes Neighborhood program includes neighborhoods in Wheaton Woods, KenGar, Stoneybrook/Parkside, and Chevy Chase for implementation.

In order to identify additional Priority Residential Neighborhoods for private property ESD implementation, a desktop assessment was performed. The criteria used for evaluation included lot size, home ownership, presence or absence of homeowners association (HOA), and presence or absence of existing stormwater management BMPs. Neighborhood areas are then broken into tiers of high, medium, and low based on the points assigned to the various criteria:

- SWM Score:
  - Yes = 0; No = 2
- Lot Size Score:
  - > 1.0 acre = 0
  - <= 0.25 BUT <= 1.0 = 3 (High)
  - <= 0.1 BUT <0.25 = 2 (Medium)
  - < 0.1 acre = 1 (Low)
- Home Ownership Score:
  - > 70% = 3 (High)
  - <= 30 BUT <=70 = 2 (Medium)
  - < 30% = 1 (Low)
- HOA Score:
  - Yes = 2 ; No = 0
- Total Priority Score:
  - >=9 = High
  - >=6 BUT <=8 = Medium
  - <= 5 = Low

Thirty percent implementation of site-scale ESD projects in the targeted neighborhoods that meet criteria associated high and median priority was assumed, which equates to 595 acres of impervious area treatment, and a cost of $177.37 Million assuming $298k per impervious acre. Figure 4 shows the priority neighborhoods in Rock Creek. Table B.7 of the Guidance Document describes the basic approach used to make pollutant reduction and cost decisions.

Outreach and Stewardship Strategy
To reduce stormwater pollution on private property, stakeholder outreach is recommended explaining the need for watershed stakeholders to capture some of the precipitation that falls on their roof and allow for groundwater recharge hence slowing the flow of surface waters and potential erosion impacts. It is recommended that this can be accomplished by expanding existing County programs such as Rainscapes, as described in the Practice Sheet entitled Roof Runoff Reduction Outreach and Stewardship Campaign.

f. Non-residential Property without Adequate Treatment ESD implementation: These are comprised of commercial properties that are not currently paying into Water Quality Protection Charge. It was assumed that 40% of the impervious cover within these properties will apply ESD practices on site. This equates to 550 acres of impervious cover. This area was assumed to be treated to the maximum extent practicable within the WTM.

Table 19: Summary of restoration opportunities within County owned facilities, schools, and LID roads options

Land Cover	***Total IA***	***Restoration Target****	***Restored IA***	***Unit Cost*****	***Restoration Cost****
Type	Acres	%	Acres	$/Acre IA	$
County Large Parking Lots[1]	112	40%	45	$317,500	$14,224,000
County Roofs[2]	125	40%	50	$508,500	$25,343,640
Schools[3]	158	40%	63	$484,000	$30,550,080
Low Density Residential Roads[4]	368	75%	276	$137,000	$37,812,000
Other County Roads	1668	40%	667	$200,000	$133,432,000
Priority Neighborhoods[5]	2316	30%	595	$298,000	$177,372,282
Non-residential Property without adequate treatment	1374	40%	550	$298,000	$163,795,104
Totals	**6,121**		**2,246**		**$582,529,106**

*Restoration target was based on a judgment of the maximum extent practicable considering physical constraints to ESD/LID

**Unit Cost was derived from an equal mix of green roofs, cisterns, permeable paving, and bioretention BMPs according to the Guidance Document.

[1] Parking lots located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.

[2] Buildings located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.

[3] Impervious cover located in public school parcels, derived using pubsch points from the County's LOCATIONS geodatabase. Some overlap with other impervious.

[4] All roads in RE2 or R200 property zoning, considered open-section roads.

[5] Rooftop area in High and Medium Priority Neighborhoods

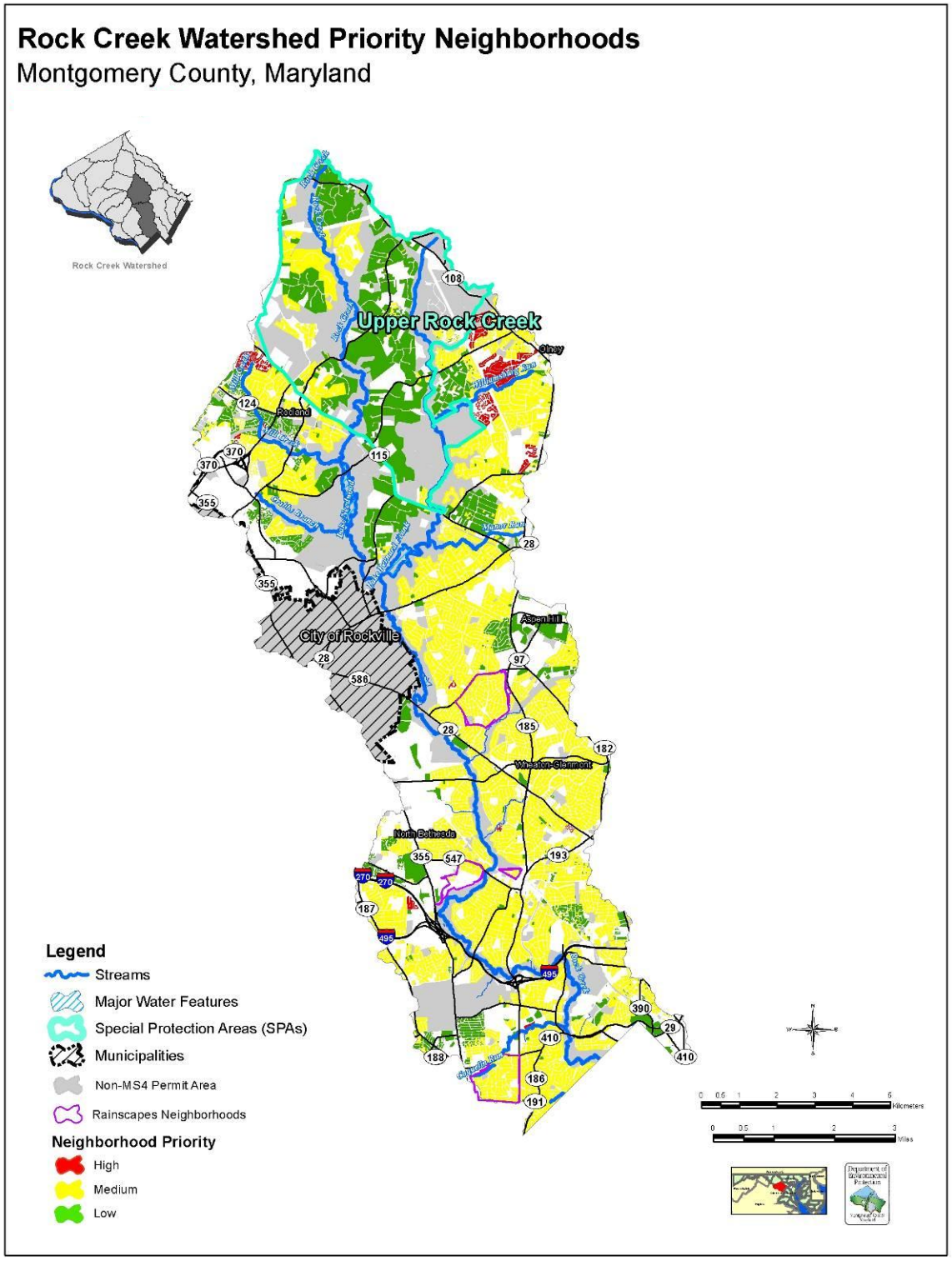


Figure 4: Priority Neighborhoods for the Rock Creek Watershed

WTM 4.0 – Habitat Restoration

Other projects on public lands and other practices that are identified in Appendix B of the Guidance Document were explored. For Rock Creek, the parameter of focus is the bacterial load.

a. Habitat restoration (riparian reforestation) – The total amount of unforested 100-ft buffer along streams was computed and then the land use area was converted to forest area in Future Management Practices (see Table B.13 of the Guidance Document, and summary of areas in Table 20 below). One-hundred percent implementation of riparian reforestation across the total area was assumed.

Outreach and Stewardship Strategy
To encourage habitat restoration on private property, stakeholder outreach is recommended on the important roles of riparian buffers. Key partnerships include the local watershed stewards such as Friends of the Rock Creek Environment (FORCE). Implementation details are contained in the Practice Sheet entitled Riparian Reforestation Outreach and Stewardship Campaign.

Table 20: Summary of land use categories within the 100-ft buffer area of County streams.

MdOP 2002 Land Cover/Land Use	*Watershed*	*Total Buffer Area*	
	Acres	*Unforested Area (acres)*	*Forested Area (acres)*
Low Density Residential	7,341	383	98
Medium Density Residential	8,891	398	110
High Density Residential	1,373	104	44
Commercial	892	47	6
Industrial	857	69	3
Municipal/Institutional- Intensive	1,754	93	48
Municipal/Institutional- Extensive	891	98	41
Total Area[1]	**22,000**	**1,192**	**351**
Total Cost[2]		**$23.8 Million**	

[1] Additional areas, not shown, include roadway, rural, and forested areas not targeted for riparian reforestation
[2] Assumes $20k per acre reforestation

WTM 5.0 – Programmatic Practices

Other MS4 programmatic practices that are identified in Appendix B of the Guidance Document were examined. For Rock Creek, this was limited to pet waste education, since the TMDL pollutant is bacteria.

a. MS4 programmatic practices - Table B.8 of the Guidance Document describes the basic approach.

Outreach and Stewardship Strategy To reduce bacterial load from private property, stakeholder outreach on the importance of pet waste pick up anywhere a pet may go is recommended. Partnerships for implementation should be fostered between homeowner associations, pet product retailers, pet waste removal companies, and the service industry. Implementation details are in the Practice Sheet entitled Pet Waste Pickup Outreach and Stewardship Campaign.

i. Pet Waste Education- The potential reduction in load was calculated using the WTM Pet Waste Education/Future Management Practice, which requires the total number of dwelling units in the watershed (78,909 RDUs). Default WTM discounts, which are based on residential surveys include an assumed 40% of households with dogs, 50% of owners who walk their dogs, 60% of owners who currently clean up after their pets, and 60% of owners willing to change their behavior. The percent willing to change is highly dependent on the establishment of ordinance and enforcement (see Caraco, 2001). An 80% dog owner targeting strategy was assumed, which is dependent on the media outlet chosen for education, which for Rock Creek was every household within the watershed at a cost of $15 per household. The potential load from pet waste is shown in Table 21.

Table 21: MS4 Programmatic Practices for Rock Creek Watershed

Strategy	*# households*	*Potential Enterococci Bacteria Source (billion MPN/yr)*	*Unit Cost*	*Total Cost*
Pet Waste	78,900	35,734	$15 per house	$1.18 Million

3.4 Preliminary Results of the Bacteria Load Reduction Analysis

The WTM was run iteratively using a series of spreadsheets for each step outlined above. Initially, the WTM was coded with the existing land use and BMP database to calculate the baseline load. This was within 6% of the MDE baseline for bacteria. Since the targeted WLA was a 96% reduction from the baseline, the reduction was applied to our WTM computed baseline to establish the 19,164 billion MPN/yr target for restoration efforts. From there, the iterative approach was used to track progress as shown in Table 22.

Table 22: Preliminary Results of WTM Modeling

Implementation Phase	*Enterococci Loading*	*Comments*	*Cumulative Cost*
	% reduction from baseline		*Million $*
WTM Baseline Load*	**0%**	**Calibrated to MDE Baseline Load**	$ -
WTM 2.0	12%	**Completed, High Priority, Low Priority and Other Potential Projects**	$ 24.2
WTM 3.0	43%	**ESD Strategies and Other Structural BMPs**	$ 612.5
WTM 4.0	47%	**Habitat Restoration**	$ 636.3
WTM 5.0	55%	**MS4 Programmatic Practices**	$ 637.5
TMDL WLA	96%		
* Excludes existing BMPs approved after the TMDL was established in 2003.			

The restoration strategy is further illustrated in Figure 5 where the implementation phases are shown in order with their resulting bacteria load in comparison to the WLA. The cost for each implementation phase is also shown. The greatest reduction is attributed to ESD strategies, while pet waste education was the most cost-efficient strategy, shown in Table 23.

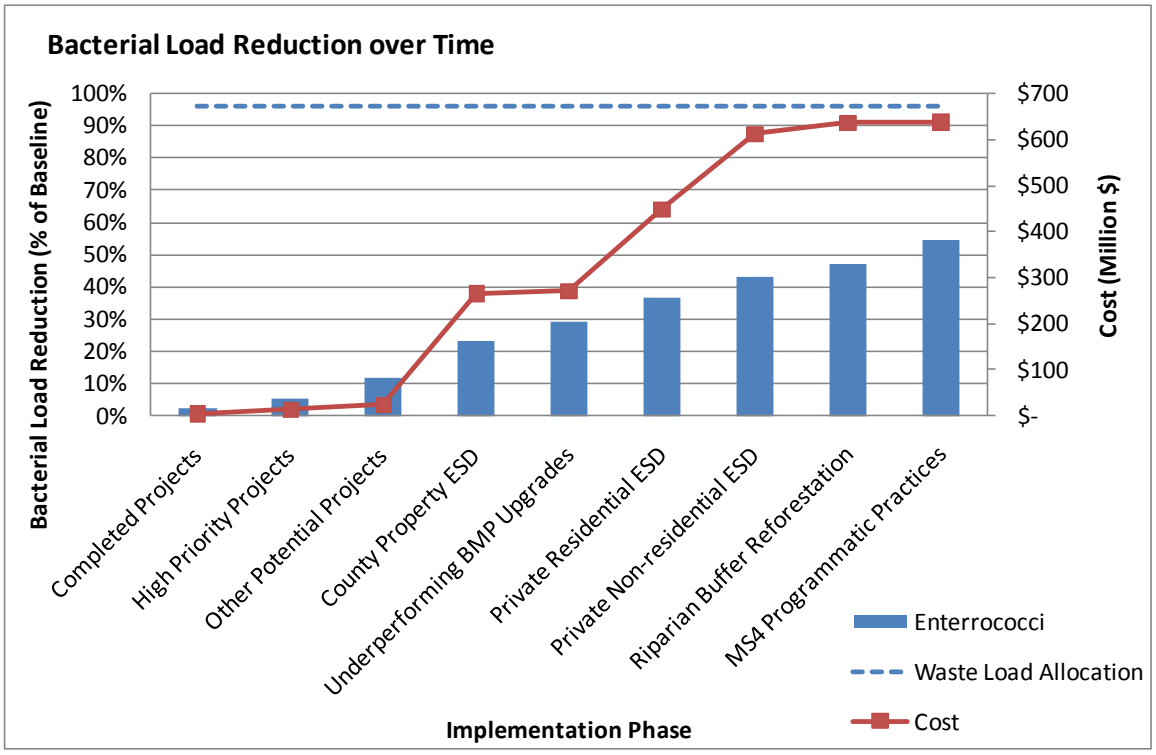


Figure 5: Bacterial loading over time of restoration implementation

Table 23: Individual restoration strategy cost effectiveness for bacterial load reduction

Rank	***Restoration Strategy***	***Enterrococci reduction***	***Incremental Cost***	***Unit Cost***
		Billion MPN/yr	Million $	Billion MPN /Million $
1	Pet Waste Management	35,734	1.18	30,190
2	Underperforming BMP Upgrades	28,800	5.77	4,995
3	Low Priority and Other Potential Projects	30,239	10.83	2,792
4	Completed Projects	12,131	4.44	2,734
5	High Priority Projects	14,239	8.90	1,600
6	Riparian Reforestation	18,999	23.84	797
7	County Property ESD Retrofits	54,519	241.36	226
8	Private Residential ESD Retrofits	35,230	177.37	199
9	Private Non-residential ESD Retrofits	32,486	163.80	198

The restoration implementation strategy should be geared to target the sources of bacteria. Stormwater management in general only targets overland flow sources of bacteria, such as runoff containing waste from domestic pets, wildlife, and potentially livestock. MDE determined the bacterial loading to Rock Creek to be from a distribution of sources including domestic animals, human, livestock, wildlife, and unknown based on bacterial source tracking (BST), as shown in Figure 6. The monitoring stations locations were North Branch, Rock Creek south of Needwood Lake, and Rock Creek near East-West Highway. The distribution shows the highest contribution of bacterial loading from wildlife, followed by livestock, domestic animals, and human sources. The TMDL assigned the Montgomery County MS4 the entire domestic pet bacterial load, as well as a portion of the wildlife load.

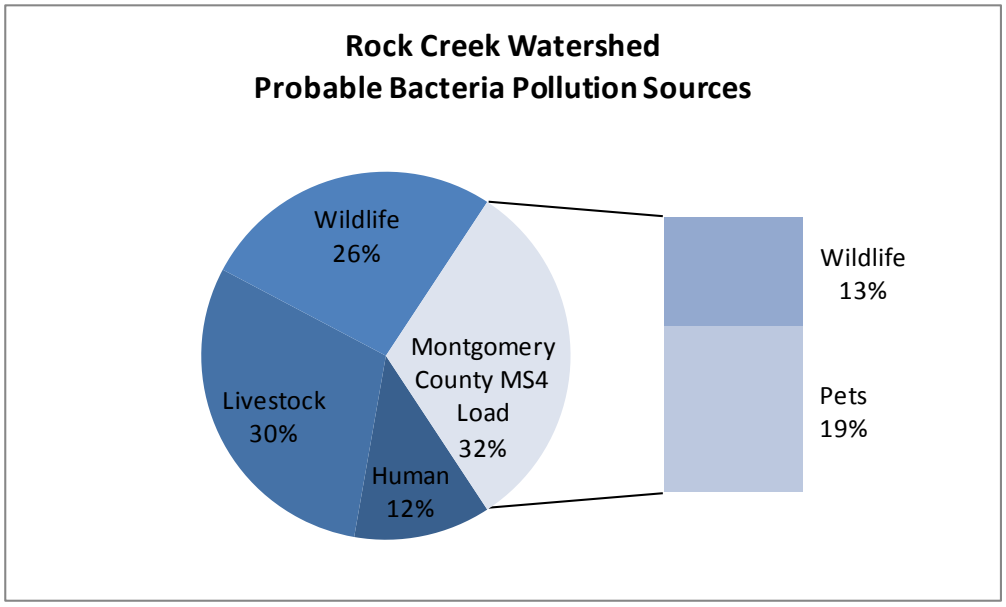


Figure 6: MDE TMDL Distribution of Fecal Bacteria Source Loads in the Rock Creek Basin

4 Evaluation of the Restoration Strategies to Meet MS4 Permit Trash Reduction Tracking

Table 24 presents recommended baseline loading rates for urban land uses in Montgomery County based on the MDE (2010) study. These rates will be used as default values in a land use-based loading calculation model similar to the WTM. The model could be applied to individual Watershed Implementation Plans, or for a countywide calculation of trash loading.

Outreach and Stewardship Strategy
To reduce trash hot spots, stakeholder outreach is recommended in partnership with HOAs, county recycling offices and athletic organizations Educating watershed residents on the importance of proper trash can maintenance, keeping playing fields clean, and dumpster maintenance is recommended for success. Implementation details are in the Practice Sheet entitled Anti-littering Outreach and Stewardship Campaign.

Table 24: Montgomery County Point Source Baseline Loading Rates for Trash

Land Use	***Loading Rate[1] (lbs/ac/yr)***
Low-density residential	1.19
Medium-density residential	19.26
High-density residential	7.88
Commercial	2.22
Industrial	2.22
Institutional	2.22
Extractive	2.22
Parkland	0.32
Roadway[2]	2.22
Agricultural	0.32
Forest	0.32
Water	0.00
Bare Ground	2.22

[1] Montgomery County Trash Loading Rates from *Draft Total Maximum Daily Loads of Trash for the Anacostia River Watershed, Montgomery and Prince George's Counties, Maryland and The District of Columbia, 2010*
[2] Prince George's County Trash Loading Rates from *Draft Total Maximum Daily Loads of Trash for the Anacostia River Watershed, Montgomery and Prince George's Counties, Maryland and The District of Columbia, 2010*

In general, trash reduction strategies fall into four categories: (1) Structural; (2) Educational; (3) Municipal; and (4) Enforcement. For the purposes of the restoration strategies, structural stormwater BMPs were assigned 95% removal credit for trash from the contributing drainage area. BMPs, while not specifically designed to capture trash, are also not very good at passing trash, and debris is prone to build up in forebays, around plants and interior elements, and

around the outlet structures. Instream controls from trash nets or traps are also assumed to have 90% capture efficiency if maintained periodically.

In addition to trash removal by structural stormwater BMPs, land use conversion, such as riparian reforestation have an incremental reduction in trash by changing the loading rate according to Table 25.

Overall, the trash load in Rock Creek was reduced by 55% using the same restoration strategies outlined for the bacteria load reduction procedures. Specific programmatic practices targeting trash load reduction were not modeled as part of this draft restoration strategy development; however, these practices can have a range of removal effectiveness between 5-30%, depending on the intensity of implementation and frequency of follow-up. Examples include: anti-litter education campaigns, plastic bag bans, recycling programs, adopt-a-road and adopt-a-stream, street sweeping, and enforcement. Table 25 and Figure 7 illustrate the reduction in trash load over time and implementation of the strategies.

Outreach and Stewardship Strategy
Convincing watershed residents that it is in their best interests to reduce trash from local streams, culverts and roadways will depend on successfully reaching a variety of ethnic and cultural groups, especially in the lower sections of the watershed.

Table 25: Preliminary Trash Results of WTM Modeling

Implementation Phase	*Trash Loading*	*Comments*	*Cost*
	% reduction from baseline		***Million $***
WTM Baseline Load	**0%**	**Uncalibrated load using Anacostia loading rates**	$ -
WTM 2.0	2%	**Completed Projects**	$ 4.44
WTM 2.0	6%	**High Priority Projects**	$ 13.34
WTM 2.0	15%	**Low Priority and Other Potential Projects**	$ 24.17
WTM 3.0	50%	**ESD Strategies and Other Structural BMPs**	$ 612.46
WTM 4.0	55%	**Habitat Restoration**	$ 636.31
WTM 5.0	55%	**MS4 Programmatic Practices**	$ 637.49

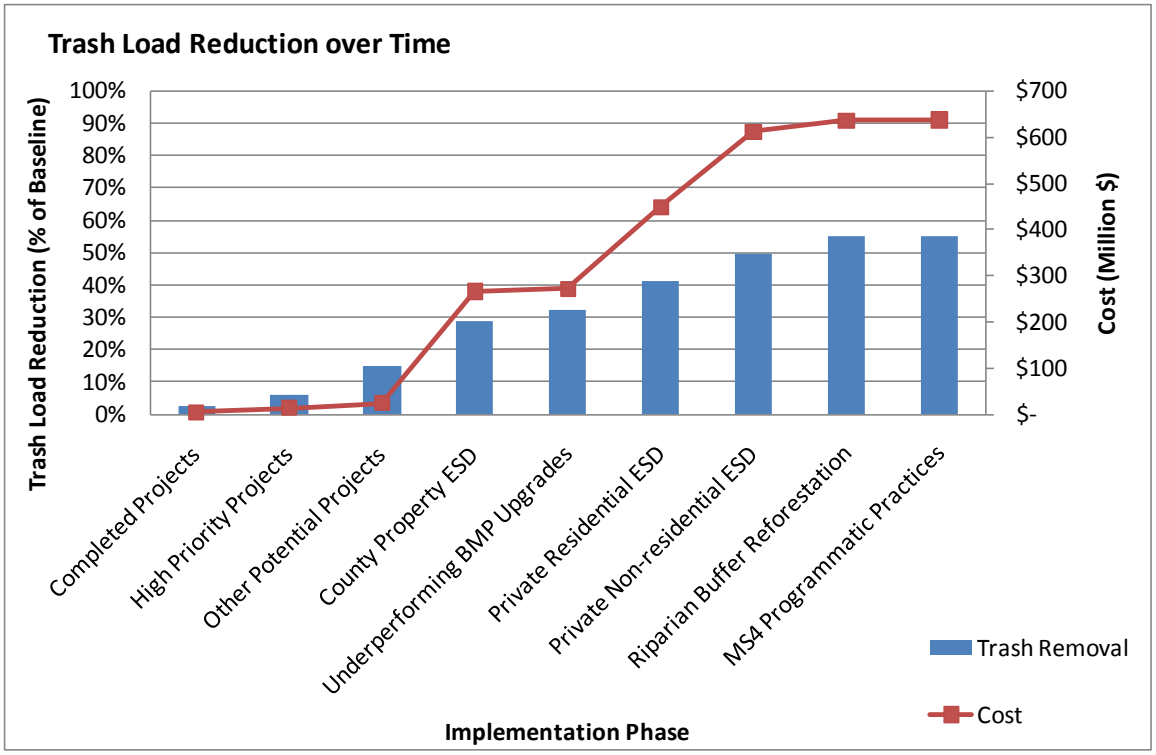


Figure 7: Trash load reduction over time and associated costs modeled using the WTM

5 Nutrient and Sediment Reduction Tracking

As of 2010, there are no EPA approved TMDLs for Rock Creek related to nutrients or sediment, although there are impairments present for these parameters. In general, nutrient (Total Nitrogen (TN) and Total Phosphorus (TP)) and sediment (Total Suspended Solids (TSS)) reduction strategies follow the same protocol proposed for bacteria and trash, only with different efficiencies. The respective efficiencies for the various strategies and assumptions about target areas follow the Guidance Document and assumptions presented in this Implementation Plan in Table 12.

Reductions in nutrient and sediment loads from a baseline condition are provided in Table 26.

Overall, the TN, TP, and TSS loads in Rock Creek were reduced by 52%, 53% and 49%, respectively if BMPs from all strategies are implemented. Since the same core restoration strategies outlined for the bacteria load reduction procedures are being followed, the cost for implementation also remains the same.

Table 26: Preliminary Sediment and Nutrient Results of WTM Modeling

Implementation Phase	***TN Loading***	***TP Loading***	***TSS Loading***	***Comments***
	% reduction from baseline	*% reduction from baseline*	*% reduction from baseline*	
WTM Baseline Load	**0%**	**0%**	**0%**	**Uncalibrated load using default loading rates**
WTM 2.0	2%	2%	3%	**Completed Projects**
WTM 2.0	4%	5%	6%	**High Priority Projects**
WTM 2.0	9%	10%	14%	**Low Priority and Other Potential Projects**
WTM 3.0	39%	40%	47%	**ESD Strategies and Other Structural BMPs**
WTM 4.0	41%	42%	49%	**Habitat Restoration**
WTM 5.0	52%	53%	49%	**MS4 Programmatic Practices**

6 Action Inventory Implementation Schedule

6.1 Rock Creek Watershed Implementation Schedule

The implementation schedule summarized in Table 27 is an action inventory matrix that identifies priorities and timeframes for implementation of the above identified watershed restoration strategies as a function of project synergies and expected funding levels countywide. For the first permit cycle (through 2015), a priority was placed on full implementation of complete, high and low priority projects. A list of the high and low priority projects is provided in Appendix A. Next, 25% implementation of other potential projects was targeted. ESD was emphasized on both public and private property (10%), with private property implementation being linked to Rainscapes Program success. Finally, outreach (100%) and stream restoration (22%) are targeted for pollutant load reduction but are not credited towards impervious cover credit. In future permit cycles, the remainder of the other potential projects are targeted along with ESD and riparian reforestation for impervious cover and pollutant load reduction. Stream restoration is a significant strategy pursued for load reduction benefits. Table 28 includes a summary of implementation goals for the 2015, 2017, 2020, 2025, and out years in order to illustrate the expected timeframe for compliance with the MS4 permit area WLA.

The bacteria load reduction does not meet the MS4 permit area WLA. However, the remaining bacteria reduction is believed to be associated with urban wildlife sources. Unless intense urban wildlife management practices are implemented, this remaining load reduction will not be possible. The assumptions for the 2020 and 2025 fiscal periods were that future MS4 permits would set a similar countywide impervious goal as in the current permit (20%). The 2017 fiscal period was important for the countywide implementation strategy for meeting the Chesapeake Bay TMDL goals within the MS4 permit area. The year 2030 was an outer milestone set for complete implementation of the strategies outlined in this Plan.

Table 27: Summary of Implementation Plan Schedule for the 2015 Fiscal Period, with expected level of ESD and pollutant load reductions

Strategies	*% Complete in Permit Cycle*	*IC Treated (acres)*	*ESD (% IC)*	*Cost (Million $)*	*ESD (% Cost)*	*% Reduction from baseline*				
						TN	*TP*	*TSS*	*Bacteria*	*Trash*
Completed and High Priority Projects	100.0%	585	1%	$13	13%	4.0%	5.0%	6.0%	5.5%	6.0%
Low Priority Projects	100.0%	665	1%	$9	7%	3.9%	3.9%	6.2%	4.9%	7.0%
Other Potential Projects	25.0%	48	0%	$1	0%	0.3%	0.3%	0.4%	0.4%	0.5%
Public ESD Retrofits	10.0%	102	100%	$25	100%	1.3%	1.3%	1.4%	1.3%	1.5%
Private ESD Retrofits	10.0%	141	100%	$34	100%	1.7%	1.7%	1.9%	1.8%	2.0%
Riparian Reforestation	0.0%	-	0%	$0	0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stream Restoration	21.8%	-	0%	$4	0%	2.0%	1.5%	21.9%	0.0%	0.0%
Programmatic Practices	100.0%	-	0%	$1	0%	11.0%	11.0%	0.0%	7.5%	0.0%
Subtotal	***38.6%***	***1,541***	***16.5%***	***$87***	***70.4%***	***24.1%***	***24.7%***	***37.8%***	***21.4%***	***17.0%***

IC: Impervious Cover
ESD: Environmental Site Design
TN: Total Nitrogen
TP: Total Phosphorus
TSS: Total suspended solids

Table 28: Summary of Implementation Plan schedule for the Rock Creek Watershed with expected MS4 permit area WLA compliance endpoints

Fiscal Year		2015	2017	2020	2025	2030	TMDL WLAs
Impervious Treated (acres)		1,541	1,961	2,381	3,625	3,989	
ESD (% Impervious)		17%	28%	36%	57%	61%	
Cost (Million $)		87	172	262	566	658	
ESD (% Cost)		70%	79%	79%	89%	90%	
% Reduction from baseline	TN	24%	30%	38%	55%	61%	
	TP	25%	30%	38%	54%	60%	
	TSS	38%	50%	92%	100%	100%	
	Bacteria	21%	27%	33%	50%	55%	96.0%
	Trash	17%	24%	31%	50%	55%	

TN: Total Nitrogen
TP: Total Phosphorus
TSS: Total suspended solids
WLA: Waste Load Allocation

7 References

Army Corps of Engineers (USACE). 2008. Sligo Creek Study. Baltimore District. Baltimore, MD.

Caraco, D. 2009. *New WTM – No Projections.xls*, Personal Email Communication, October 14, 2009.

Caraco, D. 2001. The Watershed Treatment Model: Version 3.0. U.S. Environmental Protection Agency, Region V. Center for Watershed Protection. Ellicott City, MD

Center for Watershed Protection (CWP) and URS. 2008. *Technical Memorandum: The Runoff Reduction Method*. Ellicott City,

Center for Watershed Protection (CWP) and Chesapeake Stormwater Network (CSN). 2001. *Rock Creek Watershed Restoration Action Plan*. Prepared for Montgomery County Department of Environmental Protection. Rockville, MD.

Center for Watershed Protection (CWP). 2007. *National Pollutant Removal Performance Database Version 3.0*. Center for Watershed Protection, Ellicott City, MD.

Chesapeake Bay Program (CBP) Nutrient Subcommittee. 2008. Infiltration and Filtration Practices: Definition and Nutrient and Sediment Reduction Effectiveness Estimates. Center for Watershed Protection, Ellicott City, MD.

Chesapeake Stormwater Network (CSN) and Biohabitats. 2011. *Implementation Plan Guidance Document*. Prepared for Montgomery County Department of Environmental Protection, Rockville, MD.
http://www.montgomerycountymd.gov/dectmpl.asp?url=/Content/dep/water/esdStrategy.asp

MDE (Maryland Department of the Environment). 2010. *Memorandum: 2010 Status of Approved Stormwater Wasteload Allocations for NPDES Regulated Stormwater Entities in Montgomery County*. Baltimore, MD: Maryland Department of the Environment.

MDE. 2009. *Technical Memorandum: 2009 Status of Approved Stormwater Wasteload Allocations for NPDES Regulated Stormwater Entities in Montgomery County*. Baltimore, MD.

MDE. 2007. *Total Maximum Daily Loads of Fecal Bacteria for the Non-Tidal Rock Creek Basin in Montgomery County, Maryland.* Baltimore, MD: Maryland Department of the Environment.

Schueler, T. 1998. The performance of oil grit separators in removing pollutants at small sites. Technical Note 119. *Watershed Protection Techniques*. 2(4): 539-542. See also Technical Note 120.

URS. 2001. *Rock Creek Watershed Feasibility Study*. Prepared for Montgomery County Department of Environmental Protection. Rockville, MD.

Appendix A – List of High and Low Priority Projects

High and Low Priority Project List - Rock Creek Watershed	
Project Type	**Project Name**
Environmental Site Design (ESD)	Aspen Hill Library Board of Elections Bushy Drive Recreation Center Chevy Chase Library District 2 - Bethesda Police Station Donnybrook Drive Kensington Park Library Noyes Children's Library Station 16 - Silver Spring Station 25 - Kensington Twinbrook Library
New Stormwater Pond	Derwood Industrial Park SWM Mill Creek South Number 4 NIH Pond Suburban Propane (Washington Gas) SWM retro
Stormwater Pond Retrofit	Allegis Health, ED marsh Aspen Hill SC SF construct BB-1 Loehmanns Plaza SF construct BB-2 Randolph Hills SF construct Cashell Manor No. 1, SWM retro Emory Grove No. 2, SWM retrofit Georgian Woods Colony 1 (Site 21) Manor Country Club 2 Metro Park N 1, SWM retro Metro Park N 2, SWM retro Mill Creek South No. 3 SWM retro Mineral Springs, SWM retrofit Norbeck Est SWM retro Old Georgetown Village SWM Silver Spring Ride-on/Brookville Bus Depot Stoneybrook 2 Landscape ED Marsh Tuckerman Lane SWM retro Wheaton Plaza sand filter