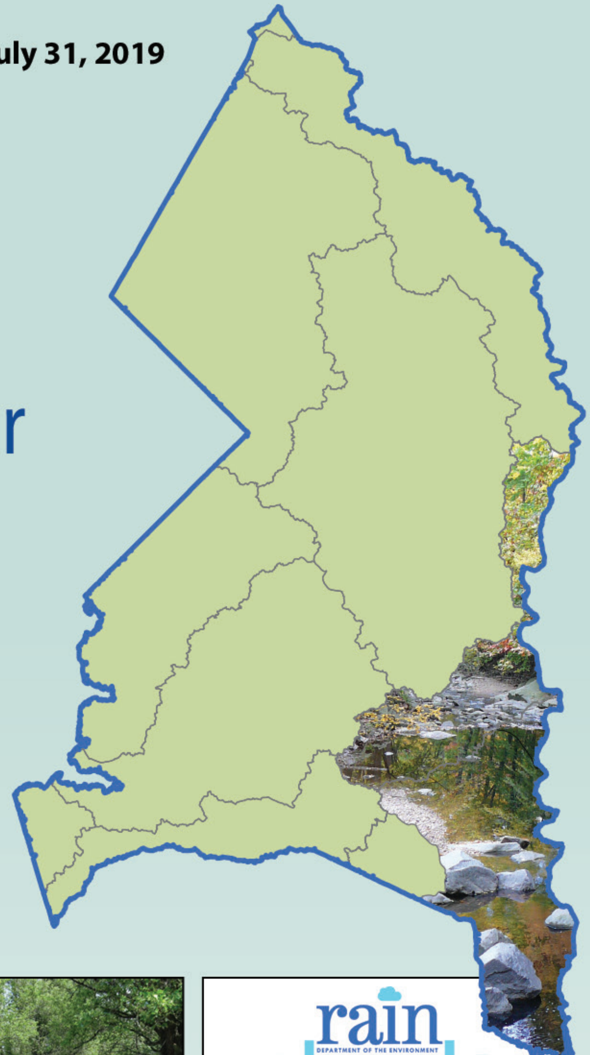
July 31, 2019

Restoration Plan for Nontidal Sediment in the Patuxent River Lower and Middle Watersheds



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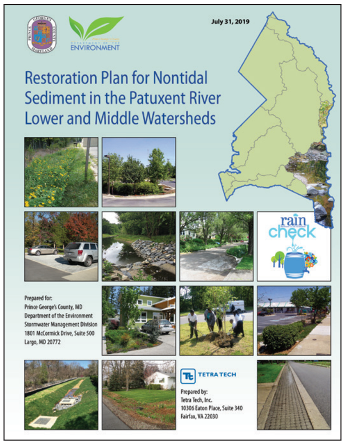

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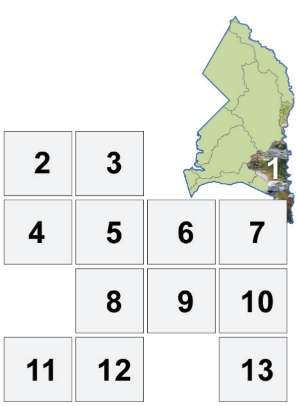

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12. USEPA
13. USEPA

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Abbreviations and Acronyms

°F	degrees Fahrenheit
ac	acre(s)
B-IBI	Benthic Index of Biotic Integrity
BMP	best management practice
BSID	Biological Stressor Identification
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
CIP	Capital Improvement Program
COMAR	Code of Maryland Regulations
COPE	Community Outreach Promoting Empowerment
CWA	Clean Water Act
CWP	Clean Water Partnership
DO	dissolved oxygen
DoE	[Prince George's County] Department of the Environment
DPW&T	Department of Public Works and Transportation
EOS	edge of stream
EPA	U.S. Environmental Protection Agency
ESD	environmental site design
FIBI	Fish Index of Biotic Integrity
GIS	geographic information system
HSG	hydrologic soil group
IBI	Index of Biotic Integrity
IDDE	illicit discharge detection and elimination
LA	load allocation
MBSS	Maryland Biological Stream Survey
MD DNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mg/L	milligrams per liter
M-NCPPC	Maryland-National Capital Park and Planning Commission
MOS	margin of safety
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
PR-L	Patuxent River Lower
PR-M	Patuxent River Middle
R1	Round 1
R2	Round 2

R3	Round 3
R4	Round 4
ROW	Right-of-way
SCA	stream corridor assessment
STORET	STOrage and RETrieval
SWM	Stormwater Management Program
TMDL	total maximum daily load
TS	trash score
TSS	total suspended solids
U.S. (adjective)	United States
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WIP	Watershed Implementation Plan
WLA	wasteload allocation

1 INTRODUCTION

1.1 Background

On January 2, 2014, the Maryland Department of the Environment (MDE) issued Prince George's County (the County) a new municipal separate storm sewer system (MS4) permit. An MS4 is a series of stormwater sewers owned by a municipal entity (e.g., the County) that discharges the conveyed stormwater runoff into a water body (e.g., Patuxent River). The County's 2014 MS4 permit requires the County to develop local restoration plans to address each U.S. Environmental Protection Agency- (EPA-) approved total maximum daily load (TMDL) with stormwater wasteload allocations (WLAs). As a result of the County's MS4 permit, restoration plans are developed for all water bodies in the County that are subject to TMDL WLAs associated with the MS4 system. The County's MS4 system has been assigned WLAs in the Patuxent River Lower (PR-L) and Patuxent River Middle (PR-M) watersheds.

This restoration plan addresses the EPA-approved TMDL for sediment, or "total suspended solids" (TSS), for the nontidal portions (first- through fourth-order streams) of the PR-M and PR-L watersheds. It covers only the County's portions of the watersheds, so that any reference in this document to one of the watersheds refers only to those areas, unless otherwise noted. It was developed in a way similar to the way in which previous plans were developed, following guidance provided in MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2014).

Local TMDL restoration plans were developed in 2014 for the County's portions of the watersheds associated with the Anacostia River (for nutrients, fecal coliform, sediment, polychlorinated biphenyls [PCBs], and trash); Mattawoman Creek (for nutrients); Piscataway Creek (for fecal coliform bacteria); the Upper Patuxent River and Rocky Gorge Reservoir (for phosphorus, sediment, and fecal coliform bacteria); the Western Branch (for the 2010 Chesapeake Bay TMDL); and PCB-impacted water bodies (Anacostia River, Mattawoman Creek, Piscataway Creek, and Potomac River). Those plans are available on the Prince George's County website at http://pgcdoe.net/pgcountyfactsheet/Factsheet/Default#watershed-restoration-plans.

1.1.1 What is a TMDL?

Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning and Management Regulations (codified in Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop TMDLs for impaired water bodies. TMDLs provide the scientific basis on which a state can establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL is a *pollution diet* that establishes the amount of a pollutant a water body can assimilate without exceeding its water quality standard for that pollutant and is represented as a mass per unit of time (e.g., pounds [lbs] per day). The mass per unit time is called the "load." For instance, a TMDL could stipulate that a maximum load of 1,000 lbs of sediment per day could be discharged into an entire stream before the stream experiences any detrimental effects. The

TMDL for a given pollutant and water body is composed of the sum of individual WLAs for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. The following equation illustrates TMDL components:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

where:

TMDL = total maximum daily load
WLAs = wasteload allocations
LAs = load allocations
MOS = margin of safety

Figure 1-1 shows a generalized schematic of a TMDL. The TMDL identifies the maximum amount of pollutant load the water body can receive and still meet applicable water quality criteria. The bar on the left represents the current pollutant load (sometimes called the "baseline") that exists in a water body before a TMDL is developed. The elevated load causes the water body to exceed water quality criteria associated with the water body's officially designated uses. The bar on the right represents the amount by which the pollutant load will need to be reduced for the water body to meet water quality criteria. Another way to convey the required load reduction is by identifying the percent reduction needed. Given the baseline load levels determined for the year 2009 and TMDLs established in 2018, the required sediment load reduction for the PR-L watershed is 61 percent, while, for the PR-M watershed, the required load reduction is 56 percent.

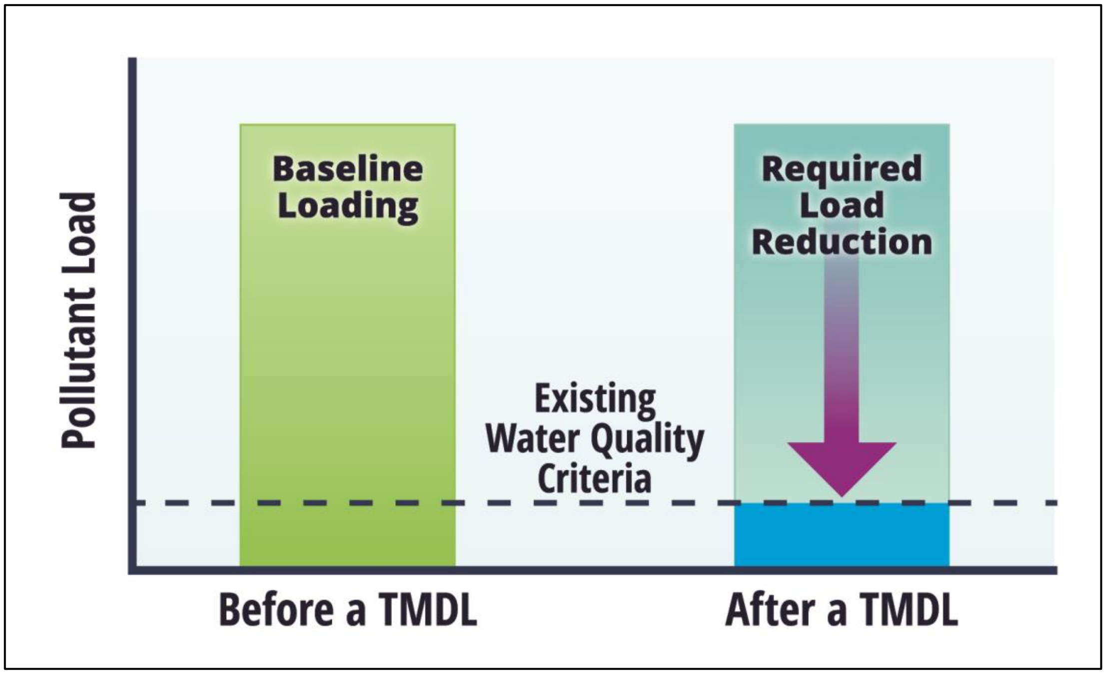


Figure 1-1. Conceptual schematic of a typical pollution diet, or TMDL.

1.1.2 What is a TMDL Restoration Plan?

A TMDL restoration plan is a strategy for managing the natural resources within a geographically defined watershed. For the County's Department of the Environment (DoE), this means managing urban stormwater (i.e., runoff originating from rain storms) to restore and protect the County's water bodies. Stormwater management is most effective when viewed in the watershed context—watersheds are land areas and their network of creeks that convey stormwater runoff to a common body of water. Successful stormwater management consists of both structural practices (e.g., vegetated roadway swale) and public outreach (e.g., pet waste campaigns and education) at both the public and private levels. The process of developing this restoration plan has addressed changes needed in the County's priorities to ensure they comply with water quality regulations, improve the health of the streams in the County, and create value for neighborhoods in the County's watersheds.

The overall goals of restoration planning are to:

- Protect, restore, and enhance habitat in the watershed;
- Restore watershed functions, including hydrology, water quality, and habitat, using a balanced approach that minimizes negative impacts;
- Support compliance with regional, state, and federal regulatory requirements; and
- Increase awareness and stewardship within the watershed, including encouraging policymakers to develop policies that support a healthy watershed.

This document represents the first stage in achieving those goals. It is not meant to be site-level planning, but rather focuses on watershed-based planning. The restoration planning process seeks to:

- Identify causes and sources of pollution,
- Estimate pollutant load reductions,
- Describe management options and identify critical areas,
- Estimate technical and financial assistance needs
- Develop an education component,
- Develop a project schedule,
- Describe interim, measurable milestones,
- Identify indicators to measure progress, and
- Develop a monitoring component.

In short, a restoration plan seeks to create the overall blueprint for restoration activities in a given watershed, allowing water bodies to achieve water quality standards.

1.2 Impaired Water Bodies and TMDLs

MDE has included the PR-L and PR-M watersheds and their tributaries, portions of which are in Prince George's County, on its Section 303(d) list—waters falling in Category 5 of Maryland's Integrated Report of Surface Water Quality—of impaired waters because of the following pollutants (listing year in parentheses) (MDE 2019b):

Patuxent River Lower (PR-L)

- Nontidal sediment in first through fourth order streams (2014)
- PCBs in fish tissue (2008)
- Unknown causes (2006)

Patuxent River Middle (PR-M)

- PCBs in fish tissue (2016)
- Nontidal sediment in first- through fourth-order streams (2014)
- Sulfates (2014)
- Fecal coliform bacteria (2012)
- Unknown causes (2010)

MDE developed TMDLs to address impairments caused by the violation of water quality standards for sediment and PCBs in the PR-L watershed as well as TMDLs for sediment and PCBs in the PR-M watershed (the PCB TMDL is for mesohaline, oligohaline, and tidal fresh segments of the Patuxent River). In addition, EPA developed an overall TMDL for the Chesapeake Bay watershed for nitrogen, phosphorus, and sediment (USEPA 2010). The County has developed a Watershed Implementation Plan (WIP) in response to the Chesapeake Bay TMDL (PGC DER 2012).

1.2.1 Water Quality Standards

Portions of the PR-L and PR-M have the following designated uses (*Code of Maryland Regulations* [COMAR] 26.08.02.08O):

- Use Class I: Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life
- Use Class II: Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (tidal reaches only)

Maryland's General Water Quality Criteria states that:

> …the waters of this State may not be polluted by…any material, including floating debris, oil, grease, scum, sludge and other floating materials attributable to sewage, industrial waste, or other waste in amounts sufficient to be unsightly; produce taste or odor; change the existing color to produce objectionable color for aesthetic purposes; create a nuisance; or interfere directly or indirectly with designated uses (COMAR 26.08.02.03B(2))].

Specific water quality criteria also apply to the specific pollutants addressed in the TMDLs for the PR-L and PR-M watersheds. The Maryland sediment water quality criterion is narrative for nontidal portions of the watershed. For tidal portions, the criterion is based on average Secchi disk depth of equal to or greater than 0.4 meters for the period from April 1 through October 31 of each year. Secchi depth is a measure of the clarity of water. The criterion is meant to protect submerged aquatic vegetation in the tidal portions of the watershed. This plan focuses on addressing the sediment TMDL for the nontidal portions of the watersheds in the County. For sediment impairments, such as the ones discussed in this plan, the water quality standard is based on biological and physical habitat measures relating to the Index of Biotic Integrity (IBI).

1.2.2 Problem Identification

This section provides a summary of the various problems identified in the PR-L and PR-M watersheds and the data supporting the impairment decisions. It was developed using the MDE-developed Biological Stressor Identification (BSID) documents for the respective watersheds (MDE 2013a, 2013b). MDE identified nontidal portions of the PR-L and PR-M watersheds as impaired for TSS, or sediments. Long-term monitoring data collected in both watersheds showed significant negative deviations from reference biological conditions, indicating impacts to biological communities that impair the watershed's ability to support aquatic life and wildlife (support of aquatic life and wildlife must be achieved to meet water quality standards). These 303(d) listings for impairment use a biological assessment methodology, the BSID method, which examines the Benthic Index of Biotic Integrity (B-IBI) and the Fish Index of Biotic Integrity (FIBI). In addition to the IBI data, the TMDL development process also examined physical habitat assessments in the context of epifaunal substrate (surfaces on which aquatic organisms may live), and other in-stream habitat considerations, finding correlated results of these measures with sediment influence in both watersheds.

Patuxent River Lower (PR-L)

MDE identified approximately 43 percent of stream miles in the PR-L watershed for nonattainment of biological water quality standards, demonstrated by 16 out of 34 monitoring locations having a B-IBI and/or FIBI significantly lower than 3.0 (on a scale of 1–5). Those data were collected during the Maryland Biological Stream Survey (MBSS) from the 1995–1997 and 2000–2004 monitoring activities. Further analyses for the purposes of developing this TMDL included all MBSS data from 1995–2009.

Patuxent River Middle (PR-M)

MDE identified approximately 47 percent of stream miles in the PR-M watershed for nonattainment of biological water quality standards, demonstrated by seven out of 17 monitoring locations having a B-IBI and/or FIBI significantly lower than 3.0 (on a scale of 1–5). Those data were collected during MBSS for the 1995–1997 and 2000–2004 monitoring activities. Further analyses for the purposes of developing this TMDL included all MBSS data from 1995–2009. For the PR-M watershed, the BSID additionally estimates that this watershed is also impacted by the presence of other inorganic water quality stressors such as sulfates. This means that, even if requirements to address sediments are met in this watershed, other pollutants might be present that could prevent the watershed from achieving biological metrics of water quality.

1.3 Previous Studies

In 2011, the County developed a countywide Chesapeake Bay WIP in response to the 2010 Chesapeake Bay Nutrient and Sediment TMDL (PGC DER 2012). The WIP was finalized in 2012 and laid out a plan for implementing best management practices (BMPs) and other restoration activities through 2017 and 2025. In addition to urban stormwater runoff, the WIP covered agricultural practices and upgrades to wastewater systems (i.e., municipal wastewater treatment plants and on-site wastewater systems). Although the WIP addresses all the County's land areas, many of its elements apply to the PR-L and PR-M watersheds and have been used to develop the restoration plan.

Bioretention facilities (above) and permeable pavement (right) installed by the Clean Water Partnership as part of the Alternative Compliance Program.

2 WATERSHED CHARACTERIZATION

Five Maryland counties—Anne Arundel, Calvert, Charles, Prince George's, and St. Mary's counties share the PR-L and PR-M watersheds, as shown in Figure 2-1.

The Patuxent River discharges into the Chesapeake Bay near Solomons, MD, and the Patuxent River Naval Air Station in Patuxent River, MD. The PR-L watershed has a drainage area of about 205,500 acres (ac), or 321 square miles, and the PR-M watershed has a drainage area of about 55,200 ac, or 86 square miles, for a total area of 407 square miles.

In the PR-L and PR-M watersheds, water flows through a dense network of streams, of which 227 miles in the PR-L watershed and 185 miles in the PR-M watershed are large enough to be mapped. The Patuxent River main stem—14 miles in the PR-L watershed and 10 miles in the PR-M watershed—is tidal throughout its reach.

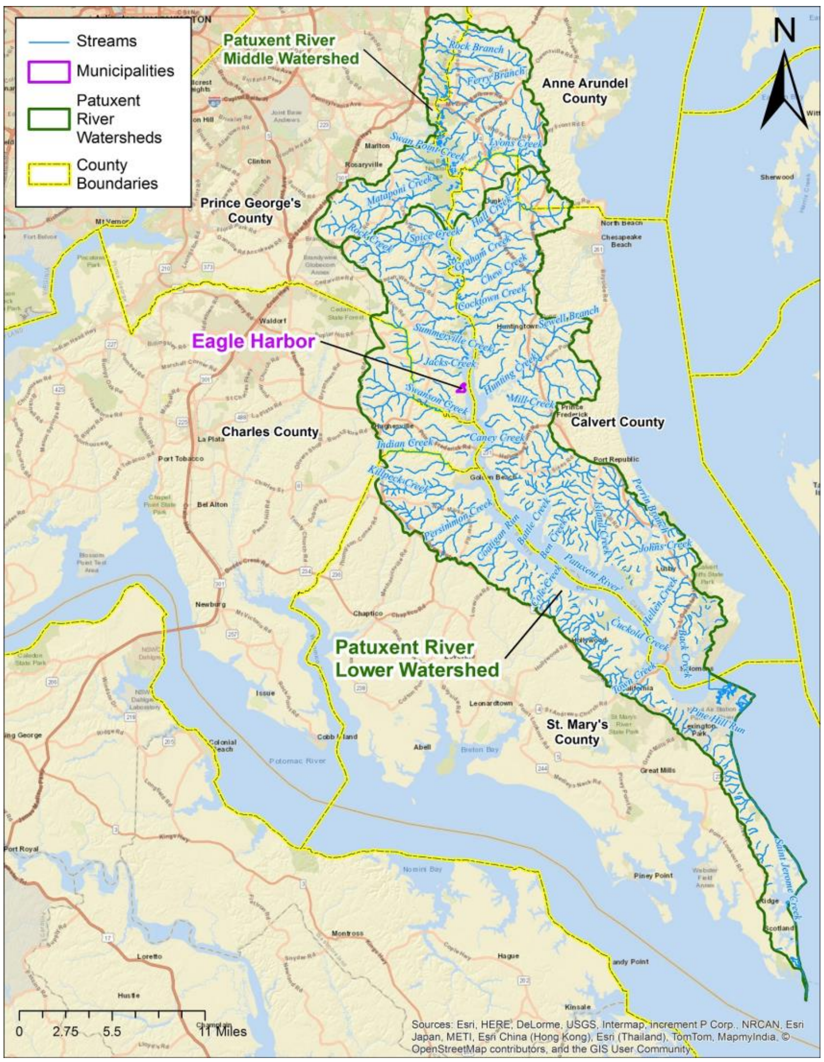


Figure 2-1. Location of the PR-L and PR-M watersheds.

2.1 Physical and Natural Features

2.1.1 Hydrology

The main stem of the Patuxent River in the Lower and Middle watersheds forms the political boundary of Prince George's County. U.S. Geological Survey (USGS) stream gages along the main stem of the PR-L and PR-M reaches are limited, which makes characterizing stream depth and discharge in those areas difficult.

Figure 2-1 shows the entire PR-L and PR-M watersheds, covering portions of multiple counties. In the County, the PR-L and PR-M watersheds are contained in its southeast corner (Figure 2-2). This TMDL restoration plan is specific to the portions of the watersheds in the County.

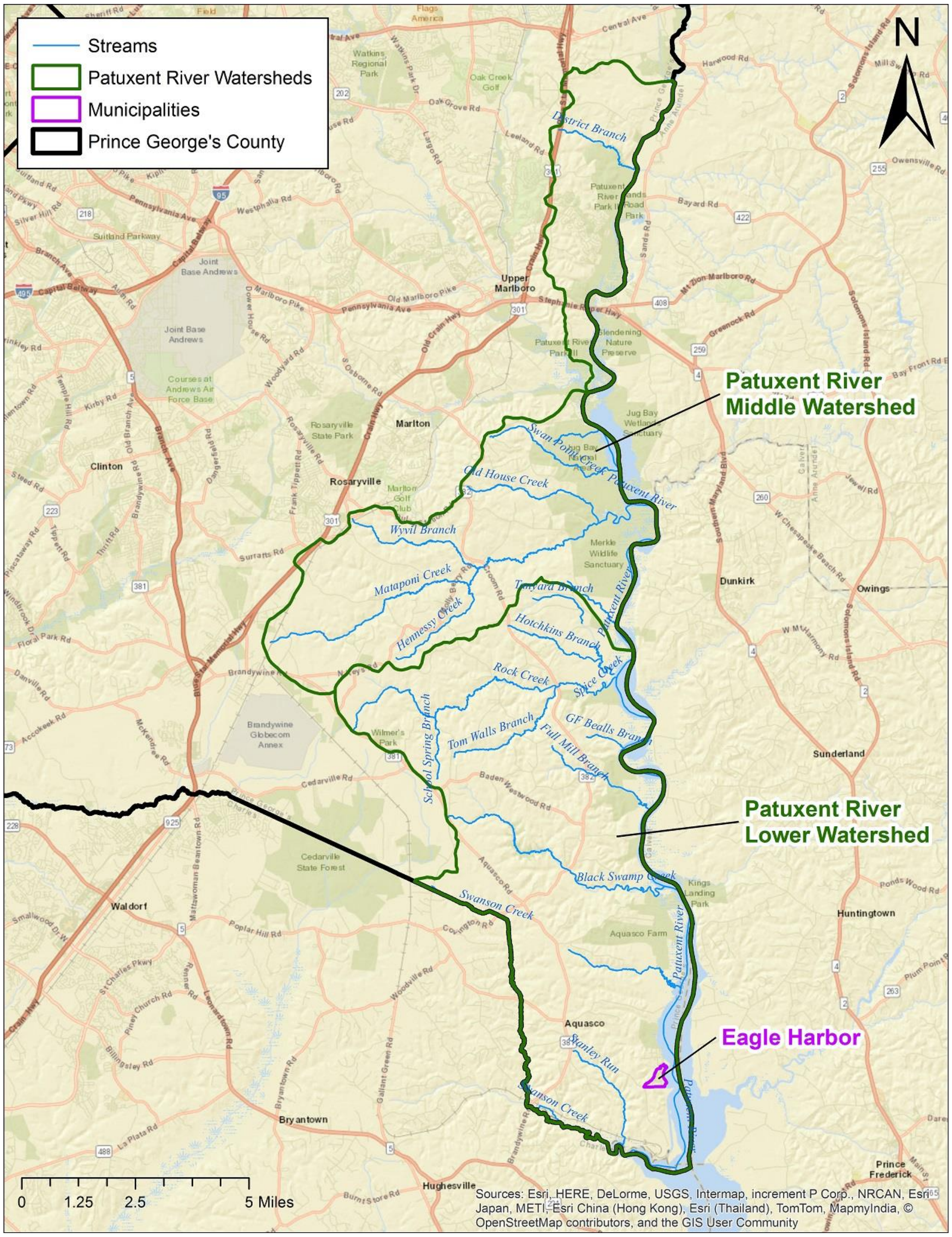
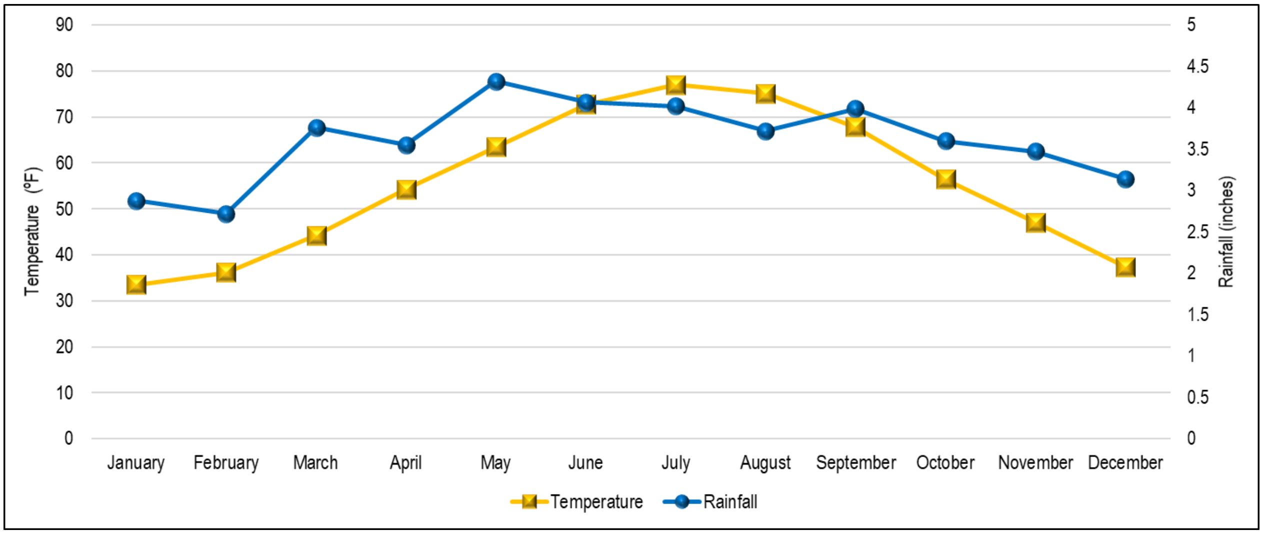


Figure 2-2. Location of PR-L and PR-M watersheds within Prince George's County.

2.1.2 Climate and Precipitation

The climate of the PR-L and PR-M watersheds is characterized as temperate. The National Weather Service Forecast Office reports a 30-year average annual precipitation of 39.74 inches (NWS 2018a). On average, winter is the driest season with 8.48 inches of precipitation, and summer is the wettest season with 10.44 inches (NWS 2018a). Precipitation is highest in late spring to late summer. The average annual temperature is 58.2 degrees Fahrenheit (°F), with the January normal low at 28.6 °F and the July normal high at 88.4 °F (NWS 2018b). Average monthly temperatures range from approximately 33 °F in January to a peak of almost 80 °F in July. The normal monthly precipitation and temperature for Upper Marlboro, the seat of Prince George's County, are presented in Figure 2-3

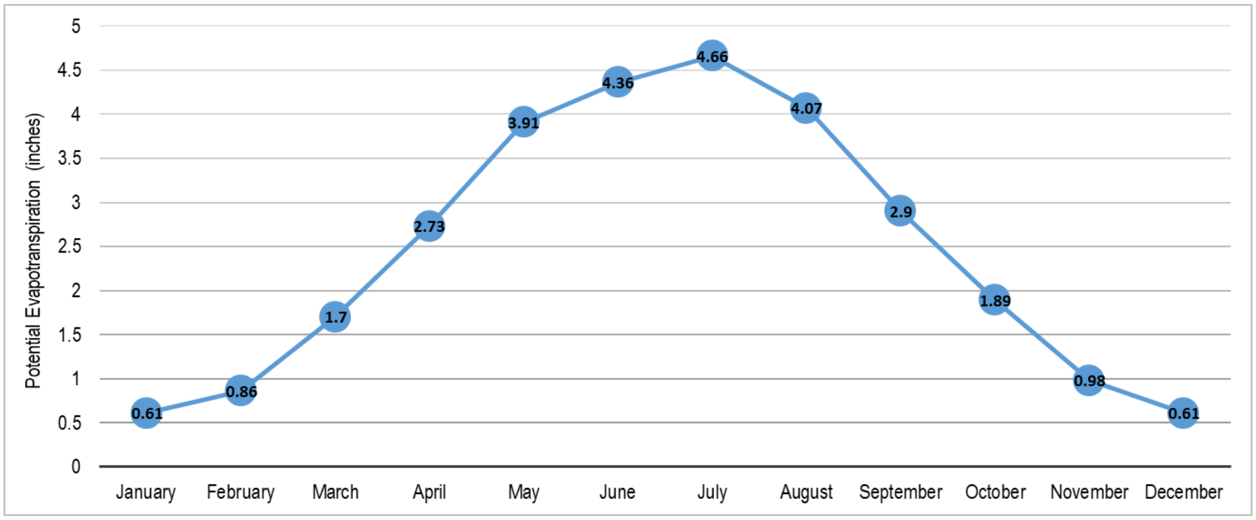


Source: NOAA 2018.

Figure 2-3. Average monthly temperature and precipitation.

Evapotranspiration accounts for water that evaporates from the land surface (including water bodies) and is lost through plant transpiration. The rate of evapotranspiration varies throughout the year based on climate but is highest in the summer. Figure 2-4 presents the "potential evapotranspiration," which is described by NOAA as ""the maximum amount of water that would be evapotranspired if enough water were available (from precipitation and soil moisture)" (NOAA n.d.). Solar radiation, air temperature, vapor pressure, and wind speed affect that amount. Expected rates of evaporation constitute a design consideration for certain BMPs, particularly those with permanent water (e.g., wet ponds) or that rely on moisture-rich soils (e.g., wetlands).

The County is reviewing the potential effects of climate change on resources in the County. Climate change is the result of rising temperatures caused by elevated levels of heat-trapping greenhouse gases such as carbon dioxide in the atmosphere. Rising temperatures are expected to increase and shift in energy distribution in the atmosphere, which could lead to a higher rate of evaporation, higher humidity, higher average rainfall, and more frequent occurrences of heavy rainstorms in some regions and droughts in others (USEPA 2016). Although average annual precipitation in Maryland has increased by approximately 5 percent in the past century, precipitation from extremely heavy events has increased in the eastern United States by more than 25 percent since 1958 (USEPA 2016). The amount and frequency of precipitation is projected to continue increasing, which could lead to more flooding such as past flooding in Upper Marlboro. Average precipitation is expected to increase during winter and spring, which will cause snow to melt earlier and intensify flooding during those seasons. The higher rates of evaporation will also likely result in drier soil during the summer and fall.



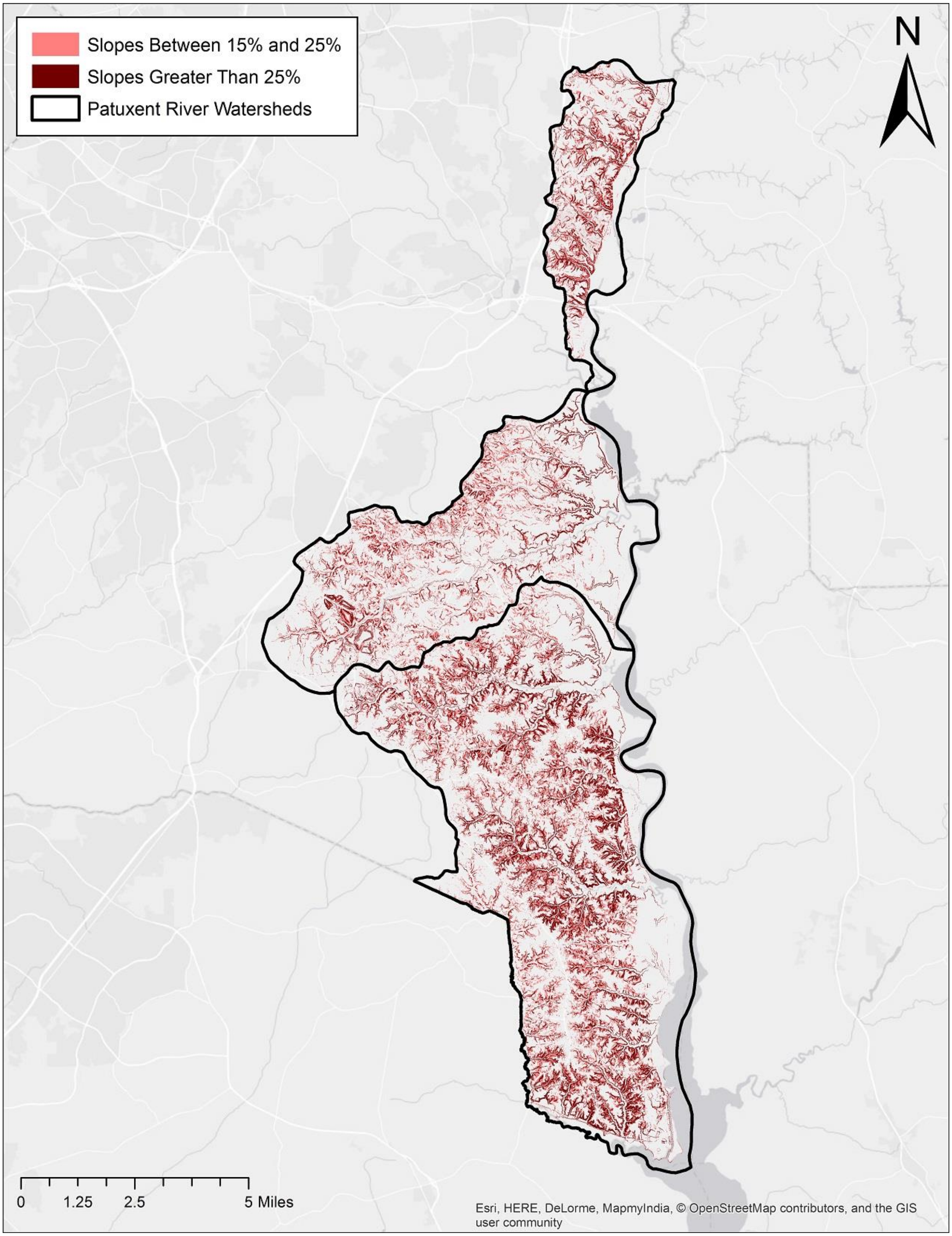
Source: NRCC 2014.

Figure 2-4. Average monthly potential evapotranspiration in inches (1981–2010).

2.1.3 Topography and Elevation

According to the Maryland Geological Survey, the PR-L and PR-M watersheds lie in the Coastal Plain geologic province, which is characterized by gentle slopes and drainage, and deep sedimentary soil complexes (MGS 2014). Figure 2-5 displays land surface slopes in two categories: slopes between 15 percent and 25 percent and slopes greater than 25 percent. This method of mapping results in a depiction of where the steepest areas of the watersheds are, which could give an indication of the variability of speed in overland runoff. That information can help to characterize some of the sediment-influencing capacity of that flow, especially when combined with other relevant information such as soils data.

As illustrated in Figure 2-6, the watershed is relatively flat, especially along the Patuxent River main stem, with higher elevations in the range of 200–250 feet in the western portions of the planning area. Since the landscape tends to have steeper slopes at the higher elevations, streams will flow faster in those areas.



Source: M-NCPPC 2014.

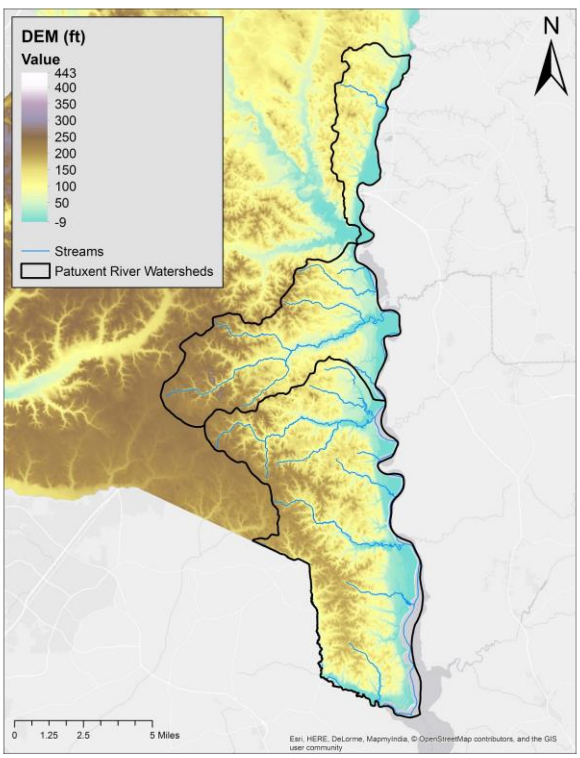
Figure 2-5. Land slopes across PR-L and PR-M watersheds.

2.1.4 Soils

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service has defined four major hydrologic soil groups (HSGs) for categorizing soils by similar infiltration and runoff characteristics: A, B, C, and D (SCS 1974). Poorly drained clay soils (group D) have the lowest infiltration rates, resulting in the highest amount of runoff, while well-drained sandy soils (group A) have high infiltration rates with little runoff; group B and group C soils, in between groups A and D, have respectively moderate levels of infiltration and runoff.

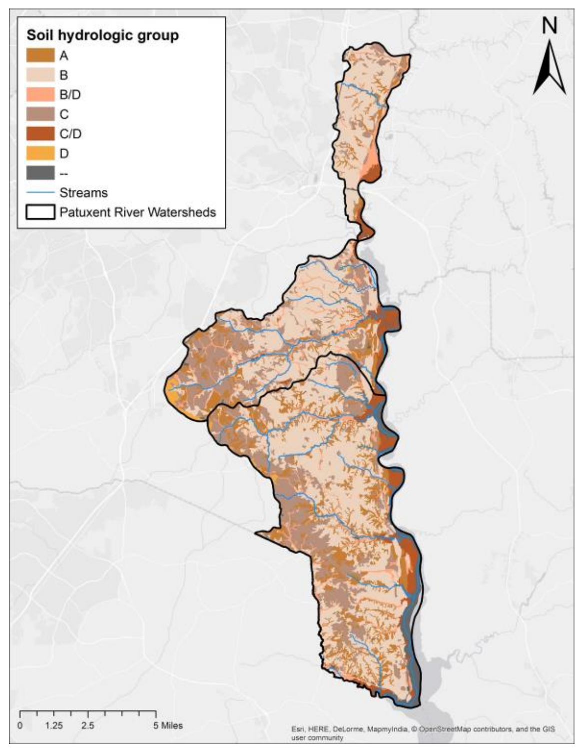
Figure 2-7 shows the locations of the different USDA HSGs across the PR-L and PR-M watersheds (USDA 2003). Soils in groups B and C are the predominant soils in the watershed, while soils in group D are the least common.

Soils in the urbanized portions of the watersheds are frequently also classified as urban land complex, or "udorthent," soils, which have been significantly altered by disturbance from land development activities. Soils affected by urbanization can have a higher density because of compaction occurring during construction activities and might be more poorly drained than other soils.



Source: M-NCPPC 2014.

Figure 2-6. Elevation in the PR-L and PR-M watersheds.



Source: USDA 2003.

Figure 2-7. Hydrologic soil groups in the PR-L and PR-M watersheds.

2.2 Land Use and Land Cover

Land use and land cover are key watershed characteristics that influence the type and amount of pollution entering the County's water bodies.

2.2.1 Land-Use Distribution

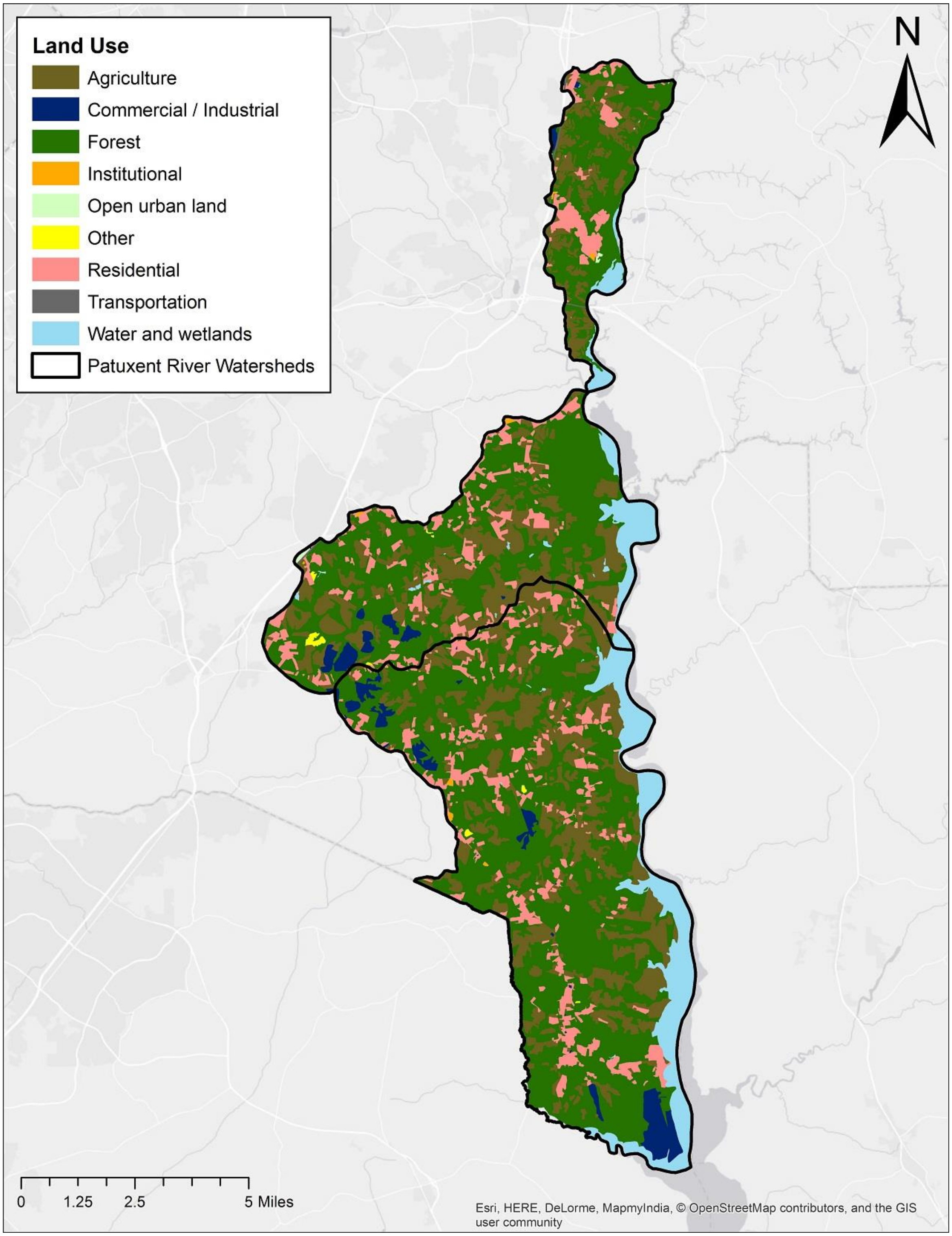
Land-use information for the PR-L and PR-M watersheds is available from the Maryland Department of Planning (MDP) 2010 land-use update (MDP 2010). Different land-use categories (e.g., agriculture, residential) have different types of land cover such as roads, roofs, turf, and tree canopy. Consequently, land use affects how readily stormwater drains from the land and how much pollution it carries. Table 2-1 summarizes the land-use distribution in the PR-L and PR-M planning area by watershed. Figure 2-8 shows land use in the watershed.

Table 2-1. PR-L and PL-M land use by watershed

Land Use	PR-M Watershed (ac)	PR-L Watershed (ac)	Total (ac)	% Total
Agriculture	7,412	6,854	14,266	25.0%
Agricultural building	167	130	297	0.5%
Cropland	4,836	5,355	10,191	17.8%
Feeding operations	68	0	68	0.1%
Large-lot subdivision (agriculture)	822	407	1,229	2.2%
Orchards/vineyards/horticulture	0	54	54	0.1%
Pasture	1,516	742	2,258	4.0%
Row and garden crops	3	166	169	0.3%
Forest	14,434	15,491	29,925	52.4%
Brush	255	159	414	0.7%
Deciduous forest	9,930	5,235	15,165	26.6%
Evergreen forest	196	218	414	0.7%
Large-lot subdivision (forest)	2,020	1,913	3,933	6.9%
Mixed forest	2,033	7,966	9,999	17.5%
Other	73	24	97	0.2%
Bare ground	73	24	97	0.2%
Urban	3,832	3,973	7,805	13.7%
Commercial	17	77	94	0.2%
Extractive	519	342	861	1.5%
High-density residential	10	12	22	0.0%
Industrial	71	555	626	1.1%
Institutional	47	27	74	0.1%
Low-density residential	2,549	2,819	5,368	9.4%
Medium-density residential	525	141	666	1.2%
Open urban land	38	0	38	0.1%
Transportation	56	0	56	0.1%
Water and wetlands	3,814	1,189	5,003	8.8%
Water	2,629	25	2,654	4.6%
Wetlands	1,185	1,164	2,349	4.1%
Total	**29,565**	**27,531**	**57,096**	**100%**

Source: MDP 2010.

Overall, about one-half (52 percent) of the land use in the two watersheds is forested and about one-half of that amount is classified as deciduous forest. There also are significant areas of agricultural land (25 percent) and urban land (14 percent).



Source: MDP 2010.

Figure 2-8. Land use in the Patuxent Lower and Middle watersheds.

This information is useful in the later stages of restoration planning because land use influences the proposed types of water quality control strategies and practices implemented—commonly known as BMPs—and where they can be installed.

Differing land uses and land covers can contribute differing amounts of sediment to a stream based on certain characteristics. Figure 2-9 illustrates where land-use and land-cover data suggest the sources of the highest loads of sediments are located. The highest per-acre sediment loading rates in the watershed are from agricultural and, in more urbanized areas, impervious land use/land cover, which is discussed in more detail in Section 2.2.3.

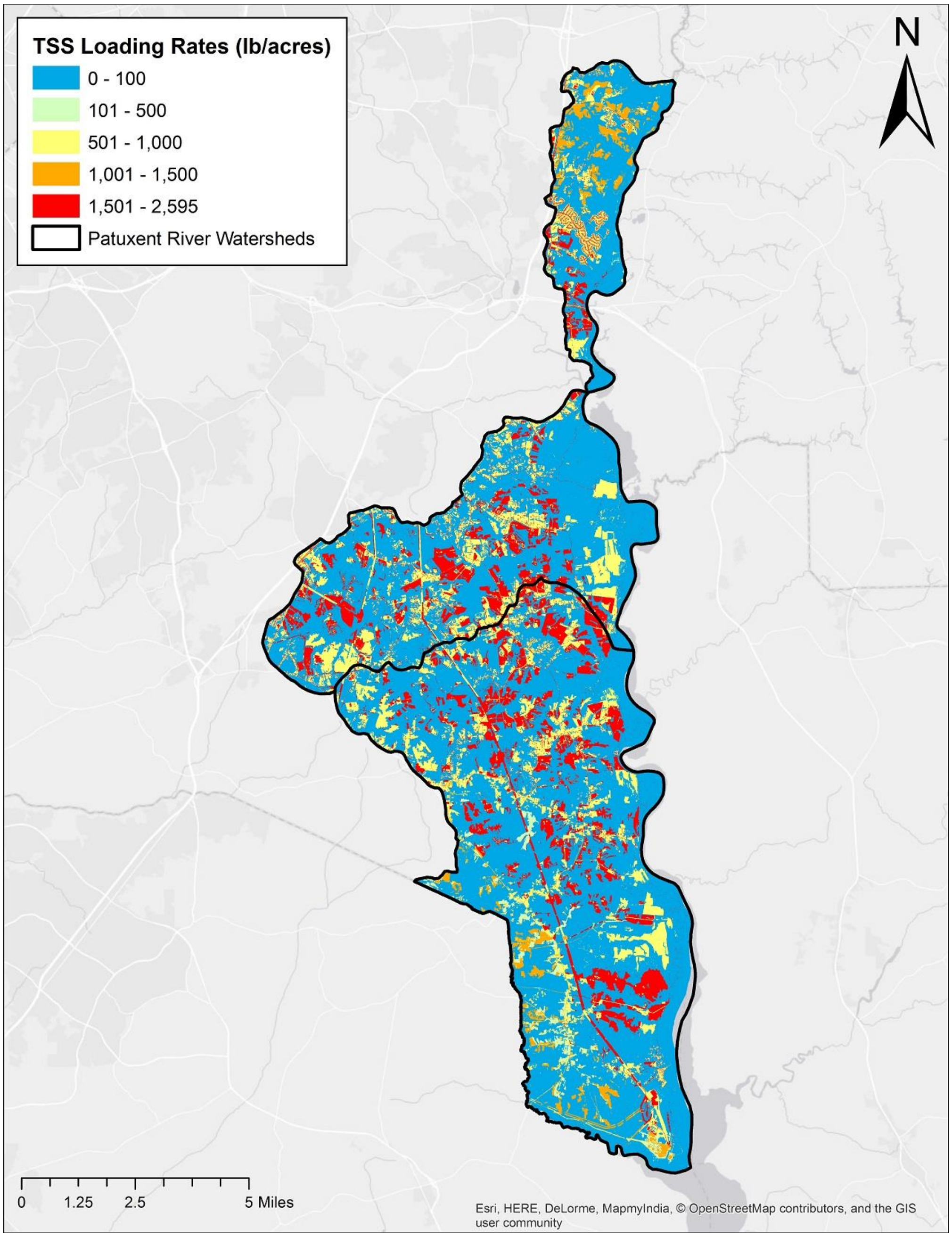


Figure 2-9. Geography of sediment loading rates within the PR-L and PR-M watersheds.

2.2.2 Land Ownership

Overall, the watershed is primarily privately owned, residential land (Figure 2-10). A closer examination of land ownership might occur during more specific restoration planning, as it can sometimes be a simpler solution to implement certain pollutant reduction BMPs on County, or otherwise publicly-owned, lands than on private property. While roadways are usually considered public rights-of-way (ROWs), Figure 2-10 was created using only parcel information, which does not include roadway information.

Figure 2-11 looks specifically at publicly owned lands in the planning area and illustrates that most open public spaces (e.g., parks) are concentrated along or near the main stem of the Patuxent River.

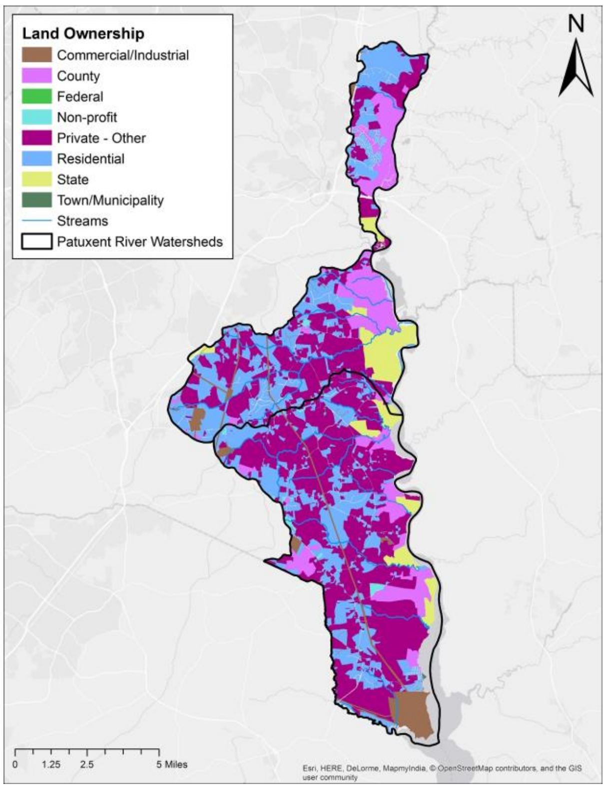


Figure 2-10. Land ownership in the PR-L and PR-M watersheds.

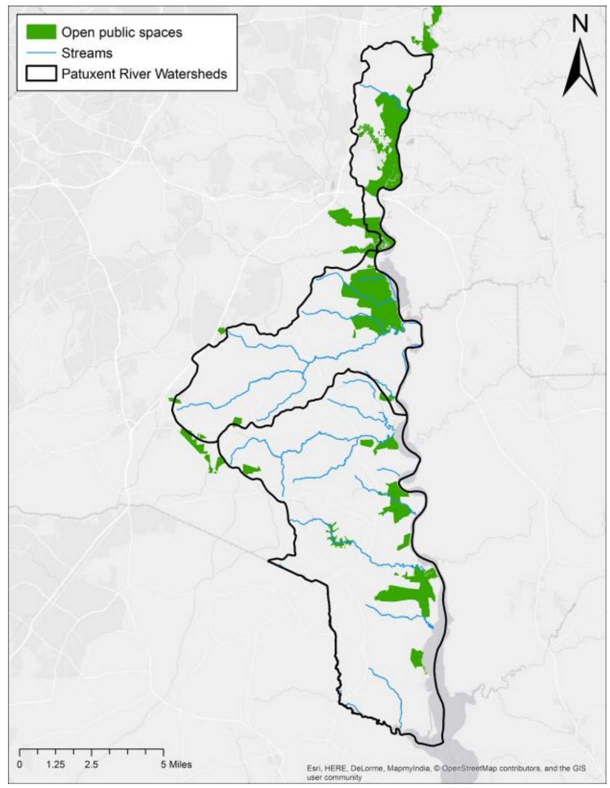


Figure 2-11. Open public spaces within the PR-L and PR-M watersheds.

2.2.3 Imperviousness

Impervious area is land surface that is covered with solid material or compacted to the point at which water cannot infiltrate into underlying soils (e.g., parking lots, roads, houses, patios, swimming pools, and compacted gravel areas). Consequently, land development, which creates impervious areas, affect both the amount and the quality of runoff.

Compared to naturally vegetated areas, impervious areas generally decrease the amount of water infiltrating into groundwater and increase the amount of water flowing to the stream channels in the watershed. This increased surface flow not only carries larger amounts of nutrients and other pollutants, but also increases the velocity of the streams, which worsens erosion. Intensified erosion increases the amount of sediment carried by the water, which can be detrimental not only to the appearance of a stream, but also to its ecological health.

The quality of runoff is affected by the type of impervious area that generates it. For instance, driveways have a higher potential than roofs for nutrient loading to waterways because of the grass clippings and potentially fertilizer that can accidentally be spread on a driveway. Sidewalks have higher bacteria loadings than driveways because of the number of dogs that are walked along sidewalks.

Data from the Maryland-National Capital Park and Planning Commission (M-NCPPC) illustrate significant amounts of forest cover throughout the planning area, with the PR-L watershed having 48–52 percent canopy cover and the PR-M watershed having 52–56 percent canopy cover. M-NCPPC data also shows the PR-L and PR-M watersheds having roughly 0–4 percent of their land surface occupied by impervious land cover as a whole. Figure 2-12 shows locations of impervious land cover, while the types and amounts of impervious land cover are shown in Figure 2-13 for PR-L and Figure 2-14 for PR-M. Higher proportions of impervious land cover might be seen in more developed areas on smaller scales, especially in the form of roadways, parking facilities, and buildings.

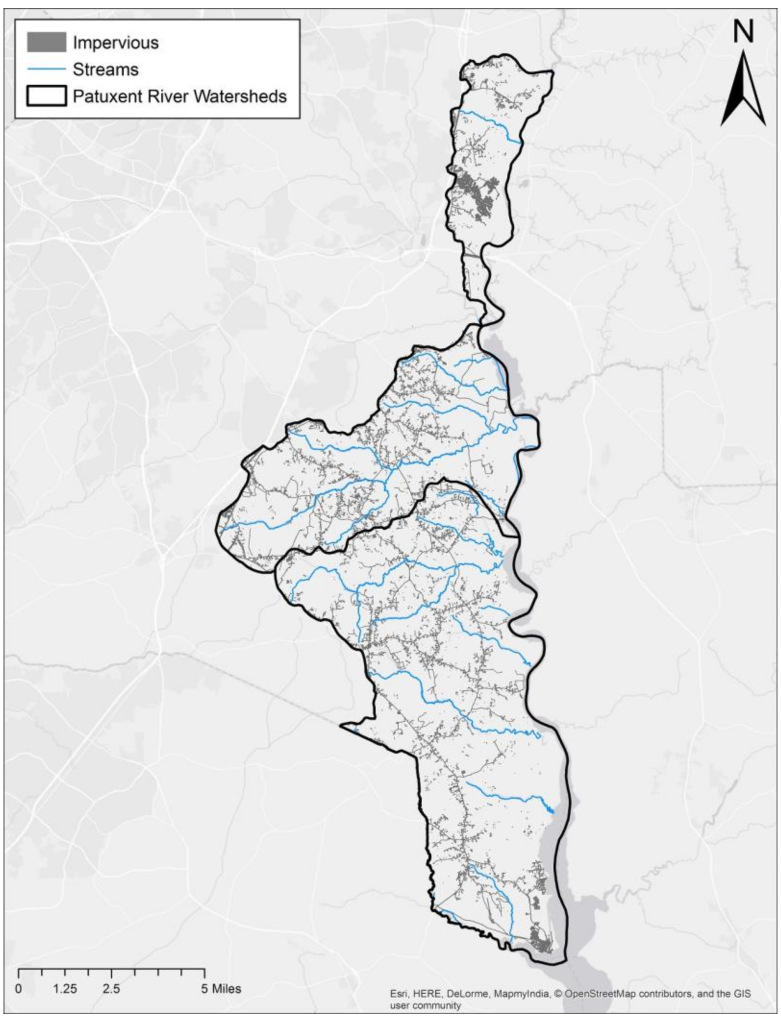


Figure 2-12. Location of impervious cover in the PR-L and PR-M watersheds.

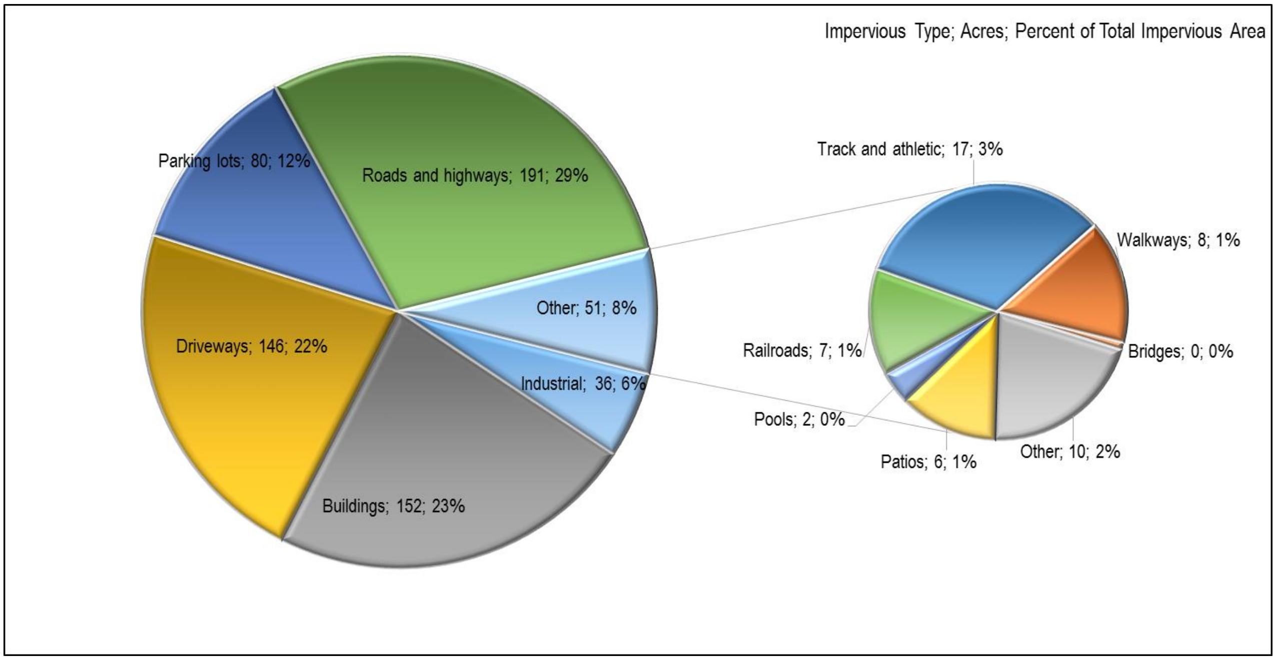


Figure 2-13. PR-L watershed percent of impervious area by type.

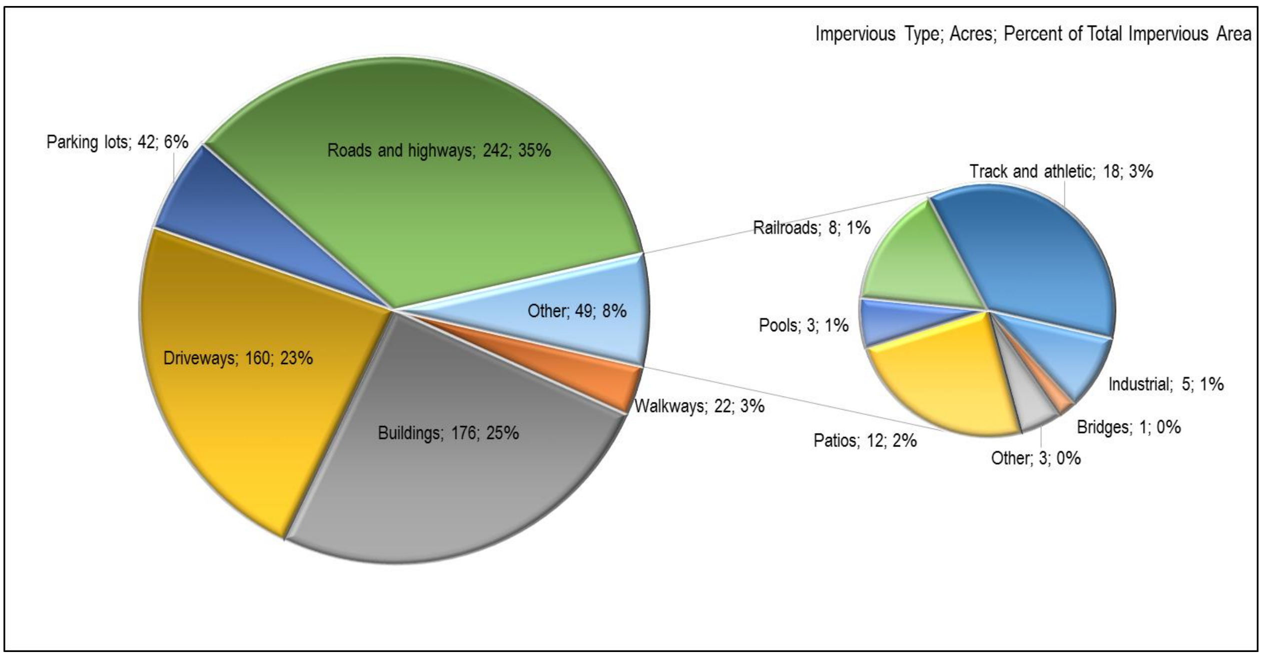


Figure 2-14. PR-M watershed percent of impervious area by type.

3 WATER QUALITY CONDITIONS

Water quality in a body of water is generally described by the different conditions (e.g., chemical, biological) present in it. Understanding those conditions helps to determine whether a water body, and its associated ecosystem, are functioning in a way that is supportive of ecological needs (including human needs). Chemical characteristics of a stream can be examined to determine the amount of certain pollutants such as nutrients and sediment that can be present in the water. Physical characteristics can help identify certain conditions in the stream that water chemistry alone might not be able to distinguish, including the type and severity of stream channel erosion, the condition of the land surface in proximity to the water body, and the presence of trash. Biological characteristics also are central to expressing aspects of water quality, as the ability of a water body to support biological processes can provide strong indicators of water quality issues.

3.1 Water Chemistry Data Assessment

Water quality data were analyzed to assess the degree to which water quality might be improving or worsening in the PR-L and PR-M watersheds. This section includes graphs that present pollutant concentrations over different periods of record. It discusses only water quality stations with water quality data after 1990 and chiefly stations with at least 10 years of data.

3.1.1 Water Chemistry Data Sources

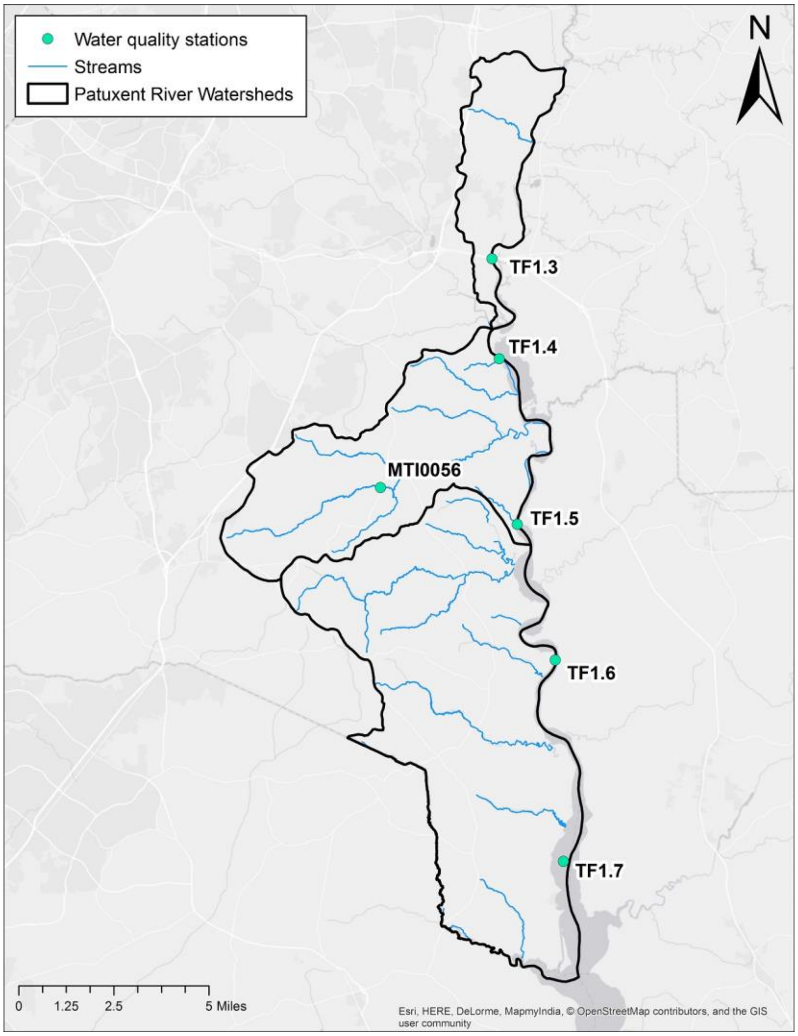
Figure 3-1 shows the locations of the water quality monitoring stations in the two watersheds that provided data used in this report. While this sediment TMDL applies to first- through fourth-order streams, most of the long-term water quality monitoring stations with sediment data in the PR-L and PR-M watersheds are positioned along the main stem. While the data from those monitoring stations were used in developing this plan, the County recognizes that the data from stations along the main stem do not directly measure water quality in the first- through fourth-order streams to which this plan applies.

The following sources had water quality data that are presented in this report:

- EPA’s STORET (STOrage and RETrieval) Data Warehouse.
- The Water Quality Portal. A cooperative service sponsored by USGS, EPA, and the National Water Quality Monitoring Council that provides access to data collected by more than 400 federal, state, local, and tribal agencies.
- MDE data not found in STORET or the Water Quality Portal.

Figure 3-2 and Figure 3-3 show time series for the water quality data for the PR-L and PR-M watersheds, respectively, from these monitoring stations for the periods in Table 3-1.

The scatter in the data points is caused by the complexity of influences in the watersheds. A variety of factors can influence the measured pollutant concentrations at any point in time, including variability in the land cover, the timing of precipitation (or lack of it), and the number of dry days before a rain event. Also complex hydrologic, chemical, and biological interactions occur in the streams that vary with season and flow conditions. Over a period of several years, land-cover changes that might help improve water quality in one location can be offset by changes that tend to decrease water quality in another location.



Source: NWQMC 2018.

Figure 3-1. Locations of water quality monitoring stations in PR-L and PR-M watersheds.

3.1.2 Total Suspended Solids

TSS are small particles, including particles that make up sediment, that water carries and can be captured by a filter. Stream channel erosion is a major source of TSS and tends to worsen because of land development if runoff is not effectively controlled.

Stream channel erosion moves soil particles into the water from both the stream banks and the stream bed. Much of the resulting suspended sediment that is generated during a stormwater runoff event can settle out in deposits as the water slows between events. But those sediments can be lifted into the water the next time the velocity of the stream increases.

Concentrations of TSS tend to increase as a result of land development. The impervious surfaces send more runoff more quickly to local streams, and the higher and faster moving water in the streams tends to increase rates of erosion. The abrasive effect of higher concentrations of suspended sediment can also contribute to accelerating erosion problems.

Table 3-1 and Figure 3-1 show TSS data for the PR-L and PR-M watersheds obtained from six monitoring stations: three in each of the watersheds). Other monitoring stations in the watersheds had no records complete enough for meaningful analysis. TSS concentrations at stations TF1.5, TF1.6, and TF1.7 in the PR-L watershed (Figure 3-2) appear to be decreasing slightly, while increasing slightly at stations TF1.3, TF1.4, and MTI0056 in the PR-M watershed (Figure 3-3). Limited sample size from station MTI0056 (12 records) contributes to the uncertainty of the reliability of this data as the slope of the trend line can be more strongly influenced by extreme values. The trend line slopes are so small it would be difficult to categorize as significant any of the observed changes in TSS concentrations over the full time scale of the dataset.

Table 3-1. Summary of TSS concentration data in the PR-L and PR-M watersheds

Watershed	Station ID	Station Name	Date Min.	Date Max.	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
Patuxent River Lower	TF1.6	TF1.6	1/16/90	2/7/17	383	15.50	50.10	210.67
	TF1.7	TF1.7	1/16/90	2/7/17	383	8.00	36.60	136.43
Patuxent River Middle	TF1.3	TF1.3	1/16/90	2/7/17	381	1.60	18.14	227.00
	TF1.4	TF1.4	1/16/90	2/7/17	382	3.00	25.90	322.00
	TF1.5	TF1.5	1/16/90	11/1/12	318	11.75	44.83	192.13
	MTI0056	MTI0056	1/24/07	12/19/07	12	2.40	6.20	19.00

Note: max. = maximum; mg/L = milligrams per liter; min. = minimum.

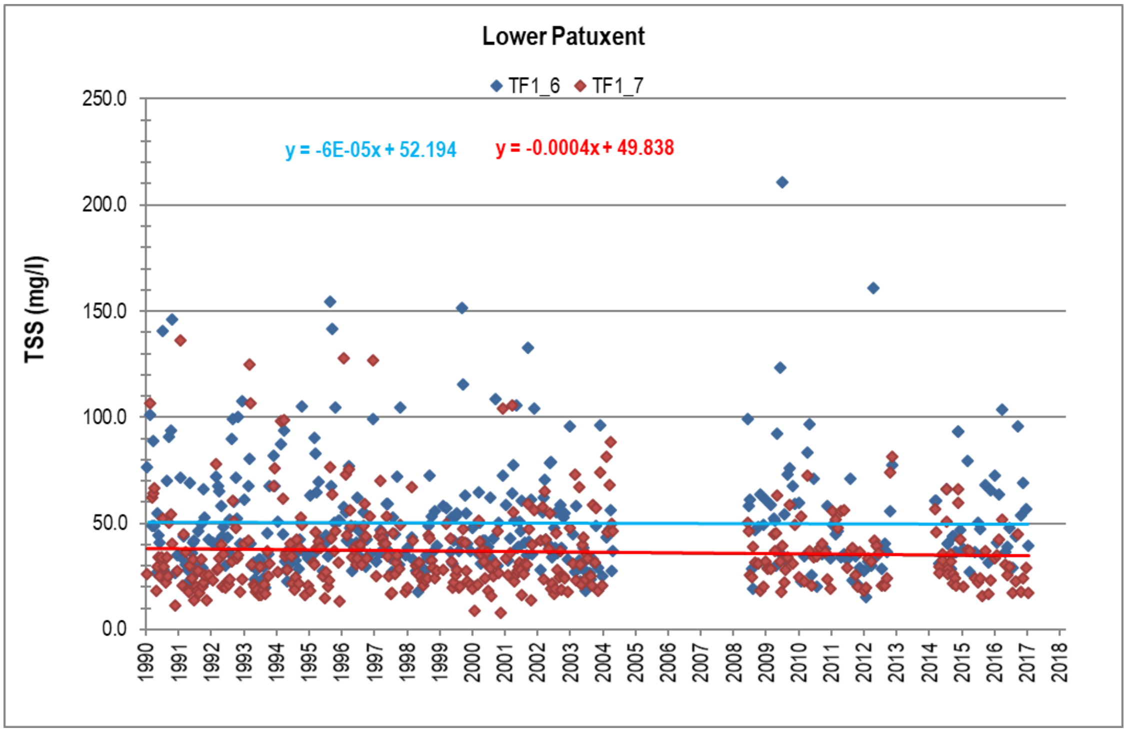


Figure 3-2. Plot of TSS concentrations over time in the PR-L watershed.

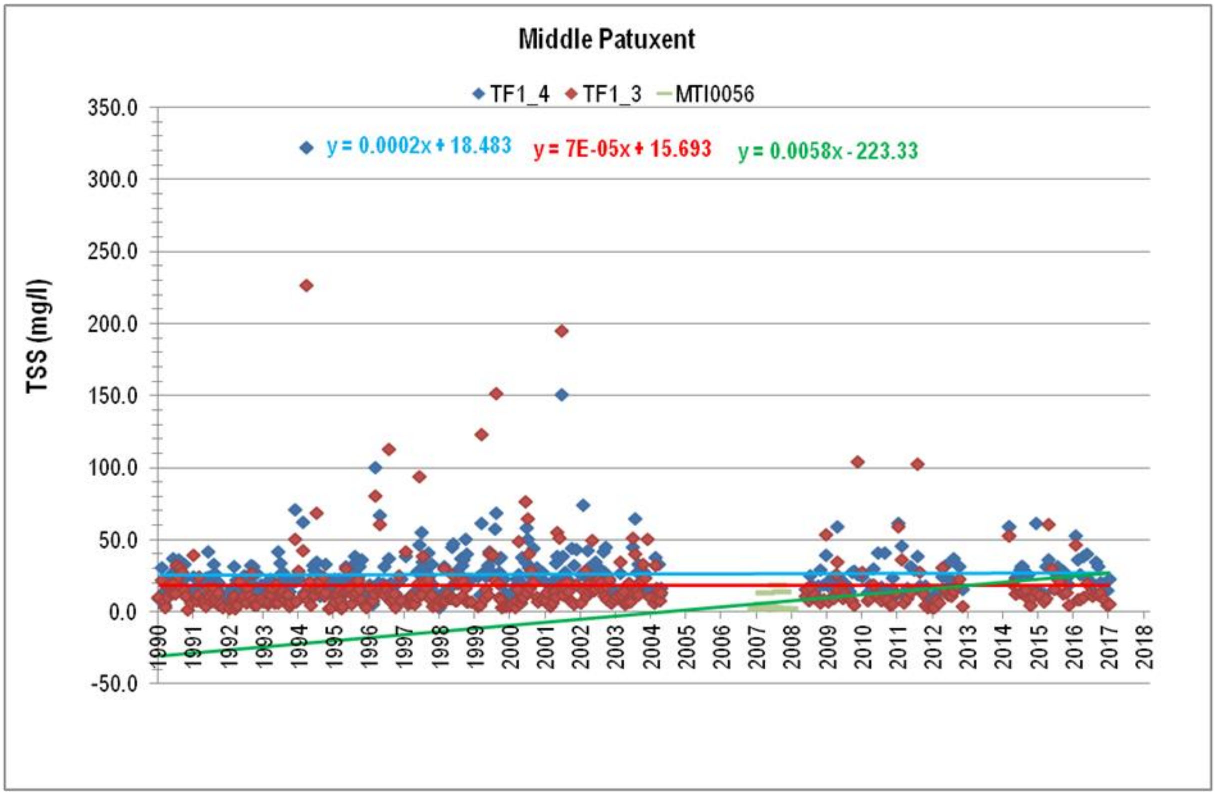


Figure 3-3. Plot of TSS concentrations over time in the PR-M watershed.

3.2 Biological Assessment

Analysis of biological monitoring data provides insights into the status and trends of ecological conditions in a stream and watershed. Watershed planners can use the biological monitoring data to identify problems; document relationships among stressor sources, stressors, and response indicators; and evaluate environmental management activities, including restoration. Especially with a TMDL for sediment that is specific to first- through fourth-order streams, biological monitoring data are central to targeting potential restoration efforts to the areas of the watershed with the greatest need.

3.2.1 Assessment Methodology

DoE began implementing its countywide, watershed-scale biological monitoring and assessment program in 1996. To date, the department has assessed more than 79 stream locations in the PR-L watershed, and 69 locations in the PR-M watershed through three rounds of data gathering: Round 1 (R1) assessed 59 sites between 1996 and 2002, Round 2 (R2) assessed 44 sites from 2011 to 2013, and Round 3 (R3) assessed 48 sites between 2015 and 2017. The primary measure of stream health is the B-IBI (Southerland et al. 2007). Because different stream conditions support different types of bottom-dwelling, or "benthic," organisms, analyzing those organisms collected along a stream reach can provide a good indication of the health of that reach.

Field sampling and data analysis protocols employed by the County for the program are comparable to the protocols used by the Maryland Department of Natural Resources (MD DNR) in the MBSS. Streams assessed are wadeable and generally first- through third-order according to the Strahler Stream Order system (Strahler 1957). Stream order designation is based on the

National Hydrography Dataset map scale of 1:100,000. The number of streams sampled in each watershed is proportional to the size of the watershed and is allocated among first- to third-order streams, with a larger number of sites sampled on smaller first-order streams. Samples and data collected at each location include benthic macroinvertebrates, visual-based physical habitat quality, substrate particle size distribution, and field chemistry (dissolved oxygen [DO], conductivity, pH, and water temperature).

For the County's biological monitoring assessment, the team sampled a 100-meter reach at each selected site. Laboratory technicians identified them each to a target taxonomic level, usually genus. The number of different kinds of organisms found was used to calculate the B-IBI numeric value or score. Based on that score, biological integrity was rated as Good, Fair, Poor, or Very Poor. Stream reaches rated as Poor or Very Poor are considered degraded. Physical habitat quality scores were rated as Optimal, Suboptimal, Marginal, or Poor, based on cumulative scores along a 200-point scale; numeric values for dominant substrate particle sizes, and field chemistry measures are reported in the next section.

3.2.2 Biological Assessment Results

The biological data reveal that the PR-L and PR-M watersheds consistently had low-to-moderate levels of degradation through the three assessment rounds, as illustrated in Figure 3-4. The narrative ratings for the biological assessment by monitoring location for R1, R2, and R3 in the PR-L and PR-M watersheds are depicted in Figure 3-5. A significant number of sites in the PR-L watershed were rated as Good or Fair, with only a few being rated as degraded (Poor or Very Poor). The data for the PR-M watershed were more mixed, with most sites being rated as Fair. Very few sites in the PR-M watershed were described as Very Poor.

These results could reflect the relatively low levels of impervious cover throughout the two watersheds at less than 4 percent, and yet still experiencing strong impacts to water quality on more localized scales. The narrative results of the biological assessment can be seen in Figure 3-6, where the PR-L watershed has more areas rated as Good than the PR-M watershed, which has more areas rated as Poor to Fair.

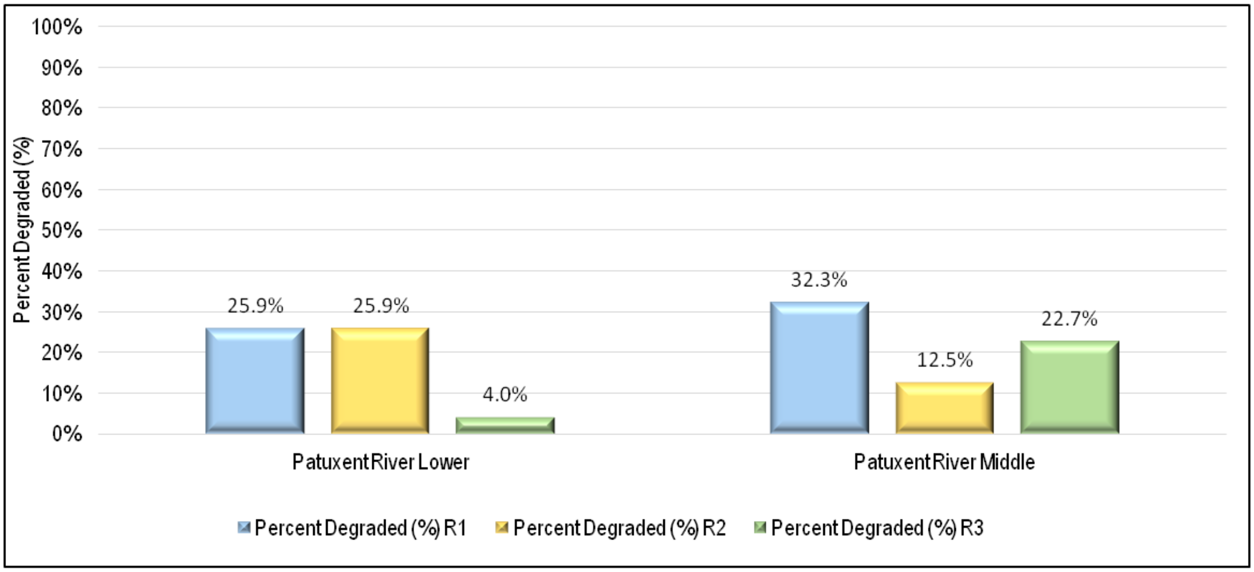


Figure 3-4. PR-L and PR-M percent degraded by sampling round.

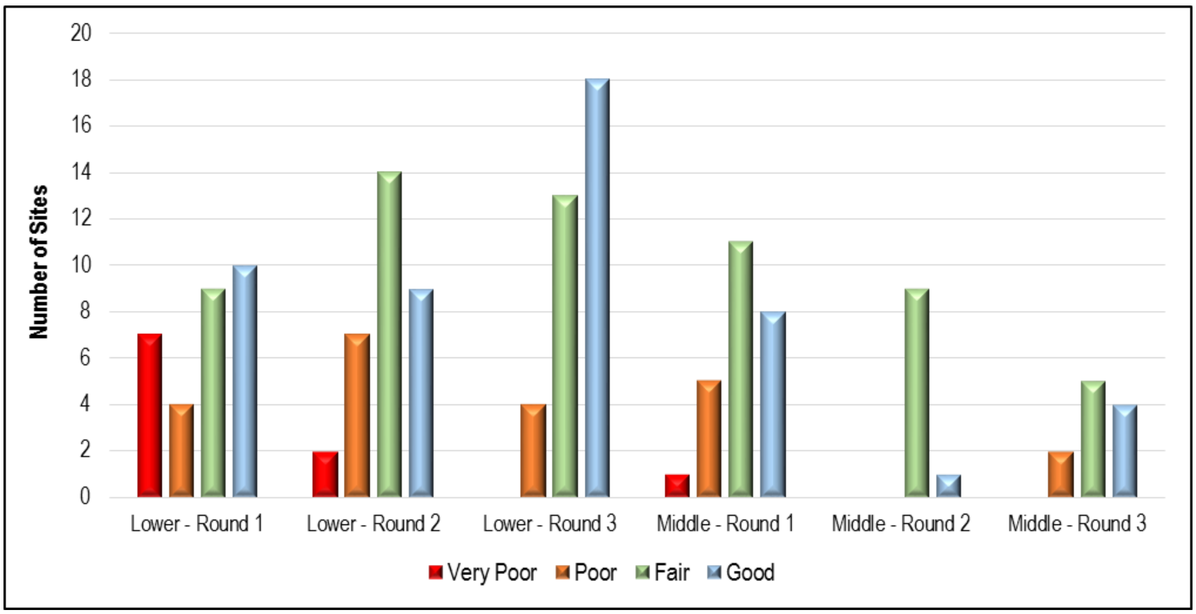


Figure 3-5. B-IBI narrative results by watershed.

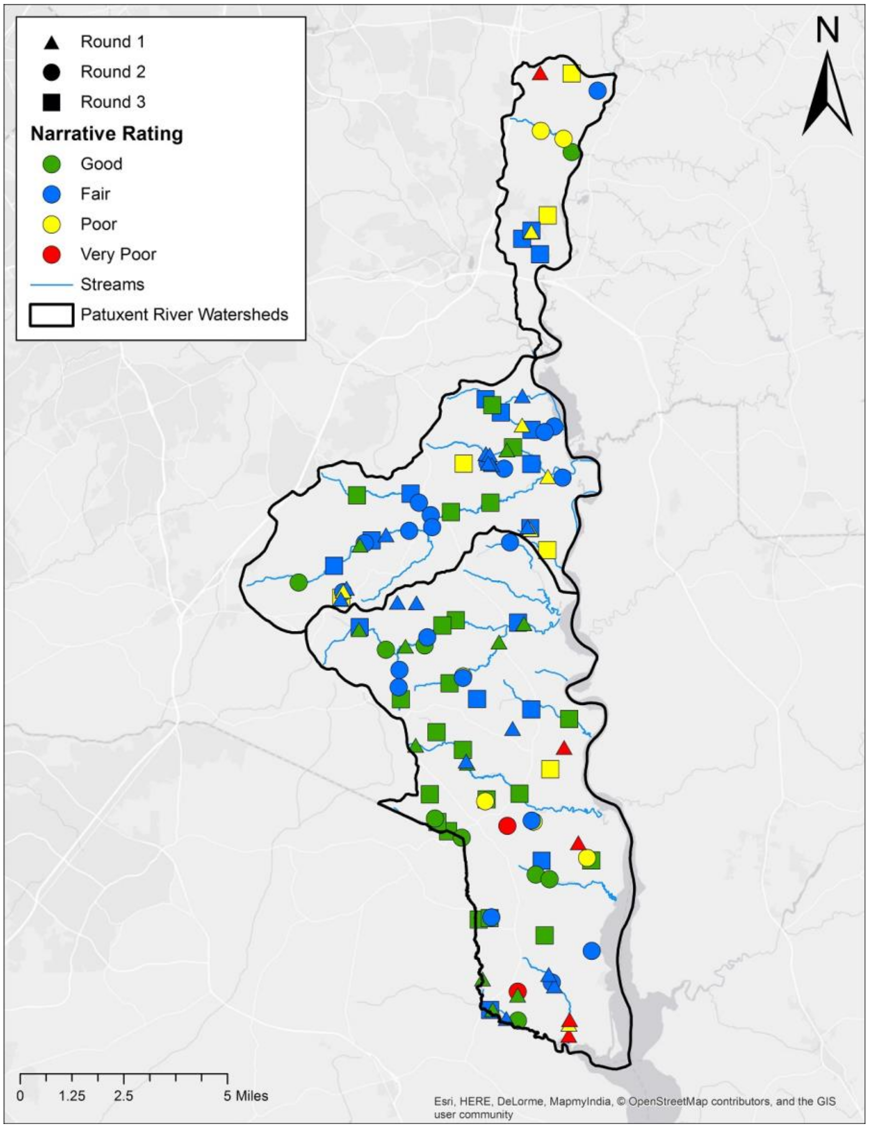


Figure 3-6. Biological assessment narrative ratings by monitoring location.

3.3 Trash Assessment

3.3.1 Trash Rating Protocol

Digital photographs taken during biological assessments can be used to assess the magnitude of trash at the sampling locations. Photographs from 133 stream sites in the watershed were evaluated for the presence of trash. A minimum of four photographs was taken of each sampled reach during biological monitoring, capturing upstream, downstream, left bank, and right bank views of the location—effectively providing a 360-degree view.

The photographs document several features pertaining to the stream conditions, including channel stability, riparian vegetation, visible flow characteristics (e.g., smooth or turbulent), and the presence of solid trash. The types of trash observed ranged from paper or small plastic items to shopping carts, tires, discarded building materials, and dislodged corrugated sewer pipes or culverts. Although the smaller items might not be visible in the photos because of their size or the water depth, the diversity, magnitude, and abundance of stream trash are often apparent. A simple rating scale, or “trash score” (TS), was used to represent the amount of trash visible in each photograph (Table 3-2).

Table 3-2. Rating criteria for the magnitude of trash in streams

Trash Score	Trash Score Narrative	Number of Trash Items
0	No trash	None
1	Light trash	1–5
2	Moderate trash	6–10
3	Abundant/heavy trash	> 10

Figure 3-7 shows four photographs that each illustrates one of the levels in the TS rating scale. After each photo from a site was rated, an aggregate score for all the photos taken at the site was calculated. If four photos were taken of a site, the scores were simply totaled. If more than four photos were taken, the scores were averaged and multiplied by 4. Consequently, the TS for a single site could range from 0 (no trash) to 12 (heavy trash).

3.3.2 Trash Assessment Results

Figure 3-8 provides a map of the assessment locations, showing the TS for each one. Most of the trash items observed were small enough that they could easily have been transported via stormwater conveyances. Occasionally, it was obvious that materials were discarded for convenience (e.g., rusty barrels, and a large pile of bricks and lumber). Of the 144 sites that were evaluated in the PR-L and PR-M watersheds, 112 sites (78 percent) showed no visible evidence of trash. The mean score of 0.5 shows that most of the watershed sites had little to no trash. Table 3-3 summarizes the overall findings.

Figure 3-7. Photographs illustrating different amounts of trash and the corresponding TS.

Table 3-3. TS statistics and percent of sites with no visible trash

Number of Sites	Trash Score Statistics			Sites with No Visible Trash	
	Minimum	Mean	Maximum	Number	Percent
144	0	0.5	11	112	78%

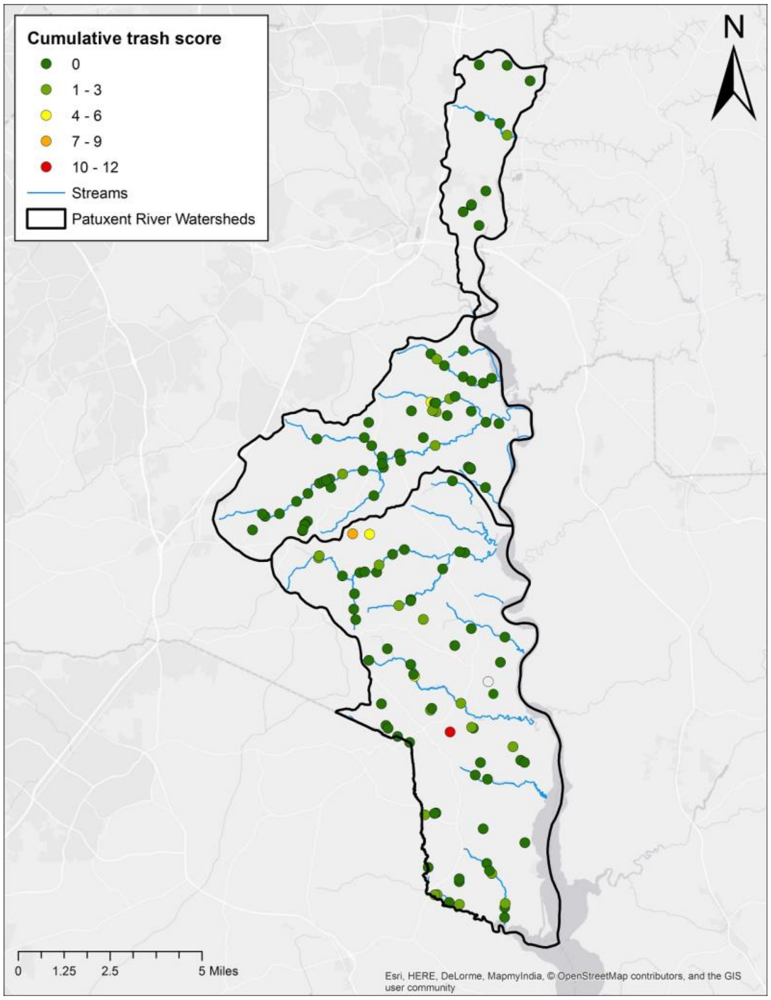


Figure 3-8. Magnitude and intensity of trash occurrences.

Permeable pavement is one way to treat runoff from impervious parking lots.

4 WATERSHED CONDITIONS

This section focuses on the main permitted and nonpermitted pollutant sources in the watersheds and how pollution-generating land-uses are regulated. It also discusses the results of previously conducted stream corridor assessments (SCAs).

4.1 Pollutant Sources

This section provides an assessment of the potential point and nonpoint pollutant sources in the watersheds. Point sources discharge effluent through distinct points that are regulated through permits from the National Pollutant Discharge Elimination System (NPDES) program. Nonpoint sources are not covered by the permitting program because they are diffuse sources that typically cannot be identified as entering a water body through a discrete conveyance at one location. Nonpoint sources can originate from land activities that contribute pollutants to surface water from rainfall runoff. Identifying the sources of sediments is valuable in developing appropriate strategies to reduce the amount of those pollutants getting into the environment.

4.1.1 NPDES-Permitted Point Sources

Under 40 CFR § 122.2, a “point source” is described as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The NPDES program, established under CWA sections 318, 402, and 405, requires permits to be issued for the discharge of pollutants from point sources, including MS4s.

Stormwater discharges are generated by runoff from urban land and impervious areas such as paved streets, parking lots, and rooftops during precipitation events. Those discharges often contain high concentrations of pollutants that can eventually enter nearby water bodies.

Under the NPDES stormwater program, operators of large, medium, and regulated small MS4s must obtain authorization from MDE to discharge pollutants. The Stormwater Phase I Rule requires all operators of medium and large MS4s to obtain NPDES permits and develop stormwater management programs (55 FR 47990, November 16, 1990). Medium and large MS4s are defined by the size of the population in the MS4 service area, not including the population served by combined sewer systems. A medium MS4 serves a population of between 100,000 and 249,999. A large MS4 serves a population of 250,000 or more. The Stormwater Phase II Rule applies to operators of regulated small MS4s serving a population of less than 100,000 not already covered by Phase I; however, the Phase II Rule is more flexible and allows greater variability of regulated entities than the Phase I Rule (64 FR 68722, December 8, 1999).

Regulated small MS4s include those within the boundaries of urbanized areas as defined by the U.S. Census Bureau and those designated by the NPDES permitting authority. The NPDES permitting authority can designate a small MS4 as requiring regulation under any of the following circumstances: the MS4’s discharges do or can negatively affect water quality; the population served exceeds 10,000; the population density is at least 1,000 people per square mile; and the contribution of pollutant loadings to a physically interconnected MS4 is evident. The Phase II MS4 in the PR-L and PR-M watersheds serves the mostly rural southeastern portions of the County. The municipality of Eagle Harbor, in the PR-L watershed, is a separate jurisdiction although it is covered by the County’s MS4 permit.

Table 4-1 lists the federal, state, and other entities in the PR-L and PR-M watershed planning area that possess an MS4 permit. Figure 4-1 displays the regulatory status of lands in the PR-L and PR-M watersheds.

Table 4-1. Phase II MS4 permitted federal, state, and other entities in the PR-L and PR-M watersheds

Watershed	Agency	Installation/Facility
Patuxent River Lower	U.S. Federal Government; Federal Aviation Administration; General Services Administration	Cluster of federal lands in vicinity of 13205 Croom Road, Upper Marlboro, MD
Patuxent River Middle	U.S. Federal Government	Small parcel adjacent to Mount Calvert Road ROW 0.4 miles west of Duvall Road, Marlboro, MD

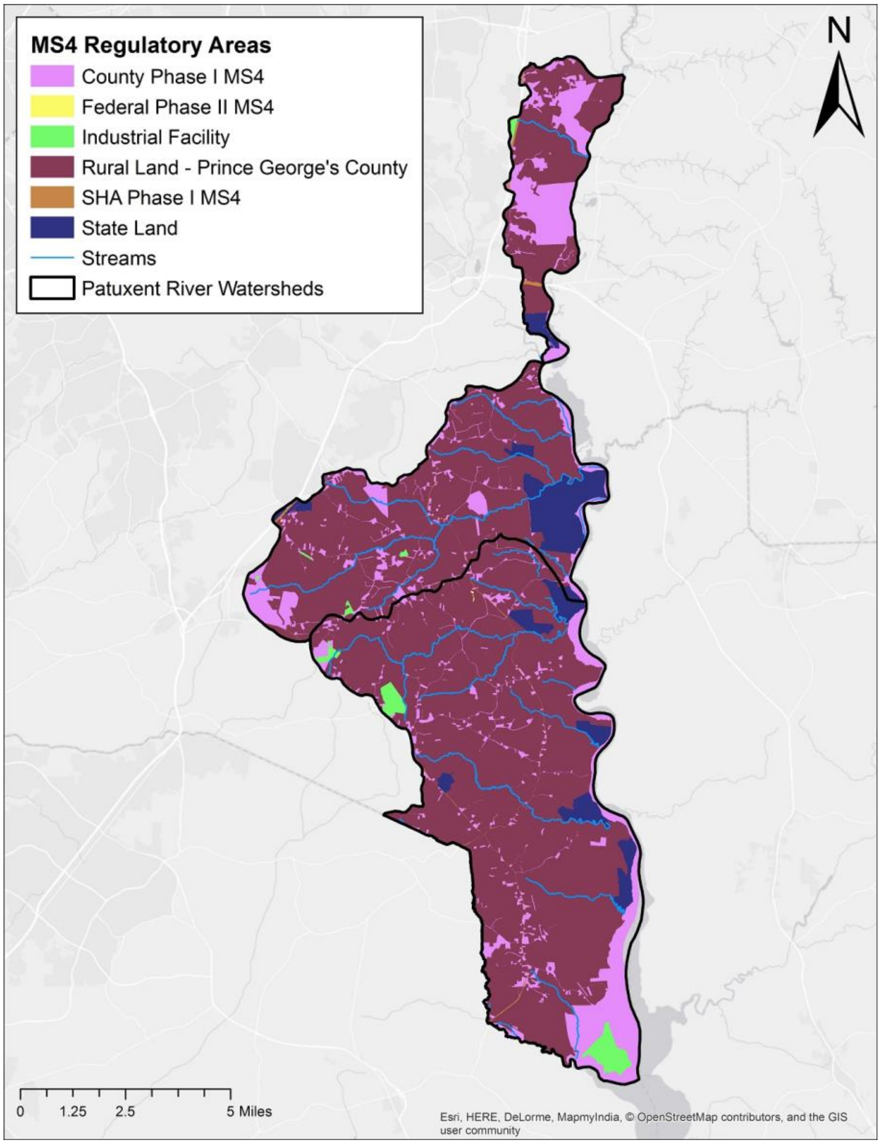


Figure 4-1. MS4 regulated areas in the PR-L and PR-M watersheds.

4.1.2 Nonpoint and Other Sources

Nonpoint sources convey pollutants from rainfall runoff (in nonurban areas) and other landscape-dependent processes that contribute sediment, organic matter, and nutrient loads to surface waters. They vary greatly and include agriculture-related activities, atmospheric deposition, on-site treatment systems, stream bank erosion, wildlife, and unknown sources.

Nonpoint sources of pollution from agricultural activities include the runoff of fertilizers and exposed soils from crop fields as well as waste from animal operations. Agricultural activities are regulated by the Maryland Department of Agriculture and are outside the jurisdiction of DoE. Consequently, the PR-L and PR-M watershed restoration plan does not include restoration activities for agricultural practices.

Two types of atmospheric deposition can occur: wet deposition and dry deposition. Wet deposition occurs through rain, fog, and snow, and dry deposition occurs from gases and particles. After the particles and gases have been deposited, precipitation can wash them into streams from trees, roofs, and other surfaces. Winds can blow the particles and gases, contributing to atmospheric deposition over great distances, including across state and other political boundaries.

On-site wastewater treatment systems (e.g., septic systems) contribute excess nitrogen to streams through leaks and groundwater flow. Since septic systems are regulated by the County Department of Health, this watershed restoration plan does not include restoration activities related to leaking septic systems.

Development in the watershed has altered the landscape from pre-settlement conditions, which included grassland and forest, to post-settlement conditions, which include cropland, pasture, and urban/suburban areas. This conversion has led to increased runoff and flow into streams as well as streambank erosion and straightening of meandering streams. The increased erosion not only increases sediment loading to water bodies but also increases loadings of nutrients that are adsorbed to sediment particles.

Streams and rivers also can be vulnerable to nutrient inputs from wildlife. Wild animals with direct access to streams include deer, raccoons, other small mammals, and avian species. This access to streams contributes bacteria and nitrogen to water bodies.

4.2 Known Stream Erosion Issues

In the 2000s, MD DNR conducted SCAs of all County watersheds. The assessments included field site visits and stream walks to determine the conditions of the streams. Each site was given an identification number and photographed. Stream bank erosion and head cutting were among the items investigated during the analysis. Stream reaches were rated on severity of erosion, correctability, and access to the stream. Additionally, pipe outfalls were investigated and rated on severity of issue, correctability, and access. If a stream or outfall had erosion issues in the 2000s, it is likely to still have them today if no corrective actions have been taken.

The severe erosion sites were scattered throughout the watersheds (Figure 4-2). The most severely eroded stream reaches were identified in the PR-M watershed, perhaps from being in closer proximity to regional urban centers to the north and west of the planning area.

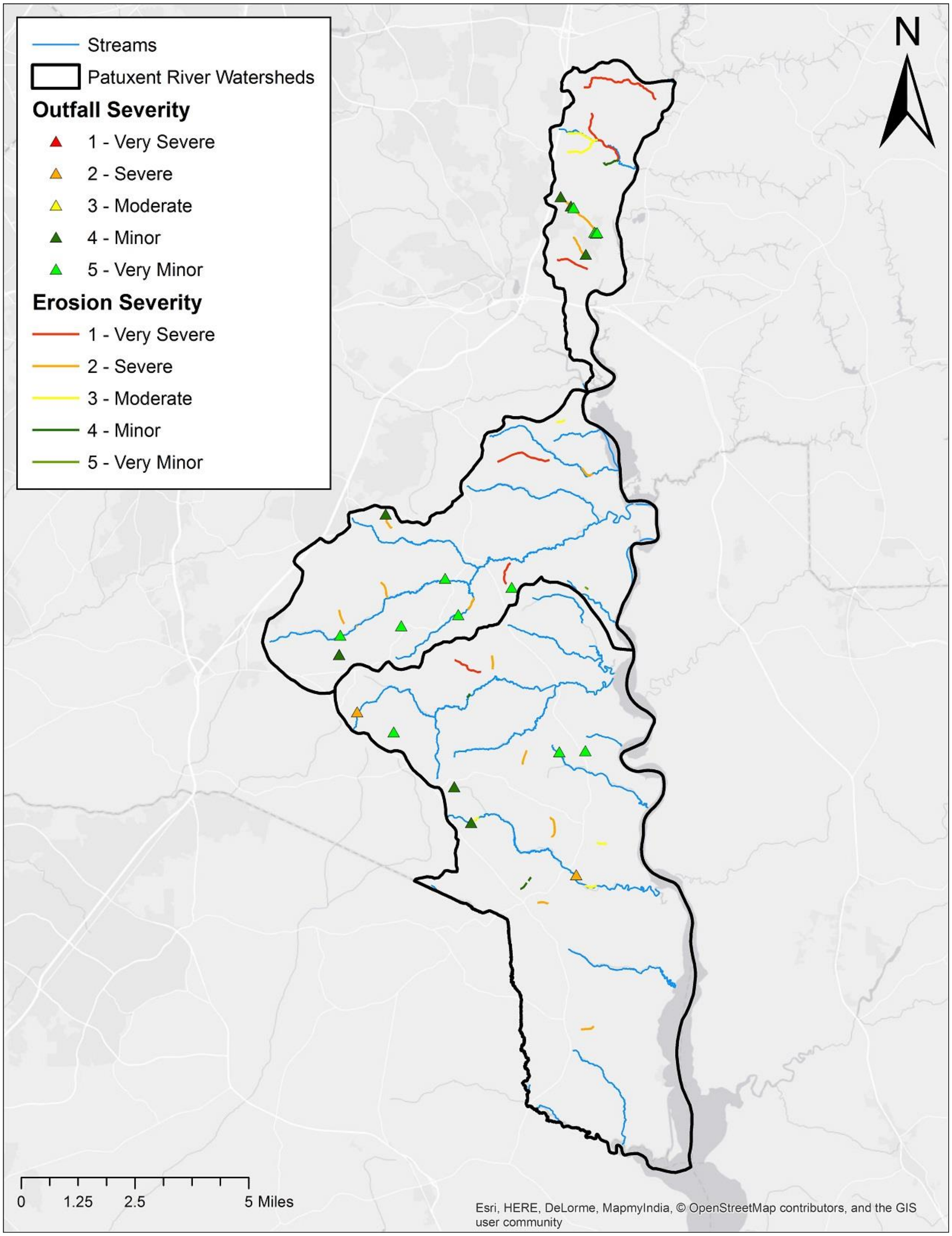


Figure 4-2. Locations of SCA-identified stream bank and outfall erosion (with severity) in the PR-L and PR-M watersheds.

5 Current Management Activities

When rain falls in the County, the resulting runoff flows off roofs, lawns, driveways, and roads into a network of stormwater sewers that discharge directly to area streams. The stormwater flow picks up pollutants such as nutrients, bacteria, and sediments and transports them into the waterways of the County. High volumes of water flowing to the stream channel during storm events cause erosion of the land and the channel itself. Many areas of the County were developed before stormwater regulations and practices were adopted in the 1970s and 1980s. No stormwater management facilities exist in those older developments.

The County enacted a stormwater management ordinance in 1971, and the State adopted a statewide stormwater law and regulations in 1983. Since 1971, developers of new and redevelopment projects in the County are required to provide water quality treatment for this urban runoff using a wide range of stormwater practices. During the initial years of stormwater regulation, those practices were somewhat crude and simple, but they have been continuously improved. Today, *environmental site design* (ESD)—the approach to stormwater management required by MDE—is based on the use of landscape-based practices such as rain gardens and bioswales and is considered an ecologically sustainable approach to stormwater management. The County is currently installing those types of BMPs. This section describes current stormwater management programs and the BMPs installed in the County.

5.1 Stormwater Management Programs

The County has implemented a wide range of programmatic stormwater management initiatives over the years to address existing water quality concerns. They are grouped into the three categories: stormwater-specific programs, tree planting and landscape revitalization programs, and public education programs. This section describes each grouping (and its respective individual initiatives), including the contributions the programs make to water quality protection and improvement.

Many of the County's stormwater-related programmatic initiatives target more than one issue area. For example, in addition to promoting adoption of on-the-ground BMPs, the Alternative Compliance Program promotes stormwater education via environmentally focused sermons at places of worship. The following programs that either directly or indirectly support water quality improvement are administered by various departments within the County government or its partners:

- Stormwater-Specific Programs
  - Stormwater Management Program
  - Clean Water Partnership (CWP)
  - Rain Check Rebate and Grant Program
  - Alternative Compliance Program
  - Rain Check Rebate and Grant Program
  - Stormwater Stewardship Grant Program
  - Countywide Green/Complete Streets Program

- Erosion and Sediment Control
- Street Sweeping
- Storm Drain Maintenance: Inlet, Storm Drain, and Channel Cleaning
- Storm Drain Stenciling
- Illicit Connection and Enforcement Program

- Tree Planting and Landscape Revitalization Programs
  - Volunteer Tree Planting
  - Tree ReLeaf Grant Program
  - Neighborhood Design Center
  - Arbor Day Every Day
  - Tree Planting Demonstrations
- Public Education Programs
  - Interactive Displays and Speakers for Community Meetings
  - Stormwater Audit Program
  - Master Gardeners
  - Flood Awareness Month

5.1.1 Stormwater-Specific Programs

As required under NPDES regulations, the County must operate an overall stormwater program that addresses six minimum control measures—public education and outreach, public participation/involvement, illicit discharge detection and elimination (IDDE), construction site runoff control, post-construction runoff control, and pollution prevention/good housekeeping. To meet that requirement, the County administers various programs and initiatives, many of which have goals that will help achieve pollution reductions in response to TMDL requirements. Stormwater-specific program initiatives are designed to reduce flow volumes and pollutant loads reaching surface waters by facilitating the implementation of practices to retain and infiltrate runoff. Stormwater-specific programs include the following:

- *Stormwater Management Program (SWM Program)*. The SWM Program is responsible for performing detailed assessments of existing water quality. It also is responsible for preparing design plans for and overseeing the construction of regional stormwater management facilities and water quality control projects. Those activities contribute to annual load reductions through improved planning and assessment and implementation of BMPs that reduce pollutant loading.
- *Clean Water Partnership* (*CWP*). The County recently initiated this program, which is a community-based public-private partnership, to assist in addressing the restoration requirements of the Chesapeake Bay WIP program. The CWP program initially focused on ROW runoff

management in older communities, which are primarily inside the Capital Beltway. The program is expected to be responsible for providing water quality treatment for impervious land.

- *Alternative Compliance Program.* The Alternative Compliance Program, administered by DoE, allows tax-exempt religious and nonprofit organizations to receive reductions in their CWA Fee if they adopt stormwater management practices. The organizations have three options and can use any combination to receive the credits. The options are to (1) provide easements so the County can install BMPs on their property; (2) agree to take part in outreach and education to encourage others to participate in the Rain Check Rebate and Grant Program and create an environmental team for trash pickups, tree planting, recycling, planting rain gardens, and so forth; and (3) agree to use good housekeeping techniques to keep their clean lots and to use lawn management companies certified in the proper use of fertilizers. The County has received more than 186 applications from eligible organizations. Thus far, 75 projects either have been completed or are under design and/or construction, treating 51.6 acres of impervious area (DoE 2018). In Fiscal Year (FY) 2018, 16 retrofit projects either were being designed, planned, or constructed or were complete.
- *Rain Check Rebate and Grant Program.* The Rain Check Rebate and Grant Program, administered by the DoE, allows property owners to receive rebates for installing County-approved stormwater management practices. It was established in 2012 through County Bill CB-40-2012 and implemented in 2013. The County will reimburse homeowners, businesses, and nonprofit entities (including housing cooperatives and places of worship) for some of the costs of installing practices covered by the program. Installing practices at the individual property level helps reduce the volume of stormwater runoff entering the storm drain system as well as the amount of pollutants in the runoff. In addition, property owners implementing these techniques through the program will reduce their CWA Fee if they maintain the practice for 3 years. Currently, rebates are capped at $4,000 for residential properties and $20,000 for commercial properties, multifamily dwellings, and nonprofit and not-for-profit groups. In FY 2018, 266 BMPs (pavement removal, permeable pavement, rain barrels, rain gardens, and tree canopy) were installed on private properties treating 2.3 acres (DoE 2018).

- *Stormwater Stewardship Grant Program.* Through the County's Stormwater Stewardship Grant Program, the Chesapeake Bay Trust currently funds requests for construction of water quality improvement projects. The Trust also funds citizen engagement and behavior change projects implemented by a variety of nonprofit groups, including homeowners associations (HOAs). Nonprofit organizations, municipalities, watershed organizations, education institutions, community associations, faith-based organizations, and civic groups can be awarded $50,000 to $200,000 for water quality projects and $50,000 to $150,000 for tree planting projects. Projects must complete on-the-ground restoration that will result in improvements in water quality and watershed health (reduction in loads of nutrients or sediment) or significantly engage members of the public in stormwater issues by promoting awareness and behavioral change. In FY 2018, 15 grants were awarded to support green infrastructure implementation, trash removal, environmental education, and tree planting.

- *Countywide Green/Complete Streets Program.* The Department of Public Works and Transportation (DPW&T) initiated a countywide Green/Complete Streets Program in 2013 as a strategy for addressing mounting MS4 and TMDL treatment requirements. The program identifies opportunities to incorporate stormwater control measures, environmental enhancements, and community amenities into the DPW&T's capital improvement projects. The types of projects that can contribute to pollutant load reductions include ESD practices, tree shading, alternative pavements, and landscape covers.
- *Erosion and Sediment Control.* MDE has assigned the responsibility for conducting erosion and sediment control enforcement to the County. It involves conducting site inspections and providing Responsible Personnel Certification courses, which educate construction site operators to conscientiously manage disturbed land areas commonly found at construction sites. These control measures prevent excess sediment from entering County water bodies from active construction sites.
- *Street Sweeping.* The County conducts street sweeping operations on select arterial, collector, and industrial roadways. Residential subdivisions are swept on a request-only basis. Street sweeping can reduce the amount of debris, including sediment that reaches waterways.
- *Litter Control*. The County maintains an aggressive litter control and collection program along County-maintained roadways. The litter service schedule is based on historical collection data; therefore, the most highly littered roadways are serviced as often as 24 times per year.
- *Storm Drain Maintenance: Inlet, Storm Drain, and Channel Cleaning.* These are systematic water quality-based storm drain programs that provide routine inspections and cleanouts of targeted infrastructure with high sediment and trash accumulation rates. Municipal inspections of the storm drain system can be used to identify priority areas. DPW&T inspects and cleans major channels on a 3-year cycle. Additionally, the County performs storm drain vacuuming that removes sediments from the storm drain system. In FY 2018, the County removed 1,124.70 pounds of debris from storm drains in the PR-M watershed, but did not perform that service in the PR-L watershed.

- *Storm Drain Stenciling.* The Storm Drain Stenciling Program continues to raise community awareness and alert community members to the connection between storm drains and the Chesapeake Bay. The County uses Chesapeake Bay Trust funding to purchase the paint, tools, and stencils used by the volunteers to stencil the "Don't Dump—Chesapeake Bay Drainage" message. It is difficult to estimate the load reduction from storm drain stenciling; however, it is expected to help reduce pollutant loads to local water bodies.
- *Illicit Connection and Enforcement Program.* DoE conducts field screening and outfall sampling to detect and eliminate nonpermitted discharges from the County's MS4.

5.1.2 Tree Planting and Landscape Revitalization Programs

When localities convert urban land to forest, significant hydrologic and water quality benefits accrue. Tree planting typically occurs piecemeal across the urban landscape whereas reforestation usually occurs on a much larger scale. In either case, to claim pollutant reduction credits from those plantings, a survival rate of 100 or more trees per acre is necessary, with at least 50 percent of the trees being 2 inches or more in diameter at 4.5 feet above ground level (MD DNR 2009, MDE 2014).

The pollutant load reduction credit for planting trees is based on the load difference when the land cover is converted from urban to forest. To qualify for the alternative credits for Reforestation on Pervious Urban Land, the County will need to demonstrate compliance with the credits criteria.

- *Volunteer Tree Planting.* DPW&T oversees volunteer tree planting in October of every year. Trees are planted by organizations (e.g., HOAs) on public spaces (e.g., parks and institutional areas). Approximately 2,000–2,500 trees are planted under the program every year.
- *Tree ReLeaf Grant Program.* DoE's Tree ReLeaf Grant Program is funded by fees-in-lieu; therefore, it only funds planting projects on public property. The program provides funding to neighborhood, civic, and community/homeowner organizations; schools; libraries; and municipalities for tree and shrub planting projects in public spaces or common areas. Goals of the program include increasing native tree canopy to improve air and water quality, conserve energy, and reduce stormwater runoff. Organizations can receive up to $5,000 under the program, and municipalities are eligible for grants up to $10,000.

- *Neighborhood Design Center.* The Neighborhood Design Center, a local nonprofit in Riverdale, is an important partner in many County initiatives. They furnish pro bono design and planning services to a wide variety of individuals, organizations, and low-to-moderate income communities. Their goal is to involve the entire community in developing and implementing initiatives and projects designed to revitalize neighborhoods. The Neighborhood Design Center develops plans for parks, gardens, and community plantings, including wetland and rain gardens, reforestation projects, and median and shade tree plantings. Collectively, these efforts have increased the County's green space, reduced stormwater runoff, and improved water quality through the creation of natural systems to cleanse stormwater runoff.
- *Arbor Day Every Day.* Arbor Day Every Day provides free trees to schools to plant and maintain on school grounds. This program educates students on the everyday importance of native trees, empowers them to enhance their community, and provides funds for planting projects.
- *Tree Planting Demonstrations.* The Sustainable Initiatives Division recently began a tree planting demonstration program to increase tree canopy and promote tree care.

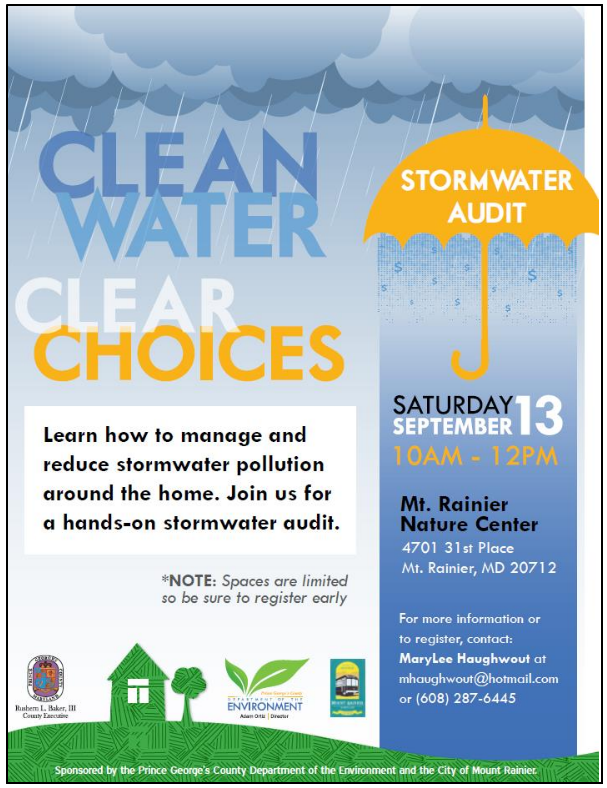
5.1.3 Public Education Programs

DoE seeks every opportunity to promote environmental awareness, green initiatives, and community involvement to protect natural resources and promote clean and healthy communities. The County also integrates water quality outreach as a vital component of watershed restoration projects. At public outreach events, DoE staff provide handouts, answer questions, make presentations, promote programs, and display posters and real-world examples of stormwater pollution prevention materials (e.g., sample rain barrels and samples of permeable pavement). The County also has published a series of brochures to raise stormwater pollution awareness and educate the residential, business, and industrial sectors on their roles in preventing stormwater pollution. Topics include stormwater BMPs such as rain gardens, cisterns, and pavement removal.

Following are details about other County-administered outreach and education efforts that have the potential to reduce stormwater pollution through BMP implementation:

- *Interactive Displays and Speakers for Community Meetings.* County staff support multiple outreach events to provide presentations, displays and handouts, answer questions, and promote environmental stewardship. At these events, County staff provide information on the importance of trees and tree planting, stormwater pollution prevention, lawn care, Bayscaping (replacing turf with plants native to the Chesapeake Bay region), and trash prevention and cleanup.

- *Stormwater Audit Program*. DoE conducts stormwater audits on residential properties. During the audits, County staff walk a property with the homeowner and make suggestions on the most appropriate types and potential locations for stormwater BMPs.



- *Master Gardeners.* Master Gardeners are volunteer educators who provide horticultural education services to individuals, groups/institutions, and communities. The mission of the program is to educate Maryland residents about safe, effective, and sustainable horticultural practices that build healthy gardens, landscapes, and communities. The program has the potential to aid overall reduction of fertilizer and pesticide use as well as promote increases in stormwater practices such as installing rain gardens and using rain barrels.
- *Flood Management.* During June, DoE works to raise awareness of flood risks and what County residents can do to protect their homes, families, and personal belongings if flooding occurs. DoE incorporates messages that encourage residents to implement flood-prevention stormwater practices (e.g., BMPs) such as using permeable pavers and rain gardens to help prevent costly property damage caused by backyard flooding.

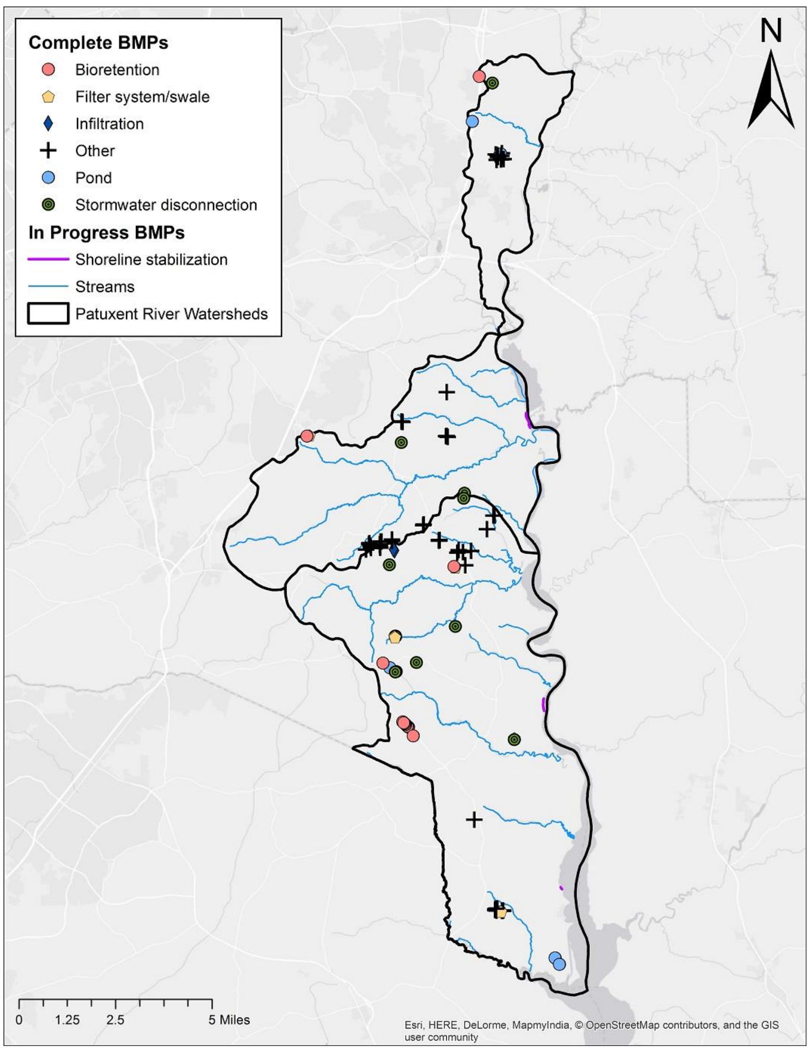
5.2 Existing BMPs

The PR-L and PR-M watersheds have limited BMP coverage and only a limited amount of that coverage can be counted in this restoration plan as being supportive of the TMDL. The County actively updates their BMP geodatabase with new information as it becomes available. The BMPs were installed either to support restoration activities or as offsets for development. Only BMPs specifically installed for restoration can be counted towards the TMDL-required load reductions. Table 5-1 lists the number of each type of BMP per watershed and categorizes them as either restoration or developer BMPs. Figure 5-1 shows the locations of the BMPs as of April 2019.

Table 5-1. Number of BMPs in the PR-L and PR-M watersheds

BMP Type	Restoration		Developer	
	PR-L	PR-M	PR-L	PR-M
Bioretention	5	4	0	0
Disconnection of Nonrooftop Runoff	0	0	0	14
Disconnection of Rooftop Runoff	0	0	10	0

BMP Type	Restoration		Developer	
	PR-L	PR-M	PR-L	PR-M
Dry Well	0	0	44	59
Extended Detention Structure, Wet	0	0	5	0
Grass Swale	0	0	4	4
Impervious Surface Elimination (to Pervious)	0	1	0	0
Microbioretention	4	10	4	0
Rainwater Harvesting	5	6	0	0
Retention Pond (Wet Pond)	0	0	0	13
Sheet Flow to Conservation Areas	0	0	8	0
Shoreline Stabilization	2	1	0	0
Stream Restoration	0	3	0	0
Tree Planting	4	14	0	0



Source: DoE 2019.

Figure 5-1. BMPs in the PR-L and PR-M watersheds.

6 LOAD REDUCTION TARGETS AND EXISTING GAP

This section discusses the calculation of load reduction targets for each watershed, reductions that have resulted from current BMPs, and reductions remaining to be met through this restoration plan. The calculations rely on land-use information from section 2.2.1, TMDL information from section 1.2, and current BMP information from section 5.2.

6.1 Load Reduction Terminology

The amount of load still required to be reduced after accounting for load reductions from current practices is called the "load reduction gap." Figure 6-1 illustrates that concept. The load reductions from current BMPs and other practices and the load reduction gap are provided in Table 6-5. Figure 6-2 and Figure 6-3 show the graphical representation of the calculated baseline loads, implementation target load, required implementation load reduction, load reduction (from baseline loads) resulting from current BMPs, and the reduction gap. The implementation target load and required implementation reduction equal the baseline loading (with slight differences due to rounding), while the current BMP reductions and the reduction gap equal the required reduction.

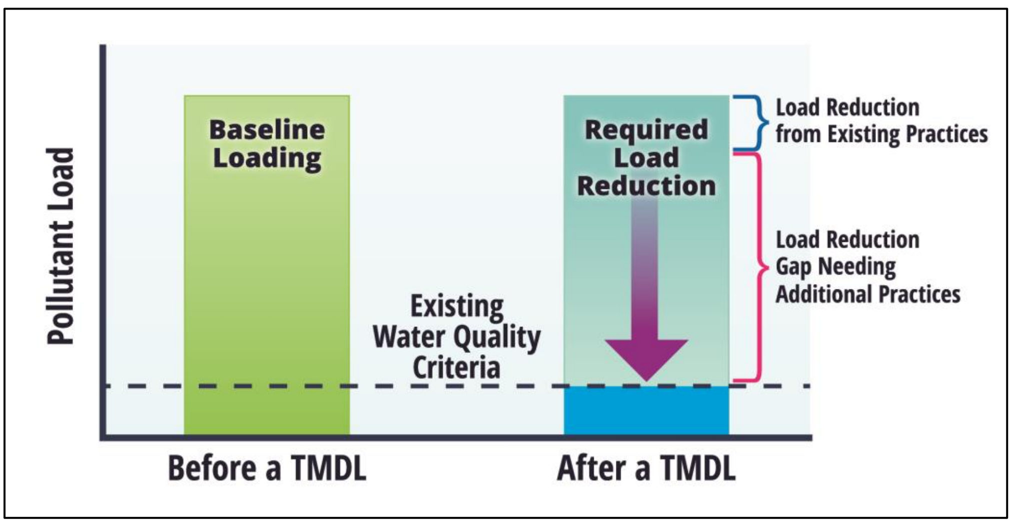


Figure 6-1. Schematic for typical pollution diet (TMDL) showing existing load reduction credits.

The following terms are used in text, tables, and plots throughout the remainder of this report:

- **Baseline load:** The pollutant load from the land surface at the time the TMDL was developed. It includes reductions from restoration BMPs installed prior to 2009.
- **Target load:** The load that will be met once load reductions specified in the Chesapeake Bay TMDL are met.
- **Required load reduction:** The load that will need to be reduced through BMPs. This load is the difference between the baseline load and the target load.
- **Current load (BMPs installed 2009–2018):** The County has already installed BMPs in the watersheds. This is the current load accounting for these BMPs and is the difference between baseline loads and the loads treated by current BMPs.

- **Load reduction to date:** The loads reduced by currently installed BMPs, or the difference between the baseline load and the current load.
- **% of target:** The percent of the required load reduction removed by installed BMPs.
- **Current load reduction gap:** The required load reduction remaining (i.e., gap) once the load reduction to date is subtracted from the required load reduction.
- **Load removed from BMPs in planning/design:** This value is the load reduction from the BMPs not yet constructed but already being planned and designed.
- **Final load gap:** The required load reduction that remains (i.e., gap) once the load reductions from current BMPs and BMPs in design and planning are subtracted. This is the load reduction this plan addresses.

6.2 Baseline Load Calculation

Baseline conditions, as defined by MDE, represent the impaired conditions the watersheds were under during TMDL development. The percent reduction of pollutants is based on loads needed to achieve the applicable water quality standards in specific water bodies. MDE's *TMDL Data Center* website (MDE 2019c) provides technical guidance for developing restoration plans for WLAs (MDE 2014). Part of this guidance allows entities to calculate updated load estimates using specific land-use and other data for restoration planning. The guidance allows entities to use their own data to develop loads if they retain the percent reduction specified in the respective TMDL between baseline loads and the allocations for the applicable pollutants (MDE 2014). This method also accounts for the loads from a more accurate and more recent urban footprint than the TMDL, so the baseline loads in this plan will not exactly match those in the TMDL documents.

DoE developed watershed- and land use-specific loading rates using information from the Chesapeake Assessment Scenario Tool (CAST) (CBP 2019). CAST uses the same information as the Chesapeake Bay Watershed Model. CAST results were used to determine land-use, edge-of-stream (EOS) loading rates for various land uses. CAST separates the loading rates to MS4-regulated areas and those to unregulated areas for urban land uses. DoE calculated the loading rates for an MS4 area, an unregulated area, and a combined area-weighted value.

Table 6-1 presents baseline loads using recent land uses and land-use data from the County's portions of the PR-L and PR-M watersheds. Those baseline loads do not include loads attributed to federal or state land. The TMDL values in the table were obtained directly from their respective MDE TMDL reports or point source technical memorandums (MDE 2018a, 2018b). The County-calculated figures are are from County land-use data and EOS loading rates developed using CAST loading data.

The TMDL loadings and targets and the County-calculated loadings and targets do not exactly match. Potential reasons for the differences in the reported numbers include changes to the watershed since the 2009 baseline data was assessed by MDE, changes in accepted land-use loading rates used by the County, potential differences in the applicability of regulatory responsibility (e.g., changes from agricultural to urban land uses), and potential changes to the MS4 service area.

Table 6-1 also presents the percent reduction as reported in the TMDL, which was applied to the calculated baseline load to determine the implementation load reduction target. That target and the amount by which the loads need to be reduced are also presented.

Table 6-1. MS4 baseline and implementation loads for the PR-L and PR-M watershed local TMDLs in Prince George's County

Watershed	Parameter	Implementation Model Baseline (tons TSS)	Percent Reduction from TMDL	Implementation Model Target Load (tons TSS)	Required Implementation Model Reduction (tons TSS)
Patuxent River Lower	TSS (ton/yr)[a]	TMDL: 126 County fig (EOS): 361	61%	TMDL: 49.14 County fig (EOS): 140.63	TMDL: 76.86 County fig (EOS): 219.96
Patuxent River Middle	TSS (ton/yr)[a]	TMDL: 158 County fig (EOS): 2,583	56%	TMDL: 69.52 County fig (EOS): 1,136.59	TMDL: 88.48 County fig (EOS): 1,446.57

6.3 BMP Pollutant Load Reduction

The main purpose of implementing BMPs is to remove sediment and other stormwater pollutants near their source and prevent pollutant loads from entering and degrading water bodies. Different types of BMPs remove pollutants with differing degrees of effectiveness, or "pollutant removal efficiency." Estimating pollutant reductions achieved through implementing BMPs is a two-step process: (1) determine the varying removal efficiencies of the BMPs being considered and (2) calculate the load reduction.

6.3.1 Removal Efficiencies

MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2014a) incorporates recent Chesapeake Bay Program (CBP) recommendations for nutrient and sediment load reduction removal efficiencies associated with implementing BMPs. By using those removal efficiencies in its reduction calculations, the County is consistent with regional efforts to meet the Chesapeake Bay TMDL.

The general pollutant removal efficiencies of ESD practices in this restoration plan are provided in Table 6-2. Removal efficiency increases as more runoff volume is treated. The table also illustrates that runoff reduction practices consistently reduce pollutant loads at a higher efficiency than structural practices at all treatment volumes. In locations where runoff reduction or ESD practices are used, or other acceptable runoff reduction practices predominate, the ESD/ runoff reduction curves should be used. Otherwise, the stormwater treatment or structural practices curves should be used.

Table 6-2. Pollutant removal rates for ESD/runoff reduction and structural practices

Runoff Depth Treated (inches)	Total Nitrogen		Total Phosphorus		TSS	
	Runoff reduction (%)	Structural practices (%)	Runoff reduction (%)	Structural practices (%)	Runoff reduction (%)	Structural practices (%)
0.00	0%	0%	0%	0%	0%	0%
0.25	32%	19%	38%	29%	40%	37%
0.50	44%	26%	52%	41%	56%	52%

Runoff Depth Treated (inches)	Total Nitrogen		Total Phosphorus		TSS	
	Runoff reduction (%)	Structural practices (%)	Runoff reduction (%)	Structural practices (%)	Runoff reduction (%)	Structural practices (%)
0.75	52%	30%	60%	47%	64%	60%
1.00[a]	57%	33%	66%	52%	70%	66%
1.25	60%	35%	70%	55%	76%	71%
1.50	64%	37%	74%	58%	80%	74%
1.75	66%	39%	77%	61%	83%	77%
2.00	69%	40%	80%	63%	86%	80%
2.25	71%	41%	82%	65%	88%	83%
2.50	72%	42%	85%	66%	90%	85%

Note:
[a] Typical scenario for redevelopment projects treating 50 percent of existing surface area.

Typical ESD/runoff reduction practices include the following:

- Bioretention
- Bioswale
- Disconnection of nonrooftop runoff
- Disconnection of rooftop runoff
- Dry swale
- Dry well
- Grass swale
- Green roof–extensive
- Green roof–intensive
- Infiltration basin
- Infiltration trench
- Landscape infiltration
- Microbioretention
- Perimeter (sand) filter
- Permeable pavements
- Rain gardens
- Rainwater harvesting
- Sheet flow to conservation areas
- Step pool storm conveyance
- Wet swale

Typical stormwater treatment/structural practices include the following:

- Extended detention–wetland
- Extended detention structure, wet
- Micropool extended detention pond
- Pocket pond
- Pocket wetland
- Retention pond (wet pond)
- Sand filter
- Shallow marsh
- Submerged gravel wetlands
- Underground filter

Table 6-3 presents the pollutant reduction efficiency of several alternative BMPs, including stream restoration (for which the load reduction efficiencies are only for planning purposes). Once the stream restoration projects are installed, the County will use the approved protocols—based on design and field measurements—to determine their actual load reductions.

Load reductions for outfall stabilization assume the same efficiencies as stream restoration and that 100 feet of stream will be restored for each failing outfall. MDE is currently evaluating an alternative method for calculating load reductions from outfall stabilization as proposed by the Maryland State Highway Administration (McCormick Taylor 2018). If MDE approves the methodology, the load reductions calculated using it are expected to be higher than those calculated using the current method. The higher load reductions will be accounted for in the County's annual MS4 reports.

Table 6-3. Pollutant removal efficiencies of selected alternative BMPs

BMP Type	ESD Practice?	Total Nitrogen (%)	Total Phosphorus (%)	TSS (%)
Planting trees or forestation on pervious urban surface	No	66%	77%	57%
Planting trees or forestation on impervious urban surface	No	71%	94%	93%
Stream restoration[a]	No	0.075 lb/ft/yr	0.068 lb/ft/yr	15.1 lb/ft/yr
Street sweeping–regen/vacuum	No	5%	6%	25%
Street sweeping–regen/vacuum[b]	No	3.5	1.4	420
Catch basin cleaning / storm drain vacuuming[c]	No	3.5	1.4	420

Source: MDE 2014.
Notes: lb/ft/yr = pound per foot per year.
a This restoration plan assumes that outfall stabilization has the same reduction efficiencies as stream restoration.
b These reductions are for high-density urban streets that are swept at least twice a month. These values are expected to change as the result of a recent Chesapeake Bay expert panel report.
c These reductions are for high-density urban areas, where storm drains are routinely maintained.

6.3.2 Load Reduction from Current Restoration BMPs

A systematic identification and locations of current BMPs as of April 2019 was conducted. Once identified, the BMPs' load reductions were quantified. The information available for most BMPs included drainage area (i.e., total land area flowing to a specific BMP [e.g., a bioretention system]). Load reductions for the existing BMPs were calculated using the documented pollutant removal rates in conjunction with BMP drainage area land cover, and land-cover-specific pollutant loading rate. That calculation provided the loading attributed to the BMP drainage area, which was then multiplied by the BMP pollutant removal efficiency to determine the amount of load reduction attributed to a specific BMP.

The load reduction calculation only included BMPs implemented since the TMDL water quality data were collected (the "baseline" year for the TMDL). For instance, the PR-L and PR-M nontidal sediment TMDLs were developed by MDE in 2018; however, the water quality data for it were collected in 2009. Therefore, any BMP or other practice implemented or established before 2009 was not included. Any BMP or practice implemented or established after 2009 was included in the load reduction calculation.

Table 6-4 lists existing restoration BMPs in the watersheds that were implemented under one of the programs discussed in section 5.1.

Table 6-4. List of BMP types in the PR-L and PR-M watersheds

BMP Type	PR-L			PR-M		
	Total number	Total acres treated	TSS reduction (lbs)	Total number	Total acres treated	TSS reduction (lbs)
Bioretention	5	1.00	779.18	4	0.84	868.34
Microbioretention	4	0.44	329.83	10	0.64	620.82
Rainwater Harvesting	5	0.042	39.21	6	0.034	33.22
Tree Planting	3	-	1,799.69	14	-	3,232.50
Tree Planting (PR-L and PR-M)[a]	2	-	503.04	2	-	503.04
Impervious Surface Elimination	-	-	-	1	0.06	44.29
Stream Restoration	-	-	-		4,417[b]	165,684.30
Street Sweeping	-	-	-	-	-	22.49
Storm Drain Cleaning	-	-	-	6	-	1,124.73
Total	19	1.48	3,450.94	43	1.57	172,133.73

Source: DoE 2019.
Notes: lb = pounds.
[a] Records split the watersheds, so total amount split.
[b] Linear feet.

6.4 Load Reduction Gap

The load reductions of the existing BMPs were calculated and used to determine the remaining load reduction gap (Figure 6-2, Figure 6-3, and Table 6-5). While the County implemented restoration BMPs prior to 2009, their load reductions are reflected in the baseline loadings, since they were in place when the TMDL was established. Besides restoration BMPs, there are BMPs installed by developers to offset the increased pollutant loads from new development and impervious areas. Because those BMPs are installed to offset new loadings and not to remove existing loadings, they are not counted towards watershed restoration.

As shown in Table 6-5, the load reductions from existing restoration activities are not sufficient to meet the targeted reductions. With the BMPs either previously implemented or planned, a reduction gap still exists in the PR-L watershed, while the PR-M watershed has exceeded its pollutant reduction goal. Additional practices will need to be planned in the PR-L to close the gap in its pollutant reduction requirements.

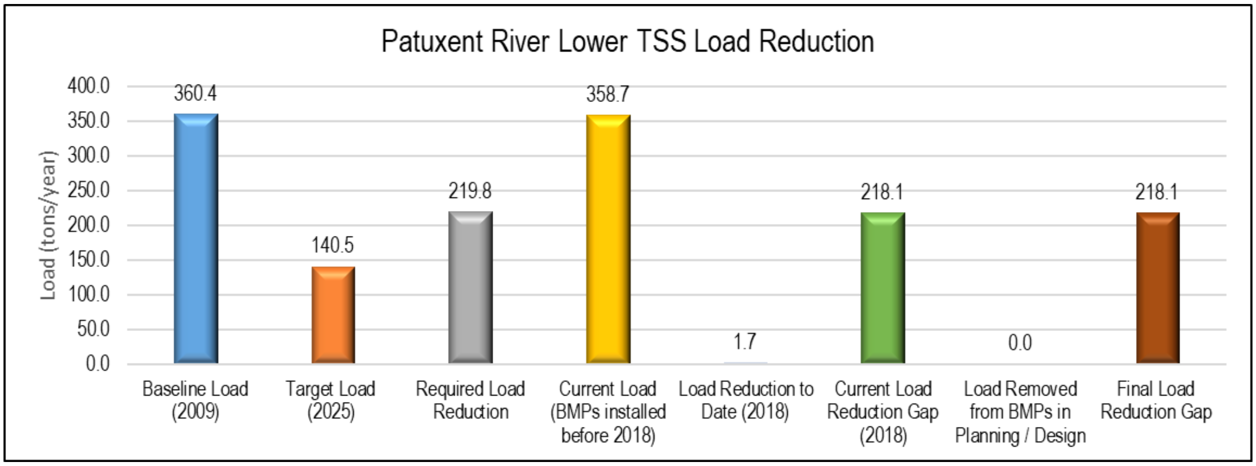


Figure 6-2. Pollutant load reduction targets and gaps for the PR-L watershed.

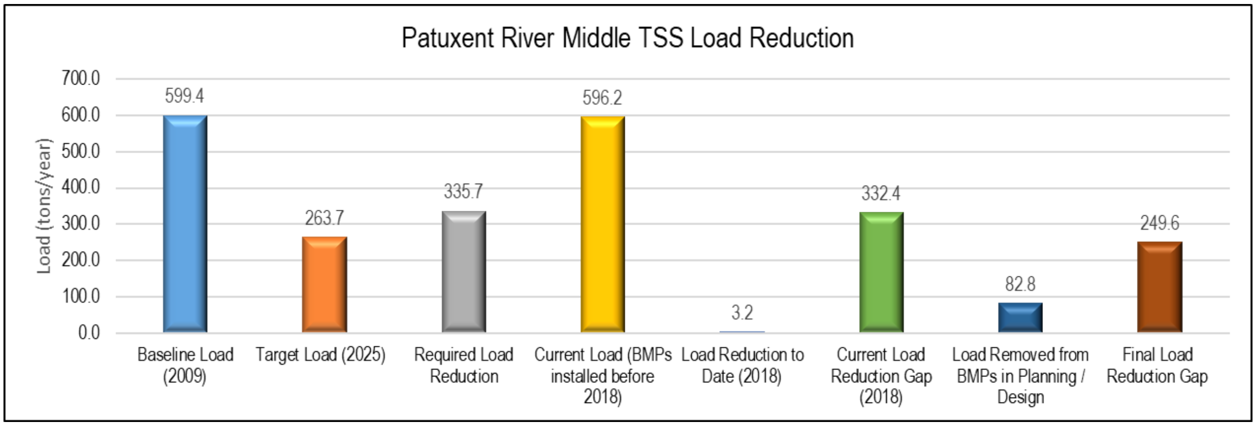


Figure 6-3. Pollutant load reduction targets and gaps for the PR-M watershed.

Table 6-5. Pollutant load reduction targets for the PR-L and PR-M watersheds

Measure	PR_L			PR-M		
	TSS (lbs/yr)	TSS (tons/yr)	% of Target	TSS (lbs/yr)	TSS (tons/yr)	% of Target
Baseline Load (2010)	720,761	360.4	163.9%	1,198,778	599.4	178.6%
Target Load (2025)	281,097	140.5	63.9%	527,462	263.7	78.6%
Required Load Reduction	439,664	219.8	100.0%	671,316	335.7	100.0%
Load Reduction to Date (2010-2018)	3,451	1.7	0.8%	5,302	2.7	0.8%
Current Load (BMPs installed 2010-2018)	717,310	358.7	163.1%	1,193,476	596.7	177.8%
Current Load Reduction Gap (2018)	436,213	218.1	99.2%	666,013	333.0	99.2%
Load Removed from BMPs in Planning / Design	0	0.0	0.0%	165,684	82.8	24.7%
Initial Load Reduction Gap	436,213	218.1	0.8%	500,329	250.2	25.5%

Notes: lbs/yr = pounds per year; tons/yr = tons per year.

7 STRATEGY DEVELOPMENT

The restoration activities in the PR-L and PR-M watersheds will require a significant increase in the current level of effort to reach the targeted water quality goals outlined in the TMDL and this restoration plan. Consequently, the County has developed a strategy that comprises five major components to achieve the goals of the plan:

- Use land-use loading rates and accepted BMP pollutant load reduction efficiencies to evaluate the ability of existing practices and programmatic initiatives to meet the local TMDL WLAs. Identify and quantify future BMPs and programmatic initiatives necessary to meet the WLAs.
- Develop cost estimates associated with implementing the identified BMPs and initiatives.
- Develop timelines associated with the deployment of identified BMP practices and initiatives to determine if the timelines required by the TMDL program can be achieved.
- Identify opportunities for BMP practices and programmatic initiatives and develop cost estimates.
- Identify the financial and technical resources required to implement the BMPs and initiatives and develop achievable timelines that can meet TMDL program requirements with the greatest efficiency.

This section describes the County's overall restoration strategy for the PR-L and PR-M watersheds. The recommended specific planned actions, cost estimates, and proposed schedule as well as descriptions of the financial and technical resources available to support implementation are discussed in section 8 and section 7.5 of this document.

7.1 Systematic and Iterative Evaluation Procedure

The County's strategy for developing a restoration plan includes evaluating the capacity of existing BMPs and restoration activities as well as identifying future activities necessary to meet the WLAs. The methodology emphasizes the use of adaptive management and a simplified project identification and implementation framework to achieve greater cost efficiency, while not sacrificing the resiliency of the restoration plan.

In a simplified framework, once the existing BMPs have been accounted for and the load reduction gap has been calculated, the County will attempt to identify potential future BMPs that could be implemented to close the remaining gap. Generally, the County's implementation of those BMPs would be prioritized by cost effectiveness in terms of meeting water quality goals. Seeking out cost-effective opportunities that deliver the greatest pollutant load reduction will ensure that the most beneficial practices that are easiest to accomplish are not overlooked during the implementation process.

The process shown in Figure 7-1 was developed to support a systematic evaluation of the number and general location of BMPs and other restoration activities that will be necessary to achieve the targeted pollutant reduction by subwatershed. The flow chart does not represent the order in which the County will implement restoration practices but illustrates a possible procedural scenario that could be used to determine the number of restoration activities necessary to meet load reduction goals. Although the restoration strategy initially suggests installing BMPs on public ROWs, it does not restrict the County from installing similar BMPs to treat other land-use types (e.g., County facilities) to obtain similar load reduction goals.

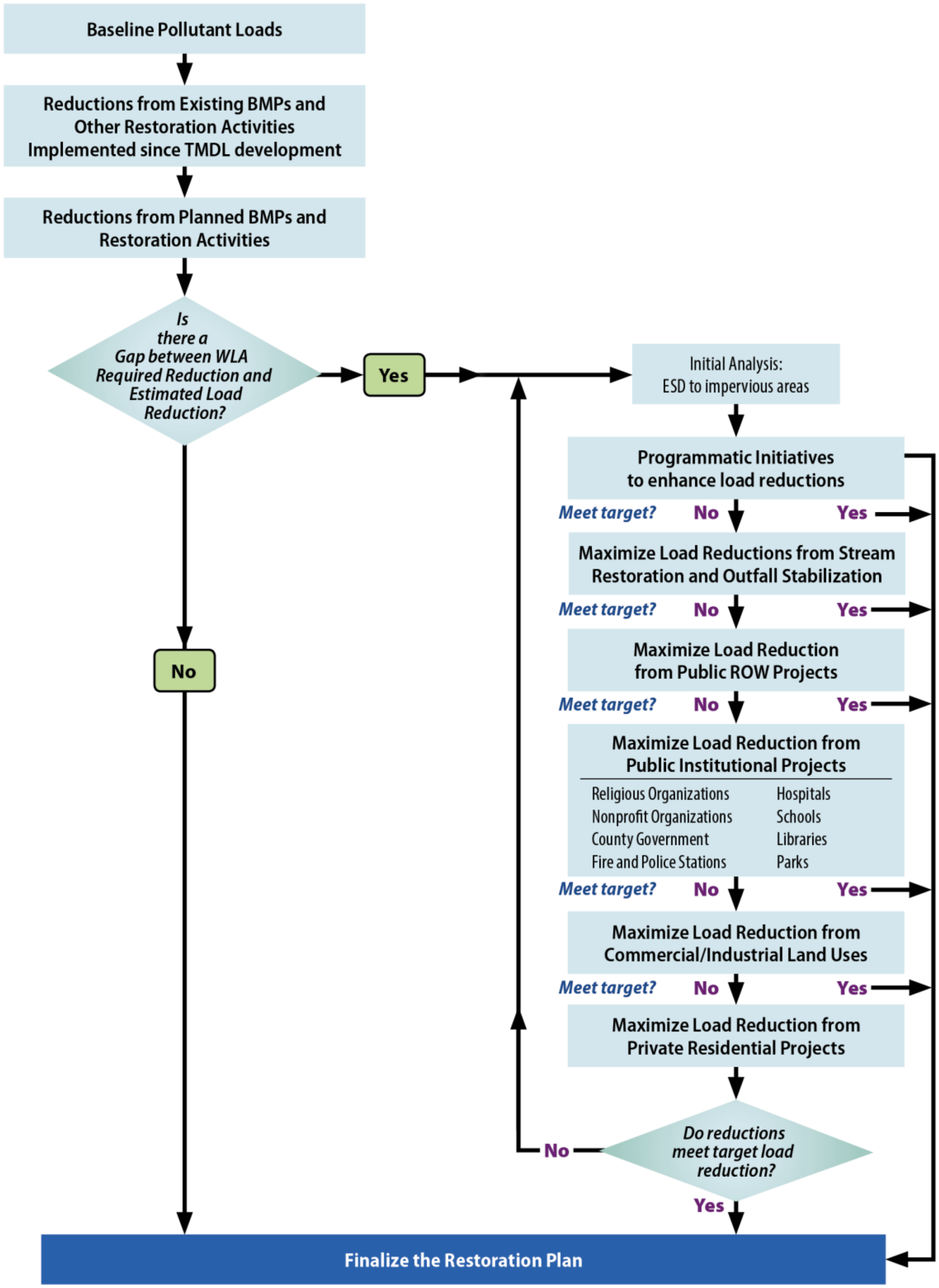


Figure 7-1. Restoration evaluation process.

7.2 Programmatic Initiatives

The County analyzed current stormwater programs (discussed in section 5.1) to determine, where possible, their contribution to the necessary load reductions. The existing programmatic activities are expected to continue and will be supplemented with additional practices, as they are identified and/or developed, to support the programmatic strategies for this restoration plan.

7.3 BMP Identification and Selection

The MDE 2000 *Stormwater Design Manual* provides guidance for designing several types of structural BMPs, which include wet ponds, wetlands, filtering practices, infiltration practices, and swales (MDE 2000). MDE also describes nonstructural BMPs that include programmatic, educational, and pollution prevention practices that work to reduce pollutant loadings. Examples of nonstructural BMPs include diverting stormwater from impervious to pervious areas, street sweeping, and homeowner and landowner education campaigns (MDE 2009).

The County has implemented and will continue to implement runoff reduction ESD practices, structural and nonstructural stormwater treatment practices, and MDE-approved alternative BMP practices to meet its programmatic goals and responsibilities, including MS4 permit compliance, TMDL WLAs, and flood mitigation.

The process illustrated in Figure 7-1 was used to assess potential pollutant load reductions from multiple potential activities such as the following:

- Retrofits of existing BMP to enhance load reductions
- Public ROW projects
- Public institutional projects
- Commercial/industrial land uses
- Residential properties

For this restoration plan, the County prefers to use a more opportunistic approach to identifying potential pollutant load reductions than it has used in earlier plans. For example, rather than considering treatments limited to public ROWs, followed by considering opportunities limited to institutional lands, this plan is geared toward considering each opportunity as it is discovered, which allows for a more fluid approach to implementing and prioritizing opportunities. The final selection of BMPs will be prioritized according to factors such as cost efficiency for pollutant load reduction and ease of implementation. For example, a project in a ROW is generally less complex because it is on public property and typically constitutes about 15–20 percent of total impervious area within a subwatershed. Stormwater controls within a ROW can be retrofitted with moderate effort. For comparison, stream restorations tend to be very resource-intensive, incurring high costs and, at times, requiring a significant community buy-in because of the physical disturbance in which they result. On the other hand, stream restorations have a very high pollutant load reduction efficiency for sediments, making that option feasible in certain situations. These are some of the kinds of factors likely to be considered in determining implementation priority.

7.3.1 Urban Stream Restoration

Urban impacts on streams typically include bank and channel erosion, stream health degradation, and loss of natural habitat. Multiple techniques for restoring a stream can be used to mimic the natural state of the stream, provide stability to the channel bed and banks, and improve stream health and habitat in nontidal areas. Various kinds of in-stream structures can be used to restore the main channel by providing stable flow steering and energy dissipation as well as creating pools where natural habitats can develop. In addition to in-stream structures, the increase in riparian vegetation can help to stabilize stream banks, further reducing in-stream erosion in high-velocity areas. Examples of stream erosion that could benefit from stabilization are shown in Figure 7-2.

The 1995–2009 MBSS data, outlined by MDE in the BSID document for each watershed (MDE 2013a, 2013b), indicate that 43 percent of stream miles in the PR-L watershed and 47 percent of stream miles in the PR-M watershed were not in attainment of biological water quality standards (the primary standard that indicates a sediment-related impairment).

Using the SCA, the County identified 3.42 mi of streams with erosion issues in the PR-L watershed and 1.16 mi of streams with erosion issues in the PR-M watershed.

Source: MD DNR n.d.

Figure 7-2. Examples of stream erosion.

7.3.2 Outfall Stabilization

Storm drainage systems in the County terminate at outfall structures that usually discharge to surface drainage features such as channels or streams. The outfall structures are often the initial source of stream erosion and degradation because they are the delivery point for the increased runoff from impervious areas. As the stream channel erodes and down cuts, it often undercuts the outfall structure, resulting in outlet failure (Figure 7-3). Outfall stabilization typically involves repairing localized areas of erosion below a storm drain pipe and addressing structural and functional problems associated with exposed infrastructure. DoE is currently identifying locations where outfalls are eroding and need to be stabilized. The County's storm drain outfall geospatial data are being used in that process. Outfall IDs will be related to areas of stream degradation and the drainage area to the outfall. The SCA field evaluations identified seven failing stormwater outfalls in the PR-L watershed and 15 failing outfalls in the PR-M watershed. Because the failing outfalls actively contribute to stream erosion and sediment generation, they present many restoration opportunities.

Source: MD DNR n.d.

Figure 7-3. Examples of pipe outfall failure.

7.3.3 Structural Practices

The County will consider opportunities to implement BMPs on all types of land uses, wherever there is a need to provide treatment to currently untreated impervious surface. Some BMPs are better suited to certain land uses than others, and this section discusses examples of those land uses and their primary corresponding, but nonexclusive, BMPs.

BMPs can be grouped into two categories: runoff reduction or ESD practices and stormwater treatment practices. These practices can be installed to manage runoff generated by all urban land uses (e.g., street ROWs, residential, and institutional). ESD practices, which have a higher level of pollutant removal, reduce pollutants through infiltration interception by vegetation and adsorption by soil (e.g., bioretention systems and permeable pavement). Stormwater treatment practices reduce pollutants through filtration or settling (e.g., sand filters and wet ponds).

Rights-of-Way

The County owns and maintains ROWs, which are public space along streets and roadways. They represent a high-priority area for restoration and will be a major focus of the County watershed restoration efforts. If opportunities to implement BMPs in ROW areas present themselves, possible retrofits for different types of ROWs are available (see Table 7-1).

Table 7-1. Potential BMP types per urban road grouping

Potential BMP	Urban Open Section with No Sidewalk	Urban Closed Section with Curb and Gutter but No Sidewalk	Urban Closed Section with Curb, Gutter, and Sidewalk	Suburban Open Section with No Curb, Gutter, or Sidewalk	Suburban Closed Section with Curb, Gutter, and Sidewalk
Permeable pavement or sidewalks	X	X	X	X	X
Permeable pavement shoulder instead of grass shoulder/buffer	X			X	
Curbside filter systems		X	X		X
Curb extension with bioretention or bioswale		X	X		X
Curb cuts to direct runoff to an underground storage/infiltration or detention device		X	X		X
Grass swales and bioswales				X	
Bioretention or bioswales to convert an ROW to a green street				X	X
Infiltration trenches with underdrains				X	

Institutional Land Use

Existing institutional land uses also offer opportunities for BMP retrofits. The land uses include County and nonprofit organization properties such as schools, libraries, places of worship, parks, government buildings, fire and police stations, and hospitals. The County has implemented the Alternative Compliance Program, administered by DoE, which allows nonprofit organization property owners to reduce their CWA Fee by installing approved stormwater management practices. Most of the properties have substantial areas of impervious cover that include rooftops, driveways, and parking areas that offer opportunities for cost-effective retrofits. A BMP retrofit matrix can be applied to these sites based on impervious cover type (Table 7-2). The retrofit matrix will help in the selection process and identify practical and feasible practices that offer the highest pollutant removal at the lowest cost.

Table 7-2. Typical impervious area BMP retrofit matrix for institutional property

BMP Description	Impervious Cover Elements				
	Roofs	Driveways	Parking	Sidewalks	Other[a]
ESD from the *Manual*					
Permeable pavements		X	X	X	X
Disconnection of rooftop runoff	X				
Disconnection of nonrooftop runoff		X	X	X	X
Sheet flow to conservation areas		X	X		
Rainwater harvesting	X				
Submerged gravel wetlands			X		
Landscape infiltration	X	X	X		X
Dry wells	X				

BMP Description	Impervious Cover Elements				
	Roofs	Driveways	Parking	Sidewalks	Other[a]
Microbioretention / rain gardens		X	X		X
Grass, wet, or bioswale		X	X		X
Enhanced filters	X	X	X	X	X
Structural Practices					
Wet ponds/wetlands			X		X
Infiltration practices			X		X
Filtering practices		X	X	X	X
Tree Planting and Reforestation					
Impervious urban to pervious		X	X		X
Planting trees on impervious urban		X	X		X

Note:
[a] Includes miscellaneous other impervious surfaces (e.g., basketball courts, tennis courts, and patios).

Commercial/Industrial Land Use

Much like institutional properties, commercial and industrial properties are characterized by large areas of impervious cover, including roofs, driveways, parking lots, and other paved areas. From a technical standpoint, the opportunities for implementing a variety of BMPs in those areas are similar to the opportunities in institutional areas (Table 7-2). Most of the commercial and industrial facilities, however, are privately owned. Consequently, the County has limited influence on the use of BMPs in those areas except along the public roads that serve them. To encourage effective BMP development on private property, the Rain Check Program administered by DoE offers financial incentives for property owners to implement approved stormwater management practices. Property owners can benefit through rebates, grants, or a reduction in a portion of their CWA Fee.

Residential Land Use

Residential areas make up roughly 11 percent of the combined PR-L and PR-M watersheds and have varying amounts of impervious cover such as roofs, driveways, walkways, and patios. Many of the practices in Table 7-2 can be used on residential land. The most common practices for individual homeowners are permeable pavement, rooftop disconnection, rainwater harvesting (e.g., rain barrels), landscape infiltration, rain gardens, and planting trees. For row houses, the most common practices probably would be permeable pavement (on sidewalks leading to houses and alleyways), rooftop disconnection, rainwater harvesting (e.g., rain barrels), and rain gardens. Apartment and condominium communities could install any of the practices listed in Table 7-2.

It is difficult to implement BMPs on residential properties, however, because they are privately owned. As with commercial and industrial property owners, the Rain Check Program offers financial incentives for residential property owners to implement approved stormwater management practices. Additionally, the County could explore opportunities to provide further education and awareness outreach on residential BMPs to help property owners learn about their benefits.

7.4 Prioritizing BMP Locations

The location of a BMP or other restoration practice has a significant impact on how successful the restoration will be. For instance, a lawn care campaign will have little effect in areas with few homeowners to implement the strategy. In identifying the best locations for BMPs, the County will consider sites where the most significant water quality benefits will be realized for available funding and installing the BMPs in a desirable time frame with minimal disruption. Three main considerations for prioritizing BMP locations are land ownership and site access, location in the stream watershed, and locations of known issues and existing treatment.

7.4.1 Land Ownership and Site Access

DoE and CWP are actively installing BMPs throughout the County. The most suitable locations to install BMP practices are municipally owned land such as town halls, police stations, public schools, libraries, and the ROWs or easements along roads and stormwater outfalls. For example, the County has site access to stormwater outfalls (usually available as flood easements), which allows the County to proceed without delays that sometimes result from negotiating with private landowners, facilitating faster implementation and reducing the resources spent for interacting with landowners.

In some instances, the County is granted permission from a property owner to install a BMP on their property. For example, the County's Alternative Compliance Program provides incentives to faith-based and other nonprofit organizations to allow the County to install BMPs on their properties. The organizations are granted credit toward their CWA Fee. The aesthetics of a restoration project are often preferred to the condition of the site before the BMP was installed. Attractive examples of watershed restoration efforts can be used in an outreach effort to encourage property owners to grant access to their own properties. A public education campaign highlighting those examples can build public support for implementing BMPs on private properties.

7.4.2 Location in the Watershed

Another factor to consider in BMP placement is how close the location is to the stream headwaters. Improvements to water quality and stream stability in stream headwaters will provide benefits along the entire length of the stream. Restoring downstream reaches first, on the other hand, will later expose the restored reaches to sediment from upstream, increasing the risk that the restored channel will fail because of the fresh sediment deposits. Water quality improvement projects that address excess sediment from stream erosion are most appropriately placed in smaller headwater (first- and second-order) subwatersheds. Adding BMPs to headwaters above stream restoration projects will help protect the stream reaches that have been restored. Restoring conditions in the headwaters makes it easier to detect and attribute the water quality improvements to each restoration project because the complexity of factors that could be affecting water quality tends to decrease with drainage area.

7.4.3 Locations of Known Issues and Existing Treatment

A third key consideration in determining where to place BMPs is identifying where known erosion issues and areas of poor biological health exist and where treatment practices exist but have not yet been adequately implemented. Figure 7-4 shows how those locations can be mapped to identify priority areas for targeted BMP development. The locations were identified by reviewing existing and planned locations and types of BMPs, regulatory agency (only County MS4 land is identified), bioassessment results, and areas of concentrated impervious surfaces.

Note: The impervious and regulatory areas are not included on the map to make it clearer and easier to read.

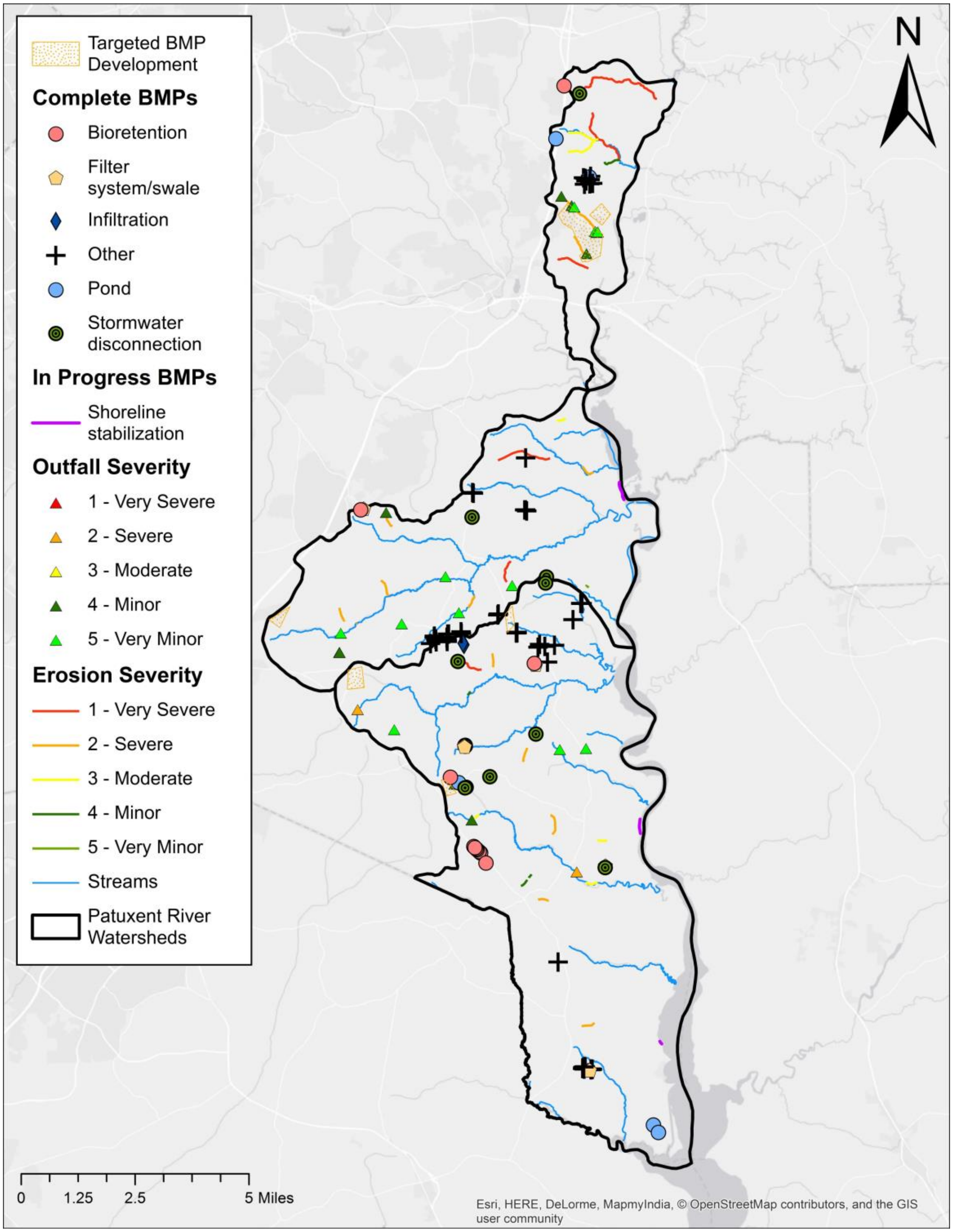


Figure 7-4. Example map for areas for BMP prioritization in the PR-L and PR-M watersheds.

7.5 Implementation Budgeting and Funding

7.5.1 Estimated Budgets

This section provides projected estimated budgets for the probable expenditures and staff resources that might be anticipated over the period of implementation. The costs are estimated in January 2018 values and do not account for inflation over the lifetime of this plan. Given the iterative and adaptive nature of the restoration plan and the potential for proposed activities being modified, the estimated budget should be considered preliminary for the year estimated and, in later years, should be revisited as the implementation period moves forward and new data become available.

Costs of Programmatic Initiatives

Generally, the costs of programmatic initiatives for nonstructural BMPs (e.g., public education, tree planting, and downspout disconnection) are more difficult to determine than costs for structural BMPs (e.g., ponds, stream restoration, and ESD practices). Some of the programmatic initiatives are current County practices. For instance, the ReLeaf Grant Program is one of the County's active tree planting programs with an existing budget. Costs for programs that result in structural BMP implementation such as the CWP are included in the BMP analysis; the only additional cost to the County is staff time for administering and coordinating the program as part of regular duties. Nonstructural BMPs are funded through DoE's operating budget whereas structural BMPs are funded through the Capital Improvement Program (CIP) budget.

Cost of BMP Implementation

Table 7-3 presents data on BMP unit cost per impervious acre treated and estimated cost per pound of TSS removed, including costs for continued operation and maintenance. These unit costs were previously developed in *Costs of Stormwater Management Practices in Maryland Counties* (King and Hagan 2011).[1] The costs were converted to January 2018 dollars using the RS Means historical cost indexes (Gordian 2018).

Table 7-3The table lists restoration practices in increasing average annual costs over 20 years. The load reduction for each practice was estimated for treating 1 impervious acre. It was then used to calculate the cost per pound of TSS removed. Of the three types of practices listed—alternative, runoff reduction, and stormwater—runoff reduction/ESD practices are the most efficient, removing 70 percent of sediment versus 66 percent for stormwater treatment practices.

[1] The cost-estimating framework used in the report develops full life-cycle cost estimates using the sum of initial project costs (preconstruction, construction, and land costs) funded by a 20-year county bond issued at 3 percent, plus total annual and intermittent maintenance costs over 20 years. Annualized life-cycle costs are estimated as the annual bond payment required to finance the initial cost of the BMP (20-year bond at 3 percent) plus average annual routine and intermittent maintenance costs.

Table 7-3. BMP costs by application

Stormwater Restoration Practices	Type of Practice	Avg. Annual Cost/Imp. Acre over 20 years[a]	Cost / Pound TSS Removed from Treating 1 Imp. Acre[b]
Street sweeping	Alternative	$832	$0.25
Vegetated open channels	Runoff reduction	$2,107	$1.73
Wet ponds & wetlands (new)	Stormwater	$2,281	$1.99
Urban forest buffers (no land acquisition acquired)	Alternative	$3,155	$3.63
Bioswale	Runoff reduction	$3,454	$2.84
Bioretention new	Runoff reduction	$4,440	$3.65
Infiltration practices without sand	Runoff reduction	$4,456	$3.66
Wet ponds & wetlands (retrofit)	Stormwater	$4,482	$3.91
Urban stream restoration	Alternative	$4,540	$3.03
Filtering (sand above ground)	Stormwater	$4,557	$3.97
Infiltration practices with sand	Runoff reduction	$4,654	$3.83
Filtering (sand below ground)	Stormwater	$4,888	$4.26
Dry ext. detention ponds retrofit	Stormwater	$5,357	$4.67
Impervious surface reduction	Alternative	$9,043	$6.19
Urban tree planting (with land acquisition)	Alternative	$11,428	$19.88[c]
Bioretention retrofit	Runoff reduction	$11,990	$9.86
Permeable pavement without sand	Runoff reduction	$15,628	$12.85
Permeable pavement with sand	Runoff reduction	$21,875	$17.98

Source: King and Hagen 2011.
Notes:
[a] Costs inflated to January 2018 dollars.
[b] Practices assumed to treat 1 inch of runoff.
[c] Considers 1 acre of pervious land.

Outfall stabilization is not included in the King and Hagen report (2011). Consequently, because this restoration plan assumes that the outfall stabilization will be a mini-stream restoration project, the unit costs for stream restoration are used for outfall stabilization, so design and construction costs for the two types of BMP projects are similar.

7.5.2 Budget Funding

Funding refers to sources of revenue to pay for annual operating expenditures, including maintenance and administrative costs; pay for management activities directly out of current revenues; and repay debt issued to finance capital improvements projects.

Sources of Funding

The County has largely relied on stormwater bonds, general obligation bonds, federal and state grants, and the State Revolving Fund to pay for the stormwater CIP that includes watershed restoration projects. The County's Stormwater Enterprise Fund pays for debt service on the bond sales and agency operating costs.

In 2013, the County enacted a CWA Fee that provides a dedicated revenue source for addressing stormwater runoff and improving water quality for regulatory mandates such as the Chesapeake Bay WIP, TMDL restoration plans, and the NPDES MS4 permit (independent of the ad valorem tax and General Fund). The fee is based on a property's assessed impervious surface coverage and provides a mechanism to equitably allocate the fee based on a property's stormwater contribution. Thus, each property contributes a fair and equitable share toward the overall cost of improving water quality and mitigating the impact of stormwater runoff. The fee is expected to collect roughly $14 million of dedicated funding annually. Depending on the rate of restoration activities completed by the CWP and County CIP efforts, the County might reevaluate funding options in the future.

Besides funds from the CWA Fee, stormwater ad valorem tax, and CIP budget, federal, state, or other grants are expected to provide a minor, but essential, contribution to funding. The County has successfully obtained various grants in the past and expects that trend to continue. The County will continue to pursue grant opportunities available for restoration projects. In addition to grants, federal and state loans (e.g., State Revolving Fund) might be an option for helping to fund part of the TMDL restoration process. In addition, the County encourages government entities (e.g., municipalities) and private organizations (e.g., watershed groups and nonprofits) to identify and apply for grant opportunities.

The County expects current Stormwater Enterprise Fund sources and funding levels to remain consistent with the County's by annual Financial Assurance Plan (FAP), expected to reoccur over the life of this restoration plan. The countywide dollars for restoration average no more than $70 million per year for all stormwater restoration. The available funding will need to compete across multiple local restoration plans, including the Chesapeake Bay WIP; however, many of the activities in the WIP can be counted toward local restoration plans. As part of its NDPES permit requirements, the County updates and submits its 2-year Financial Assurance Plan (FAP) to MDE for review. The FAP includes planned restoration projects of 5-year periods and the funding commitment for the next 2 fiscal years. The most recent plan approved by County Resolution is for FY 2019 and FY 2020.

Budget for Restoration Activities

The stormwater CIP contains project construction budget projections for the next 6 years. For countywide watershed or water quality restoration projects, the County primarily relies on two CIP projects: the CWP Project and NPDES MS4 Permit Compliance & Restoration. Other stormwater CIP projects include funding appropriation for restoration activities.

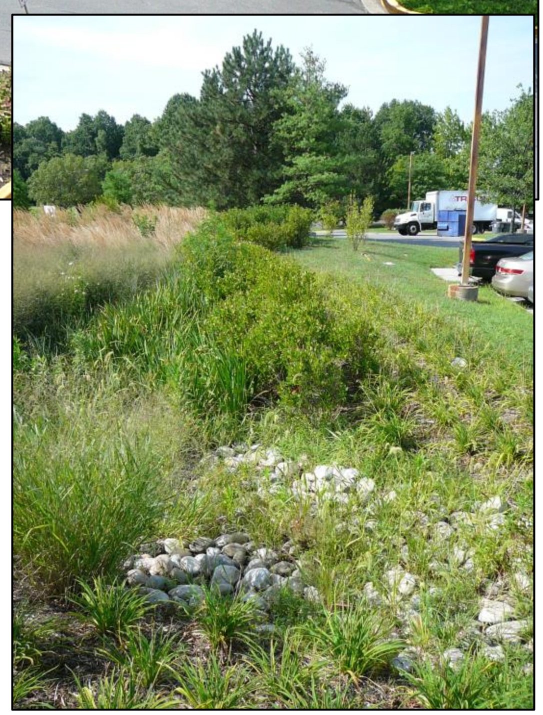
Table 7-4 provides a list of countywide stormwater CIP projects that include aspects of watershed restoration. The projects generally fund new watershed restoration activities or rehabilitation of existing assets to improve water quality. Specific watershed restoration projects or locations are not listed. However, the County maintains a project list that is used to determine the proposed funding. Once this restoration plan is completed, the County will start incorporating proposed restoration scenarios, subject to funding availability.

The County's stormwater CIP budget has in the past appropriated up to $100 million per year for countywide watershed or water quality restoration activities. For current funding capacities, the County typically prioritizes programs and shifts funding between watersheds. By doing so, the

County can prioritize and shift year-to-year load reduction goals between watersheds; however, the County aims to achieve the targeted completion dates.

Table 7-4. Proposed 2020–2025 CIP budget for stormwater management

CIP ID	Project Name	Project Class
DV 542015	Bear Branch Subwatershed	Rehabilitation
DV 546001	Clean Water Partnership NPDES	Rehabilitation
DV 541685	COE County Restoration (Anacostia River Watershed)	New construction
DV 542105	MS4/NDPES Compliance & Restoration	Rehabilitation
DV 540465	Participation Program	New construction
DV 664285	Stormwater Management Restoration	Rehabilitation



Aerial and ground-level view of bioretention facility collecting runoff from parking lot at County office building in Largo.

8 Restoration Activities

The County has constructed BMPs throughout the County, including in the PR-L and PR-M watersheds. Existing and planned BMPs, however, will meet only 0.8 percent of the TSS target goal in the PR-L watershed and 25.5 percent of the target goal in the PR-M watershed.

This section describes the County's proposed changes intended to strengthen the implementation process it uses to improve water quality and meet the goals and objectives of this restoration plan. It includes specific planned actions, cost estimates, and a proposed schedule and describes the financial and technical resources available to support and implement the plan. This section also describes how the County will involve the public throughout the plan's implementation, including keeping residents informed and encouraging them to participate directly in the implementation actions. The restoration plan creates the overall blueprint for restoration activities in the PR-L and PR-M watersheds.

8.1 Proposed Management Approach

BMP types and locations are not explicitly specified, giving the County flexibility to identify specific locations for and to work with partners on implementing BMPs (e.g., to install BMPs on institutional land). The County also will have the flexibility to select suitable ESD practices based on costs, land availability, feasibility, pollutant removal efficiencies, and other factors. Figure 8-1 presents conceptual art of an urban area with a variety of practices. It includes some practices not specifically mentioned in the plan, but that could be incorporated into the County's overall strategy.

Credit: EPA OWOW.

Figure 8-1. Conceptual urban area with ESD practices.

8.2 Estimated Restoration Load Reductions

This section presents the resultant final load reductions (from proposed programmatic initiatives and BMP implementation). Load reductions from existing BMPs are presented in section 5. Calculations to determine the load reductions from BMPs and programmatic initiatives were added to the assessment used to determine the implementation load reduction goals (see section 6). This load reduction analysis was performed using the steps presented in section 7.1. After each step, the estimated load reductions were compared to implementation load reduction goals to determine the remaining load reduction gap. These steps were followed and repeated until the implementation load reduction goal was met by the estimated load reductions:

1. Account for load reductions from current BMPs and their impervious drainage area, and subtract them from the necessary load reduction and available impervious area, respectively.
2. Subtract the load reductions from existing programmatic initiatives from the necessary load reductions.
3. Subtract the load reductions from recommended programmatic initiatives from the necessary load reductions.
4. Subtract the load reduction from planned BMPs from the necessary load reductions.
5. Subtract proposed BMPs and their associated load reductions and impervious area treated from the necessary load reductions.

8.2.1 Programmatic Initiatives

The County's existing programmatic practices (section 7.2) are expected to remain in place and will be supplemented with additional practices discussed in this section to make up the programmatic strategies for this restoration plan.

Estimating potential load reductions resulting from programmatic initiatives is challenging since some of the initiatives require public participation and changes in long-standing behaviors. Therefore, several assumptions must be made. The County has accounted for the need to reevaluate the estimated load reductions in the future in its adaptive management approach (section 0).

Some of the existing and new programmatic initiatives will result in BMPs being installed. The acreage that will be treated through those programs has not yet been estimated. BMPs installed as those programs are implemented will be credited towards the identified load reduction targets and load reduction gap discussed in section 6. These BMP-related programs include the following:

- SWM Program
- CWP Program
- Rain Check Rebate and Grant Program
- Alternative Compliance Program
- Countywide Green/Complete Streets Program
- Street Sweeping
- Storm Drain Maintenance

- Tree ReLeaf Grant Program
- Volunteer Tree Planting
- Master Gardeners Program
- Flood Management

Estimating the load reduction capabilities of some programmatic activities is impossible (e.g., storm drain stenciling or litter control). Although the cumulative effects of those activities will help reduce loads entering local water bodies in different ways, thus improving their health, their impacts cannot be calculated and are not included as part of this restoration plan. Those activities do, however, form an important part of this plan. Most of them serve to educate the public on how they can help improve water quality. The improvements in water quality resulting from the activities will be reflected through adaptive management, through which the County will assess cumulative improvements in the water quality and health of water bodies under the restoration plan.

8.2.2 Structural BMPs

This section assesses different treatment options, including stream restoration and outfall stabilization. It also explores tree planting, new wet ponds, and ESD practices (e.g., grass swales and bioretention systems) that treat stormwater runoff from both pervious and impervious land. The combination of pervious and impervious land is used in calculating the load reduction potential of new wet ponds and ESD practices. ESD practices are typically smaller and treat smaller areas than wet ponds. Wet ponds are typically regional facilities that remove sediments and other pollutants by treating runoff from large drainage areas. For costing, only the impervious area is assessed because the available cost data are provided per impervious acre treated, rather than for the total land area treated.

The County could use many different combinations of BMPs to meet the load reductions for these TMDLs. Cost and lack of available space for implementation, however, would make many of them unfeasible. The results of a cost analysis of various combinations would assist the County in selecting BMPs that could work together most effectively to meet the load reduction targets at the lowest cost.

The Microsoft Excel Solver Add-in was used to determine the most cost-effective scenarios to meet the load reductions for this restoration plan. Solver processes a set of conditions to meet the County’s objective: the lowest cost. The main condition was meeting the load reduction in every scenario. Other conditions set a range of implementation for ESD practices, outfall stabilization, stream restoration, tree planting, and new wet ponds. For example, one scenario limited ESD practices to treat runoff from 1 to 150 acres of land. Solver then determined the best value in that range for that scenario.

The overall costs for 16 scenarios ranged from $53.4 million to $81.8 million, with a median of $71.1 million. The scenario closest to the median cost (shown in Table 8-1) was selected for the restoration plan to provide the County with several options. The scenario that has been selected for presentation with this plan serves as a starting point for the County to make future decisions. The actual combination of BMPs implemented to meet the TMDL can change over time as adaptive management principles are applied to this plan. Table 8-2 presents a comparison of the eight most cost-effective scenarios.

Table 8-1. Results of cost optimization—median scenario (scenario 8)

Variable	PR-L	PR-M	Constraints
Stream restoration (linear feet)	10,848	3,686	10%–60% of SCA known issues (section 4.2)
Outfall stabilization (outfalls)	1	1	5%–60% of SCA known issues (section 4.2)
Tree planting (acres planted)	10	10	1–10 acres
New wet ponds (acres treated)	192	392	1–400 acres
ESD practices (acres treated)	150	150	1–150 acres
Cost	$40.1M	$30.4M	Lowest cost

Table 8-2. Comparisons of top 8 low-cost cost optimization scenarios

Practice	Top 8 Low-Cost Scenarios							
	8	7	6	5	4	3	2	1
Total cost ($M)	$70.5	$68.6	$68.2	$67.9	$65.2	$60.1	$54.5	$53.4
Patuxent River Lower								
Stream restoration (linear feet)	10,848	10,203	5,424	9,040	5,898	5,424	7,232	5,424
Outfall stabilization (outfalls)	1	3	5	5	3	3	3	3
Tree planting (acres planted)	10	1	10	10	1	1	1	1
New wet ponds (acres treated)	192	250	237	229	275	287	402	406
ESD practices (acres treated)	150	125	200	150	175	175	75	100
Patuxent River Middle								
Stream restoration (linear feet)	3,686	3,686	1,843	3,072	3,072	1,843	2,458	1,843
Outfall stabilization (outfalls)	1	3	5	5	3	3	3	3
Tree planting (acres planted)	10	5	10	10	5	1	1	1
New wet ponds (acres treated)	392	312	345	399	326	394	425	425
ESD practices (acres treated)	150	200	200	150	200	175	147	156

8.3 Technical Assistance

Overall success of the restoration plan will depend on the concerted effort of the County and many regional agencies, municipalities, community leaders, and local landowners. Each watershed partner (e.g., federal, state, or local government; nonprofit; business owner; or private landowner) has an important role to play in the restoration process. The proposed management actions will require significant time and resources from all those entities. Technical assistance and other in-kind support from the watershed partners and the public will be important in implementing the plan. That support will be especially important in addressing impediments to implementing the plan that include permitting challenges, technological limitations, and lack of available BMP and ESD sites. In addition, new BMP technologies are being researched that will help lower costs, decrease BMP footprint, and increase removal efficiencies. MDE and the CBP will need to approve the technologies and assign them removal efficiencies in a timely manner. In addition to having new BMP technologies approved, the County looks to MDE to continue issuing grants for stormwater restoration activities and to help in performing water quality monitoring in high-priority watersheds in the County.

Many sites that are suitable for BMP implementation are not owned by the County. The County will seek partnerships with other organizations (e.g., nonprofit organizations and businesses) to gain access to private lands and be able to conduct restoration activities on them. For example, a shopping center owner could partner with the County to gain assistance with installing BMPs ranging from technical assistance to partnering to install a BMP that treats the shopping center parking area and the County ROW. Without forming partnerships and being granted access to private land, the County will be able to install BMPs only on property to which it has direct access such as ROWs or County government-owned land.

Recently completed stream restoration project. Rocks were used to stabilize the banks and fresh vegetation was planted along both banks.

9 PROPOSED RESTORATION PLAN ESTIMATES

9.1 Load Reductions

Table 9-1 restates the load calculations from earlier in the document along with new reductions for the different restoration activities relevant to this plan (BMPs and programmatic initiatives). The most significant reductions will be obtained through stream restoration in the PR-L watershed and implementing new wet ponds in the PR-M watershed.

Table 9-1. TSS load reductions in the PR-L and PR-M watersheds in Prince George's County

Measure or practice	PR-L			PR-M		
	TSS (lbs/yr)	TSS (tons/yr)	% of Target	TSS (lbs/yr)	TSS (tons/yr)	% of Target
Baseline load (2010)	***720,761***	***360.4***	***163.9%***	***1,198,778***	***599.4***	***178.6%***
Target load (2025)	***281,097***	***140.5***	***63.9%***	***527,462***	***263.7***	***78.6%***
Required load reduction	***439,664***	***219.8***	***100.0%***	***671,316***	***335.7***	***100.0%***
Load reduction to date (2010-2018)	***3,451***	***1.7***	***0.8%***	***5,302***	***2.7***	***0.8%***
Current load (BMPs installed 2010-2018)	***717,310***	***358.7***	***163.1%***	***1,193,476***	***596.7***	***177.8%***
Current load reduction gap (2018)	***436,213***	***218.1***	***99.2%***	***666,013***	***333.0***	***99.2%***
Load removed from BMPs in planning / design	***0***	***0.0***	***0.0%***	***165,684***	***82.8***	***24.7%***
Initial load reduction gap	***436,213***	***218.1***	***0.8%***	***500,329***	***250.2***	***25.5%***
Restoration Plan						
Stream restoration / outfall stabilization	165,315	82.7	37.6%	57,175	28.6	8.5%
Tree planting	3,136	1.6	0.7%	3,459	1.7	0.5%
New wet ponds	119,310	59.7	27.1%	272,595	136.3	40.6%
ESD practices	148,453	74.2	33.8%	167,100	83.6	24.9%
Total restoration plan	***436,213***	***218.1***	***99.2%***	***500,329***	***250.2***	***74.5%***
Total Restoration Activities						
Current BMPs, planned BMPs, and restoration plan BMPs	***439,664***	***220***	***100.0%***	***671,316***	***336***	***100.0%***

Notes: lbs/yr = pounds per year; tons/yr = tons per year.

9.2 Restoration Budget

The planning level costs per restoration activity are shown in Table 9-2, along with the estimated load reductions and cost per pound of sediment reduced. The overall cost for this plan is $70.5 million. The BMP unit costs from Table 7-3 were used to determine the budget. Because this plan does not specify exact ESD types, the average of the ESD practices was used to determine the budget for the ESD practices in Table 9-2. The most cost-effective strategy is creating new wet ponds, while tree planting is the least effective, partially due to the land costs associated with planting. If trees are planted on existing properties without land having to be acquired, the cost-effectiveness of this practice will increase and the overall restoration cost will go down. In Table 9-2, the cost-effectiveness varies between the watersheds due to different land use loading rates for each watershed. Because stream restoration does not use land-use loading rates in its load reduction calculation, the cost-effectiveness for each watershed is the same.

Table 9-2. Total BMP implementation and programmatic initiatives cost and load reductions by restoration strategy (in 2018 dollars)

Practice	Lower Patuxent			Middle Patuxent		
	TSS (lbs/yr)	Budget	$/lb	TSS (lbs/yr)	Budget	$/lb
Stream restoration / outfall stabilization	165,315	$19,883,624	$120.28	57,175	$6,876,814	$120.28
Tree planting	3,136	$2,285,679	$728.83	3,459	$2,285,679	$660.83
New wet ponds	119,310	$3,246,270	$27.21	272,595	$6,616,705	$24.27
ESD practices	148,453	$14,663,988	$98.78	167,100	$14,663,988	$87.76
Total restoration plan	436,213	$40,079,560	$91.88	500,329	$30,443,185	$60.85

Notes: lbs/yr = pounds per year.

9.3 Implementation Schedule

This section provides the planning level implementation schedule for the BMP and programmatic strategy necessary to meet TMDL compliance milestones. There is no mandated end date to the local TMDL restoration plans; however, the County understands the public prefers an expedited restoration process and shares that sense of urgency. However, new BMPs with better efficiencies could be lacking and adequate site opportunities could be limited for restoration activities. Nonetheless, the County and its watershed partners are committed to finding site opportunities and expediting the planning, design, and construction phases for management activity to the maximum extent practicable.

Implementing the restoration activities in the proposed schedule will depend largely on future available funding and program capacity. The County has additional local TMDL restoration plans in the Anacostia River, Piscataway Creek, Mattawoman Creek, Rocky Gorge Reservoir, Upper Patuxent River, and PCB-impacted watersheds and will need to allocate available funding and resources across those priority watersheds.

DoE estimates that it can retrofit an average of 2 percent of its untreated impervious area a year (as per next NPDES permit conditions). This estimate is backed up by MDE in its draft Phase III Chesapeake Bay WIP (MDE 2019). Using that implementation average as a guide, we can determine the length of time needed to fully implement this restoration plan. There are 703.13 acres of untreated impervious area in the PR-M watershed and 659.17 acres in the PR-L watershed, and meeting the TMDL will require treating 267.4 acres in PR-M and 265.1 acres in PR-L watersheds. Based on the impervious area to be treated in Table 8-1, full restoration in PR-M will take 19 years and 20 years in PR-L.

Factoring in the implementation of the other competing priority restoration plans, source identification, available BMP technologies, and ease of implementation, this restoration plan will probably be fully implemented by FY 2041, reaching completion in PR-L watershed in FY 2041 while reaching completion in PR-M watershed in 2040, including treating the identified impervious acres with BMPs and all programmatic activities. Because the County already has a

FY 2020 budget and project list, work toward this restoration plan could start as early as FY 2021 or 2022 once funds are allocated and implementation site selection has begun.

Table 9-3 presents the estimated average annual number of impervious acres treated and the estimated load reductions by year from BMP implementation in the watersheds. There will be slight fluctuations in the annual load reductions due to the types of BMPs used and the land uses they treat, but the County will aim to meet or exceed the annual goals. Table 9-4 presents the overall target milestone timeline for this restoration effort. This schedule will be continuously monitored by the County to assess ways to increase the rate of implementation and to ensure practices are implemented as planned.

Table 9-3. Proposed average annual number of impervious area (acres) and load reductions goals/milestones

Fiscal Year	PR-L			PR-M		
	Impervious acres treated	TSS (ton/year)	Estimated budget	Impervious acres treated	TSS (ton/year)	Estimated budget
2021	13.18	18	$1,992,928	14.06	21	$1,601,131
2022	26.37	36	$3,985,855	28.13	42	$3,202,261
2023	39.55	55	$5,978,783	42.19	63	$4,803,392
2024	52.73	73	$7,971,710	56.25	83	$6,404,523
2025	65.92	91	$9,964,638	70.31	104	$8,005,654
2026	79.10	109	$11,957,565	84.38	125	$9,606,784
2027	92.28	127	$13,950,493	98.44	146	$11,207,915
2028	105.47	145	$15,943,420	112.50	167	$12,809,046
2029	118.65	164	$17,936,348	126.56	188	$14,410,176
2030	131.83	182	$19,929,275	140.63	208	$16,011,307
2031	145.02	200	$21,922,203	154.69	229	$17,612,438
2032	158.20	218	$23,915,130	168.75	250	$19,213,569
2033	171.38	236	$25,908,058	182.81	271	$20,814,699
2034	184.57	254	$27,900,985	196.88	292	$22,415,830
2035	197.75	273	$29,893,913	210.94	313	$24,016,961
2036	210.93	291	$31,886,840	225.00	334	$25,618,092
2037	224.12	309	$33,879,768	239.06	354	$27,219,222
2038	237.30	327	$35,872,695	253.13	375	$28,820,353
2039	250.48	345	$37,865,623	267.19	396	$30,421,484
2040	263.67	364	$39,858,550	267.38	396	$30,443,185
2041	265.13	366	$40,079,560	--	--	--

Restoration activities on the scale of this plan are difficult to estimate to the exact acres treated per year. Restoration plans are planning guides for the estimated level of effort that could be needed to meet reduction goals. The number of impervious acres to be treated every year will vary depending on funding, program capacity, and availability of sites. It is always the County's goal to exceed those estimates to speed up the restoration process. The County realizes that some efforts might be more successful than others and reserves the right to prioritize specific watersheds with higher load reduction requirements. For that reason, this restoration plan offers an adaptive management component to ensure issues are identified and addressed early. The County expects to reevaluate this plan every 5 years based on program capacity, funding, priority watersheds, staffing, and industry resources.

Table 9-4. Countywide target timeline for local TMDL restoration plans

Target	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030	FY2031	FY2032	FY2033	FY2034	FY2035	FY2036	FY2037	FY2038	FY2039	FY2040	FY2041
Public Outreach																					
Public outreach	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Measure progress/reevaluate public outreach campaigns		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BMP Implementation																					
BMP planning and design	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BMP implementation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NPDES MS4 Permit																					
5th generation	✓	✓	✓	✓																	
6th generation					✓	✓	✓	✓	✓												
Future permits										✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Monitoring																					
Countywide biological monitoring.	✓	✓		✓	✓	✓		✓	✓	✓			✓	✓	✓		✓	✓	✓		✓
Representative watershed monitoring (could be in another watershed)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tracking and Reporting																					
Update MS4 geodatabase with BMP, programmatic, and monitoring info.	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MS4 Annual Report	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adaptive Management		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

The FY 2041 projected end date was developed using estimates of the number of acres of impervious area that could be treated each year. During that period, the County will be implementing several other watershed restoration plans, creating competing priorities that could limit the pace at which restoration is accomplished in the PR-L and PR-M watersheds. Faster implementation would require additional funding, staffing, and, industry resources (e.g., bioretention soils, plants) sooner. The County is working with its watershed protection restoration program to increase the County's TMDL reduction rates. The County continues to research and evaluate innovative practices to help increase BMP efficiencies while lowering costs. Additional staff at the local level and close coordination with the State would be needed to review and approve BMP plans and permits in a timely manner so as not to slow implementation. Between now and FY 2041, implementation uncertainties could emerge that will require adjustments to the plan.

10 Public Outreach and Involvement

The County recognizes the importance to the success of its stormwater management efforts of involving the public in planning and implementing the restoration process. It welcomes any ideas citizens have to improve the process, recognizing that the people who live and work in the watersheds are most familiar with them. They can act as the eyes and ears of the County on a day-to-day basis to identify water quality issues, pollutant spills, or potential BMP opportunities. Residents can stay informed on the County's progress through the annual MS4 report to MDE, which is posted on the County's website and contains information on BMP implementation, public outreach events, and other County programs that can help meet TMDL goals. In addition, the County welcomes public input on restoration activities and potential BMP types or locations.

Besides staying informed, homeowners, nonprofit organizations, and business associations can play a more active role in the restoration process. Residents can take a pledge to clean up after their pets and practice environmentally friendly lawn care. In addition, the public can participate in the Rain Check Rebate and Grant Program and nonprofits can participate in the Alternative Compliance Program. Private landowners and nonprofit organizations can aid in restoring the watersheds by installing BMPs (e.g., rain barrels, rain gardens, and permeable pavement) on their properties to help minimize their impact on the overall pollution loading to the County's water bodies. Installing BMPs on private property reduces the owner's CWA Fee. Although those practices might seem insignificant, the overall load reductions can be significant if enough private landowners get involved. Organizations such as HOAs, neighborhood associations, and business organizations can also help by promoting the programmatic initiatives outlined in this restoration plan.

DoE has initiated a wide range of initiatives to inform County residents about the impacts their daily activities have on the health of their watershed and local water bodies. During FY 2018, the County hosted more than 500 events to promote environmental awareness, green initiatives, and community involvement in reducing the amount of pollution entering the County's waterways. More than 28,000 members of the public participated. DoE's outreach and educational programs also encourage volunteerism and environmental stewardship among community organizations, businesses, and citizens. Under DoE's Sustainability Division, the Community Outreach Promoting Empowerment (COPE) Section is the lead office managing and administering most of the education and outreach initiatives described in this section.

Current outreach programs are discussed in section 5.1. Beyond those targeted efforts, the County will work with watershed partners to ensure the public is informed of implementation progress and that active public involvement is pursued throughout the process.

10.1 Outreach to Support Implementation Activities

The County's outreach efforts continue to specifically target TMDL pollutants and pollutant-generating behaviors. Over the past several years, COPE has sponsored the following activities and projects to target TMDL pollutants and encourage the adoption of pollutant-reducing behaviors:

- ***Inventory of Environmental Outreach Programs in and around Prince George's County***. COPE inventoried existing local programs (e.g., nonprofits and educational) working toward shared goals of environmental stewardship or stormwater pollution reduction and that already have ongoing or planned outreach efforts in and around the County. This was done to identify potential outside partners and overlapping programs/efforts. COPE researched which types of programs and materials have been successful and are available to share and cross-market to target audiences.
- ***Audience Research Analysis: A Review of Target Audience Characteristics in Prince George's County for a Stormwater Outreach Strategy***. The County is made up of a diverse population in terms of age, race, culture, language, education, and income. As a result, COPE analyzed U.S. Census data and secondary research to gain an understanding of the potential target audiences and their specific characteristics as well as possible barriers to environmental messages (e.g., lack of homeownership, native language, age, and household economics). This analysis helped determine the best way to reach diverse groups and identify different messaging and methods that would resonate with target audiences.
- ***Priority Watersheds Analysis***. The County has nine major watersheds, each with different water quality concerns. COPE identified location-specific outreach needs based on water quality priorities and areas where the County should target its outreach efforts. Coupled with the Audience Research Analysis, this analysis recommended target locations and audiences for developing topic-specific outreach campaigns (e.g., pet waste and lawn care).
- ***Prince George's County Stormwater Outreach and Engagement Strategies***. COPE developed seven individual campaign strategies: pet waste disposal, increasing the tree canopy, stormwater management and implementation, antilittering, lawn stewardship, household hazardous waste, and residential car care. Each campaign included goals, target audiences, priority locations, key messages, delivery techniques (e.g., events, materials, trainings, social media, and developing and promoting programs), metrics, potential partnerships, and priority neighborhoods. The campaigns also included slogans and messages on what citizens should be doing (e.g., using fertilizer only if soil tests dictate a need) and not be doing (e.g., spilling fertilizer on driveways). COPE is using these outreach and engagement strategies to plan and implement programs, events, and other efforts to encourage residents to adopt pollutant-reducing behaviors.
- ***Enhancing and Growing Partnerships***. The County's numerous partnerships with groups such as Master Gardeners, CBT, and the University of Maryland Environmental Finance Center (EFC) continue to be fostered and supported so that outreach efforts piggybacking on the efforts undertaken by those groups can continue to grow. In addition, new partnerships with groups such as landscapers, nursery suppliers, HOAs, and local boy scout or girl scout groups help broaden stormwater outreach and reach citizens who have not been reached in the past.

Although results of outreach and involvement efforts are difficult to quantify in terms of pollutant reductions, these activities make a difference by slowly changing the mindsets and behaviors of County residents over time.

10.2 Public Involvement to Support Implementation Activities

Community organizations and citizens groups can participate in restoration activities by getting involved in local nonprofit groups with which the County is currently partnering. This section lists ways County residents and organizations can stay informed and help promote pollutant-reducing behaviors. These activities will also reduce the demand on the County's resources and staff's limited time.

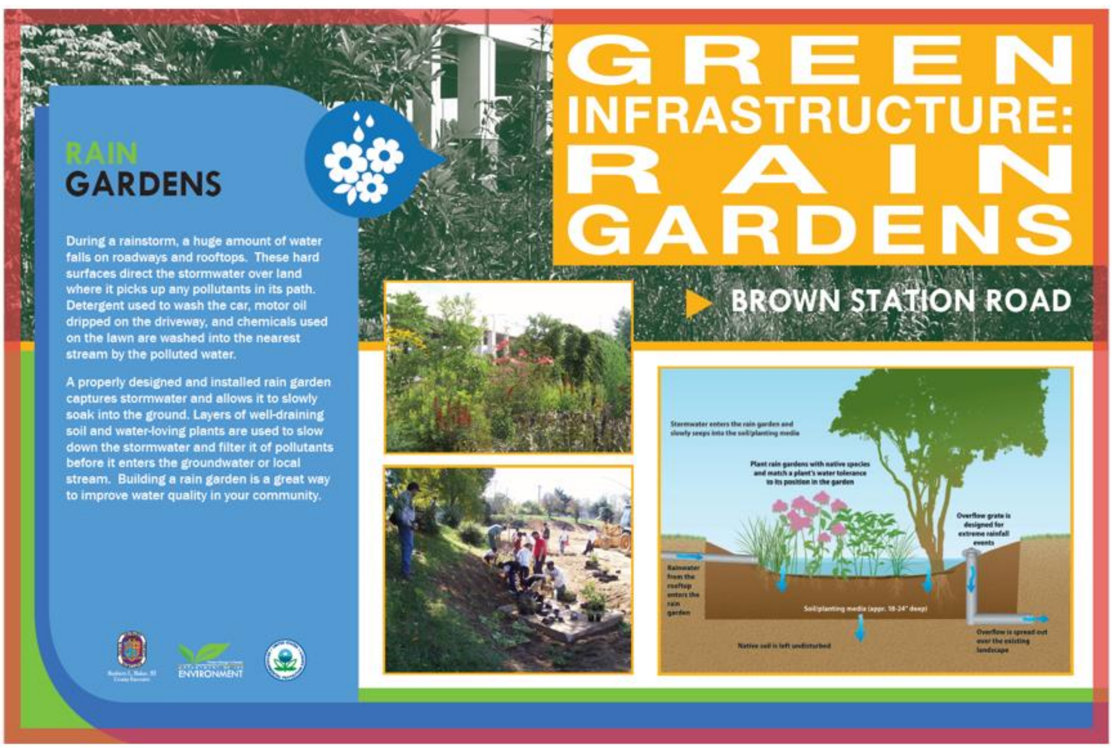
- **Learn about County programs that promote tree plantings, cleanup events, and community awareness**. COPE manages numerous programs in which citizens can get involved and promote pollutant-reducing behaviors. Residents can either organize or participate in volunteer efforts by working with their civic associations or schools, or one-on-one with property owners. The public can visit the Community Outreach web page at https://www.princegeorgescountymd.gov/351/Community-Outreach for more information on COPE programs and how to contact the County. See section 5.1.2 for details about the County's tree planting and landscape revitalization programs. Other volunteer programs included the following:
  - **Volunteer Neighborhood Cleanup Program**, which provides interested communities with technical assistance and materials such as trash bags, gloves, and roll-off containers (depending on availability). The public can visit the website at https://www.princegeorgescountymd.gov/464/Volunteer-Neighborhood-Cleanup-Program.
  - **Volunteer Storm Drain Stenciling Program**, which helps spread the word to prevent water pollution by stenciling/inlet marking the storm drains in neighborhoods with "Don't Dump - Chesapeake Bay Drainage." Stenciling serves as a visual reminder to neighbors that anything dumped in the storm drain contaminates the Chesapeake Bay. COPE provides the supplies and helps design a storm drain stenciling/inlet marking project that can be accomplished with any size team or age group at https://www.princegeorgescountymd.gov/465/Volunteer-Storm-Drain-Stenciling-Program.
- **Apply for grants to implement projects through the Chesapeake Bay Trust (CBT)**, which manages the Rain Check Rebate and Stormwater Stewardship programs as well as the Litter Reduction and Citizen Engagement Mini Grant. See section 5.1.1 for details on the Rain Check Rebate and Stormwater Stewardship programs. The public can find more information about the CBT grants at https://cbtrust.org/grants/.
  - **Litter Reduction and Citizen Engagement Mini Grants** support efforts that engage and educate residents, students, and businesses on ways to make their communities cleaner and greener. Up to $2,500 can be awarded to HOAs and nonprofits to develop and implement projects such as community cleanups, "Adopt-a-Stream" projects to remove litter from a local stream, and storm drain stenciling.
- **Stay informed**. The County provides numerous ways for residents to stay informed about community events, trainings, emergencies, and County news:
  - **Monitor the County's social media accounts** to become aware of trainings and community events that promote environmental education and include opportunities to provide feedback to the County. See the County's accounts at Facebook (PGC

Department of the Environment), Twitter (PGC Environment @PGCsprout), and Instagram (pgcsprout).

  - **Monitor the County's website** to view information about upcoming events, meetings, recent news, and details about the County's programs at https://www.princegeorgescountymd.gov/.
  - **Sign up to receive "Alert Prince George's"** to receive emergency alerts, notifications, and updates to registered devices. Example notifications include traffic conditions, government closures, public safety incidents, and severe weather. More information is available at http://www.princegeorgescountymd.gov/794/Alert-Prince-Georges.
  - **View the Clean Water Map,** an interactive tool to help the community stay informed about the health of County waters and know where restoration efforts are taking place. Residents can view BMPs, BMP drainage areas, and locations of activities such as Rain Check Rebates and Stormwater Stewardship Grants at https://princegeorges.maps.arcgis.com/apps/webappviewer/index.html?id=dc168a43d3554905b4e4d6e61799025f.

- **Provide feedback**. The County heard through numerous outreach and engagement events that several citizens and watershed groups want to provide information and feedback about on-the-ground support for BMP implementation projects, programmatic initiatives, and other outreach efforts to support implementation. Ways to provide this feedback include the following:
  - **Attend a public involvement meeting.** The County holds public outreach and involvement meetings as part of restoration planning efforts and other programs. At these meetings, residents can suggest specific locations for biological or water quality monitoring activities to be carried out based on surrounding land uses/ changes, historic water quality problems, or public desires. The County also welcomes suggestions on potential BMP types or locations so that the County can help communities identify and install the best BMPs for specific areas.
  - **Use County Click 3-1-1**, a call center (available weekdays 7 a.m. to 7 p.m.) and a website application (download CountyClick311Mobile) that allows County residents to request services or report problems. This tool could be used to report on visual inspections of installed BMPs and is available at www.countyclick311.com.
- **Help foster partnerships.** Residents and civic and environmental groups can work directly with an organization or commercial business that has a significant amount of untreated impervious surface such as large parking lots or a large building footprint. The groups can help obtain a commitment from the business to participate in the Rain Check Rebate Program or Alternative Compliance Program, or install stormwater BMPs on the property. Group members can offer technical assistance and volunteer labor hours to support installation and/or maintenance. The participating civic or environmental group should discuss the selected location and BMP type with the County prior to working with the property owner. Groups can also work with established organizations such as the Alice Ferguson Foundation https://fergusonfoundation.org/to participate in cleanup events or provide volunteer hours.

- **Become educated through partner trainings and events**. Numerous organizations in Prince George's County are always in need of volunteers. They also provide meaningful education programs in which participants learn about the issues through hands-on educational experiences. Those organizations include the following:
  - **Watershed Stewards Academy** equips and supports community leaders to recognize and address local pollution problems in their nearby streams and rivers. They provide community leaders with the tools and resources they need to bring solutions to those problems, restoring their local waterways and the communities they affect. More information is available at http://extension.umd.edu/watershed/watershed-stewards-academy.
  - **Alice Ferguson Foundation** has training and outreach events to unite students, educators, park rangers, communities, regional organizations, and government agencies throughout the Washington, DC, metropolitan area to promote the environmental sustainability of the Potomac River watershed. More information is available at https://fergusonfoundation.org/.
  - **Anacostia Watershed Society** has numerous educational programs, river restoration programs, and community events. More informaitn is available at https://www.anacostiaws.org/.



11 Tracking and Adaptive Management

The County is required by its MS4 permit to:

> …[e]valuate and track the implementation of restoration plans through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs.

The County will fulfill this requirement by producing its annual MS4 report and undertaking additional environmental monitoring. The County intends not only to track its implementation of this restoration plan but also to evaluate how well its efforts improve conditions in the County's surface waters and adjust its restoration activities accordingly. The County will use the data from tracking and monitoring efforts to inform its adaptive management of this restoration plan.

11.1 Implementation Tracking

To assess reasonable compliance with its permit, the County has an effective process in place to track and report pollutant load reductions. The County's annual MS4 report is the main mechanism for tracking permit activities and reporting them to MDE. While DoE is responsible for its submittal, it is a collaborative effort between DPW&T and the Department of Permitting, Inspections, and Enforcement. The completed annual report and appendices are posted on DoE's stormwater management website.[2]

As specified in the County's permit, the annual report includes information about the County's BMP implementation, IDDE, trash and litter control measures, public outreach and education initiatives, watershed assessments, and funding. It is the chief vehicle for tracking and reporting BMP implementation and programmatic initiatives. The annual report provides the following information:

- Estimated pollutant load reductions resulting from all completed structural and nonstructural water quality improvement projects and enhanced stormwater management programs.
- Comparison of achieved load reductions to required load reductions to determine the degree to which the County is meeting its restoration goals or needs to adjust its programs to be more effective.

The annual report is accompanied by supplemental data about BMPs (including alternative practices such as stream restoration, septic system upgrades, and tree planning), funding, and water quality. Data about all the County's stormwater BMPs are provided in a georeferenced database. For each BMP, the database provides descriptive details, including BMP type, project location, drainage area delineation, and equivalent acres of impervious surface treated. County staff update the database as new projects are completed and approved.

11.2 Biological and Water Quality Monitoring

The purpose of monitoring conditions in the watershed is to determine the degree to which implementation of the restoration plan is resulting in the intended improvements. DoE

[2] https://www.princegeorgescountymd.gov/293/NPDES-MS4-Permit. Accessed April 2019.

recognizes that effective environmental monitoring requires a long-term commitment to routine and consistent sampling, measurement, analysis, and reporting. Although some of the monitoring requirements for assessing progress toward meeting TMDLs originate with MDE, others reflect the County's own interest in providing additional meaningful information to policymakers and the public.

Biological indicators will continue to be used to document and report ecological conditions in the PR-L and PR-M watersheds. Other types of monitoring will contribute to understanding whether restoration activities are leading to the elimination, reduction, or otherwise more effective management of pollutants within the County. To ensure that the compiled data sets are of known and acceptable quality, monitoring is performed in accordance with a quality plan with standard operating procedures and performance standards for sample collection.

11.2.1 Biological Monitoring

The biological condition of the County's streams is rated using MD DNR's B-IBI, which is calculated based on the number of different kinds of organisms (benthic macroinvertebrates) found in samples taken along a stream section, or reach. Because the types of organisms found reflect the cumulative influence of a variety of environmental factors, a low B-IBI value alone is unlikely to point definitively to a singular pollutant or other stressor that should be reduced to improve the condition of the stream. Rather, the usefulness of the B-IBI in the context of a stream restoration effort is that a sufficiently long record of B-IBI values can be expected to reveal the overall effect of a broad restoration program aimed at eliminating, reducing, or otherwise managing known and potentially unknown stressors and their sources.

Since 1999, the County has been continuously implementing biological monitoring and assessment. Sampling at each stream location focuses on the benthic macroinvertebrate populations, physical habitat quality, and *in situ* water quality (pH, conductivity, temperature, and DO). Site locations were selected for each round using a stratified random process, where all wadeable, nontidal streams were stratified by subwatershed and stream order. Stream order designations (generally, first through fourth order) were based on the Strahler system of 1:100,000 map scale (Strahler 1957). Distribution of sample locations was more heavily weighted to smaller first- and second-order streams. The County is currently implementing the first year of Round 4 (R4), which will span from 2019 to 2021. For each subwatershed, the County will obtain a value for percent biological degradation from R3, noting the intensity of impairment and any known or most probable sources of pollution or other stressors. It will then compare the percent degradation with the values found in R4 to determine the direction and magnitude of changes.

The County will focus its efforts on areas of BMP implementation by the CWP. Additional and more detailed analyses of conditions and data in individual subwatersheds can help associate stream biological health with implementation of BMPs (and programmatic initiatives) so the County can adjust its restoration strategy, if needed, as part of its vision for overall adaptive management.

The approach presented in this plan assumes continuation of routine, countywide monitoring of biological conditions for wadeable streams in R4 and beyond, with potentially additional effort being applied to data analyses related to physical habitat characteristics, altered hydrology, and water chemistry. This not only provides insight into those stressors most likely causing biological degradation, but also aids in identifying sources of stressors where additional restoration efforts would be beneficial.

The stepwise progression presented in this section can be applied to any watershed in the County. The evaluation of changes in biological health is focused on the County's framework of subwatersheds, although for assessments it is possible to group on the larger scales of the major watersheds (Patuxent River [Lower, Middle, and Upper], Anacostia River, Mattawoman Creek, Piscataway Creek, and Potomac/non-Anacostia River, and Western Branch) as well as countywide.

- *Step 1*. Record percent biological degradation of subwatershed A from the most recent biological assessment report (R3), noting intensity of impairment and known or most probable sources of pollution or other stressors.
- *Step 2*. Compare percent biological degradation of subwatershed A from subsequent monitoring (R4) and determine whether positive change or an improvement (A:R3 > A:R4), negative change or further degradation (A:R3 < A:R4), or no change (A:R3 = A:R4) has occurred. Use 90-percent confidence intervals as provided in biological assessment reports to document relative significance of changes. This procedure constitutes trend analysis for assessing changes in biological condition.

Countywide biological monitoring is a routine part of the County's current monitoring strategy and occurs in 3-year cycles, for which funding is in place for 2019–2021. In addition, MD DNR conducts the MBSS (a qualitative fish survey) and, in the spring, the Metropolitan Washington Council of Governments conducts fish surveys to provide additional biological health measurements for Anacostia River tributaries.

11.2.2 Water Quality Monitoring

The County will continue dry- and wet-weather monitoring to determine the concentrations of various pollutants, including TSS, using MDE-approved methods and laboratories. Water quality monitoring is conducted to assess a set of upstream restoration practices. The County will request that MDE allow the County to relocate its two NPDES monitoring stations in Bear Branch watershed to another watershed. The new monitoring locations will be downstream of multiple planned restoration activities (e.g., ESD practices, stream restoration, and public outreach). The County also requested that MDE continue its Integrated Report assessment monitoring in the watersheds.

Currently, the County does not have the resources to conduct water quality monitoring at multiple locations throughout the County. If monitoring were to be conducted in each watershed in the County, then funding availability for implementing restoration activities would be substantially reduced. Although it is desirable to monitor the farthest downstream location in a subwatershed, several other siting factors must also be considered, including location of potential restoration activities, site accessibility, presence of stream flow gages, and proximity to prior water quality monitoring stations (which can be advantageous in helping establish long-term trends).

Monitoring will not be conducted at any individual BMP sites to assess their effectiveness in reducing pollutant loads. Pollutant removal efficiencies have already been established for the proposed BMP types, so only new and innovative BMPs will need to be individually monitored to assess their load reduction capabilities.

The County will use the monitoring data to assess the overall load reductions from upstream activities in a watershed with a large amount of planned activity. The data will also be reviewed to assess trends, including whether improvement was gradual or loadings significantly decreased in 1 year, and which practices were installed in the previous year and how they related to load reductions in the stream. There is natural variability in stream water quality. Looking into smaller watersheds with fewer implementation activities occurring could make it difficult to separate improvements from natural variability. By looking at a watershed with larger scale implementation, the improvements as a direct result of that effort should be more easily identified. The County can look at the observed load reductions in the stream, compare them to the projected load reductions, and adjust accordingly. Those adjustments would not only be applied to the monitored watershed but also countywide in other restoration plans. Adjustments could take the form of implementing more BMPs, using different types of BMPs, or expanding education and outreach efforts.

11.3 Adaptive Management Approach

The County will continue watershed restoration using the best information available at the time the plan was developed. As implementation progresses, an adaptive management approach will facilitate adjustments to restoration activities as new information becomes available and opportunities emerge to increase effectiveness and reduce costs. It will be important for the County, MDE, and watershed partners to work together on adaptive management approach to ensure successful ongoing implementation.

For this restoration plan, adaptive management will involve stream monitoring, evaluating applied strategies, analyzing and interpreting biological assessments at multiple spatial scales, assessing progress, and incorporating any useful new knowledge into expanding restoration efforts. As part of its NPDES permit, the County evaluates its countywide water restoration progress at the end of each permit cycle (anticipated to start in late 2019 / early 2020) following this adaptive management approach. The evaluation will take advantage of an updated BMP inventory, new BMP technologies, experience with the new programmatic initiatives, and more current water quality data.

Close coordination in applying adaptive management is especially valuable because of the possibility of unanticipated circumstances arising during restoration plan implementation. As examples, the installed BMPs might remove significantly more or less pollution than expected; a natural disaster could affect the plan’s implementation; or, if BMPs are being implemented at a slower rate than is called for in the restoration plan, the adaptive management process will need to include a look at the causes of the lag in implementation and either address those causes or otherwise propose changes to the plan to accommodate the lag. Implementation lags can be caused by a lack of available land, delays in obtaining the necessary permits for constructing BMPs, being denied permission to build a BMP on private land, and lapses in funding. In addition, implementing this restoration plan depends on public and private entities effectively modifying some of their behaviors regarding trash and lawn care.

Several aspects of this restoration plan support the use of adaptive management:

- Determining the most appropriate restoration practices at the best locations. The County will look across land uses to determine where restoration projects will be most cost-effective in achieving pollutant load reductions. The County reserves the right to use alternative restoration activities if the opportunity arises and the alternative practices will produce greater load reductions than ESD practices or a similar load reduction at a lower cost.
- Helping to reduce long-term costs while increasing load reduction. The County recognizes that future BMP-related research could result in new, more efficient pollution reduction technologies becoming available. Those advances could reduce cost, reduce BMP footprints, or increase load reduction efficiencies. Some of the advances could come from proprietary technologies, which the County will evaluate based on their cost and performance.
- Using biological monitoring results. DoE can adjust implementation priorities and target areas of poor stream health within the watershed. The biological assessment results will be interpreted at multiple spatial scales as Degraded/Not Degraded (for specific stream sites) and percent degradation. The County will use those results as the principal indicator of stressor reduction effectiveness. A lack of positive response will be taken as evidence that additional or more intensive stormwater management is necessary to achieve ecologically meaningful pollutant reductions.

In the future, climate change will play a role in watershed restoration and BMP implementation. The County is becoming more aware of the potential effects of climate change and their impact on BMPs. EPA conducted a modeling study investigating the resilience of BMPs in withstanding more extreme precipitation events caused by climate change (USEPA 2018). The results of the study found that BMPs designed for current conditions will most likely fail to sufficiently treat and reduce runoff from the projected larger and more intense storm events. That failure could cause stormwater to overflow or damage BMPs; the BMPs would not treat all the runoff and would not reduce runoff volume reaching the County’s water bodies. That situation, in turn, could result in downstream channel erosion and flooding. BMPs developed with current design standards will require a larger temporary storage volume or reconfigured outlet structures to reduce the hazard of flooding and channel erosion likely to be experienced from more frequent and intense precipitation events in the future.

The County proposes to evaluate progress from the local TMDL restoration plans in the third year of each MS4 permit cycle and update this plan if necessary. The new permit is expected in late 2019, so the updates would be in 2021/2022. They will use more comprehensive information on the actual rate of implementation and take advantage of recent technological advances and increases in BMP load reduction efficiencies to more accurately estimate the end date by which the load reduction targets will be met. In addition, R4 of the countywide biological assessments will be completed in 2021 and used in the revision process. The results of each of the revisions will be included in a plan addendum with updates to provisional milestones and costs.

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