December 21, 2018

Restoration Plan for the Western Branch Watershed in Prince George's County

Prepared for:
Prince George's County, MD
Department of the Environment
Stormwater Management Division
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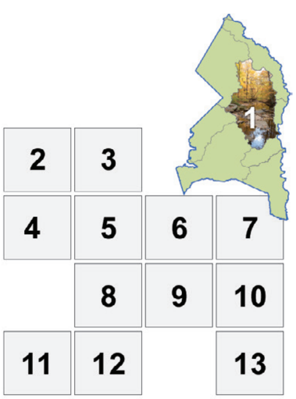

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Contents

Figures

Tables

Acronym List

B-IBI	Benthic Index of Biotic Integrity
BMP	best management practice
BOD	biochemical oxygen demand
CAST	Chesapeake Assessment Scenario Tool
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	[Prince George's County] Department of Public Works and Transportation
EFC	Environmental Finance Center
EPA	U.S. Environmental Protection Agency
ESD	environmental site design
°F	degrees Fahrenheit
FY	fiscal year
GIS	geographic information system
HSG	hydrologic soil group
IA	impervious acres
IDDE	Illicit Discharge Detection and Elimination
lb	pound
LF	linear feet
LID	low impact development
MBSS	Maryland Biological Stream Survey
MD DNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mi	mile
mg/L	milligrams per liter
M-NCPPC	Maryland-National Capital Park and Planning Commission
MS4	municipal separate storm sewer system
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
OS	outfall stabilization
ROW	right-of-way
RR	runoff reduction
SCA	Stream Corridor Assessment
SR	stream restoration
SR3	Sewer Repair, Replacement and Rehabilitation Program

SSO	sanitary sewer overflow
ST	stormwater treatment
STORET	STOrage and RETrieval
TMDL	total maximum daily loads
TN	total nitrogen
TP	total phosphorus
TS	trash score
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	wasteload allocation
WSA	Water and Science Administration
WSSC	Washington Suburban Sanitary Commission
WTM	Watershed Treatment Model

1 Introduction

The Water and Science Administration (WSA) of the Maryland Department of the Environment (MDE) awarded a grant to the Prince George's County (the County) Department of the Environment (DoE) to develop a comprehensive watershed restoration plan for the Western Branch watershed. Restoration plans were previously developed in 2014 for the County portions of the watersheds associated with the Anacostia River; Mattawoman Creek; Piscataway Creek; the Upper Patuxent River and Rocky Gorge Reservoir; and polychlorinated biphenyl (PCB) impacted water bodies. This plan was developed in a similar way, following guidance provided by MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2014).

1.1 What is a Restoration Plan?

The County's plan will address the watershed's load reduction targets from the Chesapeake Bay total maximum daily load (TMDL).

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 per day). The mass per unit time is called the "load." For instance, a TMDL could stipulate that a maximum load of 1,000 pounds of sediment per day could be discharged into an entire stream before the stream experiences any detrimental effects. The pollution diet for a given pollutant and water body is composed of the sum of individual wasteload allocations (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:

$$\text{TMDL} = \Sigma \text{ WLAs} + \Sigma \text{ LAs} + \text{MOS}$$

A WLA is the portion of the overall pollution diet assigned to permitted dischargers, such as the County's municipal separate storm sewer system (MS4) stormwater system. The County's new MS4 permit requires that the County develop local restoration plans to address each U.S. Environmental Protection Agency- (EPA-) approved TMDL with stormwater WLAs.

Figure 1-1 shows a generalized TMDL schematic. A TMDL identifies the maximum amount of pollutant load that 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 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. Relative to the baseline load levels determined for the year 2010 and TMDLs established in 2010, the required load reductions for the Western Branch watershed are

20.2 percent for total nitrogen (TN), 35.3 percent for total phosphorus (TP), and 29.7 percent for total suspended solids (TSS).

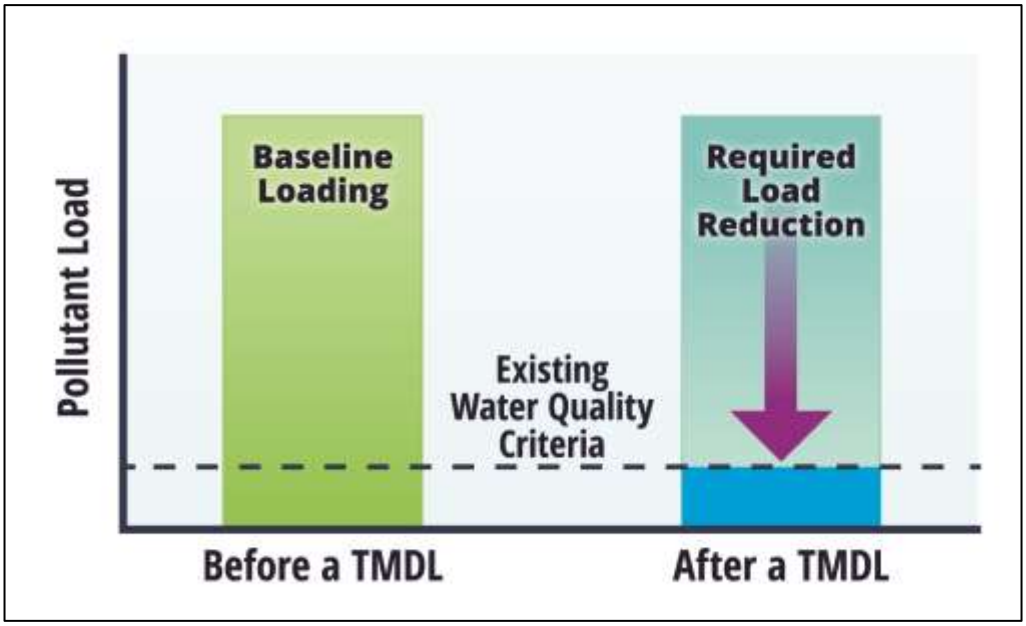


Figure 1-1. Conceptual schematic of a typical pollution diet, or TMDL.

1.2 Watershed Restoration Goals and Objectives

Watershed goals for the Western Branch should give priority to, but not be limited to, meeting the Chesapeake Bay TMDLs, which have been developed for all the watersheds in the County. The overarching goals for the Western Branch watershed are the following:

- Restore watershed functions, including predevelopment hydrology, sustained water quality for designated uses, and healthy natural habitats.
- Comply with applicable regional, state, and federal regulations.
- Increase awareness and stewardship within the watershed, including encouraging policymakers to develop policies that support a healthy watershed.
- Protect human health, safety, and property.
- Improve quality of life and recreational opportunities.

The watershed objectives describe more specific outcomes that would achieve the overarching goals. The objectives for the Western Branch watershed are the following:

- Achieve pollutant load reductions to comply with regulatory requirements.
- Restore hydrology, water quality, and habitat functions in wetlands and streams.
- Implement best management practices (BMPs) and programmatic strategies that restore hydrologic and water quality functions and protect downstream aquatic habitat and designated uses.
- Protect land that supports rare and/or threatened high-quality terrestrial, wetland, and aquatic habitats.

- Educate watershed stakeholders and create opportunities for active public involvement in watershed restoration.
- Integrate watershed protection and restoration in policy-making processes at the local level.

1.3 Structure of the Plan

This document presents the restoration plan in six major sections:

- *Section 2 Watershed Characterization* summarizes the natural features (hydrology, climate, topography, and soils) and land cover of the watershed.
- *Section 3 Water Quality Conditions* outlines the water chemistry and biology of the watershed. It also includes information on trash and litter in the watershed.
- *Section 4 Watershed Conditions* identifies pollutant sources and reviews the existing conditions in the watershed in relation to impervious area and the stormwater conveyance system.
- *Section 5 Restoration Methodology Development* documents the methodology for identifying management options.
- *Section 6 Restoration Activity Identification* provides details on the proposed management activity options, including estimated costs and load reductions.
- *Section 7 Tracking and Adaptive Management* outlines the approach for tracking and monitoring implementation progress and adaptive management.

2 WATERSHED CHARACTERIZATION

The Western Branch watershed lies entirely within Prince George's County, MD, as shown in Figure 2-1. It discharges into the Upper Patuxent River near Jug Bay and has a drainage area of about 110 square miles. The watershed includes portions of Bowie, District Heights, Glenn Dale, Goddard, Kettering, Marlton, Mitchellville, New Carrollton, Rosaryville, Springdale, Upper Marlboro, Walker Mill, and Woodmore as well as some federal lands (e.g., portions of Joint Base Andrews and the National Aeronautics and Space Administration Goddard Space Flight Center) and state lands (e.g., Rosaryville State Park). Overall, the watershed is primarily privately owned residential land (Figure 2-2). Figure 2-2 was created using parcel information, which does not include roadway information.

In the Western Branch watershed, water flows through a dense network of streams, 185 miles (mi) of which are large enough to be mapped. Stream flow is primarily nontidal, with the lower 5 mi (roughly the area below the State Route 4 bridge) influenced by tidal boundary conditions on the Patuxent River.

The population of the Western Branch watershed is approximately 177,920 (U.S. Census 2010). Figure 2-3 shows the population density by census tract.

2.1 Physical and Natural Features

2.1.1 Hydrology

The main stem of the Western Branch is approximately 20 mi long, and its depth ranges from about 1–2 feet in the upper reaches to about 3–4 feet near its confluence with the Patuxent River. Western Branch is subdivided into eight major subwatersheds (Figure 2-1). Their area and relative sizes are presented in Figure 2-4.

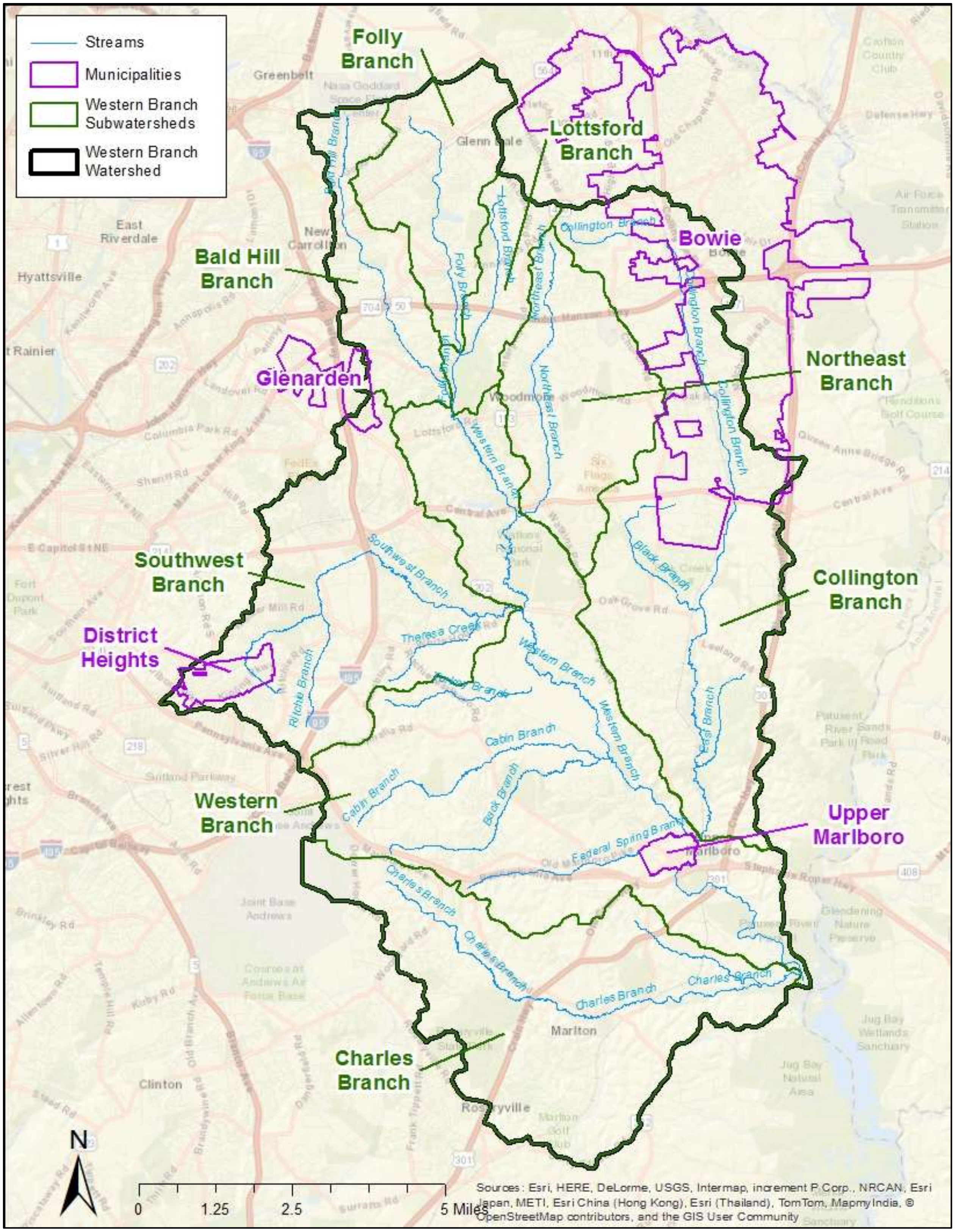


Figure 2-1. Location of the Western Branch watershed.

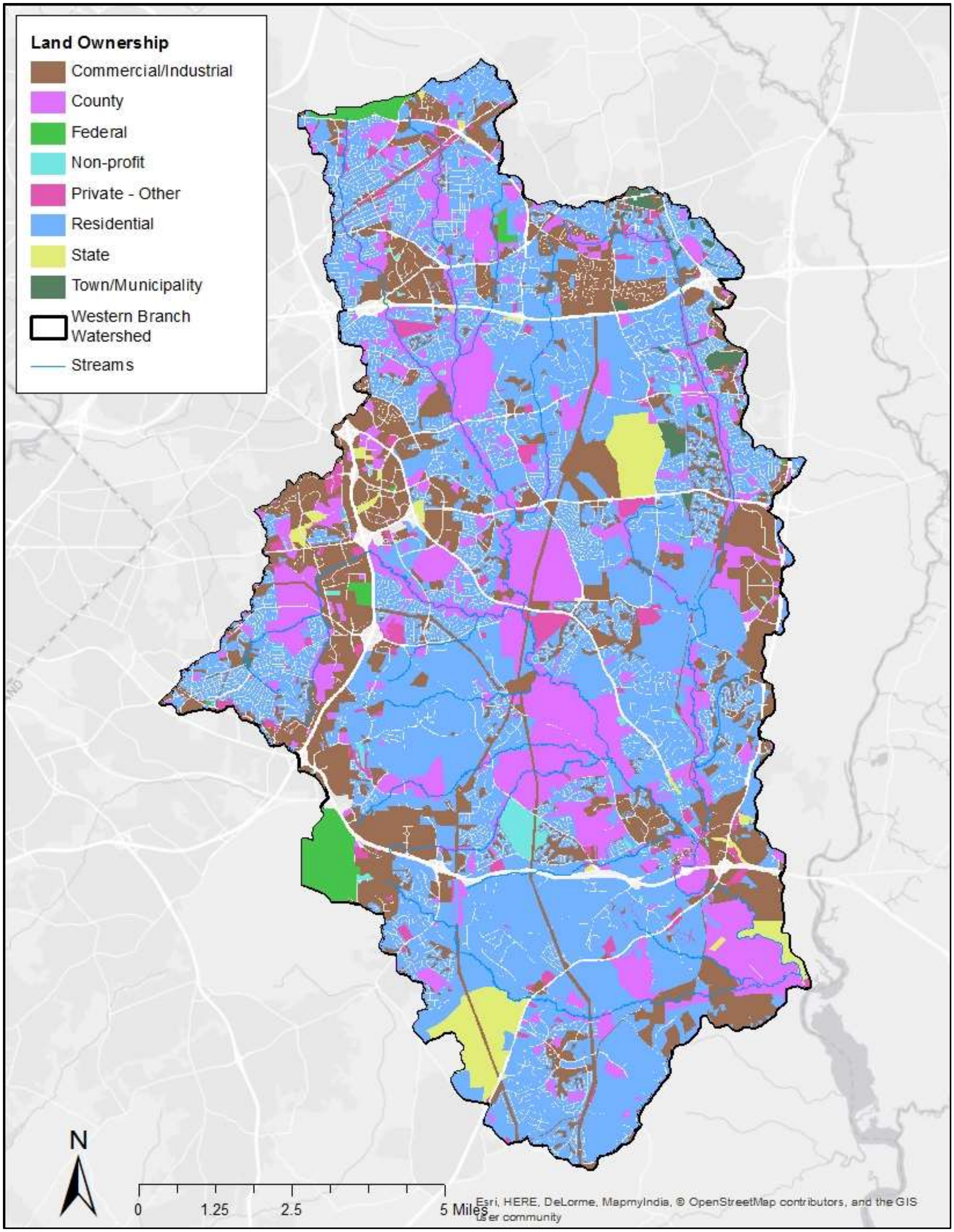
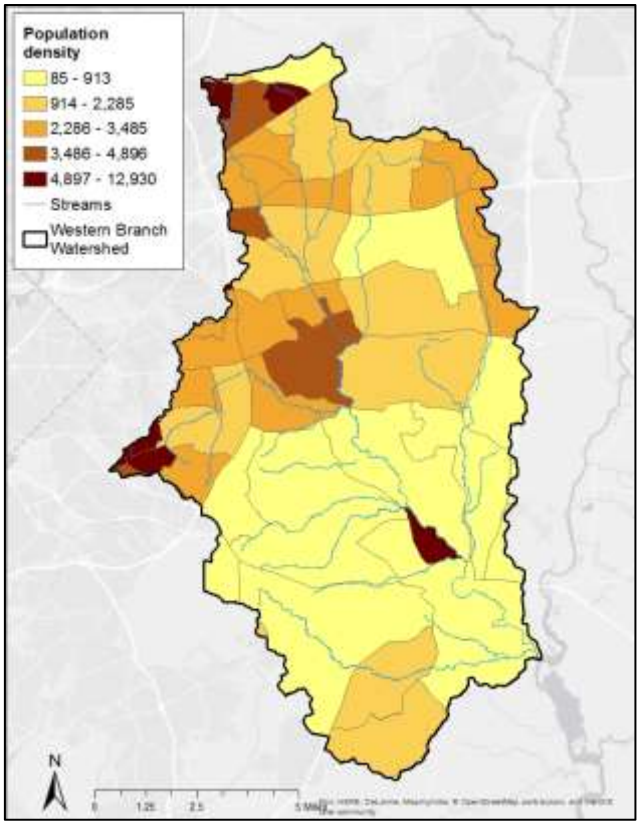


Figure 2-2. Land ownership in the Western Branch watershed.



Source: US Census 2010.

Figure 2-3. Population density (people per square mile) in the Western Branch watershed.

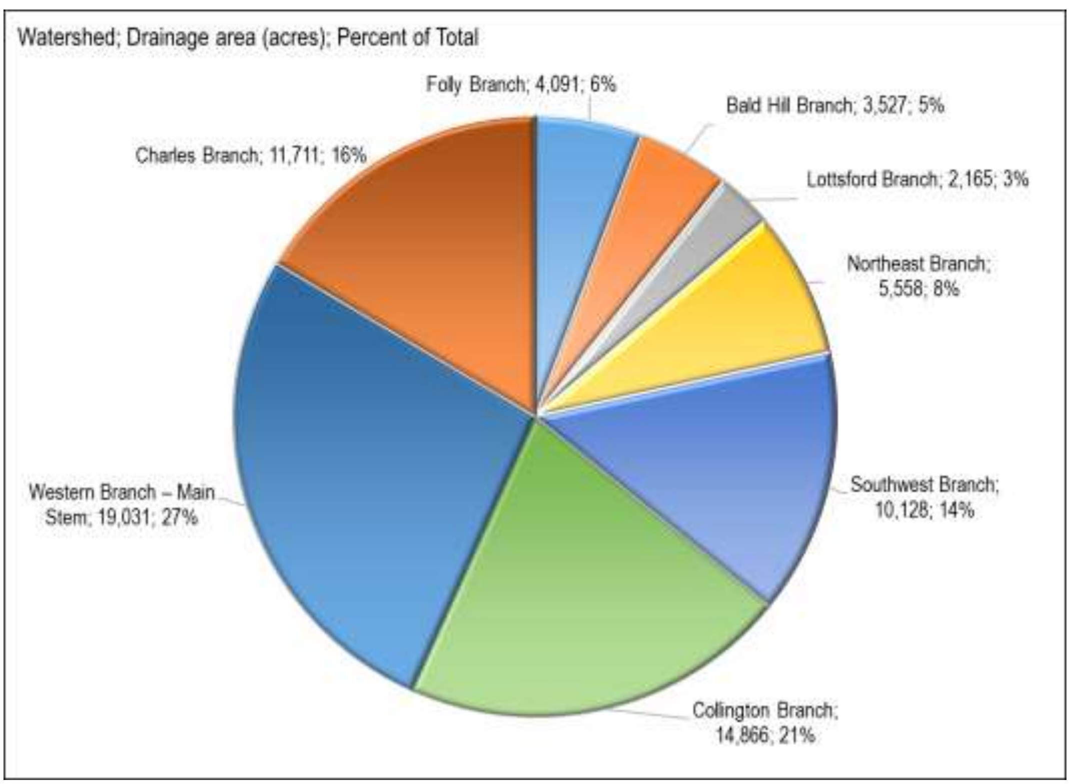


Figure 2-4. Relative areas of subwatersheds of the Western Branch.

2.1.2 Climate/Precipitation

The climate of the Western Branch watershed is characterized as temperate. The National Weather Service Forecast Office (NWS 2018a) reports a 30-year average annual precipitation of 39.74 inches. 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). 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). The normal monthly precipitation and temperature for Upper Marlboro are presented in Figure 2-5 (NOAA 2018). Average monthly temperatures range from approximately 33 °F in January to a peak of almost 80 °F in July. Precipitation is highest in late spring to late summer.

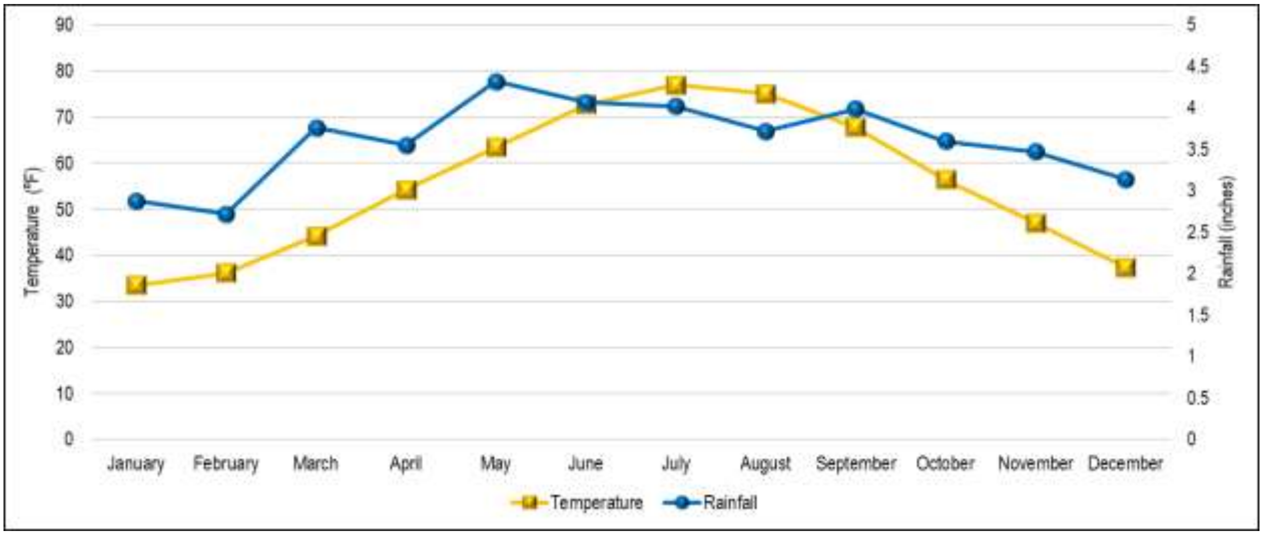
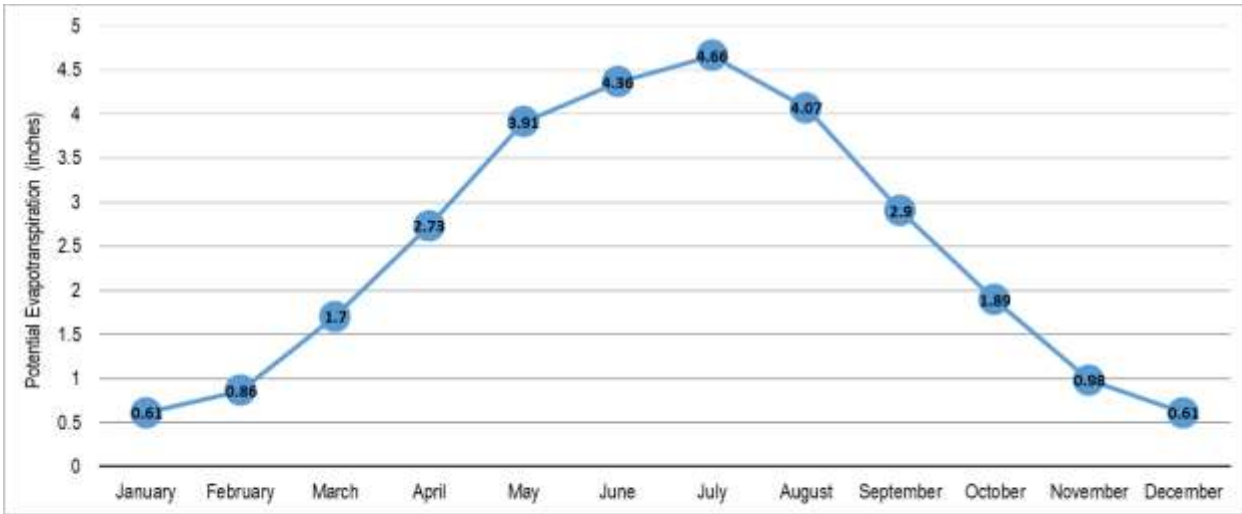


Figure 2-5. Average monthly temperature and precipitation.

Evapotranspiration accounts for water that evaporates from the land surface (including water bodies) or is lost through plant transpiration. Evapotranspiration varies throughout the year because of climate but is greatest in the summer. A standard quantity called "potential evapotranspiration" (Figure 2-6) is the amount of water that would be pulled into the air from a healthy grass-covered surface. That amount is affected by solar radiation, air temperature, vapor pressure, and wind speed. Expected rates of evaporation constitute a design consideration for certain BMPs, particularly those that have permanent water (e., wet ponds) or rely on moisture-rich soils (e.g., wetlands).

The County is reviewing the potential effects of climate change in the County. Climate change is the result of rising temperatures due to 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 increased evaporation, increased humidity, higher average rainfall, and greater occurrences of heavy rainstorms in some regions and droughts in others (USEPA 2016). Though 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 increased 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 these seasons. The higher rates of evaporation will also likely result in drier soil during the summer and fall.



Source: NRCC 2018.

Figure 2-6. Average monthly potential evapotranspiration in inches (1981–2010).

2.1.3 Topography/Elevation

According to the Maryland Geological Survey, the Western Branch watershed lies in the Coastal Plain geologic province, which is characterized by gentle slopes and drainage, and deep sedimentary soil complexes (MGS 2014). As illustrated in Source: M-NCPPC 2014.

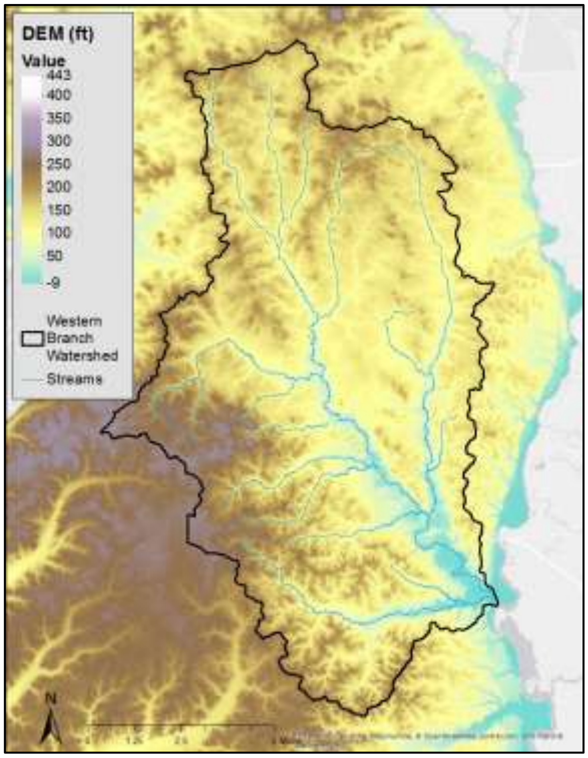
Figure 2-7, the watershed is relatively flat, with higher elevations in the range of 200 feet in the upper portions of the Southwest, Turkey, and Cabin branches. Since the landscape tends to have steeper slopes at the higher elevations, streams will flow faster in those areas. Tides in the downstream section are quite weak and variable, with the head of tide near the Route 301 bridge south of Upper Marlboro.

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 (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.

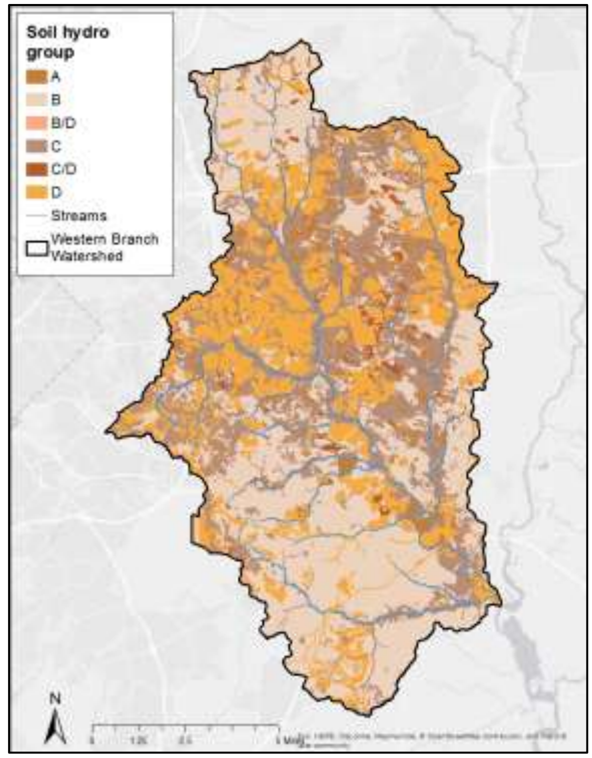
Figure 2-8 shows the locations of the different USDA HSGs across the Western Branch watershed (USDA 2003). Soils in group B are the predominant soils in the watershed, while soils in group A are the least common.

Soils in the urbanized portions of the watershed are frequently also classified as urban land complex, or “udorthent,” soils. These soils 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.



Source: M-NCPPC 2014.

Figure 2-7. Elevation in the Western Branch watershed.



Source: USDA 2003.

Figure 2-8. Hydrologic soil groups in the Western Branch watershed.

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 Western Branch subwatersheds is available from the Maryland Department of Planning 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 Western Branch watershed by subwatershed. Figure 2-2 shows land use in the watershed. Figure 2-10 shows the percent of tree canopy in each subwatershed.

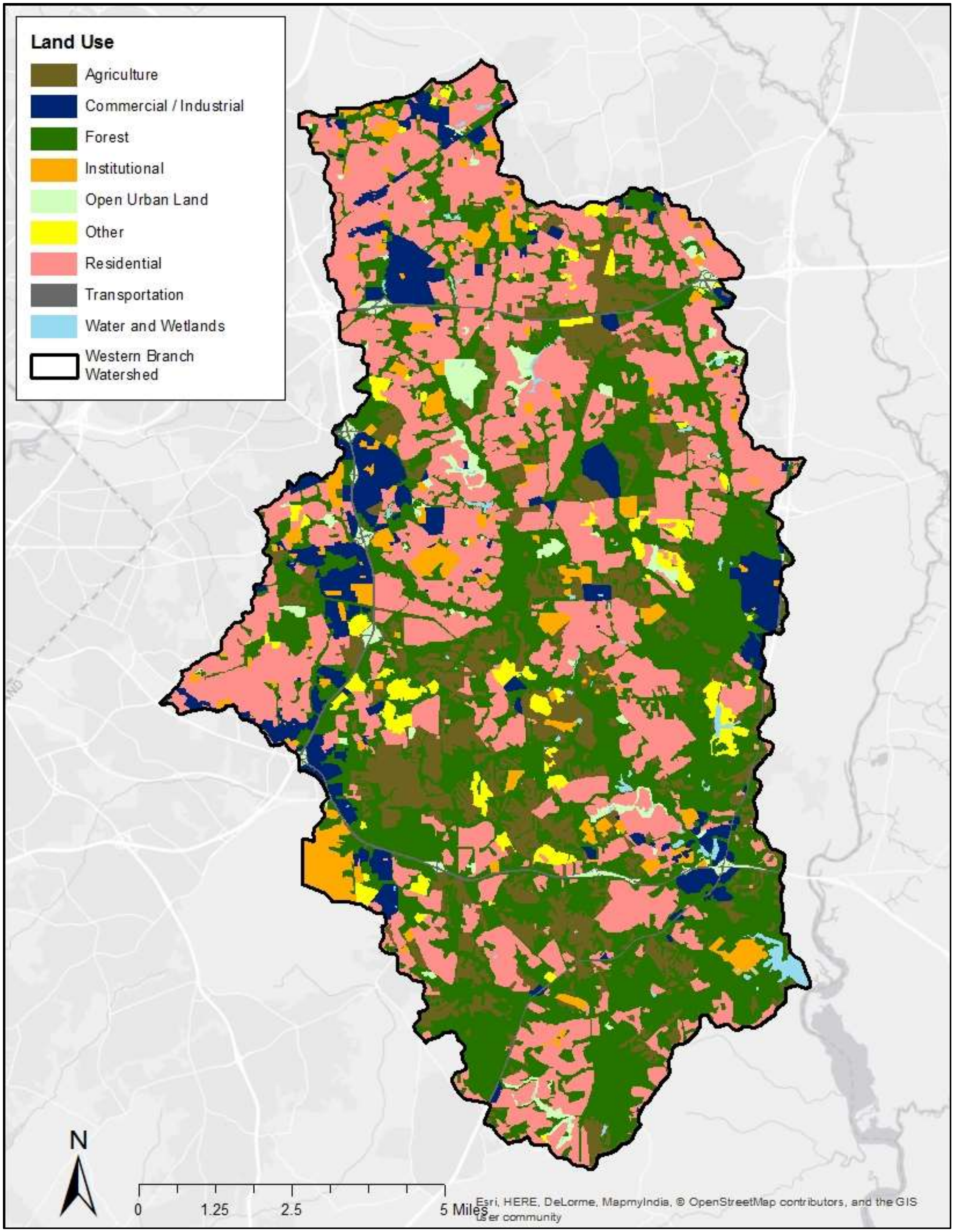
Overall, about half (48 percent) of the land use in the watershed is urban and about one-third of that is residential. In the residential land use category, 19 percent of the land is characterized as medium-density residential, with smaller amounts as high- and low-density residential. There are also significant areas of forested land (36 percent) and agriculture land (12 percent).

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

Table 2-1. Western Branch watershed land use by subwatershed

Land Use (acres)	Bald Hill Branch	Charles Branch	Collington Branch	Folly Branch	Lottsford Branch	Northeast Branch	Southwest Branch	Western Branch Main Stem	Total	% Total
Agriculture	28	1,479	1,523	29	156	891	724	3,807	8,636	12.2%
Agricultural building		18	7					14	39	0.1%
Cropland	7	906	1,181		101	685	476	2,574	5,930	8.3%
Large lot subdivision (agriculture)		50	44	5	22	44	16	59	240	0.3%
Pasture	20	426	291	24	34	162	232	1,124	2,313	3.3%
Row and garden crops		80				0		36	115	0.2%
Forest	745	5,655	5,863	853	566	1,624	2,665	7,743	25,714	36.2%
Brush		180	259	13	20	77	170	648	1,367	1.9%
Deciduous forest	602	5,010	5,369	645	504	1,268	2,333	6,613	22,344	31.4%
Evergreen forest	12	73	30	22			5	65	207	0.3%
Large lot subdivision (forest)	21	341	195	13	26	90	43	265	993	1.4%
Mixed forest	111	52	10	159	17	188	114	152	803	1.1%
Other	64	145	591	39	14	91	257	606	1,807	2.5%
Bare ground	64	145	591	39	14	91	257	606	1,807	2.5%
Urban	2,683	4,357	6,795	3,129	1,424	2,918	6,467	6,611	34,383	48.3%
Commercial	63	91	259	284	38	296	593	414	2,038	2.9%
High-density residential	159	211	420	232	95	237	1,015	767	3,135	4.4%
Industrial	349	154	634	275			1,140	361	2,914	4.1%
Institutional	283	555	298	164	165	108	693	827	3,093	4.4%
Low-density residential	149	1,772	2,007	660	355	1,277	229	1,165	7,614	10.7%
Medium-density residential	1,579	1,363	2,827	1,473	519	832	2,385	2,427	13,405	18.9%
Open urban land	55	139	200	27	229	136	198	420	1,403	2.0%
Transportation	47	72	149	14	23	31	215	231	782	1.1%
Water and wetlands	7	75	94	41	5	34	14	265	535	1.0%
Water	7	33	87	41	5	34	14	127	348	0.5%
Wetlands	0	42	7	0	0	0	0	138	187	0.3%
Total	**3,527**	**11,711**	**14,866**	**4,091**	**2,165**	**5,558**	**10,128**	**19,031**	**71,076**	**100.0%**

Source: MDP 2010.



Source: MDP 2010.

Figure 2-9. Land use in the Western Branch watershed.

2.2.2 Imperviousness

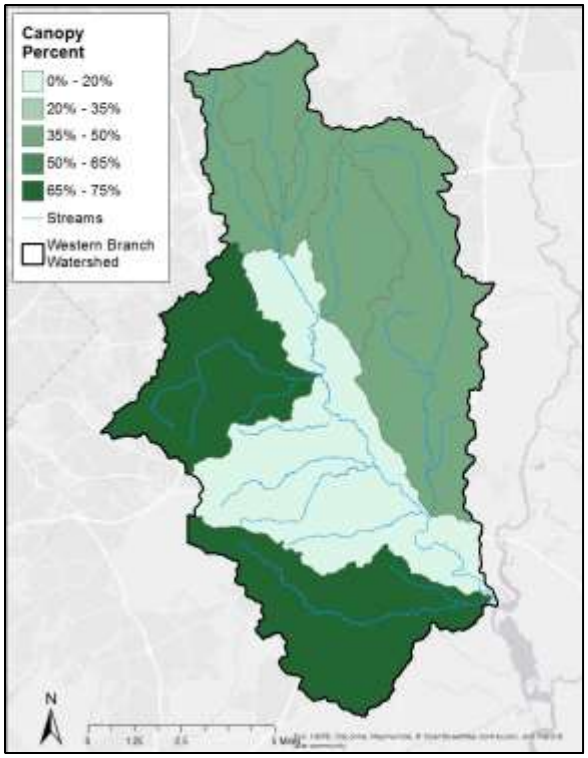
Impervious area is the land surface that is covered with solid material or is compacted to the point at which water cannot infiltrate into underlying soils (e.g., parking lots, roads, houses, patios, swimming pools, and compacted gravel areas). Consequently, impervious areas resulting from land development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

Compared to naturally vegetated areas, impervious areas generally decrease the amount of water infiltrating into the soils to become groundwater and increase the amount of water flowing to the stream channels in the watershed. This increased surface flow not only carries greater amounts of nutrients and other pollutants, but also increases the velocity of the streams, which worsens erosion. More 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 for nutrient loading to waterways than roofs because of the grass clippings and potentially fertilizer, which can accidentally be spread on a drive way. Sidewalks have higher bacteria loadings than driveways because of the number of dogs that are walked along sidewalks.

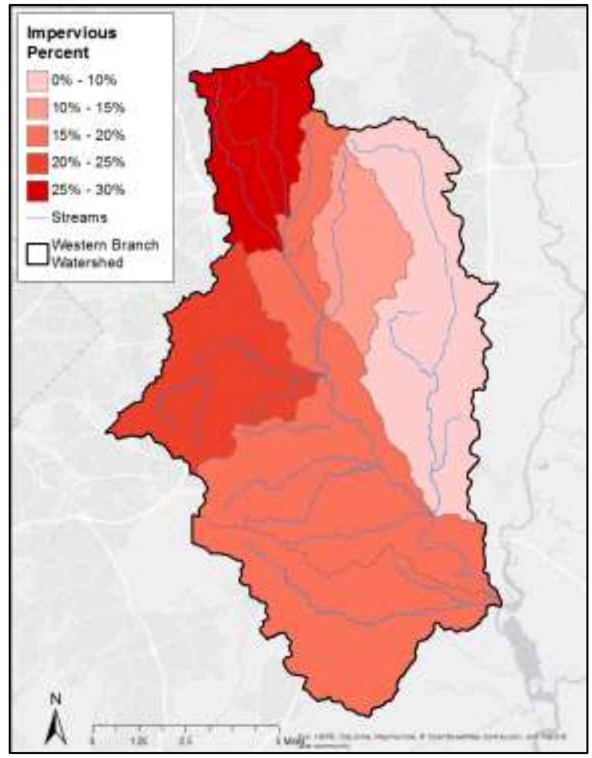
The Western Branch characterization study found the overall imperviousness among the subwatersheds to range from very low (0.7 percent) in the lower Western Branch to over 20 percent in Bald Hill Branch and the upper Southwest Branch (MD DNR 2003). More recent data from the Maryland-National Capital Park and Planning Commission (M-NCPPC) show the total imperviousness for the Western Branch watershed to be 16.8 percent (M-NCPPC 2014). Figure 2-11 shows the percent of impervious area for each Western Branch subwatershed (M-NCPPC 2014). Figure 2-12 shows the amount of impervious area in the watershed by type. Most of the impervious area comprises roads (30 percent), buildings (27 percent), and parking lots (22 percent). The percent of impervious area is higher among the more urbanized subwatersheds in the upper and western portions of the Western Branch watershed than in the other subwatersheds.

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



Source: M-NCPPC 2014.

Figure 2-10. Tree canopy in the Western Branch watershed.



Source: M-NCPPC 2014.

Figure 2-11. Percent of impervious area in the Western Branch watershed.

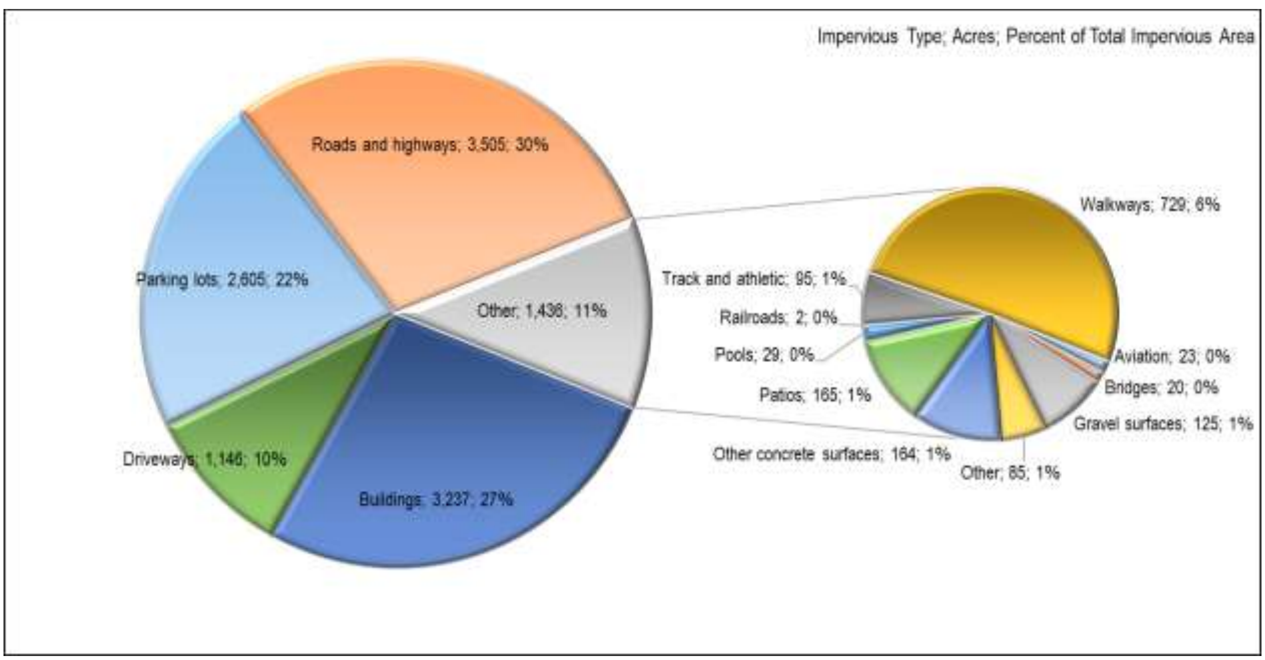


Figure 2-12. Western Branch watershed percent of impervious area by source.

3 Water Quality Conditions

3.1 Water Quality Impairments

Western Branch is listed as impaired for several pollutants under the requirements of section 303(d) of the Clean Water Act (CWA) (MDE 2018b).

- The watershed is subject to the Chesapeake Bay TMDL for TN, TP, and TSS. Under the Chesapeake Bay nutrient and sediment TMDL, TN is subject to a 20.2 percent reduction, TP is subject to a 35.3 percent reduction, and sediment (i.e., TSS) is subject to a 29.7 percent reduction (MDE 2018c).
- The watershed is listed for biochemical oxygen demand (BOD). The watershed has an established TMDL, which focused on low-flow stream conditions that are not influenced by urban stormwater and required additional treatment at the Western Branch wastewater treatment plant, which has been completed.
- The Western Branch is also listed as impaired for fish and benthic indices of biological integrity; however, because the exact pollutant is unknown, the Western Branch is listed as impaired for unknown sources (MDE 2018b).

3.2 Water Quality Trends

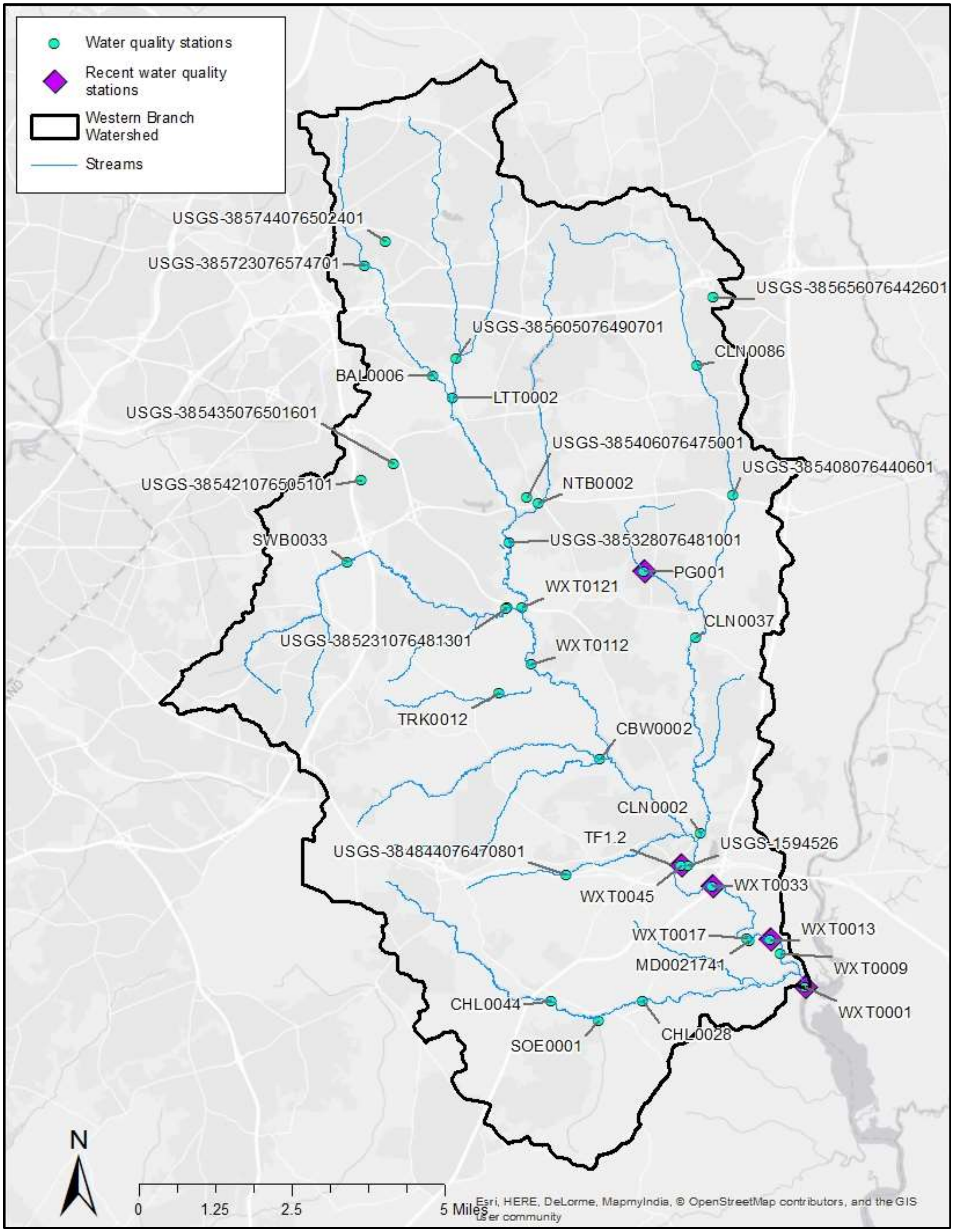
Water quality data were analyzed to assess the degree to which water quality might be getting better or worse. Graphs later in this section present a record of pollutant concentrations over different periods of record. This section only discusses stations with recent water quality data after 2007 and stations with at least 10 years of data. Figure 3-1 presents the locations of the water quality monitoring stations in the watershed and highlights those stations with recent data used in this report.

Water quality data were obtained from the following sources:

- County's MS4 long-term monitoring program.
- EPA's STORET (STOrage and RETrieval) Data Warehouse.
- Federal Water Quality Portal (www.waterqualitydata.us/). (Service sponsored by EPA, U.S. Geological Survey (USGS), and the National Water Quality Monitoring Council and collects data from more than 400 federal, state, local, and tribal agencies.)
- MDE data not found in the Water Quality Portal or STORET.

The graphs display the value of the coefficient of determination (R^2) derived from a simple linear regression as a standard approach to describing the strength of any apparent trend. The R^2 value is a measure of how well the regression line represents the collection of data points. An R^2 value of 1.0 represents a perfect fit, meaning the line goes through all the data points. An R^2 value of 0.4102 indicates a high degree of variability in the data, with only 41 percent of the variation explained by the trend line and the remaining 59 percent unexplained.

The low R^2 values derived from the pollutant data in this report indicate that the trend lines do not represent the data with a high degree of confidence. Although several plots appear to show a trend, the variance—or "scatter"—in the data shows poor correlation between time and water quality. Consequently, conclusions drawn from these trend lines about whether water quality has improved might be unreliable.



Sources: NWQMC 2018.

Figure 3-1. Flow and water quality monitoring stations in the Western Branch watershed.

The scatter in the data points can be explained by the complexity of influences in the watershed. A variety of factors can influence the measured pollutant concentrations at any point in time, including variability in the land cover, timing of precipitation (or lack of it), and number of dry days before a rain event. There are also complex hydrologic, chemical, and biological interactions 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.

3.2.1 Nutrients: Nitrogen and Phosphorus

Nitrogen is a nutrient that can get into surface waters in several ways: via runoff, as leachate from groundwater, as deposition from air pollution, or as a component of eroding stream banks. The nitrogen in fertilizers that stimulate the growth of crops will also stimulate the growth of aquatic vegetation. The growth of large algal blooms becomes problematic when the algae die and decompose, depleting the water of dissolved oxygen (DO) and causing eutrophication. Advanced eutrophication can lead to anoxia (absence of oxygen) in which all DO is depleted from the water column and a “kill zone,” which cannot support aquatic life, develops.

Like nitrogen, phosphorus enters surface water via stormwater runoff or as a component of eroding stream banks. Phosphorous is also stimulates the growth of aquatic vegetation and can contribute to eutrophication and anoxia. In addition, phosphorus can be adsorbed on sediment particles and carried along with the sediment as it moves downstream.

Air deposition of nitrogen, which generally accounts for a portion of nitrogen getting into the streams in this region, should be decreasing (USEPA 2015). Under the Clean Air Act of 1970, the EPA established regulations to reduce the emissions from stationary and mobile sources. The regulations resulted in the reduction of particle pollution, which contains nitrogen and phosphorus compounds (USEPA 2015). In 2006 and 2012, the EPA revised the particle pollution regulations to lower the acceptable levels of particulate matter, which should further lower rates of nitrogen deposition across the watersheds of the Chesapeake Bay (USEPA 2015).

Table 3-1 shows overall nitrogen and phosphorus concentrations at selected monitoring stations in the Western Branch watershed. Looking at the entire period of record, these concentrations appear to be trending downward, as shown in Figure 3-3; however, the scatter in the data is so great that clear trends cannot be reliably projected.

Table 3-1. Summary of TN and TP data in the Western Branch watershed

Parameter	Station ID	Station Name	Date Min.	Date Max.	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
TN	TF1_2	TF1_2	01/16/90	01/10/17	321	0.23	0.92	3.56
	WXT0001	Western Branch	10/09/90	02/07/17	275	0.69	1.99	10.91
	WXT0013	Western Branch	12/15/97	01/12/17	42	0.00	1.49	10.07
TP	TF1.2	TF1.2	01/16/90	02/07/17	281	0.01	0.09	0.60
	WXT0001	Western Branch	10/09/90	02/07/17	233	0.02	0.21	1.29

Notes: max. = maximum; mg/l = milligrams per liter; min = minimum.

Figure 3-4 shows the variation in TN nitrogen loading rates among the eight subwatersheds in this study, and Figure 3-5 presents the variation in TP loading rates (Tetra Tech 2014b). These loadings were determined using unit loading rates in Watershed Treatment Model (WTM), which was developed during the 2014 watershed characterizations and restoration planning for the County (Tetra Tech 2014a).

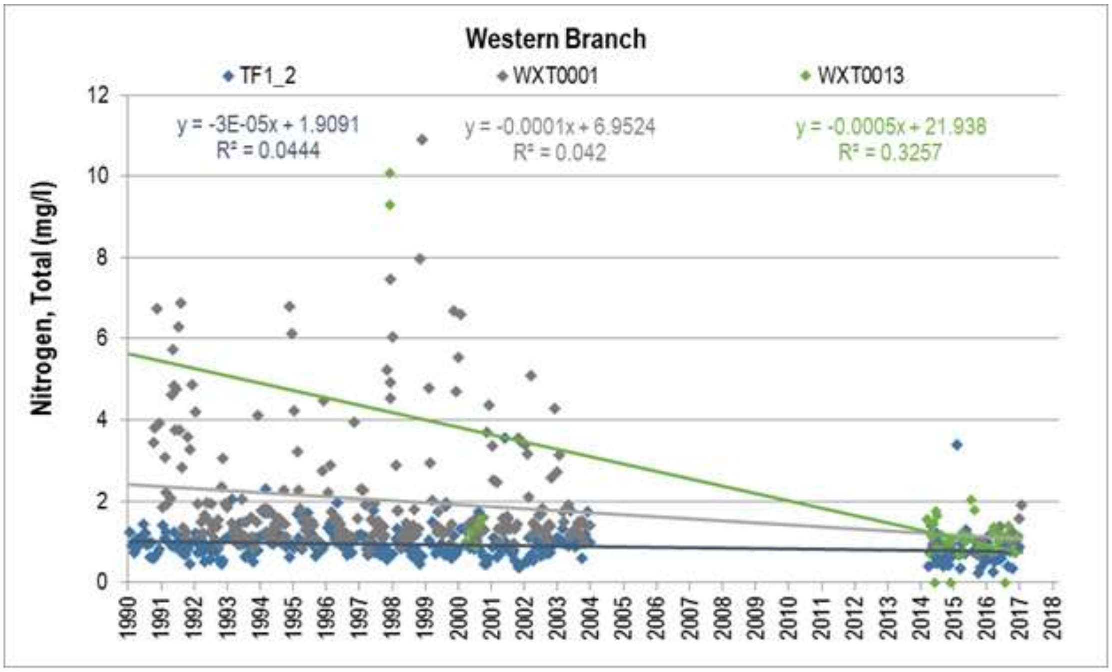


Figure 3-2. Plot of TN over time in the Western Branch watershed.

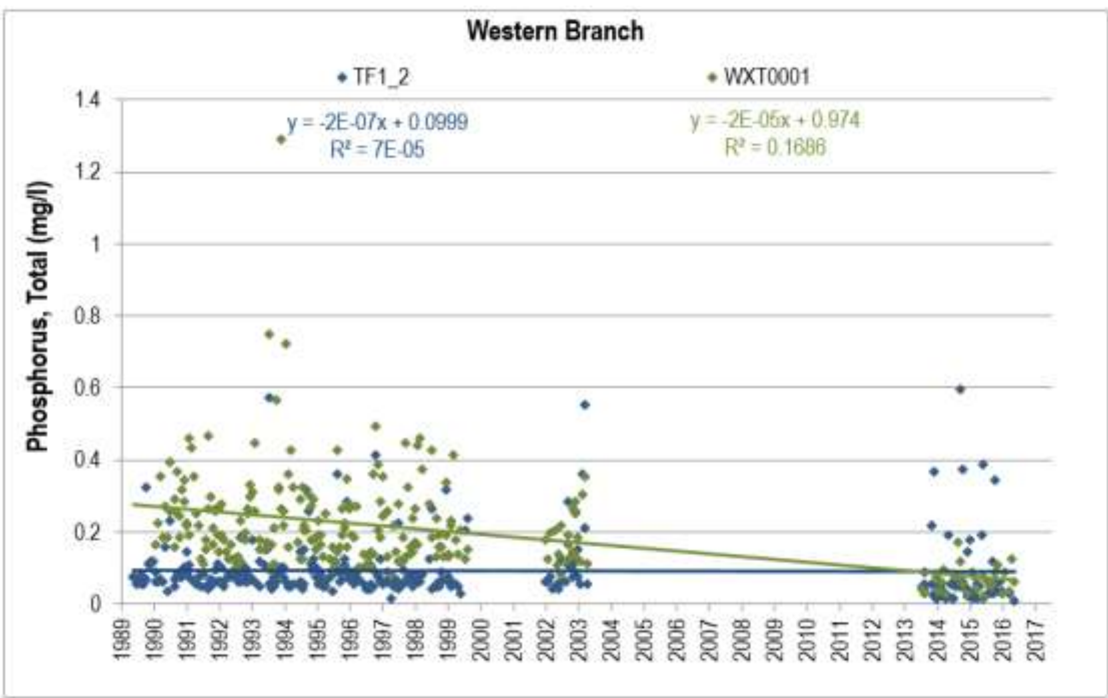
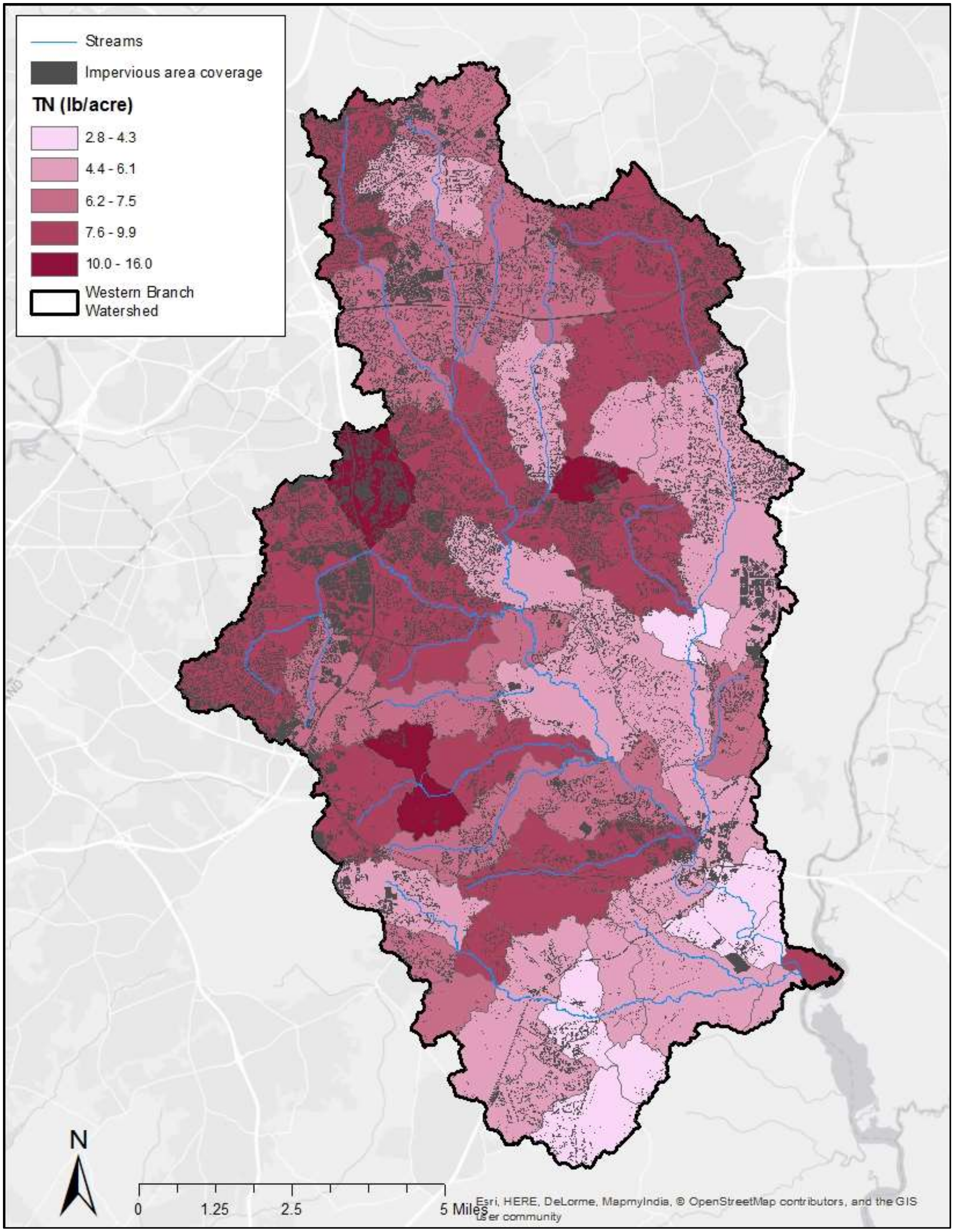
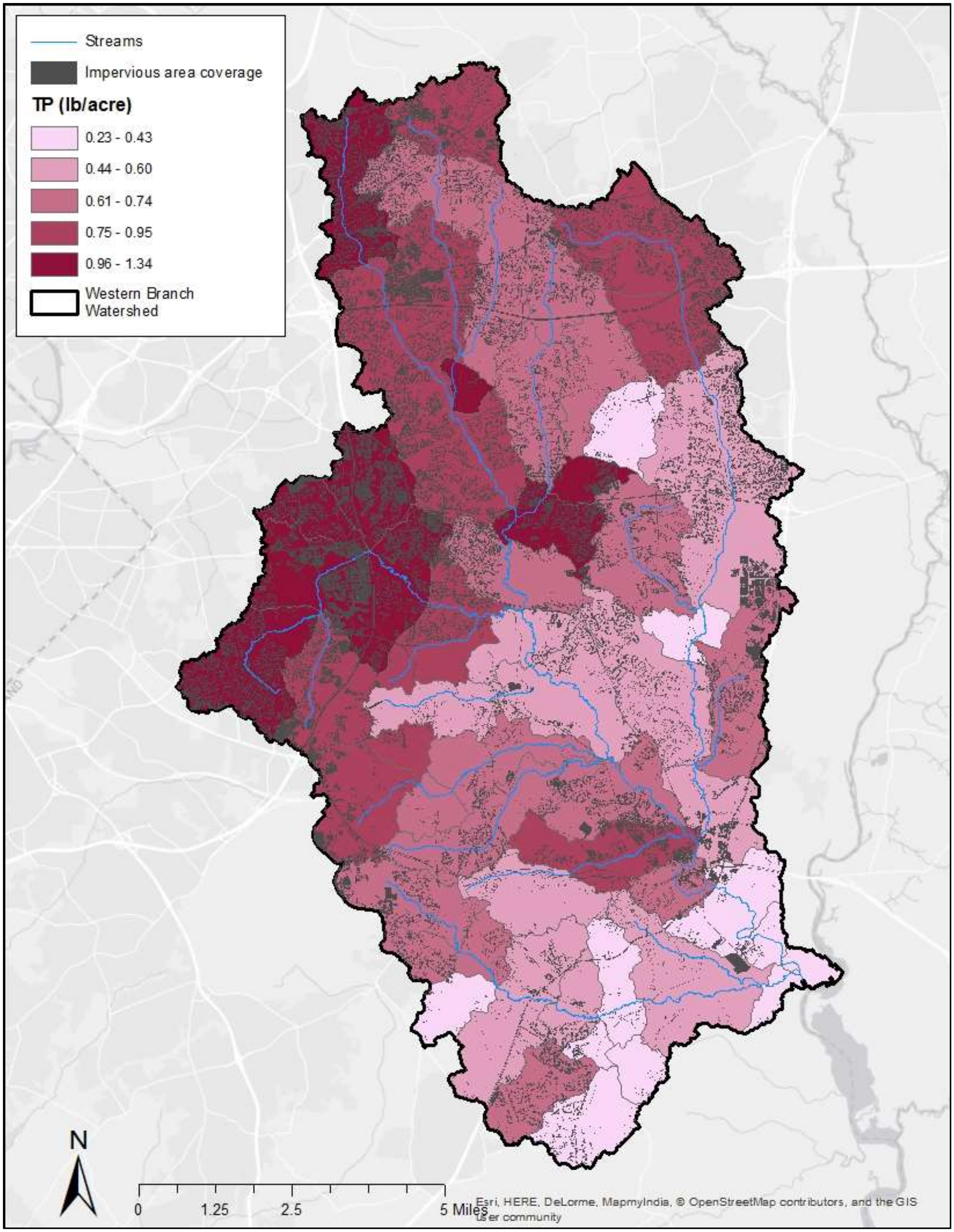


Figure 3-3. Plot of TP over time in the Western Branch watershed.



Sources: M-NCPPC 2014; Tetra Tech 2014b.

Figure 3-4. TN loading rates in the Western Branch watershed.



Sources: M-NCPPC 2014; Tetra Tech 2014b.

Figure 3-5. TP loading rates in the Western Branch watershed.

3.2.2 Total Suspended Solids

TSS are small particles, including particles that make up sediment, that are carried in water and capable of being captured by a filter. Stream channel erosion is a major source of TSS and tends to worsen as a result of land development if runoff is not effectively controlled.

A major source of TSS is stream channel erosion, which 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 could 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 because 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.

Three monitoring stations are located in the Western Branch watershed (Table 3-2 and Figure 3-1. TSS concentrations at stations TF1.2 and WXT0013 appear to be increasing, but again the R^2 values are too low to conclude that a clear trend exists. Station WXT0001 has not shown any significant change in TSS concentration over the historical record. It is in an estuary upstream of the confluence between the Western Branch and the Patuxent River, a location that experiences lower water velocity, which could allow suspended solids to settle out of the water column. Station TF1.2 is in Upper Marlboro and could be influenced by an increase in impervious surfaces, which causes an increase in flow during precipitation events. As stated previously, increased flow can induce channel erosion, which results in higher TSS concentrations in the water column. Station WXT0013 is located downstream of the Washington Suburban Sanitary Commission’s (WSSC’s) Western Brach Wastewater Treatment Plant.

Figure 3-7 presents the TSS loading rates in the Western Branch watershed (Tetra Tech 2014b). The modeling team determined loadings using unit loading rates in WTM (Tetra Tech 2014a).

Table 3-2. Summary of TSS data in the Western Branch watershed

Station ID	Station Name	Date Min.	Date Max.	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
TF1.2	TF1.2	01/16/90	02/07/17	402	-	31.82	934.00
WXT0001	Western Branch	10/09/90	02/07/17	369	3.50	23.38	275.00
WXT0013	Western Branch	12/15/97	02/01/17	81	2.40	21.27	154.00

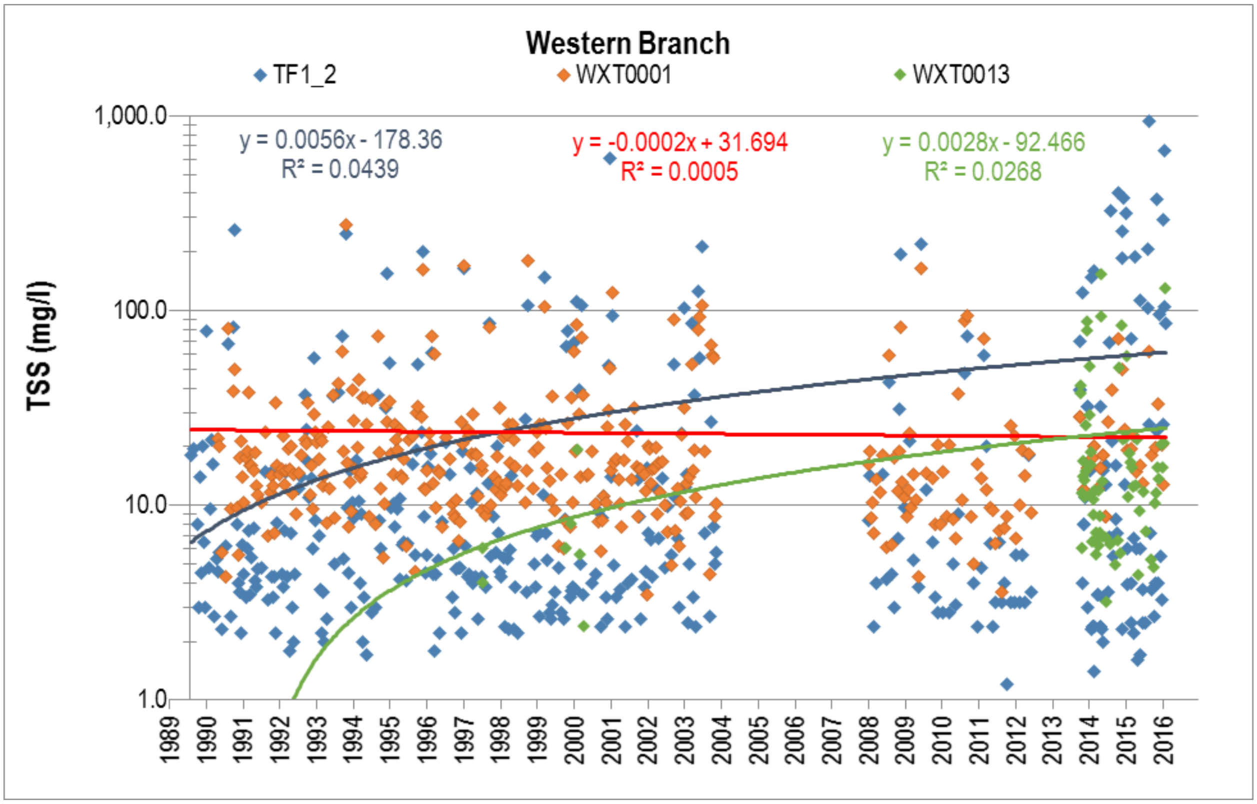
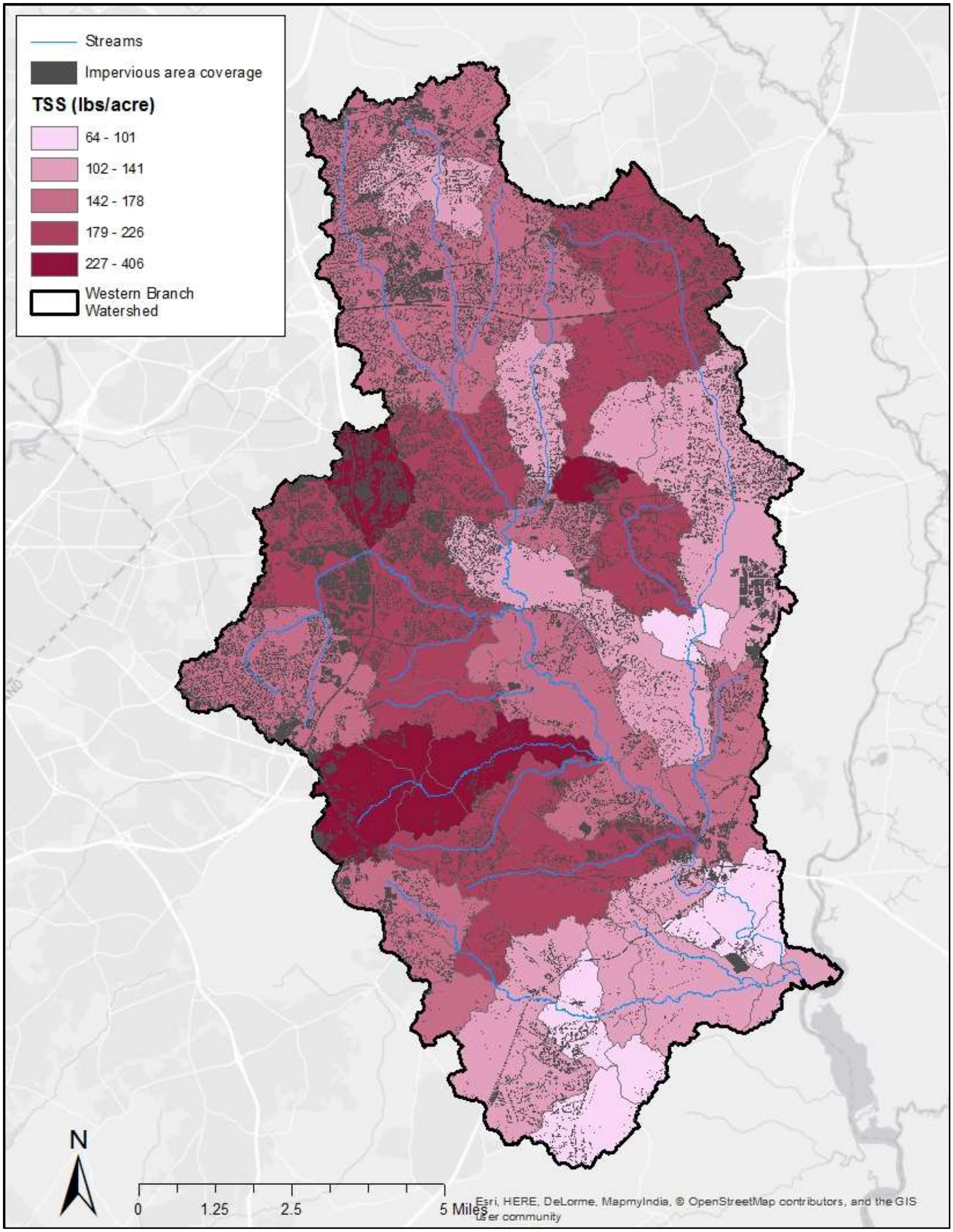


Figure 3-6. Plot of TSS over time in the Western Branch watershed.



Sources: M-NCPPC 2014; Tetra Tech 2014b.

Figure 3-7. TSS loading rates in the Western Branch watershed.

3.2.3 Biochemical Oxygen Demand and Dissolved Oxygen

DO is necessary to sustain many forms of aquatic life, including fish, invertebrates, and plants. BOD is a measure of the amount of oxygen needed to completely break down organic material in the water. Nutrients entering a natural water body will stimulate the production of organic material in the water body, such as algae and aquatic plants, and the increase in BOD will result in a reduction in DO unless mechanisms are at work to keep the water oxygenated (e.g., mechanical aerators or a high degree of natural turbulence).

Currently no historical records are available for BOD in the watershed, except for a short duration monitoring effort on Black Branch (2006–2008), as detailed in Table 3-3. This short sampling record showed that the BOD values ranged from 2.0 to 5.3 milligrams per liter (mg/L). The mean value of 2.8 mg/L was slightly higher than the detection limit of 2.0 mg/L. Figure 3-8 presents a plot of the BOD data. The USGS station at Upper Marlboro (1594525) had the most available data on BOD, but the data are from the period of 1985–2000. The historical records for DO provide better documentation. Table 3-3 presents data summaries for stations in the Western Branch. Some stations have a very short record, and the data are outdated (e.g., PG001 and WXT0033).

Figure 3-9 presents DO data over time for the four stations with the most data. The two locations along the main stem of the Western Branch, TF1.2 and WXT0001, have the most DO data. During summer periods, DO levels fall below the water quality limit of 5 mg/L, but during the rest of the periods, healthy DO levels as high as 14 mg/L are recorded. Many tributaries show minimum DO levels more than 5 mg/L, although some, including Bald Hill Branch and Lottsford Branch, show minimum values less than the 5 mg/L threshold. The Western Branch contains two stations: TF1.2 and WXT0001. Both display a slight downward trend in DO concentration.

Figure 3-10 presents the BOD loading rates in the Western Branch watershed (Tetra Tech 2014b). The modeling team determined loadings using unit loading rates in WTM (Tetra Tech 2014a).

Table 3-3. Summary of available BOD and DO data in the Western Branch watershed

Station ID	Station Name/Description	Parameter	Date		Number of Records	Value (mg/L)		
			Min.	Max.		Min.	Mean	Max.
PG001	Black Branch	BOD	11/08/06	02/01/08	10	2.0	2.8	5.3
TF1.2	TF1.2	DO	01/09/85	02/07/17	466	4.9	9.3	13.9
WXT0001	Western Branch	DO	10/09/90	02/07/17	350	3.8	8.1	12.6
WXT0013	Western Branch	DO	12/15/97	12/15/15	123	5.1	7.4	12.2
WXT0033	Western Branch	DO	12/15/97	11/16/11	30	5.4	8.8	13.0

Notes: max. = maximum; mg/l = milligrams per liter; min. = minimum.
No station met the 10-year data threshold for BOD; however, the most recent data are included in this table.

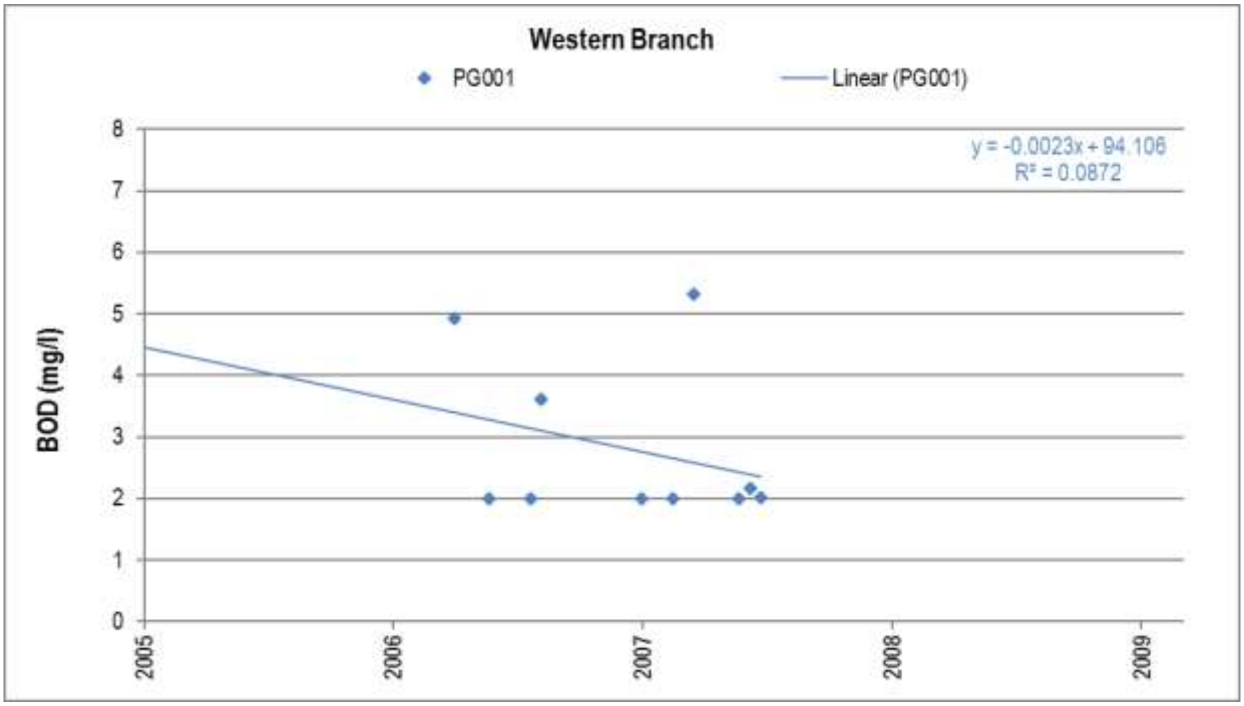


Figure 3-8. Plot of BOD over time in the Western Branch watershed (2005–2009).

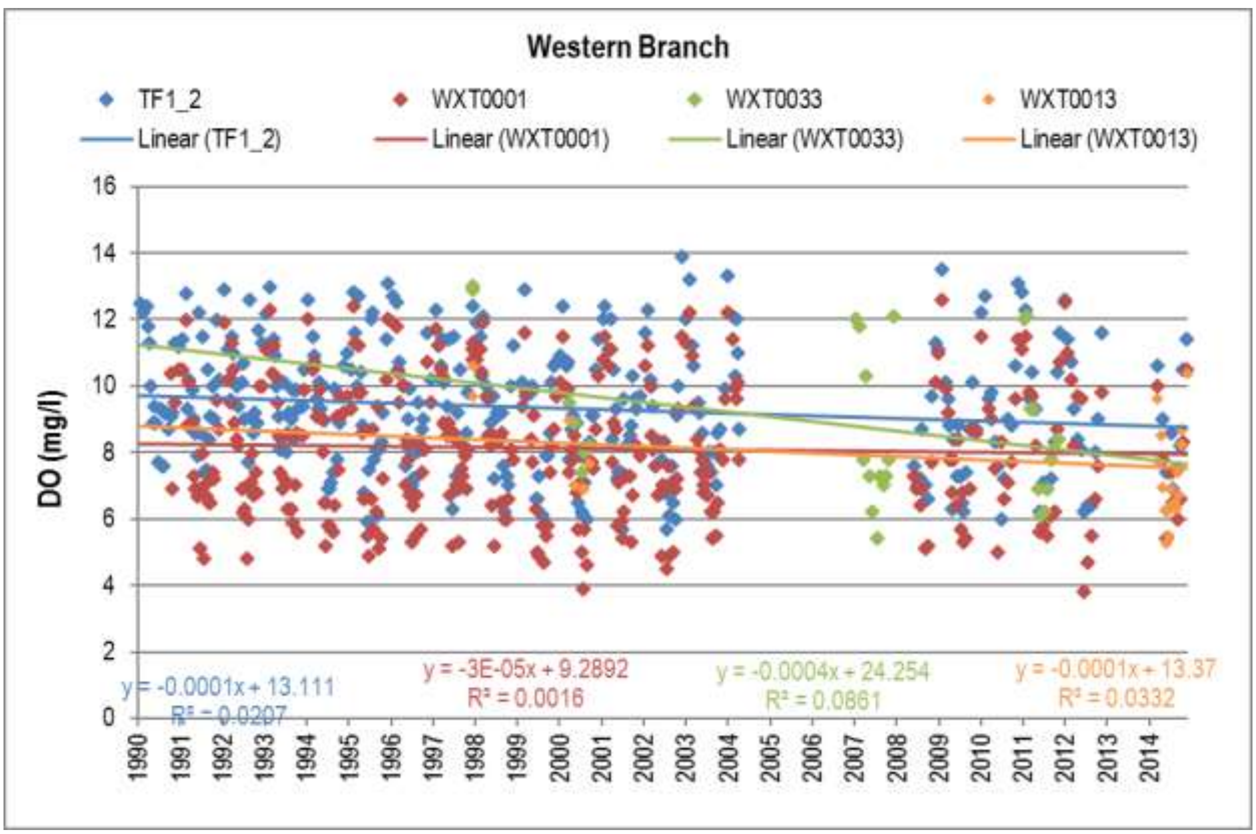
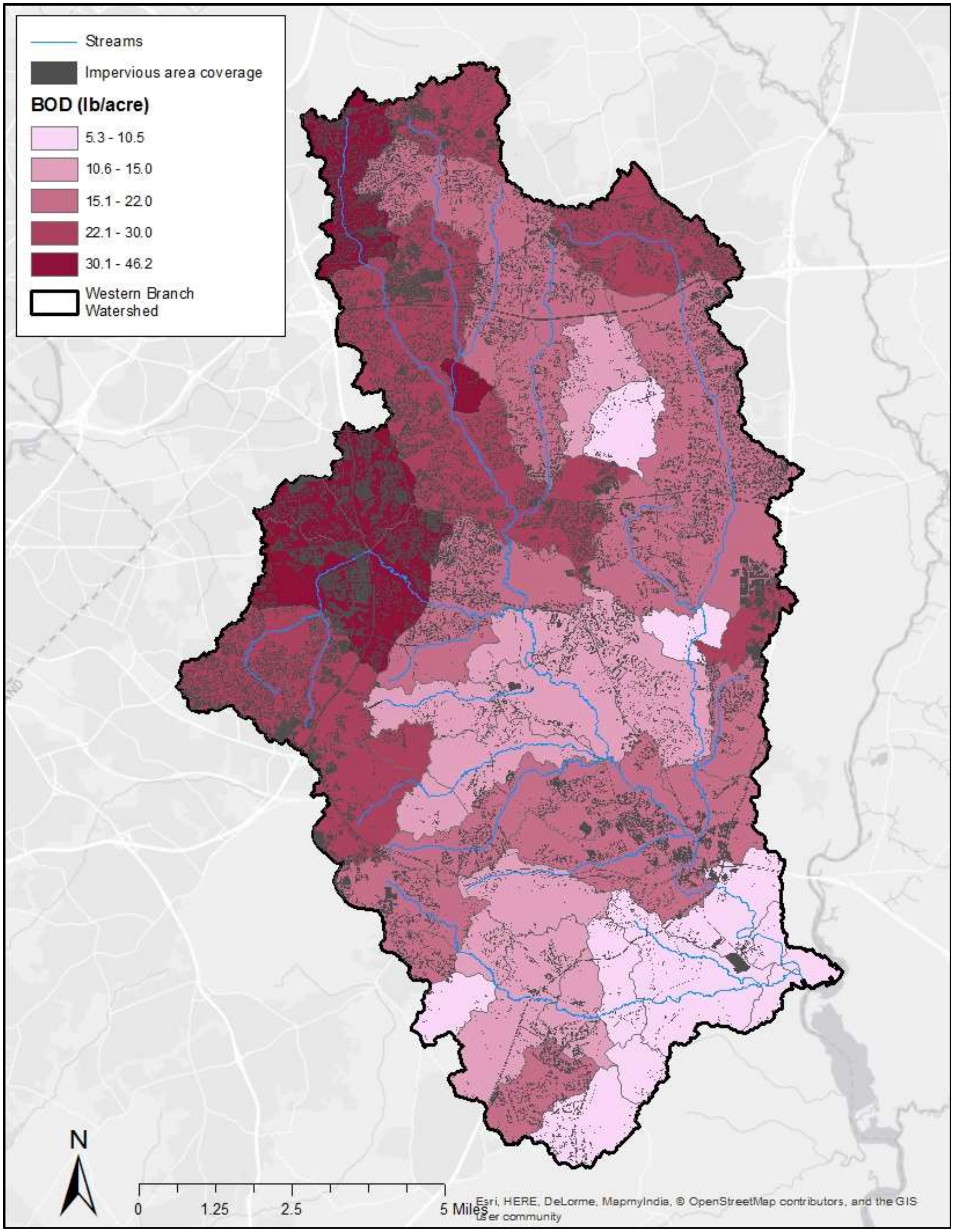


Figure 3-9. Plot of DO over time in the Western Branch watershed (1990–2014).



Sources: M-NCPPC 2014; Tetra Tech 2014b.

Figure 3-10. BOD loading rates in the Western Branch watershed.

3.2.4 Fecal Coliform Bacteria

Currently no data are available on bacteria concentrations in the Western Branch watershed. Periodic sanitary sewer overflows (SSOs), however, do occur in the watershed (see section 4.1.1.2 for additional information). In 2017, SSOs discharged more than 123,000 gallons of untreated sewage effluent to the watershed.

Fecal bacteria (e.g., Escherichia coli [*E. coli*], fecal streptococci, and enterococci) are single-celled pathogens found in the wastes of warm-blooded animals. Pathogens are microscopic organisms known to cause disease or sickness in humans. The bacteria can enter surface waters through leaking sewage and septic systems, stormwater runoff, or direct deposit into the water.

E. coli and enterococci are the most commonly monitored forms of fecal bacteria because they indicate the presence of untreated sewage, which often carries pathogens. Excessive amounts of fecal bacteria in surface waters indicate an increased risk of pathogen-induced illness to humans. These potential illnesses include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases (USEPA 1986). Pathogen-induced diseases are easily transmitted to humans through contact with contaminated surface waters, often through recreational contact or ingestion.

Figure 3-11 presents the fecal bacteria loading rates in the Western Branch watershed (Tetra Tech 2014b). Modelers determined the loadings using unit loading rates in WTM (Tetra Tech 2014a).

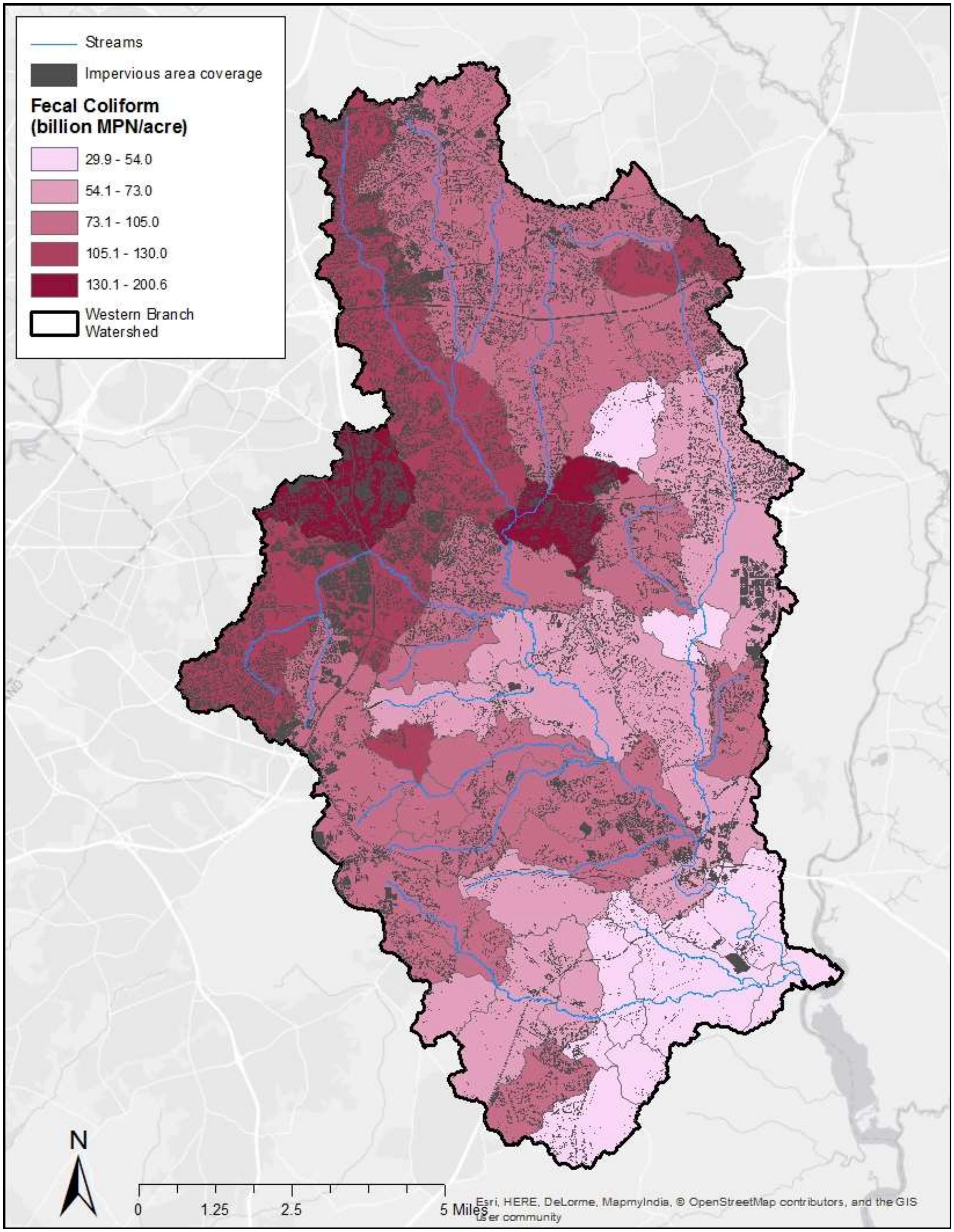
3.2.5 Analysis of Water Quality Data Gaps

Spatial Gaps

Inadequate spatial resolution of data could result in uncertainty in identifying the best locations for remediation or restoration efforts. Sampling stations in smaller streams can more clearly show progress in reducing the pollutant as BMPs and other retrofits are installed. A BMP with the capacity to treat 20 acres, for example, will have a more easily measurable effect at a point in the watershed that drains 200 acres than if the same BMP were installed at a point in the watershed that drains 2,560 acres.

A spatial analysis was completed to identify waterways or stream segments without water monitoring stations or water quality data. From this analysis, tributaries and stream reaches were identified for which no water quality data is available in the following waterways:

- Cabin Branch upstream of confluence with Back Branch
- Charles Branch upstream of the confluence with Southwest Branch
- Federal Spring Branch
- Folly Branch
- Lottsford Branch
- Ritchie Branch
- Southwest Branch upstream of the confluence with Ritchie Branch
- Theresa Creek



Sources: M-NCPPC 2014; Tetra Tech 2014b.

Figure 3-11. Fecal coliform bacteria loading rates in the Western Branch watershed.

Temporal Gaps

Temporal gaps in data records make it more difficult to draw clear conclusions from the available data as to if progress has been made in reducing the concentrations of a pollutant at a given location over time. Table 3-4 presents temporal data gaps for the Western Branch watershed from January 1990 through February 2017.

Table 3-4. Summary of temporal gaps in Western Branch water quality data (01/16/90–02/07/17)

Pollutant and Data Gaps				
TN	**TP**	**TSS**	**DO**	**Bacteria**
2005–2014	2001–2002; 2005–2014	2005–2008	2005–2008	No data

3.3 Biological Assessment

The County's biological monitoring program provides data about the status and trends of stream and watershed ecological conditions. DoE personnel can use the biological monitoring data to identify problems; document the relationships among stressor sources, stressors, and response indicators; and evaluate environmental management activities, including restoration.

3.1.1. Assessment Methodology

DoE began implementing its countywide, watershed-scale biological monitoring and assessment program in 1999. To date, the department has assessed more than 155 stream locations in Western Branch watershed through three rounds of data gathering. Round 1 (R1) of the assessments assessed 45 sites between 1999 and 2003, Round 2 (R2) assessed 55 sites from 2010 to 2013, and Round 3 (R3) assessed 56 sites between 2015 and 2017. The primary measure of stream health is the Benthic Index of Biological Integrity (B-IBI) (Southerland et al. 2007). Because different stream conditions support different types of "benthic"—or bottom-dwelling—organisms, analyzing the benthic 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 in the Maryland Department of Natural Resources' (MD DNR's) Maryland Biological Stream Survey (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 (NHD) map scale of 1:100,000. The number of streams sampled in each watershed are proportional to the size of the watershed and are allocated among first- to third-order streams, with a larger number of sites 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 (DO, conductivity, pH, and water temperature).

For the County's biological monitoring assessment, a 100-meter reach was sampled at each selected site. At a laboratory, technicians identified them each to a target taxonomic level, usually genus. The numbers of the different kinds of organisms found were used to calculate the B-IBI numeric value or score. Based on that score, the 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.

3.1.2. Biological Assessment Results

The biological data reveal that the Western Branch watershed consistently had high levels of degradation through the three assessment rounds. Figure 3-12 summarizes the monitoring results by subwatershed. Figure 3-13 presents the biological assessment narrative ratings by monitoring location for rounds 1 through 3. A significant number of sites were rated as Fair and a few as Good, but many more were rated as degraded (Poor and Very Poor), which in many cases could reflect the high percentage of impervious surfaces in the watershed. The level of degradation for the Western Branch ranged from 49.1 percent (R2) to 62.8 percent (R1).

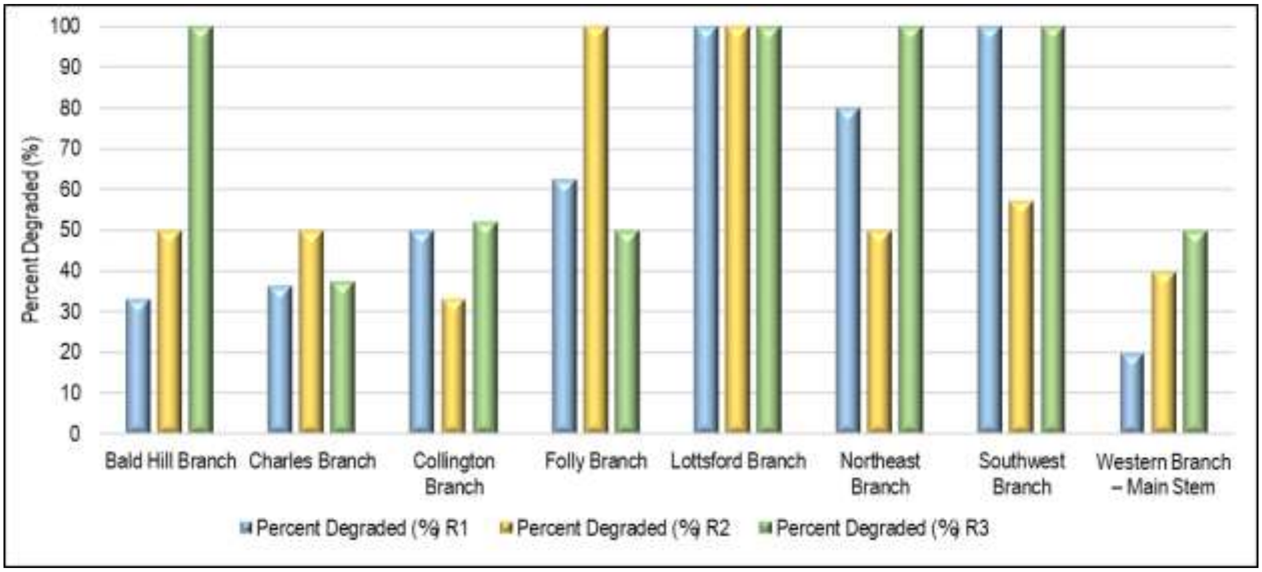


Figure 3-12. Western Branch subwatershed percent degraded.

The Impervious Cover Model states that watersheds with impervious cover of 11 to 25 percent have impacted or impaired streams, while watersheds with impervious cover greater than 25 percent are considered to be no longer supportive of their designated uses (Schueler 1994). Figure 2-11 presents the percent imperviousness in the watershed and shows that most of the subwatersheds have more than 11 percent impervious area. The Southwestern Branch subwatershed is in the range of 20–25 percent impervious, while the Bald Hill, Folly, and Lottsford branches are in the nonsupporting range of more than 25 percent. Overall the Western Branch watershed is 17 percent impervious.

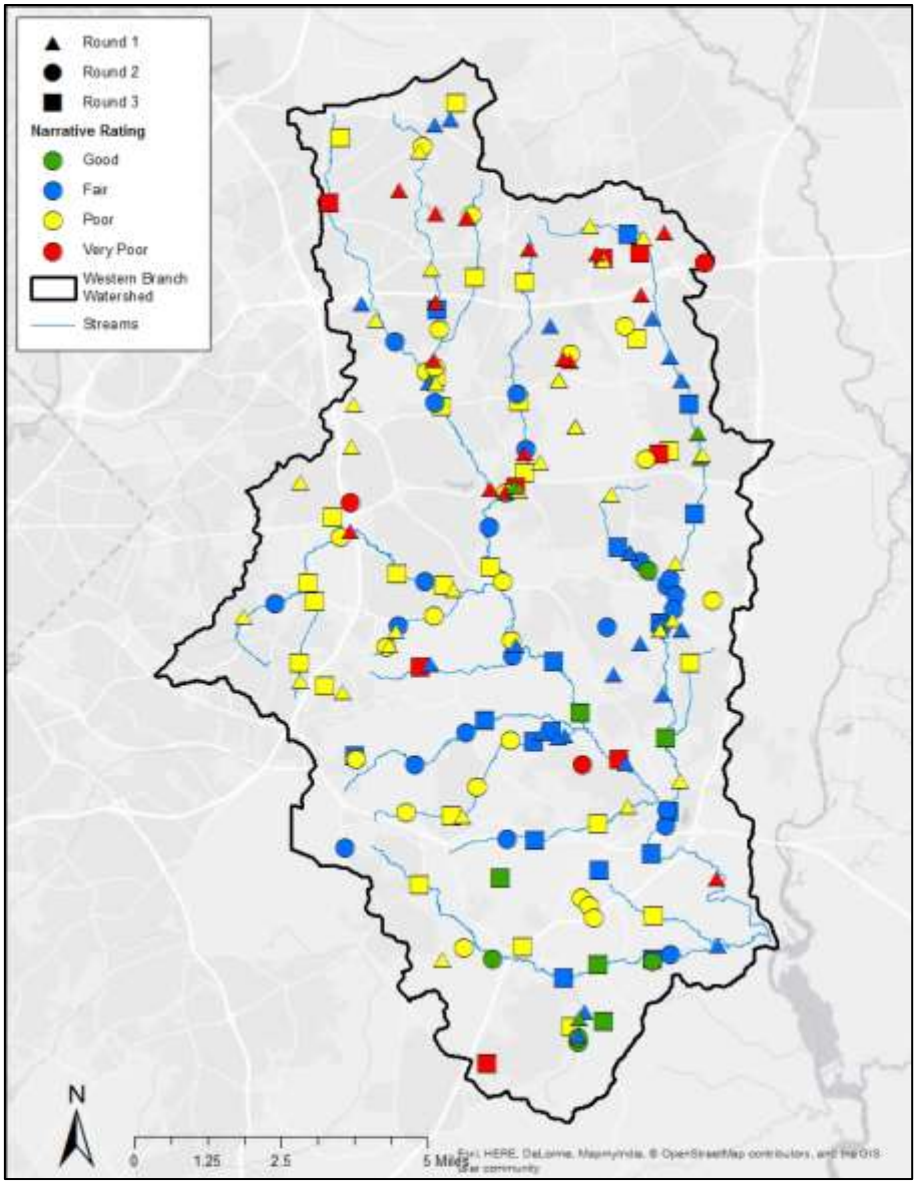


Figure 3-13. Biological assessment narrative ratings by monitoring location.

3.4 Trash Assessment

3.4.1 Trash Rating Protocol

The digital photographs that were taken during the biological assessments can be used to assess the magnitude of trash at those locations. The photographs from 154 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° 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 from 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 (i.e., trash score [TS]) was used to represent the amount of trash visible in each photograph (Table 3-5).

Table 3-5. Rating criteria for the magnitude of trash in streams

Trash Score	Trash Score Narrative	Number of Trash Items
0	None	None
1	Light	1–5
2	Moderate	6–10
3	Abundant/heavy	>10

Figure 3-14 shows four photographs that demonstrate what each major level in the rating scale represents. After each photo from a site was rated, an aggregate score for all the photos taken at the site was calculated. If there were four photos, the scores were simply totaled. If more than four photos had been taken, the scores were averaged and multiplied by four. Consequently, the trash score for a single site could range from 0 (no trash) to 12 (heavy trash).

Figure 3-14. Photographs illustrating different amounts of trash and corresponding trash score.

3.4.2 Results of Trash Assessment

Figure 3-15 provides a map of the assessment locations, showing the trash score at each one. Most of the trash items seen 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 154 sites that were evaluated in the Western Branch watershed, 73 sites (47.4 percent) showed no visible evidence of trash. The mean score of 1.4, shows that the majority of the watershed had light to moderate trash. Table 3-6 summarizes the overall findings.

Table 3-6. Trash score 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
154	0	1.4	10	73	47.4%

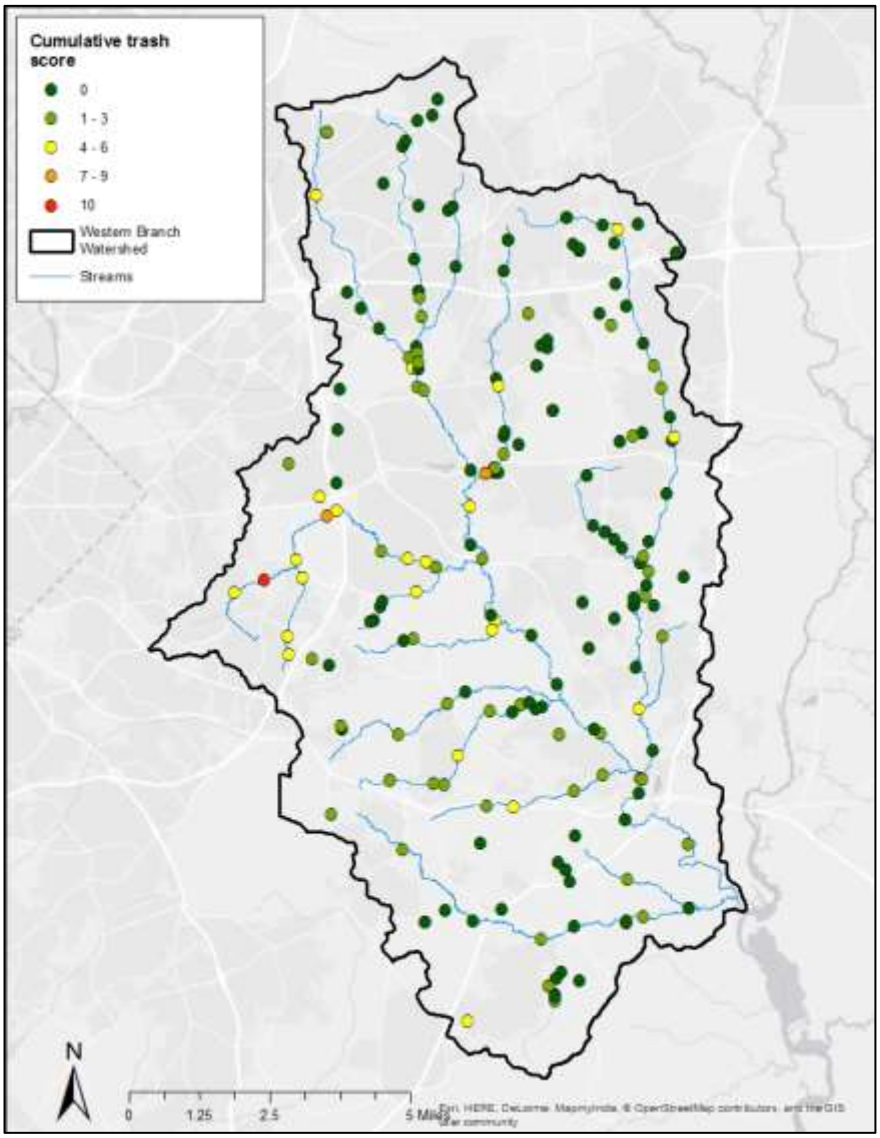


Figure 3-15. Magnitude and intensity of trash occurrences at assessment locations.

4 WATERSHED CONDITIONS

4.1 Pollutant Sources

This section provides an assessment of the potential point and nonpoint pollutant sources in the watershed. Point sources are permitted through the NPDES program. Nonpoint sources are not permitted. 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 nutrients or TSS to surface water from rainfall runoff. Identifying the sources of pollutants of concern 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 Title 40 of the *Code of Federal Regulations* section 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 for the discharge of pollutants from point sources, including urban stormwater systems known as MS4s. The County is an MS4-permitted discharger.

4.1.1.1 MS4s

Stormwater discharges are generated by runoff from urban land and impervious areas such as paved streets, parking lots, and rooftops during precipitation events. These 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 does the Phase I Rule (64 FR 68722, December 8, 1999).

Regulated small MS4s include those lying 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; or the contribution of pollutant loadings to a physically interconnected MS4 is evident. The Phase II MS4 in the Western Branch watershed serves portions of Bowie and Glenarden, as well as Upper Marlboro and District Heights. The County is responsible for all municipal Phase II MS4s in the County, except for the system that serves the city of Bowie, as the city of Bowie maintains its own MS4 program.

Table 4-1 lists the federal, state, and other entities in the Western Branch watershed that possess an MS4 permit. Figure 4-1 shows the areas served by permitted MS4s within the Western Branch watershed.

Table 4-1. Phase II MS4 permitted federal, state, and other entities in the Western Branch watershed

Agency	Installation/Facility
Maryland Air National Guard	Multiple Properties
Maryland Department of Transportation Motor Vehicle Administration	Multiple Properties
Maryland State Highway Administration	Multiple (outside Phase I jurisdictions)
Maryland Transit Administration	Multiple Properties
Maryland Transportation Authority	Multiple Properties
National Aeronautics and Space Administration	Goddard Space Flight Center
U.S. Department of the Air Force	Joint Base Andrews
Washington Metropolitan Area Transit Authority	Metrorail Stations
Washington Suburban Sanitary Commission	Multiple Properties

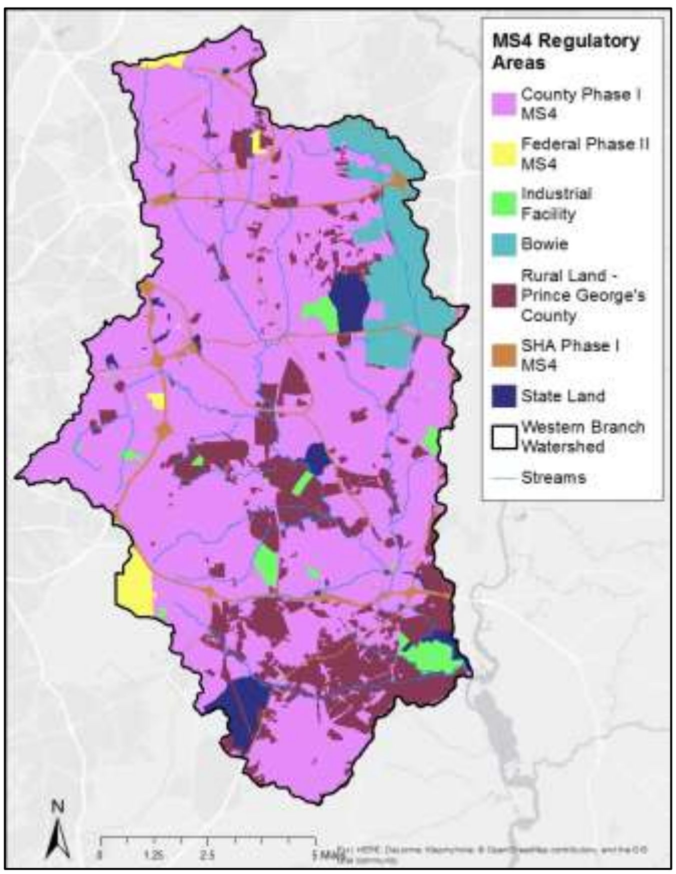


Figure 4-1. MS4 regulated areas in the Western Branch watershed.

4.1.1.2 Sanitary Sewer Overflows

Under unusual circumstances, sanitary sewer systems occasionally discharge raw sewage to surface waters during events SSO events. These events can send significant amounts of additional nutrients, bacteria, and solids into local waterways and can be caused by sewer blockages, pipe breaks, defects, and power failures.

The Maryland Reported Sewer Overflow Database contains bypasses, combined sewer overflows, and SSOs reported to MDE since January 2005. Table 4-2 summarizes data on SSOs in the County obtained from the database. Since 2005 an estimated 41.8 million gallons of sanitary overflows have been reported in the County in the Western Branch watershed. The average amount of annual overflow has been 4.6 million gallons for the Western Branch.

Figure 4-2 shows the locations of SSOs. WSSC is currently addressing problems that cause SSOs through their Sewer Repair, Replacement and Rehabilitation (SR3) Program.

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. Potential nonpoint sources 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 and waste from animal operations. Agricultural activities are regulated by the Maryland Department of Agriculture and are outside of the jurisdiction of DoE. Consequently, the Western Branch watershed restoration plan does not include restoration activities for agricultural practices.

Atmospheric deposition occurs by two main methods: wet and dry. Wet deposition occurs through rain, fog, and snow. 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 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 presettlement 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 versus presettlement conditions, 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.

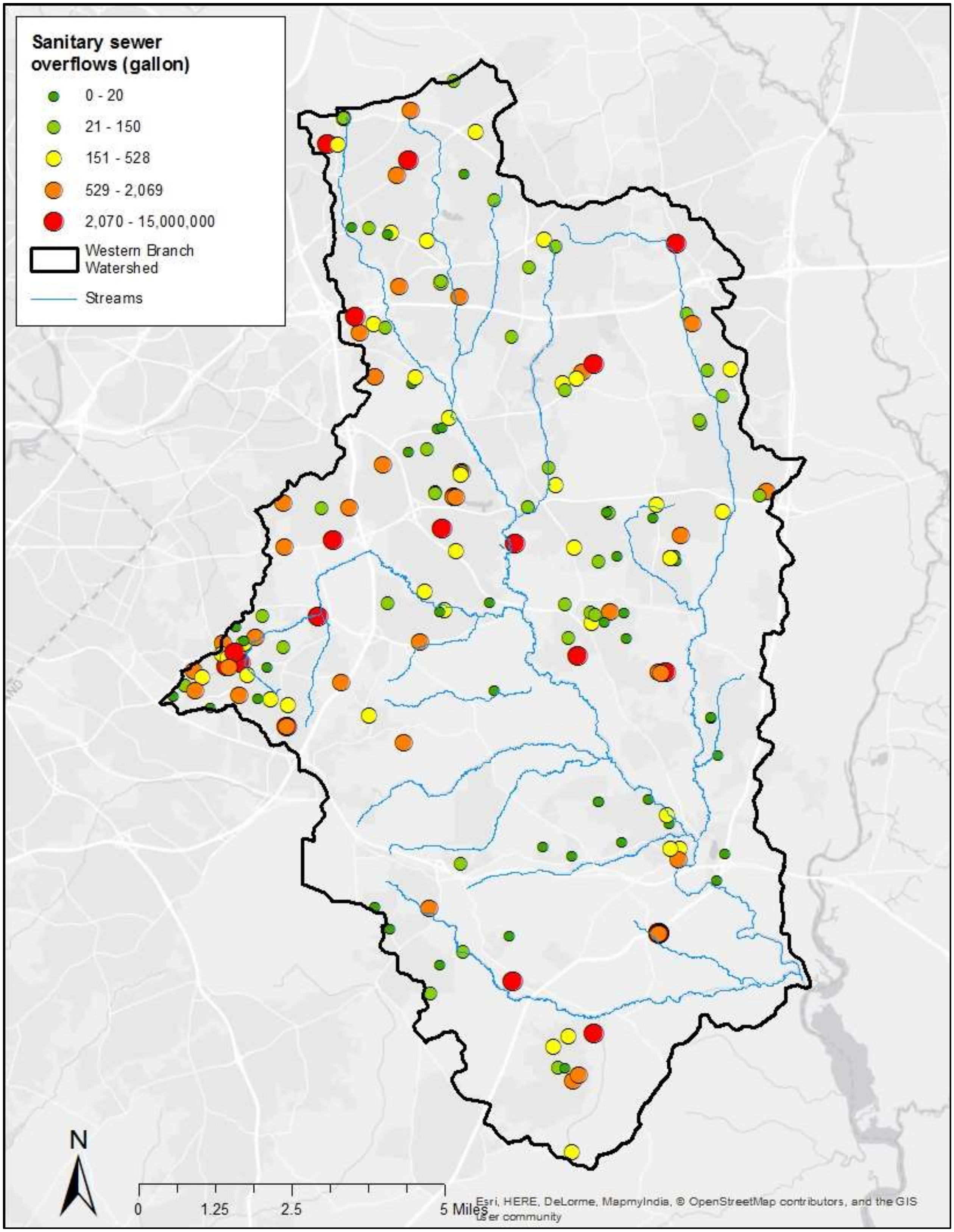
Streams and rivers can be vulnerable to nutrient inputs from wildlife. Wild animals with direct access to streams include deer, raccoons, other small mammals, and avian species. This access to streams contributes bacteria and nitrogen to water bodies.

Table 4-2. Summary SSO overflow (gallons) in the Western Branch watershed by year (2005–2017)

Cause	2005	2006	2007	2008	2009	2010	2011
Blockage	375	2,149	1,686	1,150	4,283		605
Construction Activity	1,000						
Defective Equipment/Workmanship					1,588		
Equipment Failure		200	12,618				592
Equipment Wear							
Grease	3,992	12,309	24,682	20	18,935	608	3,952
High Flow/Precipitation	50,000		8,002,200	20,000,000			13,600,000
Mechanical Failure	500		80		300		
Other	5,000	1,360				22	
Rocks, Mud							
Roots		1,260			131		20
Roots/Grease				362		218	154
Stream Erosion							
Third-Party Damage				145		8	
Unknown		113	5,079	741	123	363	75

Cause	2012	2013	2014	2015	2016	2017
Blockage	1,586	84	251	192		300
Construction Activity						
Defective Equipment/Workmanship				904		
Equipment Failure				200,000		1,000
Equipment Wear						
Grease	3,811	6,285	1,793	651		1,079
High Flow/Precipitation		1,000				100,300
Mechanical Failure			5,000,000			
Other		50	6		1	
Rocks, Mud						300
Roots	375	1		555	490	
Roots/Grease	7,740	4,461		1,834		200
Stream Erosion	3,968		73,134			
Third-Party Damage						75
Unknown	1,840	50	5	1,129	4,061	20,102

Source. MDE 2018b.



Source. MDE 2018b.

Figure 4-2. SSO locations and volume in the Western Branch watershed (2005–2017).

4.1.3 Illicit Discharge Detection and Elimination

Since 2015, the County has conducted the illicit discharge detection and elimination (IDDE) program, in which inspectors examine major stormwater outfalls and test the water for unusual levels of pollutants that must be controlled upstream because the stormwater system is not designed to handle them. Major outfalls are the ends of stormwater pipes that release runoff from commercial and industrial land into a body of water.

County inspectors perform IDDE inspections at all valid major outfalls. Inspectors also investigate water quality complaints from citizens about potential illicit discharges. If flow is present, the inspectors record any evidence of possible secondary sources of pollution, including water color, clarity, floatables (e.g., trash/debris and oil sheen), odor, and deposits. They take a sample when possible and tested for water quality indicators, including ammonia, chlorine, copper, detergents, phenols, turbidity, and pH. Readings above certain thresholds indicate an illicit discharge. Samples giving pH readings below 6.5 and above 8.5 are considered to contain illicit discharges. The following are concentrate limits for some of these pollutants:

- Chlorine—0.4 mg/L
- Copper—0.21 mg/L
- Detergents—0.5 mg/L
- Phenol—0.17 mg/L

Out of the 127 inspection records since 2015, five cases have failed the IDDE inspection since 2015, including 4 for ammonia and 1 for chlorine. Table 4-3 indicates the pollutants for which each outfall failed. Of the 127 sites inspected in the Western Branch watershed, 69 had secondary indicators of pollutants (Table 4-4). Figure 4-3 shows the location of the failed outfalls and ones with secondary indicators.

Table 4-3. Failed outfalls and pollutants in the Western Branch watershed

Case #	Ammonia	Phenol	Detergents	Chlorine	Copper	pH	Illicit flow	Inspector comment
3	Fail	0	0	0	0	0	Fail	Outfall is half submerged. Sample taken from first upstream structure. Flow is red, presumably from active construction site upstream.
3	Fail	0	0	0	0	0	Fail	No upstream structures visible except headwall inlet with standing water and no flow plus collapsed fifth upstream structure. No source of flow seen. Could not collect pristine bacterial sample.
5	Fail	0	0	0	0	0	Fail	Standing water in outfall. Milky water discharging from outfall. Intermittent flow in first upstream structure.
8	Fail	0	0	0	0	0	Fail	Flow arises from a pipe in curb on Chrysler Way and flows into southern 3rd upstream structure. Could not collect bacterial sample directly.
16	0	0	0	Fail	0	0	Fail	Outfall is partially submerged. Sample taken from first upstream structure.
18	Fail	0	0	0	0	0	Fail	Spalling on concrete apron. General smell of sewage around the outfall. No smell detected on water.
18	Fail	0	0	0	0	0	Fail	Iron flocculent in upstream structures. Flow arises between Buena Vista Ave and Washington Blvd. Flow is likely groundwater. Spalling on outfall apron.

Table 4-4. Number of outfalls per watershed with secondary indicators

Total Secondary Indicators	Odor	Deposits	Floatables	Color	Clarity	Erosion
69	2	53	30	3	7	8

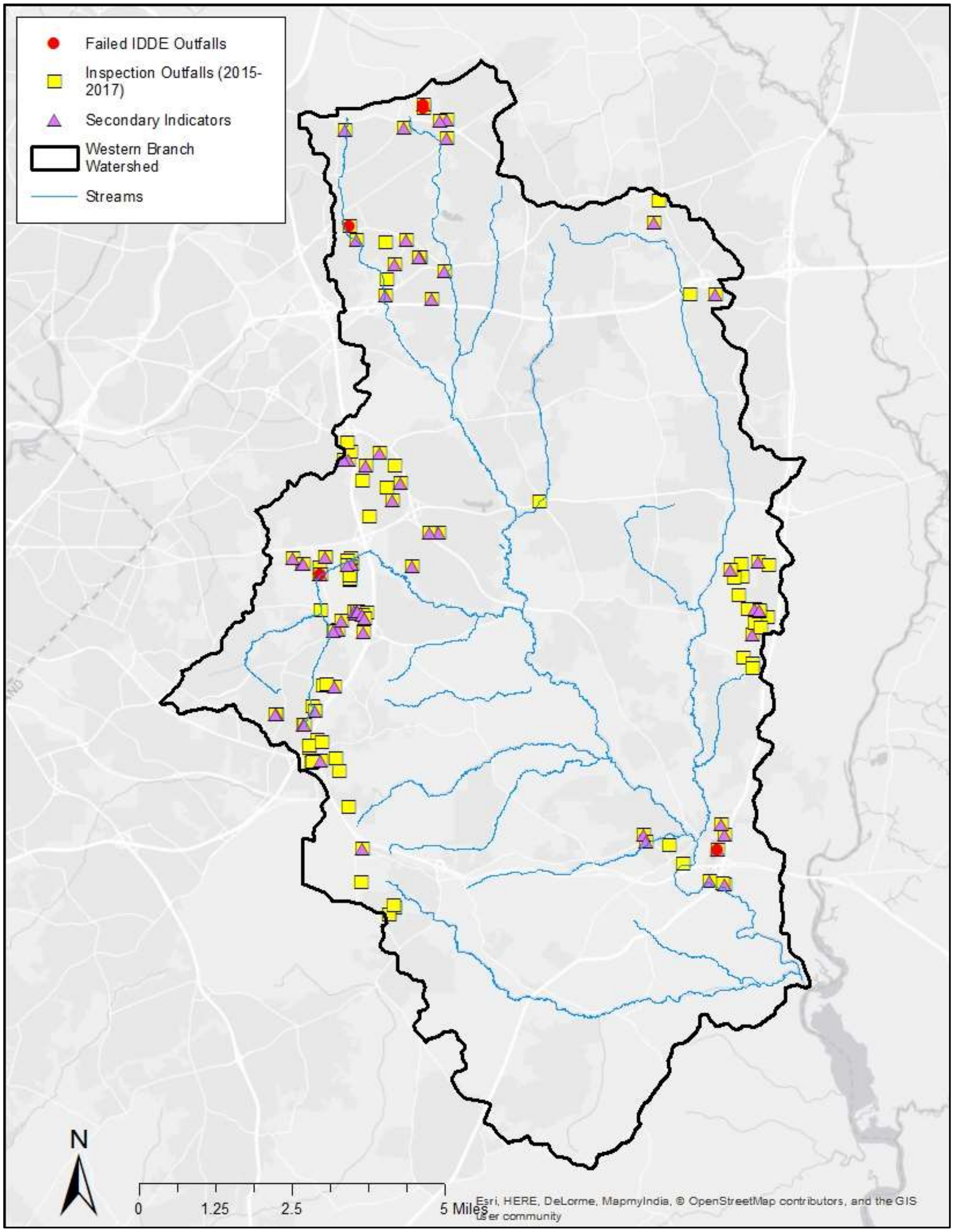


Figure 4-3. Selected IDDE failed outfalls in the Western Branch watershed.

4.2 Existing Stormwater BMPs

Since the Chesapeake Bay TMDL was developed in 2010, the County has implemented stormwater management practices to control and reduce the total pollutant load in the Western Branch watershed. This section describes the type and distribution of BMPs the County has installed in the watershed and evaluates the load reductions from the BMPs.

BMPs are measures used to control and reduce sources of pollution. They can be structural or nonstructural and are used to address both urban and agricultural sources of pollution. Structural practices include the placement of detention ponds, porous pavement, or bioretention systems. Nonstructural BMPs include institutional, educational, or pollution prevention activities that, when implemented, work to reduce pollutant loadings. Examples of nonstructural BMPs include implementing strategic disconnection of impervious areas in a municipality, street sweeping, homeowner and landowner education campaigns, and nutrient management. Different BMP types remove pollutants at different levels of efficiency. Ponds tend to have lower efficiencies but can treat large areas, while bioretention systems and infiltration practices tend to have higher efficiencies but can treat only smaller areas.

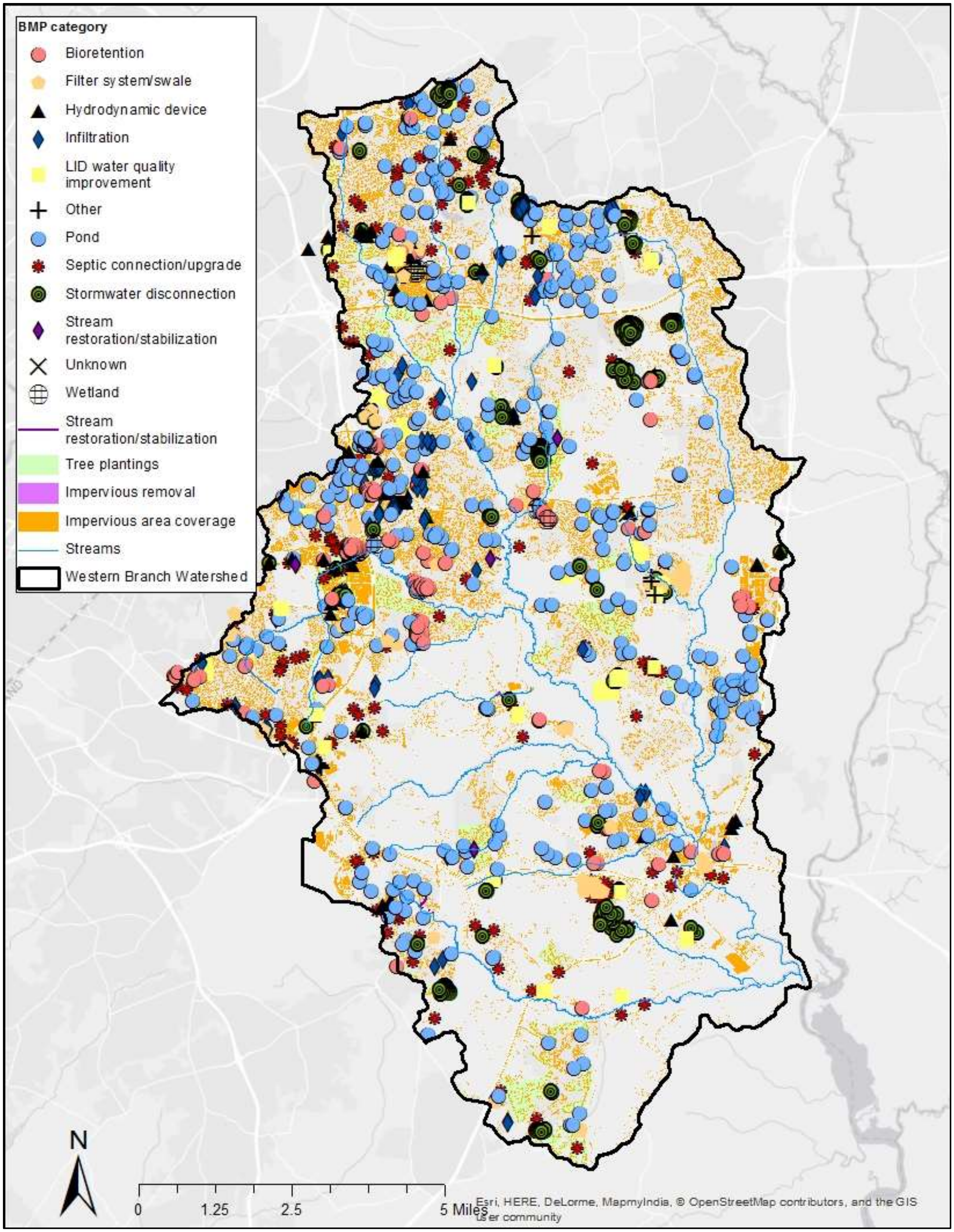
The County has implemented both structural and nonstructural BMPs for a variety of purposes, including NPDES permit compliance, TMDL WLAs, and flood mitigation. Table 4-5 shows the total number of BMPs by subwatershed and construction status. The numbers in parentheses indicate how many BMPs were installed specifically for watershed restoration as opposed to those installed to meeting development requirements. BMPs listed as under construction or in the planning phase are for watershed restoration. Stormwater ponds are the most implemented BMP and usually are designed to treat residential and nonurban areas. Infiltration practices are the second most implemented stormwater control element. They tend to treat smaller areas but add volume reduction and control as well as greater pollutant removal efficiency. Figure 4-4 presents the locations of all BMPs. The County also engages in street sweeping, public outreach to promote environmental awareness, green initiatives, and community involvement.

Table 4-5. Number of BMPs installed by subwatershed and status

BMP Type / Phase	Bald Hill Branch	Charles Branch	Collington Branch	Folly Branch	Lottsford Branch	Northeast Branch	Southwest Branch	Main Stem
Bioretention								
Constructed	5	2	4	8		14 (6)	142 (11)	20 (4)
Under Construction			1 (1)	2 (2)		1 (1)		
Planning			7 (7)			2 (2)	92 (92)	3 (3)
Other								
Constructed			7					
Planning							4 (4)	
Pond								
Constructed	26 (1)	25	76 (3)	45	9	31 (1)	70	55
Under Construction	1 (1)	1 (1)				1 (1)	4 (4)	1 (1)
Planning	5 (5)	6 (6)	7 (7)	3 (3)		6 (6)	12 (12)	8 (8)

BMP Type / Phase	Bald Hill Branch	Charles Branch	Collington Branch	Folly Branch	Lottsford Branch	Northeast Branch	Southwest Branch	Main Stem
Stormwater disconnection								
Constructed			2					14 (14)
Under Construction						7 (7)		
Planning			1 (1)			1 (1)		
Filter system/swale								
Constructed	2	10 (1)	29 (1)	3		2 (1)	19 (3)	20
Under Construction							2 (2)	2 (2)
Planning	3 (3)							4 (4)
Wetland								
Constructed				5		2 (1)		
Planning							1 (1)	
Infiltration								
Constructed	6	68	142	49	41	154	73 (1)	31
Planning							5 (5)	
Stream restoration/stabilization								
Constructed						2 (1)	2 (1)	6 (4)
Under Construction		1 (1)						
Planning	1 (1)	5 (5)						1 (1)
Tree plantings								
Constructed	8 (8)	2 (2)	4 (4)	4 (4)	8 (8)	2 (2)	6 (6)	5 (5)
Under Construction	4 (4)	2 (2)	5 (5)			6 (6)	5 (5)	8 (8)
Impervious surface removal								
Constructed							4 (4)	
Planning								2 (2)
Septic connection/upgrade								
Constructed	10 (10)	22 (22)	16 (16)	23 (23)	3 (3)	7 (7)	46 (46)	31 (31)
Hydrodynamic device								
Constructed	12	2	9	12	2	3	46	13
LID water quality improvement								
Constructed	12	11	33	5	4	7	20	36

Note: LID = low impact development.
Source: DoE 2018.



Source: DoE 2018; M-NCPPC 2018.

Figure 4-4. BMPs and impervious areas in the Western Branch watershed.

4.3 Existing Conditions

This section examines how landscape and physical characteristics in the watershed might influence conditions in the subwatersheds of the Western Branch. Available data were reviewed to examine the relationships among the B-IBI rating, impervious cover, and BMP locations.

Water quality, stream stability, and aquatic health are strongly affected by watershed characteristics such as land use type and cover, especially the percentage of impervious cover and the condition of the storm drainage network. Multiple studies have shown that, as the amount of impervious cover increases, frequency, peak flow, duration, and total volume of stormwater runoff increase. This situation generally results in increased flow velocities, particularly at the outfalls where storm drain systems deliver the runoff to receiving streams. These altered hydrologic conditions frequently result in severe erosion of the bed and banks of the receiving streams (Arnold and Gibbons 1996; Schueler 1994).

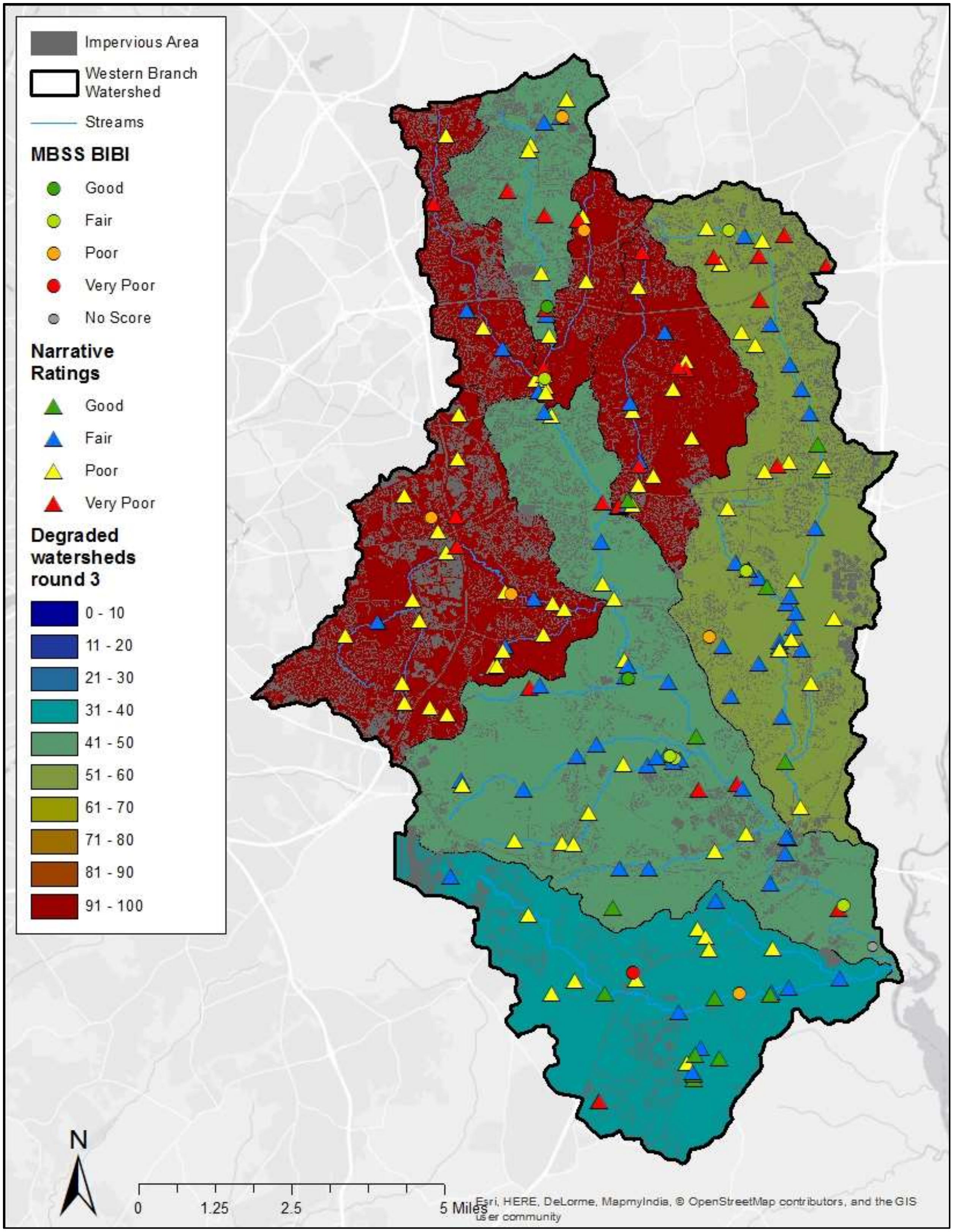
4.3.1 Stream Biology and Impervious Cover

Figure 4-5 presents on a map the B-IBI rating at different points in the watershed, showing the location of impervious areas. Overall the watershed has B-IBI ratings of Poor, Very Poor, some Fair, and some Good. The monitoring locations with Poor and Very Poor ratings tend to be concentrated in the upper subwatersheds, including Bald Hill Branch, Folly Branch, Lottsford Branch, Southwest Branch, Northeast Branch, and Upper Collington Branch—the subwatersheds with the highest percentages of impervious surfaces (Figure 2-11). The monitoring locations with ratings of Good are in the lower Western Branch, where imperviousness is very low. The other Good ratings are in areas surrounded by other areas with more pervious surfaces such as turf or forested patches. These results help identify priority areas for watershed restoration activities such as outfalls and streams.

4.3.2 Storm Drain Network

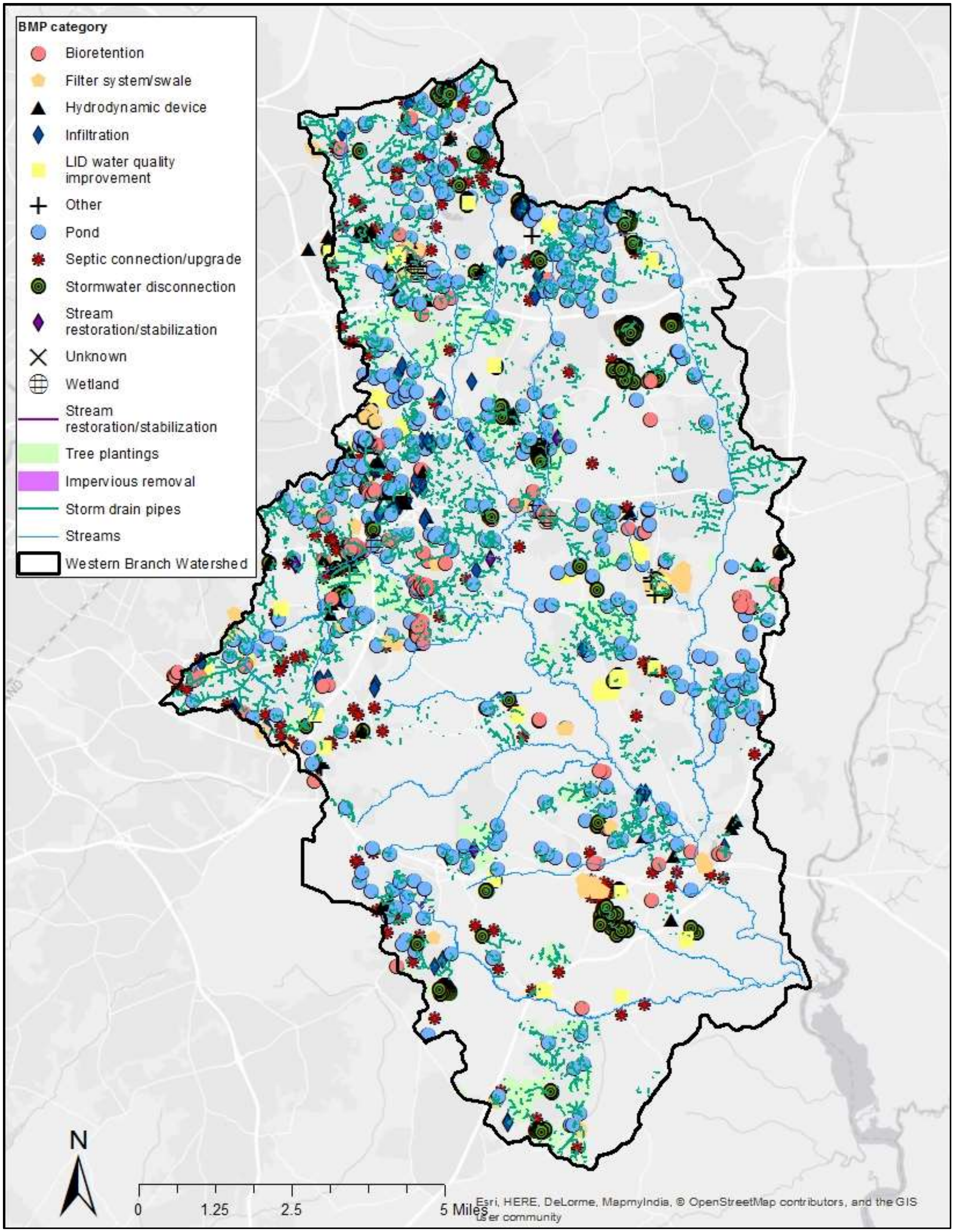
Figure 4-6 compares BMP locations to the current storm drain network. A close association tends to exist between the prevalence of impervious area, the location of BMPs, and the density of the storm drain network. Most storm drain networks discharge to a natural stream through an outfall. Many of the outfalls are failing, which can cause accelerated stream erosion. This mapping will assist the study team in identifying those outfall locations and potential BMP restoration sites.

Figure 4-7 presents the variation in annual runoff amount throughout the watershed and illustrates how runoff is affected by impervious cover (Tetra Tech 2014b). The runoff rates were determined using unit rates in WTM (Tetra Tech 2014a). The drainage areas for tributaries such as Bald Hill Branch and Southwest Branch (with over 20-percent impervious cover) exhibit larger volumes of runoff than the other subwatersheds, which corresponds to more stream erosion, larger pollutant loads, and biological stream degradation. The subwatersheds with more impervious cover and higher density of storm drain networks will become primary candidates for watershed restoration activities.



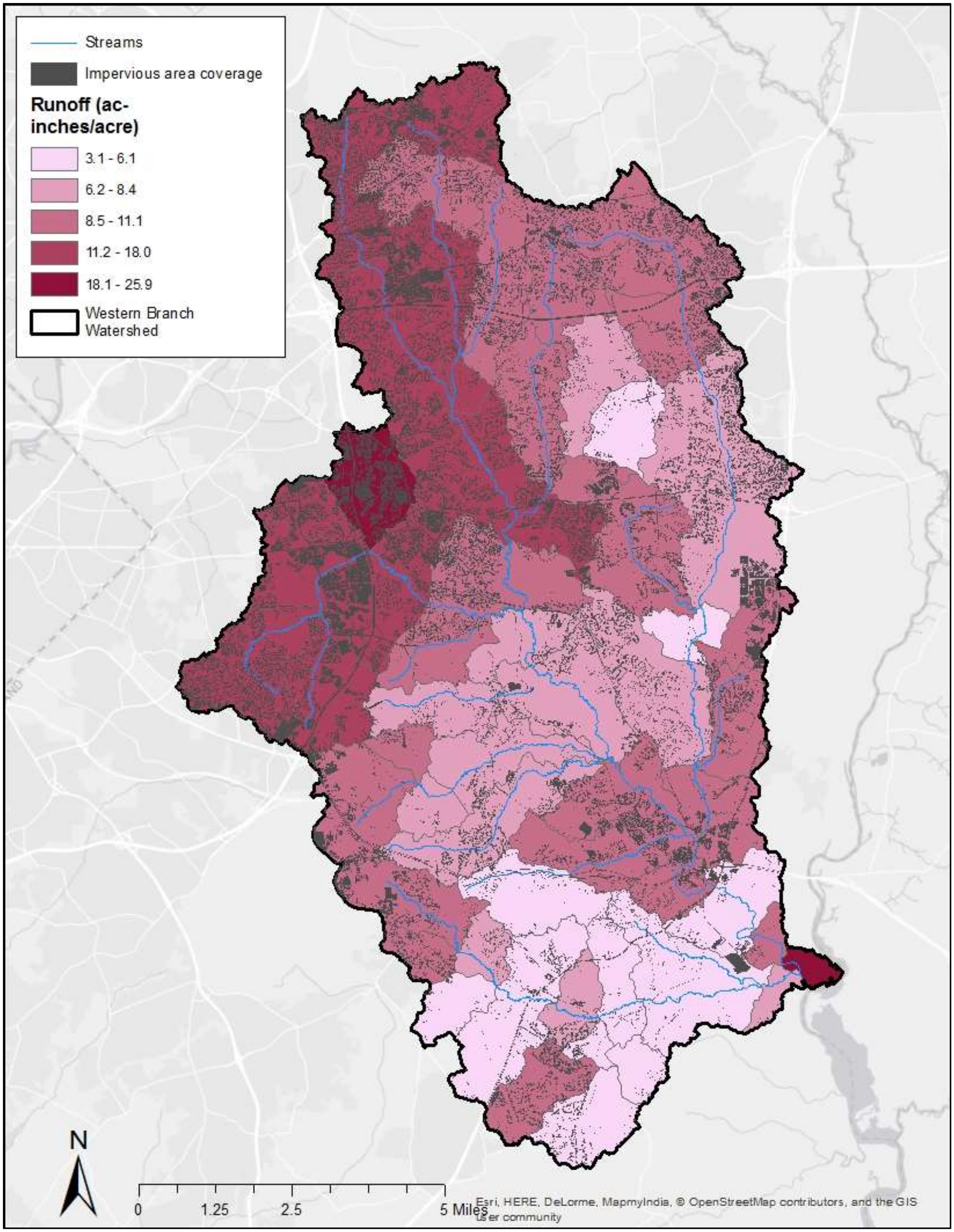
Sources: MD DNR; Tetra Tech 2014; M-NCPPC 2018.

Figure 4-5. Comparison of biological conditions and impervious area in the Western Branch watershed.



Source: DoE 2018.

Figure 4-6. Comparison of BMP locations and storm drain network in the Western Branch watershed.



Sources: M-NCPPC 2014; Tetra Tech 2014b.

Figure 4-7. Comparison of runoff amount and impervious areas in the Western Branch watershed.

5 Restoration Methodology Development

5.1 Strategy for Developing the Restoration Plan

The County's strategy for developing a restoration plan includes evaluating the ability of existing BMPs and restoration activities to meet the Chesapeake Bay WLAs as well as identify and quantify future restoration activities necessary to meet the WLAs.

The procedure shown in Figure 5-1 was developed to support the 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 the procedure to be used to evaluate the number of restoration activities necessary to meet load reduction goals. These are the major steps in the systematic evaluation procedure:

1. Determine baseline pollutant loads (section 5.2).
2. Calculate reductions from existing BMPs and other restoration activities implemented since TMDL water quality data were collected (section 5.2).
3. Subtract loads treated by existing BMPs and restoration activities from the load removal goals to determine load reduction gap (section 5.2).
4. Identify and evaluate proposed strategy management options and calculate their load reductions (section 6.1).
    a. Determine new programmatic strategies.
    b. Retrofit existing BMPs (e.g., dry ponds) to enhance load reductions.
    c. Maximize load reductions from stream restoration, including outfall stabilization projects.
    d. Maximize load reductions from public right-of-way (ROW) projects.
    e. Maximize load reductions from public institutional projects.
    f. Maximize load reductions from commercial/industrial land uses.
    g. Maximize load reductions from residential properties.
5. Identify potential restoration opportunities (section 5.3.3 and 6.3).
6. Finalize the restoration plan.

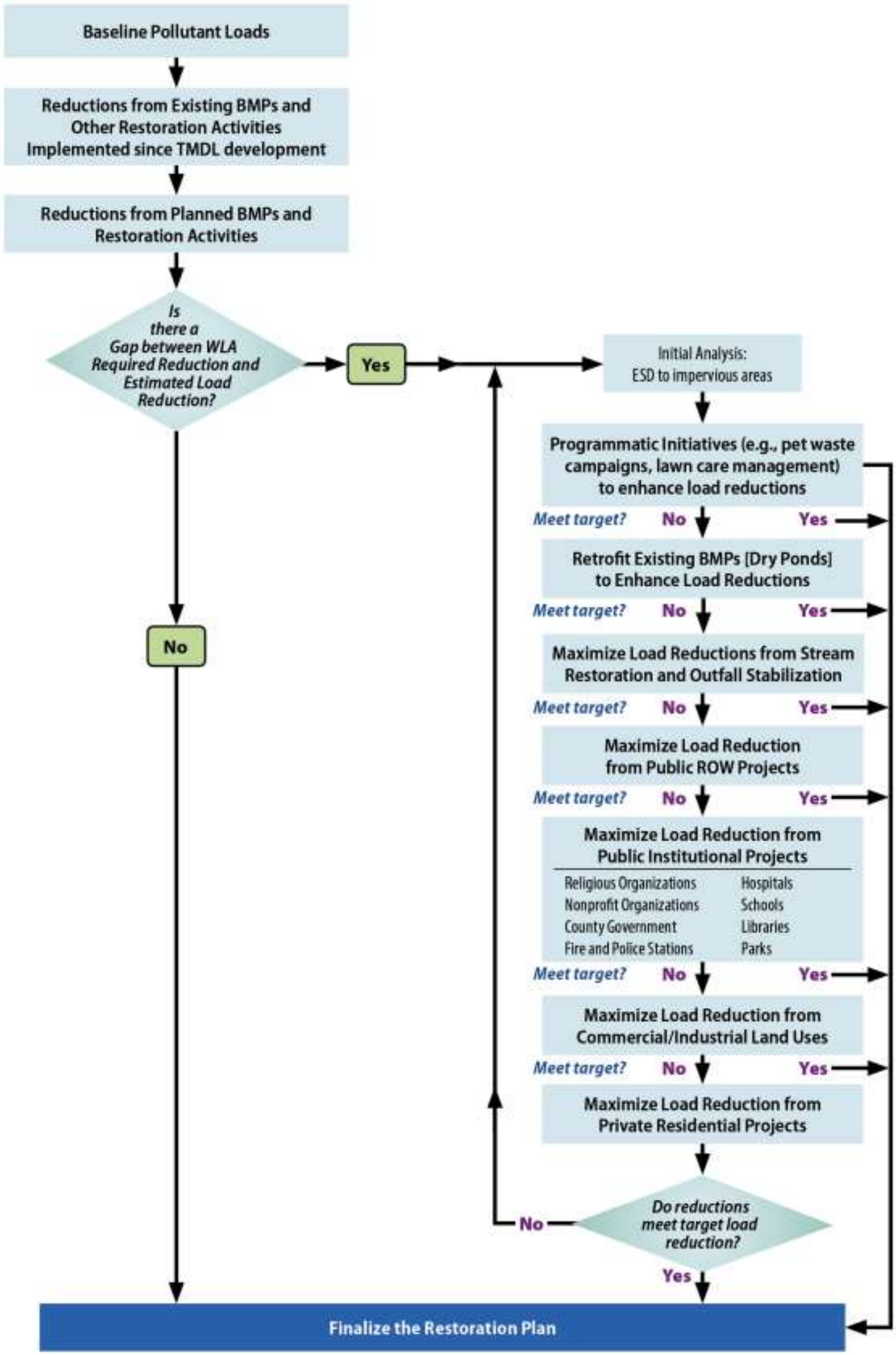


Figure 5-1. Restoration plan development evaluation procedure.

5.2 Load Reduction Targets and Existing Gap

This section identifies the load reductions for Western Branch watershed from the Chesapeake Bay TMDL. Throughout this section and the remainder of the report, the following terms are used in text, tables, and plots:

- **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 2010.
- **Target Load:** The load that will meet the reductions specified in the Chesapeake Bay TMDL.
- **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 2010–2018):** The County has already installed BMPs in the watershed. 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 that are reduced by currently installed BMPs.
- **% of Target:** The percent of the required load reduction that is removed by installed BMPs.
- **Current Load Reduction Gap:** The required load reduction that is remaining (i.e., gap) once the load reductions from current BMPs are subtracted.
- **Load Removed from BMPs in Planning / Design:** The County is currently designing several BMPs and is in the initial planning stages for other BMPs. This value is the load reduction from the BMPs that are not yet constructed but are 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.

The target loads were obtained from MDE's *TMDL Data Center* (MDE 2018c). These loads are the same as those reported in the Countuy's annual MS4 report (DoE 2018). The *TMDL Data Center* also contained the required percent reductions, from which, the baseline and load reductions were obtained (Figure 5-2, Table 5-1).

Since the Chesapeake Bay TMDL was established in 2010, the County has been implementing BMPs specifically for watershed restoration. The load reductions of these BMPs were calculated and used to determine the remaining load reduction gap (Figure 5-2, Table 5-1). While, the County implemented restoration BMPs prior to 2010, 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 that are installed by developers to offset the increased pollutant loads from new development and impervious areas. Because these BMPs are installed to offset new loadings and not to remove existing loadings, they are not counted towards watershed restoration.

As shown in Table 5-1, the load reductions from existing restoration activities are not sufficient to meet the targeted reductions. Even with the BMPs that the County is already planning or designing, the load reduction targets will not be met, so additional practices need to be planned.

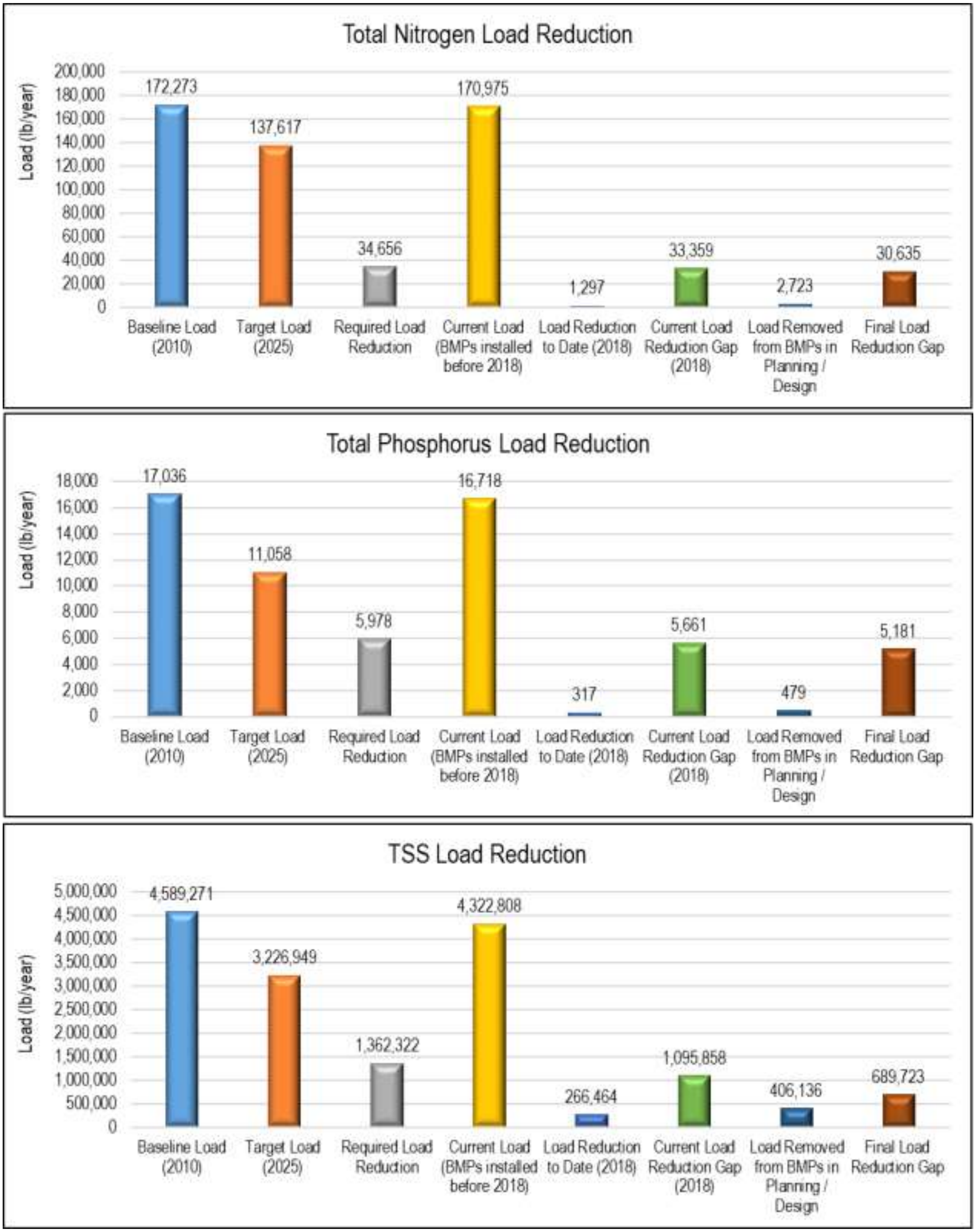


Figure 5-2. Pollutant load reduction targets and gaps for the Western Branch watershed.

Table 5-1. Pollutant load reduction targets for the Western Branch watershed

	TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)	TSS (tons/yr)
Baseline Load (2010)	172,273	17,036	4,589,271	2,295
Target Load (2025)	137,617	11,058	3,226,949	1,613
Required Load Reduction	34,656	5,978	1,362,322	681
Load Reduction to Date (2018)	1,297	317	266,464	133
Current Load (BMPs installed 2010–2018)	170,975	16,718	4,322,808	2,161
% of Target	3.7%	5.3%	19.6%	1.0%
Current Load Reduction Gap (2018)	33,359	5,661	1,095,858	548
Load Removed from BMPs in Planning / Design	2,723	479	406,136	203
Final Load Reduction Gap	30,635	5,181	689,723	345
% of Target	11.6%	13.3%	49.4%	49.4%

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

The Optional Worksheet for MS4 WLA Implementation Planning (Planning Worksheet) allows for determining loads a finer subwatershed resolution (MDE 2015). The Planning Worksheet was used to determine the relative loading contributions for each subwatershed to the remaining load reduction gap. Figure 5-3 shows the relative contribution of each subwatershed. While the Southwestern Branch is only 14 percent of the western Branch watershed, it accounts for 20 percent of the remaining load reductions, while the Charles Branch accounts for 12 percent of the remaining load, but 16 percent of the drainage area (Figure 2-4).

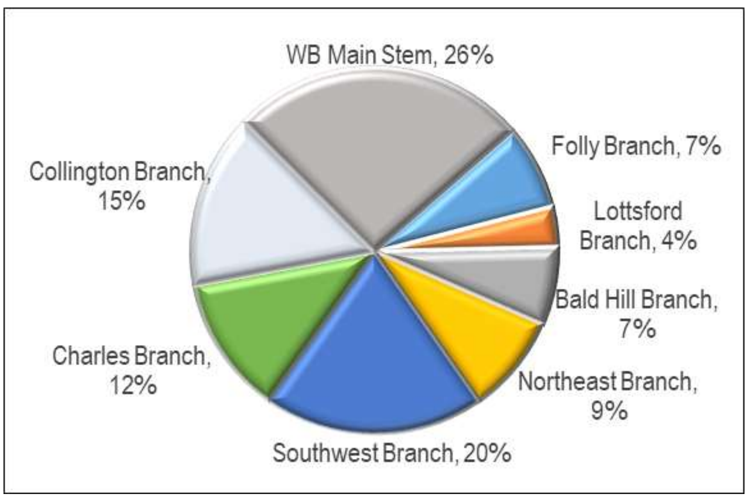


Figure 5-3. Pollutant load reduction targets and gaps for Western Branch watershed.

5.3 Strategy Management Options and Their Load Reductions

The next step in the restoration plan development evaluation procedure (Figure 5-1) is to identify new or enhanced programmatic initiatives followed by implemented BMPs to treat stormwater runoff from impervious surfaces.

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, when implemented, work to reduce pollutant loadings. Examples of nonstructural BMPs include implementation of strategic disconnection of impervious areas in a municipality, street sweeping, homeowner and landowner education campaigns, and nutrient management (e.g., fertilizer usage) (MDE 2009).

The County has implemented and will continue to implement runoff reduction environmental site design (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.

5.3.1 Programmatic Initiatives

Current restoration efforts were reviewed to determine, where possible, their contribution to the necessary load reductions. The existing programmatic initiatives will remain in effect and will be supplemented with additional practices for this restoration plan. These practices are discussed in section 6.4.1 and include programs and activities such as Rain Check Rebate program, pet waste public outreach campaigns, Tree ReLEAF Grant Program, and the Comprehensive Community Cleanup program. Many of these programs provide a degree of load reduction, but their effectiveness is often difficult to quantify or predict. Therefore, load reductions directly attributed to these activities are not included in this restoration plan.

5.3.2 Structural BMPs

Structural urban BMPs are grouped into several types of practices:

- Runoff Reduction (RR) Practices: Rain gardens, bioswales, permeable pavement, bioretention, and urban infiltration.
- Stormwater Treatment (ST) Practices: Urban filtering practices, converting dry ponds to wet ponds, dry detention ponds and hydrostatic devices, dry extended detention ponds, and wet pond and wetland systems.
- MDE-Approved Alternative BMP Practices: Street sweeping, impervious urban area elimination, urban tree planting, urban stream restoration, outfall enhancement, urban forest buffers, and advanced IDDE programs.

The Planning Worksheet can be used to calculate load reductions from retrofits and BMPs for treating impervious surfaces, as shown in Figure 5-1, to meet the load reduction gaps identified in Table 5-1, including the following:

- Retrofit existing ponds to enhance load reductions.
- Restore degraded urban stream channels
- Enhance or restore failing storm drain outfalls.
- Maximize load reductions from public ROW projects.
- Maximize load reductions from public institutional projects.
- Maximize load reductions from commercial/industrial land uses.
- Maximize load reductions from residential properties.

As shown above, the initial focus of restoration planning is retrofitting (i.e., improving) the first generation of stormwater practices such as dry ponds and extended detention dry ponds—which are not very effective in removing pollutants—and bringing them into conformance with current water quality standards. If the load reduction goals are not met after retrofitting the dry ponds, the focus shifts to restoring degraded urban streams and repairing and enhancing existing storm drain outfalls. In some of the subwatersheds, these three activities will prove sufficient to meet the pollutant removal targets. For subwatersheds in which a load reduction gap still exists, the focus then turns to treating the impervious surfaces of the public roads and ROWs. If load reduction gaps still exist, then the next step is to determine if institutional properties (e.g., religious institutions, government offices and facilities, and municipally owned organizations [libraries, fire stations, and schools]) could help to fill the remaining gap. Next, the focus shifts to commercial and industrial land and finally to residential land. These land use types were prioritized according to increasing complexity for planning and implementation of stormwater controls. For example, a ROW is the least complex because it is public property. Stormwater controls within a ROW can be retrofitted with moderate effort.

Retrofit of Existing BMPs

Existing BMPs will be evaluated to see if any practices can be retrofitted with more efficient practices to achieve larger pollutant load reductions. For example, dry ponds can be retrofitted with ESD practices as a priority—or converted to wet ponds and wetlands as a second priority, if ESD practices are not suitable—at reasonable cost to increase the load reductions. The ponds were initially designed for flood control, not water quality improvements, therefore they do not receive load reduction credits from MDE due to their low pollutant removal potential. A dry pond reduces nitrogen by only 5 percent, phosphorus and sediments by 10 percent, and BOD by 27 percent. Converting dry ponds to an ESD practice, which provides reductions of at least 50 percent for nitrogen and BOD, 60 percent for phosphorus, and 90 percent for sediments, will improve pollution reduction at a relatively low cost. These retrofits constitute simple solutions that can be achieved at reasonable cost and in a 2–3-year span. Some of the ponds were designed under now-outdated design criteria. Improvements such as retrofitting to current ESD standards would increase their pollutant reduction potential. The Clean Water Partnership (CWP) is currently enhancing ponds in the watershed.

Urban Stream Restoration

Urban impacts on streams typically include bank and channel erosion, stream health degradation, and loss of natural habitat. Stream restoration uses multiple techniques to mimic the natural state of the stream, provide stability to the channel bed and banks, and improve stream health and habitat. Various kinds of in-stream structures can be used to restore the main channel by providing stable flow steering and energy dissipation and creating pools where natural habitats can develop.

The Western Branch watershed contains a dense network of streams that are extensively degraded (Figure 5-4). Stream flow is primarily nontidal, with the lower 5 mi—below the State Route 4 bridge—influenced by tides on the Patuxent River. The MBSS for 1997–1999 indicates that 42 percent of streams in the County are degraded or severely degraded, while 36 percent are partially degraded. Urban stream restoration might be a highly desirable BMP option. The County's extensive biological monitoring database will be used to identify degraded streams and potential restoration opportunities.


Source: MD DNR n.d.

Figure 5-4. Examples of stream erosion.

Severe erosion, or head cuts, have been observed in the Western Brach watershed, which is a strong indication that there are opportunities for stream restoration in the County (Figure 5-5). A head cut is where there is a sharp change in stream bed elevation due to erosion of the stream bed. These areas continue to erode in an upstream direction, releasing sediment that is conveyed downstream.

Figure 5-5. Example of a stream head cut.

Outfall Stabilization

All 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 for 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 5-6).

Source: Clar 2001.
Figure 5-6. Examples of pipe outfall failure.

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 evaluating locations where outfalls are eroding and need to be stabilized. The County's storm drain outfall geospatial data will be used to identify potential outfall stabilization locations. Outfall IDs will be related to areas of stream degradation and the drainage area to the outfall. Currently MDE limits the pollutant load credit that can be obtained to be equivalent to the treatment of 2 acres of impervious surface.

Rights-of-Way

The County owns and maintains ROWs, which are public space along roads. They represent a high-priority area for restoration and will be a major focus of the County watershed restoration efforts.

In general, urban densities increase inside the Capital Beltway to the Washington, DC, boundary and decrease outside the Beltway. Roads can be classified as either closed (roads bounded by curbs or gutters) or open (roads bounded by lawns and other vegetation without curbs or gutters). The local roads that serve these communities can be organized into several groupings:

- 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

Figure 5-7 provides examples of the different groupings. County ROWs can be present along a road in any of these groupings. Each grouping has its own set of potential BMPs. Table 5-2 is a matrix of road groupings and potential BMPs for ROWs along each type of road. Before BMPs are planned for ROWs on open suburban roadways, MDE's requirements for nonrooftop impervious area disconnection should be evaluated to determine if the road can be considered disconnected.

Urban open section with no sidewalk: Mt. Rainier–Varnum Street.

Urban closed section with curb and gutter but no sidewalk: Capitol Heights–Balboa Avenue.

Urban closed section with curb, gutter, and sidewalk: Mt. Rainier–39th Place.

Suburban open section with no curb, gutter, or sidewalk: Glendale–Dubarry Street.

Suburban closed section with curb, gutter, and sidewalk: Kettering–Herrington Drive.

Source: Google Maps

Figure 5-7. Examples of urban road groupings.

Table 5-2. Practical BMP types for urban road groupings

BMP Type	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 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. These land uses include both County and nonprofit organization properties such as schools, libraries, places of worship, parks, government buildings, fire and police stations, and hospitals, but exclude roadways. The County has initiated discussions with its Board of Education to coordinate and take advantage of available land for BMP retrofits. The County has implemented the Alternative Compliance Program, administered by DoE, which allows nonprofit organization property owners to reduce their CWA (stormwater) fee for 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 on the basis of the impervious cover type (Table 5-3). 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.

Commercial/Industrial Land Use

Commercial and industrial properties are located throughout the watershed. Much like the institutional properties, they 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 5-3). Most of the commercial and industrial facilities are privately owned, however, and some have their own stormwater discharge permits. Consequently, the County has limited influence on the use of BMPs in these areas with the exception of 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.

Table 5-3. Practical BMP matrix for institutional areas

BMP Type	Impervious Cover Elements				
	Roofs	Driveways	Parking	Sidewalks	Other[a]
ESD to the maximum extent practicable from the MDE Design Manual *(MDE 2009)*					
Green roofs	X				
Permeable pavements		X	X	X	X
Reinforced turf		X	X		
Disconnection of rooftop runoff	X				
Disconnection of nonrooftop runoff		X	X	X	X
Sheetflow to conservation areas		X	X		
Rainwater harvesting	X				
Submerged gravel wetlands			X		
Landscape infiltration	X	X	X		X
Dry wells	X				
Microbioretention		X	X		X
Rain gardens		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
Impervious urban to forest					
Planting trees on impervious urban		X	X		X
Tree planter		X	X	X	X

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

Residential Land Use

Residential areas make up 29.6 percent of the watershed and have varying amounts of impervious cover such as roofs, driveways, walkways, and patios. Many of the practices in Table 5-3 could be used on residential land. The most common practices for individual homeowners probably would be 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/condominium communities could install any of the practices listed in Table 5-3.

It is difficult to implement BMPs on residential properties, however, because they are privately owned. One approach the County could take to addressing this difficulty is forming partnerships with apartment and condominium communities to install BMPs in common areas. Also, as with commercial and industrial property owners, the Rain Check Program offers financial incentives for residential property owners to implement approved stormwater management practices.

5.3.3 BMP Siting Procedures

This section describes the procedures used for identifying stream restoration and outfall stabilization opportunities and for using the BMP Siting Tool to identify potential BMP locations, such as bioretention facilities and stormwater ponds (USEPA 2014). The tool is not able to identify potential locations for stream restoration or outfall stabilization opportunities, which were sited using other means.

Stream Restoration

The County conducted a stream corridor assessment (SCA) in its watersheds in the 2000s. These 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. The SCA data was used to identify potential reaches for stream restoration and biological monitoring (section 3.3). It is assumed that if a stream had erosion issues in the 2000s, it will still have them today if no corrective actions have been taken. The result was a map and list of potential stream restoration reaches and the estimated stream length of each stream restoration project.

Outfall Repairs and Stabilization

For this restoration plan, areas for potential outfall repairs and stabilization was determined through geospatial analysis. In the SCA the County conducted in the 2000s, pipe outfalls were among the items investigated. Outfalls were rated on severity of issue, correctability, and access. That information will be reviewed along with outfall pipe characteristics including age, diameter, and construction material. The result was a list and a map of potential outfall repairs or stabilization efforts that will be cross-checked against the list of recent or planned outfall activities to remove those outfalls from consideration in this plan.

BMP Siting Analysis

The BMP Siting Tool, available from EPA, can be used to identify available locations to install BMPs (USEPA 2014). The tool does not generate the drainage area for each BMP footprint.

The general procedure for setting up and running the Siting Tool is as follows:

- Select the structural BMP types for siting analysis.
- Define the site suitability criteria for each BMP type.
- Gather GIS data required for the selected site suitability criteria.
- Develop a geodatabase for the selected GIS data.

- Process GIS data to preferred projection type and spatial extent.
- Enter the site suitability criteria for each selected BMP in the input screen.
- Run the siting tool.

Suitability Criteria

The BMP Siting Tool currently has default criteria for each BMP types. Table 5-4 presents the default suitability criteria for each BMP type. These are the criteria that were used for this analysis. Figure 5-8 shows the criteria input screen for the BMP Siting Tool.

Table 5-4. Default site suitability criteria for structural BMP types

BMP Type	Drainage Area (acre)	Drainage Slope (%)	Impervious Area (%)	Hydrologic Soil Group	Water Table Depth (ft)	Road Buffer (ft)	Stream Buffer (ft)	Building Buffer (ft)
Bioretention	< 2	< 5%	> 0%	A-D	> 2	< 100	> 100	--
Cistern	--	--	--	--	--	--	--	< 30
Grassed swale	< 5	< 4%	> 0%	A-D	> 2	< 100	--	--
Green roof	--	--	--	--	--	--	--	--
Infiltration basin	< 10	< 15%	> 0%	A-B	> 4	--	> 100	--
Infiltration trench	< 5	< 15%	> 0%	A-B	> 4	--	> 100	--
Porous pavement	< 3	< 1%	> 0%	A-B	> 2	--	--	--
Sand filter	< 10	< 10%	> 0%	A-D	> 2	--	> 100	--
Vegetated filterstrip	--	< 10%	> 0%	A-D	> 2	< 100	-	--

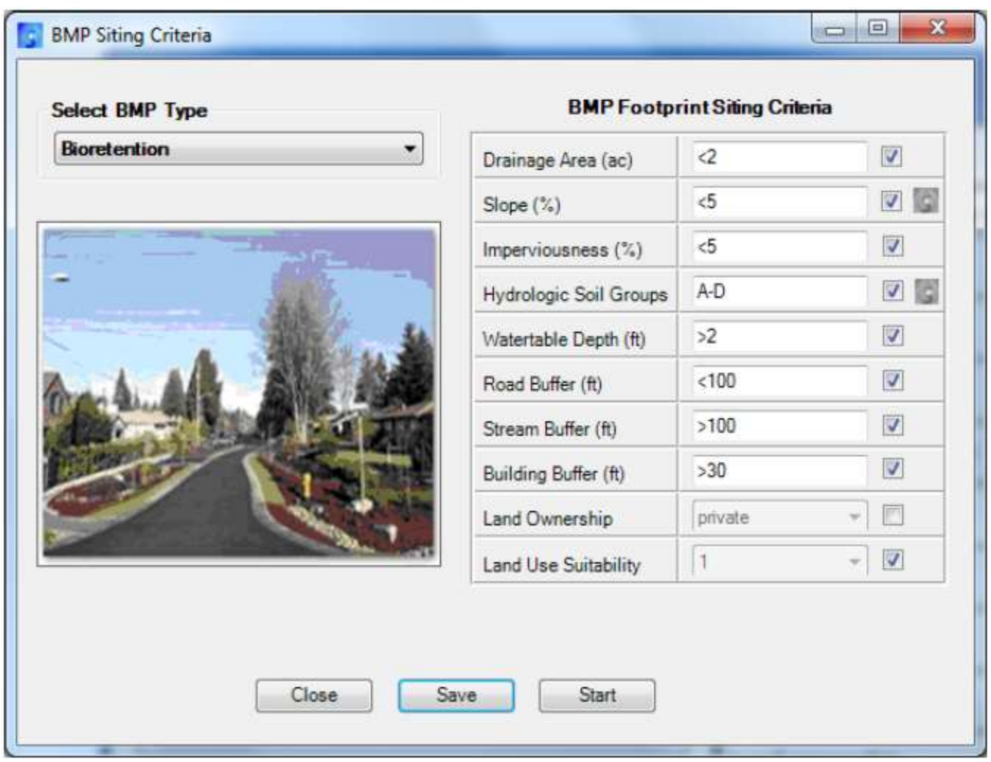


Figure 5-8. Examples of urban road BMP Siting Tool criteria input screen.

Siting Tool Processing

The output of the siting tool analysis is a set of geospatial data that shows the areas that meet the specified site-suitability criteria for placement of the selected BMPs. The results for each BMP type are the “BMP footprints,” or areas where the BMP could be built. Following are several additional postprocessing steps that were needed after the siting analysis is run:

- Remove BMP footprints that are on state or federal lands or within the boundaries of the city of Bowie.
- Remove BMP footprints that are within 25 feet of existing BMP footprints.
- Flag BMP footprints within the drainage areas of existing BMPs.
- Identify a land use type (e.g., residential, commercial) and an ownership type (e.g., municipal, private) for each BMP footprint.
- Assign subwatershed to each BMP footprint.

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

6 RESTORATION ACTIVITY IDENTIFICATION

The County has constructed BMPs throughout the County, including in the Western Branch watershed (see Table 4-5 and Figure 4-4). Existing BMPs and BMPs in the planning stage, however, will meet only 5.5 percent of TN load reduction goals, 5.4 percent of TP goals, and 6.2 percent of TSS goals. This section describes and evaluates the different restoration options available to the County, including structural and programmatic. The load reductions and costs of the structural practices are evaluated.

6.1 Load Reductions from Structural BMPs

This section assesses different treatment options, including stream restoration, outfall stabilization, and ESD practices. The County's MS4 permit requires the treatment of 20 percent of the County's untreated impervious areas. MDE's WLA guidance allows impervious area treatment credits for stream restoration and outfall stabilization (MDE 2014). This section also explores 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 from ESD practices. For costing, only the impervious area is assessed because the available cost data are provided per impervious acre.

6.1.1 Retrofit Existing BMPs

The County evaluated the benefits associated with retrofitting existing dry ponds to being wet ponds or wetlands and already has plans to retrofit and improve the performance of 50 dry and wet ponds in the Western Branch watershed. The County BMP database contains 10 additional dry ponds that could be retrofit and have their load reduction performance improved. Those ponds collect runoff from 1,623 acres, including 500 acres of impervious cover. The five dry ponds that treat the largest areas represent 484 acres of impervious area (97 percent of all impervious area treated by dry ponds) and 1,600 acres of total drainage area (99 percent of all area treated by dry ponds). Table 6-1 shows the number of existing dry ponds, with their drainage areas, by subwatershed. Because of the number of pond retrofits already in planning, this restoration plan does not include additional pond retrofits and focuses on other opportunities.

Table 6-1. Total number of dry pond facilities and their total drainage areas by subwatershed

Subwatershed	Number of Facilities	Total Drainage Area (acres)	Impervious Drainage Area (acres)	Pervious Drainage Area (acres)
Bald Hill Branch	0	0	0	0
Charles Branch	5	281	60	221
Collington Branch	1	4	4	0
Folly Branch	0	0	0	0
Lottsford Branch	2	479	226	253
Northeast Branch	1	357	51	307
Southwest Branch	0	0	0	0
Western Branch Main Stem	1	502	158	343
Total	10	1,623	500	1,123

6.1.2 Stream Restoration and Outfall Stabilization Projects

Stream Restoration. Using the SCA and biological monitoring data, the County identified 58.4 mi of streams with erosion issues in the Western Branch watershed. With this data, several stream restoration (SR) scenarios were evaluated:

- SR 1: Restoring 10 percent of degraded stream mi—5.8 mi (30,814 linear feet [LF])
- SR 2: Restoring 20 percent of degraded stream mi—11.7 mi (61,628 LF)
- SR 3: Restoring 50 percent of degraded stream mi—29.2 mi (154,070 LF)
- SR 4: Restoring 100 percent of degraded stream mi—58.4 mi (308,141 LF)

The outcomes of each scenario were quantified in terms of both pollutant load reductions and impervious area credited (Table 6-2). The load reductions were calculated using MDE guidance (MDE 2014). Figure 6-1 illustrates how SR3 and SR4 will meet load reductions for phosphorus and TSS, while SR2 will also meet reductions for TSS.

Table 6-2. Summary of urban SR scenarios

SR Scenarios	Load Reductions from SR Scenarios (lbs/year)			Treatment Credit Potential (acres of impervious area credit)[a]
	TN	TP	TSS	
SR 1: Restore 10% of SCA-eroded stream mi	2,311	2,095	465,293	308
Load reduction (current/planned BMPs + SR 1)	6,332	2,892	1,137,892	
Achieved % of required load reduction	18%	48%	84%	
Remaining required load reduction	28,324	3,086	224,430	
SR 2: Restore 20% of SCA-eroded stream mi	4,622	4,191	930,585	616
Load reduction (current/planned BMPs + SR 2)	8,643	4,987	1,603,185	
Achieved % of required load reduction	25%	83%	100%	
Remaining required load reduction	26,013	991	0	
SR 3: Restore 50% of SCA-eroded stream mi	11,555	10,477	2,326,463	1,541
Load reduction (current/planned BMPs + SR 3)	15,576	11,273	2,999,062	
Achieved % of required load reduction	45%	100%	100%	
Remaining required load reduction	19,080	0	0	
SR 4: Restore 100% of SCA-eroded stream mi	23,111	20,954	4,652,926	3,081
Load reduction (current/planned BMPs + SR 4)	27,131	21,750	5,325,525	
Achieved % of required load reduction	78%	100%	100%	
Remaining required load reduction	7,525	0	0	

Notes: lbs/year = pounds per year.
[a] Crediting methodology from Table 7 in MDE (2014) guidance.

According to MDE policy, the effectiveness of stormwater management practices in reducing pollutant loads can be expressed in terms of an area of imperviousness that would generate that amount of pollution above the amount generated by a naturally wooded area. That amount of impervious area constitutes the “treatment credit” for a practice or set of practices. Current MDE policy considers every 100 feet of stream restoration as providing a treatment credit of 1 acre of impervious surface (MDE 2014).

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

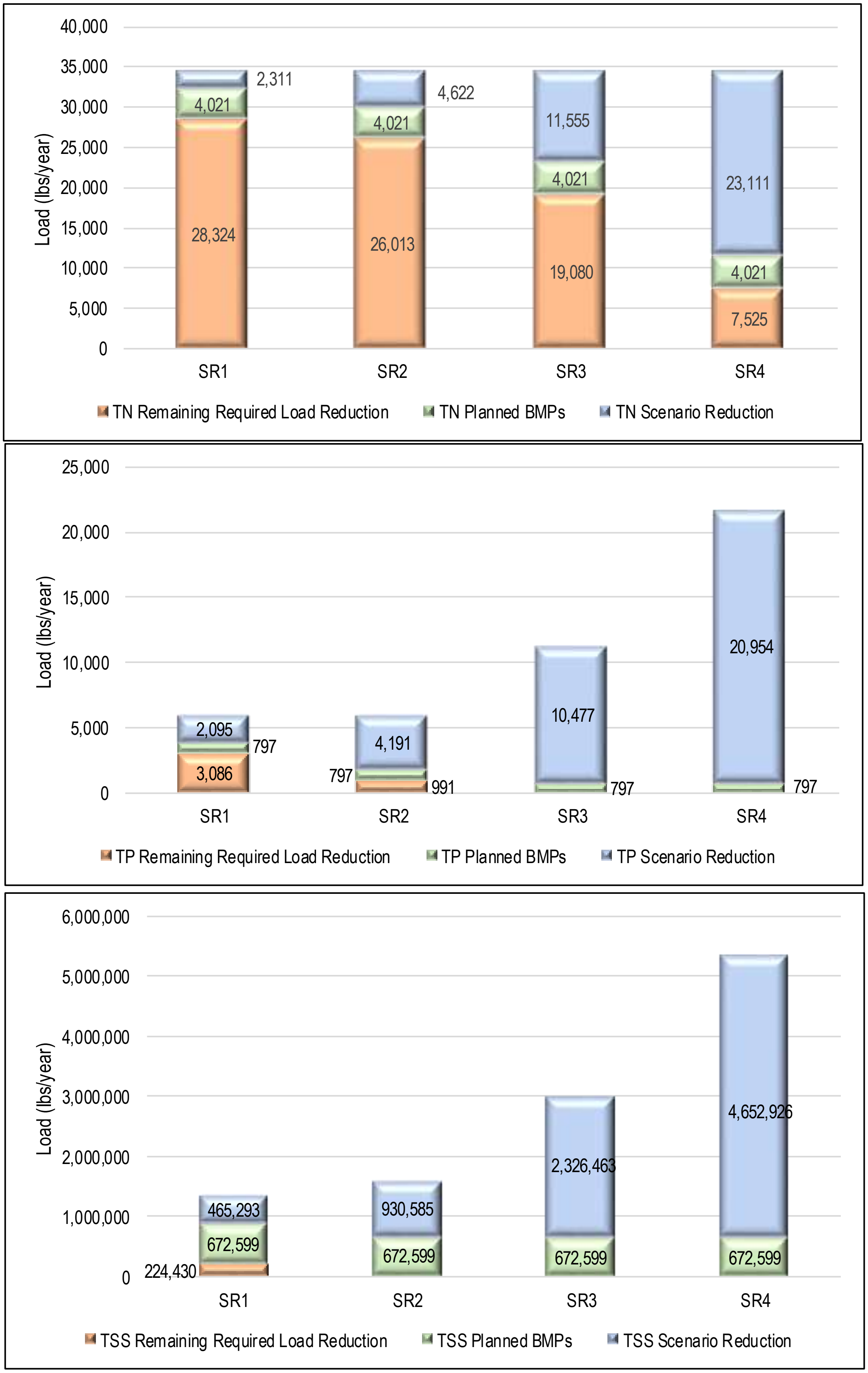


Figure 6-1. Summary of urban SR scenarios (Table 6-2).

Outfall Stabilization. Although the County's outfall database does not indicate which outfalls are failing, it can be used to identify potential outfall stabilization project sites from the outfalls and associated drainage areas upstream of the degraded stream reaches. The SCA field evaluations identified 356 failing stormwater outfalls (out of more than 6,700 in the watershed), with pipe diameters ranging from 12 to 60 inches. Many of the outfalls are described as the headwaters of a stream. These failing outfalls actively contribute to stream erosion and sediment generation and consequently present many restoration opportunities. Table 6-3 summarizes the number of failing outfalls documented in SCA report by subwatershed. Table 6-4 shows the load reductions and impervious area treated for stabilizing all 356 outfalls, along with the required remaining load reduction and the equivalent impervious area treated. Because the SCA data is more than 10 years old, the number of failing outfalls in 2018 could be much higher. Obtaining an accurate current count would require additional field work. The load reductions in Table 6-4 represent current load reduction calculations. MDE is in the process of evaluating an alternative method for calculating load reductions for outfall stabilization as proposed by the Maryland State Highway Administration (McCormick Taylor 2018). If MDE approves the methodology, the load reductions from the alternative method are expected to be higher than the current method. These higher load reductions will be accounted for in the County's annual MS4 reports.

Table 6-3. Summary of outfall facilities by subwatershed

Subwatershed	SCA-documented failing outfalls	Treatment Credit Potential (acres of impervious area credit)[a]
Bald Hill Branch	51	102
Charles Branch	74	148
Collington Branch	24	48
Folly Branch	28	56
Lottsford Branch	31	62
Northeast Branch	36	72
Southwest Branch	9	18
Western Branch Main Stem	103	206
Total	356	712

Note:
[a] Crediting methodology from Table 7 in MDE (2014) guidance. 100 LF/1 acre impervious credit, up to 2 acres of impervious area credit per stabilized outfall.

Table 6-4. Summary of outfall stabilization scenario

Outfall Stabilization (OS)	Load Reductions from OS Scenarios (lbs/year)		
	TN	TP	TSS
OS 1: Stabilize all SCA-eroded outfalls	5,340	4,842	1,075,120
Load reduction (current/planned BMPs + OS 1)	9,361	5,638	1,747,719
Achieved % of required load reduction	27%	94%	100%
Remaining required load reduction	24,766	2,709	0

Notes: lbs/year = pounds per year.

6.1.3 Environmental Site Design Practices

ESD practices are grouped into two categories: RR and ST practices. These practices can be installed to manage runoff generated by all urban land uses (e.g., street ROWs, residential, and institutional). ST practices reduce pollutants through filtration or settling (e.g., sand filters, wet ponds). RR practice reduce pollutants through infiltration interception by vegetation, and adsorption by soil (e.g., bioretention systems, permeable pavement). RR practices have a higher level of pollutant removal than ST practices because of the pollutant removal mechanisms. For this restoration plan, only RR practices have been considered.

To aid in restoration planning, there is set of standard BMP load reduction efficiencies for the various categories of stormwater management practices (MDE 2014). These efficiencies can be used to develop the loading removal rates by BMP type (Table 6-5). The loading rates for impervious and pervious land were obtained from Chesapeake Assessment Scenario Tool (CAST) and are specific to the Western Brach watershed. Using the BMP efficiencies for RR practices, the overall loading removal rate was calculated (Table 6-5). On average for BMPs in the County's records, 71 percent of the treated drainage area for current BMPs is impervious area. Consequently, the weighted average loading rate is 71 percent of the impervious surface loading rate and 29 percent of the pervious loading rate. The weighted average loading rates are shown in Table 6-5.

Table 6-5. Loading rates and efficiencies for RR practices

Parameter	Loading Rates (lb/acre/yr) for Untreated Land		Treatment / Removal Rates[a]	Loading Removal Rates (lb/acre/yr) by BMP Type		
	Impervious Rate	Pervious Rate		Impervious Surface	Pervious Surface	Weighted Average
TN	12.55	6.05	57%	7.2	3.4	6.1
TP	0.79	0.85	66%	0.5	0.6	0.53
TSS	1,559.7	551.7	70%	1,092	386	887

Source: CAST.
Notes: lb/acre/yr = pounds per acre per year.
[a] Removal rates are based on treating first inch of runoff. (MDE 2014)

Based on the rates shown in Table 6-5, a significant amount of area would need to drain to RR practices to meet the target load reduction from Table 5-1:

- TN = 30,635 lbs ÷ 6.1 lbs/acre = 5,022 acres
- TP = 5,181 lbs ÷ 0.53 lbs/acre = 9,775 acres
- TSS = 683,723 lbs ÷ 887 lbs/acre = 778 acres

The 9,775 acres that would need to be treated are 28 percent of the 34,383 acres of urban land in the Western Branch watershed, which is 48.3 percent of the total watershed area (Table 6-6). The dominant urban land uses are medium density residential (18.9 percent) and low-density residential (10.7 percent), which represent 61 percent of the urban area in the watershed. Residential areas are generally composed of approximately 25 percent impervious land cover (USDA 1986). By contrast, institutional land uses only make up 9.0 percent of the urban area. Institutional areas make up the easiest opportunities for the County to implement BMPs.

Table 6-6. Western Branch watershed land use by subwatershed

Land Use	Bald Hill Branch	Charles Branch	Collington Branch	Folly Branch	Lottsford Branch	Northeast Branch	Southwest Branch	Western Branch Main Stem	Total Area	% Total Watershed Area
Commercial	63	91	259	284	38	296	593	414	2,038	2.9%
High-density residential	159	211	420	232	95	237	1,015	767	3,135	4.4%
Industrial	349	154	634	275	0	0	1,140	361	2,914	4.1%
Institutional	283	555	298	164	165	108	693	827	3,093	4.4%
Low-density residential	149	1,772	2,007	660	355	1,277	229	1,165	7,614	10.7%
Medium-density residential	1,579	1,363	2,827	1,473	519	832	2,385	2,427	13,405	18.9%
Open urban land	55	139	200	27	229	136	198	420	1,403	2.0%
Transportation	47	72	149	14	23	31	215	231	782	1.1%
Total Urban Area	**2,683**	**4,357**	**6,795**	**3,129**	**1,424**	**2,918**	**6,467**	**6,611**	**34,383**	**48.3%**
Total Watershed Area	**3,527**	**11,711**	**14,866**	**4,091**	**2,165**	**5,558**	**10,128**	**19,031**	**71,076**	**100.0%**

Source: MDP 2010.

6.1.4 Load Reduction Scenarios

No single scenario will meet the load reduction targets except for the structural BMPs, which are typically more expensive than the other types. Therefore, a combination of the types of restoration activities need to be considered. Table 6-7 presents the remaining load reduction needed after the load reductions from OS 1 and the four stream restoration scenarios are combined and subtracted from the load reduction gap presented in Table 5-1. Because no combination of the OS and SR scenarios will meet the TN load reduction targets, ESD BMPs will have be used to achieve the remaining load reduction. The area that needs to be treated to meet that load reduction can be calculated using the weighted average loading rate information for area provided in Table 6-5 (Table 6-7). The amount of urban land that will need to be treated by RR practices is greatly reduced from 9,775 acres by combining stream restoration, outfall stabilization, and RR practices.

Table 6-7. Combined load reduction analysis

Stream Restoration and Outfall Stabilization Scenario Combinations	Remaining Load Reduction (lb/yr)			Total Acres Needed to be Treated by RR Practices to Achieve Remaining Load Reduction		
	TN	TP	TSS	TN	TP	TSS
OS 1 & SR 1	22,984	0	0	3,768	0	0
OS 1 & SR 2	20,673	0	0	3,389	0	0
OS 1 & SR 3	13,740	0	0	2,252	0	0
OS 1 & SR 4	2,185	0	0	358	0	0

6.2 Restoration Strategy Costing

6.2.1 Unit Cost Determination

This section provides an analysis of the costs associated with the various BMP strategies. Table 6-8 presents the data on BMP unit cost per impervious acre treated. These unit costs were previously developed by Tetra Tech (2015) and are based on *Costs of Stormwater Management Practices in Maryland Counties* (King and Hagan 2011).[1] Stream restoration costs were taken directly from the King and Hagan (2011) report. These costs were converted to January 2018 dollars using the RSMeans historical cost indexes (Gordian 2018). Table 6-8 contains information on the total life cycles of BMPs. Although individual life cycles can range from 10 to 50 years, the lifetime of on-the-ground BMPs is generally considered to be about 20 years, with BMPs it the ROW having a shorter life span of 10 years.

Table 6-8. BMP costs by application

BMP Type	Life Span (years)	Preconstruction & Construction Cost/Imp. Acre	O&M Unit Cost/ Imp. Acre/Year	Total Life Costs	Annualized Cost/ Imp. Acre
ESD on ROW: open section	10	$58,199	$1,085	$69,054	$6,905
ESD on ROW: closed section	10	$61,697	$2,624	$87,940	$8,794
ESD on institutional	20	$56,665	$1,529	$87,244	$4,362
ESD on commercial/industrial	20	$56,665	$1,529	$87,244	$4,362
Stream restoration	20	$55,156	$983	$74,814	$3,741
Outfall stabilization	20	$55,156	$983	$74,814	$3,741

Notes: cost/imp. acre = cost per impervious acre; cost/imp. acre/year = cost per impervious acre per year; O&M = operation and maintenance. Costs in January 2018 dollars.

Outfall stabilization was not used in the 2015 restoration plans. Consequently, the unit costs for stream restoration are used for outfall stabilization because the design and construction costs for the two types of BMP projects are similar. The remaining BMP group type costs are averages of different specific BMP types. The following is a discussion of the methods used to determine the BMP type costs presented in Table 6-8.

ROW: Open Section. Several ESD practices can be used on an open section ROW. They were ranked from the lowest cost (impervious disconnection) to the highest cost (permeable pavement). Because this restoration plan does not specify which practices will be used, the final costs were weighted according to an estimated proportion for each practice to arrive at the final cost. Based on professional judgment and experience in the County and the State, it was assumed that 20 percent of open section roadways might qualify for impervious disconnect credit, 30 percent could be treated with swales or bioswales, 40 percent could be treated with vegetated open channels, and 10 percent would require a permeable pavement practice. Because the King

[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.

and Hagan report (2011) does not contain any values for impervious disconnection, the urban grass filter cost was used as a surrogate.

ROW: Closed Section. A similar analysis was conducted for the closed section ROW. The ranking of potential ESD practices ranged from the least expensive (tree box) to the most expensive (permeable pavement). The tree box will generally not meet the performance criteria as a stand-alone practice, but will need to be coupled with other practices such as bioretention/rain garden practices. Based on professional judgment and experience in the County and the State, it was projected that this combination of practices could treat the runoff from 40 percent of the closed section ROW acres and that another 40 percent might require a hydrodynamic device or a similar practice. In addition, it was projected that approximately 15 percent of the areas would require an urban filter and 5 percent would require a permeable pavement solution.

Institutional/Industrial/Commercial. The institutional, industrial, and commercial land use applications were subject to a similar analysis. As previously described, the institutional land use applications have a much larger grouping of ESD practice options. The ranking by cost was the same as for open section ROWs. The institutional applications also usually have more space available for stormwater practices. In addition, roof areas could be treated using impervious area disconnection coupled with storage devices such as dry wells, landscape planters, or rain gardens. This accounts for 30 percent of the total institutional impervious area. Based on professional judgment and experience in the County and the State, another 45 percent could be treated with landscape-based practices such as bioretention. In addition, urban filtering practices might make up 20 percent and another 5 percent could require the use of permeable pavement in parking areas.

6.2.2 Cost Analysis for Stream Restoration and Outfall Stabilization

Table 6-9 presents the total costs for each of the scenarios described in sections 6.1.1 and 6.1.2 for dry pond conversions, stream restoration, and outfall stabilization. The table also presents the annualized costs, unit costs per impervious acre treated, and cost per pound of pollutant treated.

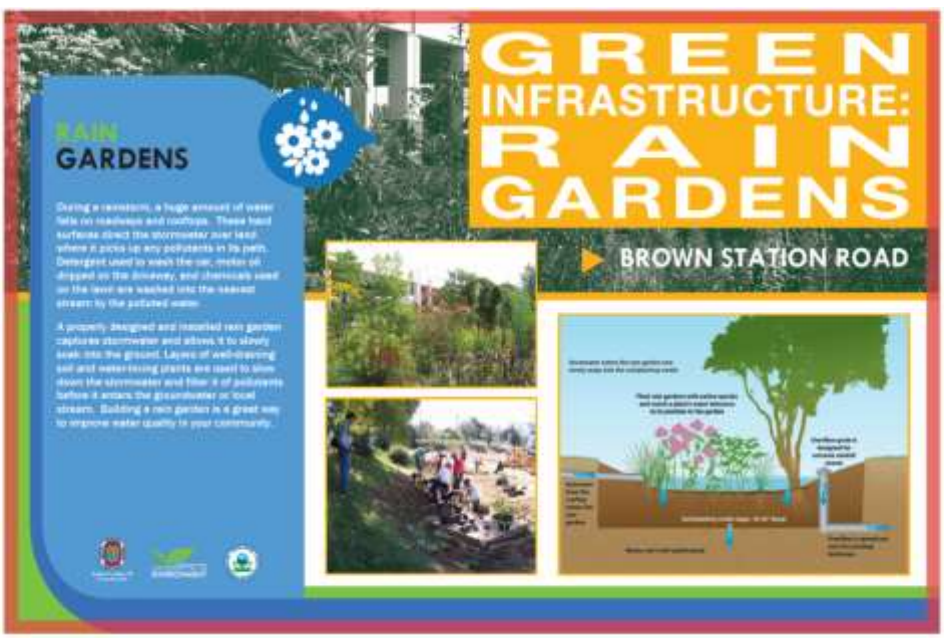


Table 6-9. Cost analysis for stream restoration and outfall stabilization

ESD Practice by Land Use	Restoration Amount	Treatment Credit Potential (acres of impervious area credit)[a]	Cost / Treatment Credit	Total Cost	Lbs TN Removed	Cost / Lb TN	Lbs TP Removed	Cost / Lb TP	Lbs TSS Removed	Cost / Lb TSS
Stream Restoration										
SR 1: Restore 10% of SCA-eroded stream mi	5.8 miles	308	$55,156	$16,995,917	2,311	$7,354	2,095	$8,111	465,293	$36.53
SR 2: Restore 20% of SCA-eroded stream mi	11.7 miles	616	$55,156	$33,991,835	4,622	$7,354	4,191	$8,111	930,585	$36.53
SR 3: Restore 50% of SCA-eroded stream mi	29.2 miles	1,541	$55,156	$84,979,587	11,555	$7,354	10,477	$8,111	2,326,463	$36.53
SR 4: Restore 100% of SCA-eroded stream mi	58.4 miles	3,081	$55,156	$169,959,174	23,111	$7,354	20,954	$8,111	4,652,926	$36.53
Outfall Stabilization										
OS 1: Stabilize all SCA-eroded outfalls	356 outfalls	712	$55,156	$39,271,311	5,340	$7,354	4,842	$8,111	1,075,120	$36.53

Notes: cost/lb = cost per pound; lbs = pounds. Costs in January 2018 dollars.

[a] Crediting methodology from Table 7 in MDE (2014) guidance. 100 LF/1 acres impervious credit, up to 2 acres of impervious acre credit per stabilized outfall

6.2.3 Cost Analysis for ESD BMPs

Implementing the combination of restoration strategies described above will result in substantial progress towards meeting the TMDL target loads. The remaining pollutant loads can be targeted using RR practices in ROWs and institutional, commercial/industrial, and residential land uses.

Using the distribution of different urban land use types within the watershed as documented in Table 6-6, the following percentages for distribution of BMPs by land use type to treat the areas identified in Table 6-7.

- Residential (including local streets and ROWs) = 60%
- Institutional & Transportation = 5%
- Commercial and Industrial = 35%

This strategy produces the cost estimate of the RR practices shown in Table 6-10. The table presents four sets of scenarios corresponding to the scenarios listed in Table 6-7. For example, Combination 1 looks at the costs associated with performing outfall stabilization on the SCA-identified outfalls and 10 percent of the stream with erosions issues identified in the SCA. From Table 6-7, there are additional acres that must be treated by ESD practices to meet load reduction targets. Those acres are split into residential ROWs, institutional/transportation, and commercial/industrial lands.

Table 6-10 summarizes the pollutant removal benefits, total area treated (for RR practices only), impervious treatment credit, and total costs associated with the four comprehensive watershed restoration strategies for the Western Branch watershed. All four strategies meet the TMDL pollutant removal targets, and implementing any of them will also result in considerable progress toward treating impervious surfaces in the watershed as required by the MS4 permit. Combination 4, at a cost of $224 million, is the lowest cost strategy. It requires treating 358 acres of urban area, or 1 percent of total urban area. This scenario assumes a 100-percent restoration of eroded streams identified in the SCA, which might prove to be impractical depending on site conditions. Combination 3 assumes only that 50 percent of the eroded streams identified in the SCA are restored. The scenario would cost $218 million. This scenario requires treating 2,252 acres of urban area, or 7 percent of all urban areas in the watershed. A detailed field study will be necessary to determine the amount of stream restoration and outfall stabilization that can be completed in the Western Branch watershed. With that new information, the County can reassess the costs shown in Table 6-10.

Table 6-10a. RR practice restoration strategy cost analysis

ESD Practice by Land Use	Total Acres Treated	Treatment Credit (Imp. acres)	Cost / Treatment Credit	Total Cost	Lbs TN Removed	Cost / Lb TN	Lbs TP Removed	Cost / Lb TP	Lbs TSS Removed	Cost / Lb TSS
Combination 1										
ESD: Residential Open ROW (30%)	1,130	802	$58,199	$46,692,864	6,869	$6,797	602	$77,542	1,002,518	$46.58
ESD: Residential Closed ROW (30%)	1,130	802	$61,697	$49,499,322	6,869	$7,206	602	$82,203	1,002,518	$49.37
ESD: Institutional & Transportation (5%)	189	134	$56,665	$7,603,932	1,149	$6,618	101	$75,499	167,678	$45.35
ESD: Commercial & Industrial (35%)	1,319	936	$56,665	$53,066,593	8,018	$6,618	703	$75,499	1,170,196	$45.35
ESD Practices Subtotal	**3,768**	**2,675**	**--**	**$156,862,711**	**22,906**	**$6,848**	**2,008**	**$78,123**	**3,342,910**	**$46.92**
OS 1: Stabilize all SCA-eroded outfalls	--	712	$55,156	$39,271,311	5,340	$7,354	4,842	$8,111	1,075,120	$36.53
SR 1: 10% SCA-eroded streams	--	308	$55,156	$16,995,917	2,311	$7,354	2,095	$8,111	465,293	$36.53
TOTAL	**--**	**3,695**	**--**	**$213,129,939**	**30,557**	**$6,975**	**8,945**	**$23,827**	**4,883,322**	**$43.64**
Combination 2										
ESD: Residential Open ROW (30%)	1,017	722	$58,199	$42,023,578	6,182	$6,797	542	$77,542	902,266	$46.58
ESD: Residential Closed ROW (30%)	1,017	722	$61,697	$44,549,390	6,182	$7,206	542	$82,203	902,266	$49.37
ESD: Institutional & Transportation (5%)	169	120	$56,665	$6,799,283	1,027	$6,618	90	$75,499	149,934	$45.35
ESD: Commercial & Industrial (35%)	1,186	842	$56,665	$47,715,678	7,210	$6,618	632	$75,499	1,052,200	$45.35
ESD Practices Subtotal	**3,389**	**2,406**	--	**$141,087,928**	**20,602**	**$6,848**	**1,806**	**$78,124**	**3,006,667**	**$46.93**
OS 1: Stabilize all SCA-eroded outfalls	--	712	$55,156	$39,271,311	5,340	$7,354	4,842	$8,111	1,075,120	$36.53
SR 2: 20% SCA-eroded streams	--	616	$55,156	$33,991,835	4,622	$7,354	4,191	$8,111	930,585	$36.53
TOTAL	**--**	**3,734**	**--**	**$214,351,074**	**30,564**	**$7,013**	**10,838**	**$19,777**	**5,012,372**	**$42.76**

Notes: cost/lb = cost per pound; imp. acres = impervious acres; lbs = pounds. Costs in January 2018 dollars.

(Table continues on next page.)

Table 6-10b. RR practice restoration strategy cost analysis

ESD Practice by Land Use	Total Acres treated	Treatment Credit (Imp. acres)	Cost / Treatment Credit	Total Cost	Lbs TN Removed	Cost / Lb TN	Lbs TP Removed	Cost / Lb TP	Lbs TSS Removed	Cost / Lb TSS
Combination 3										
ESD: Residential Open ROW (30%)	676	480	$58,199	$27,933,076	4,109	$6,797	360	$77,542	599,736	$46.58
ESD: Residential Closed ROW (30%)	676	480	$61,697	$29,611,984	4,109	$7,206	360	$82,203	599,736	$49.37
ESD: Institutional & Transportation (5%)	112	80	$56,665	$4,506,034	681	$6,618	60	$75,499	99,365	$45.35
ESD: Commercial & Industrial (35%)	788	559	$56,665	$31,703,165	4,790	$6,618	420	$75,499	699,101	$45.35
ESD Practices Subtotal	**2,252**	**1,599**	--	**$93,754,259**	**13,690**	**$6,848**	**1,200**	**$78,125**	**1,997,939**	**$46.93**
OS 1: Stabilize all SCA-eroded outfalls	--	712	$55,156	$39,271,311	5,340	$7,354	4,842	$8,111	1,075,120	$36.53
SR 1: 50% SCA-eroded streams	--	1,541	$55,156	$84,979,587	11,555	$7,354	10,477	$8,111	2,326,463	$36.53
TOTAL	**--**	**3,852**	**--**	**$218,005,157**	**30,585**	**$7,128**	**16,518**	**$13,198**	**5,399,522**	**$40.37**
Combination 4										
ESD: Residential Open ROW (30%)	107	76	$58,199	$4,421,360	650	$6,797	57	$77,542	94,929	$46.58
ESD: Residential Closed ROW (30%)	107	76	$61,697	$4,687,104	650	$7,206	57	$82,203	94,929	$49.37
ESD: Institutional & Transportation (5%)	19	13	$56,665	$764,416	116	$6,618	10	$75,499	16,856	$45.35
ESD: Commercial & Industrial (35%)	125	89	$56,665	$5,029,055	760	$6,618	67	$75,499	110,898	$45.35
ESD Practices Subtotal	**358**	**254**	--	**$14,901,935**	**2,176**	**$6,847**	**191**	**$78,114**	**317,612**	**$46.92**
OS 1: Stabilize all SCA-eroded outfalls	--	712	$55,156	$39,271,311	5,340	$7,354	4,842	$8,111	1,075,120	$36.53
SR 2: 100% SCA-eroded streams	--	3,081	$55,156	$169,959,174	23,111	$7,354	20,954	$8,111	4,652,926	$36.53
TOTAL	**--**	**4,048**	**--**	**$224,132,421**	**30,627**	**$7,318**	**25,986**	**$8,625**	**6,045,658**	**$37.07**

Notes: cost/lb = cost per pound; imp. acres = impervious acres; lbs = pounds. Costs in January 2018 dollars.

6.3 BMP Siting

This section describes the results of the geospatial analyses undertaken to identify locations that appear to be technically suitable for several types of BMPs. This plan proposes only the number of BMPs needed, not specific BMP types and locations, thus giving the County the flexibility to identify specific locations and work with partners (e.g., to install BMPs on institutional or private land). Selection of actual projects to fund and complete will involve a more comprehensive evaluation of potential projects in terms of costs, land availability, site accessibility, technical feasibility and constraints, pollutant removal, and other factors.

6.3.1 Stream Restoration

For this analysis, the team assumed that, if a stream was found to have erosion issues during the SCA undertaken in the 2000s and no corrective actions have been taken since, the stream channel will still have those issues. There were 446.7 mi of stream reaches with known erosion issues (from very minor to very severe) identified in the SCA data. There are an additional 11.7 miles of streams that were identified using biological assessment monitoring data for potential stream restoration. All these reaches are being considered for stream restoration in the restoration plan (Figure 6-2). Table 6-11 present the potential stream restoration miles per subwatershed by severity of the observed erosion. Collington Branch and the main stem of the Western Branch subwatersheds contain 72 percent of the stream restoration opportunities.

Table 6-11. Summary of potential stream restoration

	Severity of Erosion in River Miles by Subwatershed								
	Identified by SCA Data					Identified by Biological Data			
Subwatershed	Very Severe	Severe	Moderate	Minor	Very Minor	Very Severe	Severe	Moderate	Total
Bald Hill Branch	1.70	0.93	0.15	0	0	0.25	3.35	0	6.38
Charles Branch	3.92	0.54	0	0.39	0.06	0	0.85	0	5.76
Collington Branch	5.32	2.18	11.62	0.98	0.08	0	0	0.30	20.48
Folly Branch	0	0.27	0.34	0	0	0	0.36	0.44	1.42
Lottsford Branch	0.10	0	0.29	0.25	0.10	0	0	0	0.75
Northeast Branch	0.58	0.25	0.66	0	0	0	0	0	1.49
Southwest Branch	0.59	0.82	0.96	0.08	0.11	0	1.61	1.00	5.17
Western Branch Main Stem	7.68	4.09	0.94	0.53	0.14	2.28	0.80	0.46	16.91
Total	19.89	9.09	14.97	2.23	0.49	2.53	6.97	2.20	58.36

6.3.2 Outfall Repairs/Stabilization

To identify outfalls for the County to stabilize or repair, the team further reviewed the SCA data and removed outfalls on state or federal land and outfalls in the city of Bowie from consideration. Figure 6-2 shows the locations of the remaining outfalls in the County along with the severity of the outfall erosion. Of the 356 outfalls, 74 had moderate or severe erosion in the early 2000s, and where no corrective action has been taken since then, is the team assumed that the outfall would still have erosion issues (Table 6-12). These locations should be prioritized for corrective action in the implementation of this restoration plan.

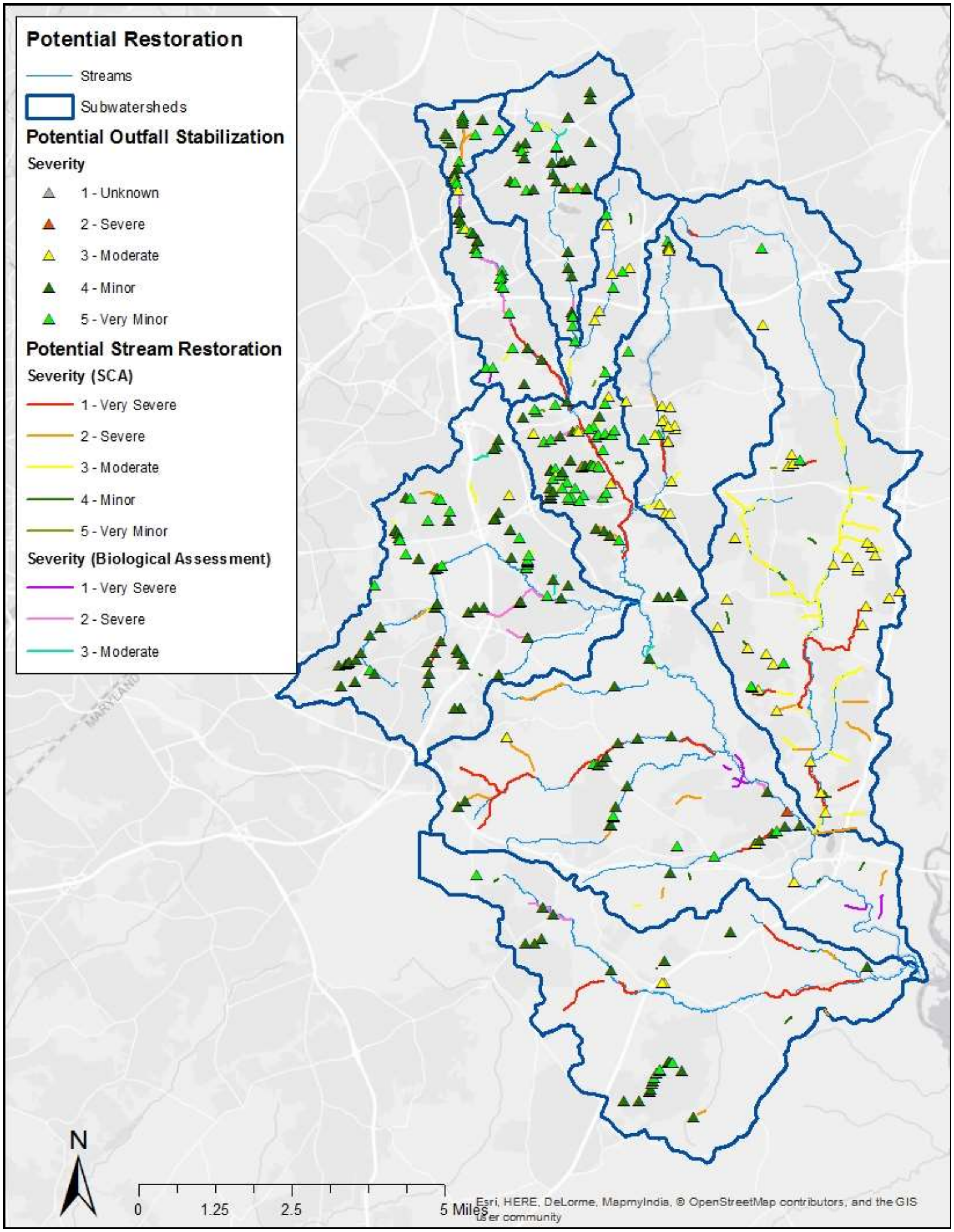


Figure 6-2. Potential stream restoration and outfall stabilization locations.

Table 6-12. Summary of potential outfall stabilization locations

Subwatershed	Number of Outfalls by Severity of Erosion			
	Moderate	Minor	Very Minor	Total
Bald Hill Branch	4	22	25	51
Charles Branch	2	18	7	28[a]
Collington Branch	27	0	4	31
Folly Branch	3	23	10	36
Lottsford Branch	5	0	4	9
Northeast Branch	17	0	7	24
Southwest Branch	1	52	21	74
Western Branch Main Stem	14	48	40	103[b]
Total	73	163	118	356

[a] Includes one location of unknown severity.
[b] Includes one outfall with severe erosion.

6.3.3 BMP Siting Analysis

Potential BMP sites were identified using the methodology described in section 5.3.3 and screened to ensure that none are located on state or federal land or within the city of Bowie. The output of the siting analysis was a geospatial dataset that shows the areas that meet the specified site suitability criteria.

Figure 6-3 shows a street-level example of the BMP siting results around the intersection of Walker Mill Road and Ritchie Road. The site conditions satisfy the criteria for several various kinds of BMPs. The County can further evaluate the BMP options using additional factors such as aesthetics before selecting a final set of BMPs for that location. Because of similar BMP siting criteria, several BMP types were sited on the same strip of land. These will provide the County options in considering additional factors (e.g., aesthetics) in selecting the type of BMP at a location. The siting analysis identified several large buildings that could be candidates for green roofs. Many buildings were identified as candidates for either cisterns (larger buildings) or rain barrels (smaller buildings). The analysis also found many opportunities other practices.

Figure 6-4 shows the general BMP siting results for the entire watershed. The potential locations have been categorized by the land type. For instance, many opportunities for BMPs were found on residential properties. Table 6-13 presents the number of land parcels with opportunities for BMPs among different types of land use (e.g., schools, parks, and municipal buildings). In the table, one commercial complex or park can cover multiple parcels. For instance, a strip mall and the surrounding parking lots could cover 10 parcels. If a BMP opportunity was identified on each of those parcels, 10 parcels would be identified in Table 6-13. As a result, the number of parcels for some categories seems high (e.g., parks, commercial, and golf courses).

The siting analysis found many opportunities in northern, more developed areas of the watershed, but not all those opportunities represent feasible projects. The analysis did not account for the presence of overhead or underground utilities, for example, which could greatly complicate efforts to place BMPs. The majority of potential BMP sites (97 percent of the parcels) were on private property, where the County cannot construct BMPs unless they obtain easements (Figure 6-4 and Table 6-13). In addition, any BMP that the County installs on private property requires a maintenance agreement between the County and property owner.

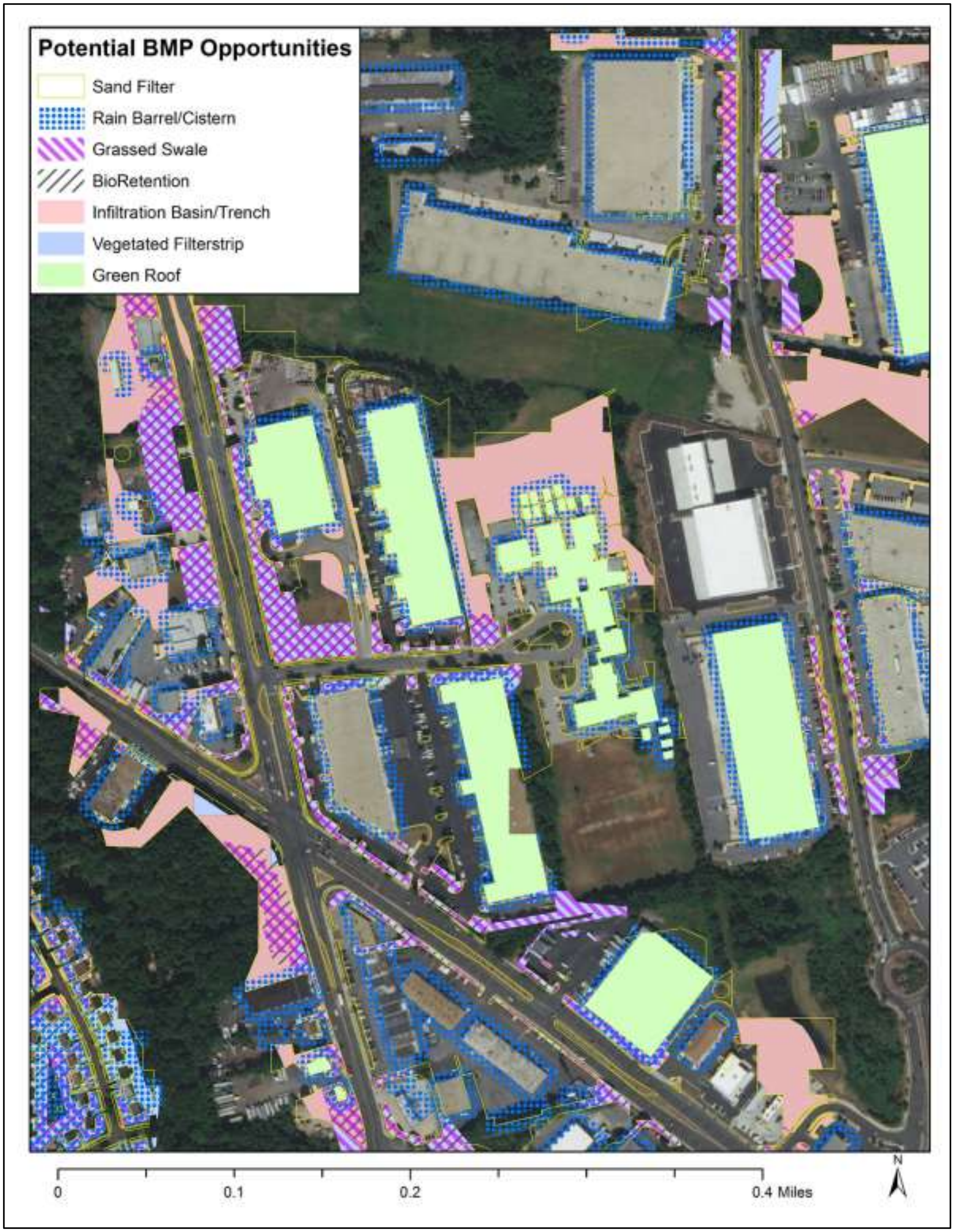


Figure 6-3. Example of BMP siting results (intersection of Walker Mill Road and Ritchie Road).

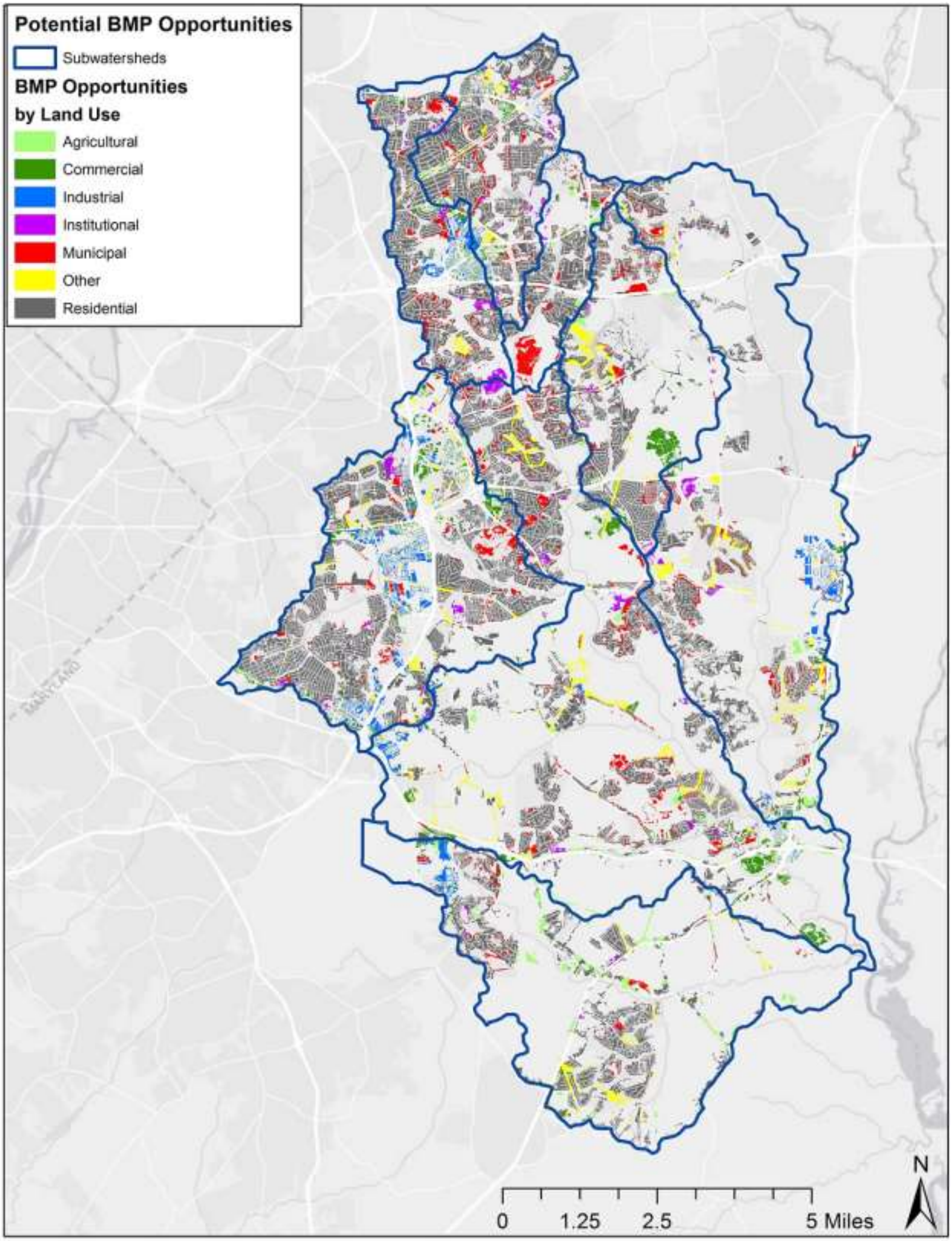


Figure 6-4. BMP siting results for the Western Branch watershed.

Table 6-13a. Number of parcels with potential BMP opportunities by ownership and land use type

Subwatershed	Municipal Parcels					Institutional Parcels		
	Municipal Building/ Property	Fire/ Police Station	Library	School	Park	Cemetery	Hospital / Nursing Home	Nonprofit/ Church
Bald Hill Branch	32	1	0	12	127	0	2	16
Charles Branch	12	0	0	6	123	1	0	12
Collington Branch	18	1	1	3	292	0	1	13
Folly Branch	21	1	0	8	138	1	4	24
Lottsford Branch	1	1	0	1	51	0	2	0
Northeast Branch	4	0	0	6	143	2	0	13
Southwest Branch	58	2	1	22	161	0	1	63
Western Branch Main Stem	41	2	1	16	358	4	3	30
Total	187	8	3	74	1,393	8	13	171

Table 6-13b. Number of parcels with potential BMP opportunities by ownership and land use type

Subwatershed	Residential Parcels					
	Apartment/ Condo	Single Family	Town Home	Mobile Home	Open Space	Vacant
Bald Hill Branch	9	4,815	576	1	4	130
Charles Branch	6	3,550	1,220	4	2	310
Collington Branch	14	3,959	1,381	1	4	148
Folly Branch	4	3,871	1,231	1	11	297
Lottsford Branch	0	1,432	330	0	0	34
Northeast Branch	11	2,982	903	0	8	59
Southwest Branch	99	7,125	4,091	1	10	188
Western Branch Main Stem	47	7,015	4,104	1	14	224
Total	190	34,749	13,836	9	53	1,390

Table 6-13c. Number of parcels with potential BMP opportunities by ownership and land use type

Subwatershed	Other Parcels						
	Commercial	Industrial	Agricultural	Parking Lot	Utility	Other/ Vacant	Golf Course
Bald Hill Branch	80	54	3	2	4	91	0
Charles Branch	45	47	106	1	18	37	20
Collington Branch	65	54	22	0	11	158	31
Folly Branch	170	37	0	6	7	204	1
Lottsford Branch	8	0	9	0	1	14	0
Northeast Branch	12	0	15	0	2	14	3
Southwest Branch	449	329	7	13	20	149	0
Western Branch Main Stem	146	42	60	2	27	114	18
Total	975	563	222	24	90	781	73

6.3.4 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 greatest water quality benefit will be realized for available funding and installing the BMPs in a desirable time frame and with minimal disruption. Three main considerations for prioritizing BMP locations are land ownership / site access, location in the stream watershed, and locations of known issues and existing treatment.

Land ownership and site access

DoE and CWP are actively installing BMPs throughout the County. The easiest locations in which to install practices are on 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 at stormwater outfalls (usually available as flood easements), which allows the County to proceed without the delays of negotiating with private landowners, facilitating faster implementation, and reducing the resources spent 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 towards 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 these examples can build public support for implementing BMPs on private property.

Location in the watershed

Another factor to consider in BMP placement is the location relative to the stream's headwaters. Improvements to water quality and stream stability in the stream's headwaters will provide benefits along the entire length of the stream. For instance, stream restoration is best undertaken by starting at the headwaters and working downstream so that, during restoration, upstream excess sediment will not damage newly restored areas downstream. Water quality improvement projects that can address the excess sediment from stream erosion are more appropriate to smaller headwater (first- and second-order) subwatersheds. 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. 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.

Locations of known issues and existing treatment

A third key consideration in determining where to place BMPs is identifying where they have not yet been adequately implemented and where known erosion issues and areas of poor biological health exist. Figure 6-5 shows how these locations can be mapped to identify priority areas for targeted BMP development. These locations were identified by reviewing existing and planned locations and types of BMPs (e.g., RR or ST), regulatory agency (only County MS4 land is identified), bioassessment results, and areas of concentrated impervious surfaces. The impervious and regulatory areas were not included on the map to make it clearer and easier to read.

6.4 Additional Load Reduction Activities

In addition to implementing BMP, the County can further reduce nutrient and sediment loads through nonstructural implementation activities. It can be difficult, however, to estimate the load reduction from these activities because of difficulties in collecting data and institutional barriers. Programmatic nutrient reduction strategies rely on the public participating in watershed restoration and behavior changes (e.g., lawn care) and participation can be difficult to track and link directly to load reductions. On-site wastewater systems and sanitary sewer leaks also contribute nutrients to the County's water bodies; however, nutrient reduction activities related to wastewater are not under the responsibilities of DoE. Finally, there are contributions of nitrogen from atmospheric deposition. These sources are harder to control, but the Clean Air Act is helping to reduce these nitrogen contributions to the watershed. This section explores in detail nonstructural nutrient reduction strategies and programs to address the sources discussed above.

6.4.1 Programmatic Strategies

DoE has initiated a wide range of education and outreach initiatives to inform the public about the impacts of their daily activities on the health of their watershed and local water bodies. This section describes County programs that directly or indirectly support water quality improvement and help the public form a general understanding of watersheds and water quality and promote behavior change and support for restoration projects. During fiscal year (FY) 2017, the County hosted more than 350 environmental education and outreach events to promote environmental awareness, green initiatives, and community involvement in reducing the amount of pollution entering the County's waterways. More than 15,000 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.

The County plans to continue to support and operate each of these programs. While each program has the potential to improve water quality, the potential load reductions from each one have not been estimated for this restoration plan. The DoE education and outreach initiatives discussed in this section include stormwater management, pet waste disposal, increasing the tree canopy, and litter control. County programs also address lawn stewardship by educating residents on how to fertilize wisely. Much of the County's lawn stewardship outreach is conducted through the County's Master Gardener program but is also conveyed through outreach in their tree programs.

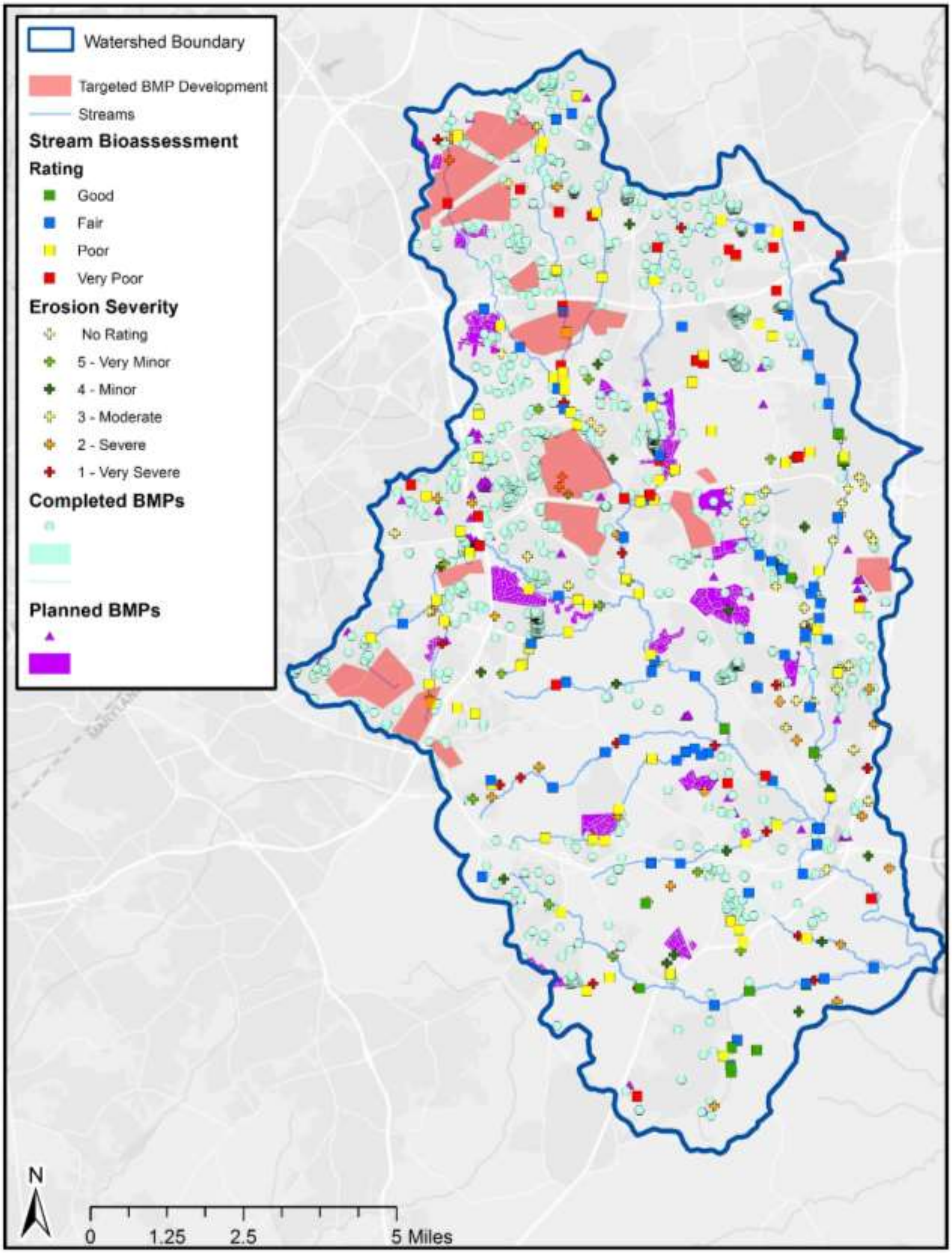


Figure 6-5. Example map for areas for BMP prioritization in the Western Branch watershed.

Many items in this section are described in the *Prince George's County 2017 Annual NPDES MS4 Report* (DoE 2018). The County also uses social media (e.g., Facebook) and partnering organizations to promote messages, programs, and community events.

Residential and Community Stormwater Management

Numerous County programs address residential and community stormwater management and implementation. These programs promote stormwater projects on residential and institutional land. These practices do provide load reduction benefits. The County could receive load reduction credit for these practices, if properly installed and reported to the County. For example, the Rain Check Rebate program promotes installation of eligible stormwater practices that can reduce runoff from yards and landscaping in residential areas. Those practices can include installing permeable pavement/pavers, disconnecting roof downspouts from the storm drain system, tree planting, and installing structural practices—such as rain gardens, rain barrels, and green roofs—to reduce stormwater volume and pollutant load. Homeowners, businesses, and nonprofit entities can be reimbursed for part of the cost of installing practices covered by the program. Property owners implementing these techniques through the program will reduce their CWA fee if the practice is maintained for 3 years.

Rain Check Rebate Program Eligible Stormwater

The County also promotes stormwater management through the Alternative Compliance Program, which works with faith-based organizations and other nonprofits to identify ways to encourage the installation of stormwater management practices. The Stormwater Stewardship Grant Program provides funds for on-the-ground restoration activities that improve communities and water quality and engage County residents in restoring and protecting the local rivers and streams. In FY 2017, the County and the Chesapeake Bay Trust funded 23 new projects to support stormwater restoration efforts for a total of more than $2 million through the Stormwater Stewardship Grant Program. Those projects included on-the-ground efforts such as rain gardens and bioretention practices as well as outreach campaigns to engage citizens in schools, faith-based organizations, and their neighborhoods. In addition, technical assistance was provided for tree planting on private individual residential properties and installing Bandalong trash traps in the Anacostia River watershed and through environmental education ("Treating and Teaching").

Pet Waste Disposal

Besides being unsightly and smelly, pet waste contributes nitrogen, phosphorus, bacteria, and other pollutants to local water bodies if not disposed of properly. The County's goal for their pet waste campaign is to spur behavior change by raising residents' awareness and concern about pet waste disposal. COPE uses a multipronged approach to supporting pet waste pickup and disposal activities in the County:

- Building and maintaining partnerships such as:
  - Working with Greenbelt and the city of Bowie to assist in their pet waste campaigns.
  - Partnering with the Environmental Finance Center (EFC) at the University of Maryland and the People for Change Coalition to increase awareness about pet waste pollution and encourage residents to pick up their pets' poop.
  - Attending the 2017 Greenbelt Pet Waste Expo.

"Scoop that Poop" game at a community event.

- Partnering DoE with EFC to host a Prince George's County Pet Waste Management Summit on April 6, 2017, in Largo. This free event kicked off DoE's efforts to address the problem of pet waste in communities across the County and its impact on the health of residents and local waterways. The summit had 86 registrants, with 57 people attending the event. All registrants and attendees received an extensive meeting follow-up with the summit presentations, outreach campaign material, and pet waste outreach program templates.
- Participating in community and municipal festivals and events. County representatives attend numerous festivals and community events where DoE provides materials to engage with the public to increase awareness of pet waste pollution.
- Developing printed materials:
  - "Scoop the Poop" pledge card asks County residents to commit to picking up after their pets.
  - A "Scoop the Poop" game (based on a Snohomish County, WA, poop toss game).
  - "Why Scoop that Poop?" and "What Happens When You Don't Scoop that Poop?" brochures in English and Spanish.

"Why Scoop that Poop" dog park sign.

  - 3-foot by 4-foot posters for "Do Your Doody Scoop That Poop," "Target Locations," and "Promoting Pet Waste Pickup."
  - Community signage for high-use areas (for children and adults).
  - "Why Scoop that Poop" dog park sign
- Installing pet waste disposal stations:
  - The County used stormwater stewardship grants to select the People for Change Coalition to work with Glendale and Lanham homeowner associations to install

pet waste disposal stations and promote awareness of the problem that pet waste can cause.

- With funding from the 2017 Chesapeake Bay Trust watershed stewardship grant, EFC helped launch the County's new pet waste education campaign, which was piloted in six municipalities, including District Heights, which is in the Western Branch watershed. EFC developed community marketing and communications plans as well as maintenance and monitoring plans tailored to each community. Fund was also provided for 60 new pet waste stations. They have engaged 30 unique communities in the municipalities through events geared toward identifying goals related to pet waste and stormwater management.

- Developing a GIS-based pet waste tracking application. EFC and DoE began development of a tracking application to measure the amount of pet waste collected in the pet waste stations and help assess the success of educational efforts. It is assumed that the amount of pet waste collected will increase as individual awareness through education increases.

Increasing the Tree Canopy

Trees are known to provide numerous public health and social benefits. Trees clean the air, beautify neighborhoods and landscapes, help to conserve energy, help to reduce water pollution and soil erosion, cool city streets, increase property values, and provide food and habitat for wildlife, among other benefits. The County's goal is to preserve, maintain, enhance, and restore tree canopy coverage on developed and developing sites for the benefit of County residents and future generations. The County is working to promote and increase tree plantings and increase the County's tree canopy coverage, which will help improve water and air quality, and provide habitat benefits. The County has several programs and materials that promote tree plantings:

- Tree ReLEAF Grant Program. Civic organizations, neighborhoods, communities, homeowner associations, and local municipalities are eligible to apply for and receive grants of up to $5,000 ($10,000 for municipalities) to plant native trees and shrubs in public or common areas. The program requires a 50-percent match, which in turn provides a hands-on opportunity for applicants to learn how to properly plant and care for trees and shrubs. Between October 2016 and May 2017, six projects were completed, resulting in 139 native trees being planted. Based on the National Tree Benefit Calculator, trees for these projects will intercept 5,977 gallons of stormwater runoff per year.

- Tree planting demonstrations. In FY 2016, DoE initiated a tree-planting demonstration program to increase tree canopy and tree survival by showing residents and businesses the proper way to plant and care for trees. Since FY 2017, the County has conducted 16 demonstrations.

- Arbor Day Every Day program. This program seeks to increase the number of native trees and shrubs planted on school grounds. Coordinating with Prince George's County Public Schools, the program educates students on the everyday importance of trees, empowers them to enhance their community, and provides funds or trees for planting projects. DoE assists with the development of planting and maintenance plans, orders and arranges delivery of trees and materials, marks the holes for plants based on the plan, and provides training on planting and care. Under this program, 92 native trees and shrubs were planted at five County schools in FY 2017.
- Stormwater Stewardship Grants for Trees. In FY 2017, DoE used several stormwater stewardship grants to fund tree plantings on private property. These projects supported DoE's effort to increase urban tree canopy with an emphasis on underserved areas as well as to assist in improving water and air quality. Prince George's Green, a nonprofit group, in partnership with Ecoasis Garden Center, a local nursery, and Central Kenilworth Avenue Revitalization Community Development Corporation received $50,000 for this effort. With these funds, the corporation planted 123 trees on residential property, and Prince George's Green and Ecoasis planted 100 trees. In addition, the Interstate Commission on the Potomac River planted 11 trees and 7 shrubs on school property through their stormwater stewardship grant.
- Right Tree, Right Place program. This program removed 1,900 high-risk or dying trees and planted 4,700 new trees that provided a net increase of 2,800 new trees.

Litter Control

Few things diminish the beauty of an area more than garbage littering the ground or floating along a creek. DoE is working to reduce litter throughout the County by removing existing litter and encouraging residents to change their behavior to prevent littering.

The County uses a variety of trash control measures that help prevent, intercept, and clean up litter. The County's antilittering strategy addresses littering at its source to prevent it from occurring. The litter control programs are intended to reduce incidents of littering (e.g., by installing trash and recycling receptacles and marketing to support a new antilitter campaign). Since human behavior is the root cause of litter in our communities and creeks, promoting litter pickup and prevention is vital to the County's success in reducing the impacts of litter in local waterways.

The County's trash reduction efforts in the Anacostia watershed in FY 2017 included collecting more than 1,000 bags and an estimated 43 tons of trash. The overall Anacostia trash reduction program was estimated to reduce the annual trash load by more than 32 tons.

The County's trash reduction, litter reduction, and recycling programs seek to establish partnerships with individuals, nonprofit organizations, and municipalities and to develop programs that will increase the tonnage of litter captured, removed, and prevented in communities and waterways. Partnerships and programs include:

- Adopt-a-Stream project. This project aims to reduce litter in and around streams, rivers, and other local waterways. DoE encourages residents, businesses, civic organizations, and academic institutions to adopt a stream segment to enhance the aesthetics, remove pollutants, and improve habitat and water quality for aquatic plants and animals. Adopt-a-Stream groups can also survey their stream section and notify DoE of pollution and illegal dumping.
- PGCLitterTRAK application. This smartphone application can be used by community groups and individual citizens to report their efforts to reduce litter in their communities.
- Comprehensive Community Cleanup program. This program is designed to revitalize, enhance, and help maintain unincorporated areas of the County. DoE works with organized civic and homeowners associations to provide a concentrated focus on cleanup and maintenance services in their community over a 2-week period. This program provides 21 cleanup phases annually.
- Volunteer Neighborhood Cleanup program. This program assists communities in cleanup efforts to control litter. Active participation in the cleanup of a local neighborhood, park, road, street, or pond removes potential stormwater pollutants and builds community pride. Many participating groups further enhance and beautify their areas by planting trees, sowing seeds, weeding, watering, and mowing grass. DoE's Sustainability Division provides each interested community with technical assistance and materials such as trash bags and gloves, and may also provide roll-off containers depending on availability.
- Volunteer Storm Drain Stenciling project. The storm drain stenciling project spreads the word throughout a community to act to prevent water pollution and maintain a clean environment. Volunteers help prevent water pollution by stenciling/inlet marking the storm drains with "Don't Dump–Chesapeake Bay Drainage." Stenciling serves as a visual reminder that anything dumped in the storm drain contaminates the Chesapeake Bay. Volunteer groups supply the volunteers and the County provides the supplies, which may include DoE participation.

6.4.2 Additional County 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, IDDE, construction site runoff control, postconstruction 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 beyond BMP implementation.

- Street sweeping. The County conducts street-sweeping operations on select arterial, collector, and industrial streets. Residential subdivisions are swept on a request-only basis. Street sweeping can reduce the amount of debris, including sediment that reaches waterways. The street-sweeping data collected for the arterial and industrial streets are recorded in four seasonal cycles, with 3 months of data recorded for each cycle. In FY 2017, the County swept 1,491 mi in the County (including some roads in the Western Branch watershed) and removed 2,240 tons of debris from County roadways before the material had a chance to enter local water bodies.
- Storm drain maintenance: Inlet, storm drain, and channel cleaning. This is a systematic water quality-based storm drain program in which routine inspections and cleanouts are conducted on 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 69 major channels on a 3-year cycle. In FY 2017, DPW&T performed maintenance on 31,244 LF of channel.
- Illicit Connection and Enforcement program. In partnership with the County's Comprehensive Community Cleanup program, DoE conducts field screening and outfall sampling. This program is designed to revitalize, enhance, and help maintain unincorporated areas of the County, providing a wide range of cleanup and maintenance services to a community over a 2-week to 1-month period. Outfall sampling serves to detect and eliminate stormwater pollutants and support clean, healthy communities. Enforcement actions associated with violations involving the improper storage of materials and/or dumping on private property are the responsibility of the Department of Permitting, Inspections, and Enforcement. Enforcement action for illegal dumping on public property is the responsibility of DPW&T. Prevention of human exposure to sewage is administered by the Health Department in accordance with on-site sewage disposal systems regulations. The control of hazardous chemicals and substances is governed by the Fire Safety Code. Where appropriate, the County also refers enforcement cases to MDE.
- Cross-connection elimination program. Another potential source of nutrients, BOD, and bacteria is the "cross-connection," or a location where a dwelling's sewers are directly connected to the storm sewer instead of the sanitary sewer. These connections can be discovered by means of dye testing, smoke tracing, and chemical signatures. An aggressive program to discover and eliminate cross-connections can also substantially reduce human bacteria loads. The County has a program to detect these illicit discharges into the County's stormwater system, and thus into the County's water bodies.

6.4.3 Wastewater Programs

On-Site Disposal System Repair and Replacement

Nutrient loads from failing septic tanks are not part of the County's stormwater MS4 load reductions. Upgrading septic systems or connecting houses to a sanitary sewer system will help the overall achievability of the target load reductions. It is difficult, however, to accurately predict the number of failing septic systems or the number of failures addressed through septic system upgrades or removal (after homes are connected to sanitary sewers). Significantly reducing the number of failing septic systems—or even the number of septic systems in general— might help reduce the number of stormwater BMPs required to support water bodies in meeting applicable water quality criteria in the watershed. This would be determined through monitoring and the restoration plan's adaptive management approach. Load reductions associated with septic system maintenance, enhancements, and conversions can be used by local governments as alternative practices in meeting NPDES stormwater permit requirements as per MDE guidance (MDE 2014).

Sewer Repair and Rehabilitation

Another source of nutrients and bacteria in stormwater is aging sewer lines and manholes. More than 850 mi of sanitary sewers exist in the Anacostia River watershed. Of those, more than 100 mi of sewers were installed before 1940 and another almost 300 mi were built in the 1940s and 1950s. In extreme cases, aging sewer lines result in SSOs. As a result, the single most effective measure in reducing SSOs is repairing and rehabilitating existing sewer lines. WSSC is under a 2005 consent decree with the EPA to overhaul its sewer lines to reduce SSOs under their SR3 Program. As part of that program, improvements to leaky sewer lines could dramatically reduce human bacteria loads as well as nutrients, BOD, and sediment. Because this effort is not administered by the County, it is difficult to determine the amount of rehabilitation effort would be involved. Its cost would be borne by WSSC. Loads from sewer overflows and leaks, however, are not part of the County's MS4 load reduction. Loadings from SSOs and other sewer leaks are reflected in water quality monitoring data. The correction of SSOs and other sewer leaks will help the overall achievability of the local water quality requirements.

6.4.4 Atmospheric Deposition Reductions

Data and modeling results analyzed for the Chesapeake Bay TMDL show that atmospheric deposition is the largest single input load of nitrogen to the Bay watershed. They also indicate that during the 1985 to 2005 Bay modeling period, those input loads were declining. The Chesapeake Bay TMDL (, which includes the entire Western Branch watershed, provides load allocations for atmospheric deposition of nitrogen. Analysis of atmospheric deposition for the Bay TMDL separated air deposition nitrogen into two parcels: (1) atmospheric deposition occurring on the land and nontidal waters in the Bay watershed, which is subsequently transported to the Bay; and (2) atmospheric deposition occurring directly onto the Bay tidal surface waters. The Bay TMDL considers deposition on land as part of the jurisdiction's allocated loads because it (1) becomes mixed with nitrogen loads from other land-based sources, (2) is controlled in the same way as other land-based sources, and (3) is indistinguishable from other land-based sources. The Bay TMDL assumes that implementation of Clean Air Act measures through 2020 will result in significant emissions reductions that will, in turn, reduce the amount of nitrogen deposited on land surfaces.

7 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 intent of the County is not only to track its implementation of this restoration plan but also to evaluate how well its implementation 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 to inform its adaptive management of this restoration plan.

7.1 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 MS4 annual 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.

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:

- Includes the estimated pollutant load reductions resulting from all completed structural and nonstructural water quality improvement projects and enhanced stormwater management programs.
- Compares 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.

7.2 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 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 Western Branch watershed. 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 accurate, monitoring is performed in accordance with a quality plan with standard operating procedures for sample collection.

The County will continue to evaluate options for its own monitoring activities in consultation with MDE. No matter which monitoring activities are undertaken by the County, it will remain MDE's responsibility to perform the official monitoring for the state's Integrated Report assessments and impairment. MDE gathers monitoring data for every watershed in the state on a 5-year cycle.

7.2.1 Biological Monitoring

The biological condition of the County's streams is rated using MD DNR's B-IBI, which is calculated based on the numbers 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 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 implementing biological monitoring. Sampling at each stream location encompassed 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 planning Round 4 (R4), which will start in 2019 and run 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 rapid BMP implementation through 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.

The approach presented here 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.

7.2.2 Water Quality Monitoring

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. Instead, water quality monitoring is conducted to asses a set of upstream restoration practices. The County currently monitors the Bear Branch watershed (part of the Upper Patuxent River watershed) as part of its MS4 permit requirements.

The County will continue dry- and wet-weather monitoring to determine the concentrations of TN, TP, and TSS using MDE-approved methods and laboratories. The County will request that MDE continue its Integrated Report assessment monitoring in the watershed and that MDE provide permission to relocate its current two NPDES monitoring stations in Bear Branch watershed to a subwatershed in the Piscataway Creek watershed. The new monitoring locations will be downstream of multiple planned restoration activities (e.g., ESD practices, stream restoration, and public outreach).

Currently, the County does not have the resources to perform water quality monitoring at multiple locations throughout the watershed and County. If monitoring were to be conducted in each of the eight subwatersheds in the Western Branch watershed (or 41 countywide), 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).

7.3 Adaptive Management Approach

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

Close coordination for adaptive management is especially valuable because of the possibility of unanticipated circumstances arising during restoration plan implementation. For example, the installed BMPs might remove significantly more or less than the amount of pollution expected. A natural disaster could affect the plan’s implementation. And 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 additional activities to compensate for 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, lawn care, and pet waste.

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 its impact on BMPs. USEPA conducted a modeling study investigating the resilience of BMPs with the potential for more extreme precipitation events due to climate change (USEPA 2018). The results of the study found that BMPs that have been designed for current conditions will most likely fail to treat and reduce runoff from the larger and more intense storm events projected in future conditions. This failure could cause stormwater to overflow BMPs, thus the BMPs would not treat all the runoff and would not reduce runoff volume reaching the Country's water bodies. This could result in downstream channel erosion and flooding impacts. BMPs built with current design standards will require a larger temporary storage volume or will need reconfigured outlet structures to reduce the hazard of flooding and channel erosion likely to be experienced due to more frequent and intense precipitation events.

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 further restoration activities. The County will evaluate its progress during its next permit cycle 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 recent water quality data.

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

- The County will use adaptive management to determine the most appropriate restoration practices at the best locations. This means that 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.
- Part of the adaptive management strategy is to help 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. These advances could decrease cost, decrease the footprints of the BMPs, or increase load reduction efficiencies. Some of the advances could come from proprietary technologies, which the County will evaluate on the basis of their cost and performance.
- The full size and extent of several potential sources of nutrients are difficult to determine. These sources include illicit sewer connections, SSOs, cross-connections, septic leaks, and atmospheric deposition. Although the magnitude of their contribution to pollutant loads is unknown, some load reduction can be achieved by WSSC's SR3 Program, the removal of illicit connections, and reductions of emissions that lead to

atmospheric deposition. Any measurable load reductions from these activities will decrease the need for BMPs to reduce loads, potentially decreasing cost to the County.

- Using biological monitoring results, DoE can adjust implementation priorities and target areas of poor stream health within the Western Branch watershed. The biological assessment results will be interpreted at multiple spatial scales as Degraded/Not Degraded (for specific stream sites) and percent degradation (for sets of sites within subwatersheds and the Western Branch watershed as a whole). The County will use these 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.

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

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