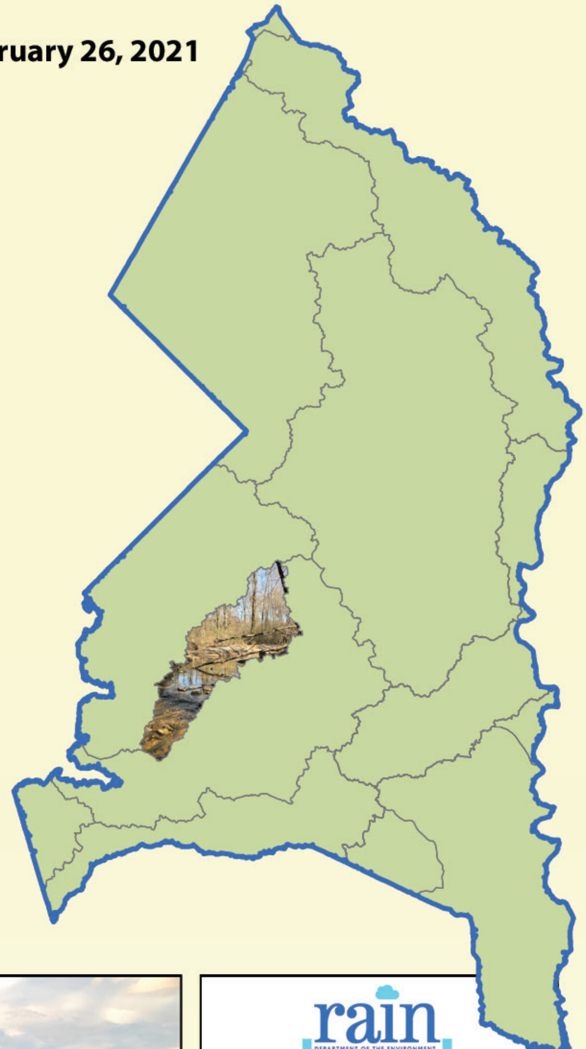
February 26, 2021

ANGELA ALSOBROOKS
COUNTY EXECUTIVE

Prince George's County
DEPARTMENT OF THE
ENVIRONMENT



Watershed Plan for the Tinker's Creek Watershed in Prince George's County

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DEPARTMENT OF THE ENVIRONMENT
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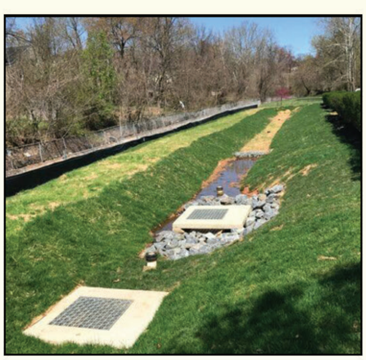
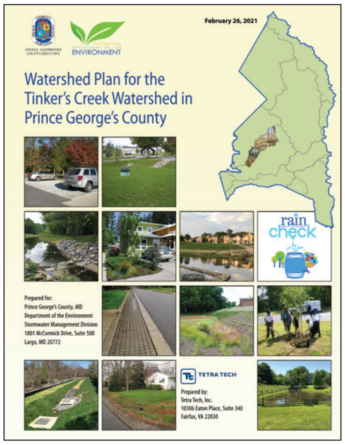
Prepared for:
Prince George's County, MD
Department of the Environment
Stormwater Management Division
1801 McCormick Drive, Suite 500
Largo, MD 20772



TETRA TECH

Prepared by:
Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030



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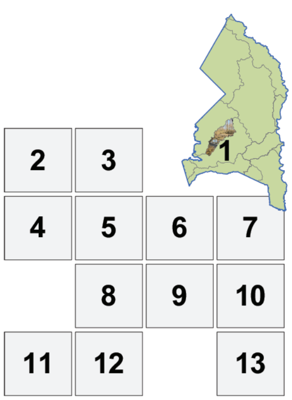

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13. Clean Water Partnership

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Acronym List

AMD	Animal Management Division
B-IBI	Benthic Index of Biotic Integrity
BMP	best management practice
BOD	biochemical oxygen demand
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
DPIE	[Prince George's County] Department of Permitting, Inspection, and Enforcement
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
IDDE	Illicit Discharge Detection and Elimination
lb	pound
MD DNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
mi	mile
mg/L	milligrams per liter
M-NCPPC	Maryland-National Capital Park and Planning Commission
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
ROW	right-of-way
RR	runoff reduction
SR3	Sewer Repair, Replacement and Rehabilitation Program
SSO	sanitary sewer overflow
ST	stormwater treatment
STORET	STOrage and RETrieval
TMDL	total maximum daily load
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
WSSC	Washington Suburban Sanitary Commission

1 INTRODUCTION

The Water and Science Administration 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 Tinkers Creek watershed. Tinkers Creek was chosen because of a planned stream restoration project in the watershed. This watershed was included in the 2014 restoration plan due to elevated bacteria levels in Piscataway Creek, into which Tinkers Creek flows. In addition to bacteria, this plan also focuses on reducing nitrogen, phosphorus and sediment loads. This plan was developed similar to the 2014 restoration plan, except this plan follows guidance provided by MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2020a).

The purpose of this restoration plan is to provide a set of activities and identify potential locations/areas for best management practice (BMP) implementation, increasing the likelihood of practices being installed. The plan will expand on a large stream restoration project currently being implemented in the upper reaches of watershed that will improve more than 5 miles of Tinkers Creek. This plan identifies upland BMP opportunities to help protect the stream after the stream restoration is completed, while also identifying additional restoration opportunities (structural or nonstructural) throughout the watershed to provide ecosystem enhancements.

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 it 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 2014 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 designated use class. The bar on the right represents the amount of pollutant load that 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. The target load reductions for the Tinkers Creek watershed are 22.2 percent for total nitrogen (TN) and 41.0 percent for total phosphorus (TP) for the Chesapeake Bay TMDL and 42.6 percent for bacteria and 51.0 percent for sediment for local TMDLs.

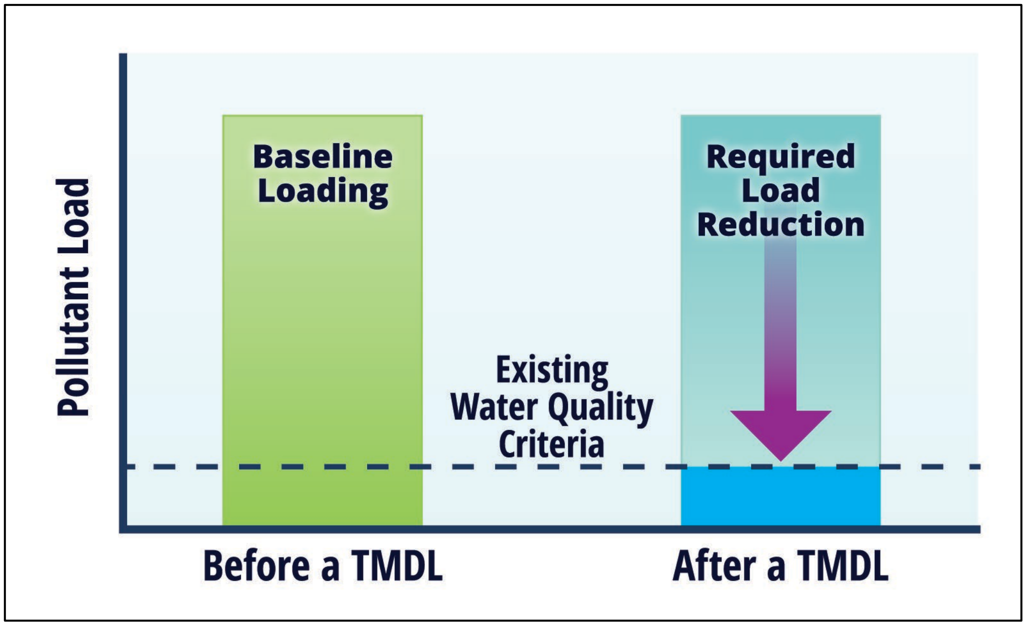


Figure 1-1. Conceptual schematic of a typical pollution diet, or TMDL.

1.2 Watershed Restoration Goals and Objectives

Watershed goals for Tinkers Creek 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 Tinkers Creek 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 Tinkers Creek 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 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 eight major sections:

- *Section 2 Watershed Characterization* summarizes the natural features (hydrology, topography, and soils) and land cover of the watershed.
- *Section 3 Watershed and Water Quality Conditions* outlines the water chemistry and biology of the watershed. It also identifies pollutant sources and reviews the existing conditions in relation to impervious area and the stormwater conveyance system.
- *Section 4 Current Stormwater Management Programs* details the current DoE programs that enhance or could potentially enhance stormwater quality and watershed restoration in the County.
- *Section 5 Load Reduction Targets and Current Progress* discusses the calculation of load reduction targets, current load reduction progress and reductions remaining to be met.
- *Section 6 Load Reduction Strategy Development* provides details regarding the proposed management activity options, including estimated costs and load reductions.
- *Section 7 Proposed Restoration Plan Activities* describes the County's proposed changes to meet the goals of this restoration plan, including cost estimates, proposed schedules, and plans to involve the public in implementation of the plan.
- *Section 8 Public Outreach and Involvement* details the various public outreach and involvement initiatives and how to involve the public in the watershed restoration process.
- *Section 9 Tracking and Adaptive Management* outlines the approach for tracking and monitoring implementation progress and adaptive management.

2 Watershed Characterization

The Tinkers Creek (Figure 2-1) watershed lies entirely within Prince George's County, MD, as shown in Figure 2-1. It discharges into Piscataway Creek between Livingston and Gallathan Roads and has a drainage area of 18.5 square miles. The watershed includes portions of Clinton, Chapel Hill, Morningside and Camp Springs as well as some federal lands (e.g., portions of Joint Base Andrews) and county lands (e.g., Homewood Park, Tinkers Creek Stream Valley Park, and Rose Valley Park). The watershed consists of primarily privately-owned residential land, while a large portion of the main stem of Tinkers Creek flows through municipal-owned land (Figure 2-2). Meetinghouse Branch and Paynes Branch originate mainly on Joint Base Andrews. Figure 2-2 was created using parcel information, which does not include roadway information.

In the Tinkers Creek watershed, water flows through a network of streams, approximately 15 miles (mi) of which are large enough to be mapped. Stream flow is not subjected to semidiurnal tidal fluctuations as the confluence with Piscataway Creek is upstream of the tidal zone.

2.1 Physical and Natural Features

2.1.1 Hydrology

The main stem of Tinkers Creek is approximately 8 mi long. For this restoration plan, Tinkers Creek is subdivided into eight subwatersheds.

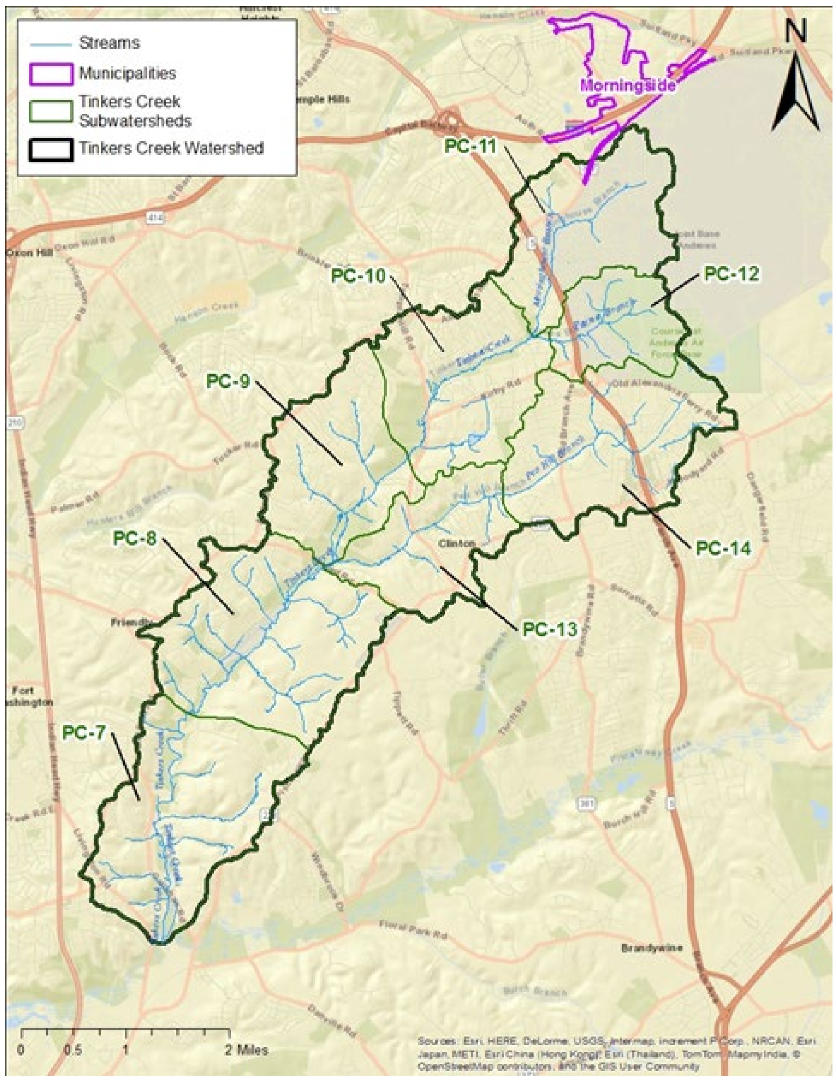


Figure 2-1. Location of the Tinkers Creek watershed

Climate/Precipitation

The climate of the Tinkers Creek watershed is characterized as temperate. The National Weather Service Forecast Office reports a 30-year average annual precipitation of 39.74 inches (NWS 2018a). On average, winter is the driest season with 8.48 inches of precipitation, and summer is the wettest season with 10.44 inches (NWS 2018a). 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 average monthly precipitation and temperatures for Upper Marlboro are presented in Figure 2-3 (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.

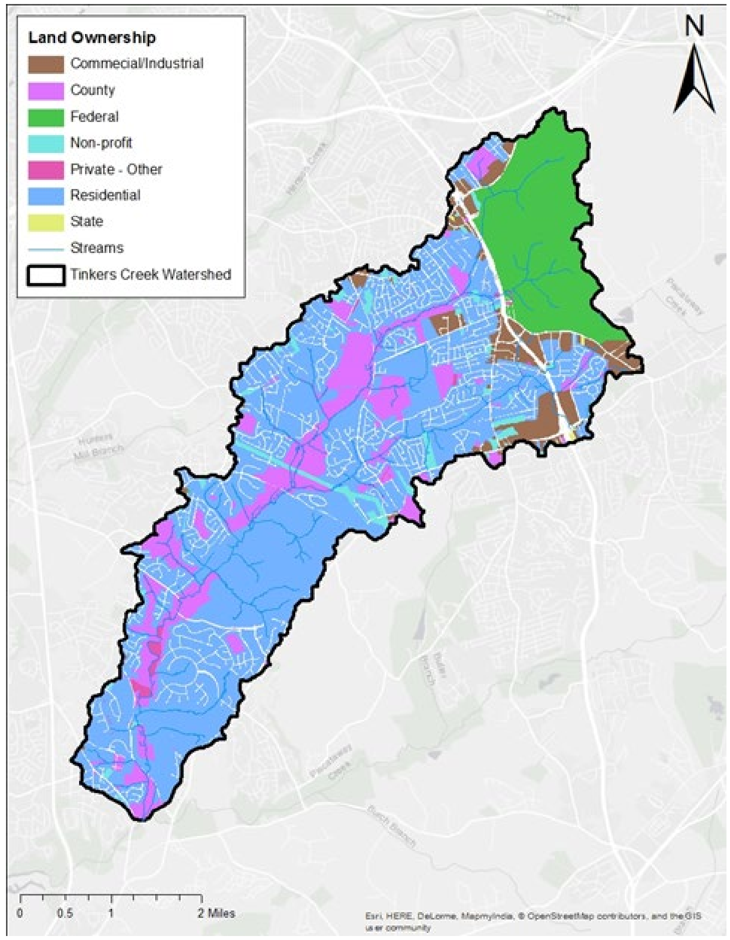


Figure 2-2. Land ownership in the Tinkers Creek watershed

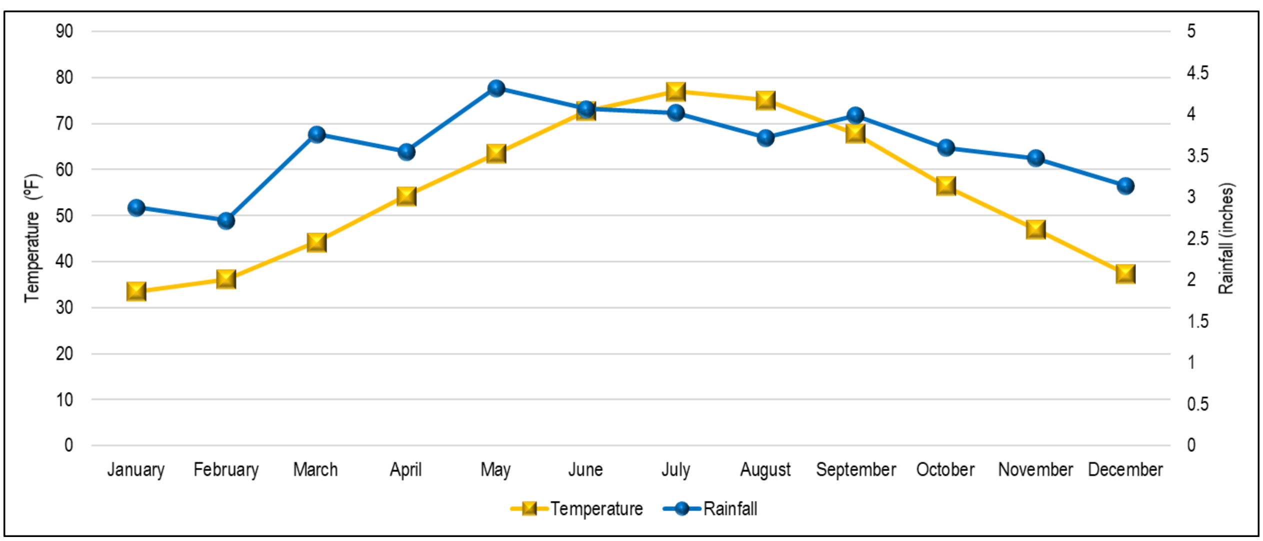
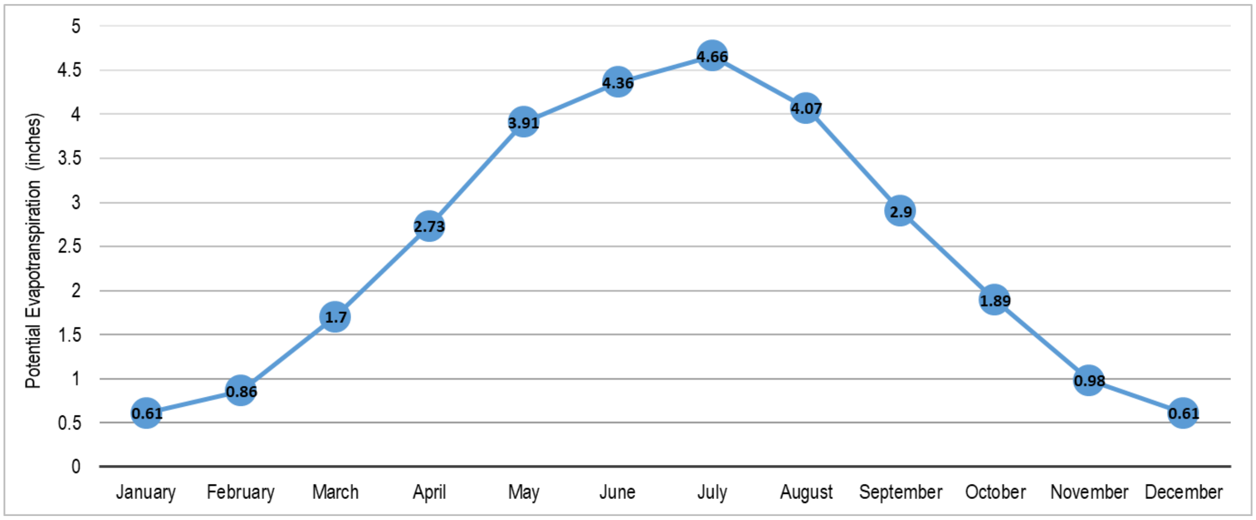


Figure 2-3 Average monthly temperature and precipitation.

Evapotranspiration accounts for water that evaporates from the land surface (including water bodies) or is lost through plant transpiration. Evapotranspiration varies throughout the year but is greatest in the summer. A standard quantity called "potential evapotranspiration" (Figure 2-4) 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 (wet ponds) or rely on moisture-rich soils (wetlands).



Source: NRCC 2018.

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

The County is reviewing the potential effects of climate change. 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 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 other nearby watersheds, such as 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.

2.1.2 Topography/Elevation

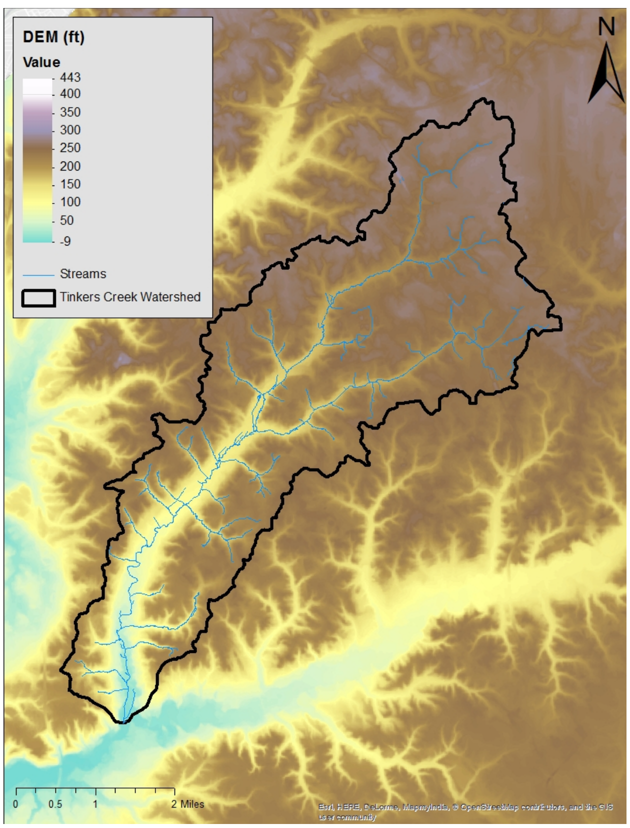
According to the Maryland Geological Survey, the Tinkers Creek watershed lies in the Coastal Plain geologic province, which is characterized by gentle slopes and drainage and deep sedimentary soil complexes (MGS 2014). Figure 2-5 shows that the watershed is relatively flat, with higher elevations in the range of 200 to 280 feet in the upper portions of the Meetinghouse, Paynes, and Pea Hill branches. Since the landscape tends to have steeper slopes at the higher elevations, streams will flow faster in those areas.

2.1.3 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.

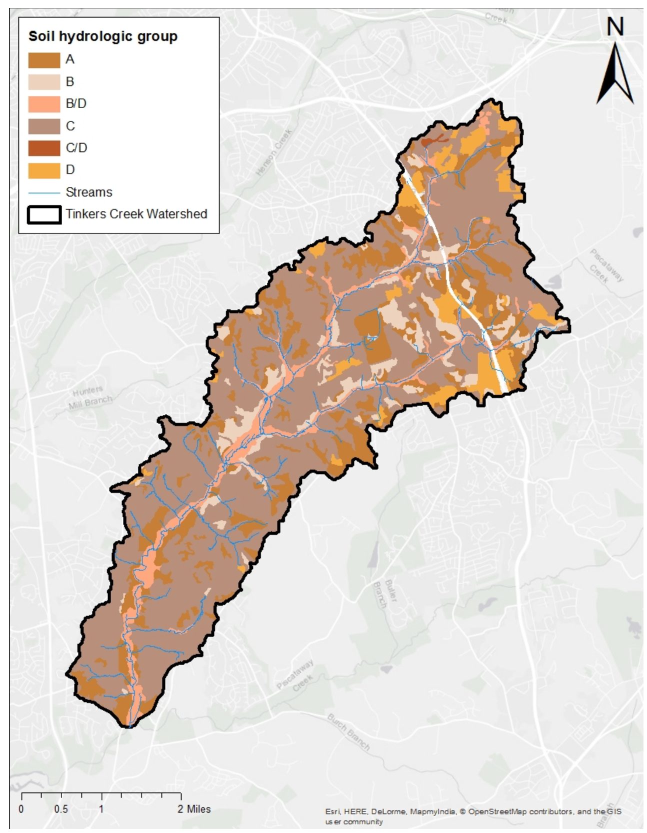
Figure 2-6 shows the locations of the different USDA HSGs across the Tinkers Creek watershed (USDA 2003). Soils in group C are the predominant soils in the watershed, while soils in group C/D are the least common.

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 are typically poorly drained.



Source: M-NCPPC 2014.

Figure 2-5. Elevation in the Tinkers Creek watershed



Source: USDA 2003.

Figure 2-6. Hydrologic soil groups in the Tinkers Creek 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 Tinkers Creek 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 the frequency and quantity of stormwater runoff from the land as well as how much pollution it carries. Table 2-1 summarizes the land use distribution in the Tinkers Creek watershed. Figure 2-7 shows the land use cover in the watershed. Figure 2-7 shows the amount of tree canopy in the watershed.

Overall, 62.7 percent of the land use in the watershed is urban and at 38.3 percent, residential makes up more than half. In the residential land use category, 28.4 percent of the land is characterized as medium-density residential, with smaller amounts as high- and low-density residential. Forested land accounts for 26.5 percent and agricultural land(accounts for 9 percent of significant land uses

Table 2-1. Tinkers Creek watershed land use

Land Use	Acres	% Total
Agriculture	**974**	**9.00%**
Agricultural building	48	0.40%
Cropland	614	5.70%
Large lot subdivision	26	0.20%
Pasture	286	2.70%
Forest	**2,856**	**26.50%**
Brush	59	0.50%
Deciduous forest	1,323	12.30%
Evergreen forest	155	1.40%
Large lot subdivision	117	1.10%
Mixed forest	1,201	11.10%
Other	**180**	**1.70%**
Bare ground	180	1.70%

Land Use	Acres	% Total
Urban	**6,770**	**62.70%**
Commercial	590	5.50%
Extractive	111	1.00%
High-density residential	104	1.00%
Industrial	102	0.90%
Institutional	1,224	11.30%
Low-density residential	963	8.90%
Medium-density residential	3,069	28.40%
Open urban land	520	4.80%
Transportation	87	0.80%
Water and wetlands	**12**	**0.10%**
Water	12	0.10%
Total	**10,792**	**100.00%**

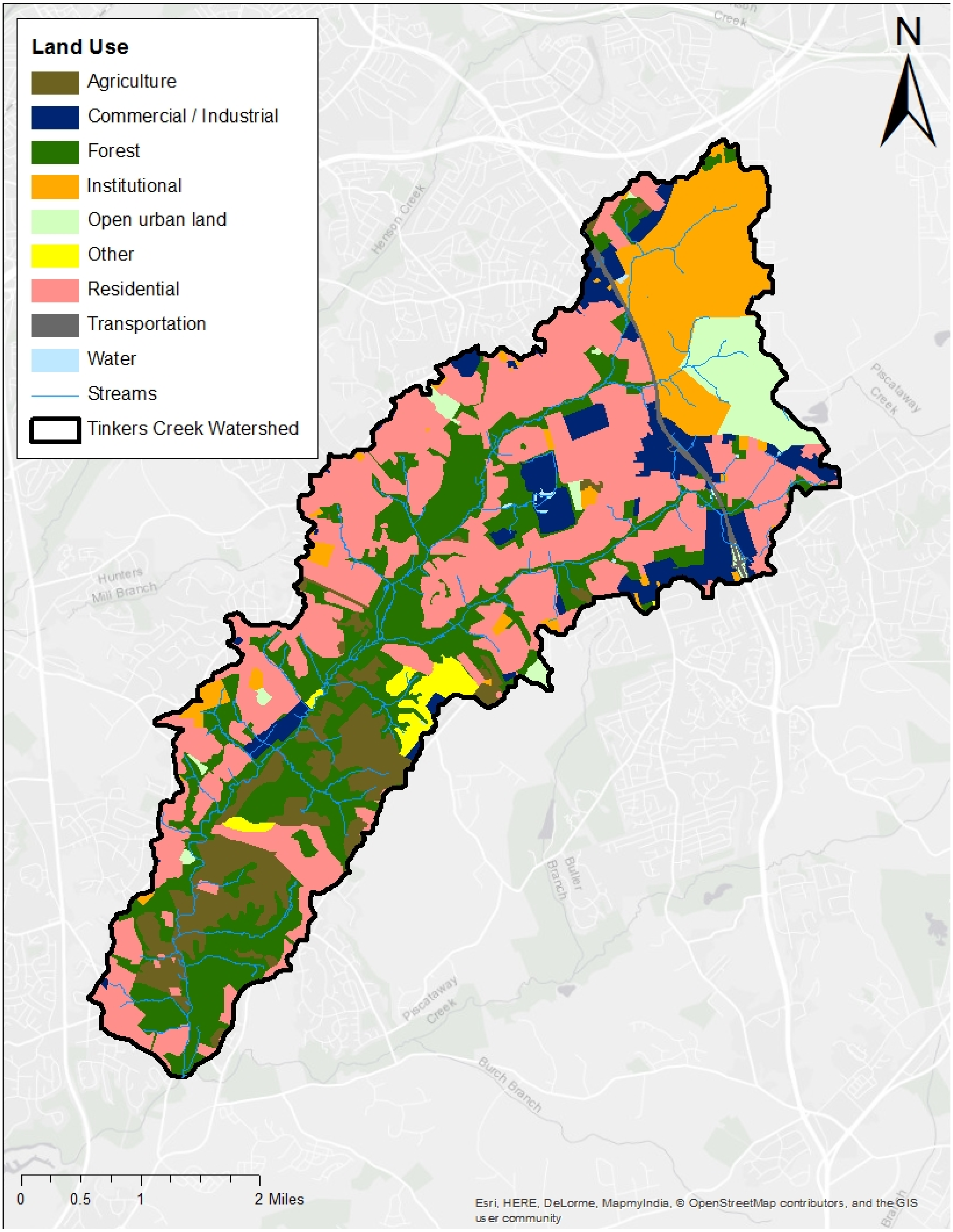


Figure 2-7. Land use/cover in the Tinkers Creek watershed

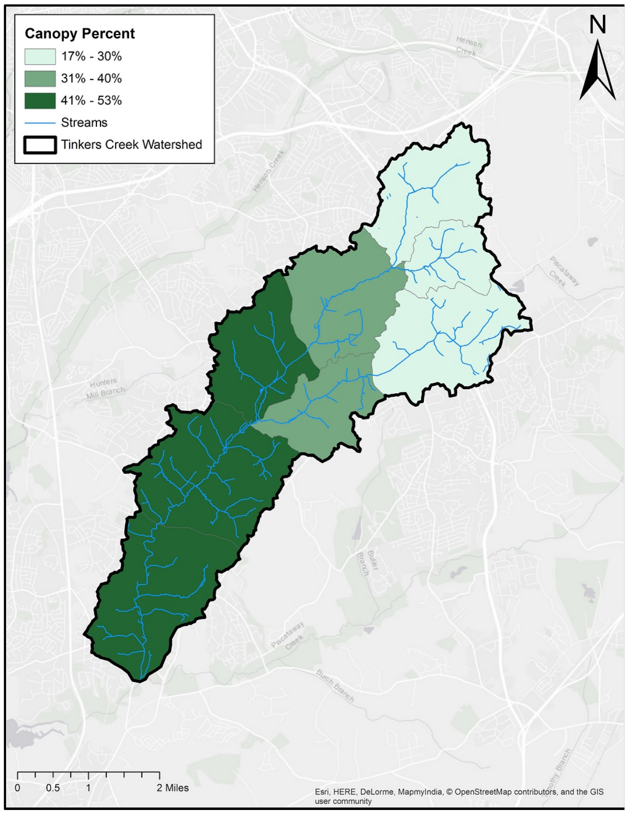
2.2.2 Impervious Area

Impervious area is land surface that is covered with impervious 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 quantity 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. Additional 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.

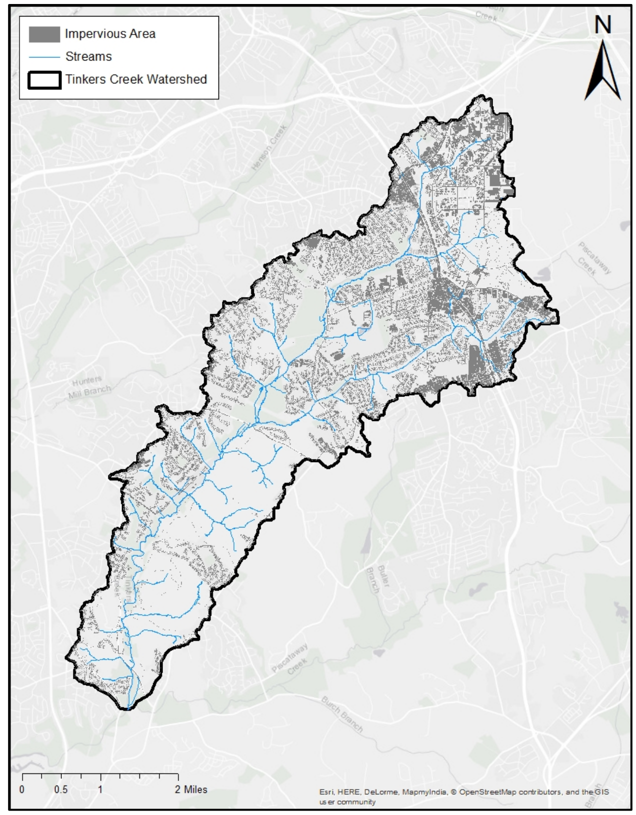
The quality of runoff is affected by the type of impervious area that generates it. For instance, driveways have a higher potential for nutrient loading to waterways than roofs because of the grass clippings and potential fertilizer, which can accidentally be spread on a driveway. Sidewalks have higher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

The Tinkers Creek characterization study found the overall imperviousness among the subwatersheds to range from very low (0.7 percent) in the lower Tinkers Creek to over 20 percent in Bald Hill Branch and the upper Southwest Branch (MD DNR n.d.). More recent data from the Maryland-National Capital Park and Planning Commission (M-NCPPC) shows the total imperviousness for the Tinkers Creek watershed to be 16.8 percent (M-NCPPC 2018). Figure 2-8 shows the percent of impervious area for each Tinkers Creek watershed (M-NCPPC 2018). Figure 2-9 shows the amount of impervious area in the watershed by type. Most of the impervious area is comprised of roads (28 percent), buildings (28 percent), and parking lots (22 percent). The percent of impervious area is highest among the more urbanized subwatersheds in the upper and western portions of Tinkers Creek watershed.



Source: M-NCPPC 2018

Figure 2-7. Tree canopy in the Tinkers Creek watershed.



Source: M-NCPPC 2018

Figure 2-8. Impervious areas in the Tinkers Creek watershed.

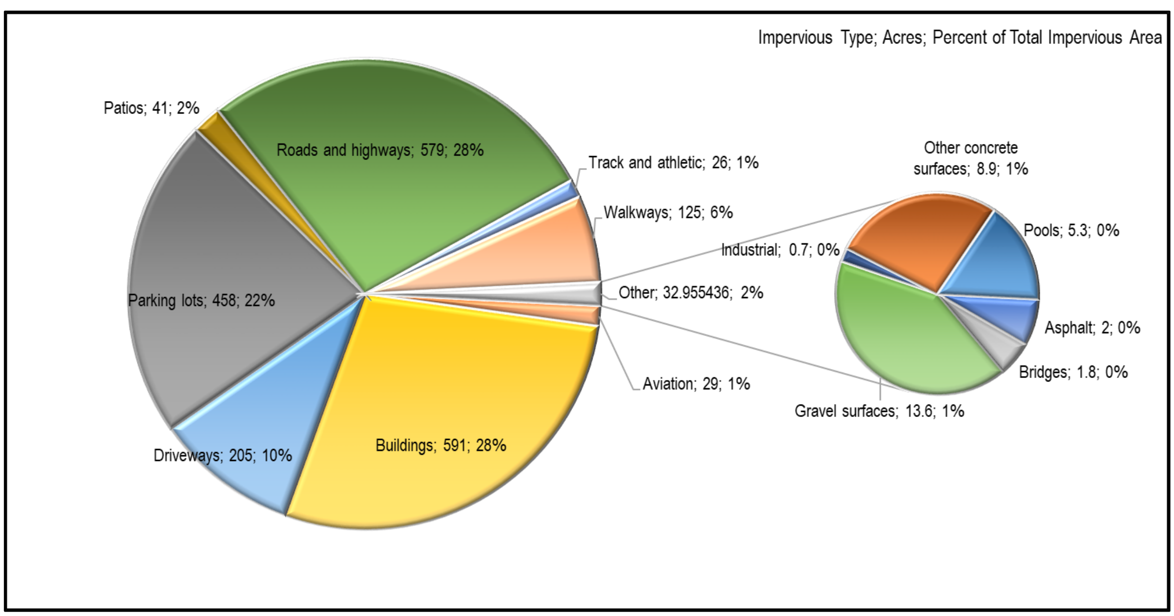


Figure 2-9. Tinkers Creek watershed percent impervious area by source

3 Watershed and Water Quality Conditions

3.1 Water Quality Impairments

Tinkers Creek is listed as impaired for several pollutants under the requirements of section 303(d) of the Clean Water Act (CWA) (MDE 2020b).

- The watershed is subject to the Chesapeake Bay TMDL for TN, TP, TSS. Under the Chesapeake Bay nutrient and sediment TMDL, TN is subject to a 22.2 percent reduction and TP is subject to a 41.0 percent reduction (MDE 2020c). While the Chesapeake Bay TMDL includes TSS, there are no load reductions associated with TSS, as it is assumed that if the TN and TP reductions are met, that TSS will also be met.
- Piscataway Creek (including Tinkers Creek) is listed as impaired for bacteria (completed 2014 restoration plan), sediment (in process 2021 restoration plan), and chloride (TMDL needed) (MDE 2020b). Piscataway Creek has other impairments, but they only apply to the tidal area. The watershed has a 42.6 percent reduction for bacteria and a 51 percent reduction for sediment.

3.2 Water Quality Trends

Water quality data collected from in-stream monitoring stations can be analyzed for trends to assess the degree to which water quality could be getting better or worse. Trends can be determined through the simple linear regression of long continuous records. A continuous ten-year record is preferred for conducting a trend analysis. Recent data is preferred as it provides the opportunity to examine current trends and determine immediate areas of concern for further analysis.

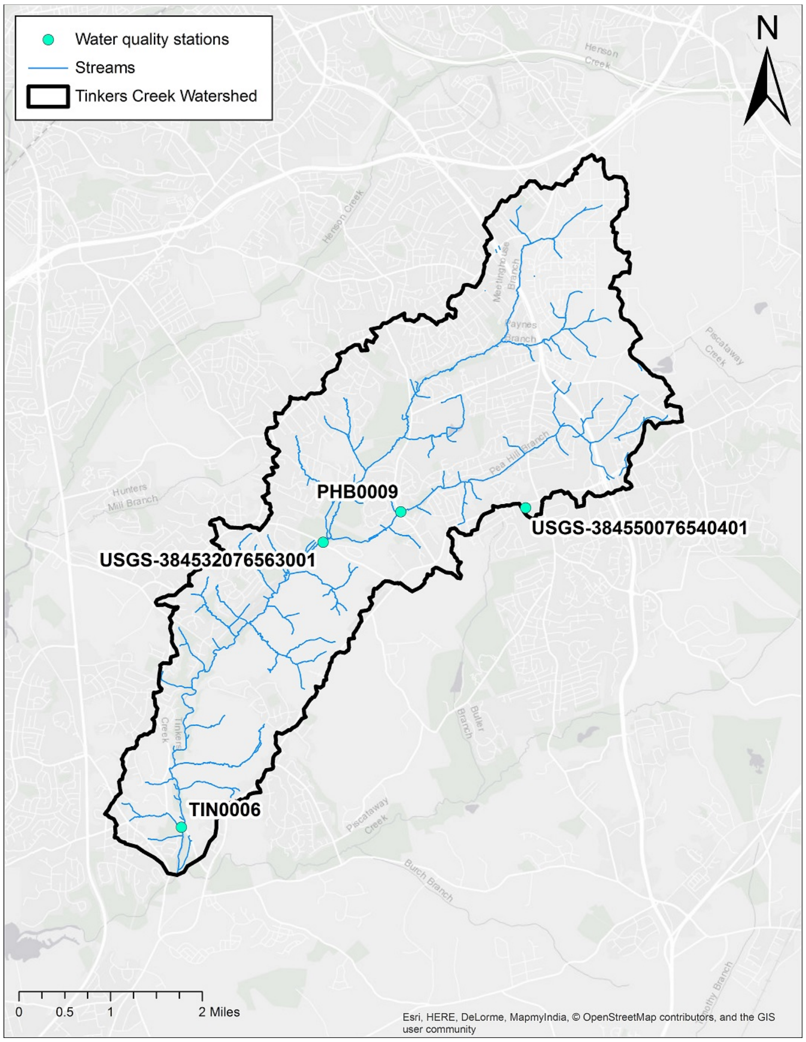
Graphs are used to display the data and include the value of the coefficient of determination (R^2) derived from a simple linear regression as a standard approach to describing the strength of any apparent trend. The R^2 value is a measure of how well the regression line represents the collection of 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. Low R^2 values indicate that the trend lines do not represent the data with a high degree of confidence. Although plots may appear to show a trend, the variance—or "scatter"—in the data shows poor correlation between time and water quality. Consequently, conclusions drawn from such trend lines about whether water quality has improved are unreliable.

The scatter in 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.

Figure 3-1 presents the locations of the water quality monitoring stations in the watershed.

Water quality data were obtained from the following sources:

- 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.



Sources: NWQMC 2018.

Figure 3-1. Flow and water quality monitoring stations.

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 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 the TN and TP data available from the Tinkers Creek monitoring stations. Of the four monitoring locations with data, two only had 1 data point each, while the remaining two stations had 12 data points in a single year. There are not sufficient records available for total nitrogen or total phosphorus monitoring to complete a trend analysis. Figure 3-2 shows TN over time in the watershed. Figure 3-3 shows TP over time in the watershed. Because data was only available for a single year, there are not enough records available for TSS monitoring within Tinkers Creek to complete a trend analysis.

Table 3-1. Summary of TN and TP data in the Tinkers Creek watershed

Nutrient	Source-Station ID	Station Name	Date Min.	Date Max.	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
TN	USGS-384532076563001	Pea Hill Branch at Camp Springs	05/02/00	05/02/00	1	0.74	0.74	0.74
	USGS-384724076540401	PG Ed 17	04/05/00	04/05/00	1	1.4	1.4	1.4
	MDE-TIN0006	Tinkers Creek	01/29/08	12/16/08	12	0.40	0.882	1.61
	MDE-PHB0009	Pea Hill Branch	01/29/08	12/16/08	12	0.590	0.945	1.26
TP	USGS-384532076563001	Pea Hill Branch at Camp Springs	05/02/00	05/02/00	1	0.047	0.047	0.047
	USGS-384724076540401	PG Ed 17	04/05/00	04/05/00	1	0.042	0.042	0.042
	MDE-TIN0006	Tinkers Creek	01/29/08	12/16/08	12	0.0307	0.109	0.281
	MDE-PHB0009	Pea Hill Branch	01/29/08	12/16/08	12	0.0192	0.040	0.098

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

In 2000, EPA published the *Ambient Water Quality Criteria Recommendations* (EPA 2000). The document presents "criteria provide EPA's recommendations to States and authorized Tribes for use in establishing their water quality standards consistent with section 303(c) of CWA" (EPA 2000). The criteria are given for TN and TP for rivers and streams in each ecoregion across the country. Tinkers Creek watershed is in Ecoregion IX. This has a TN criterion of 0.69 mg/L and a

TP criterion of 0.03656 mg/L. The majority of both TN and TP concentrations were above these criteria. The values fall within the range of what the County sees at other County monitoring locations.

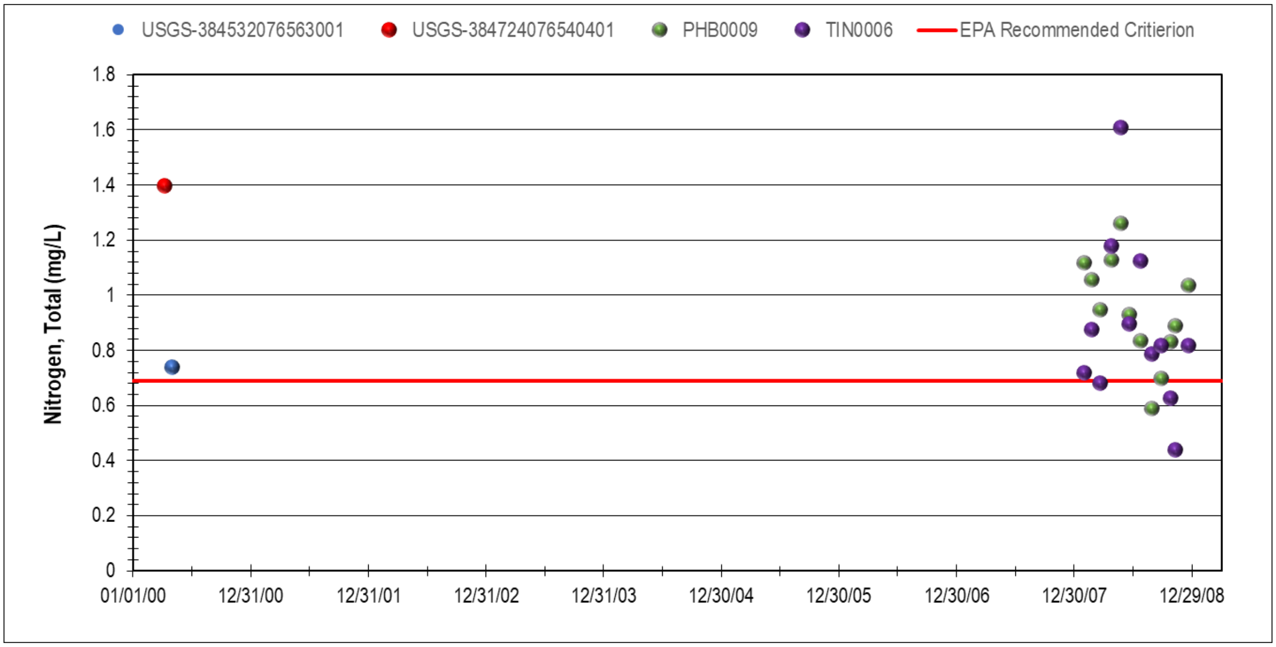


Figure 3-2. Plot of TN over time in the Tinkers Creek watershed.

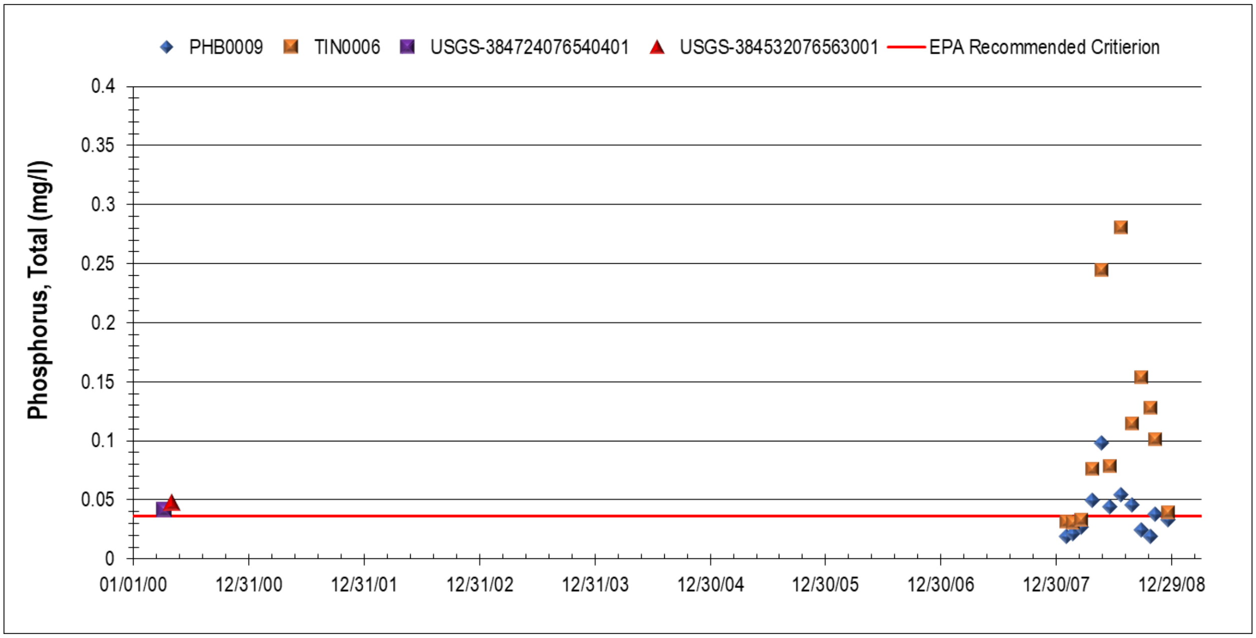


Figure 3-3. Plot of TP over time in the Tinkers Creek watershed.

3.2.2 Total Suspended Solids

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 suspended and transported downstream with increased stream flow velocity.

TSS tend to increase with impervious surface in a watershed. As the impervious surfaces send more runoff more quickly to local streams, the higher velocities, and volumes of water in typically incised stream channels tends to increase rates of erosion. The abrasive effect of higher concentrations of suspended sediment can also contribute to accelerating erosion problems.

In addition to the erosive effects, excessive settling of sediment on the stream bed and into the gravel blocks the flow of fresh, oxygenated water into the substrate. This situation leads to the destruction of fish spawning beds, a loss of aquatic habitat, and an increase in the mortality rate of macroinvertebrates from damaged or clogged gills and loss of food sources. Suspended sediment blocks light transmission, which limits the growth and survival of submerged aquatic vegetation. Sediment and sediment deposits in tidal reaches can contribute to the demise of aquatic life there as well.

TSS are monitored at two water monitoring stations located in the Tinkers Creek watershed (Table 3-2 and Figure 3-1). Figure 3-4 shows the TSS over time for two stations in the watershed. Because data was only available for a single year, there are not enough records available for total suspended solids monitoring within Tinkers Creek to complete a trend analysis. The values fall within the range of what the County sees at other County monitoring locations.

Table 3-2. Summary of TSS data in the Tinkers Creek watershed

Source-Station ID	Station Name	Date Min.	Date Max.	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
MDE-PHB0009	Pea Hill Branch	01/29/08	12/16/08	12	2	11.71	84
MDE-TIN0006	Tinkers Creek	01/29/08	12/16/08	12	2.4	38.78	248

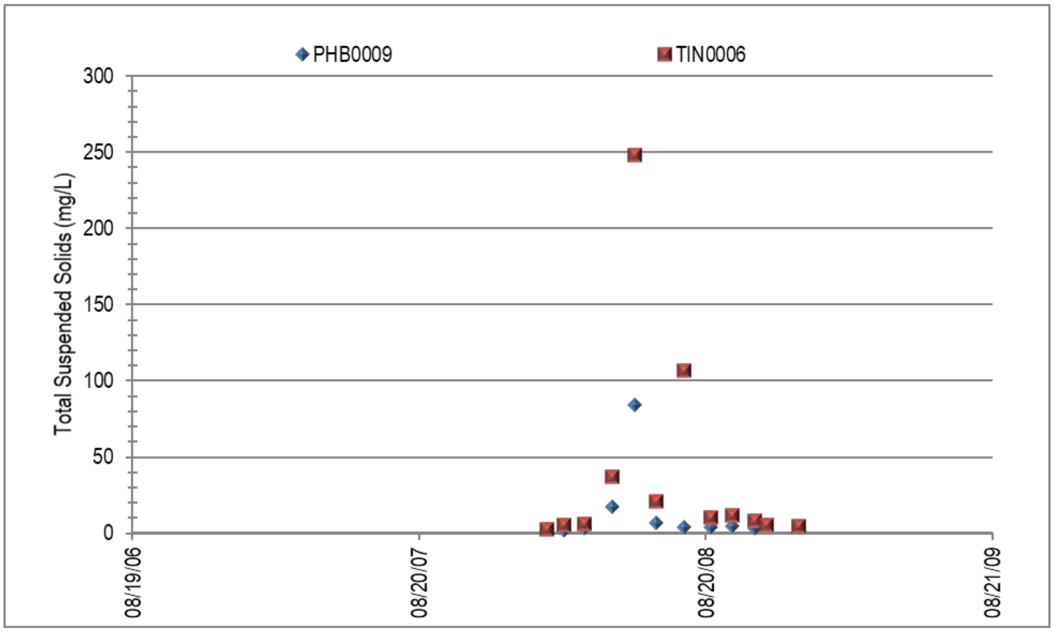


Figure 3-4. Plot of TSS over time in the Tinkers Creek watershed.

3.2.3 Fecal Coliform Bacteria

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.

MDE has only monitored one station for bacteria (*E. coli*) in the watershed, along the mainstem of Tinkers Creek. Table 3-3 presents the statistical data for this station. Figure 3-5 presents *E. coli* data over time for this station. Because data was only available for a single year, there are not sufficient records available for *E. coli* monitoring to complete a trend analysis. The EPA *E. coli* single sample maximum allowable concentration for *infrequently used full body contact recreation* is 576 counts/100 mL, which is show in Figure 3-5 (USEPA 1986). All but two samples were below the criterion. The values fall within the range of what the County sees at other County monitoring locations.

Table 3-3. Summary of available *E. coli* data in the Tinkers Creek watershed

Source-Station ID	Station Name/Description	Date		Number of Records	Value (mg/L)		
		Min.	Max.		Min.	Mean	Max.
MDE-TIN0006	Tinkers Creek	10/23/02	10/20/03	25	10	253.44	2,010

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.

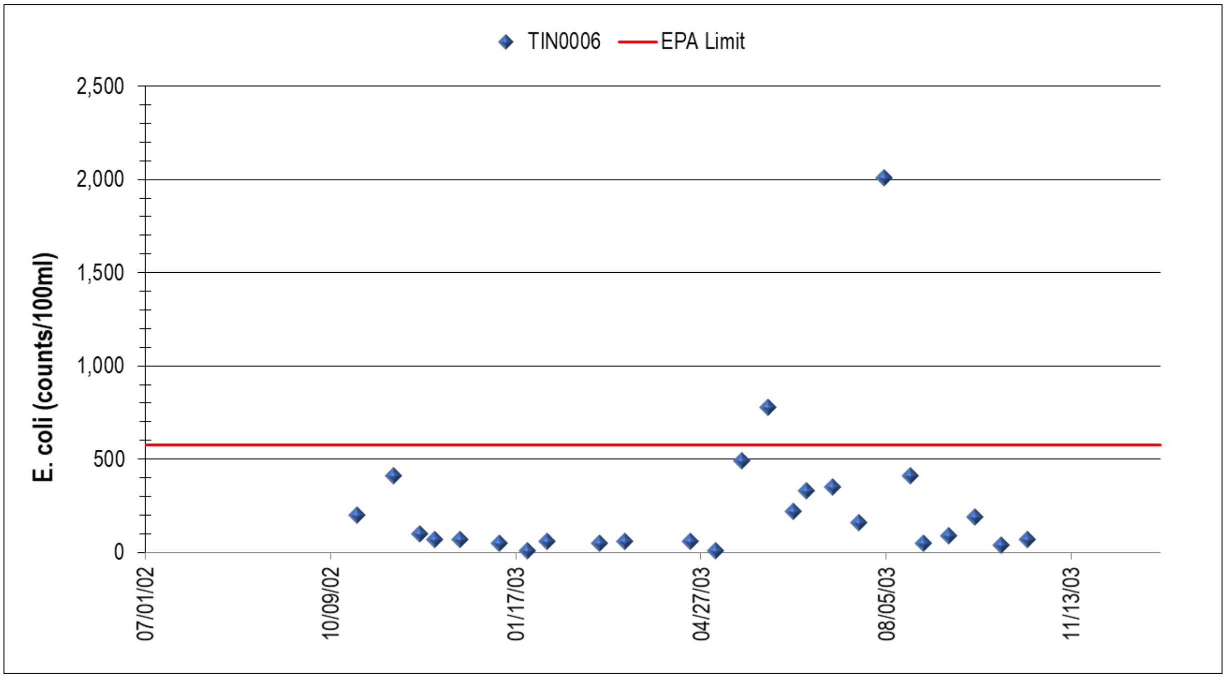


Figure 3-5. Plot of *E. coli* over time in the Tinkers Creek watershed.

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.

3.3.1 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 Tinkers Creek watershed through three rounds of data gathering. Round 1 (R1) 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. Streams assessed are wadeable and generally first through third order according to the Strahler Stream Order system (Strahler 1957). Stream order designation is based on the National Hydrography Dataset map scale of 1:100,000. The number of streams sampled in each watershed 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 each sampled organism to a target taxonomic level, usually genus. The quantities of 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.

3.3.2 Biological Assessment Results

The biological data reveal that the Tinkers Creek watershed consistently had high levels of degradation through the three assessment rounds. Figure 3-6 summarizes the biological monitoring results by year, along with the percent degraded. The percent degraded for the watershed has increased each monitoring period. The level of degradation for the Tinkers Creek ranged from 49.1 percent (Round 2) to 62.8 percent (Round 1).

Figure 3-7 illustrates the number of sites that attained each biological score in each monitoring year. A significant number of sites were rated as Fair and a few as Good, but most were rated as degraded (Poor and Very Poor), which is most likely a reflection of the high percentage of impervious surfaces in those sub-watersheds. Figure 3-8 shows the biological results in the watershed.

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). Most of Tinkers Creek subwatersheds have more than 11 percent impervious area (Figure 2-8). Tinkers Creek subwatershed is in the range of 20–25 percent impervious. Overall, the Tinkers Creek watershed is 17 percent impervious.

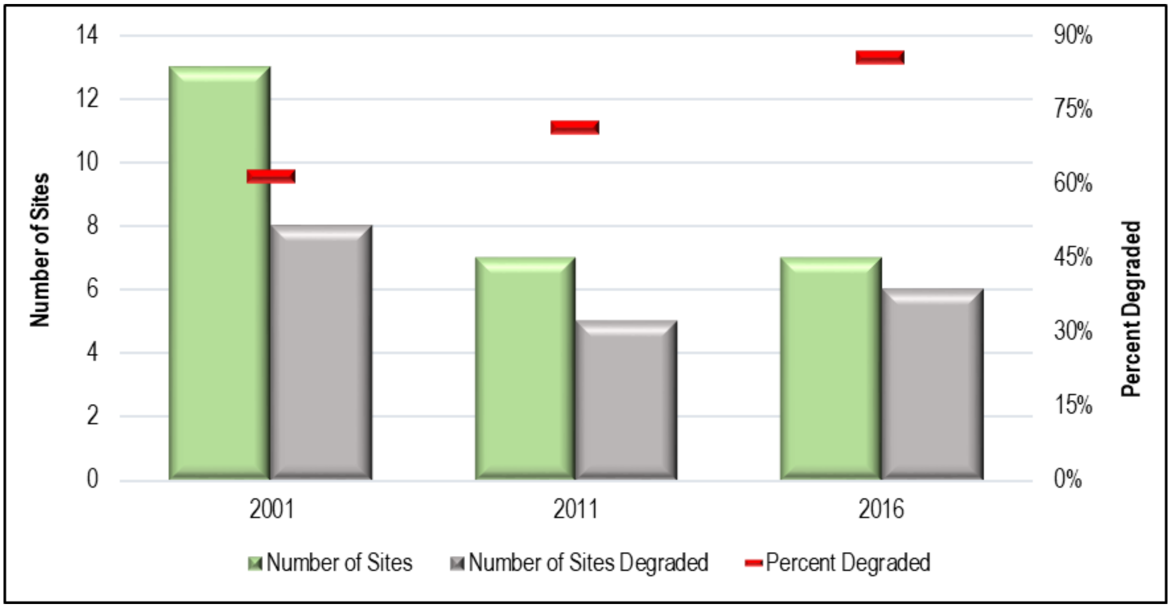


Figure 3-6. Number of Degraded Sites and Percent Degraded by Monitoring Year.

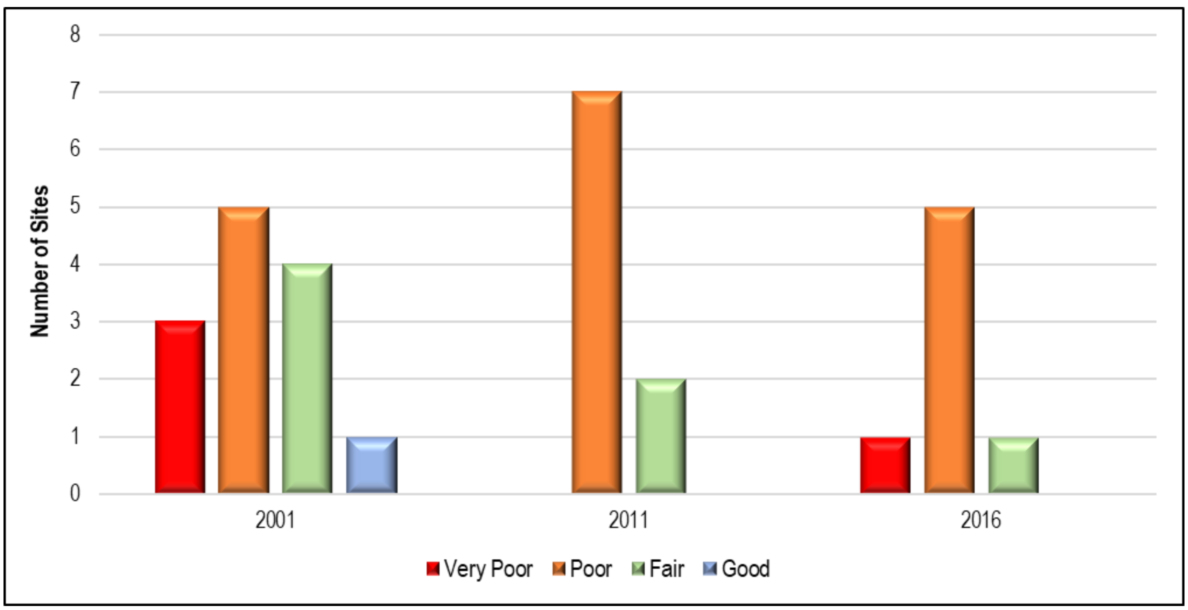


Figure 3-7. Number of Sites per Monitoring Year by Biological Score.

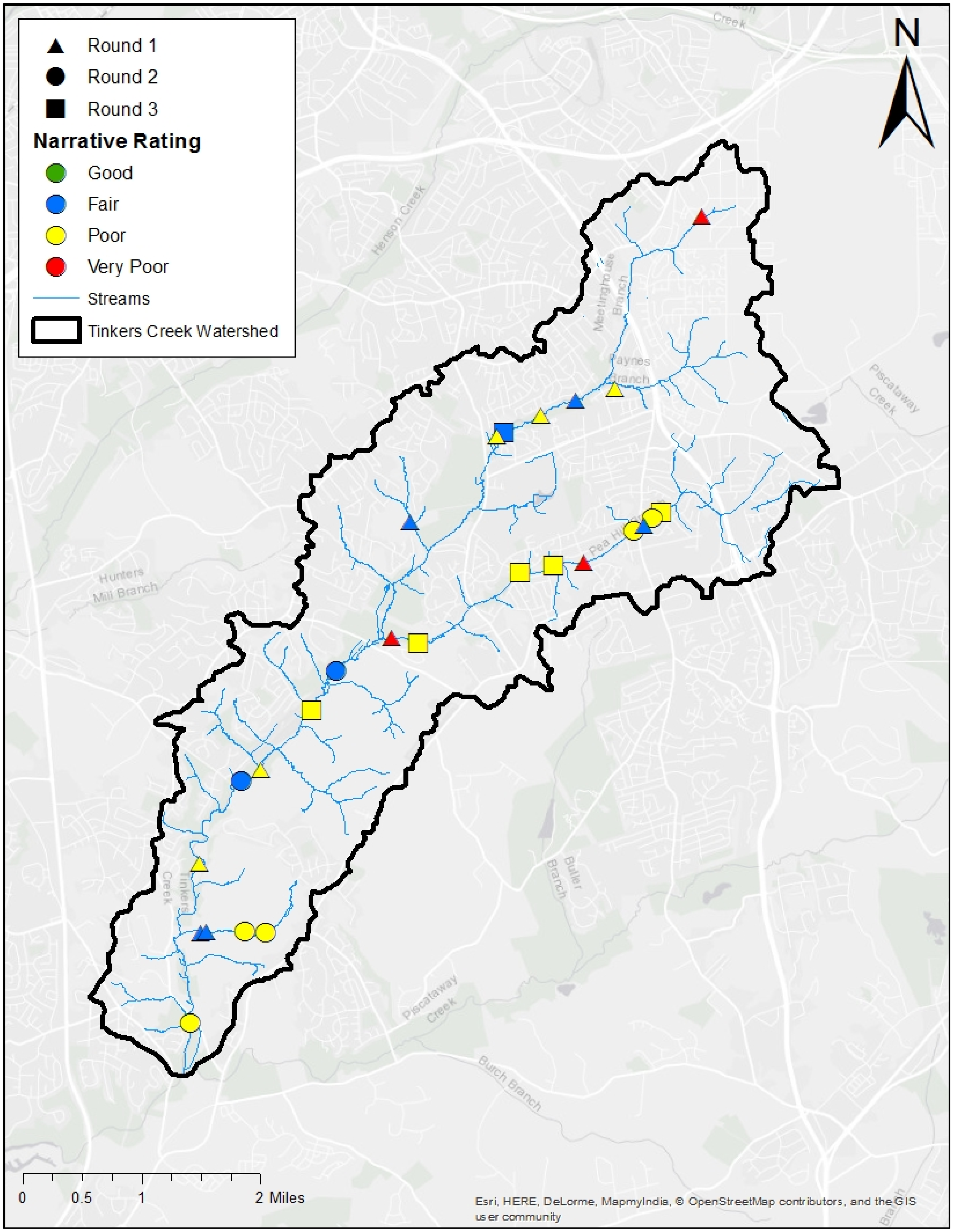


Figure 3-8. Biological assessment narrative ratings by monitoring location.

3.4 Trash Assessment

3.4.1 Trash Rating Protocol

The digital photographs taken during the biological assessments have been used to assess the magnitude of trash at those locations. A minimum of four photographs was taken of each sampled reach during biological monitoring, capturing the 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 photographs because of their size or the water depth, the diversity, magnitude, and abundance of stream trash. A simple rating scale (i.e., trash score [TS]) was used to represent the amount of trash visible in each photograph (Table 3-4).

Table 3-4. 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 3-9 shows four photographs that demonstrate what each major level in the rating scale represents. After each photograph from a site was rated, an aggregate score for all the photographs taken at the site was calculated. If there were four photographs, the scores were simply totaled. If more than four photographs were taken, the scores were averaged and multiplied by four. Consequently, the TS for a single site could range from 0 (no trash) to 12 (heavy trash).

3.4.2 Results of Trash Assessment

Figure 3-10 shows the number of sites by trash score per year. Figure 3-11 provides a map of the assessment locations, showing the TS at each one. Of the 29 sites that were evaluated in the Tinkers Creek watershed, 11 sites (22.4 percent) showed no visible evidence of trash. Most of the trash items seen were small enough that they could easily have been transported via stormwater conveyance. Occasionally, it was obvious that materials were discarded for convenience (e.g., rusty barrels, and a large pile of bricks and lumber).

Figure 3-9 . Photographs illustrating different amounts of trash and corresponding trash score.

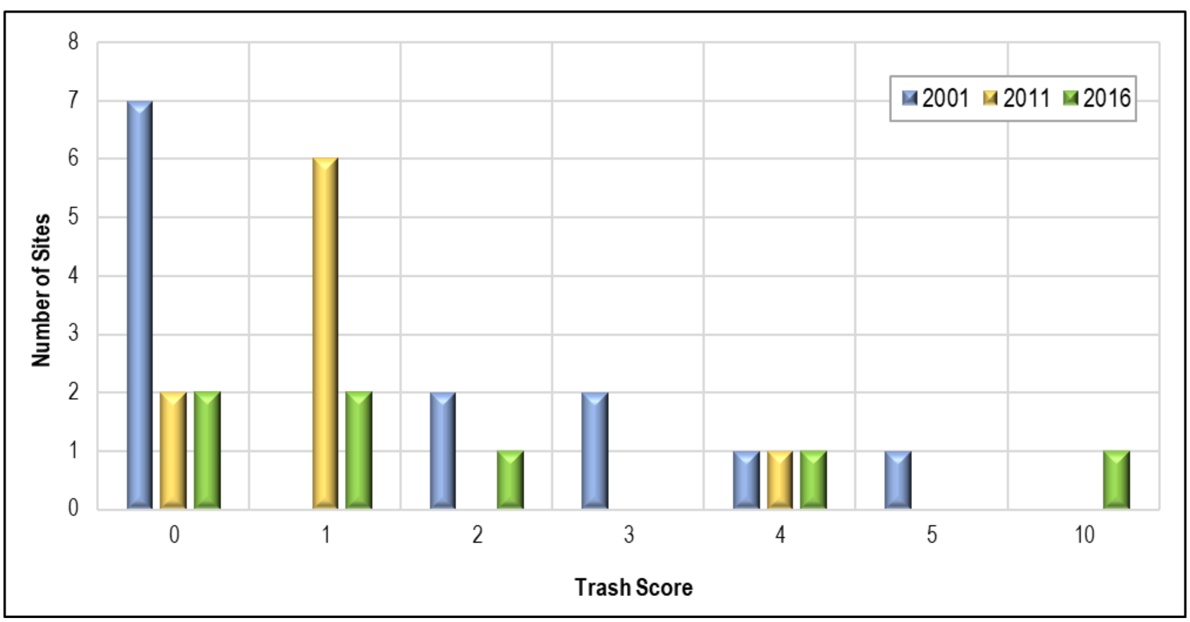


Figure 3-10. Number of sites per year by trash score.

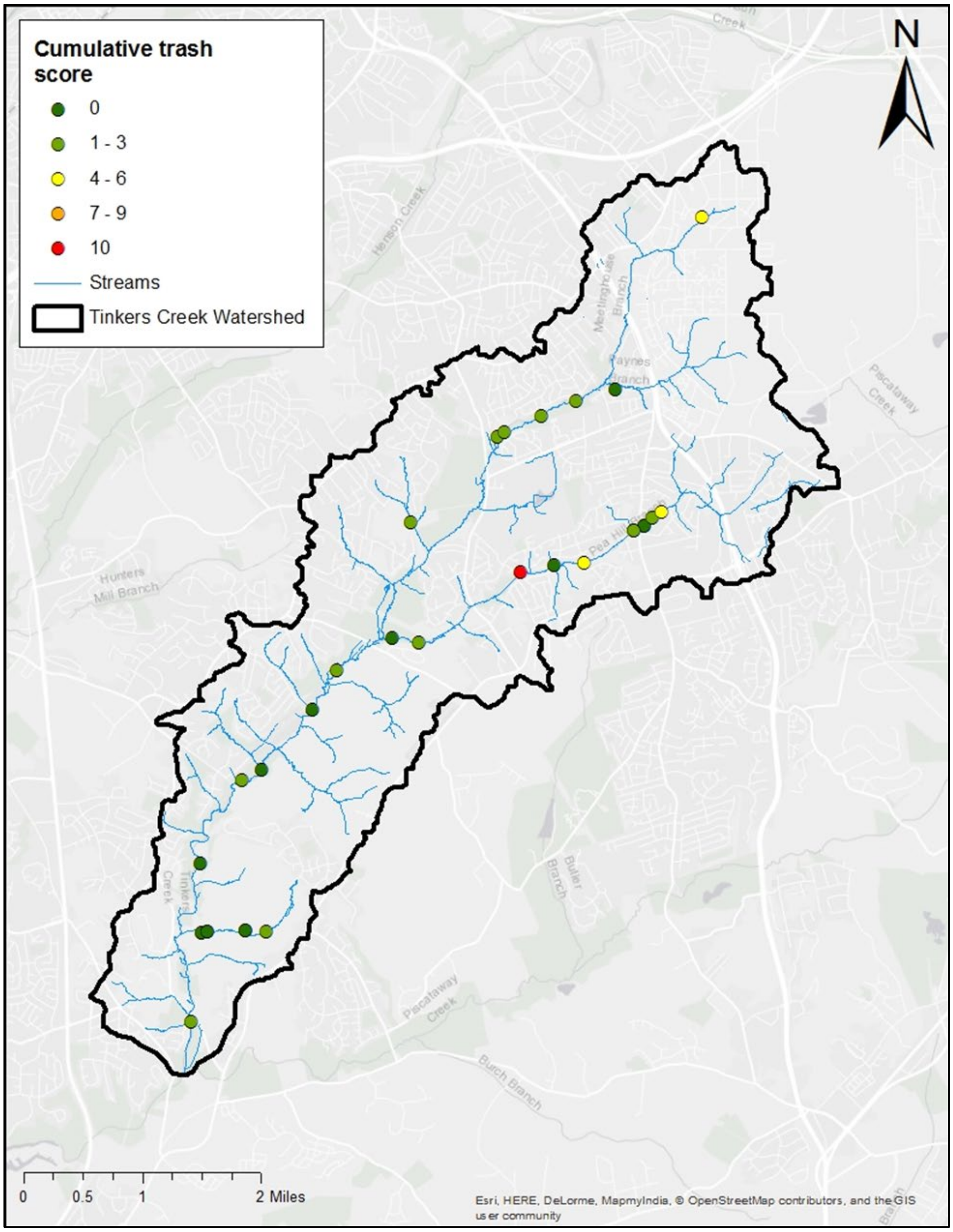


Figure 3-11. Magnitude and intensity of trash occurrences at assessment locations.

3.5 Pollutant Sources

This section provides an assessment of the potential point and nonpoint pollutant sources in the watershed. Point sources are permitted through the National Pollutant Discharge Elimination System (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.

3.5.1 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.

MS4s

Stormwater discharges are generated by runoff from land with 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 County is a Phase I MS4 jurisdiction. In addition, the city of Bowie has its own Phase II MS4 permit. The County is responsible for all discharges it he County except those from state and federal properties (e.g., Joint Base Andrews, state highways) and from the city of Bowie. Table 3-5 lists the federal, state, and other entities in Tinkers Creek watershed that possess an MS4 permit. Figure 3-12 shows the areas served by permitted MS4s within the Tinkers Creek watershed.

Table 3-5. Phase II MS4 permitted federal, state, and other entities in Tinkers Creek watershed

Agency	Installation/Facility	Acres
Maryland State Highway Administration	Multiple (outside Phase I jurisdictions)	149
U.S. Department of the Air Force	Joint Base Andrews	1,498
Washington Suburban Sanitary Commission	Multiple Properties	117

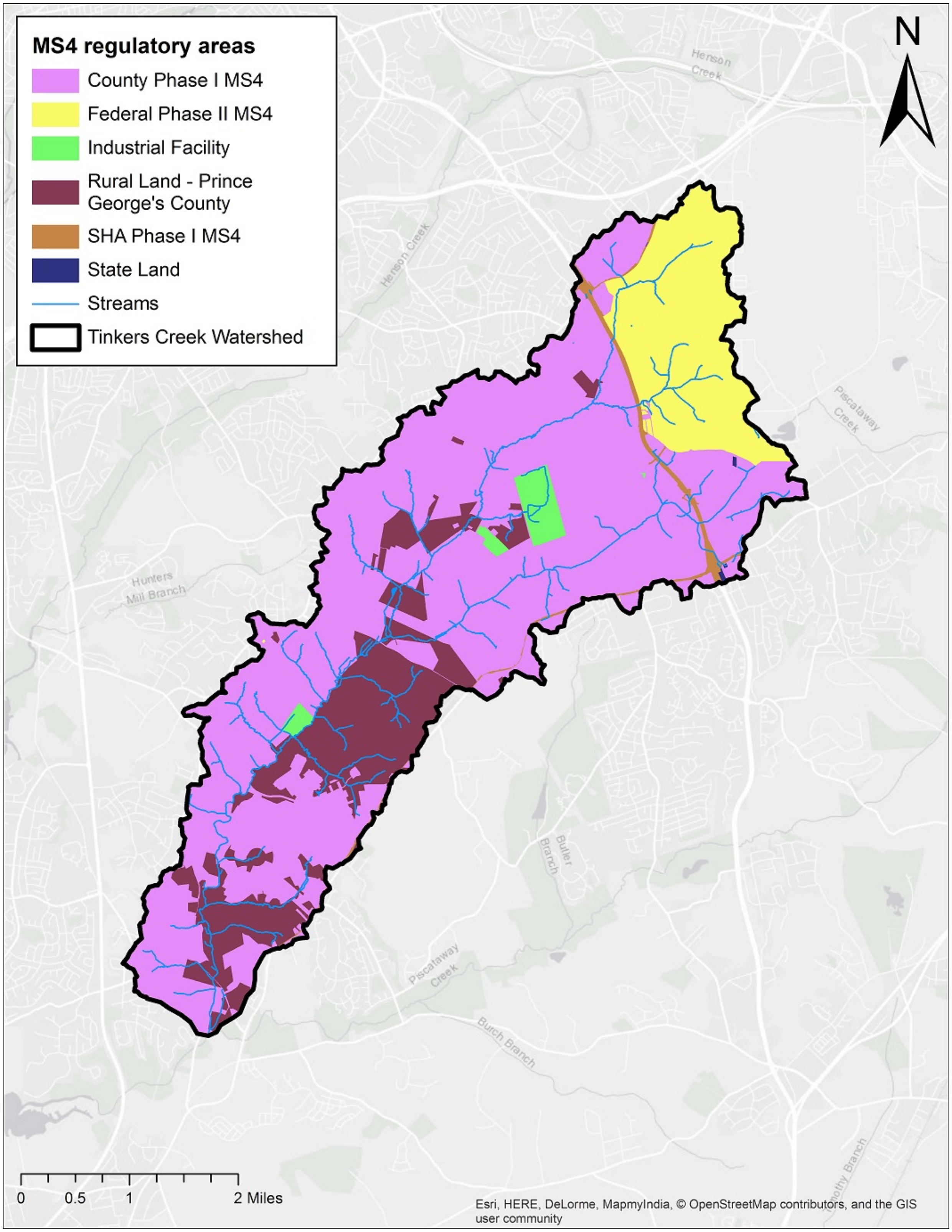


Figure 3-12. MS4 regulated areas in Tinkers Creek watershed.

Sanitary Sewer Overflows

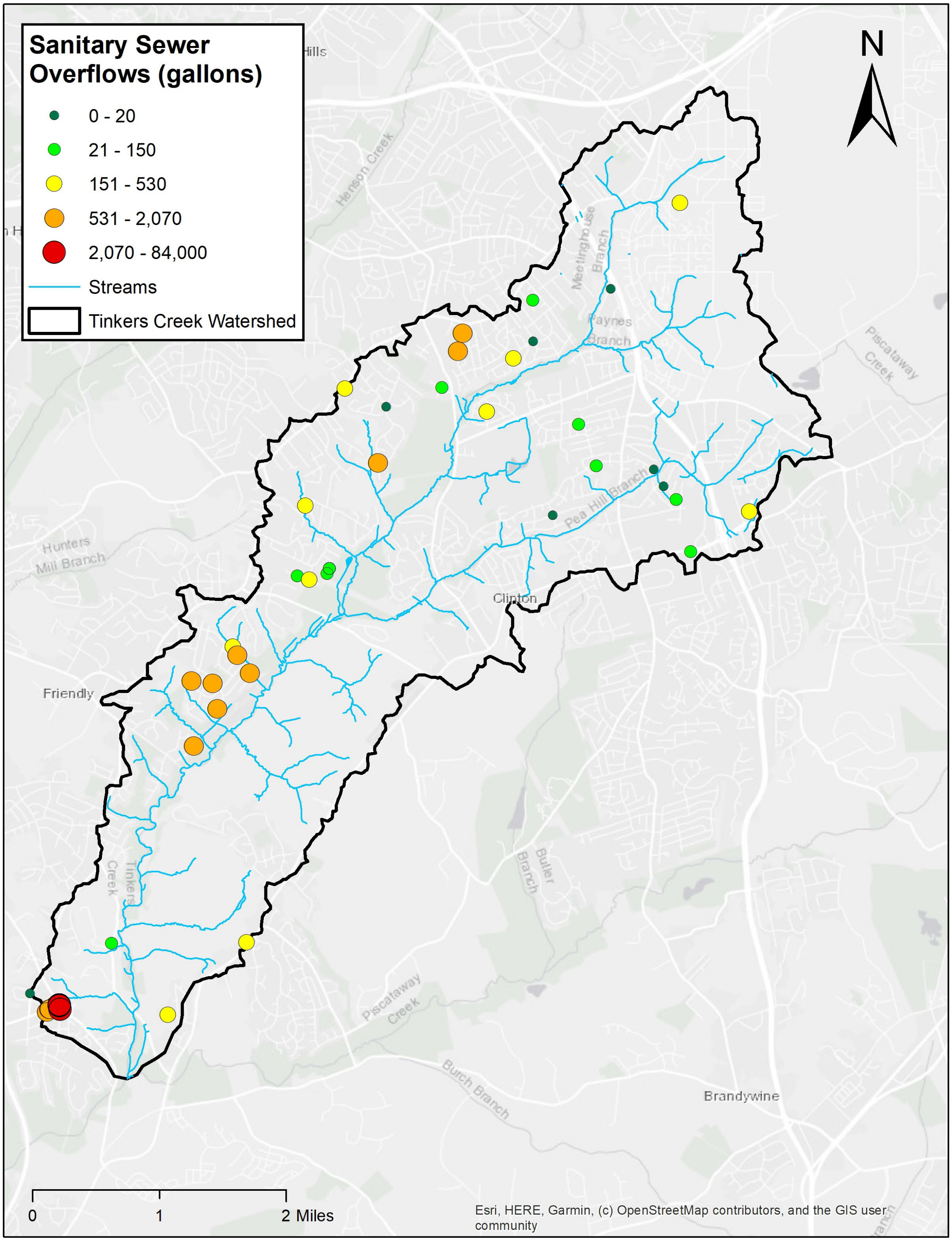
Under unusual circumstances, sanitary sewer systems occasionally discharge raw sewage to surface waters during sanitary sewer overflow (SSO) events. These events can send significant amounts of additional nutrients, bacteria and solids into local waterways and can be caused by sewer blockages, pipe breaks,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

The Maryland Reported Sewer Overflow Database contains bypasses, combined sewer overflows and SSOs reported to MDE since January 2005. Table 3-6 summarizes data on SSOs in the County as obtained from the database. No overflows were reported in Tinkers Creek during 2010 or 2017. The number of gallons of overflow ranged from 540 (2005) to 152,622 (2011) in other years.

Figure 3-13 shows the locations of SSOs and volumes of the sewer overflows in Tinkers Creek watershed (MDE 2018). The Washington Suburban Sanitary Commission (WSSC) is currently addressing problems that cause SSOs through their Sewer Repair, Replacement and Rehabilitation (SR3) Program.

Table 3-6. Summary SSO overflow (gallons) in Tinkers Creek watershed by year (2005–2017)

Cause	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Blockage			1,138										
Debris		201						20	2				
Defective Material											808		
Grease	340	150		894	179			388		85			
High Flow/Precipitation		13,000		110,000	1,900		152,450	58,000		19,950			
Mechanical Failure	200												
Other		1											
Pipe Failure		1,367			755					676			
Roots		2	245	65			70			50	831	65	
Roots/Grease									2,052				
Stream Erosion		1,470		464				850				1,116	
Third-Party Damage								20					
Unknown			151	97	909		102			582	15	139	
Totals	540	16,191	1,534	111,520	3,743	0	152,622	59,278	2,054	21,343	1,654	1,320	0



Source. MDE 2018.

Figure 3-13. SSO locations and volume in Tinkers Creek watershed (2005–2017).

3.5.2 Non-point and Other Sources

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

Non-point 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 Tinkers Creek watershed restoration plan does not include restoration activities for agricultural practices.

Atmospheric deposition occurs through two main methods: wet and dry. Wet deposition occurs from 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 pre-settlement conditions, which included grassland and forest, to post-settlement conditions, which include cropland, pasture, and urban/suburban areas. This conversion has led to increased runoff and flow into streams versus pre-settlement conditions, as well as streambank erosion and incising of stream channels. 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 and grazing farm animals. Wild animals with direct access to streams include deer, raccoons, other small mammals and avian species. This access to streams contributes bacteria and nitrogen to water bodies.

4 CURRENT STORMWATER MANAGEMENT PROGRAMS

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

The State adopted a statewide stormwater law and regulations in 1983 and the County enacted a stormwater management ordinance soon after. Since 2000, following new state regulations, developers of new and re-development projects in the County are required to provide water quality treatment for this urban runoff using a wide range of stormwater practices. During the initial years of stormwater regulation, those practices were somewhat crude and simple, but they have been continuously improved. Today, *environmental site design* (ESD)—the approach to stormwater management required by MDE—is based on the use of landscape-based practices such as rain gardens and bioswales and is considered an ecologically sustainable approach to stormwater management for water quality. The County is currently installing those types of BMPs. This section describes current stormwater management programs and the types of BMPs installed in the County.

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

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

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

  - Street Sweeping
  - Storm Drain Maintenance: Inlet, Storm Drain, and Channel Cleaning
  - Storm Drain Stenciling
  - Illicit Discharge Detection and Elimination (IDDE) Program
- Tree Planting and Landscape Revitalization Programs
  - Volunteer Tree Planting
  - Tree ReLeaf Grant Program
  - Neighborhood Design Center
  - Arbor Day Every Day
  - Tree Planting Demonstrations
- Public Education Programs
  - Interactive Displays and Speakers for Community Meetings
  - Stormwater Audit Program
  - Master Gardeners
  - Flood Awareness Month

4.1 Stormwater-Specific Programs

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

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

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

- *Alternative Compliance Program.* The Alternative Compliance Program, administered by DoE, allows tax-exempt religious and nonprofit organizations to receive reductions in their CWA Fee if they adopt stormwater management practices. The organizations have three options and can use any combination to receive the credits. The options are to (1) provide easements so the County can install BMPs on their property; (2) agree to take part in outreach and education to encourage others to participate in the Rain Check Rebate and Grant Program and create an environmental team for trash pickups, tree planting, recycling, planting rain gardens, and so forth; and (3) agree to use good housekeeping techniques to keep their clean lots and to use lawn management companies certified in the proper use of fertilizers.
- *Rain Check Rebate and Grant Program.* The Rain Check Rebate and Grant Program, administered by the DoE, allows property owners to receive rebates for installing County-approved stormwater management practices. It was established in 2012 through County Bill CB-40-2012 and implemented in 2013. The County will reimburse homeowners, businesses, and nonprofit entities (including housing cooperatives and places of worship) for some of the costs of installing practices covered by the program. Installing practices at the individual property level helps reduce the volume of stormwater runoff entering the storm drain system as well as the amount of pollutants in the runoff. In addition, property owners implementing these techniques through the program will reduce their CWA Fee if they maintain the practice for 3 years. Currently, rebates are capped at $4,000 for residential properties and $20,000 for nonprofit groups and residential, commercial, industrial, and institutional properties and nonprofit groups.

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

- *Countywide Green/Complete Streets Program.* The Department of Public Works and Transportation (DPW&T) initiated a countywide Green/Complete Streets Program in 2013 as a strategy for addressing mounting MS4 and TMDL treatment requirements. The program identifies opportunities to incorporate stormwater control measures, environmental enhancements and community amenities into the DPW&T's capital improvement projects. The types of projects that can contribute to pollutant load reductions include ESD practices, tree shading, alternative pavements and landscape covers.
- *Erosion and Sediment Control.* MDE has assigned the responsibility for conducting erosion and sediment control enforcement to the County. For new developments, this responsibility is assigned to Department of Permitting, Inspection, and Enforcement (DPIE). It involves conducting site inspections and providing Responsible Personnel Certification courses which educate construction site operators to conscientiously manage disturbed land areas commonly found at construction sites. These control measures prevent excess sediment from entering County water bodies from active construction sites.
- *Street Sweeping.* The County conducts street sweeping operations on select arterial, collector and industrial roadways. Residential subdivisions are swept on a request-only basis. Street sweeping can reduce the amount of debris, including sediment that reaches waterways.
- *Litter Control*. The County maintains an aggressive litter control and collection program along County-maintained roadways. The litter service schedule is based on historical collection data; therefore, the most highly littered roadways are serviced as often as 24 times per year.
- *Storm Drain Maintenance: Inlet, Storm Drain, and Channel Cleaning.* These are systematic water quality-based storm drain programs that provide routine inspections and cleanouts of targeted infrastructure with high sediment and trash accumulation rates. Municipal inspections of the storm drain system can be used to identify priority areas. DPW&T inspects and cleans major channels on a 3-year cycle. Additionally, the County performs storm drain vacuuming that removes sediments from the storm drain system. In FY 2019, the County removed 49.5 tons of debris from storm drains in the County.

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

- *Illicit Connection and Enforcement Program.* DoE conducts field screening and outfall sampling to detect and eliminate non-permitted discharges from the County's MS4.

4.2 Tree Planting and Landscape Revitalization Programs

When localities convert urban land to forest, significant hydrologic and water quality benefits accrue. Tree planting typically occurs piecemeal across the urban landscape whereas reforestation usually occurs on a much larger scale. In either case, to claim pollutant reduction credits from those plantings, a survival rate of 100 or more trees per acre is necessary, with at least 50 percent of the trees being 2 inches or more in diameter at 4.5 feet above ground level (MD DNR 2009, MDE 2019).

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

- *Volunteer Tree Planting.* DPW&T oversees volunteer tree planting in October of every year. Trees are planted by organizations (e.g., HOAs) on public spaces (e.g., parks and institutional areas). Approximately 2,000–2,500 trees are planted under the program every year.
- *Tree ReLeaf Grant Program.* DoE's Tree ReLeaf Grant Program is funded by fees-in-lieu; therefore, it only funds planting projects on public property. The program provides funding to neighborhoods, civic, and community/homeowner organizations; schools; libraries; and municipalities for tree and shrub planting projects in public spaces or common areas. Goals of the program include increasing native tree canopy to improve air and water quality, conserve energy and reduce stormwater runoff. Organizations can receive up to $5,000 under the program, and municipalities are eligible for grants up to $10,000.
- *Neighborhood Design Center.* The Neighborhood Design Center, a local nonprofit in Riverdale, is an important partner in many County initiatives. They furnish pro bono design and planning services to a wide variety of individuals, organizations and low-to-moderate income communities. Their goal is to involve the entire community in developing and implementing initiatives and projects designed to revitalize neighborhoods. The Neighborhood Design Center develops plans for parks, gardens, and community plantings, including wetland and rain gardens, reforestation projects and median and shade tree plantings. Collectively, these efforts have increased the County's green space, reduced stormwater runoff and improved water quality through the creation of natural systems to cleanse stormwater runoff.

- *Arbor Day Every Day.* Arbor Day Every Day provides free trees for schools to plant and maintain on school grounds. This program educates students on the everyday importance of native trees, empowers them to enhance their community and provides funds for planting projects.
- *Tree Planting Demonstrations.* The Sustainable Initiatives Division recently began a tree planting demonstration program to increase tree canopy and promote tree care.

4.3 Public Education Programs

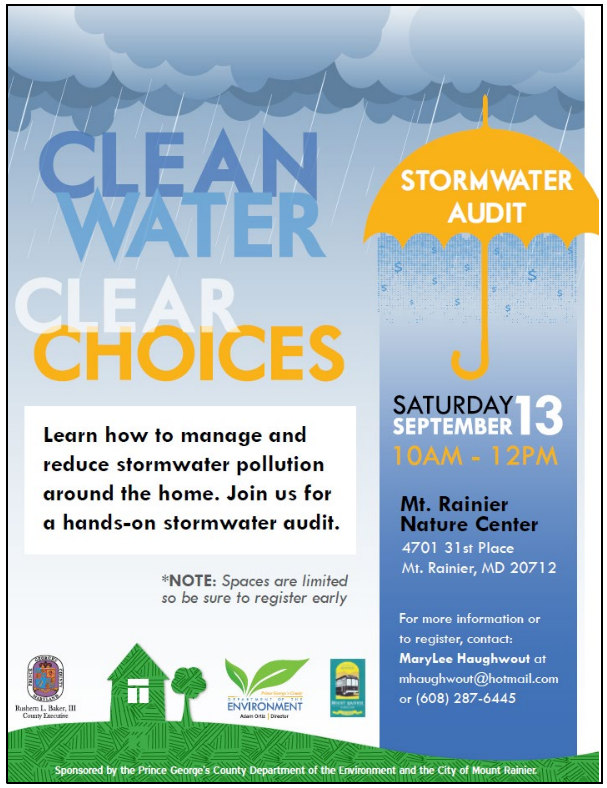
DoE seeks every opportunity to promote environmental awareness, green initiatives and community involvement to protect natural resources and promote clean and healthy communities. The County also integrates water quality outreach as a vital component of watershed restoration projects. At public outreach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

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

- *Interactive Displays and Speakers for Community Meetings.* County staff support multiple outreach events to provide presentations, displays and handouts, answer questions, and promote environmental stewardship. At these events, County staff provide information on the importance of trees and tree planting, stormwater pollution prevention, lawn care, Bayscaping (replacing turf with plants native to the Chesapeake Bay region) and trash prevention and cleanup.
- *Stormwater Audit Program*. DoE conducts stormwater audits of residential properties. During the audits, County staff walk a property with the homeowner and make suggestions regarding the most appropriate types and potential locations for stormwater BMPs.
- *Master Gardeners.* Master Gardeners are volunteer educators who provide horticultural education services to individuals, groups/institutions and communities. The mission of the program is to educate Maryland residents about safe, effective and sustainable horticultural practices that build healthy gardens, landscapes and communities. The program has the potential to aid overall reduction of fertilizer and pesticide use as well as

promote increases in stormwater practices such as installing rain gardens and using rain barrels.

- *Flood Management.* During June, DoE works to raise awareness of flood risks and details what County residents can do to protect their homes, families and personal belongings if flooding occurs. DoE incorporates messages that encourage residents to implement flood-prevention stormwater practices (e.g., BMPs) such as using permeable pavers and rain gardens to help prevent costly property damage caused by backyard flooding.



4.4 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 Tinkers Creek 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 non-structural 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. Non-structural BMPs include institutional, educational or pollution prevention activities that, when implemented, work to reduce pollutant loadings. Examples of non-structural 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 4-1 lists the number and acreage of each type of BMP and categorizes them by the period they were installed in. Figure 4-1 shows the locations of the BMPs as of August 2020. Most of the BMPs were installed prior to 2015.

Table 4-1. BMPs in Tinkers Creek watershed as of August 2020

	Baseline (< 2017)		Progress (2017–2020)		Planned (>2020)		Total	
BMP Type	#	Acres[a]	#	Acres[a]	#	Acres[a]	#	Acres[a]
Bioretention/raingarden	22	22.56	2	1.80	0	0.00	24	24.36
Dry extended detention structure	1	24.86	0	0.00	0	0.00	1	24.86
Dry pond	3	29.83	0	0.00	0	0.00	3	29.83
Dry swale	1	no data	no data	no data	no data	no data	1	no data
Dry well	37	1.85	0	0.00	0	0.00	37	1.85
Flood management area	1	1.70	0	0.00	0	0.00	1	1.70
Infiltration trench	27	84.79	0	0.00	0	0.00	27	84.79
Micro-bioretention	no data	no data	2	no data	no data	no data	2	89.30
Non-rooftop disconnect	2	0.10	0	0.00	0	0.00	2	0.10
Oil grit separator	6	2.76	0	0.00	0	0.00	6	2.76
Rooftop disconnect	1	0.05	2	no data	0	0.00	3	0.05
Submerged gravel wetland	0	0.00	2	10.12	1	no data	3	10.12
Surface sand filter	2	3.76	2	no data	0	0.00	4	3.76
Underground filter	1	1.70	2	no data	0	0.00	3	1.70
Wet extended detention pond	6	90.04	0	0.00	0	0.00	6	90.04
Wet pond	14	165.32	2	36.36	0	0.00	16	201.68
Tree planting	0	0.00	2	8.24	0	0.00	2	8.24
Stream restoration	0	0.00	8	2,971.19	1	31,047.85	9	34,019.04

Source: DoE 2020

[a] Stream restoration totals are provided in linear feet.

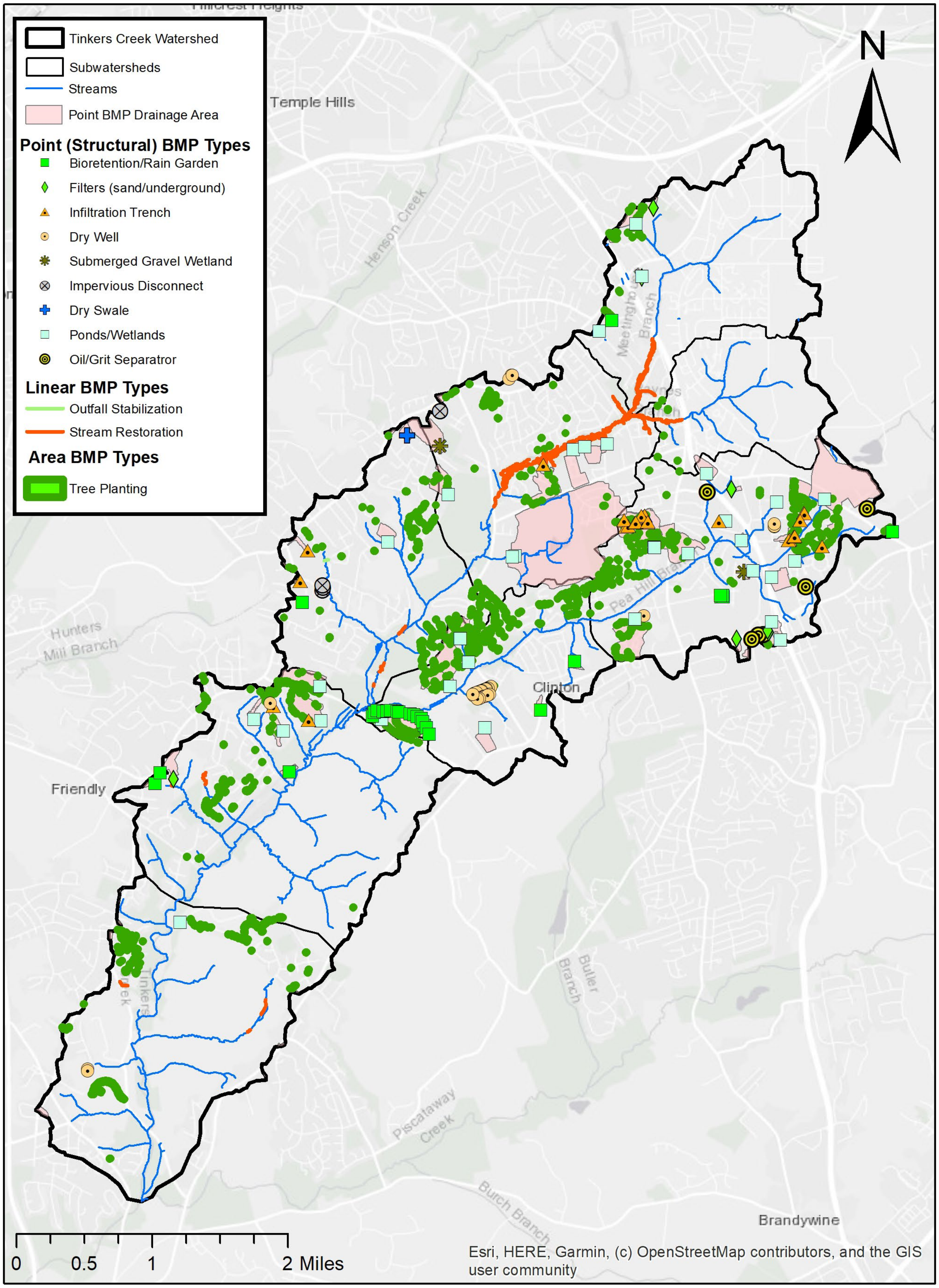


Figure 4-1. BMPs in Tinkers Creek watershed as of August 2020.

5 Load Reduction Targets and Current Progress

This section discusses the calculation of load reduction targets for the watershed, reductions that have resulted from current BMPs and reductions remaining to be met through this restoration plan. The calculations rely on TMDL information, land-use information, and current BMP information. This restoration plan will feature TN and TP reductions from the Chesapeake Bay TMDL and local TMDL sediment reductions for Tinkers Creek watershed. MDE is finalizing draft guidance on how to address bacteria WLAs. This guidance is expected to focus on programmatic activities and not require load reduction calculations or tracking. Therefore, this restoration plan will not address loadings for bacteria.

5.1 Load Reduction Terminology

The amount of load still required to be reduced after accounting for load reductions from current practices is called the "load reduction gap." Figure 5-1 illustrates that concept.

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

- **No-action load:** The pollutant load directly from the land surface without the influence of any BMPs.
- **Baseline load:** The pollutant load from the land surface at the time the TMDL was developed. It includes reductions from BMPs installed prior to 2017.
- **Target load:** The load that will be met once load reductions specified in the Chesapeake Bay TMDL are met.
- **Required load reduction:** The load that will need to be reduced through BMPs. This load is the difference between the baseline load and the target load.
- **Current load (BMPs installed 2017–2020):** The County has already installed BMPs in the watersheds. This is the current load accounting for these BMPs and is the difference between baseline loads and the loads treated by current BMPs.
- **Load reduction to date:** The loads reduced by currently installed BMPs that are eligible for restoration credit, or the difference between the baseline load and the current load.
- **% of target:** The percent of the required load reduction removed by installed BMPs.
- **Current load reduction gap:** The required load reduction remaining (i.e., gap) once the load reduction to date is subtracted from the required load reduction.
- **Load removed from BMPs in planning/design:** This value is the load reduction from the BMPs not yet constructed but already being planned and designed.
- **Final load gap:** The required load reduction that remains (i.e., gap) once the load reductions from current BMPs and BMPs in design and planning are subtracted. This is the load reduction this plan addresses.

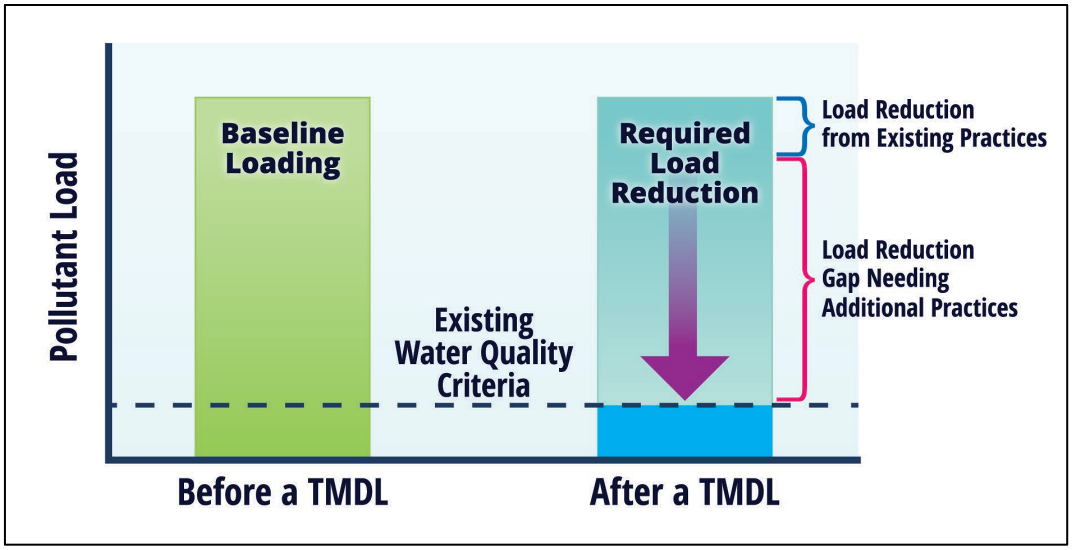


Figure 5-1. Schematic for typical pollution diet (TMDL) showing existing load reduction credits.

In developing its loads, the County used the land use-specific loading rates for TN, TP, and TSS provided by MDE in its June 2020 draft *Accounting for Stormwater Wasteload Allocations and impervious Acres Treated* guidance (MDE 2020a). The MDE rates were derived from the latest Chesapeake Bay model data and include loading contributions from stream bed and bank erosion. The County also used additional land use loading rates provided in MDE's *Phase 6 Chesapeake Bay Watershed Model Stormwater WLA* modeling Tool (MDE 2020d). This tool contained a few additional land use loading rates and was accompanied with land use geospatial data, which the County used in calculations for this plan.

The County's load calculation process used a similar approach to that of the August 2020 MDE spreadsheet tool (MDE 2020d) , but the County's tool breaks down the loadings into smaller subwatersheds for planning purposes. For example, the County's tool follows the MDE spreadsheet tool in only including impervious area and turf in its baseline load calculations. Like the MDE tool the County's load calculations did not include loads generated from agriculture, wetlands, forested areas, or mixed open land areas. Similarly, loads from state and federal lands were not used in this restoration plan. BMP Pollutant Load Reduction

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

5.1.1 Removal Efficiencies

MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2020) incorporates recent Chesapeake Bay Program (CBP) recommendations for nutrient and sediment load reduction removal efficiencies associated with implementing BMPs. By using those removal efficiencies in its reduction calculations, the County is consistent with regional efforts to meet the Chesapeake Bay TMDL.

The general pollutant removal efficiencies are provided in Table 5-1. The County load calculation process uses the pollutant removal efficiency for individual BMP types. These were obtained from the August 2020 MDE spreadsheet tool for TN, TP, and TSS, and were compared to those used by the Chesapeake Bay Model. Some BMP types have different removal efficiencies based on the use of underdrains and the soil type at the BMP location. The County used USGS soils data (section 2.1.3) to determine if the BMP was constructed in A, B, C or D hydrologic soil groups. When applicable, the County assumed that a BMP has an underdrain. These BMP types that could potentially have underdrains include bioretention/rain gardens, infiltration practices, permeable pavement, and vegetated open swales.

Table 5-1. Pollutant removal rates for ESD/runoff reduction and structural practices

BMP Type	TN Rate	TP Rate	TSS Rate
Bioretention A/B	70.0%	75.0%	80.0%
Bioretention C/D	25.0%	45.0%	55.0%
Bio-Swale	70.0%	75.0%	80.0%
Enhanced Filter	40.0%	60.0%	80.0%
Grass Swale	70.0%	75.0%	80.0%
Infiltration Trench A/B	80.0%	85.0%	95.0%
Micro Bioretention A/B	70.0%	75.0%	80.0%
Micro Bioretention C/D	25.0%	45.0%	55.0%
Permeable Paver A/B	45.0%	50.0%	70.0%
Permeable Paver C/D	10.0%	20.0%	55.0%

Sources: MDE 2020d
Note: These removal efficiencies assume 1-inch treatment volume.

Table 5-2 presents the pollutant reduction efficiency of several alternative BMPs, including stream restoration (for which the load reduction efficiencies are only for planning purposes). Once the stream restoration projects are installed, the County will use the approved protocols—based on design and field measurements—to determine their actual load reductions.

Table 5-2. Pollutant removal efficiencies of selected alternative BMPs

BMP Type	Units	TN	TP	TSS
Stream restoration (planning only)	lb/ft/yr	0.075	0.068	248
Outfall stabilization (planning only)	lb/ft/yr	0.075	0.068	248
Shoreline management (planning only)	lb/ft/yr	0.173	0.122	328
Impervious surface reduction (imp. to turf)	lb/ac/yr	6.96	0.45	5,241
Forest planting (turf to forest)	lb/ac/yr	11.12	1.78	2,805
Street trees (imp. to tree canopy over imp.)	lb/ac/yr	3.10	0.76	1,404
Urban tree canopy planting (turf to tree Canopy over turf)	lb/ac/yr	3.20	0.50	206
Conservation landscaping (turf to mixed open)	lb/ac/yr	5.24	0.53	0.00
Riparian forest planting (turf to forest)	lb/ac/yr	14.34 & 25%	2.50 & 50%	4,411 & 50%

BMP Type	Units	TN	TP	TSS
Riparian conservation landscaping (turf to mixed open)	lb/ac/yr	6.75 & 12.5%	0.74 & 25%	0.00 & 25%

Source: MDE 2020.
Notes:
lb/ac/yr = pound per acre per year.
lb/ft/yr = pound per foot per year.

5.1.2 Load Reduction from BMPs

The baseline year will be 2017. All BMPs (restoration, retrofit, and developer) installed up to 2017 were used to calculate the baseline loads. Only the BMPs that are eligible to receive restoration credit and were installed after 2017 were included in the current progress loadings. Table 5-3 lists load reductions by BMP type for the baseline period and for those counted towards TMDL progress. It also includes load reductions from specific BMPs that are already in the planning, design, or construction phase.

This table includes BMPs that were implemented under one of the programs discussed in section 4.1.

Table 5-3. Load Reductions by BMP types in the Tinkers Creek watershed

BMP Type	TN reduction (lbs)	TP reduction (lbs)	TSS reduction (lbs)
Baseline			
Bioretention Basin	41.25	10.12	28,791.23
Sand Filter	12.67	2.92	10,006.55
Underground Filter	13.66	3.11	12,674.77
Infiltration Trench	70.03	12.14	35,015.70
Dry Well	0.74	0.22	642.81
Non-Rooftop Disconnect	0.25	0.04	160.23
Rooftop Disconnect	1.00	0.18	625.33
Dry Swale	34.68	5.74	14,470.75
Wet Extended Detention	213.27	77.60	279,055.92
Wet Retention Pond	637.17	230.04	801,248.23
Dry Extended Detention	14.22	4.64	12,027.07
Dry Pond	44.65	6.75	65,692.28
Total	**1,083.64**	**353.54**	**1,260,410.93**
Progress			
Bioretention Basin	9.84	2.69	10,337.23
Tree Planting	22.09	4.02	4,331.01
Sand Filter	68.20	15.61	59,543.27
Underground Filter	5.34	1.21	5,181.11
Micro-Bioretention	3.71	0.79	25,511.55
Grass Swale	102.84	35.85	136,146.92

BMP Type	TN reduction (lbs)	TP reduction (lbs)	TSS reduction (lbs)
Rooftop Disconnect	0.02	0.005	18.08
Wet Retention Pond	151.65	53.74	207,805.29
Stream Restoration	267.37	242.42	884,122.32
Total	**631.06**	**356.34**	**1,332,996.78**
Planned			
Grass Swale	6.31	2.15	8,904.77
Stream Restoration	1,713.77	1,553.82	5,666,881.71
Total	**1,720.09**	**1,555.98**	**5,675,786.48**

Source: DoE 2020.
Notes: lb = pounds.

5.2 Baseline and Target Load Calculation

Table 5-4 presents baseline loads for Tinkers Creek watershed. Those baseline loads do not include loads attributed to federal or state land. These loads account for all BMPs installed through 2017. The methodology for calculating the baseline loads followed MDE's *Phase 6 Chesapeake Bay Watershed Model Stormwater WLA* modeling Tool (MDE 2020d). Table 5-4 also presents the percent reduction as reported in the TMDL, which was applied to the calculated baseline load to determine the implementation load reduction target. As listed in section 3.1 (Water Quality Impairments), the TMDL percent reduction values were obtained directly from the MDE *TMDL Data Center* (MDE 2020c). That target and the amount by which the loads need to be reduced are also presented.

Table 5-4. Pollutant load reduction targets for Tinkers Creek watershed

Measure	TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)	TSS (tons/yr)
No-Action Load	66,694	10,754	28,755,842	14,378
Baseline Reductions (<2017)	1,084	354	1,260,411	630
Baseline Load	65,611	10,401	27,495,431	13,748
Average Reduction Required %	*22%*	*41%*	*51%*	*51%*
Target Load	51,045	6,136	13,472,761	6,736
Required Reduction	14,566	4,264	14,022,670	7,011
Progress Reductions (2017–2020)	631	356	1,309,997	655
Progress Load	64,980	10,044	26,185,435	13,093
Current Load Reduction Gap	13,934	3,908	12,712,673	6,356
Planned Reductions (>2020)	1,720	1,556	5,675,786	2,838
Planned Load	63,260	8,488	20,509,648	10,255
Restoration Gap	12,214	2,352	7,036,887	3,518

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

The load reductions of the existing BMPs were calculated and used to determine the remaining load reduction gap (Figure 5-2 through Figure 5-5 and Table 5-4). The figures show the graphical representation of the calculated no-action loads, baseline loads, implementation target load, required implementation load reduction, load reduction (from baseline loads) resulting from current BMPs, the reduction gap, planned reductions and the restoration gap.

While the County implemented restoration BMPs prior to 2017, their load reductions are reflected in the baseline loadings. Besides restoration BMPs, there are BMPs installed by developers to offset the increased pollutant loads from new development. Because those BMPs are installed to offset new loadings and not to remove existing loadings, they are not counted towards watershed restoration. Partial credits can be counted towards restoration from redevelopment BMPs if the BMPs meet certain requirements.

As shown in Table 5-4, the load reductions from existing restoration activities are not sufficient to meet the targeted reductions. With the BMPs either previously implemented or planned, a reduction gap still exists in the Tinkers Creek watershed. Additional practices will need to be planned to close the gap in its pollutant reduction requirements.

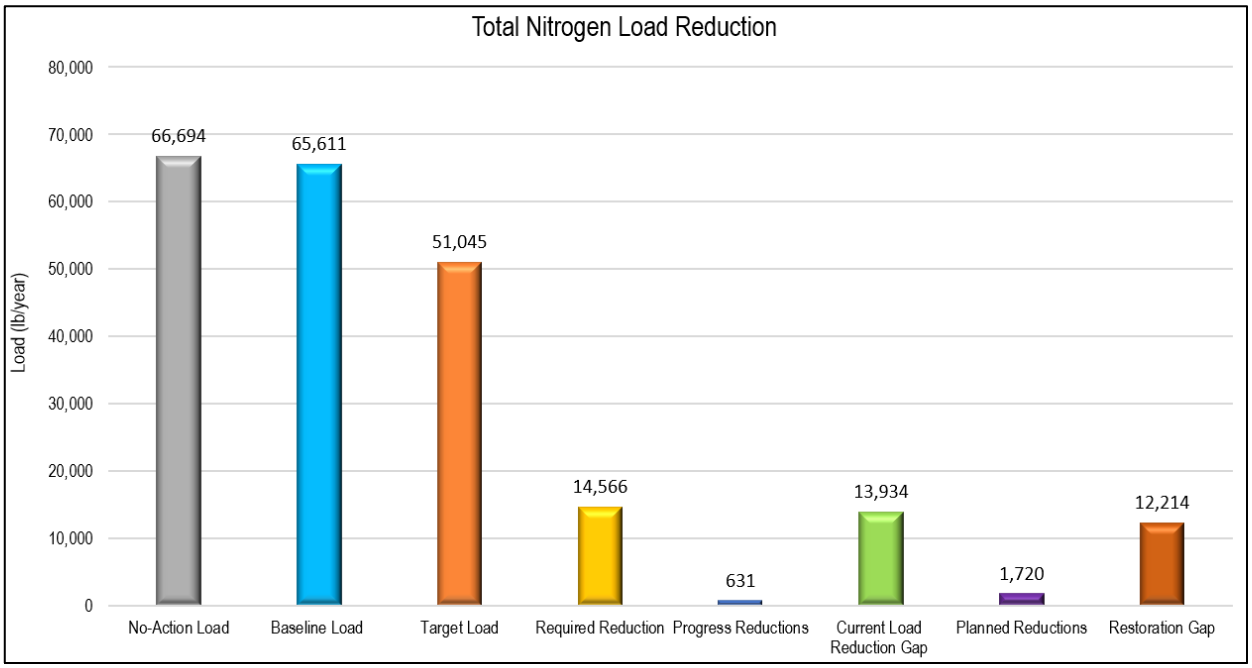


Figure 5-2. Total Nitrogen load reduction targets and gaps.

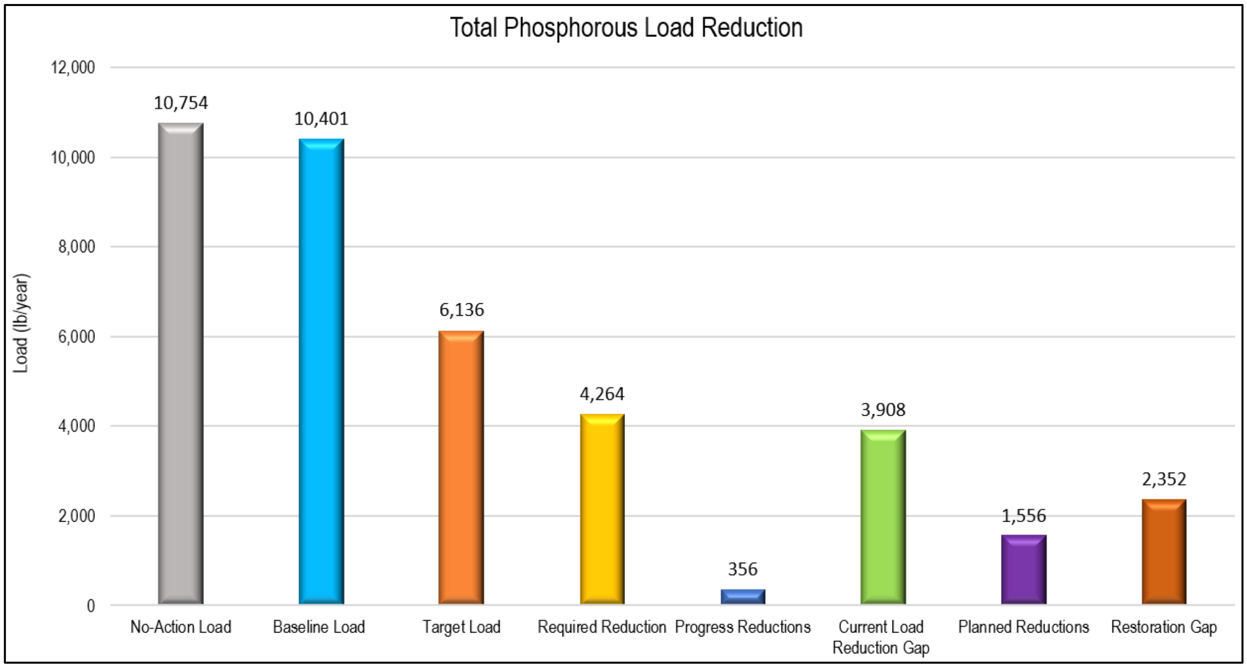


Figure 5-3. Total Phosphorous reduction targets and gaps.

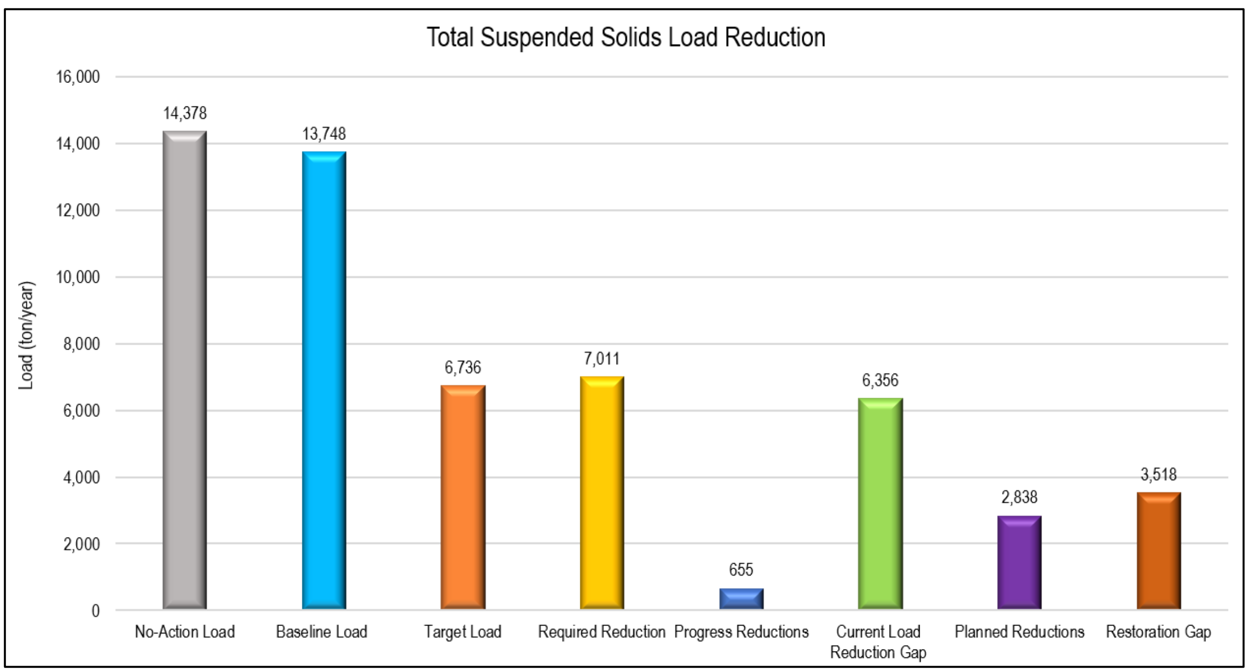


Figure 5-4. Total Suspended Solids load reduction targets and gaps.

6 Load Reduction Strategy Development

The County has constructed BMPs throughout the County, including Tinkers Creek watershed. The restoration activities in Tinkers Creek watershed will require a significant increase in the current level of effort to reach the targeted water quality goals outlined in the TMDL and this restoration plan. Consequently, the County has developed a strategy that comprises four major components to achieve the goals of the plan:

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

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

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

The overall load calculation process will follow these general steps:

1. Calculate the *no action* load using the MDE land use and land use loading rates. Reductions from BMPs implemented through 2017 will be subtracted from that load to determine baseline load at the subwatershed and 8-digit HUC level.
2. Apply the TMDL percent reduction to the baseline load to obtain the target load.
3. Calculate the total reduction required.
4. Calculate the load reductions from restoration BMPs installed between 2017 and 2020 to determine the current restoration progress.
5. Determine the remaining load reduction gap.
6. Calculate the load reductions from BMPs that are currently in the planning, design, or construction phase.

7. Determine the remaining load reduction gap.
8. Determine the amount of BMPs needed to fill in the load restoration gap.

6.1 Programmatic Initiatives

The County analyzed current stormwater programs (discussed in section 4.1) to determine. The existing programmatic activities are expected to continue and will be supplemented with additional practices, as they are identified and/or developed, to support the programmatic strategies for this restoration plan. In addition, the County is waiting for new MDE guidance on programmatic elements for meeting bacteria TMDLs. This guidance was not available at the time of this report.

6.2 BMP Identification and Selection

The MDE 2000 *Stormwater Design Manual* provides guidance for designing several types of structural BMPs, which include wet ponds, wetlands, filtering practices, infiltration practices and swales (MDE 2000). MDE also describes non-structural BMPs that include programmatic, educational, and pollution prevention practices that work to reduce pollutant loadings. Examples of non-structural BMPs include diverting stormwater from impervious to pervious areas, street sweeping, and homeowner and landowner education campaigns (MDE 2009). Additionally, the County will use the MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2020a).

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

As previously stated, this restoration plan includes a large stream restoration project in the upper reaches of the watershed and ESD practices throughout the watershed.

6.2.1 Urban Stream Restoration

Urban impacts on streams typically include bank and channel erosion, stream health degradation and loss of natural habitat. Multiple techniques for restoring a stream can be used to mimic the natural state of the stream, provide stability to the channel bed and banks and improve stream health and habitat in nontidal areas. Various kinds of in-stream structures can be used to stabilize the main channel by providing flow steering and energy dissipation as well as creating pools for natural habitat. In addition to in-stream structures, the increase in riparian vegetation can help to stabilize stream banks, further reducing in-stream erosion in high-velocity areas. The County is currently undergoing a major stream restoration project (almost 6 said 5 previously miles) in the upper reaches of the watershed. This project is estimated to remove just over 2,000 pounds of TN and TP, in addition to almost 4,000 tons of sediment. The actual load reductions will be calculated after the project is completed in 2023 and might be less than the estimated values.

6.2.2 Outfall Stabilization

Storm drainage systems in the County terminate at outfall structures that usually discharge to surface drainage features such as channels or streams. The outfall structures are often the initial source of stream erosion and degradation because they are the delivery point for the increased runoff from impervious areas. As the stream channel erodes and back cuts, it often undercuts the outfall structure, resulting in outlet failure (Figure 7-3). Outfall stabilization typically involves repairing localized areas of erosion below a storm drainpipe and addressing structural and functional problems associated with exposed infrastructure. Because the failing outfalls actively contribute to stream erosion and sediment generation, they present many restoration opportunities.

6.2.3 Structural Practices

The County will consider opportunities to implement BMPs on all types of land uses wherever there is a need to provide treatment to currently untreated impervious surface. Some BMPs are better suited to certain land uses than others. This section discusses examples of those land uses and their primary corresponding, but nonexclusive, BMPs. The County also looks to restore or create BMPs upstream from the ongoing stream restoration project to help reduce runoff and future potential erosion in the restored stream.

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

Rights-of-Way

The County owns and maintains rights-of-way (ROW), which are public spaces along streets and roadways. They contribute to the impervious runoff impact and represent a high-priority area for restoration and will be a major focus of the County watershed restoration efforts. If opportunities to implement BMPs in ROW areas present themselves, possible retrofits for different types of ROW are available (see Table 6-1).

Table 6-1. Potential BMP types per urban road ROW grouping

Potential BMP	Urban Open Section with No Sidewalk	Urban Closed Section with Curb and Gutter but No Sidewalk	Urban Closed Section with Curb, Gutter, and Sidewalk	Suburban Open Section with No Curb, Gutter, or Sidewalk	Suburban Closed Section with Curb, Gutter, and Sidewalk
Permeable pavement or sidewalks	X	X	X	X	X
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

Potential BMP	Urban Open Section with No Sidewalk	Urban Closed Section with Curb and Gutter but No Sidewalk	Urban Closed Section with Curb, Gutter, and Sidewalk	Suburban Open Section with No Curb, Gutter, or Sidewalk	Suburban Closed Section with Curb, Gutter, and Sidewalk
Grass swales and bioswales				X	
Bioretention or bioswales to convert an ROW to a green street				X	X
Infiltration trenches with underdrains				X	

Institutional Land Use

Existing institutional land uses also offer opportunities for BMP retrofits. The land uses include County and non-profit organization properties such as schools, libraries, places of worship, parks, government buildings, fire and police stations and hospitals. The County has implemented the Alternative Compliance Program, administered by DoE, which allows nonprofit organization property owners to reduce their CWA Fee by installing approved stormwater management practices. Most of the properties have substantial areas of impervious cover that include rooftops, driveways, and parking areas that offer opportunities for cost-effective retrofits. A BMP retrofit matrix can be applied to these sites based on impervious cover type (Table 6-2). The retrofit matrix will help in the selection process and identify practical and feasible practices that offer the highest pollutant removal at the lowest cost.

Table 6-2. Typical impervious area BMP retrofit matrix for institutional property

BMP Description	Impervious Cover Elements				
	Roofs	Driveways	Parking	Sidewalks	Other[a]
Runoff Reduction Practices					
Permeable pavements		X	X	X	X
Rainwater harvesting	X				
Submerged gravel wetlands			X		
Landscape infiltration	X	X	X		X
Dry wells	X				
Bioretention / rain gardens		X	X		X
Grass, wet, or bioswale		X	X		X
Enhanced filters	X	X	X	X	X
Structural Practices					
Wet ponds/wetlands			X		X
Infiltration practices[b]			X		X
Filtering practices		X	X	X	X
Tree Planting and Reforestation					
Impervious urban to pervious		X	X		X
Planting trees on impervious urban		X	X		X
Other					

BMP Description	Impervious Cover Elements				
	Roofs	Driveways	Parking	Sidewalks	Other[a]
Disconnection of rooftop runoff	X				
Disconnection of nonrooftop runoff		X	X	X	X
Sheet flow to conservation areas		X	X		

Note:
[a] Includes miscellaneous other impervious surfaces (e.g., basketball courts, tennis courts, and patios).
[b] Considered stormwater treatment unless designed according to Section VI of MDE 2020a.

Commercial/Industrial Land Use

Much like institutional properties, commercial and industrial properties are characterized by large areas of impervious cover, including roofs, driveways, parking lots, and other paved areas. From a technical standpoint, the opportunities for implementing a variety of BMPs in those areas are similar to the opportunities in institutional areas (Table 6-2). Most of the commercial and industrial facilities, however, are privately owned. Consequently, the County has limited influence on the use of BMPs in those areas except along the public roads that serve them. The Rain Check Program offers financial incentives for property owners to implement approved stormwater management practices. Property owners can benefit through rebates, grants or a reduction in a portion of their CWA Fee.

Residential Land Use

Residential areas make up roughly 39 percent of the watershed and have varying amounts of impervious cover such as roofs, driveways, walkways and patios. Many of the practices in Table 6-2 can be used on residential land. The most common practices for individual homeowners are permeable pavement, rooftop disconnection, rainwater harvesting (e.g., rain barrels), landscape infiltration, rain gardens and planting trees. For row houses, the most common practices are likely permeable pavement (on sidewalks leading to houses and alleyways), rooftop disconnection, rainwater harvesting (e.g., rain barrels) and rain gardens. Apartment and condominium communities could install any of the practices listed in Table 6-2.

It is difficult to implement BMPs on residential properties, however, because they are privately owned. As with commercial and industrial property owners, the Rain Check Program offers financial incentives for residential property owners to implement approved stormwater management practices.

6.3 Implementation Budgeting and Funding

6.3.1 Estimated Budgets

This section provides projected estimated budgets for the probable expenditures and staff resources that might be anticipated over the period of implementation. The costs are estimated in January 2020 values and do not account for inflation over the lifetime of this plan. Given the iterative and adaptive nature of the restoration plan and the potential for proposed activities being modified, the estimated budget should be considered preliminary for the year estimated and, in later years, should be revisited as the implementation period moves forward and new data become available.

Costs of Programmatic Initiatives

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

Cost of BMP Implementation

Table 6-3 presents data on BMP unit cost per impervious acre treated and estimated cost per pound of TSS removed, including costs for continued operation and maintenance. These unit costs were previously developed in *Costs of Stormwater Management Practices in Maryland Counties* (King and Hagan 2011).[1] The costs were converted to January 2020 dollars using the RS Means historical cost indexes (Gordian 2020). Table 6-3 lists restoration practices in increasing average annual costs over 20 years.

Table 6-3. BMP costs by application

Stormwater Restoration Practices	Type of Practice	Avg. Annual Cost/Imp. Acre over 20 years[a]	Cost / Pound TSS Removed from Treating 1 Acre Impervious
Vegetated open channels	Runoff reduction	$2,332	$0.38
Wet ponds & wetlands (new)	Stormwater	$2,525	$0.44
Urban forest buffers (no land acquisition acquired)	Alternative	$3,492	$0.79
Bioswale	Runoff reduction	$3,823	$0.62
Bioretention new	Runoff reduction	$4,915	$0.80
Infiltration practices without sand	Runoff reduction	$4,932	$0.80
Wet ponds & wetlands (retrofit)	Stormwater	$4,961	$0.85
Urban stream restoration	Alternative	$5,026	$3.35
Filtering (sand above ground)	Stormwater	$5,044	$0.87
Infiltration practices with sand	Runoff reduction	$5,152	$0.84
Filtering (sand below ground)	Stormwater	$5,411	$0.93
Dry ext. detention ponds retrofit	Stormwater	$5,929	$1.02
Impervious surface reduction	Alternative	$10,010	$1.36
Urban tree planting (with land acquisition)	Alternative	$12,650	$4.51

[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.

Stormwater Restoration Practices	Type of Practice	Avg. Annual Cost/Imp. Acre over 20 years[a]	Cost / Pound TSS Removed from Treating 1 Acre Impervious
Bioretention retrofit	Runoff reduction	$13,272	$2.16
Permeable pavement without sand	Runoff reduction	$17,299	$2.81
Permeable pavement with sand	Runoff reduction	$24,214	$3.93

Source: King and Hagen 2011.
Note:
[a] Costs inflated to January 2020 dollars.

6.3.2 Budget Funding

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

Sources of Funding

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

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

Besides funds from the CWA Fee, stormwater ad valorem tax, and CIP budget, federal, state, or other grants are expected to provide a minor, but essential, contribution to funding. The ad valorem tax is based on property assessment, which vary annually, and supports the DPIE's development process and DPW&Ts long term stormwater management maintenance program. The County has successfully obtained various grants in the past and expects that trend to continue. The County will continue to pursue grant opportunities available for restoration projects. In addition to grants, federal and state loans (e.g., State Revolving Fund) might be an option for helping to fund part of the TMDL restoration process. In addition, the County encourages government entities (e.g., municipalities) and private organizations (e.g., watershed groups and nonprofits) to identify and apply for grant opportunities.

The County expects current Stormwater Enterprise Fund sources and funding levels to remain consistent with the County's bi-annual Financial Assurance Plan (FAP), expected to reoccur over the life of this restoration plan. The countywide budget for restoration averages no more than $70 million per year for all stormwater restoration. The available funding will need to compete across multiple local restoration plans, including the Chesapeake Bay WIP; however, many of the activities in the WIP can be counted toward local restoration plans. As part of its' NDPES permit requirements, the County updates and submits its 2-year FAP to MDE for review. The FAP includes planned restoration projects of 5-year periods and the funding commitment for the next 2 fiscal years. The most recent plan approved by County Resolution is for FY 2019 and FY 2020. The County has created a new FAP for FY 2021 and FY 2022, but it has not been approved at the time of this report.

Budget for Restoration Activities

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

Table 6-4 provides a list of countywide stormwater CIP projects that include aspects of watershed restoration. The projects generally fund new watershed restoration activities or rehabilitation of existing assets to improve water quality. Specific watershed restoration projects or locations are not listed. However, the County maintains a project list that is used to determine the proposed funding. Once this restoration plan is completed, the County will start incorporating proposed restoration scenarios, subject to funding availability.

The County's stormwater CIP budget has in the past appropriated up to $100 million per year for countywide watershed or water quality restoration activities, in addition to various crucial programs (e.g., flooding, levies). For current funding capacities, the County typically prioritizes programs and shifts funding between watersheds. By doing so, the County can prioritize and shift year-to-year load reduction goals between watersheds; however, the County aims to achieve the targeted completion dates.

Table 6-4. Proposed FY 2021 – FY 2026 CIP budget for stormwater management

CIP ID	Project Name	Project Class
5.54.0016	Bear Branch Subwatershed	Rehabilitation
5.54.0018	Clean Water Partnership NPDES	Rehabilitation
5.54.0012	COE County Restoration (Anacostia River Watershed)	Rehabilitation
5.54.0015	Emergency Response Program	Rehabilitation
5.54.0014	Endangered Structure Acquisition Program	Land acquisition
5.54.0005	Flood Protection and Drainage Improvement	New construction
5.54.0019	MS4/NDPES Compliance & Restoration	Rehabilitation
5.66.0003	Major Reconstruction Program (DPW&T)	Replacement
5.54.0006	Participation Program	New construction
5.54.0007	Stormwater Contingency Fund	Non construction
5.66.0002	Stormwater Management Restoration	Rehabilitation

Source: Prince George's County 2020.

6.4 Technical Assistance

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

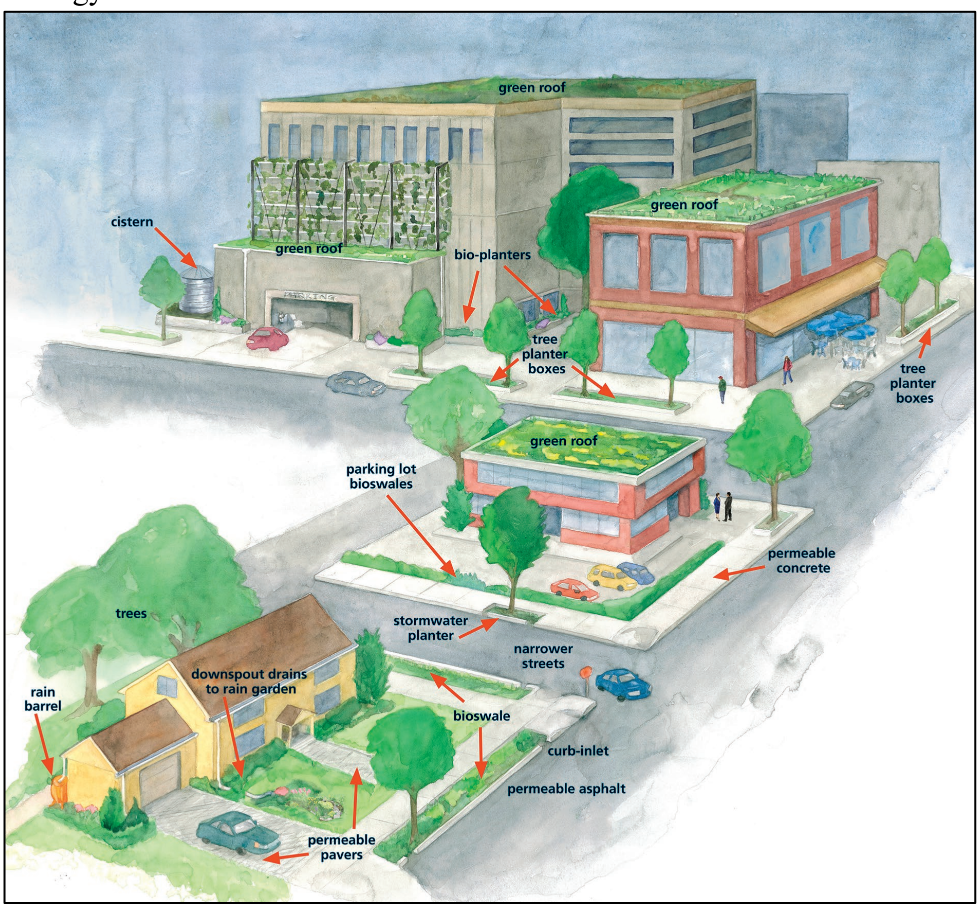
Many sites that are suitable for BMP implementation are not owned by the County. The County will seek partnerships with other organizations (e.g., nonprofit organizations and businesses) to gain access to private lands and be able to conduct restoration activities on them. For example, a shopping center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

7 Proposed Restoration Plan Activities

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

7.1 Proposed Management Approach

BMP types and locations are not explicitly specified, giving the County flexibility to identify specific locations for, and to work with, partners on implementing BMPs (e.g., to install BMPs on institutional land). The County also will have the flexibility to select suitable BMPs based on costs, land availability, feasibility, pollutant removal efficiencies, and other factors. Figure 7-1 presents conceptual art of an urban area with a variety of practices. It includes some practices not specifically mentioned in the plan, but that could be incorporated into the County's overall strategy.



Credit: EPA OWOW.

Figure 7-1. Conceptual urban area with ESD practices.

7.2 Programmatic Initiatives

The County's existing programmatic practices (Section 6.1) are expected to remain in place and will be supplemented with additional practices discussed in this section to make up the programmatic strategies for this restoration plan.

Estimating potential load reductions resulting from programmatic initiatives is challenging since some of the initiatives require public participation and changes in long-standing behaviors. Some of the programmatic initiatives will result in BMPs being installed. The acreage that will be treated through those programs has not yet been estimated. BMPs installed as those programs are implemented will be credited towards the identified load reduction targets and load reduction gap discussed in section 4.4. These BMP-related programs were described in section 4.

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

As mentioned in section 6-2, MDE will be coming out with guidelines for addressing bacteria WLAs, including programmatic activities such as water quality monitoring, source tracking, and source elimination. The County will determine an overarching bacteria restoration strategy after reviewing the MDE guidance.

7.3 Structural BMPs

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

This section presents the BMP types and amounts, along with their load reductions needed to meet the Chesapeake Bay and local TMDLs. For this restoration plan, two different methods were used to determine the amount of BMPs needed to met the target load reductions and reduction gap identified in Table 5-4. The first method was to use GIS-based tool and manual iterative scenarios. The second was to use the Microsoft Excel Solver Add-in to find the lowest cost options. Both methods had similar results. For both methods, the TN reductions were the hardest to be met. This is likely because TN load reductions are more difficult to meet than TP and TSS and stream restoration does not remove as much TN as it does for TP or TSS.

7.3.1 BMP Scenario Tool

In 2018, Tetra Tech developed a geographic information system (GIS)-based *BMP Accounting, Tracking, and Reporting Tool* in to help the County to better plan, evaluate, and report the performance of current and planned BMPs. The ArcGIS tool can evaluate future planning scenarios through BMP placements to meet water quality requirements such as a TMDL without extensive modeling efforts. The baseline, current loading/reduction, and future scenario calculations use static load and removal estimation for different land uses and BMPs.

The BMP Scenario Tool was updated with the most recent MDE land use and land use loading rate. Information for all current and planned BMPs were also entered into the tool. The tool uses BMP reduction curves for BMP reduction calculations. Because of how the tool operates, the no action load and the baseline load are the same for this analysis.

Once the tool processed the information, various amounts of restoration BMPs were added until the target load reductions were met for the watershed. Table 7-1 presents one of the many combinations of restoration BMPs that could be used to meet target load reductions in Tinkers Creek watershed. Table 7-2 presents the load reductions from the BMPs in Table 7-1.

Table 7-1. BMP Scenario Tool restoration practice to meet target load reduction

Land Use Type	Runoff Reduction BMPs (acres)	Stormwater Treatment BMPs (acres)	Stream Restoration (linear feet)
Impervious Non-Roads	32	400	Not applicable
Impervious Roads	4	96	Not applicable
Tree Canopy Over Impervious Non-Roads	5	96	Not applicable
Tree Canopy Over Impervious Roads	1	16	Not applicable
Tree Canopy Over Turf	6	528	Not applicable
Turf	3	464	Not applicable
Total	**51**	**1,600**	**5,000**

Table 7-2. BMP Scenario Tool load reductions in Tinkers Creek watershed

Measure or Practice	TN		TP		TSS	
	TN (lbs/yr)	% of Target	TP (lbs/yr)	% of Target	TSS (lbs/yr)	% of Target
No-Action Load / Baseline Load	66,371	450%	10,959	244%	28,863,218	196%
Target Load	51,637	350%	6,466	144%	14,142,977	96%
Required Reduction	14,734	100%	4,493	100%	14,720,241	100%
Current, Progress, and Planned Reductions	4,548	31%	2,381	53%	8,493,935	58%
Planned Load	61,823	420%	8,579	191%	20,369,283	138%
Restoration Gap	10,186	69%	2,112	47%	6,226,306	42%
Restoration Plan						
Stream Restoration / Outfall Stabilization	375	3%	340	8%	1,240,000	8%
Runoff Reduction (ESD) Practices	653	4%	114.1	3%	402,439	3%

Measure or Practice	TN		TP		TSS	
	TN (lbs/yr)	% of Target	TP (lbs/yr)	% of Target	TSS (lbs/yr)	% of Target
Stormwater Treatment Practices (e.g., wet ponds)	9,173	62%	2,332	52%	7,797,549	53%
Total BMP Scenario Tool	10,201	69%	2,786	62%	9,439,989	64%
Total Restoration Activities						
Current BMPs, Planned BMPs, and BMP Scenario Tool BMPs	14,749	100%	5,167	115%	17,933,924	122%

7.3.2 Desktop Excel Analysis

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

The Microsoft Excel Solver Add-in was used to determine the most cost-effective scenarios to meet the load reductions for this restoration plan. Solver processes a set of conditions to meet the County's objective: the lowest cost. For this restoration plan, we looked at two main conditions.

- Meeting the load reduction for TN and TP for the Chesapeake Bay TMDL and TSS from the local sediment TMDL.
- Meeting the load reduction TSS from the local sediment TMDL.

The second condition was added once it became clear that meeting the Chesapeake Bay TN load reductions was a limiting factor. Within these two main conditions, a range of implementation for ESD practices, outfall stabilization, stream restoration, tree planting, and new wet ponds were set. For example, one scenario limited ESD practices to treat runoff from 1 to 150 acres of land. Solver then determined the best value in that range for that scenario.

As seen in Table 7-3, the top 8 low-cost scenarios that had to meet all applicable TMDL load reductions had a relatively narrow range of cost from $50.3 million to $59.6 million. Figure 7-2 shows that for these scenarios, practices such as wet ponds were consistent but practices such as stream restoration could be done in either small or large capacities.

In contrast to these scenarios, Table 7-4 shows that the scenarios that only met the TSS local TMDL, while overall Chesapeake Bay TMDL reductions were meet elsewhere in the County. These had much more variability in BMP amounts and a lower overall cost. Costs ranged from $42.4 million to $54.7 million. While practices such as outfall stabilization remained the same, there was a wider range of amounts for practices such as wet ponds. Overall, meeting only TSS load reduction results in much fewer BMPs required.

Table 7-3. Comparisons of top 8 low-cost scenarios meeting TN, TP, and TSS load reductions

Practice	Top 8 Low-Cost Scenarios (TN, TP, TSS)							
	8	7	6	5	4[a]	3	2	1
Total Cost ($M)	59.62	59.05	59.01	57.93	56.41	54.41	53.47	50.34
Stream restoration (linear feet)	2,128	142	2,837	4,256	2,837	709	142	142
Outfall stabilization (# of outfalls)	34	24	34	34	34	34	24	24
Tree planting (acres planted)	10	10	10	1	5	10	15	1
Wet pond (acres treated)	1,900	1,800	1,946	1,974	1,990	2,000	2,000	2,000
ESD practices (acres treated)	97	164	70	50	50	58	66	70

Note:
[a] This scenario is further explored in sections 7.3.3, 7.3.4, and 7.5.

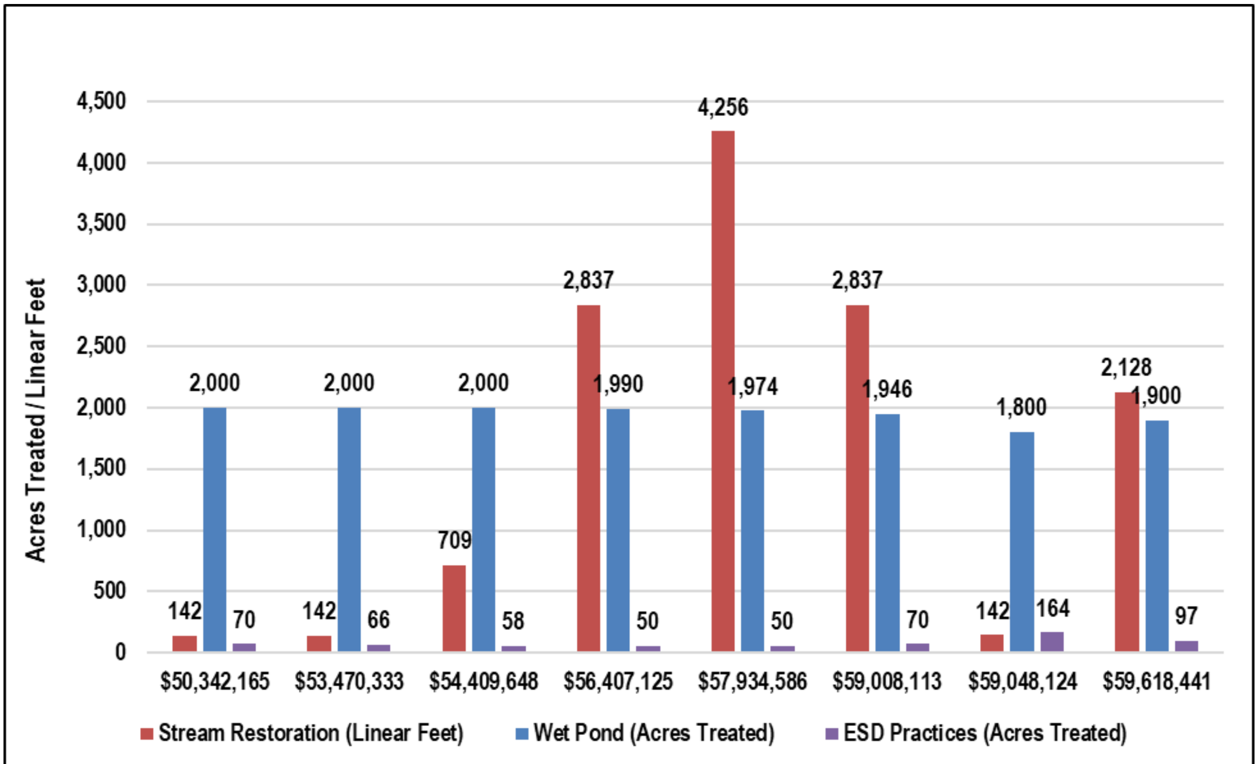


Figure 7-2. Top 8 Low-Cost Scenarios Meeting TN, TP, and TSS Load Reductions

Table 7-4. Comparisons of 5 low-cost scenarios meeting TSS only

Practice	Top 5 Low-Cost Scenarios (TSS)				
	5	4	3	2	1
Total Cost ($M)	54.72	46.78	46.47	44.92	42.44
Stream restoration (linear feet)	11,349	975	1,000	1,000	1,200
Outfall stabilization (# of outfalls)	24	24	24	24	24
Tree planting (acres planted)	5	5	5	1	1
Wet pond (acres treated)	800	975	1,000	1,000	1,200
ESD practices (acres treated)	100	10	10	1	1

Table 7-5 restates the load calculations from earlier in the document along with new reductions for the different restoration activities relevant to this plan (BMPs and programmatic initiatives). The restoration activities chosen for this are from the fourth or median low-cost scenario that meets all three load reductions from Table 7-3.

Table 7-5. Desktop Excel Analysis load reductions in Tinkers Creek watershed

	TN		TP		TSS	
Measure or Practice	**TN (lbs/yr)**	**% of Target**	**TP (lbs/yr)**	**% of Target**	**TSS (lbs/yr)**	**% of Target**
No-Action Load	66,694	457.8%	10,754	252.2%	28,755,842	205.1%
Baseline Reductions (<2017)	1,084	7.4%	354	8.3%	1,260,411	8.9%
Baseline Load	65,611	450.5%	10,401	243.9%	27,495,431	196.1%
Target Load	51,045	350.5%	6,136	143.9%	13,472,761	96.1%
Required Reduction	14,566	100.0%	4,264	100.0%	14,022,670	100.0%
Progress Reductions (2017–2020)	631	4.3%	356	8.4%	1,309,997	9.3%
Progress Load	64,980	446.1%	10,044	235.5%	26,185,435	186.7%
Current Load Reduction Gap	13,934	95.7%	3,908	91.6%	12,712,673	90.7%
Planned Reductions (>2020)	1,720	11.8%	1,556	36.5%	5,675,786	40.5%
Restoration Gap	12,214	16.1%	2,352	44.8%	7,036,887	49.8%
Restoration Plan						
Stream Restoration / Outfall Stabilization	468	3.2%	424	9.9%	1,546,860	11.0%
Tree Planting	16	0.1%	9	0.2%	5,371	0.0%
Wet Ponds	11,150	76.5%	2,477	58.1%	7,639,650	54.5%
ESD Practices	581	4.0%	92	2.2%	274,327	2.0%
Total Restoration Plan	**12,214**	**83.9%**	**3,002**	**70.4%**	**9,466,207**	**67.5%**
Total Restoration Activities						
Current BMPs, Planned BMPs, and Restoration Plan BMPs	**14,566**	**100.0%**	**4,914**	**115.2%**	**16,451,991**	**117.3%**

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

7.3.3 BMP Identification

A desktop GIS analysis identified more than 90 potential BMP locations in Tinkers Creek watershed, many of which were upstream of the current stream restoration project. These BMPs were first reviewed using a desktop analysis of factors, such as soils, site ownership, and potential site constraints (e.g., utility poles/boxes, vegetation, fire hydrants, barriers and guardrails, small available space). Each BMP had its drainage area delineated to determine the toral area and amount of impervious area that could potentially be treated. There were 77 BMPs remaining after these reviews. These BMPs could be used to help met load reduction targets and the needed BMPs determined in sections 7.3.1 and 7.3.2.

Table 7-6 provides the types of potential BMPs and how much area they could treat. Table 7-7 provides the potential load reduction by sub-watershed (Figure 2-1). Figure 7-3 shows the locations of these potential BMPs within the watershed. As can be seen in the figure, the potential BMP opportunities are focused in the urban areas of the watershed.

Table 7-6. Summary of potential BMPs

BMP Type	Number of sites	Treated Impervious Area (acres)	Total Treated Area (acres)
Bioretention	6[a]	13.9	25.9
Bio-swale	7	1.5	4.6
Enhanced filter	34	14.4	22.9
Grass swale	2	0.4	1.6
Infiltration trench	3	1.8	4.8
Micro-bioretention	10	2.6	4.0
Pavement removal	1	0.0	0.4
Permeable paver	5	2.6	2.8
Roof top disconnection	9	0.1	0.1
Total	77	37.3	67.1

Note:
[a] Multiple bioretention system opportunities at some sites account for a larger combined drainage area..

Table 7-7. Summary of load reductions from potential BMPs

Subwatershed	Reduced TN Load (lb/yr)	Reduced TP Load (lb/yr)	Reduced TSS Load (lb/yr)	Note
PC-7	3.16	0.53	965	
PC-8	9.83	2.01	7,291	
PC-9	57.99	11.80	41,678	
PC-10	79.85	18.27	65,493	Upstream of stream restoration
PC-11	67.26	15.65	66,941	Upstream of stream restoration
PC-12	0.00	0.00	0	Within Joint Base Andrews
PC-13	83.48	17.34	56,463	
PC-14	148.69	32.68	118,661	
Total	**450.26**	**98.28**	**357,492**	
Upstream	147.11	33.92	132,434	Upstream of stream restoration project (PC-10, PC-11, PC-12)

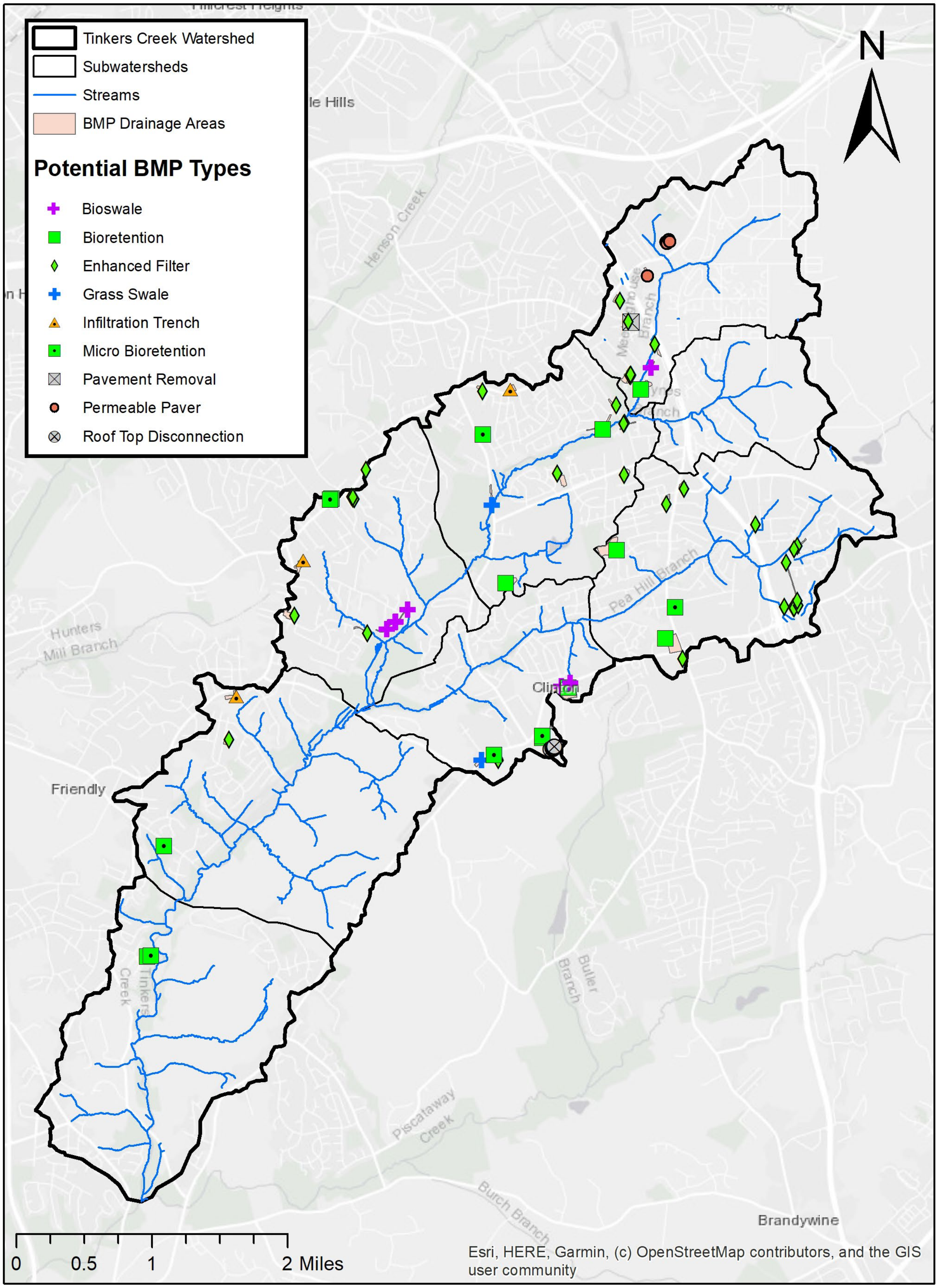


Figure 7-3. Locations of potential BMP locations in Tinkers Creek watershed.

7.4 Restoration Budget

The planning level costs per restoration activity are shown in Table 7-8 and are based on the. The fourth lowest cost scenario (Table 7-3) from the Excel analysis (section 7.3.2) was selected for the restoration plan to provide the County with several options. overall cost for this plan is $56.4 million.

The BMP unit costs from Table 6-3 were used to determine the budget. Because this plan does not specify exact ESD types, the average of the ESD practices was used to determine the budget for the ESD practices in Table 7-8. The most cost-effective strategy is creating new wet ponds, while tree planting is the least effective, partially due to the land costs associated with planting. If trees are planted on existing properties without land having to be acquired, the cost-effectiveness of this practice will increase, and the overall restoration cost will go down.

The 4th lowest cost scenario serves as a starting point for the County to make future decisions. The actual combination of BMPs implemented to meet the TMDL can change over time as adaptive management principles are applied to this plan. For costing, only the impervious area is assessed because the available cost data are provided per impervious acre treated, rather than for the total land area treated.

Table 7-8. Total BMP proposed implementation costs by restoration strategy (2020 dollars)

Practice	Budget	TN	TP	TSS
		$/lb	$/lb	$/lb
Stream restoration / outfall stabilization	$12,539,299	$26,804.80	$29,564.12	$8.11
Tree planting	$1,265,022	$79,686.46	$141,422.30	$235.54
Wet pond	$37,192,222	$3,335.74	$15,017.33	$4.87
ESD practices	$5,410,581	$9,311.47	$58,721.85	$19.72
Total Restoration Plan	**$56,407,125**	**$4,618.09**	**$18,790.83**	**$5.96**

Notes: lbs/yr = pounds per year.

7.5 Implementation Schedule

This section provides the planning level implementation schedule to meet load reduction milestones. There is no mandated end date to the local TMDL restoration plans; however, the County understands the public prefers an expedited restoration process and shares that sense of urgency. The County and its watershed partners are committed to finding site opportunities and expediting the planning, design, and construction phases for management activity to the maximum extent practicable. Any BMPs installed by the County to address local TMDLs will help meet Chesapeake Bay load reduction goals for 2025.

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

DoE estimates that it can retrofit an average of 2 percent of its untreated impervious area a year (as per anticipated new NPDES permit conditions). This estimate is backed up by MDE in its draft Phase III Chesapeake Bay WIP (MDE 2019). Using that implementation average as a guide, we can determine the length of time needed to fully implement this restoration plan. There is 1,328 acres of untreated impervious area in Tinkers Creek watershed and meeting the TMDL will require treating 793 acres. Based on the impervious area to be treated, full restoration in will take 29.9 years to meet TN, TP, and TSS load reductions.

Factoring in the implementation of the other competing priority restoration plans, source identification, available BMP technologies, and ease of implementation, this restoration plan will probably be fully implemented by FY 2050, including treating the identified impervious acres with BMPs and all programmatic activities. Because the County already has a FY 2021 budget and project list, work toward this restoration plan could start as early as FY 2022 or 2023 once funds are allocated and implementation site selection has begun.

Table 7-9 presents the estimated average annual number of impervious acres treated and the estimated load reductions by year from BMP implementation in the watersheds. There will be slight fluctuations in the annual load reductions due to the types of BMPs used and the land uses they treat, but the County will aim to meet or exceed the annual goals. This schedule will be continuously monitored by the County to assess ways to increase the rate of implementation and to ensure practices are implemented as planned. By comparison, the lowest-cost scenario to only meet TSS reduction would take 19.5 years.

Table 7-9. Proposed average annual number of impervious area (acres) and load reductions goals/milestones

Fiscal Year	Impervious Acres Treated	Estimated Budget	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2021	26.56	$1,888,533	409	101	316,932
2022	53.12	$3,777,066	818	201	633,865
2023	79.68	$5,665,599	1,227	302	950,797
2024	106.24	$7,554,132	1,636	402	1,267,730
2025	132.80	$9,442,665	2,045	503	1,584,662
2026	159.36	$11,331,198	2,454	603	1,901,594
2027	185.92	$13,219,731	2,863	704	2,218,527
2028	212.48	$15,108,264	3,272	804	2,535,459
2029	239.04	$16,996,797	3,680	905	2,852,392
2030	265.60	$18,885,330	4,089	1,005	3,169,324
2031	292.16	$20,773,863	4,498	1,106	3,486,256
2032	318.72	$22,662,396	4,907	1,206	3,803,189
2033	345.28	$24,550,929	5,316	1,307	4,120,121
2034	371.84	$26,439,462	5,725	1,407	4,437,054
2035	398.40	$28,327,995	6,134	1,508	4,753,986
2036	424.96	$30,216,528	6,543	1,608	5,070,918
2037	451.52	$32,105,061	6,952	1,709	5,387,851
2038	478.08	$33,993,594	7,361	1,809	5,704,783

Fiscal Year	Impervious Acres Treated	Estimated Budget	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2039	504.64	$35,882,127	7,770	1,910	6,021,716
2040	531.20	$37,770,660	8,179	2,010	6,338,648
2041	557.76	$39,659,193	8,588	2,111	6,655,580
2042	584.32	$41,547,727	8,997	2,211	6,972,513
2043	610.88	$43,436,260	9,406	2,312	7,289,445
2044	637.44	$45,324,793	9,815	2,412	7,606,377
2045	664.00	$47,213,326	10,224	2,513	7,923,310
2046	690.56	$49,101,859	10,632	2,613	8,240,242
2047	717.12	$50,990,392	11,041	2,714	8,557,175
2048	743.68	$52,878,925	11,450	2,814	8,874,107
2049	770.24	$54,767,458	11,859	2,915	9,191,039
2050	793.30	$56,407,125	12,214	3,002	9,466,207

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

The FY 2050 projected end date was developed using estimates of the number of acres of impervious area that could be treated each year. During that period, the County will be implementing several other watershed restoration plans, creating competing priorities that could limit the pace at which restoration is accomplished in the Tinkers Creek watershed. Faster implementation would require additional funding, staffing and industry resources (e.g., bioretention soils, plants) sooner. The County is working with its watershed protection restoration program to increase the County's TMDL reduction rates. The County continues to research and evaluate innovative practices to increase BMP efficiencies while lowering costs. Additional staff at the local level and close coordination with the State would be needed to review and approve BMP plans and permits in a timely manner so as not to slow implementation. Between now and FY 2050, implementation uncertainties could emerge that will require adjustments to the plan.

8 PUBLIC OUTREACH AND INVOLVEMENT

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

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

DoE has initiated a wide range of initiatives to inform County residents about the impacts their daily activities have on the health of their watershed and local water bodies. During FY 2019, the County hosted more than 500 events to promote environmental awareness, green initiatives, and community involvement in reducing the amount of pollution entering the County's waterways, during which nearly 33,000 members of the public participated (DoE 2019). DoE's outreach and educational programs also encourage volunteerism and environmental stewardship among community organizations, businesses, and citizens. Under DoE's Sustainability Division, the Community Outreach Promoting Empowerment (COPE) Section is the lead office managing and administering most of the education and outreach initiatives described in this section.

Current outreach programs are discussed in section 4.3. Beyond those targeted efforts, the County will work with watershed partners to ensure the public is informed of implementation progress and that active public involvement is pursued throughout the process.

8.1 Pet Waste Activities

This section identifies outreach opportunities to educate and engage residents and businesses in Tinkers Creek Watershed about pet waste. Besides being unsightly and smelly, pet waste contributes nitrogen, phosphorus, bacteria, and other pollutants to local waterbodies if not disposed of properly. A targeted pet waste strategy in Tinkers Creek Watershed can raise residents' awareness and concern about pet waste disposal enough to spur behavior change that will reduce bacteria in the watershed.

Linking pet waste pickup messages to the idea of being a responsible pet owner can help to build a community of responsible pet owners who care for their pets and, more importantly, clean up after them. Most dog owners consider their pets to be members of their family and want to make the right choices to protect the health of their pets and their family. Enhancing existing efforts and implementing several new activities should help spread the word about the need for pet waste pickup and encourage good behaviors. Messages and actions focusing on proper pet waste pickup as a routine behavior of responsible pet owners will help residents who already see themselves as responsible but might not be consistently picking up after their dogs, more likely to adopt the behavior as permanent.

In order to educate and engage the community about pet waste, the County will continue their current outreach programs involving pet waste and also look for opportunities to partner with trusted community messengers and attend existing community meetings, events, and school functions in locations where the highest concentrations of dog licenses and strays exist in the watershed.

8.1.1 Existing County Pet Waste Programs

The County has already initiated numerous countywide education and outreach initiatives to inform the public about the impacts of pet waste. The County is currently implementing their Pet Waste Outreach Strategy, which identifies activities and key pet waste messages for target audiences and locations throughout the County.

Pet Waste Disposal

DoE’s COPE Section under the Sustainability Division manages and administers the pet waste disposal program to raise residents’ awareness and concern about pet waste disposal enough to spur behavior change. The overall message is “Be a responsible pet owner by picking up your dog’s waste.” The slogan is “Do Your Doody! Scoop That POOP! Scoop it, bag it, trash it.” COPE uses a multi-pronged approach to support pet waste pickup and disposal activities in the County:

- Building and maintaining partnerships, such as working with the cities of Greenbelt and 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 (see more details below).
- Conducting numerous Pet Waste Expos and Pet Waste Management Summits
- Participating in community and municipal festival and events to provide materials and engage with the public to increase the public’s awareness about pet waste pollution (Figure 8-1).
- Development and distribution of pet waste materials:
  - “Scoop the Poop” pledge card asks County residents to commit to picking up after their pets.
  - “Why Scoop that Poop” brochure in English and Spanish.
  - “What Happens When You Don’t Scoop that Poop?” brochure in English and Spanish.
  - “Do Your Doody Scoop That Poop” 3’ by 4’ poster.

- “Target Locations” 3×4 foot poster.
- “Promoting Pet Waste Pick-up” 3×4 foot poster.
- Pet waste giveaways (with County’s campaign slogan): bag dispensers with baggies for dog owners and poop emoji squeezable toys for children who play the poop game (Figure 8-1).
- Community signage for high use areas (for children and adults):
  - “Why Scoop that Poop” dog park sign (Figure 8-2).
  - Installation of pet waste disposal stations (Figure 8-3).

Figure 8-1. Playing "Scoop that Poop" game with a Mount Rainier resident.

- GIS-based pet waste tracking application. EFC and DoE developed a mobile application that allows community members to report the relative amount of pet waste collected via the pet waste stations and help assess the success of educational efforts. It is assumed that as the amount of pet waste collected increases, individual awareness through education has also increased. The pet waste tracking application is only available to communities where pet waste stations have been installed.

Figure 8-2. Why Scoop That Poop Dog Park Sign

Animal Management

The Animal Management Division (AMD) sponsors and hosts adoption events, dog spay and neuter clinics, and public education events. These activities help reduce the number of stray animals in the County, thus reducing the amount of animal waste that is not properly disposed of. The Division tracks the number of stray animals that are taken to County facilities (Figure 8-4). This information can help determine if the overall stray population is decreasing and where to focus outreach messaging. AMD is also responsible for removing dead animals from roadways. This prevents nutrients and bacteria loads from the decomposing animals from entering the stormwater network, and thus the County's water bodies. These load reductions, however, are not able to be determined.

Figure 8-3***.*** Pet waste disposal station encourages residents to pick-up and dispose of pet waste

8.1.2 New Opportunities for Pet Waste Education and Outreach

The section identifies what locations in Tinkers Creek Watershed the County will target to educate and inform residents about pet waste. The County will target the locations of dog licenses and strays in the watershed. In addition, the County hopes to reach the most residents at existing and established events that are already being attended by watershed residents. This section also describes the use of trusted partners to help disseminate and educate using existing materials, methods and assist in the establishment of pet waste disposal stations. Some potential opportunities are described below. The County welcomes additional ideas for outreach from residents. Interested parties should contact the DoE's Sustainability Division.

8.1.3 Locations of dog licenses and strays

Based on data from 2014 to 2018, the County has 322 dog licenses and picked up 519 stray dogs in Tinkers Creek Watershed (Figure 8-4). These locations are the general areas where the County will prioritize outreach and education efforts. The target audience for the County's pet waste efforts in Tinkers Creek Watershed are dog owners – which is where the dog licenses are located. The County will also focus efforts in the stray dog locations since no owners are around to pick-up the waste left by stray dogs. Educating the public in these locations will hopefully change behaviors and reduce the amount of pet waste entering the County's water bodies. Education and outreach efforts will also include the need to spay or neuter pets so that the number of stray dogs in the watershed is reduced.

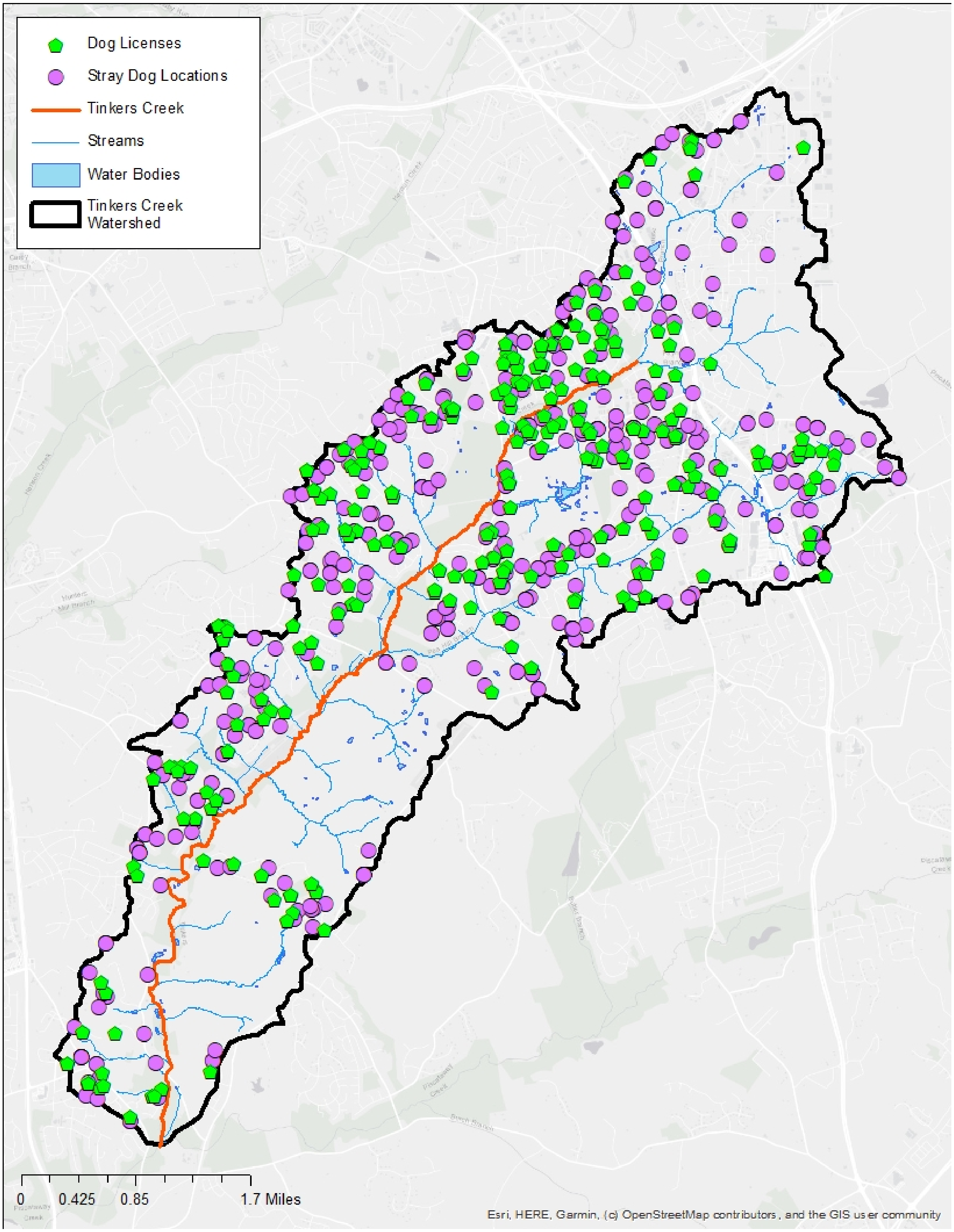


Figure 8-4. Locations of dog licenses and strays in Tinkers Creek Watershed

8.1.4 Existing Community Gathering Locations and Events

There are numerous locations in Tinkers Creek Watershed where community members and businesses gather to share information. These locations are where pet waste education in the watershed should occur. Tinkers Creek Watershed is in County Council District 8 and includes more than 75 homeowners and civic associations. One of the largest communities in Prince George's County is Camp Springs with 19,000 civilians and 7,000 military families. Their civic association is active in the community and conducts six meetings a year with residents, businesses owners, and local elected officials. The watershed also includes five elementary schools, two middle schools, one high school, one senior center, one community center, and numerous public parks (Figure 8-5 and Figure 8-6). The parks are owned by M-NCPPC and host numerous communitiy events. The watershed also includes the largest employer in Prince George's County – Joint Base Andrews (noted in yellow on Figure 8-5 and Figure 8-6).

The County will look into presenting pet waste information at an existing homeowners or civic association meeting, at a tabling event at one of the parks in the watershed, or during a pre-scheduled school function. The dates and locations for Camp Springs community meetings are already known. The dates and locations for other community meetings can be obtained from this list: https://pgcares.com/site-map/civic-associations-prince-georges-county/.

To reach adults and children in the center of the watershed where most of the pet licenses and strays exist, the County will explore setting up a table during a sporting event at the Stephen Decatur Community Center. As displayed in Figure 8-4, dog licenses and strays are located throughout the watershed but there are clusters in Camp Springs and near the Stephen Decatur Community Center. To reach the southern and eastern portions of the watershed, the County may also set up a table at an already planned event at Friendly Highschool or Rose Valley Elementary School. Events at churches throughout the watershed would also be a beneficial for educating residents about pet waste and can be included in the education and outreach component of the County's Alternative Compliance Program with non-profit and faith-based organizations. School events could be combined with water quality education assemblies such as litter pick-up. Pet waste education could also be combined with pet adoption events and spay and neuter clinics.

At each of the community events, the County will use and distribute educational materials already developed by the County or one of the trusted messengers. In addition, the events could include the "Scoop that Poop" game to engage residents, including children.

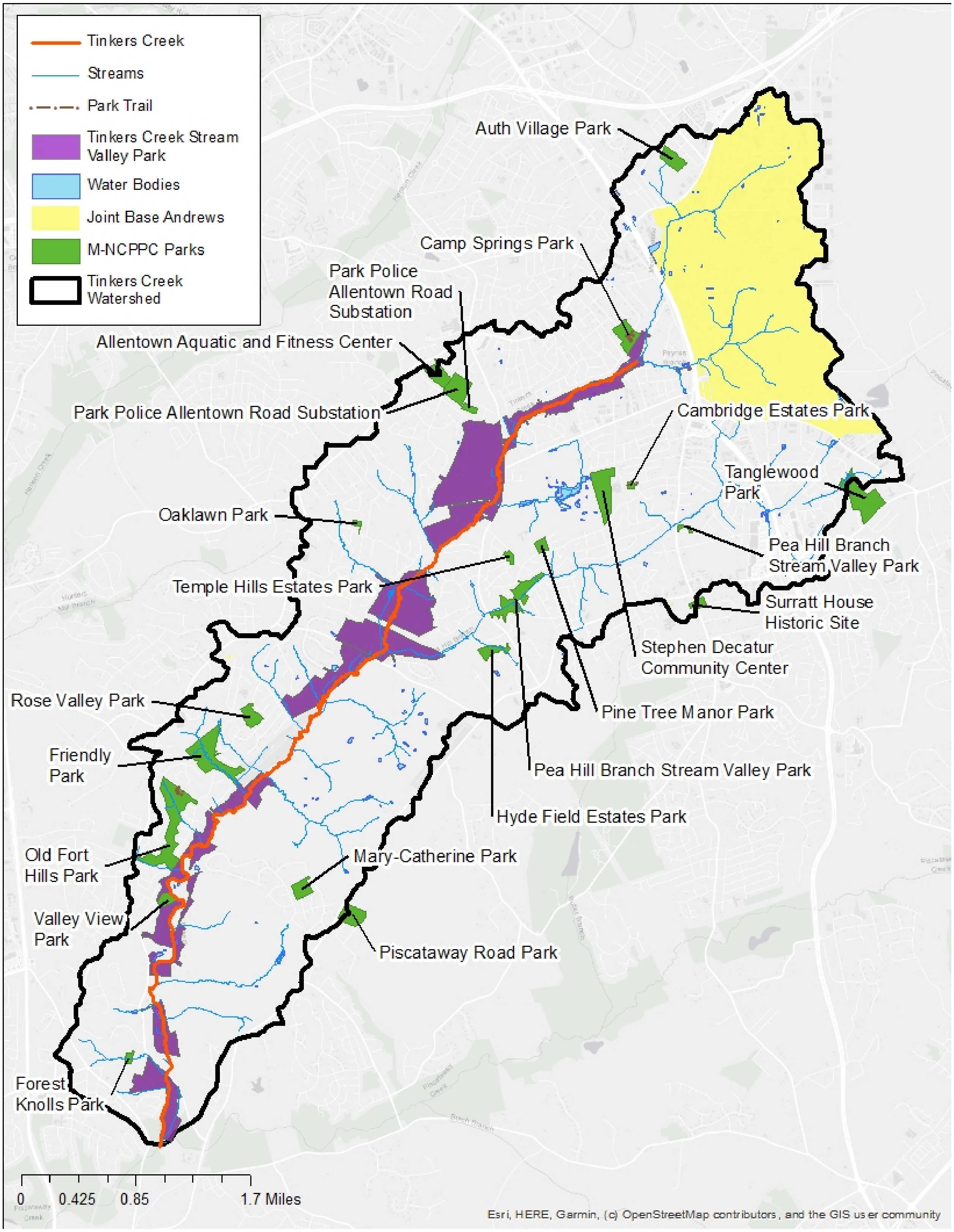


Figure 8-5. Parks in Tinkers Creek Watershed

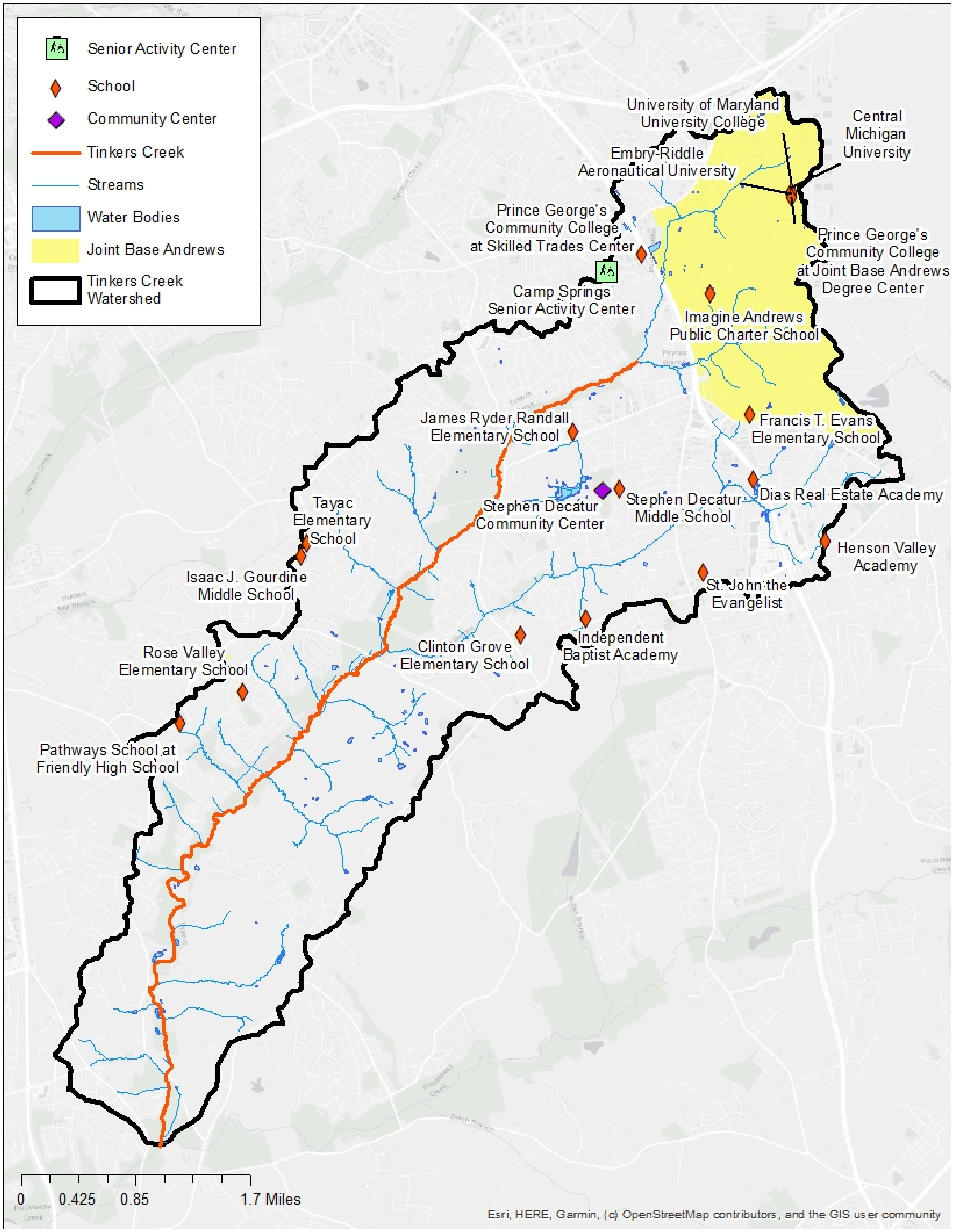


Figure 8-6. Schools and Community Centers in Tinkers Creek Watershed

8.1.5 Pet Waste Outreach Already Conducted by Trusted Partners

There are several organizations or trusted partners in the County that have conducted pet waste education and outreach. None of the outreach conducted by these trusted partners occurred in Tinkers Creek Watershed, however, the pet waste education materials and approaches used in other communities could be replicated in Tinkers Creek Watershed.

The University of Maryland and Sustainable Maryland received a $135,000 grant to develop and implement a pet waste education campaign for the College Park, Riverdale Park, Capitol Heights, Edmonston, Brentwood, and Greenbelt communities in the County. In addition, the University received another $100,000 grant to conduct pet waste education for the communities of Capitol Heights, Colmar Manor, Seat Pleasant, Berwyn Heights, Forest Heights, Glenarden, and Hyattsville. The People for Change Coalition were awarded grants to install pet waste disposal stations and promote awareness of the problems that pet waste can cause in Kettering, Glendale/Lanham and Largo Town Homes homeowner associations. These grants were funded through the County's Stormwater Stewardship Grant by the Chesapeake Bay Trust. The Stormwater Stewardship Grant provides funds for on-the-ground restoration activities that improve neighborhoods, improve water quality, and engage County residents in the restoration and protection of the local rivers and streams.

The People for Change Coalition hosted a "Scoop da Poop" Town Hall for residents at the Kentland Community Center in June 2017. The event was attended by homeowner associations, businesses, community leaders, nonprofits, and residents who learned about why pet waste is a concern, current pet waste laws, and how they can get pet waste stations installed in their communities. University of Maryland and Sustainable Maryland supported the County in hosting three Pet Waste Management Summits between 2016 and 2019. The summits were attended by County elected officials, municipal staff, and residents to learn more about pet waste management and how they can incorporate pet waste best management practices into their overall sustainability initiatives. Attendees also learned about the County's Pet Waste Campaign and resources available to start their own local pet waste management program. The People for Change could partner again with the County to conduct similar events at a local school or community center in the Tinkers Creek Watershed.

8.1.6 Pet Waste Disposal Stations and Dog Parks

EFC, also with funding from the Chesapeake Bay Trust, assisted these communities to implement local pet waste awareness programs and install the pet waste disposal stations: Bladensburg, Brentwood, Cottage City, District Heights, Edmonston, and Landover Hills. *EFC planned to install 60 new pet waste stations by the end of 2017*. (have they done it?) EFC has engaged 30 unique communities in these municipalities through events geared toward identifying goals related to pet waste and stormwater management. They have also adapted the County's English outreach education material into Spanish.

DoE will consider working with one of the trust partners and one of the local communities, such as Camp Springs, to apply for a Stormwater Stewardship Grant to conduct pet waste education and install and maintain pet waste disposal stations in common areas and parks. Funding to install pet waste disposal stations will not only improve water quality in the watershed but will also increase awareness and encourage proper disposal of pet waste. Training for the use of the pet waste disposal stations could be conducted at any of the local schools, churches, or community centers in the Tinkers Creek Watershed.

The County could also consider working with M-NCPPC to add pet waste disposal stations in existing parks or adding a delegated, fenced-in dog park with pet waste disposal stations (Figure 8-3) in the watershed that would be sited away from water bodies. There is one dog park within the Joint Base Andrews boundary, but none on public land in the watershed. Adding a dog park with pet waste disposal stations will allow a greater flow path for treatment of the nutrient- and bacteria-enriched runoff from the dog park while also encouraging pet owners to pick up and dispose of their pet's waste. Dog parks would also be an excellent location to install some existing educational signs and reminders that DoE has installed pet waste stations in other communities.

8.2 Additional Outreach to Support Implementation Activities

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

- ***Inventory of Environmental Outreach Programs in and around Prince George's County***. COPE inventoried existing local programs (e.g., nonprofits and educational) working toward shared goals of environmental stewardship or stormwater pollution reduction and that already have ongoing or planned outreach efforts in and around the County. This was done to identify potential outside partners and overlapping programs/efforts. COPE researched which types of programs and materials have been successful and are available to share and cross-market to target audiences.
- ***Audience Research Analysis: A Review of Target Audience Characteristics in Prince George's County for a Stormwater Outreach Strategy.*** The County is made up of a diverse population in terms of age, race, culture, language, education, and income. As a result, COPE analyzed U.S. Census data and secondary research to gain an understanding of the potential target audiences and their specific characteristics as well as possible barriers to environmental messages (e.g., lack of homeownership, native language, age, and household economics). This analysis helped determine the best way to reach diverse groups and identify different messaging and methods that would resonate with target audiences.
- ***Priority Watersheds Analysis***. The County has nine major watersheds, each with different water quality concerns. COPE identified location-specific outreach needs based on water quality priorities and areas where the County should target its outreach efforts. Coupled with the Audience Research Analysis, this analysis recommended target locations and audiences for developing topic-specific outreach campaigns (e.g., pet waste and lawn care).
- ***Prince George's County Stormwater Outreach and Engagement Strategies***. COPE developed seven individual campaign strategies: pet waste disposal, increasing the tree canopy, stormwater management and implementation, antilittering, lawn stewardship, household hazardous waste, and residential car care. Each campaign included goals, target audiences, priority locations, key messages, delivery techniques (e.g., events,

materials, trainings, social media, and developing and promoting programs), metrics, potential partnerships, and priority neighborhoods. The campaigns also included slogans and messages on what citizens should be doing (e.g., using fertilizer only if soil tests dictate a need) and not be doing (e.g., spilling fertilizer on driveways). COPE is using these outreach and engagement strategies to plan and implement programs, events, and other efforts to encourage residents to adopt pollutant-reducing behaviors.

- ***Enhancing and Growing Partnerships***. The County's numerous partnerships with groups such as Master Gardeners, CBT, and the University of Maryland EFC continue to be fostered and supported so that outreach efforts piggybacking on the efforts undertaken by those groups can continue to grow. In addition, new partnerships with groups such as landscapers, nursery suppliers, HOAs, and local boy scout or girl scout groups help broaden stormwater outreach and reach citizens who have not been reached in the past.

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

8.3 Public Involvement to Support Implementation Activities

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

- **Learn about County programs that promote tree plantings, cleanup events, and community awareness**. COPE manages numerous programs in which citizens can get involved and promote pollutant-reducing behaviors. Residents can either organize or participate in volunteer efforts by working with their civic associations or schools, or one-on-one with property owners. The public can visit the Community Outreach web page at https://www.princegeorgescountymd.gov/351/Community-Outreach for more information on COPE programs and how to contact the County. See section 4.2 for details about the County's tree planting and landscape revitalization programs. Other volunteer programs included the following:
- **Volunteer Neighborhood Cleanup Program** provides interested communities with technical assistance and materials such as trash bags, gloves, and roll-off containers (depending on availability). The public can visit the website at https://www.princegeorgescountymd.gov/464/Volunteer-Neighborhood-Cleanup-Program.
- **Volunteer Storm Drain Stenciling Program** helps spread the word to prevent water pollution by stenciling/inlet marking the storm drains in neighborhoods with "Don't Dump - Chesapeake Bay Drainage." Stenciling serves as a visual reminder to neighbors that anything dumped in the storm drain contaminates the Chesapeake Bay. COPE provides the supplies and helps design a storm drain stenciling/inlet marking project that can be accomplished with any size team or age group at https://www.princegeorgescountymd.gov/465/Volunteer-Storm-Drain-Stenciling-Program.

- **Apply for grants to implement projects through the Chesapeake Bay Trust (CBT)**, which manages the Rain Check Rebate and Stormwater Stewardship programs as well as the Litter Reduction and Citizen Engagement Mini Grant. See section 4.1 for details on the Rain Check Rebate and Stormwater Stewardship programs. The public can find more information about the CBT grants at https://cbtrust.org/grants/.
- **Litter Reduction and Citizen Engagement Mini Grants** support efforts that engage and educate residents, students, and businesses on ways to make their communities cleaner and greener. Up to $2,500 can be awarded to HOAs and nonprofits to develop and implement projects such as community cleanups, "Adopt-a-Stream" projects to remove litter from a local stream, and storm drain stenciling.
- **Stay informed**. The County provides numerous ways for residents to stay informed about community events, trainings, emergencies, and County news:
- **Monitor the County's social media accounts** to become aware of trainings and community events that promote environmental education and include opportunities to provide feedback to the County. See the County's accounts at Facebook (PGC Department of the Environment), Twitter (PGC Environment @PGCsprout), and Instagram (pgcsprout).
- **Monitor the County's website** to view information about upcoming events, meetings, recent news, and details about the County's programs at https://www.princegeorgescountymd.gov/.
- **Sign up to receive "Alert Prince George's"** to receive emergency alerts, notifications, and updates to registered devices. Example notifications include traffic conditions, government closures, public safety incidents, and severe weather. More information is available at http://www.princegeorgescountymd.gov/794/Alert-Prince-Georges.
    - **View the Clean Water Map,** an interactive tool to help the community stay informed about the health of County waters and know where restoration efforts are taking place. Residents can view BMPs, BMP drainage areas, and locations of activities such as Rain Check Rebates and Stormwater Stewardship Grants at https://princegeorges.maps.arcgis.com/apps/webappviewer/index.html?id=dc168a43d3554905b4e4d6e61799025f.
- **Provide feedback**. The County heard through numerous outreach and engagement events that several citizens and watershed groups want to provide information and feedback about on-the-ground support for BMP implementation projects, programmatic initiatives, and other outreach efforts to support implementation. Ways to provide this feedback include the following:
    - **Attend a public involvement meeting.** The County holds public outreach and involvement meetings as part of restoration planning efforts and other programs. At these meetings, residents can suggest specific locations for biological or water quality monitoring activities to be carried out based on surrounding land uses/ changes, historic water quality problems, or public desires. The County also welcomes suggestions on potential BMP types or locations so that the County can help communities identify and install the best BMPs for specific areas.

  - **Use County Click 3-1-1**, a call center (available weekdays 7 a.m. to 7 p.m.) and a website application (download CountyClick311Mobile) that allows County residents to request services or report problems. This tool could be used to report on visual inspections of installed BMPs and is available at www.countyclick311.com.

- **Help foster partnerships.** Residents and civic and environmental groups can work directly with an organization or commercial business that has a significant amount of untreated impervious surface such as large parking lots or a large building footprint. The groups can help obtain a commitment from the business to participate in the Rain Check Rebate Program or Alternative Compliance Program, or install stormwater BMPs on the property. Group members can offer technical assistance and volunteer labor hours to support installation and/or maintenance. The participating civic or environmental group should discuss the selected location and BMP type with the County prior to working with the property owner. Groups can also work with established organizations such as the Alice Ferguson Foundation https://fergusonfoundation.org/ to participate in cleanup events or provide volunteer hours.
- **Become educated through partner trainings and events**. Numerous organizations in Prince George's County are always in need of volunteers. They also provide meaningful education programs in which participants learn about the issues through hands-on educational experiences. Those organizations include the following:
  - **Watershed Stewards Academy** equips and supports community leaders to recognize and address local pollution problems in their nearby streams and rivers. They provide community leaders with the tools and resources they need to bring solutions to those problems, restoring their local waterways and the communities they affect. More information is available at http://extension.umd.edu/watershed/watershed-stewards-academy.
  - **Alice Ferguson Foundation** has training and outreach events to unite students, educators, park rangers, communities, regional organizations, and government agencies throughout the Washington, DC, metropolitan area to promote the environmental sustainability of the Potomac River watershed. More information is available at https://fergusonfoundation.org/.
  - **Anacostia Watershed Society** has numerous educational programs, river restoration programs, and community events. More information is available at https://www.anacostiaws.org/.

9 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 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 tracking and monitoring data to inform its adaptive management of this restoration plan.

9.1 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 annually to MDE in a georeferenced database. For each BMP, the database provides descriptive details including BMP type, project location, implementation date, implementation purpose (e.g., new development, restoration), drainage area delineation and equivalent acres of impervious surface treated. County staff update the database as new projects are completed and approved.

9.1.1 Bacteria Tracking

MDE is finalizing draft guidance on how to address bacteria WLAs. This guidance is expected to focus on programmatic activities and not require load reduction calculations or tracking. DoE will create a bacteria tracking strategy based on the MDE guidance. This strategy could include potential source tracking (e.g., SSOs as in section 3.5.1) and selective monitoring. In addition, the County is expecting its fifth generation MS4 permit in 2021 that will include a requirement to perform monthly bacteria sampling i*n* watersheds with a bacteria TMDL, including Piscataway Creek watershed, which Tinkers Creek is part of. At the time of this document, it is not known where in the Piscataway Creek watershed samples will be taken.

9.1.2 Biological Monitoring

The purpose of monitoring conditions is to determine the degree to which implementation of the restoration plan results 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.

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.

Biological indicators will continue to be used to document and report ecological conditions throughout the County. 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 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.

The County has been implementing biological monitoring since 1999. 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 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 that could be sampled by wading. The County is currently conducting Round 4 (R4), which started in 2019 and will run till 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 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.

9.2 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, adaptive management allows 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 to ensure successful ongoing implementation.

Close coordination is especially valuable for adaptive management 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 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 Sewer Repair, Replacement and Rehabilitation (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. 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 as a 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.

10 References

DoE (Prince George's County Department of the Environment). 2019. *2019 Annual NPDES MS4 Report*. Prince George's County, Department of the Environment, Largo, MD.

DoE (Prince George's County Department of the Environment). 2020. Prince George's County BMP Database. Prince George's County Department of the Environment, Largo, MD.

Gordian. 2020. RSMeans Historical Cost Indexes for Washington DC. Retrieved November 11, 2020. Gordian, Rockland, MA. https://www.rsmeans.com/products/online.aspx

King, D., and P. Hagan. 2011. *Costs of Stormwater Management Practices in Maryland Counties*. University of Maryland Center for Environmental Science (UMCES) Technical Report Series No. TS-626-11. Prepared for the Maryland Department of the Environment. UMCES, Solomons Island, MD.

M-NCPPC (Maryland-National Capital Park and Planning Commission). 2018. GIS Open Data Portal. Accessed March 28, 2018. http://gisdata.pgplanning.org/opendata/.

MDE (Maryland Department of the Environment). 2000. *2000 Maryland Stormwater Design Manual*. Vol. I & II. Prepared by the Center for Watershed Protection and the Maryland Department of the Environment, Water Management Administration, Baltimore, MD.

MDE (Maryland Department of the Environment). 2009. *2000 Maryland Stormwater Design Manual*. Vol. I & II. Prepared by Center for Watershed Protection, Ellicott City, MD, and the Water Management Administration, Maryland Department of the Environment, Baltimore, MD. Revised May 2009. Accessed August 2014. http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx.

MDE (Maryland Department of the Environment). 2018. Maryland Reported Sewer Overflow Database. Accessed February 23, 2018. https://mde.maryland.gov/programs/water/compliance/pages/reportedseweroverflow.aspx

MDE (Maryland Department of the Environment). 2020a. *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits (June 2020 Draft)*. Maryland Department of the Environment, Baltimore, MD.

MDE (Maryland Department of the Environment). 2020b. Maryland's Searchable Integrated Report Database [Combined 303(d)/305(b) List]. Retrieved March 2019. https://mde.maryland.gov/programs/water/tmdl/integrated303dreports/pages/303d.aspx.

MDE (Maryland Department of the Environment). 2020c. Maryland TMDL Data Center. Retrieved July 2020. https://mde.maryland.gov/programs/water/tmdl/datacenter/pages/index.aspx.

MDE (Maryland Department of the Environment). 2020d. Phase 6 Chesapeake Bay Watershed Model Stormwater WLA Modeling Tool. Dated August 2020.

MDP (Maryland Department of Planning). 2010. Land Use/Land Cover. Accessed March 28, 2018. http://planning.maryland.gov/Pages/OurProducts/DownloadFiles.aspx.

MGS (Maryland Geological Survey). 2014. Maryland Geology. Accessed March 28, 2018. http://www.mgs.md.gov/geology/index.html.

NOAA. 2018. Climate Data Online database. NOAA National Climatic Data Center (NCDC) NOAA National Centers for Environmental Information (NCEI). October 31, 2018. https://www.ncdc.noaa.gov/cdo-web/search?datasetid=NORMAL_MLY

NRCC (Northeast Regional Climate Center). 2014. Monthly average PET (potential evapotranspiration) estimates. Accessed March 28, 2018. http://www.nrcc.cornell.edu/wxstation/pet/pet.html.

NWS (National Weather Service Forecast Office). 2018a. Reagan National Average Monthly Precipitation. Accessed March 28, 2018. https://www.weather.gov/media/lwx/climate/dcaprecip.pdf.

NWS (National Weather Service Forecast Office). 2018b. Washington National Airport Normals, Means and Extremes. Accessed March 28, 2018. https://www.weather.gov/lwx/dcanme.

NWQMC (National Water Quality Monitoring Council). 2018. Water Quality Portal. National Water Quality Monitoring Council. Accessed December 13, 2017. https://www.waterqualitydata.us/

Prince George's County. 2020. FY 2021-2026 *Proposed Capital Improvement Program & Budget—Stormwater Management*. Prince George's County. Office of Management and Budget. Largo, MD. Accessed November 4, 2020. https://www.princegeorgescountymd.gov/DocumentCenter/View/29056/Stormwater-Management.

Schueler, T. 1994. The importance of imperviousness. *Watershed Protection Techniques* 1(3):100–111.SCS (Soil Conservation Service). 1974. United States Department of Agriculture Soil Survey of Charles County, MD. Soil Conservation Service, <city, state>.

SCS (Soil Conservation Service). 1974. United States Department of Agriculture Soil Survey of Charles County, MD. Soil Conservation Service, Washington, DC.

Southerland, M.T., G.M. Rogers, M.J. Kline, R.P. Morgan, D.M. Boward, P.F. Kazyak, R.J. Klauda, and S.A. Stranko. 2007. Improving biological indicators to better assess the ecological condition of streams. *Ecological Indicators* 7:751–767.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. *Transactions of the American Geophysical Union* 38(6):913–920.

Tetra Tech. 2015a. Development of Prince George's County Local TMDL Restoration Plans Using WTM. Prepared for the Department of the Environment, Prince George's County, Tetra Tech, Inc., Fairfax, VA.

Tetra Tech. 2015b. Restoration Plan for the Piscataway Creek Watershed in Prince George's County. Technical Memorandum. Prepared for the Department of the Environment, Prince George's County by Tetra Tech, Inc., Fairfax, VA.

USDA (United States Department of Agriculture). 2003. Soil Survey Geographic (SSURGO) Database for Maryland. United States Department of Agriculture, Natural Resources Conservation Service, Washington, DC. Accessed June 17, 2014. https://websoilsurvey.sc.egov.usda.gov/.

USEPA (U.S. Environmental Protection Agency). 1986. *Ambient Water Quality Criteria for Bacteria—1986*. EPA A440/5-84-002. U.S. Environmental Protection Agency, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 1991. *Guidance for Water Quality-Based Decisions: The TMDL Process*. EPA 440/-4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2000. *Ambient Water Quality Criteria Recommendations Information Supporting the Development of State and Tribal Nutrient Criteria Rivers and Streams in Nutrient Ecoregion IX*. EPA 822-B-00-019. U.S. Environmental Protection Agency, Washington, DC. Accessed July 20, 2020. https://www.epa.gov/sites/production/files/documents/rivers9.pdf.

USEPA (U.S. Environmental Protection Agency). 2014. *Best Management Practices (BMPs) Siting Tool*. U.S. Environmental Protection Agency, Washington, DC. Accessed July 13, 2018. https://www.epa.gov/water-research/best-management-practices-bmps-siting-tool

USEPA (U.S. Environmental Protection Agency). 2015. *The Importance of Clean Air to Clean Water in the Chesapeake Bay*. U.S. Environmental Protection Agency, Washington, DC. Accessed May 13, 2018. https://www.epa.gov/sites/production/files/2015-06/documents/cb_airwater_fact_sheet_jan2015.pdf.

USEPA (U.S. Environmental Protection Agency). 2016. *What Climate Change Means for Maryland.* EPA 430-F-16-022. U.S. Environmental Protection Agency Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2018. *Improving the Resilience of Best Management Practices in a Changing Environment: Urban Stormwater Modeling Studies.* EPA/600/R-17/469F. National Center for Environmental Assessment Office of Research and Development U.S. Environmental Protection Agency Washington, DC.

Appendix A: BMP Types

Enhanced Filter (M-9)

Major benefits:

- It can be designed to achieve higher run off reduction.
- It can accommodate bigger drainage area than other micro-scale practices

Constraints/Setbacks/Limitations:

- It requires underdrain.
- Desired slopes of less than 5%.
- Desired minimum BMP surface area to drainage area is 2%.

Micro Bioretention (M-6)

Major benefits:

Constraints/Setbacks/Limitations:

- Maximum allowed drainage area is 20,000 sq ft.
- Desired slopes of less than 5%.
- Desired minimum BMP surface area to drainage area is 2%.

Bio-Swale (M-8)

Major benefits:

- It can accommodate drainage area up to one acre.

Constraints/Setbacks/Limitations:

- It requires underdrain.
- Desired channel slopes of less than 4%.
- Required to safely convey 10-year storm.
- No detention is allowed.

Rain Garden (M-7)

Major benefits:

Constraints/Setbacks/Limitations:

- Desired slopes of less than 5%.
- Maximum allowed drainage area is 2,000 sq ft.

Bioretention (F-6)

Major benefits:

- It can be designed to achieve higher run off reduction.
- It can accommodate bigger drainage area up to 10 acres

Constraints/Setbacks/Limitations:

- It requires underdrain, overflow required for 10-year storm.
- It requires pre-treatment.
- If designed with enhanced features, it requires 25’ dedicated buffer.

Infiltration Trench (I-1)

Major benefits:

- It can be designed to achieve higher run off reduction.
- It can accommodate bigger drainage area up to 5 acres.

Constraints/Setbacks/Limitations:

- Overflow required for 10-year storm.
- It requires pre-treatment.
- If designed with enhanced features, it requires 25’ dedicated buffer.

Permeable pavement (A-2)

Major benefits:

Constraints/Setbacks/Limitations:

- Maximum allowed drainage area is 10,000 sq ft.
- Desired slopes of less than 5%.
- Detention not allowed.