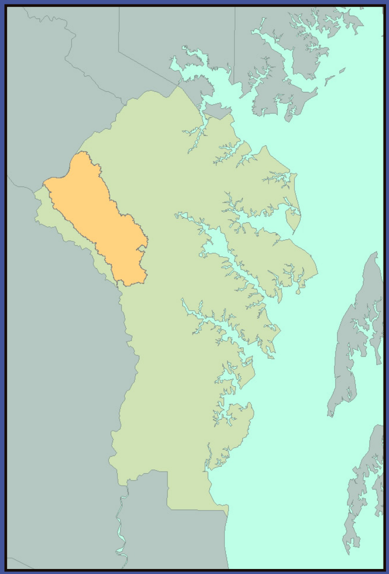
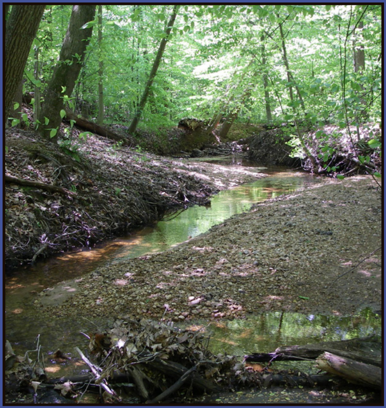


Little Patuxent River
Sediment TMDL Restoration Plan

Anne Arundel County, Maryland
February 2015

Anne Arundel County WATERSHED Protection & Restoration PROGRAM



Little Patuxent River
Sediment TMDL Restoration Plan

February 2015

Prepared for:

Anne Arundel County
Department of Public Works
Watershed Protection and Restoration Program
2662 Riva Road, P.O. Box 6675
Annapolis, Maryland 21401

Prepared by:

KCI Technologies, Inc.
936 Ridgebrook Road
Sparks, Maryland 21152

Table of Contents

List of Tables

List of Figures

List of Acronyms

AAWSA	Anne Arundel Watershed Stewards Academy
BMP	Best Management Practices
BSID	Biological Stressor Identification
CBP	Chesapeake Bay Program
CIP	Capital Improvement Program
EOS	Edge of Stream
H&H	Hydrologic and Hydraulic
LULC	Land use / Land cover
MAST	Maryland Assessment Scenario Tool
MDE	Maryland Department of the Environment
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
OSDS	On-site Disposal Systems
SPSC	Step Pool Storm Conveyance
SW to MEP	Stormwater to the Maximum Extent Practicable
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
WIP	Watershed Implementation Plan
WPRP	Watershed Protection and Restoration and Program

1 Introduction

1.1 Background and Purpose

The Anne Arundel County Department of Public Works (DPW) Watershed Protection and Restoration Program (WPRP) is developing restoration plans to address local water quality impairments for which a Total Maximum Daily Load (TMDL) has been established by the Maryland Department of the Environment (MDE) and approved by the U.S. Environmental Protection Agency (EPA). A TMDL establishes a maximum load of a specific single pollutant or stressor that a waterbody can assimilate and still meet water quality standards for its designated use class.

Under the Federal Clean Water Act (CWA), the State of Maryland is required to assess and report on the quality of waters throughout the state. Where Maryland’s water quality standards are not fully met, Section 303(d) requires the state to list these water bodies as impaired waters. States are then required to develop a TMDL for pollutants of concern for the listed impaired waters. The Little Patuxent River watershed has several impaired waters listings in Maryland’s Integrated Report of Surface Water Quality [303(d) list and 305(b) Report] including nutrients, sediment, heavy metals, *Escherichia coli*, and polychlorinated biphenyls (PCBs). There are currently three final approved TMDLs within the Little Patuxent; a total suspended solids (TSS; sediment) TMDL from urban stormwater sources approved in 1996, a sedimentation/siltation TMDL from agricultural sources approved in 1998, and a phosphorus TMDL from agricultural sources approved in 1998. These TMDLs apply to several jurisdictions including Howard, Prince Georges, and Anne Arundel Counties. This plan will specifically address the Little Patuxent sediment TMDL under the responsibility of Anne Arundel County. The sedimentation/siltation and phosphorus TMDLs are being addressed by Anne Arundel County in separate plans.

Responsibility for Little Patuxent sediment reduction is divided among the contributing jurisdictions, listed above. The TMDL loading targets, or allocations, are also divided among the pollution source categories, which in this case includes non-point sources (termed load allocation or LA) and point sources (termed waste load allocation or WLA). The WLA consists of loads attributable to regulated process water or wastewater treatment, and to regulated stormwater. For the purposes of the TMDL and consistent with implementation of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Discharge Permit (MS4), stormwater runoff from MS4 areas is considered a point source contribution.

Anne Arundel County’s current MS4 permit (11-DP-3316, MD0068306) issued in its final form by the MDE in February of 2014 requires development of restoration plans for each stormwater WLA approved by EPA prior to the effective date of the permit (permit section IV.E.2.b). This plan satisfies this permit requirement and provides the loading target, recommended management measures, load reduction estimates, schedule, milestones, cost estimates and funding sources, and the tracking and monitoring approaches to meet the stormwater WLA (SW-WLA).

It is noted that TMDL restoration plans are an important first step. The MS4 permit calls for an iterative and adaptive plan for implementation. If new methods of stormwater treatment are identified, or better approaches to source control are found, the plans can be extended and updated to take the changes into account. Similarly, if some elements of the plans are not as successful as expected, adaptations and improvements will be incorporated in future updates.

This plan demonstrates that Anne Arundel County will meet its sediment SW-WLA for the Little Patuxent River Watershed by 2025. The strategies proposed will provide treatment to reduce current sediment loads while also accounting for expected additional loads due to growth in the urban stormwater sector.

1.2 TMDL Allocated and Planned Loads Summary

The following Restoration Plan only addresses loads allocated to Anne Arundel County NPDES regulated stormwater point source sediment. Additional SW-WLAs for the Little Patuxent watershed TMDL assigned to Howard County, Maryland State Highway Administration, and other NPDES regulated stormwater are not the responsibility of Anne Arundel County and will not be addressed in this plan. A large section of Fort George G. Meade, a federal property owned by the U.S. Army, is located in the central portion of the watershed. Pollutant loads from Fort Meade are the responsibility of the federal government and are not addressed in this plan.

The Little Patuxent watershed TMDL requires a 20.5% reduction of sediment loads from 2005 baseline levels to achieve the target SW-WLA for Anne Arundel County NPDES regulated stormwater. A planning horizon of 2025 will be used as the date to achieve these load reductions with a proposed 2017 interim milestone.

This section of the plan, including Table 1, provides a concise summary of the loads and reductions at important timeline intervals including the 2005 baseline, 2013 progress, 2017 milestone and 2025 final planning intervals. These terms and dates are used throughout the plan and explained in more detail in the following sections. They are presented here to assist the reader in understanding the definitions of each, how they were derived, and to provide an overall summary demonstrating the percent reduction required and percent reduction achieved through full implementation of this plan. Sediment loads and wasteload allocations are presented as tons/year in the local TMDL but will be discussed as lbs/year in this restoration plan.

- **2005 Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from 2005 conditions in the Little Patuxent watershed using the Maryland Assessment Scenario Tool (MAST) Chesapeake Bay Program Phase 5.3.2 (CBP P5.3.2) model. Baseline loads were used to calculate the stormwater allocated sediment loads, or SW-WLA.
- **2013 Progress Loads and Reductions**: Progress loads and load reductions achieved from stormwater best management practice (BMP) implementation through 2013.
- **2017 Interim Milestone Goal Loads and Planned Loads and Reductions**: 2017 Interim Milestone loads were calculated by subtracting 60% of the absolute reduction goal from 2005 baseline loads. Planned 2017 loads and reductions will result from implementation of strategies through 2017.
- **2025 Allocated Load**: Allocated loads are calculated from the 2005 baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: 2005 Baseline – (2005 Baseline x 0.222); or, 2005 Baseline x (1 – 0.222)
- **2025 Planned Loads and Planned Reductions**: Loads and reductions that will result from implementation of this plan.

Table 1: Little Patuxent Local TMDL Allocated and Planned Loads

	Sediment (tons/year)	Sediment (lbs/year)
2005 Baseline Loads	638	1,275,211
2013 Progress Loads	600	1,200,569
2013 Progress Reductions	37	74,642
2017 Interim Milestone Loads	559	1,118,360
2017 Planned Loads*	572	1,144,851
2017 Planned Reductions	65	130,359
2025 TMDL Allocated Loads	507	1,013,792
2025 Planned Loads*	506	1,011,161
2025 Planned Reductions	132	264,049
Required Percent Reduction	20.5%	20.5%
Planned Percent Reduction Achieved	20.7%	20.7%

*2017 and 2025 planned loads include additional projected land use loading from new development through 2025. It is assumed that all new development will be treated with SW to the MEP implementation to achieve 90% sediment removal.

1.3 Restoration Plan Elements and Structure

This plan is developed within in the context of on-going watershed management planning, restoration, and resource protection being conducted by Anne Arundel County. The County initiated comprehensive watershed assessment and management plans in 2000 and has currently completed plans for seven of the 12 major watersheds. A draft comprehensive watershed assessment for the Little Patuxent watershed is currently underway with expected completion at the beginning of 2015. The County also prepared a Phase II Watershed Implementation Plan (WIP) in 2012 in response to requirements set forth in the Chesapeake Bay TMDL for nitrogen, phosphorus and sediment. Information synthesized and incorporated into this plan for the Little Patuxent watershed draws upon these sources with updates and additions where necessary to meet the specific goals of the SW-WLA. The TMDL analyses and reports developed by MDE are also referenced. These primary sources include:

- Little Patuxent River Watershed Assessment Comprehensive Summary Report (Anne Arundel County, 2014 DRAFT)
- Chesapeake Bay TMDL, Phase II Watershed Implementation Plan, Final (Anne Arundel County, 2012)
- Total Maximum Daily Load of Sediment in the Little Patuxent River Watershed, Howard and Anne Arundel Counties, Maryland (MDE, 2011a)

MDE has prepared several guidance documents to assist municipalities with preparation of TMDL restoration plans. This plan is developed following the guidance detailed in the following documents with modifications as necessary:

- General Guidance for Developing a Stormwater Wasteload Allocation (SW-WLA) Implementation Plan (MDE, May 2014)

- Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs (MDE, June 2014)
- Guidance for Developing Stormwater Wasteload Allocation Implementation Plans for Nutrient and Sediment Total Maximum Daily Loads (MDE, November 2014)
- Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (MDE, August 2014)

The Little Patuxent plan has been prepared in accordance with the EPA's nine essential elements for watershed planning. These elements, commonly called the 'a through i criteria' are important for the creation of thorough, robust, and meaningful watershed plans and incorporation of these elements is of particular importance when seeking implementation funding. The EPA has clearly stated that to ensure that Section 319 (the EPA Nonpoint Source Management Program) funded projects make progress towards restoring waters impaired by nonpoint source pollution, watershed-based plans that are developed or implemented with Section 319 funds to address 303(d)-listed waters must include at least the nine elements.

The Little Patuxent watershed restoration plan is organized based on these elements. A modification to the order has been incorporated such that element c., a description of the management measures, is included before element b., the expected load reductions. We feel this modified approach is easier to follow. The letters (a. through i.) are included in the headers of the plan's major sections to indicate to the reader the elements included in that section. The planning elements are:

a. An identification of the causes and sources that will need to be controlled to achieve the load reductions estimated in the plan and to achieve any other watershed goals identified in the plan, as discussed in item (b) immediately below. (Section 3)

b. An estimate of the load reductions expected for the management measures described under paragraph (c) below, recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time. (Section 5)

c. A description of the management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above as well as to achieve other watershed goals identified in the plan, and an identification of the critical areas in which those measures will be needed to implement this plan. (Section 4)

d. An estimate of the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. (Section 6)

e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the recommended management measures. (Section 7)

f. A schedule for implementing the management measures identified in this plan that is reasonably expeditious. (Section 8)

g. A description of interim, measurable milestones for determining whether management measures or other control actions are being implemented. (Section 8)

h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised. (Section 9)

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above. (Section 10)

The outcomes of the planning effort are to provide guidance for the strategic implementation of watershed protection and restoration efforts that will advance progress toward meeting Anne Arundel County's local TMDLs pollutant loading allocations, and ultimately meeting water quality standards. Successful implementation of the plan will lead to improvements in local watershed conditions and aquatic health.

2 Watershed Characteristics

2.1 Watershed Delineation

The Little Patuxent is one of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the western portion of the County (Figure 1). The watershed shares political boundaries with Howard County. The Little Patuxent watershed is a part of the Chesapeake Bay watershed with the Little Patuxent mainstem joining the Patuxent River just southeast of the Patuxent Research Refuge before discharging to the tidal portions of the Patuxent River in Calvert County before entering the Chesapeake Bay.

2.2 Little Patuxent River

The Little Patuxent watershed is approximately 27,752 acres (43.4 square miles) in area and contains approximately 1,200 total miles of stream reaches. The watershed includes several named streams including Dorsey Run, Midway Branch, Towsers Branch, and the mainstem of the Little Patuxent River. These named streams are distributed among 21 subwatersheds, as shown below in Table 2 and on Figure 2. These subwatersheds were used as planning units for the watershed assessment and management plan completed for this watershed by the County in 2014 (Draft). Although the average subwatershed size is 1,321 acres, the subwatersheds range in size from 485 in LPH to 2,646 in LPI. The channel length in each subwatershed also varies similarly.

Communities within the Little Patuxent include Gambrills and Crofton. A large section of Fort George G. Meade, a U.S. Army owned installation, and approximately half of the Patuxent Research Refuge North, a federal property owned and operated by the Fish and Wildlife Service of the U.S. Department of Interior, are located in the central portion of the watershed (Figure 2).

Table 2: Little Patuxent River Watershed Drainage Area and Stream Miles

Subwatershed Code	Subwatershed Name	Drainage Area (Acres)	Drainage Area (Square Miles)	Stream Miles
LP0	Little Patuxent 2	670	1.0	6.3
LP1	Dorsey Run 1	621	1.0	6.0
LP2	Dorsey Run 3	876	1.4	8.7
LP3	Towsers Branch 1	1,334	2.1	6.1
LP4	Rogue Harbor 1	1,902	3.0	11.3
LP5	Little Patuxent 1	1,158	1.8	8.7
LP6	Towsers Branch 2	1,013	1.6	2.4
LP7	Little Patuxent 5	1,701	2.7	10.2

Subwatershed Code	Subwatershed Name	Drainage Area (Acres)	Drainage Area (Square Miles)	Stream Miles
LP8	Little Patuxent 4	1,096	1.7	8.2
LP9	Rogue Harbor 2	2,287	3.6	12.1
LPA	Oak Hill	1,031	1.6	7.9
LPB	Dorsey Run 6	1,732	2.7	12.8
LPC	Towsers Branch 3	1,954	3.1	8.3
LPD	Dorsey Run 4	1,592	2.5	10.0
LPE	Piney Orchard	932	1.5	7.0
LPF	Little Patuxent 6	1,503	2.3	13.4
LPG	Crofton Golf	1,690	2.6	10.0
LPH	Little Patuxent 3	485	0.8	3.7
LPI	Dorsey Run 5	2,660	4.2	153.0
LPJ	Dorsey Run 2	919	1.4	299.6
LPK	Jessup	594	0.9	593.3
Little Patuxent River Total		**27,752**	**43.4**	**1,198.8**

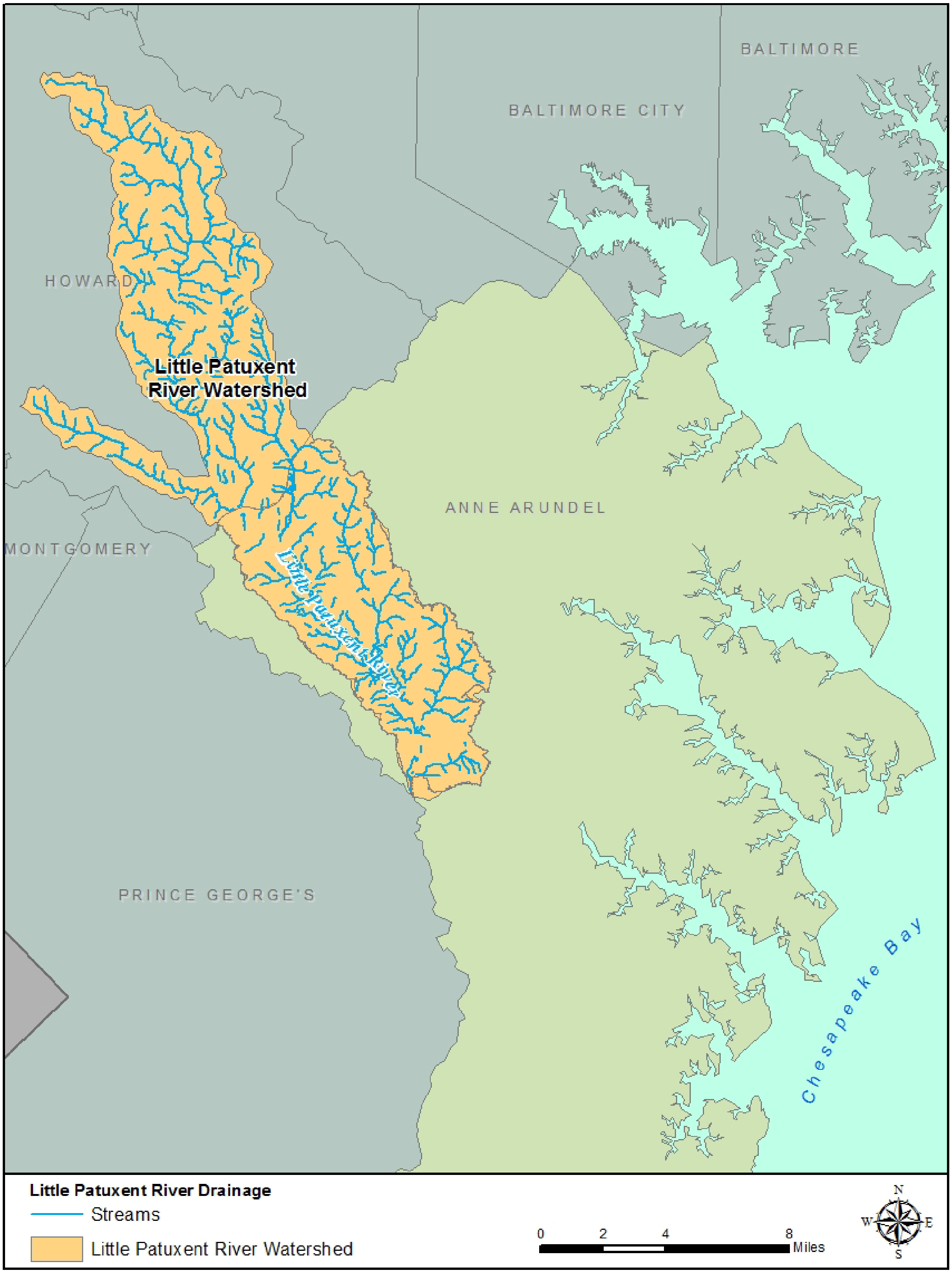
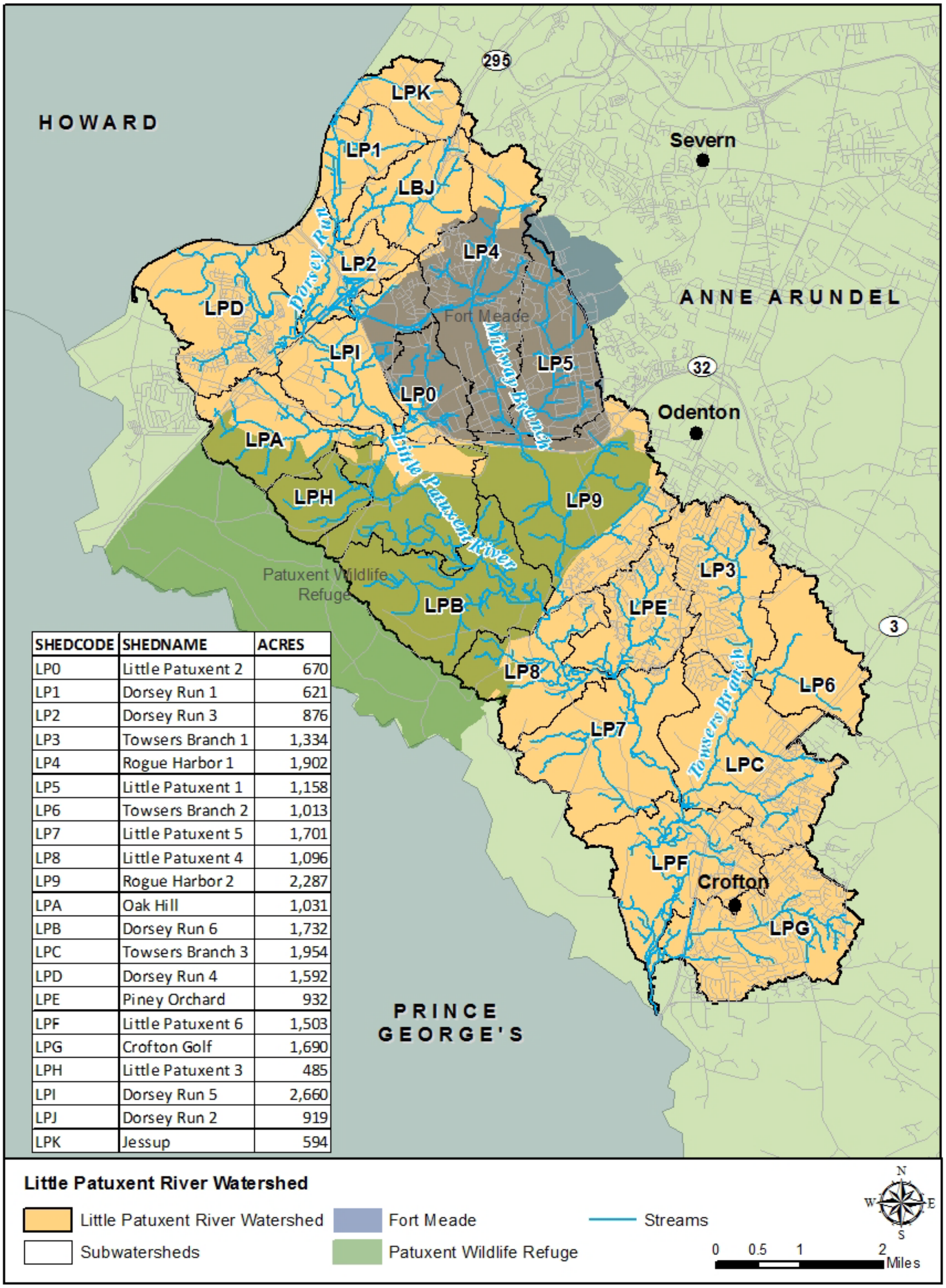


Figure 1: Little Patuxent River Watershed



SHEDCODE	SHEDNAME	ACRES
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1,334
LP4	Rogue Harbor 1	1,902
LP5	Little Patuxent 1	1,158
LP6	Towsers Branch 2	1,013
LP7	Little Patuxent 5	1,701
LP8	Little Patuxent 4	1,096
LP9	Rogue Harbor 2	2,287
LPA	Oak Hill	1,031
LPB	Dorsey Run 6	1,732
LPC	Towsers Branch 3	1,954
LPD	Dorsey Run 4	1,592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1,503
LPG	Crofton Golf	1,690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2,660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Figure 2: Little Patuxent River Subwatershed Location

2.3 Land Use/Land Cover

The type and density of various land uses can have a dramatic effect on water quality and stream habitat. Forested areas slow stormwater flow and allow water to gradually seep into soils and drain into streams. Vegetation and soils bind nutrients and pollutants found within stormwater—improving water quality as it infiltrates the ground. Developed areas, with a high percentage of impervious surfaces (buildings, paved roads, parking lots, etc.), do not reduce either the volume or flow of stormwater—increasing the amount of pollutants entering streams. Increased stormflow affects stream habitat negatively by increasing bank erosion and decreasing instream and riparian habitat. Agricultural land, if managed incorrectly, can also impair streams with increases nutrients and bacteria.

See Figure 3 for aerial imagery of the Little Patuxent River watershed. Land use / land cover (LULC) data from the Anne Arundel County Office of Information Technology (2011) is presented in Figure 4. Data presented in the figures below were used to characterize the watershed and show potential pollution sources. These LULC data were not used in the calculations of loads and load reduction, which were based instead on the land-river segment scale from the Chesapeake Bay Program Partnership Watershed Model.

2.3.1 Existing Land Use/Land Cover

According to 2011 LULC data (Table 3), the largest category in the Little Patuxent is forested land, or woods (45.9%) followed by open space (11.8%). Developed land accounts for 36.6% of the watershed and largely consists of residential (1/8 acre 10.2%, 1/4 acre 6.2%), and commercial (8.4%). Residential areas as a total make up 19.6% of the watershed.

Table 3: 2011 Land Use / Land Cover

Land Use / Land Cover	Acres	Percent of Watershed
Airport	66	0.2%
Commercial	2,323	8.4%
Forested Wetland	52	0.2%
Industrial	756	2.7%
Open Space	3,274	11.8%
Open Wetland	100	0.4%
Pasture/Hay	454	1.6%
Residential 1/2-acre	154	0.6%
Residential 1/4-acre	1,723	6.2%
Residential 1/8-acre	2,836	10.2%
Residential 1-acre	169	0.6%
Residential 2-acre	568	2.0%
Row Crops	471	1.7%
Transportation	1,179	4.2%
Utility	384	1.4%
Water	503	1.8%
Woods	12,740	45.9%
Total	**27,752**	**100.0%**

2.3.2 Impervious Surfaces

Impervious surfaces concentrate stormwater runoff, accelerating flow rates and directing stormwater to the receiving stream. This accelerated, concentrated runoff can cause stream erosion and habitat degradation. Runoff from impervious surfaces picks up and washes off pollutants and is usually more polluted than runoff generated from pervious areas. In general, undeveloped watersheds with small amounts of impervious cover are more likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover. Impervious cover is a primary factor when determining pollutant characteristics and loadings in stormwater runoff.

The degree of imperviousness in a watershed also affects aquatic life. There is a strong relationship between watershed impervious cover and the decline of a suite of stream indicators. As imperviousness increases the potential stream quality decreases with most research suggesting that stream quality begins to decline at or around 10 percent imperviousness (Schueler, 1994; CWP, 2003). However, there is considerable variability in the response of stream indicators to impervious cover observed from 5 to 20 percent imperviousness due to historical effects, watershed management, riparian width and vegetative protection, co-occurrence of stressors, and natural biological variation. Because of this variability, one cannot conclude that streams draining low impervious cover will automatically have good habitat conditions and a high quality aquatic life.

Impervious surfaces make up 15.7% of the overall Little Patuxent drainage (Table 4; impervious surfaces data obtained from Anne Arundel County Office of Information Technology - 2011). Impervious surface is highest in areas surrounding Odenton and Crofton.

Table 4: Little Patuxent River Watershed Percent Impervious Cover

Subwatershed Code	Subwatershed Name	% Impervious Cover
LP0	Little Patuxent 2	31.5%
LP1	Dorsey Run 1	14.2%
LP2	Dorsey Run 3	20.5%
LP3	Towsers Branch 1	21.3%
LP4	Rogue Harbor 1	21.0%
LP5	Little Patuxent 1	24.5%
LP6	Towsers Branch 2	12.4%
LP7	Little Patuxent 5	4.6%
LP8	Little Patuxent 4	4.8%
LP9	Rogue Harbor 2	14.3%
LPA	Oak Hill	6.7%
LPB	Dorsey Run 6	0.4%
LPC	Towsers Branch 3	22.6%
LPD	Dorsey Run 4	21.6%
LPE	Piney Orchard	22.5%
LPF	Little Patuxent 6	18.3%
LPG	Crofton Golf	26.5%
LPH	Little Patuxent 3	0.1%

Subwatershed Code	Subwatershed Name	% Impervious Cover
LPI	Dorsey Run 5	12.4%
LPJ	Dorsey Run 2	12.1%
LPK	Jessup	14.0%
Little Patuxent River Total		**15.7%**

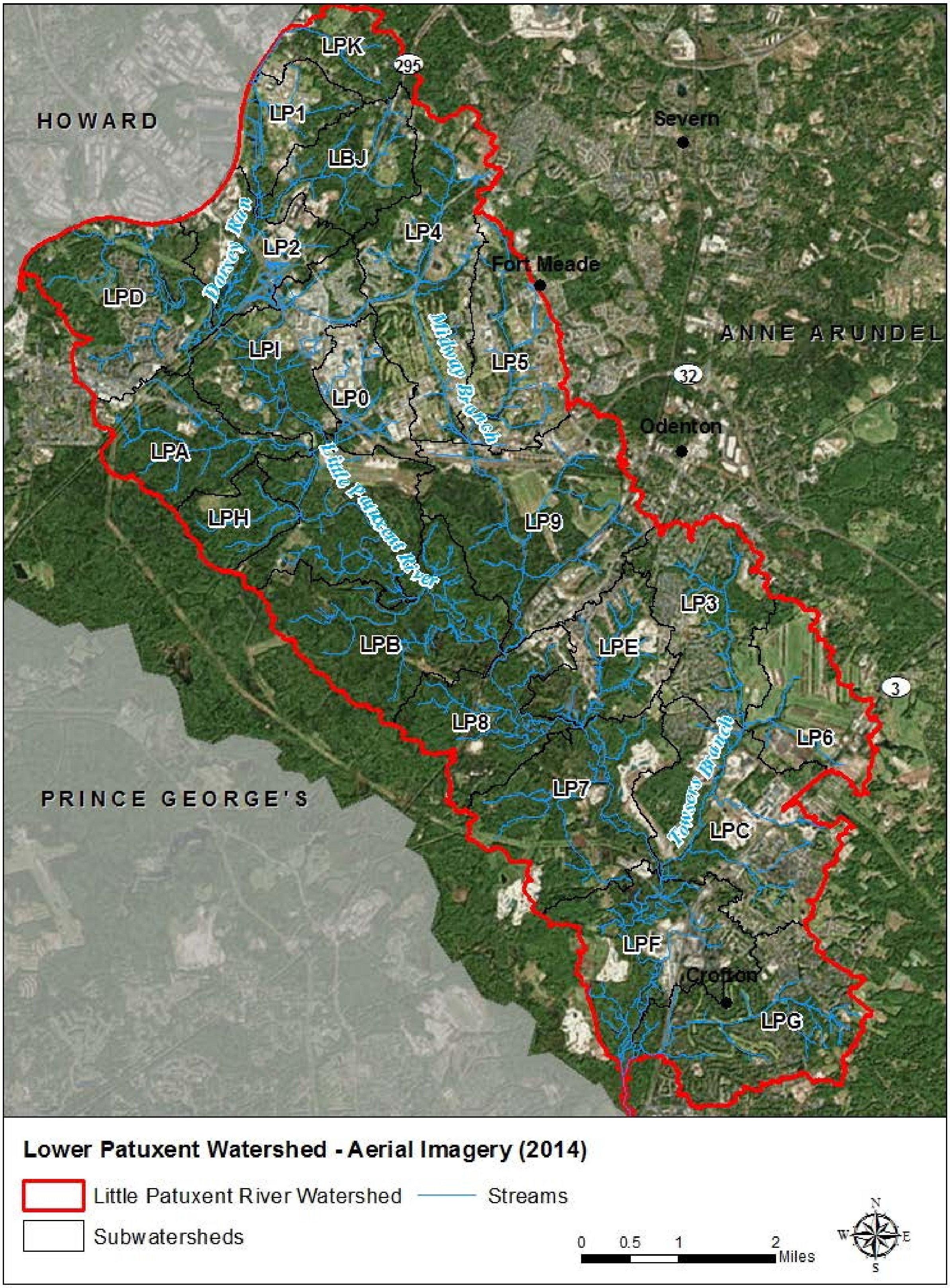


Figure 3: Little Patuxent River Watershed Aerial Imagery (2014)

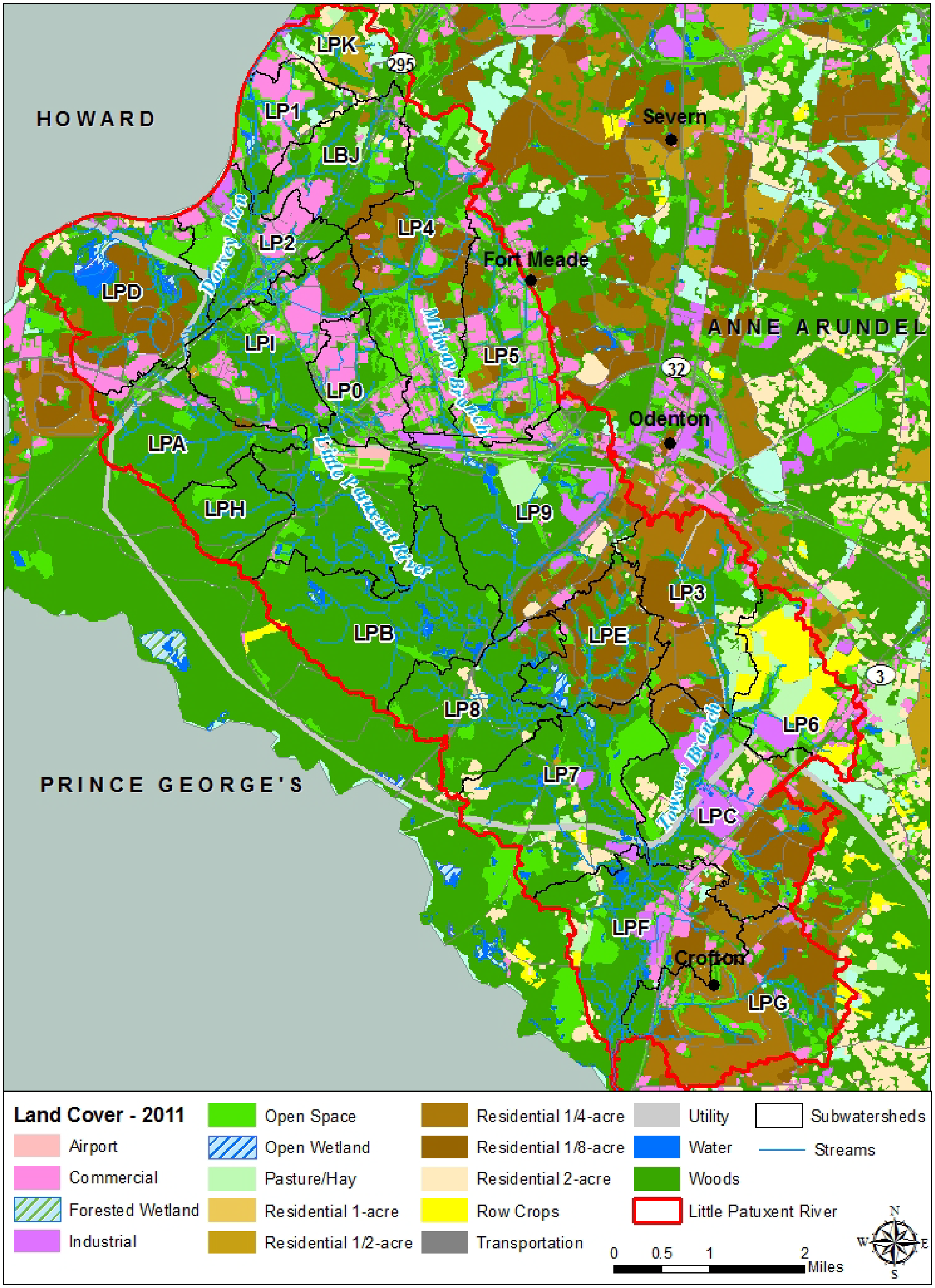


Figure 4: Little Patuxent River Watershed Land Cover (2011)

2.4 Water Quality

2.4.1 Use Designations

According to water quality standards established by MDE in the Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality, Little Patuxent is classified as Use I waters which are designated to support water contact recreation, and protection of non-tidal warmwater aquatic life. Designations include recreation; industrial and agricultural water supply; and fish, aquatic life, and wildlife (Table 5).

Table 5: Use Designations of the Little Patuxent River

Designated Uses	Little Patuxent
Growth and propagation of fish (not trout), other aquatic life and wildlife	X
Water contact sports	X
Leisure activities involving direct contact with surface water	X
Fishing	X
Agricultural water supply	X
Industrial water supply	X
Propagation and harvesting of shellfish	-
Seasonal migratory fish spawning and nursery use	-
Seasonal shallow-water submerged aquatic vegetation use	-
Open-water fish and shellfish use	-
Seasonal deep-water fish and shellfish use	-
Seasonal deep-channel refuge use	-
Growth and propagation of trout	-
Capable of supporting adult trout for a put and take fishery	-
Public water supply	-

Source: http://www.mde.state.md.us/programs/Water/TMDL/Water%20Quality%20Standards/Pages/programs/ waterprograms/ tmdl/wqstandards/wqs_designated_uses.aspx

2.4.2 303(d) Impairments

According to Maryland's final 2012 and draft 2014 303(d) list of impaired waters (MDE, 2012a; MDE, 2014a), several segments within the Little Patuxent watershed are listed for water quality impairments. The Little Patuxent watershed contains three Category 4a stream segments which include those waters that are not meeting their use designation but for which a TMDL has been developed to address the impairments. Category 4a waters include the entire watershed listed for sediment from urban runoff sources and two listings from agricultural sources for Centennial Lake in Howard County, one for sedimentation/siltation and another for phosphorus. Category 5 waters for the Little Patuxent watershed, which include those waters that are not meeting their use designation and require a TMDL, include the entire watershed for chlorides.

2.4.3 TMDLs

Total Maximum Daily Loads (TMDLs) are established for waterbodies on Maryland's 303(d) integrated list of impaired waterbodies to set pollutant limits to achieve attainment of the designated use. For each combination of waterbody and pollutant, the State must estimate the maximum allowable pollutant load, or TMDL, that the waterbody can receive and still meet water quality standards. TMDLs are required by Clean Water Act.

Category 4a of the 303(d) list describes impaired waters with a TMDL or other reduction measure in place. Category 5 lists impaired waters in need of a TMDL. One listing for chlorides in the Little Patuxent is currently in need of a TMDL.

The Little Patuxent currently has three final TMDLs completed - one for sediment from urban runoff sources (approved 2011), a second for sediment from agricultural sources (approved 2002), and a third for phosphorus from agricultural sources (approved 2002). This Restoration Plan focuses on implementing strategies to address the sediment TMDL which requires a 20.5% reduction of Anne Arundel County NPDES regulated stormwater point source sediment.

In addition to local TMDLs in the Little Patuxent, the County must also meet WLAs allocated from the *Chesapeake Bay Total Maximum Daily Loads for Nitrogen, Phosphorus, and Sediment* (USEPA, 2010). The Bay TMDL is a result of requirements under the CWA to meet water quality standards and executive order 13508 signed by President Barack Obama in 2009 that put a renewed emphasis and focus on the Chesapeake Bay. The local sediment TMDL for the Little Patuxent is more geographically specific than the Bay-wide allocated loads assigned in the Bay TMDL. However, all load reductions achieved from implementation efforts described in this plan will help support the County's Bay TMDL goals.

2.4.4 NPDES

Section 402(p) of the Clean Water Act required the EPA to add Municipal Separate Storm Sewer System (MS4) discharges to the NPDES permit program. In 2002, EPA directed permit writers to include WLA requirements in NPDES permits, including those for MS4 discharges. Anne Arundel County holds a Phase I – Large Jurisdiction (greater than 250,000 population) MS4 permit (11-DP-3316, MD0068306) issued by the MDE. The County's first generation permit was issued in 1993. The current fourth generation permit was issued in February of 2014.

TMDL Permit Requirements

The objective of this plan is to meet the County's MS4 NPDES permit requirement to develop restoration plans for local TMDLs per permit condition IV.E.2.b. Plans must be developed within the first year of permit issuance. Anne Arundel County's final permit was issued on February 12, 2014 therefore the restoration plans must be complete by February 11, 2015.

The permit states the County must submit "…a restoration plan for each stormwater Waste Load Allocation (WLA) approved by EPA prior to the effective date of the permit." For each WLA, the County is required to:

PART IV. Standard Permit Conditions
E. Restoration Plans and Total Maximum Daily Loads
2. Restoration Plans

b. Within one year of permit issuance, Anne Arundel County shall submit to MDE for approval a restoration plan for each stormwater WLA approved by EPA prior to the effective date of the permit. The County shall submit restoration plans for subsequent TMDL WLAs within one year of EPA approval. Upon approval by MDE, these restoration plans will be enforceable under this permit. As part of the restoration plans, Anne Arundel County shall:

    i. Include the final date for meeting applicable WLAs and a detailed schedule for implementing all structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs;

ii. Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;

iii. Evaluate and track the implementation of restoration plans through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs; and

iv. Develop an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the County's watershed assessments.

Further, the permit requires continual outreach to the public regarding the development of its watershed assessments and restoration plans and requires public participation in the TMDL process (permit section IV.E.3.a-d).

The permit requires an annual progress report presenting the assessment of the NPDES stormwater program based on the fiscal year. A TMDL assessment report to include complete descriptions of the analytical methodology used to evaluate the effectiveness of the County’s restoration plans and how these plans are working to achieve compliance with EPA approved TMDLs is a component of the annual report. The assessment will include: estimated net change in pollutant load reductions from water quality improvement projects; a comparison of the net change to targets, deadlines, and applicable WLAs; cost data for completed projects; cost estimates for planned projects; and a description of a plan for implementing additional actions if targets, deadlines, and WLAs are not being met (permit section IV.E.4.a-e).

Impervious Surface Permit Requirements

The County’s permit requires implementation of restoration efforts for 20% of the County’s impervious surface area that has not already been restored to the maximum extent practicable (MEP) (permit section (IV.E.2.a). Though projects and strategies outlined in this plan will certainly add treatment of impervious surfaces, accounting for impervious treatment is not included in this report.

3 Causes and Sources of Impairment (a)

3.1 Impairments

Elevated levels of sediment currently impair the Little Patuxent watershed as evident through the 303(d) listings and local TMDL requirement. Sediment, both from upland and in-stream sources, can impact in-stream habitat by covering and filling gravelly and rocky substrate, which is a preferred substrate habitat for some aquatic organisms (fish and benthic community) and necessary for some fish species for spawning. Finer clays, silts and sands associated with sediment as a pollutant are more mobile and transient and provide less liveable space for more sensitive benthic macroinvertebrate species by filling the interstitial spaces between larger substrate particles in the channel bottom. Increases in sediment loads in channels that cannot adequately transport the load can lead to deposition and aggrading streams. These factors often negatively impact channel flow, causing additional erosion and increases in flooding, particularly if road crossing capacity is limited by sediment accumulation. Suspended sediment in the water column may limit light penetration and prohibit healthy propagation of algae and submerged aquatic vegetation. Suspended sediments can cause gill abrasion in fish and can limit clarity which impacts aquatic species that rely on sight for feeding.

3.2 Sources

The majority of sediment loads in the Little Patuxent originate from urban stormwater runoff from development and in-stream sources related to channel erosion.

3.2.1 Urban Stormwater Runoff

The contribution of urban stormwater to sediment loading was analyzed in the Little Patuxent Watershed Assessment (Anne Arundel County, 2014 Draft). Figure 5 presents the annual total suspended solids runoff load as the relative quantity of sediment contributed from each subwatershed (i.e., lowest to highest). The water quality model used for the assessment was based on EPA's Simple Method (Schueler, 1987) and PLOAD models (EPA, 2001) using event mean concentrations (EMCs) for each LULC type. The results presented here are only the sediment associated with runoff, and do not reflect in-stream sources. The most significant contributing LULC categories related to urban stormwater in terms of loading rates include airport, transportation, and commercial and industrial areas. Residential development, while a lower loading rate, makes up a large portion of the watershed (19.6%) and is therefore also a significant contributor.

Subwatersheds contributing the lowest amount of existing sediment loads include LP8, LPA, LPB, LPH, and LPK. Subwatersheds contributing the highest amount of existing sediment loads include LP4, LP6, LP9, LPG, and LPI and to a lesser extent, subwatersheds LP3, LPC, LPD, and LPF. Management measures targeted in subwatersheds with high existing sediment loads will be the priority of this restoration plan to ensure required reductions are achieved and maintained.

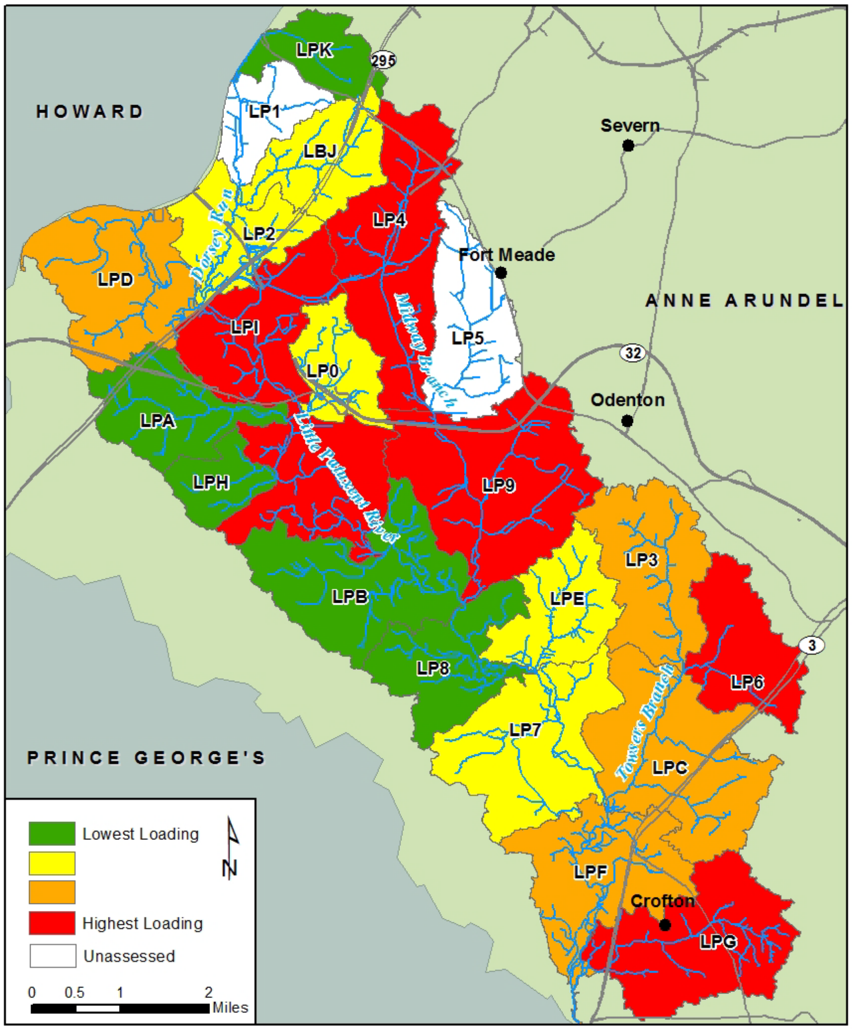


Figure 5: Total Suspended Solids Load from Runoff Based on Existing Conditions - Includes BMP Reductions (Anne Arundel County, 2014 Draft)

3.2.2 In-stream Sources

Although channel bed and bank erosion occurs naturally as streams work to maintain a state of dynamic equilibrium, excessive erosion can occur due to increased stream velocities associated with development activities that increase imperviousness within the watershed. Channel erosion can deliver excessive pollutants, such as sediment and phosphorus, downstream, where water quality can be impacted and important habitat for fish spawning and benthic invertebrates can be smothered. Excessive erosion can also threaten the stability of other nearby built infrastructure. The Biological Stressor Identification Analysis (BSID; MDE, 2011b) for the Little Patuxent has determined that biological communities in this watershed are likely degraded due to flow/sediment related stressors. These stressors often result from altered hydrology and increased runoff from impervious area, specifically from channel erosion and subsequent elevated suspended sediment transport through the watershed. Thus, suspended sediment was identified as a probable cause and confirmed the 2008 Category 5 listing for total suspended sediment as an impairing substance in this watershed.

Approximately 116 miles of streams were assessed and characterized for the Little Patuxent Watershed Assessment (Anne Arundel County, 2014 Draft). Streams located on Fort Meade and Jessup Correctional Institute property were not assessed, which included the majority of streams within subwatersheds LP1 and LP5 and portions of subwatersheds LP0, LP4, LP9, and LPI. Collected data included stream classifications, physical habitat condition assessment, inventory of infrastructure and environmental features, habitat scores, channel geomorphology, road crossing flood potential, bioassessments, and aquatic resource indicators. Within each perennial reach, channel erosion was assessed and scored based on severity. A score of 5 was considered Moderate impact, a score of 7 was considered Severe, and a score of 10 was considered an Extreme condition. A total of 431 erosion locations impacting approximately 49,000 linear feet of stream reaches were cataloged in the Little Patuxent with the majority of points scored as moderate or severe erosion (Table 6 and Table 7). Over half of the erosion sites (53.3%) were located in Towsers Branch (LP3 and LPC), Dorsey Run (LPD and LPJ), and Oak Hill (LPA).

Table 6: Erosion Inventory and Severity per Subwatershed (Anne Arundel County, 2014 DRAFT)

Subwatershed and stream miles assessed		Number of Erosion Impacts			Total
		5	7	10	
LP0	1.2	3	1		4
LP1	0.1				0
LP2	3.7	12	1		13
LP3	6.1	19	14	2	35
LP4	1.8	4			4
LP5	0.0	Not Assessed			
LP6	2.3	6	1		7
LP7	7.8	16	13		29
LP8	6.9	20	1		21
LP9	7.1	9			9
LPA	7.0	44	15		59
LPB	10.6	10	1		11
LPC	7.0	25	4	4	33
LPD	8.6	19	7	4	30
LPE	6.1	22	14	3	39
LPF	10.7	11	5		16
LPG	8.7	20	5	3	28
LPH	3.7	22	5		27
LPI	10.3	8	2	2	12
LPJ	4.0	19	15		34
LPK	2.0	17	3		20
Total number per rating		**306**	**107**	**18**	
Total number per type		**413**			

Gray =<5 sites | Green = 5-10 sites | Yellow = 11-20 sites | Orange = 21-50 sites

Table 7: Linear Feet of Erosion per Subwatershed (Anne Arundel County, 2014 DRAFT)

Subwatershed	Erosion Impacts and Linear Feet			Total Linear Feet
	5	7	10	
LP0	110	15	0	125
LP1	Not Assessed			
LP2	1,360	120	0	1,480
LP3	3,565	4,020	140	7,725
LP4	200	0	0	200
LP5	Not Assessed			
LP6	1,870	50	0	1,920
LP7	2,000	825	0	2,825
LP8	3,040	100	0	3,140
LP9	370	0	0	370
LPA	2,825	1,180	0	4,005
LPB	2,025	100	0	2,125
LPC	2,160	510	405	3,075
LPD	1,211	1,845	185	3,241
LPE	4,940	3,640	130	8,710
LPF	1,550	280	0	1,830
LPG	1,320	395	500	2,215
LPH	1,655	260	0	1,915
LPI	950	100	250	1,300
LPJ	805	885	0	1,690
LPK	1,075	90	0	1,165
Total	**33,031**	**14,415**	**1,610**	**49,056**

An assessment of channel geomorphology utilizing Rosgen Level I geomorphic classifications was also administered for each single-threaded, perennial reach throughout the watershed as part of the Little Patuxent Watershed Assessment (Anne Arundel County, 2014 Draft). An assessment of channel geomorphology is useful to better understand the stability of a stream and its associated behaviors including channel entrenchment. The Rosgen classification system has four levels. The Level I classification is a geomorphic characterization that groups streams as Types A through G based on aspects of channel geometry, including water surface slope, entrenchment, width/depth ratio, and sinuosity. Over half of the assessed perennial streams (54%) in the Little Patuxent watershed were Type C channels, which exhibit a well-developed floodplain, higher sinuosity, and susceptibility to de-stabilization when flow regimes are altered. Approximately one-quarter of streams (21%) were Type B channels, which are very stable, moderate gradient channels with low sinuosity and low erosion rates. Sixteen percent were Type F and G channels (7% and 9%, respectively), which are generally low gradient, entrenched channels with high erosion rates.

3.3 Anticipated Growth

The Anne Arundel County General Development Plan was finalized April 2009 and was adopted in October 2009 (Bill No. 64-09; Anne Arundel County, 2009). The next update of the plan is due by 2019. Anne Arundel County is considered one of the fastest growing counties in the region with 14.6%

population growth (427,239 to 489,656 persons) over 1990-2000 compared to 6.9% growth in the Baltimore region and 10.8% growth throughout the State of Maryland (Anne Arundel County, 2009). The population in Anne Arundel County is projected to increase to 564,925 persons by 2025, which is an increase of 15.4% from 2000 data and to 579,137 persons by 2035, an increase of 18.3% from 2000 data.

The primary developed areas located in Little Patuxent watershed are Crofton and the outer limits of Odenton, which includes various commercial developments, specifically the shops at Waugh Chapel Towne Centre. Portions of the Little Patuxent, including Crofton and Piney Orchard, are a part of the County's Priority Funding Areas which are areas where the County directs new growth. Anne Arundel County continues to utilize strategies such as promoting low impact development and implementing stormwater BMPs for water quality treatment. However, increased urban stormwater related loads will inevitably occur as growth continues.

To account for growth and increases in loads over time, an analysis was completed using a combination of MAST modeled loading estimates, and estimates based on recent growth patterns. Figure 6 shows initial conditions loads without BMPs as modeled in MAST (grey bars) at the Little Patuxent 8-digit subwatershed scale as well as projected loads with (blue bars) and without (orange bars) the application of stormwater BMPs to the maximum extent practicable (SW to the MEP). Projected loads were calculated by applying the average percent change observed between MAST loading results from 2010 through 2015 (2.0%) to loads of the previous year. In this manner a 2.0% annual increase in loads would be expected from 2015 to 2025 if development were to occur at the same rate and be implemented without BMPs. Because in actuality new development will follow Maryland's stormwater regulations, the resultant loading increases were reduced by 90% based on the MAST removal rates for sediment treated by stormwater treatment to the maximum extent practicable (SW to the MEP). The results are shown as the blue bars in Figure 6. Additional projected loads without the application of SW to the MEP sediment removal rates are shown as the orange bars in Figure 6.

Projected loading in 2025 with the application of SW to the MEP, will be incorporated in TMDL modeling efforts to account for growth in the watershed.

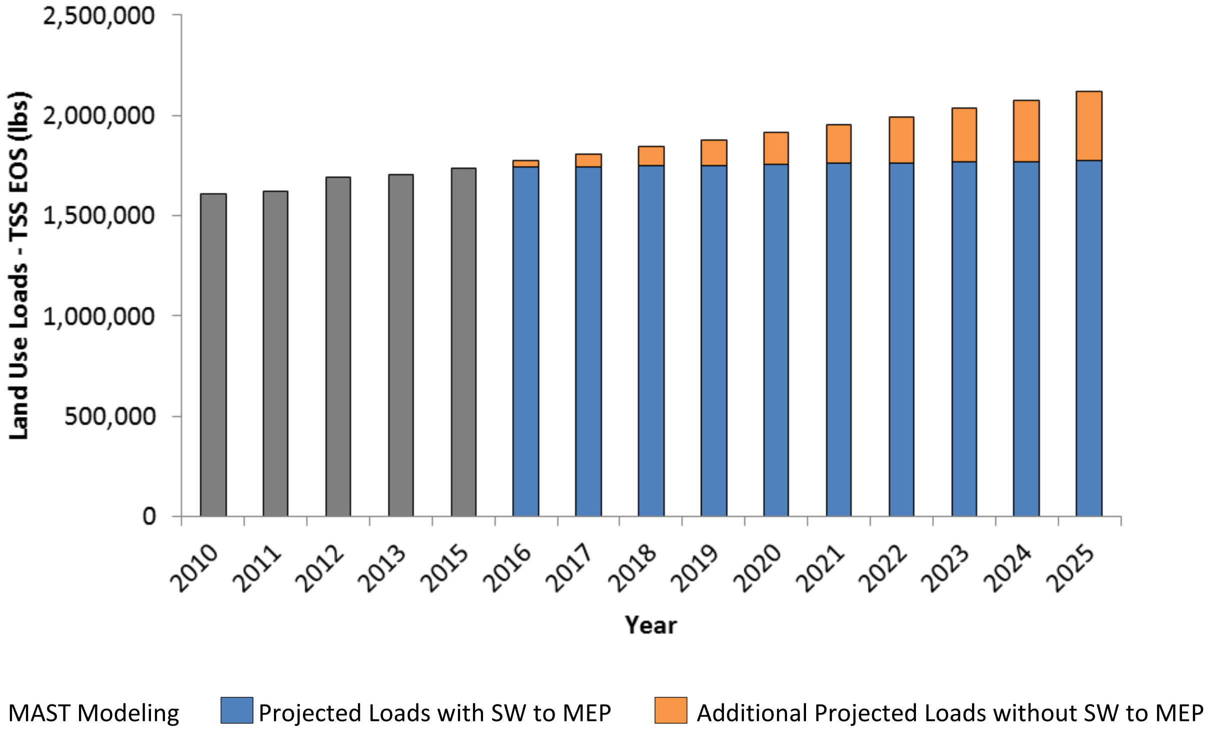


Figure 6: Modeled and Projected Land Use Loads

Figure 7 depicts sediment runoff loading by subwatershed based on a future conditions modeling scenario with the implementation of projects funded in the County's Capital Improvement Program (CIP) as recommended in the Little Patuxent Watershed Assessment (Anne Arundel County, 2014 Draft) and discussed further in Section 4: Management Measures. In general, future sediment loading is projected to be highest in the Rogue Harbor and Towsers Branch subwatersheds (LP4, LP6, LP9, LPC) in addition to the Crofton Golf subwatershed (LPG).

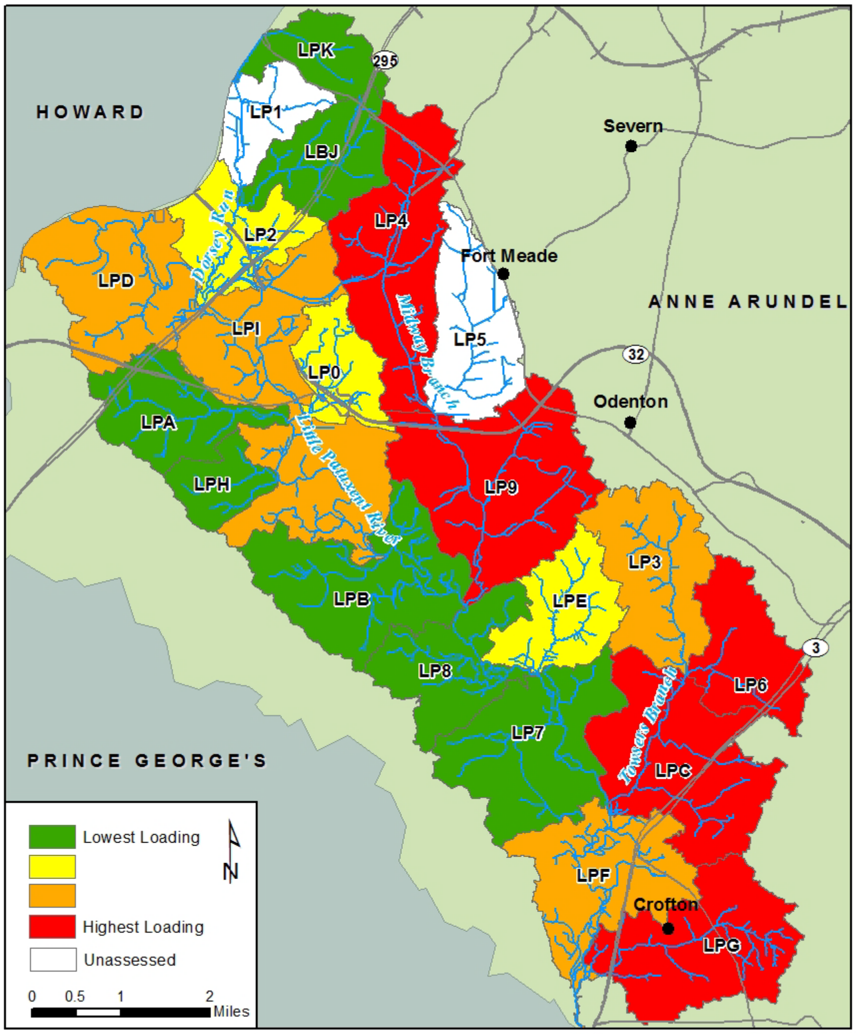


Figure 7: Total Suspended Solids Loads from Runoff Based on Future Conditions - Includes BMP Reductions (Anne Arundel County, 2014 Draft)

4 Management Measures (c)

Best management practices (BMPs) are either already implemented or are planned for implementation to achieve and maintain the Little Patuxent local TMDL load reductions. This section serves to describe the types of BMPs and management measures being implemented in the watershed. Load reductions that result from these measures are discussed in the following section, Section 5: Expected Load Reductions.

4.1 Modeling Approach

Each BMP provides a reduction for nitrogen, phosphorus, and sediment, along with other pollutants. The pollutant load for the Little Patuxent watershed was determined using MAST, which calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model. MAST, created by Devereux Environmental Consulting for MDE, is a web-based pollutant load estimating tool that streamlines environmental planning. Users specify a geographic area (e.g., County, watershed) and then select BMPs to apply on that area. MAST builds the scenario and provides estimates of pollutant load reductions and allows users to understand which BMPs provide the greatest load reduction benefit and the extent to which these BMPs can be implemented. Based on the scenario outputs, users can refine their BMP choices in their planning. MAST facilitates an iterative process to determine if TMDL allocations are met. Scenarios may be compared to each other, to TMDL allocations, or to the amount of pollutants reduced by current BMP implementation.

MAST estimates of load reductions for point and nonpoint sources include: agriculture, urban, forest, and septic loading. Load reductions are not tied to any single BMP, but rather to a suite of BMPs working in concert to treat the loads. Both MAST and the Watershed Model calculate reductions from all BMPs as a group, much like a treatment train. Reductions are processed in order, with land use change BMPs first, load reduction BMPs next, and BMPs with individual effectiveness values at the end. The overall the load reduction can vary depending on which BMPs are implemented.

Pollutant load reductions achieved by maintenance efforts (e.g., street sweeping and inlet cleaning) are calculated outside of MAST. As discussed in the following section 4.2: Best Management Practices, inlet cleaning and street sweeping will be practiced in the Little Patuxent watershed. Sediment reduction credit for street sweeping and inlet cleaning is calculated following methods described in MDE (2014b). Vacuum-assisted street sweeping at a rate of 2 times per month reduces the load on the swept area by 25%. Inlet cleaning receives credit based on the mass of material collected, at the rate of 420 lb TSS per ton of wet material.

Both the Watershed Model and MAST provide loads at two different scales: Edge-of-Stream (EOS) and Delivered (DEL). Delivered loads show reductions based on in-stream processes, such as nutrient uptake by algae or other aquatic life. This TMDL plan focuses on reducing load on the land, so EOS estimates are more appropriate and were used for all the modeling analysis.

This section presents the level of BMP implementation. Section 9 presents information on how progress toward load reductions will be evaluated and management plans adapted on an on-going basis.

4.2 Best Management Practices

Many stormwater BMPs address both water quantity and quality, however, some BMPs are more effective at reducing sediment than others. The stormwater practices listed below keep the focus on “green technology” to reduce the impacts of stormwater runoff from impervious surfaces. These BMPs were selected specifically for three reasons: 1) effectiveness for water quality improvement, 2) willingness among the public to adopt, and 3) implementable in multiple facility types without limitations by zoning or other controls.

These practices are consistent with those currently being implemented by Anne Arundel County DPW as water quality improvement projects. The County has the technical expertise, operational capacity, and system resources in place to site, design, construct and maintain these practices.

The recommended practices are also consistent with those proposed in the County’s Phase II WIP for the Chesapeake Bay TMDL and in the County’s comprehensive watershed planning efforts. Exceptions to this are dry ponds which include dry detention ponds and dry extended detention ponds. These practices are no longer considered for future implementation; however, there are many existing facilities that are still actively treating runoff throughout the County so they are described here as well. The practices include:

- **Bioretention** — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. Rain gardens may be engineered to perform as a bioretention.
- **Bioswales** —An open channel conveyance that functions similarly to bioretention. Unlike other open channel designs, there is additional treatment through filter media and infiltration into the soil.
- **Dry Detention Ponds** – Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow MAST modeling includes hydrodynamic structures in this category. These devices are designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.
- **Dry Extended Detention Ponds** - Depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. They are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, allowing additional wet sedimentation to improve treatment effectiveness.
- **Impervious Surface Reduction** - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Disconnection of rooftop and non-rooftop runoff, rainwater harvesting (e.g., rain barrels), and sheetflow to conservation areas are examples of impervious surface reduction.
- **Infiltration** — A depression or trench to form a shallow basin where sediment is trapped and stormwater infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil; they are not constructed on poor soils, such as C and D soil types. Yearly inspections to determine if the basin or trench is still infiltrating runoff are planned. Dry wells, infiltration basins, infiltration trenches, and landscaped infiltration are all examples of this practice type.
- **Outfall Enhancement with Step Pool Storm Conveyance (SPSC)** – The SPSC is designed to stabilize outfalls and provide water quality treatment through pool, subsurface flow, and vegetative uptake. The retrofits promote infiltration and reduce stormwater velocities. This strategy is modeled in MAST as bioswales.
- **Permeable Pavement -** Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.
- **Stream Restoration -** Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.
- **Stormwater Retrofits –** Anne Arundel County plans to construct a variety of retrofits throughout the County. Stormwater retrofits may include converting dry ponds, dry extended detention

ponds, or wet extended detention ponds into wet pond structures, wetlands, infiltration basins, or decommissioning the pond entirely to install SPSC (step pool storm conveyance).

- **Urban Filtering** - Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.
- **Urban Tree Plantings** - Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting
- **Vegetated Open Channels** - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.
- **Wet ponds or wetlands** — A water impoundment structure that intercepts stormwater runoff then releases it at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached pollutants. Until 2002 in Maryland, these practices were generally designed to meet water quantity, not water quality objectives. There is little or no vegetation within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal, but phosphorus and sediment are reduced.

The measured effectiveness for each of these practices may be found in Table 8.

Table 8: Typical Sediment Reduction from Stormwater BMPs

BMP	Sediment Reduction
Bioretention	55 – 80%
Bioswales	80%
Dry Detention Ponds	10%
Dry Extended Detention Ponds	60%
Impervious Surface Reduction*	-
Infiltration	95%
Outfall Enhancement with SPSC**	80%
Stream Restoration	15.13 lbs/linear ft
Urban Filtering	80%
Urban Tree Plantings*	-
Vegetated Open Channels	70%
Wet Ponds or Wetlands	60%

Sources: Simpson and Weammert, 2009; and Maryland Assessment Scenario Tool (MAST) documentation
* Calculated as a land use change to a lower loading land use
**Outfall enhancement with SPSC modeled as bioswales in MAST

Along with the structural BMPs listed above, treatment will also be provided through non-structural measures. These are treatments that rely on programs that continue throughout the year and are repeated annually.

- **Inlet Cleaning -** Storm drain cleanout practice ranks among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with their NPDES stormwater permits. Sediment reduction credit is based on the mass of material collected, at the rate of 420 lb TSS per ton of wet material (MDE, 2014b).
- **Street sweeping** — Starting Fiscal Year 2015, Anne Arundel County has enhanced their street sweeping program which now includes sweeping curb-miles and parking lots within the Little Patuxent (Anne Arundel County DPW, 2015). This enhanced program targets impaired watersheds and curbed streets that contribute trash/litter, sediment, and other pollutants. For full credit by MDE, street sweeping should occur twice a month or 26 times a year on urban streets. This frequent sweeping of the same street will reduce nitrogen and phosphorus as well as sediment. Under the enhanced street sweeping program Anne Arundel County is sweeping arterial streets within the Little Patuxent watershed on a bi-weekly basis (26 times a year) and collector and local streets on a monthly basis (12 times a year). Vacuum-assisted street sweeping at a rate of 2 times per month reduces the load on the swept area by 25%. In order to quantify sediment load reductions from monthly sweeping efforts, the removal rate of 22% for vacuum-assisted monthly sweeping was applied to total sediment collected from collector and local streets (CWP, 2008).

4.3 Offsetting Sediment Loads from Future Growth

Growth and development is expected to occur throughout Anne Arundel County, and depending on when and where this growth occurs, pollutant loading from urban stormwater sources may also increase. It is anticipated that new development will make use of ESD stormwater treatment according to MDE's Stormwater Regulations.

Maryland's 2007 Stormwater Management Act went into effect in October of 2007, with resulting changes to COMAR and the 2000 Maryland Stormwater Design Manual in May of 2009. The most significant changes relative to watershed planning are in regard to implementation of ESD. The 2007 Act defines ESD as "using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources." As such Anne Arundel County has updated Articles 16 and 17 of the County Code to incorporate the requirements for ESD. Anne Arundel County finalized the *Anne Arundel County Stormwater Management Practices and Procedures Manual* to incorporate criteria specific to the County that are not addressed within the Maryland Design Manual (Anne Arundel County, 2010).

Figure 6 in Section 3.3: Anticipated Growth shows projected land use loads with and without the application of stormwater BMPs to the maximum extent practicable (SW to the MEP). TMDL modeling efforts include the application of SW to the MEP to represent ESD treatment for new development in the watershed. SW to the MEP will control 90% of sediment loads for that new development; therefore the plan is to address the residual 10% of the load that is uncontrolled.

5 Expected Load Reductions (b)

WLAs in the sediment TMDL were developed using the Chesapeake Bay Program Phase 5 (CBP P5) watershed model. Currently, MAST is using a computational framework that is compatible with an updated version of the model: CBP P5.3.2. Because the TMDL was developed under an older version of the model, the TMDL WLA needed to be translated into a MAST-compatible target load. In order to do this, the 2005 baseline sediment load was re-calculated in MAST with the 8-digit county split geography (Little Patuxent 02131105, Anne Arundel County). The required reduction percent assigned to the Anne Arundel County Phase I MS4 source (20.5%) in the local TMDL regulation was then applied to the new baseline load to calculate required sediment reduction. The required sediment reduction was then subtracted from the new baseline load to calculate the MAST-compatible target TMDL WLA. Sediment loads required for the Little Patuxent Anne Arundel County Phase I MS4 source are shown in Table 9.

Table 9: Sediment Loads Required for the Little Patuxent River Local TMDL Anne Arundel County Phase I MS4 Source

2005 Baseline Load (lbs/yr)	Required Reduction %	Required Reductions (lbs/yr)	TMDL Load Allocation (lbs/yr)
1,275,211	20.5%	261,418	1,013,792

5.1 2013 Progress – Actual Implementation

Anne Arundel County maintains an extensive geodatabase of stormwater urban BMP facilities and water quality improvement projects (WQIP). Approximately 2,630 acres of County Phase I MS4 land has been treated through 2013 in addition to 10,504 linear feet of stream restoration and the implementation of other non-structural BMPs (source: WPRP urban BMP and WQIP database, 2014). Current BMP implementation through 2013 in the Little Patuxent is shown in Table 10.

Table 10: Current BMP Implementation through 2013 for Little Patuxent River

BMP	Unit	2013 Current Implementation
Bioretention	acre	70.9
Bioswale	acre	3.6
Dry Ponds	acre	655.6
Extended Detention Dry Ponds	acre	552.1
Impervious Surface Reduction	acre	11.8
Infiltration	acre	228.5
Inlet Cleaning	no. of inlets	202
Stormwater Retrofits[1]	acre	15.2
SW to the MEP	acre	0.1
Urban Filtering	acre	17.8
Urban Tree Plantings	acre	1.5
Urban Stream Restoration	linear feet	10,504.0
Vegetated Open Channels	acre	21.8
Wet Ponds or Wetlands	acre	1,067.7

Source: WPRP urban BMP and WQIP database

[1]Includes projects that will convert dry ponds into wet ponds. Stormwater retrofits are modeled by decreasing acreage for dry ponds and increasing acreage for wet ponds.

2013 Progress results are shown in Table 11.

Table 11: 2013 Progress Reductions Achieved

Baseline Load and TMDL WLA	**TSS-EOS lbs/yr**
2005 Baseline Scenario Load	1,275,211
Required Percent Reduction	20.5%
Required Reduction	261,418
Local TMDL WLA	1,013,792
2013 Progress Results	**TSS-EOS lbs/yr**
2013 Progress Scenario Load	1,200,569
2013 Progress Reduction Achieved	74,642
2013 Percent Reduction Achieved	5.9%

5.2 Planned Implementation

Table 12 compares implementation of existing BMPs with planned levels of implementation. This increase in implementation will achieve the loads required in the local TMDL and ensure that future growth (through 2025) is treated. These loads meet the TMDL required reductions for the Little Patuxent (Table 13).

The majority of 2025 planned management strategies incorporate CIP stormwater retrofits and outfall enhancement projects. Feasibility studies of the planned strategies may reveal that some existing structures identified for retrofitting or enhancement may not be feasible candidates for future projects and may be eliminated from consideration. The County will take an adaptive management approach and will reevaluate treatment needs as feasibility studies progress. The County will continue to track the overall effectiveness of the various BMP strategies and will adapt the suite of solutions based on the results. In addition, new technologies are continuously evaluated to determine if the new technologies allow more efficient or effective pollution control.

Figure 8 shows baseline and progress loads (green bars) and planned loads (yellow bars) compared to milestone goal loads (red bars and red line) and background land use loads (grey bars). As discussed in Section 3.3: Anticipated Growth, initial conditions loads (2011 – 2015) without BMPs were modeled in MAST at the Little Patuxent 8-digit subwatershed scale. To account for growth and increases in loads over time, loads were projected (2017 – 2025) with the application of SW to the MEP. This comparison shows that all background loads will be treated to the required TMDL allocated load with current and future BMP implementation.

Table 12: BMP Implementation - Current 2013 and Planned 2025 Levels for the Little Patuxent River

BMP	Units	2013 Current Implementation	2025 Planned Implementation
Bioretention	acre	70.9	-
Bioswale	acre	3.6	-
Dry Ponds	acre	655.6	-
Extended Detention Dry Ponds	acre	552.1	-
Impervious Surface Reduction	acre	11.8	-

BMP	Units	2013 Current Implementation	2025 Planned Implementation
Infiltration	acre	228.5	-
Inlet Cleaning	no. of inlets	202	1,602
Outfall Enhancement with SPSC	acre	0.0	612.8
Stormwater Retrofits[1]	acre	15.2	257.5
Street Sweeping (parking lots)	acres	0.0	0.7
Street Sweeping (roads)[2]	curb-miles	0.0	61.0
SW to the MEP	acre	0.1	-
Urban Filtering	acre	17.8	-
Urban Tree Plantings	acre	1.5	-
Urban Stream Restoration	linear feet	10,504.0	-
Vegetated Open Channels	acre	21.8	-
Wet Ponds or Wetlands	acre	1,067.7	-

[1]Includes projects that will convert dry ponds or dry extended detention ponds into wet ponds.
[2]Includes curb-miles for arterial, collector, and local streets. Arterial streets swept bi-weekly (26 times a year) and collector and local streets swept monthly (12 times a year).

Table 13: 2025 Planned Reductions

Baseline Load and TMDL WLA	TSS-EOS lbs/yr
2005 Baseline Scenario Load	2,032,381
Required Percent Reduction	22.2%
Required Reduction	451,189
Local TMDL WLA	1,581,193
2025 Planned Results	**TSS-EOS lbs/yr**
2025 Planned Load[1]	1,011,161
2025 Planned Reduction Achieved	264,049
2025 Percent Reduction Achieved	20.7%

[1]2025 Planned load includes additional projected land use loading from new development through 2025. It is assumed that all new development will be treated with SW to the MEP implementation to achieve 90% sediment removal.

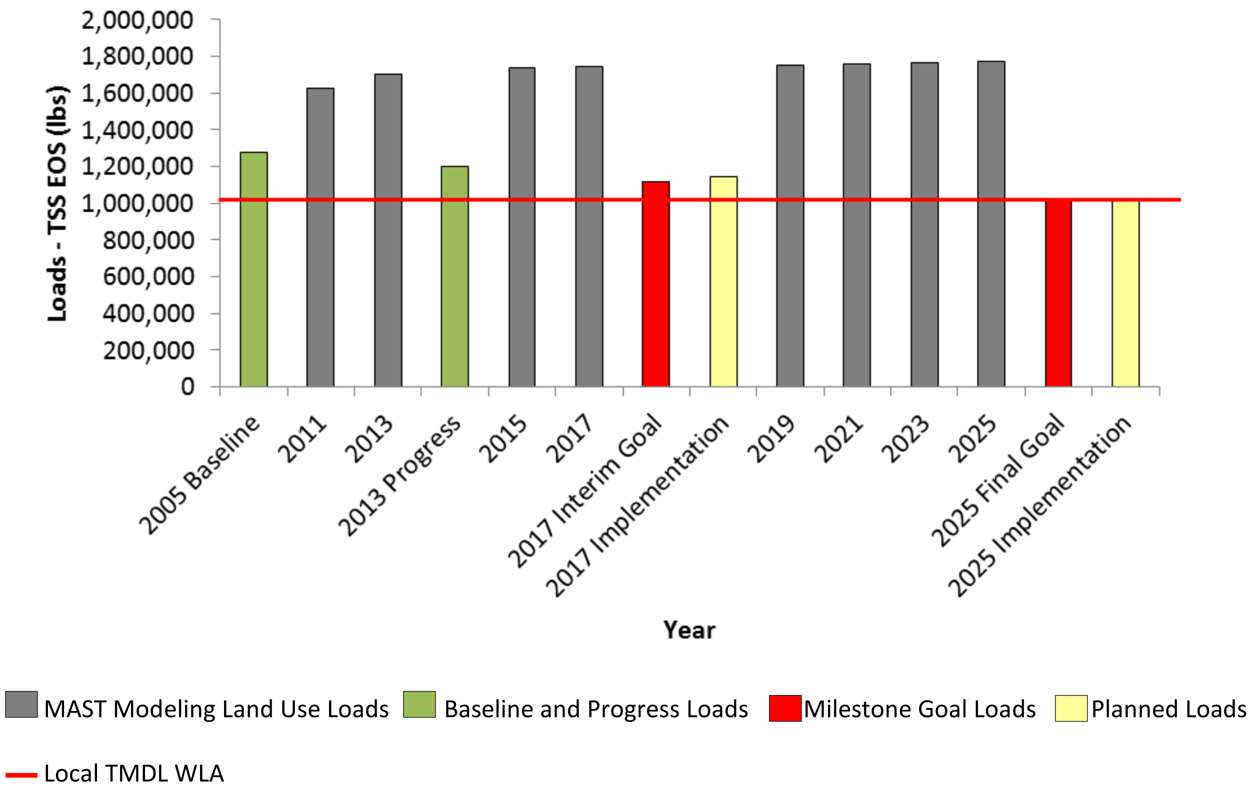


Figure 8: Progress and Planned Reductions in the Little Patuxent River Watershed

6 Technical and Financial Assistance Needs (d)

Technical Needs

Technical assistance to meet the reductions and goals of a TMDL takes on many forms including MDE assistance to local governments, state and local partner assistance to both MDE and municipalities, and technical consultants contracted to provide support across a wide variety of service areas related to BMP planning and implementation.

MDE has and will provide technical assistance to local governments through training, outreach and tools, including recommendations on ordinance improvements, technical review and assistance for implementation of BMPs at the local level, and identification of potential financial resources for implementation (MDE, 2014b).

Anne Arundel County DPW contracts with consultants through several contract vehicles including open-end task based assignments, to provide a variety of technical services. These services, provided by planners, engineers, environmental scientists and GIS specialists, include watershed assessment and management, stream monitoring, stormwater planning and design, stream restoration design, outfall enhancement, and environmental permitting, among others. The County itself has complementary staff in DPW and other County departments to manage contracts, provide review and approval of planning and design work, conduct assessments, and develop and administer planning and progress tracking tools.

Anne Arundel County has many partners that provide outreach to homeowners and communities in the form of technical assistance, education, and funding for implementation of best management practices within local communities. The Watershed Stewards Academy, further discussed in Section 7: Public Participation/Education, routinely engages and informs the public on reducing pollution sources and employing stormwater/rainscaping retrofits to reduce their impacts.

Technical assistance for Public Participation and Education and for Monitoring will also be necessary to fully implement and track progress towards meeting the goals of the local TMDL. These elements are discussed in sections 7 and 10 of this plan.

Financial Needs

The total projected cost to implement the County's CIP projects described in this plan for the Little Patuxent watershed is $22,438,745 including $14,945,417 towards outfall enhancements with SPSC, $4,677,801 towards stormwater pond retrofits, $1,522,400 for inlet cleaning, and $1,293,127 for street sweeping. Structural BMP project costs are estimated based on the average cost per pound of nitrogen removed based on a group of completed projects consisting of various BMP types. Since these practices reduce nitrogen and phosphorus as well as sediment, costs derived from this method translate for sediment removal. This approach was used to calculate structural BMP costs in the County's Phase II WIP. Non-structural BMP costs for inlet cleaning and street sweeping were derived from historic County data and include equipment, operations, and maintenance costs.

Table 14 includes a summary of funding need per CIP project BMP type and project phase. Project cost is split throughout the implementation timeframe with design and land ROW estimated costs to occur the first year of the project, construction costs to occur in the second year, and overhead costs split between the first and second year.

Table 14: Little Patuxent River Cost Over Milestone Periods

BMP	2014-2015	2016-2017	2018-2019	2020-2021	2022-2025	Total Cost
Outfall Stabilization	**$532,944**	**$6,939,765**	**$7,472,709**			**$14,945,417**
Design	$289,015	$470,098	$759,113			$1,518,226
Land ROW	$57,803	$94,020	$151,823			$303,645
Construction		$6,072,904	$6,072,904			$12,145,808
Overhead	$186,126	$302,743	$488,869			$977,738
SWM Pond Retrofit	**$1,521,576**			**$1,578,113**	**$1,578,113**	**$4,677,801**
Design	$158,004			$160,312	$160,312	$478,628
Land ROW	$0			$32,062	$32,062	$64,125
Construction	$1,264,030			$1,282,497	$1,282,497	$3,829,024
Overhead	$99,542			$103,241	$103,241	$306,024
Inlet Cleaning	**$80,800**	**$80,800**	**$360,000**	**$360,000**	**$640,800**	**$1,522,400**
Street Sweeping	**$168,106**	**$168,106**	**$281,255**	**$281,255**	**$394,404**	**$1,293,127**

6.1 Funding Sources

Prior to the passage of Maryland House Bill 987 and, as stated in the Anne Arundel County Phase II WIP (Anne Arundel County, 2012), the County's funding capacity to implement urban stormwater restoration/retrofit projects was limited by the County's Capital Improvement Program (CIP) budget for environmental restoration and water quality improvement projects. To comply with forthcoming requirements of the Phase I NPDES MS4 permit, and to support restoration efforts towards reducing pollutant loads required for both the Chesapeake Bay TMDL and local TMDLs throughout Maryland, the State Legislature passed a law in 2012 (House Bill 987) mandating that Maryland's 10 largest jurisdictions (those with Phase I MS4 permits), including Anne Arundel County, develop a Watershed Protection and Restoration Program and establish a Stormwater Remediation Fee. To comply with the State legislation, Anne Arundel County passed legislation in 2013, Bill 2-13.

The County's Stormwater Remediation Fee provides a dedicated source of revenue for the implementation of local stormwater management plans through stormwater management practices and stream and wetland restoration activities and is assessed to Anne Arundel County property owners based on the amount of impervious surface on their property. The Stormwater Remediation Fee is structured to provide sufficient funding for projects to meet the pollutant load reduction required by the Chesapeake Bay TMDL, EPA approved individual TMDLs with a stormwater WLA and to meet the impervious surface management requirements as well as other stormwater obligations set forth in the County's NPDES MS 4 Permit. The fee is assessed to Anne Arundel County property owners as a separate line item on the owner's real property tax bill.

In addition to the Stormwater Remediation Fee, Anne Arundel County actively pursues grant funding from Federal, State and non-governmental organizations (NGOs) to leverage funding for its restoration projects. And, with the creation of the Stormwater Remediation Fee, the County has developed a Grant Program to provide funding to local NGOs to facilitate implementation of restoration projects that further the County's ability to meet its regulatory requirements.

7 Public Participation / Education (e)

Anne Arundel County has given numerous public presentations throughout the development of the County's Phase II WIP in order to disseminate information on the Chesapeake Bay TMDL, WIP process, and strategies for meeting the County's assigned pollutant load reductions. In addition to providing a level of understanding to the public, the County uses the presentations as an opportunity to receive input and comment on restoration efforts. Anne Arundel County has a variety of organizations interested in water quality, including Severn River Association; South River Federation; Anne Arundel County Commercial Owners; Anne Arundel Watershed Stewards Academy; Anne Arundel County Chamber of Commerce, Environmental Committee; Leadership Anne Arundel; and, Chesapeake Environmental Protection Association (Anne Arundel County, 2012).

In order to implement an effective strategy to meet water quality standards and achieve pollutant load reduction, an effort to engage a very broad audience of landowners was a necessity. The Anne Arundel Watershed Stewards Academy (AAWSA), a pre-eminent non-profit (501(c)3) environmental organization, was formed through Anne Arundel County Department of Public Works and the County Board of Education's Arlington Echo Outdoor Education Center (Anne Arundel County, 2012). AAWSA's mission is to identify, train, and support citizens to become Master Watershed Stewards who take action with their neighbors to restore local waterways in Anne Arundel County. This program is a unique way to integrate education as a vital element in its role in preservation, conservation and advocacy. There are currently more than 100 certified Master Watershed Stewards throughout Anne Arundel County and adjacent areas.

The AAWSA has extensive resources through the Consortium of Support Professionals which is composed of over 80 governmental, non-profit and business professionals who provide technical assistance to Master Watershed Stewards. Consortium members are experts in their field of conservation, ecology, government laws, landscape architecture, low impact design, water quality monitoring, and watershed assessment and provide consulting on design and development of watershed restoration projects. The AAWSA is also supported by staff that provides day to day guidance to Master Watershed Stewards, connecting Stewards to Anne Arundel County resources, coordinating Stewards certification, post certification professional development, and networking opportunities for Stewards and Consortium of Support Professionals.

The AAWSA has an interactive website (www.aawsa.org) that provides guidance to common water quality problems including information on the following:

- Reduce Your Pollution
  - Practice Bay-Friendly Lawn Care
  - Maintain and Upgrade your Septic System
  - Pick Up Pet Waste
  - Choose Non-Toxic Household Products
  - Maintain your Car and Boat
  - Reduce your Energy Use
- Capture Stormwater
  - Install a Rain Barrel or Cistern
  - Build a Rain Garden
  - Choose to Have Conservation Landscapes
  - Plant Native Trees
  - Direct Water with Swales and Berms
  - Use Permeable Pavers and Pavement
- Clean Up!
  - Invasive Species Removal
  - Dump Site Cleanup
- Conserve and Preserve
  - Land Preservation

These programs and others like them could be more focused on the Little Patuxent watershed.

In addition to the AAWSA, the following organizations have been identified for possible partnerships and education and outreach for the Little Patuxent:

- Master Gardeners
- Audubon Society
- Students for the Environment
- Maryland civic associations and service clubs:
  - Maryland Home Builders Assoc.
  - Audubon Naturalist Society of the Central Atlantic States

- Audubon Society of Central Maryland
- Blue Water Baltimore
- Chesapeake Audubon Society
- Chesapeake Bay Program
- Chesapeake Bay Foundation
- Chesapeake Bay Trust
- Chesapeake Ecology Center
- Center for Watershed Protection
- Alliance for the Chesapeake Bay
- Alliance for Sustainable Communities
- Baywise Master Gardeners
- Sierra Club – Maryland Chapter
- Magothy River Association
- Patuxent Riverkeeper
- West/Rhode Riverkeeper
- Nature Conservancy
- Smithsonian Environmental Research Center
- Anne Arundel Community College
- University of Maryland
- University of Maryland Extension
- Volunteer Center for Anne Arundel County

WPRP also provides public outreach tools through web and social media platforms. WPRP has developed a comprehensive web-based informational program including a dedicated webpage, Facebook page, and Twitter account to provide information to the public. WPRP's website (www.aarivers.org) offers valuable information on Anne Arundel County watersheds including an interactive clickable map that displays geographically referenced environmental, utility, and land use data in addition to restoration project locations, descriptions, and drainage areas. This outreach platform is also used to notify the public of the opportunity to review and comment on this and other TMDL restoration plans.

8 Implementation Schedule and Milestones (f & g)

This section presents the target loads and the activities required to achieve those targets based on the 2017 interim and 2025 final loads and implementation targets. The following schedule and milestones follows the Chesapeake Bay TMDL milestone date framework (60% progress by 2017) and end date (2025; USEPA, 2010). This schedule has previously been approved by the CBP for the applicable Bay TMDLs and is believed to be a good option for tracking progress towards reduction goals of the Little Patuxent local TMDL.

8.1 Loading Allocations and Milestone Targets

Planning loads for 2017 and final loads for 2025 for the Little Patuxent watershed are presented in Table 15 below. As mentioned in Section 5: Expected Load Reductions (b) (see Tables 10 and 11), progress is already underway with the implementation of strategies throughout the watershed.

Table 15: Little Patuxent Planning and Target Loads (edge-of-stream loads)

Load	Sediment Load (lbs/year)
2005 Baseline Load	1,275,211
2013 Progress Load	1,200,569
2017 Interim Milestone (60% of reduction achieved)	1,118,360
2025 TMDL Allocated Load	1,013,792
Percent Reduction between 2005 Baseline and 2025 Loads	20.5%

8.2 Implementation Milestones

To meet the loading allocations and milestones outlined in the previous section, implementation of programs and BMPs must keep pace and meet planned implementation targets. Table 16 details the implementation for each tracked BMP with the associated unit of measure. The 2013 data reflects existing BMPs while the 2017, 2021, and 2025 values reflect the planned implementation for those years.

The majority of 2025 planned management strategies incorporate CIP stormwater retrofits and outfall enhancement projects. Feasibility studies of the planned strategies may reveal that some existing structures identified for retrofitting or enhancement may not be feasible candidates for future projects and may be eliminated from consideration. The County will take an adaptive management approach and will reevaluate treatment needs as feasibility studies progress. The County will continue to track the overall effectiveness of the various BMP strategies and will adapt the suite of solutions based on the results. In addition, new technologies are continuously evaluated to determine if the new technologies allow more efficient or effective pollution control.

Table 16: Little Patuxent Planning Milestones for Implementation

BMP	Unit	2013 Implementation	2015 Planned	2017 Planned	2021 Planned	2025 Planned
Bioretention	acre	70.9				
Bioswale	acre	3.6				
Dry Ponds	acre	655.6				
Extended Detention Dry Ponds	acre	552.1				
Impervious Surface Reduction	acre	11.8				
Infiltration	acre	228.5				
Inlet Cleaning	no. of inlets/yr	202	202	202	900	1,602
Outfall Enhancement with SPSC	acre			306.4	306.4	
Stormwater Retrofits[1]	acre	15.2	77.9		89.9	89.9

BMP	Unit	2013 Implemen-tation	2015 Planned	2017 Planned	2021 Planned	2025 Planned
Street Sweeping (parking lots)	acre		0.7	0.7	0.7	0.7
Street Sweeping (roads)	curb-miles		26.0	26.0	43.5	61.0
SW to the MEP	acre	0.1				
Urban Filtering	acre	17.8				
Urban Tree Plantings	acre	1.5				
Urban Stream Restoration	linear feet	10,504.0				
Vegetated Open Channels	acre	21.8				
Wet Ponds or Wetlands	acre	1,067.7				

[1]Includes projects that will convert dry ponds or dry extended detention ponds into wet ponds.
[2]Includes curb-miles for arterial, collector, and local streets. Arterial streets swept bi-weekly (26 times a year) and collector and local streets swept monthly (12 times a year)

8.3 Implementation Priorities

To meet the loading allocations and milestones outlined in the previous sections, implementation will be planned based on prioritization analyses presented in the Little Patuxent Watershed Assessment (Anne Arundel, 2014 DRAFT). Little Patuxent subwatersheds were prioritized for restoration/retrofit project selection potential using four separate prioritization models. The models integrated historical environmental data, current stream assessment monitoring data, drainage area characteristics (GIS data), and watershed modeling results into indicators of watershed condition and need. The indicators are combined into the four models:

- Stream Reach Restoration
- Subwatershed Restoration
- Subwatershed Preservation
- Parcel Preservation

The models were designed to operate at three management scales, first at the individual stream reach scale, second at the subwatershed scale, and lastly at the parcel scale. Additionally the models differentiated between identification of restoration opportunities for the degraded portions of the watershed (reach and subwatershed scale), and identification of preservation opportunities (subwatershed and parcel scale) for high quality sensitive areas that could be subject to additional stressors in future scenarios. For the purpose of this Restoration Plan, prioritization results for Stream Reach Restoration and Subwatershed Restoration are presented below to address in-stream sources and urban stormwater runoff, respectively.

8.3.1 Stream Reach Restoration

The stream restoration prioritization uses a suite of indicators that are weighted and then combined into a final relative rating for each perennial reach as identified in the Physical Habitat Condition Assessment. The suite of stream restoration indicators used in the Little Patuxent watershed, along with the indicator weight is presented in Table 17.

Table 17: Stream Restoration Assessment Indicators (Anne Arundel, 2014 DRAFT)

Category	Indicator	Weight
Stream Habitat	2003 MPHI score	31.6%
Stream Morphology	Rosgen Level I classifications	5.3%
Land Cover	Percent Imperviousness	5.3%
Infrastructure	Buffer impacts	5.3%
	Erosion impacts	10.5%
	Head cut impacts	5.3%
	Dump site impacts	5.3%
	Other infrastructure impacts (pipes, ditches, crossings, and obstructions)	15.8%
Hydrology and Hydraulics	Road Crossing flooding potential	15.8%

A total of 304 reaches were processed in the stream restoration model. Ten reaches were categorized as "High" priority or worst condition, 62 were "Medium High", 117 were "Medium", and 115 were "Low" priority or best condition (Table 18 and Figure 9). The Towsers Branch subwatershed ranked as a very high priority overall, as six of the ten "High" reaches and 25% of "Medium High" reaches are located in Towsers Branch. The Piney Orchard and Crofton Golf subwatersheds had a combined total of 26 reaches (42%) rated in the "Medium High" category.

Table 18: Stream Restoration Assessment Results (Anne Arundel County, 2014 Draft)

	Number of Reaches with Priority Rating			
Subwatershed	High	Medium High	Medium	Low
LP0		3	1	5
LP1	Not Assessed			
LP2		1	3	4
LP3	2	10	7	4
LP4			3	1
LP5	Not Assessed			
LP6	No Perennial Reaches			
LP7			5	12
LP8		2	4	5
LP9			12	5
LPA		1	10	16
LPB			1	11
LPC	4	6	9	3
LPD		2	14	5
LPE	3	12	14	3
LPF			6	10

Subwatershed	Number of Reaches with Priority Rating			
	High	Medium High	Medium	Low
LPG	1	14	17	13
LPH			1	8
LPI			3	2
LPJ		6	4	7
LPK		5	3	1
Total	**10**	**62**	**117**	**115**

Figure 9: Stream Reach Priorities for Restoration (Anne Arundel County, 2014 Draft)

8.3.2 Subwatershed Restoration

Similarly to the stream restoration assessment, the subwatershed assessment used a collection of restoration indicators to assign a rating to each subwatershed. The indicators were weighted and combined into a single restoration rating for each subwatershed. Restoration indicators fell into one of six categories: stream ecology, TMDL impairments, On-site Disposal Systems (OSDS), BMPs, Hydrologic and Hydraulic (H&H) Modeling, Water Quality, and Landscape. Each category contains one to four different indicators. Table 19 provides a summary of the categories, indicators, and relative weighting assigned by the County.

Table 19: Subwatershed Priority Rating Indicators for Restoration (Anne Arundel, 2014 DRAFT)

Category	Indicator	Weight
Stream Ecology	Final habitat score	7.5%
	Bioassessment score	7.5%
303(d) List	Number of TMDL impairments	7.5%
OSDSs (Septics)	Nitrogen Loads from septics (lbs)	9.3%
BMPs	Impervious area treated by BMPs (%)	6.6%
H&H (Land and Soils only)	Peak flow from 1-year storm event (cfs/acre)	4.5%
	Peak flow from 2-year storm event (cfs/acre)	4.5%
	Runoff volume from 1-year storm event (inches/acre)	5.8%
	Runoff volume from 2-year storm event (inches/acre)	5.8%
Water Quality (Land only)	Nitrogen load from runoff (lbs/acre/yr)	6.9%
	Phosphorus load from runoff (lbs/acre/yr)	6.9%
	Total Suspended Solids from runoff (Tons/acre/yr)	0.0%
Landscape	Impervious cover (%)	9.4%
	Forest within the 100 ft stream buffer (%)	10.3%
	% of existing wetlands to potential wetlands	9.4%
	Acres of developable critical area	5.3%

The final ratings range from “Lowest Priority for Restoration” to “Highest Priority for Restoration” where “Lowest Priority” indicates that a subwatershed is a low priority for restoration and therefore in good condition whereas “Highest Priority” indicates that a subwatershed should be a priority for restoration. The Little Patuxent 2 (LP0) and Jessup (LPK) subwatersheds were rated the highest priority for restoration. Three watersheds, LP7, LP8, and LPH were rated the lowest priorities for restoration (Figure 10). It is also important to focus restoration efforts in subwatershed that ranked highest for existing TSS loads from urban runoff, which include subwatersheds LP4, LP6, LP9, LPG, and LPI (Figure 5).

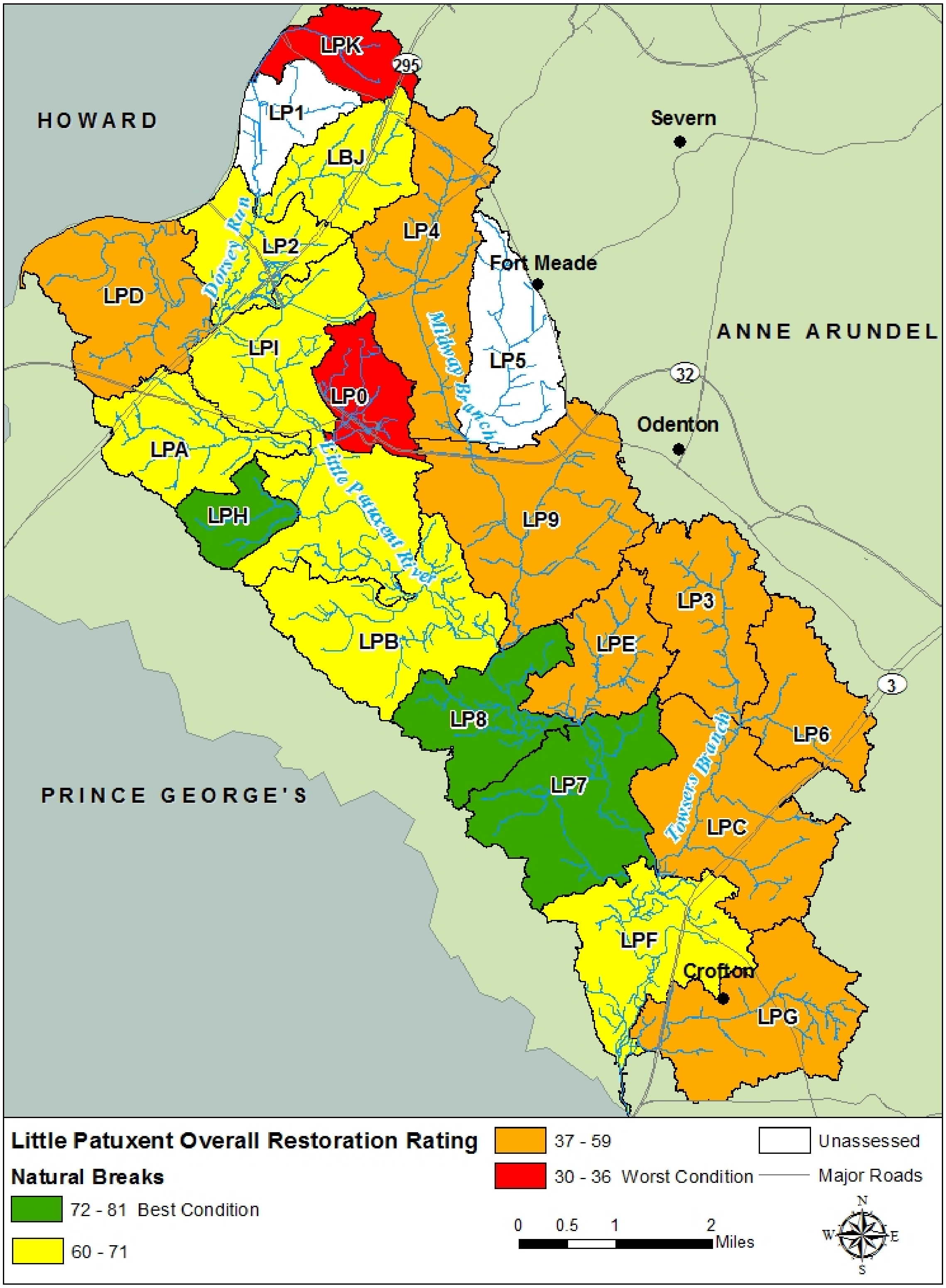


Figure 10: Subwatershed Priorities for Restoration (Anne Arundel County, 2014 Draft)

8.3.3 Prioritization of Strategy Implementation

As stated in the Anne Arundel County's Phase II WIP, the County uses three major categories to classify urban stormwater strategies: Core Strategy Tier I, Core Strategy Tier II, and Potential Load Reductions Outside the Tier I and Tier II Core Strategy (Anne Arundel County, 2012). BMP planning and implementation will be prioritized based on these three categories with highest priority given to Tier I and Tier II strategies.

Core Urban Stormwater Strategy Tier I includes the following:

- Restoration of ephemeral and perennial streams with a Department of Natural Resources (DNR) Maryland Biological Stream Survey's (MBSS) Maryland Physical Habitat Index (MPHI) score of severely degraded or degraded,
- Implementing stormwater management treatment at currently untreated major pipe outfalls; and,
- Retrofitting stormwater management ponds built prior to 2002 to optimize the pollutant reduction and ecosystem functions for the facilities

Core Urban Stormwater Strategy Tier II includes additional pollutant reduction activities that must be implemented to meet the 2025 allocations; which includes the following:

- Monthly vacuum assisted street sweeping and associated inlet cleaning for all closed section roads,
- Reforestation plan for available public open space land; and,
- SW to the MEP retrofits for County-owned properties including recreation areas

Potential Load Reductions Outside the Tier I and Tier II Core Strategies includes the following:

- Focuses on the work of private citizens and Watershed Master Stewards in implementing SW to the MEP for residential rooftops, in high density areas, and for private commercial and industrial properties.
- These areas have been selected geographically outside the area treated by the WIP core strategy.

9 Load Reduction Evaluation Criteria (h)

Adaptive management is a critical component of achieving and maintaining the Little Patuxent TMDL and this restoration plan. The milestones proposed in Section 8: Implementation Milestones (2015, 2017, and 2021) provide interim planning targets. The planning targets will be used to reevaluate against progress and will be revised, if necessary, to ensure that Anne Arundel County continues to maintain TMDL requirements. Progress evaluation will be measured through three approaches: tracking implementation of management measures, estimating load reductions through modeling, and tracking overall program success through long term monitoring.

9.1 Tracking Implementation of Management Measures

Implementation will be measured by determining whether the targets for implementation shown in Table 16 are maintained according to the milestone schedule presented. Anne Arundel County manages a comprehensive system for adding and tracking projects and accounting for new programs. New BMPs constructed through new development and redevelopment projects are entered into the County's BMP database as they come on line. WPRP is responsible for implementing and tracking Water Quality

Improvement Projects (WQIP; i.e., restoration and retrofit projects and programs). Additional internal County groups including Bureau of Highway Road Operation Division who are responsible for maintenance efforts (i.e., street sweeping and inlet cleaning) report back to WPRP. Another way the County is capturing and tracking projects is through the AAWSA. Watershed stewards can enter their own data and implementation projects through the WPRP website (www.aarivers.org). Once these data are reviewed and validated by the County, they are incorporated into the County's master list of environmental restoration projects.

The majority of 2025 planned management strategies incorporate CIP stormwater retrofits and outfall enhancement projects. Feasibility studies of the planned strategies may reveal that some existing structures identified for retrofitting or enhancement may not be feasible candidates for future projects and may be eliminated from consideration. The County will take an adaptive management approach and will reevaluate treatment needs as feasibility studies progress. The County will continue to track the overall effectiveness of the various BMP strategies and will adapt the suite of solutions based on the results. In addition, new technologies are continuously evaluated to determine if the new technologies allow more efficient or effective pollution control.

Two-Year Milestone Reporting

As a part of the federal Chesapeake Bay Accountability Framework and in support of Maryland's BayStat accountability system, the County is required to report two-year milestones representing near-term commitments and progress to MDE towards achieving load reduction goals for the Bay TMDL. These efforts will also support local TMDL planning and tracking at the County level.

Milestones are reported in two forms: Programmatic and BMP Implementation. Programmatic milestones identify the anticipated establishment or enhancement of the institutional means that support and enable implementation. Examples of Programmatic milestones include projected funding, enhancement of existing programs and resources, and the establishment of new programs and studies. The milestone period for Programmatic covers two calendar years – for example, the period for 2014 - 2015 is from January 1, 2014 through December 31, 2015. BMP Implementation milestones are a quantitative account of various types of restoration activities (e.g., structural BMPs, stream restoration, maintenance efforts), which have geo-located coordinates. The period for BMP implementation milestones differs from the Programmatic milestones period and covers two state fiscal years – for example, the period for 2014 – 2015 is from July 1, 2013 through June 30, 2015. Planned BMP Implementation milestones reported to MDE include the action (e.g., BMP type), proposed restoration over the 2-year milestone period (e.g., area treated, length restored), actual rate of implementation over 1 year, and percent progress.

The Programmatic and BMP Implementation milestone submittal and reporting process follows an iterative approach and includes three separate submittals to MDE. The first is an initial milestone submittal to MDE by January 31st of the first milestone calendar year (e.g., 2014), followed by an interim milestone progress report submittal by January 31st of the second milestone calendar year (e.g., 2015), and concluding with a final milestone progress submittal by January 31st of the start of the subsequent milestone period (e.g., 2016).

Annual NPDES Reporting

As a requirement of the NPDES permit described in Section 2.4.4, the County must submit on or before the anniversary date of the permit a progress report demonstrating the implementation of the NPDES stormwater program based on the fiscal year. If the County's annual report does not demonstrate compliance with their permit and show progress toward meeting WLAs, the County must implement BMP and program modifications within 12 months.

The annual report includes the following – items in bold font directly relate to elements of the load reduction evaluation criteria:

a. The status of implementing the components of the stormwater management program that are established as permit conditions including:
    i. Source Identification
    ii. Stormwater Management
    iii. Erosion and Sediment Control
    iv. Illicit Discharge Detection and Elimination
    v. Litter and Floatables
    vi. Property Management and Maintenance
    vii. Public Education
    viii. Watershed Assessment
    ix. Restoration Plans
    x. TMDL Compliance
    xi. Assessment of Controls; and,
    xii. Program Funding

b. A narrative summary describing the results and analyses of data, including monitoring data that is accumulated throughout the reporting year

c. Expenditures for the reporting period and the proposed budget for the upcoming year

d. A summary describing the number and nature of enforcement actions, inspections, and public education programs

e. The identification of water quality improvements and documentation of attainment and/or progress toward attainment of benchmarks and applicable WLAs developed under EPA approved TMDLs; and,

f. The identification of any proposed changes to the County's program when WLAs are not being met

g. Attachment A – The County is required to complete a database containing the following information:
    i. Storm drain system mapping
    ii. Urban BMP locations
    iii. Impervious surfaces
    iv. Water quality improvement project locations
    v. Monitoring site locations
    vi. Chemical monitoring results
    vii. Pollutant load reductions
    viii. Biological and habitat monitoring
    ix. Illicit discharge detection and elimination activities
    x. Erosion and sediment control, and **stormwater program information**
    xi. Grading permit information
    xii. Fiscal analyses – cost of NPDES related implementation

9.2 Estimating Load Reductions

Progress assessments are scheduled by the Chesapeake Bay Program for 2017 and 2021. At this time, multiple lines of evidence including: several models, monitoring data, and the most recent science on BMP effectiveness and water quality response will be evaluated. The milestones and progress assessments will contribute to constant reassessment of management plans, and adapting responses accordingly as technologies and efficiencies change, programs mature, credit trading is enacted, and regulations are put in place. The County will model load reductions in MAST at the interim (2014, 2016, 2018) and milestone (2015, 2017, 2019) years, which equates to about once a year at minimum.

9.3 Tracking Overall Program Success through Monitoring

Overall program success will be evaluated using trends identified through the long term monitoring program described below in Section 10: Monitoring. TMDL compliance status will be evaluated to determine if the Restoration Plan needs to be updated. If it is found during the evaluation of BMP implementation and load reductions that the milestone targets are no longer being met, a revision of the plan may be necessary.

10 Monitoring (i)

Official monitoring for Integrated Report assessments and impairment status is the responsibility of the State; however the County has many on-going monitoring programs that can support the State's efforts.

To determine the specific parameters to be monitored for tracking progress, one must understand the approach used for the initial listing. The Little Patuxent was originally listed for sediments in 1996 as a suspended sediment listing. This was refined in 2008 to a listing for total suspended solids. In 2002, the State began listing biological impairments on the Integrated Report, at the 8-digit scale, based on a percentage of stream miles degraded and whether they differ significantly from a reference condition watershed (<10% stream miles degraded). The biological listing is based on Benthic and Fish Indices of Biotic Integrity (BIBI/FIBI) results from wadeable streams from assessments conducted by the Maryland Department of Natural Resources (MDNR) Maryland Biological Stream Survey (MBSS). The Little Patuxent was listed for biological community impairment in 2006.

MDE then utilized its Biological Stressor Identification (BSID) process to identify the probable or most likely causes of poor biological conditions. For sediment specifically, the BSID identified 'altered hydrology and increased runoff from urban impervious surfaces have resulted in channel erosion and subsequent elevated suspended sediment transport through the watershed.' Overall, the results indicated inorganic pollutants (i.e. chlorides) and flow/sediment related stressors as the primary stressors.

Based on the results of the BSID, MDE replaced the biological impairment listing with a listing for total suspended solids (TSS). The 2012 final and 2014 draft integrated reports lists 'Habitat Evaluation' as the indicator, and urban runoff/storm sewers as the source. It is noted that the *Decision Methodology for Solids for the April 2002 Water Quality Inventory (updated in February of 2012)*[1], makes a specific distinction between two different, although related 'sediment' impairment types in free flowing streams:

[1]http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Documents/Assessment_Methodologies/AM_Solids_2012.pdf

1. **TSS**: The first type is an impact to water clarity with impairment due to TSS using turbidity measured in Nephelometer Turbidity Units (NTUs). Although numeric criteria have not been established in Maryland for TSS, MDE uses a threshold for turbidity, a measurement of water clarity, of a maximum of 150 Nephelometer Turbidity Units (NTU's) and maximum monthly average of 50 NTU as stated in Maryland COMAR regulations (26.08.02.03-3). Turbidity also may not exceed levels detrimental to aquatic life in Use I designated waters.
2. **Sedimentation / siltation**: The second type is an impact related to erosional and depositional impacts in wadeable streams. The measures used are biocriteria and the critiera for Use I streams (the protection of aquatic life and growth and propagation of fish (other than trout) and other aquatic life).

With these two sediment impairments in mind the Little Patuxent, which is listed as impaired for TSS, would seem to be water clarity issue; however the methodology used for listing (biological and habitat measures related sediment deposition) seems to point to an in-stream sediment deposition problem. In all likelihood both types of impairment, water clarify and sedimentation, are factors and both should be incorporated into monitoring programs to track changes in the watershed condition over time.

Anne Arundel County's Watershed Protection and Restoration Program (WPRP) has several on-going monitoring programs that target measures of water clarity and sedimentation. These programs are described here.

Countywide Biological Monitoring

In 2004, a Countywide Biological Monitoring and Assessment Program for Anne Arundel County, Maryland was developed to assess the biological condition of the County's streams at multiple scales (i.e., site-specific, primary sampling unit (PSU), and countywide). Under the Countywide Biological Monitoring and Assessment program, biology (i.e., benthic macroinvertebrates) and stream habitat, as well as geomorphological and water quality parameters, are assessed at approximately 240 sites throughout the entire County over a 5-year period using a probabilistic, rotating-basin design. Round One of the County's Biological Monitoring and Assessment Program occurred between 2004 and 2008, and Round Two took place between 2009 and 2013. Round Three is scheduled to be conducted beginning in 2016.

The biological monitoring program's stated goals are applicable at three scales; Countywide, Watershed-wide, and Stream-specific, and include the following components.

- Status: describe the overall stream condition
- Trends: how has the overall stream condition changed over time
- Problem identification/prioritization: identify the impaired and most degraded streams
- Stressor-response relationships: identify anthropogenic stressors and their biological response
- Evaluation of environmental management activities: monitor the success of implemented programs and restoration/retrofit projects

The Little Patuxent watershed is made up of one PSU – Little Patuxent. Ten sampling sites were sampled in each of these PSUs in each round of sampling. Methodologies follow those used by MBSS for the biological sampling (benthic macroinvertebrates only) and habitat evaluations have included both MBSS's Physical Habitat Index (PHI) and the EPA's Rapid Bioassessment Protocol (RBP) metrics. In-situ water quality measures are also collected at each site along with a geomorphic evaluation utilizing cross-sections, particle substrate analysis using pebble counts, and measures of channel slope.

Following these procedures, the County is collecting several parameters related to water clarity and sediment deposition at each site.

- Water Quality Measures and Observations
    - Turbidity (measured), observations of general water clarity and color
- Biological Measures
    - Benthic macroinvertebrates (BIBI)
- Habitat Measures
    - General: bar formation and substrate, presence/absence of substrate type
    - PHI: epibenthic substrate, instream habitat
    - RBP: epifaunal substrate / available cover, pool substrate characterization, sediment deposition, channel alteration
- Geomorphic Measures
    - Particle size analysis using modified Wolman pebble counts at 10 transects proportioned by channel bed features

Results summarized at the PSU scale with mean BIBI and habitat ratings (PHI and RBP) are presented in Table 20.

Table 20: Countywide Biological Monitoring Results for Little Patuxent River

PSU Name	Round	PSU Code	Year Sampled	Drainage Area (acres)	BIBI Rating	PHI Rating	RBP Rating
Little Patuxent	1	17	2007	28,196	P	D	PS
Little Patuxent	2	17	2009	28,196	P	PD	PS

BIBI Ratings: G = Good, F = Fair, P = Poor, VP = Very Poor
PHI Ratings: MD = Minimally Degraded, PD = Partially Degraded, D = Degraded, SD = Severely Degraded
RBP Ratings: C = Comparable, S = Supporting, PS = Partially Supporting, NS = Non-Supporting

Restoration Monitoring

To evaluate management activities, the County uses assessment methods similar to the Countywide program (biological monitoring, water chemistry sampling, physical habitat, geomorphic evaluation) to assess baseline and post-restoration conditions for select stream, wetland and stormwater restoration and retrofit sites. In addition, these techniques are utilized to meet several NPDES MS4 permit monitoring requirements, particularly related to Assessment of Controls and Watershed Restoration Assessment.

Watershed Assessment

In 2001, Anne Arundel County initiated a series of systematic and comprehensive watershed assessments and management plans for restoration and protection across the County. The plans are developed within a regulatory context that includes NPDES MS4 requirements, local TMDLs and Watershed Implementation Plans for the Chesapeake Bay TMDL, Maryland Stormwater Regulations and the Water Resources Element of the County's General Development Plan.

Biological monitoring is a component of the characterization and prioritization process within the management plans. The biological monitoring data is primarily utilized in the County's Watershed Management Tool (WMT), which is developed and maintained by the WPRP. Within this program, sampling sites are selected using a targeted approach with the goal of having at least one, and sometimes two sites located within each subwatershed planning unit in order to examine the relationships between land use and ecological conditions downstream. Monitoring components include benthic macroinvertebrate community sampling, *in situ* water chemistry measurements, and instream and riparian physical habitat condition assessments. Water quality grab sampling and detailed geomorphic assessments have been included for some watershed studies, but not as routine monitoring components.

The WAP program's stated goals include:

- Characterize subwatersheds;
- Prioritize subwatersheds for preservation and restoration; and
- Inform stressor-response relationships for planning and modeling.

The County continues to reevaluate its monitoring programs as the state of the science progresses, as the understanding of water quality and ecological interactions are improved, and as regulatory programs are added or modified. The WPRP is currently reviewing the Countywide monitoring program to ensure that the methods used are appropriate and meaningful, and that TMDL and NPDES requirements continue to be met.

11 References

Anne Arundel County. 2009. General Development Plan. Adopted October 19, 2009; Bill No. 64-09. Annapolis, MD.

Anne Arundel County. 2010. Stormwater Management Practices and Procedures Manual. Revised November 22, 2010; updated February 1, 2012. Annapolis, MD.

Anne Arundel County. 2012. Anne Arundel County Government Chesapeake Bay TMDL Phase II Watershed Implementation Plan – July 2, 2012. Annapolis, MD.

Anne Arundel County. 2014. Little Patuxent River Watershed Assessment Comprehensive Summary Report. Prepared by Anne Arundel County Watershed Assessment and Planning Program, Annapolis MD;

Anne Arundel County, Department of Public Works. 2015. FY15 Enhanced Street Sweeping Program. Annapolis, MD.

CWP. 2003. Impacts of impervious cover on aquatic ecosystems. Center for Watershed Protection, Ellicott City, Maryland. 142p.

CWP. 2008. Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin. Prepared by the Center for Watershed Protection, Ellicott City, MD. Prepared for U.S. EPA as fulfillment of the U.S. EPA Chesapeake Bay Program grant CB-973222-01.

House Bill 987. 2012. State of Maryland General Assembly. Annapolis, MD

MDE. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26- Department of the Environment. 26.08.02.01- Water Quality.

MDE. 2011a. Total Maximum Daily Loads of Sediment in the Little Patuxent River Watershed, Howard and Anne Arundel Counties, Maryland. Maryland Department of the Environment, Baltimore, MD. Prepared for Water Protection Division, U.S. Environmental Protection Agency, Region III. Philadelphia, PA.

MDE. 2011b. Watershed Report for Biological Impairment of the Little Patuxent River in Anne Arundel and Howard Counties, Maryland – Biological Stressor Identification Analysis Results and Interpretation. Maryland Department of the Environment, Baltimore, MD. Prepared for Water Protection Division, U.S. Environmental Protection Agency, Region III. Philadelphia, PA.

MDE. 2012a. Maryland's Final 2012 Integrated Report of Surface Water Quality. Maryland Department of the Environment. Baltimore, MD. Online at: http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Pages/2012_IR.aspx

MDE. 2012b. Decision Methodology for Solids for the April 2002 Water Quality Inventory (updated in February of 2012).

http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Documents/Assessment_Methodologies/AM_Solids_2012.pdf

MDE. 2014a. Maryland's Draft 2014 Integrated Report of Surface Water Quality. Maryland Department of the Environment. Baltimore, MD. Online at: http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Pages/2014IR.aspx

MDE. 2014b. General Guidance for Developing a Stormwater Wasteload Allocation (SW-WLA) Implementation Plan. Maryland Department of the Environment. October 2014. Baltimore, MD.

Rosgen, D.L. 1996. Applied River Morphology (Second Edition). Wildland Hydrology. Pagosa Springs, CO.

Scueler, T.R. 1987. Controlling urban runoff: a practical manual for planning and designing urban BMPs. Metropolitan Washington Council of Governments. Washington, D.C.

Schueler, T. 1994. The importance of imperviousness. Watershed Protection Techniques, 1(3), 100-111.

Simpson, T., and S. Weammert. 2009. Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus, and Sediment in the Chesapeake Bay Watershed. December 2009. University of Maryland Mid-Atlantic Water Program.

USEPA. 2001. PLOAD Version 3.0, An ArcView Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects. January 2001. Developed by CH2M HILL.

USEPA. 2010. Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment, December 29, 2010. U.S. Environmental Protection Agency in collaboration with Delaware, the District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia. Region 3 - Chesapeake Bay Program Field Office. Annapolis, MD.
http://www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/tmdlexec.html