PATUXENT WATERSHED IMPLEMENTATION PLAN (including Pre-Assessment)

PREPARED FOR:

MONTGOMERY COUNTY

DEPARTMENT OF ENVIRONMENTAL PROTECTION

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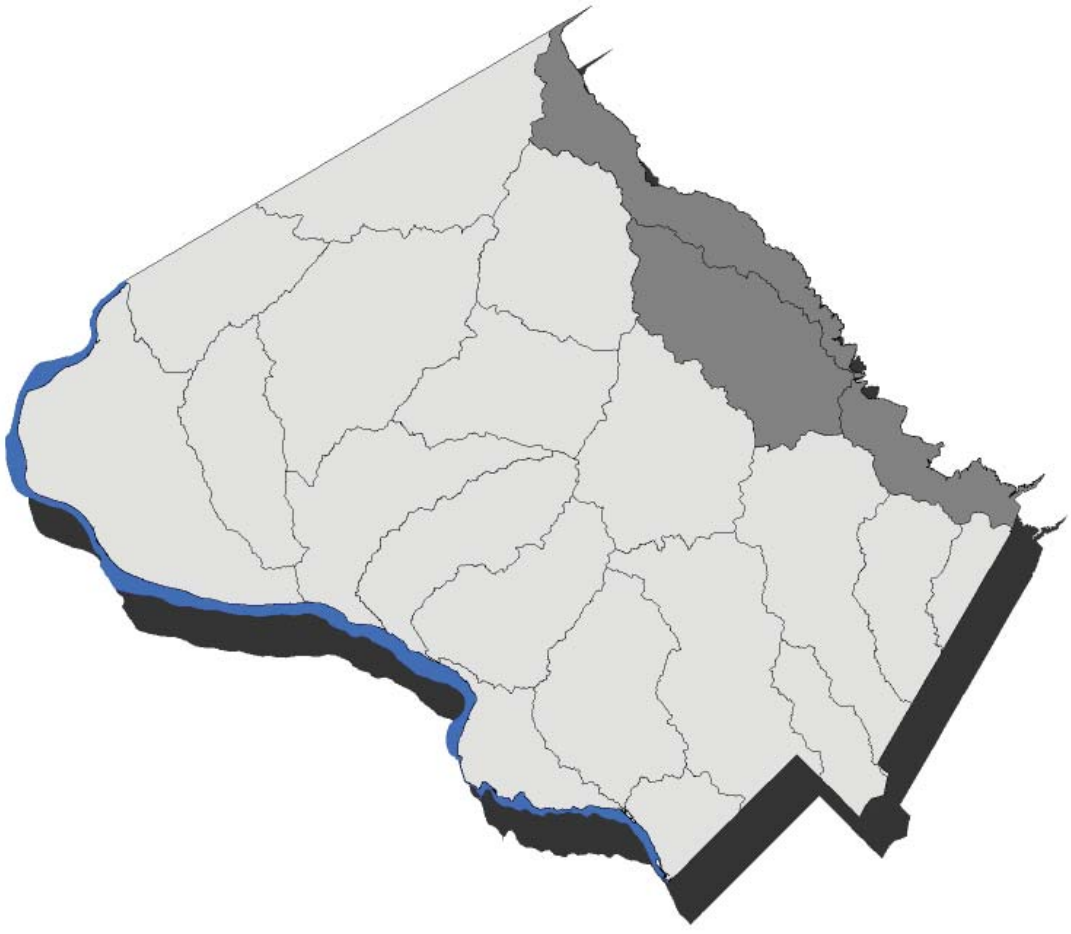

January 2012

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Patuxent Watershed Draft Implementation Plan (including Pre-Assessment)

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Notes to Reader:

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

Acronym list

BMPs – best management practices

DA – drainage area

DEP – Department of Environmental Protection

DF – discount factor

DU – dwelling unit

EPA – Environmental Protection Agency

ESD – environmental site design

GIS – geographic information systems

HOA – homeowners association

IA – impervious area

IC – impervious cover

LDR – low density residential

LID – low impact development

MDE – Maryland Department of the Environment

MEP – maximum extent practicable

MDP – Maryland Department of Planning

MNCPPC – Maryland National Capital Parks and Planning Commission

MPN – most probable number

MPR – maximum practicable reductions

MS4 – municipal separate storm sewer system

NPDES – National Pollutant Discharge Elimination System

SPA – special protection area

TFPI – Trash Free Potomac Watershed Initiative

TMDLs – total maximum daily loads

TN – total nitrogen

TP – total phosphorus

TSS – total suspended solids

USACE – U.S. Army Corps of Engineers

WLAs – waste load allocations

WQPC – water quality protection charge

WRAP – watershed restoration action plan

WTM – watershed treatment model

1 Goals and Existing Conditions

1.1 Introduction to the Draft Implementation Plan (including Pre-Assessment) and Watershed Goals

To successfully meet its regulatory requirements and environmental goals, Montgomery County must complete watershed assessments until all land area in the County is covered by a specific implementation plan to address the water quality problems that are identified through the assessments. No plan has yet been completed for the Patuxent Watershed, nor have watershed assessments been completed for two of its three component subwatersheds – the Upper Patuxent subwatershed and the Lower Patuxent subwatershed. Therefore, the County has undertaken preparation of this combined "pre-assessment" and draft implementation plan as the first step toward completing a Watershed Implementation Plan ("The Plan"). The plan must meet the requirements of the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer (MS4) Permit to show progress towards meeting the wasteload allocations (WLAs) for any EPA-approved total maximum daily loads (TMDLs) and add runoff management to drainage from impervious acres not currently managed to the maximum extent practicable. The Recommended Framework for Future Watershed Implementation Plans describes this process in detail and provides background information on how the pre-assessments are being developed and will evolve into watershed implementation plans.

The specific goals of this document for the Patuxent Watershed are to

- Summarize the current environmental conditions of the watershed including known sources of impairment such as 303d listed waterbodies, 305b reports, and indices of biological integrity and integrate the Hawlings River Watershed Restoration Action Plan (WRAP).
- Describe the current land uses of the watershed, particularly imperviousness and its distribution across land uses, as well as forest cover, especially as it relates to stream buffer
- Describe existing stormwater management practices
- Conduct a neighborhood-scale desktop analysis of best management practice (BMP) opportunities using priorities previously agreed upon by MCDEP
- Meet the requirements of relevant County MS4 permit sections
    a. Targeted waste load allocations (WLAs) for EPA-approved **Total Maximum Daily Loads (TMDLs)**
    b. Watershed restoration via **runoff management and impervious cover treatment**

This draft Plan outlines a comprehensive roadmap for watershed restoration that targets runoff management, phosphorus and sediment reduction for the Montgomery County controlled portions of the Upper Patuxent subwatershed which drain into the Triadelphia reservoir, and County controlled portions for the Lower Patuxent subwatershed and Hawlings River subwatershed which drain into the Rocky Gorge

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

Reservoir. The draft Plan focuses the restoration effort on the County MS4 permit area which comprises 14% of the total Patuxent Watershed. The County MS4 permit area has approximately 15% (826 acres) impervious cover within the Patuxent Watershed.

TMDLs

The 2008 TMDL document (MDE 2008), submitted by the Maryland Department of the Environment (MDE) in 2007 and approved by EPA in November 2008, establishes TMDLs for the nutrient and sediment impairments in the Triadelphia Reservoir and nutrient impairment in the Rocky Gorge Reservoir. In addition, the MDE will be developing nutrient WLAs as part of the Chesapeake Bay TMDL for the State of Maryland. This draft Plan addresses and documents phosphorus and sediment loading to the Patuxent reservoirs from the County MS4 permit area of the Patuxent Watershed in Montgomery County. It also tracks potential reduction of phosphorus and sediment loads through application of various watershed restoration practices. This Plan focuses on achieving the maximum practicable reductions as recommended by the state in the TMDL document. MDE indicated that the required reduction should be implemented to result in the attainment of the water quality criteria that support the Use I-P (Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply) and IV-P (Recreational Trout Waters and Public Water Supply) designation for Rocky Gorge and Triadelphia Reservoirs and result in acceptable lifespan for the Rocky Gorge Reservoir.

The restoration potential of the full suite of BMPs presented in this Plan can result in 43% load reductions for total phosphorus (TP) and 40% for total suspended solids (TSS).

Runoff Management and Impervious Cover Treatment

The County MS4 permit requires that the County restore an additional 20% of untreated impervious cover to the maximum extent practicable (MEP) on a Countywide basis during the five-year County MS4 permit cycle. Full implementation of projects identified through this Plan can provide control of an additional 429 acres of untreated impervious.

1.2 Existing Conditions in the Patuxent Watershed

Introduction to the Patuxent Watershed

The Patuxent Watershed in Montgomery County drains to the two-reservoir system maintained by Washington Suburban Sanitary System (WSSC): Triadelphia and Rocky Gorge Reservoirs. The Patuxent River begins in Frederick County and then flows through seven other counties: Howard, Montgomery, Prince George's, Anne Arundel, Charles, Calvert, and St. Mary's Counties. It is a major tributary to the Chesapeake Bay and has been the focus of interjurisdictional watershed protection since the early 1980s. The 132-square-mile drainage area for the two reservoirs is distributed among four counties, but 99% of the drainage area lies in Montgomery County and Howard County, with

Outreach and Stewardship Strategy Demographic Snapshot:
The Patuxent Watershed is dominated by single family homes. There are not a lot of schools in this watershed; consequently, outreach and education activities should not focus heavily on school children, but rather target homeowners.

Language Considerations:
Asian and Latino populations are minimal in this watershed. Consequently, outreach and stewardship education materials can be provided in English with little risk of missing significant portions of the population.

39,600 acres or 46% of the total watershed in Montgomery County and 44,800 acres or 53% of the total watershed in Howard County. Less than 1% lies within Prince George's and Frederick counties (Montgomery County DEP 1995).

In Montgomery County, there are three subwatersheds – Upper Patuxent, Lower Patuxent, and Hawlings River – as seen in Figure 1. The total drainage area of these subwatersheds is approximately 61 square miles, about seven percent of the total Patuxent River basin. Principal land uses in the Patuxent Reservoirs watershed are agricultural cropland, pasture, and large-lot residential, with many large areas of forested parkland. Since 1996, there has been a local, interjurisdictional agreement to protect the resources of the reservoirs, tributaries, and contributing drainage.

The Reservoirs

The Triadelphia Reservoir (basin code 02-13-11-08), created by construction of the Brighton Dam in 1943, and the Rocky Gorge Reservoir (basin code 02-13-11-07), created by construction of the T. Howard Duckett Dam in 1952, and the watershed that feeds them, provide source drinking water (11 billion gallons annually) for the approximately 650,000 inhabitants in the supply area of Prince George's and Montgomery counties Maryland. The reservoirs are located in the upper, non-tidal reaches of the 100-mile long Patuxent River. The Triadelphia Reservoir drains 79 square miles. The Rocky Gorge lies 13 miles downstream and drains 132 square miles in total (EA Engineering, 1991).

Outreach and Stewardship Strategy Potential Partners:
The Plan could build on existing intergovernmental relationships that are a part of the watershed protection group, and include them in outreach and education activities in this watershed.

The current efforts of WSSC to reach out and organize a group of Montgomery and Howard county residents around their passion for the reservoirs should continue to be supported as well as the efforts of MNCPPC to cooperate with the Patuxent Riverkeeper to strengthen its outreach activities in the watershed as sources of volunteers for watershed activities and as a catalyst to forming "Friends of" organizations in the watershed.

Angler groups such as Trout Unlimited, and schools such as Rosa Parks MS and the townships of Olney and Brookeville should be nurtured as partners for information dissemination and a source of volunteers for riparian buffer installations and similar projects.

Upper Patuxent

The Upper Patuxent subwatershed is largely rural and residential, including portions of Damascus, and drains 13,316 acres (21 square miles). The Upper Patuxent River supports a naturally reproducing brown trout population and Maryland Department of Natural Resources has designated this reach as a special catch and release stream above Triadelphia Reservoir. The streams in this subwatershed are generally of high quality and many serve as reference streams for the County's stream monitoring program.

Hawlings River

The Hawlings River begins south of the intersection of Routes 108 and 650, and flows into the Patuxent River upstream of the Rocky Gorge Reservoir. It drains 18,034 acres (28 square miles). There are three distinct land types associated with the Hawlings River. The headwaters are

characterized by rolling agricultural lands. The middle area has a steep, narrow valley with a rocky grade where stream velocity increases substantially and is protected by the Rachel Carson Conservation Area. The lower portion of the stream transitions into a sandy loam floodplain. The transition in geology, combined with uncontrolled storm flows from the Olney Mill tributary have resulted in severe bank erosion and scour pools.

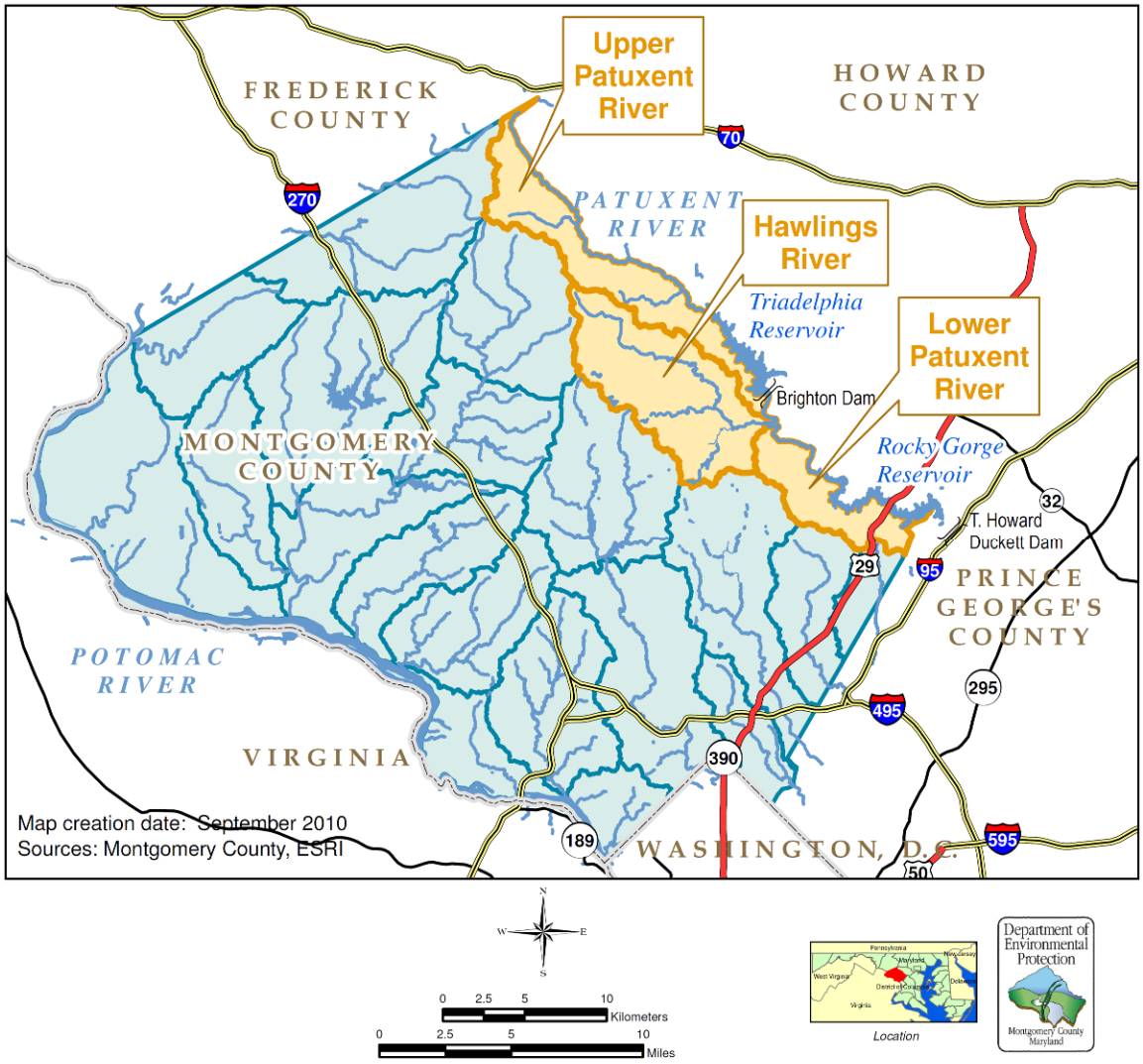

Figure 1: The Patuxent Watershed in Montgomery County, MD, including the three constituent subwatersheds: Upper Patuxent, Hawlings River, and Lower Patuxent

The County completed the Hawlings River Watershed Restoration Study (CPJ and EQR, 2003) to inventory problems and to identify possible retrofit and stream restoration projects to reduce sediment and nutrient loads to Rocky Gorge Reservoir and protect the local stream systems. The Study's recommendations are detailed in Section 2.2 below.

Of the three subwatersheds to the Patuxent Reservoirs, the Hawlings River has the most urban/suburban uses, including drainage from Olney and Brookeville. There is also significant

drainage from the closed Oaks Landfill. Regional instream stormwater ponds were used in several tributaries of Reddy Branch. This type of structure reduces instream habitat upstream from the structure due to the need for heavy bank armoring to prevent erosion.

Lower Patuxent

The Lower Patuxent subwatershed consists of the drainage area downstream of Brighton Dam and from the confluence of the Hawlings River to the County line. It drains 7,170 acres. This area primarily receives drainage from areas of agricultural and large-lot developments except for some limited commercial development along Rte. 29 in Burtonsville. The drainage flows into the Rocky Gorge Reservoir. The mainstem and lower reaches of the main tributaries are protected by state park lands and a forested buffer also protects the WSSC Reservoir; however, streams in the Lower Patuxent tend to exhibit higher levels of impairment than do the upstream tributaries.

Outreach and Stewardship Strategy Potential Partners:
The strength of the agricultural community in this watershed makes it likely that the local 4-H organization and soil conservation district has an in-place communication network that the county could work with for dissemination of outreach and education information.

Subwatershed Summaries

An initial overview summary of the Patuxent Watershed and each subwatershed is provided in Tables 1 through 3. A map depicting existing conditions is presented in Figure 2 and a map depicting resource conditions is presented in Figure 3.

Table 1: Upper Patuxent Subwatershed Profile

Metric	***Acres***	***Percent of Watershed***
Upper Patuxent		
Watershed Drainage Area	13316	100%
Impervious Cover	312	2%
Watershed Area Subject to County MS4 permit[1]	1346	10%
Impervious Cover Subject to County MS4 permit[1]	95	7%
Pervious Cover (e.g., forest, turf, meadow, farm fields)[1]	1,251	93%

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

Table 2: Hawlings River and Lower Patuxent Subwatershed Profile

Metric	*Acres*	*Percent of Watershed*
Hawlings River and Lower Patuxent		
Watershed Drainage Area	25204	100%
Impervious Cover	1321	5%
Watershed Area Subject to County MS4 permit[1]	4082	16%
Impervious Cover Subject to County MS4 permit[1]	731	18%
Pervious Cover (e.g., forest, turf, meadow, farm fields)[1]	3,351	82%

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

Table 3: Patuxent Watershed Profile

Metric	*Acres*	*Percent of Watershed*
Entire Patuxent Watershed		
Watershed Drainage Area	38,520	100%
Impervious Cover	1635	4%
Watershed Area Subject to County MS4 permit[1]	5428	14%
Impervious Cover Subject to County MS4 permit[1]	826	15%
Pervious Cover (e.g., turf, meadow, farm fields)[1]	4,602	85%

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

The entire watershed subject to the County MS4 permit is 14% of the total watershed grouping. A total of 15% (826 acres) of all imperviousness in the Patuxent Watershed is subject to the County MS4 permit. Excluding rural zoning, all Maryland National Capital Park and Planning Commission (MNCPPC) lands, Federal and State property, and Federal and State roads, 18% of the watershed grouping is covered by forest.

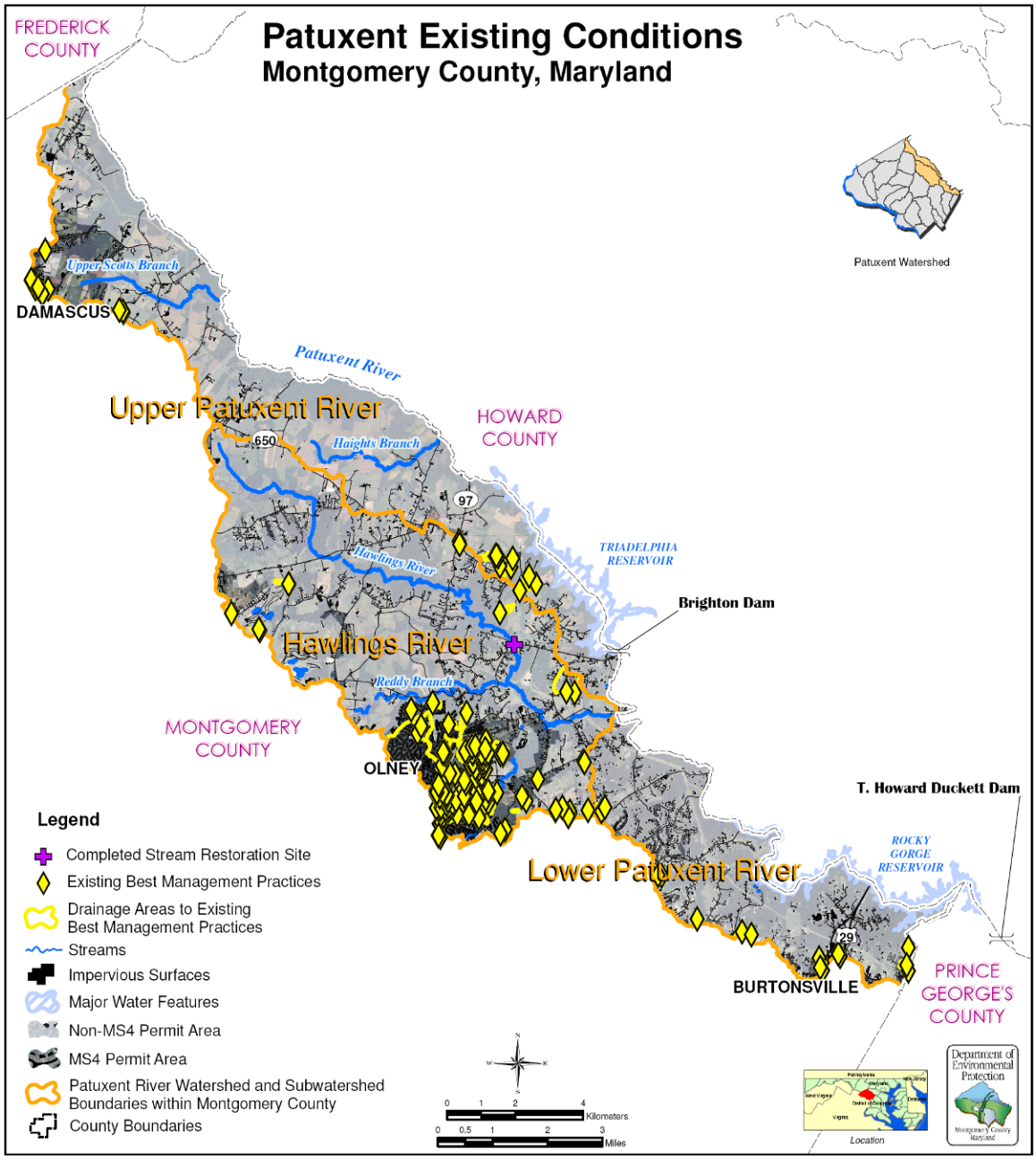

Figure 2: Existing conditions in Patuxent Watershed

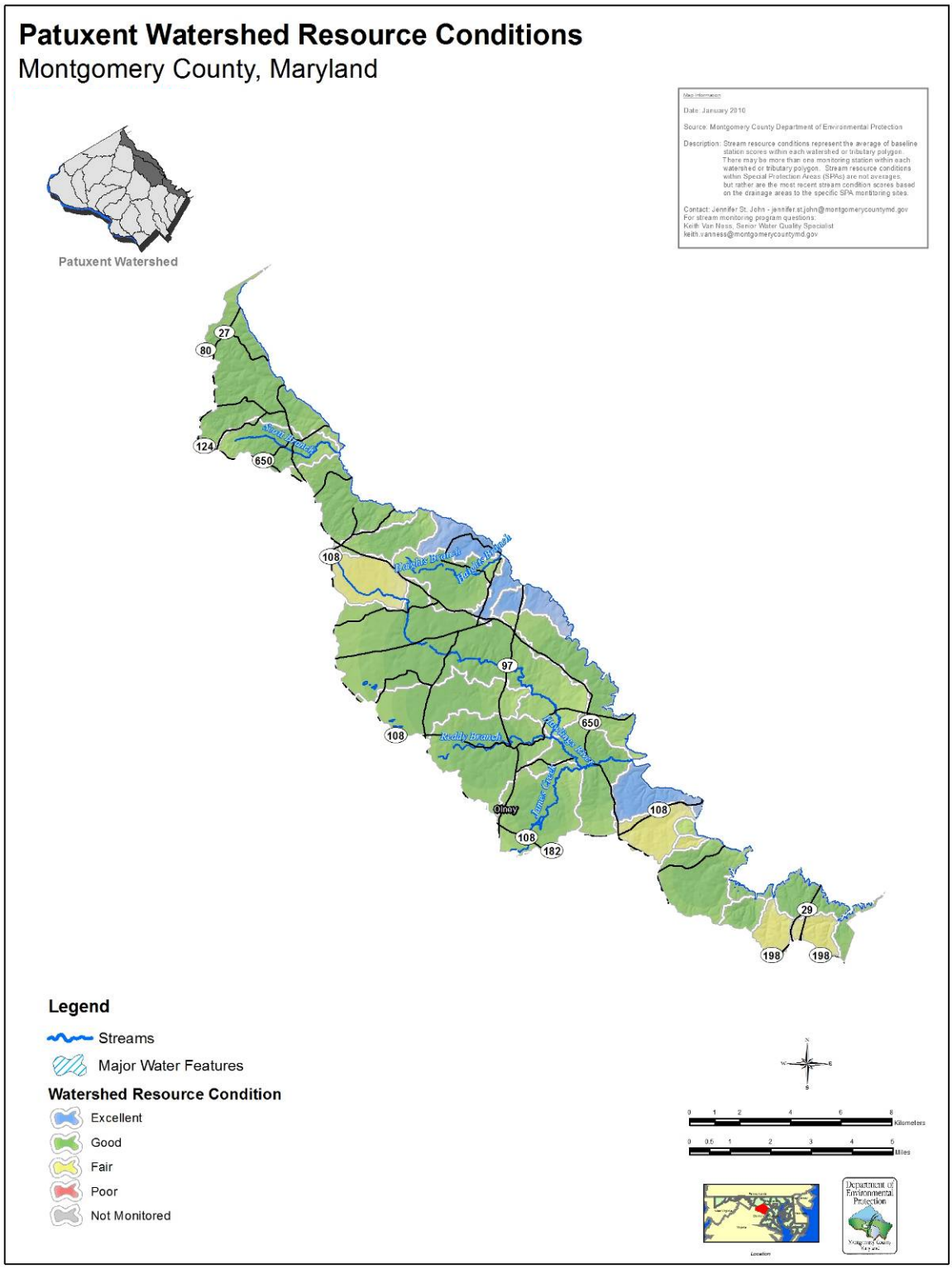

Figure 3: Stream Resource Conditions for the Patuxent Watershed

2 Upper and Lower Patuxent Pre-Assessment

2.1 Land Use Characteristics

Figure 4 and Table 4 below depict detailed 2002 land use characteristics for the Upper and Lower Patuxent subwatersheds in the Patuxent Watershed. The Hawlings River subwatershed is not included here as it was already the focus of two studies but subwatershed analysis is presented subsequently in Section 2.2. Figure 5 depicts the location of impervious surfaces within the Upper and Lower Patuxent subwatersheds and Figure 6 shows the extent of forest cover in Upper and Lower Patuxent subwatersheds, as well as the extent of County MS4 permit area.

Table 4: Land use characteristics in the Upper and Lower Patuxent subwatersheds, Montgomery County, Maryland. Hawlings River subwatershed is not included here.

Land use group	*Upper Patuxent*		*Lower Patuxent*	
	Acres	*Percent of total*	*Acres*	*Percent of total*
Open Urban Land, Forest, Institutional, Water, and Wetlands	5,686.7	42.7	3,536.2	49.3
Low-density residential	993.9	7.5	2,214.2	30.9
Medium-density residential	74.7	0.6	33.9	0.5
Roadways	170.4	1.3	158.2	2.2
Commercial	37.4	0.3	89.9	1.3
Agricultural operations	6,313.7	47.4	1,128.0	15.7
High-density residential	0.0	0.0	0.0	0.0
Industrial	0.0	0.0	0.0	0.0

Data source: Maryland Department of Planning, 2002

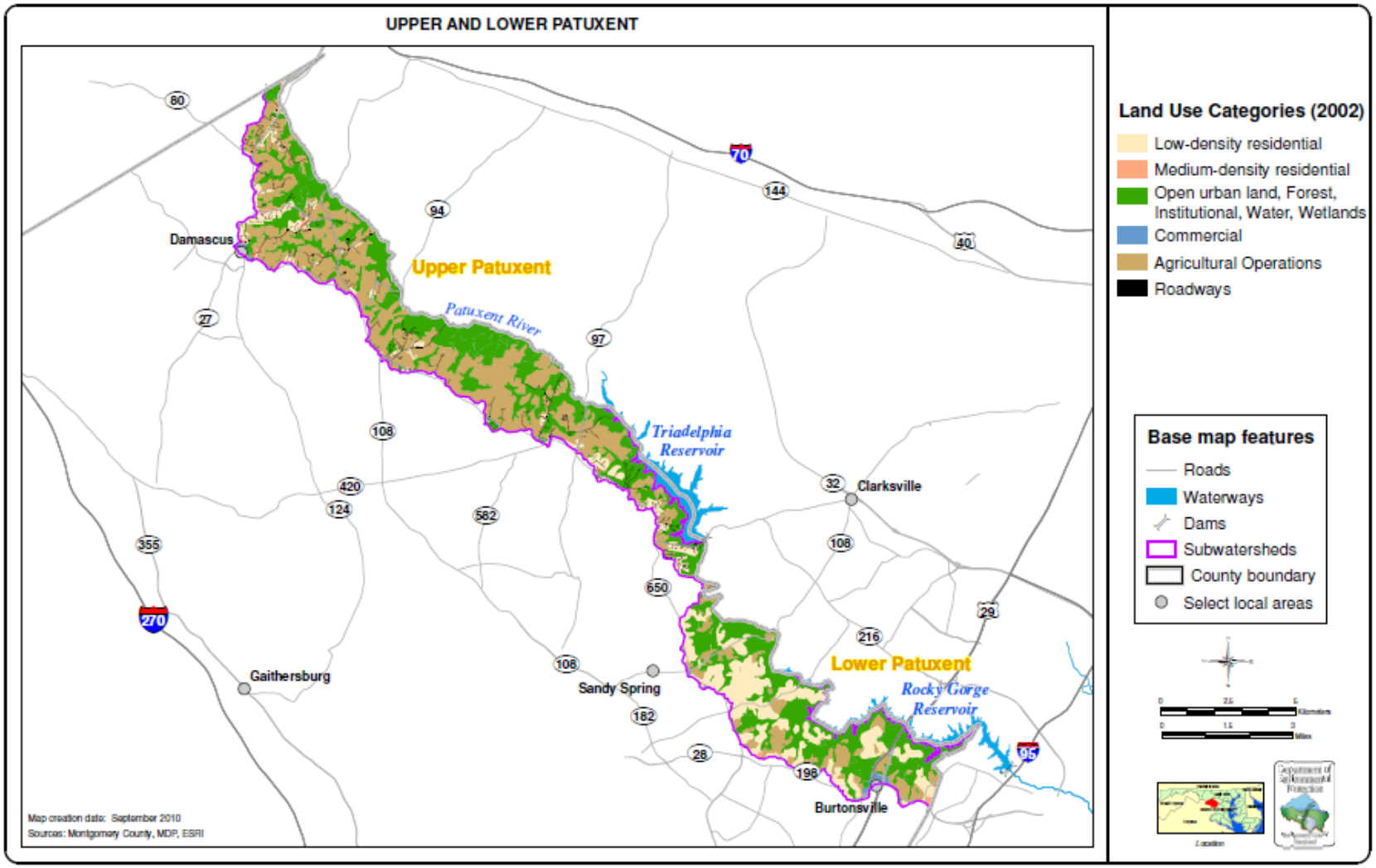

Figure 4: Land use characteristic of the Upper and Lower Patuxent subwatersheds, 2002 land use, Montgomery County, Maryland.

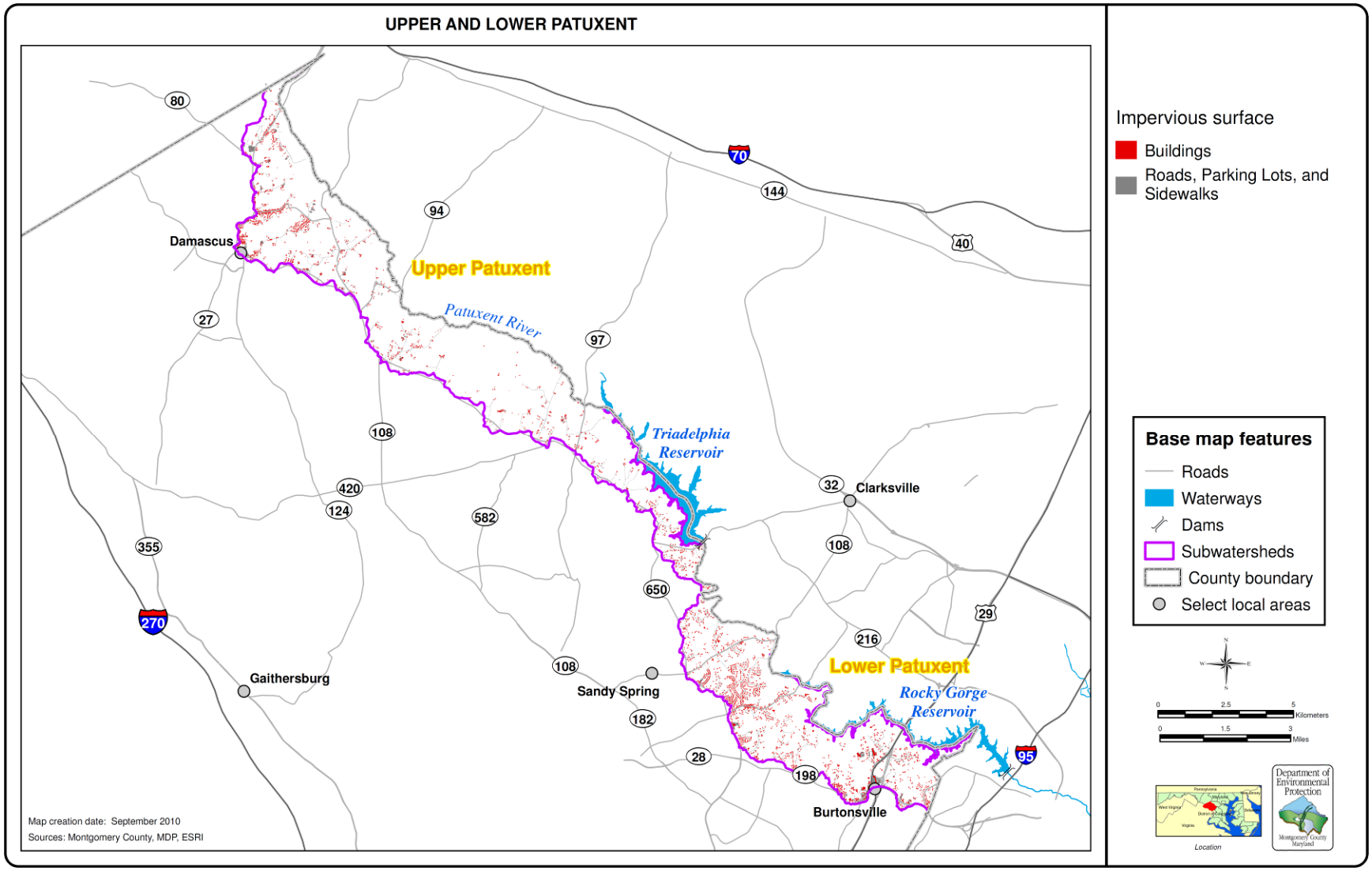

Figure 5: Extent of impervious surfaces in the Upper and Lower Patuxent subwatersheds of Montgomery County, Maryland.

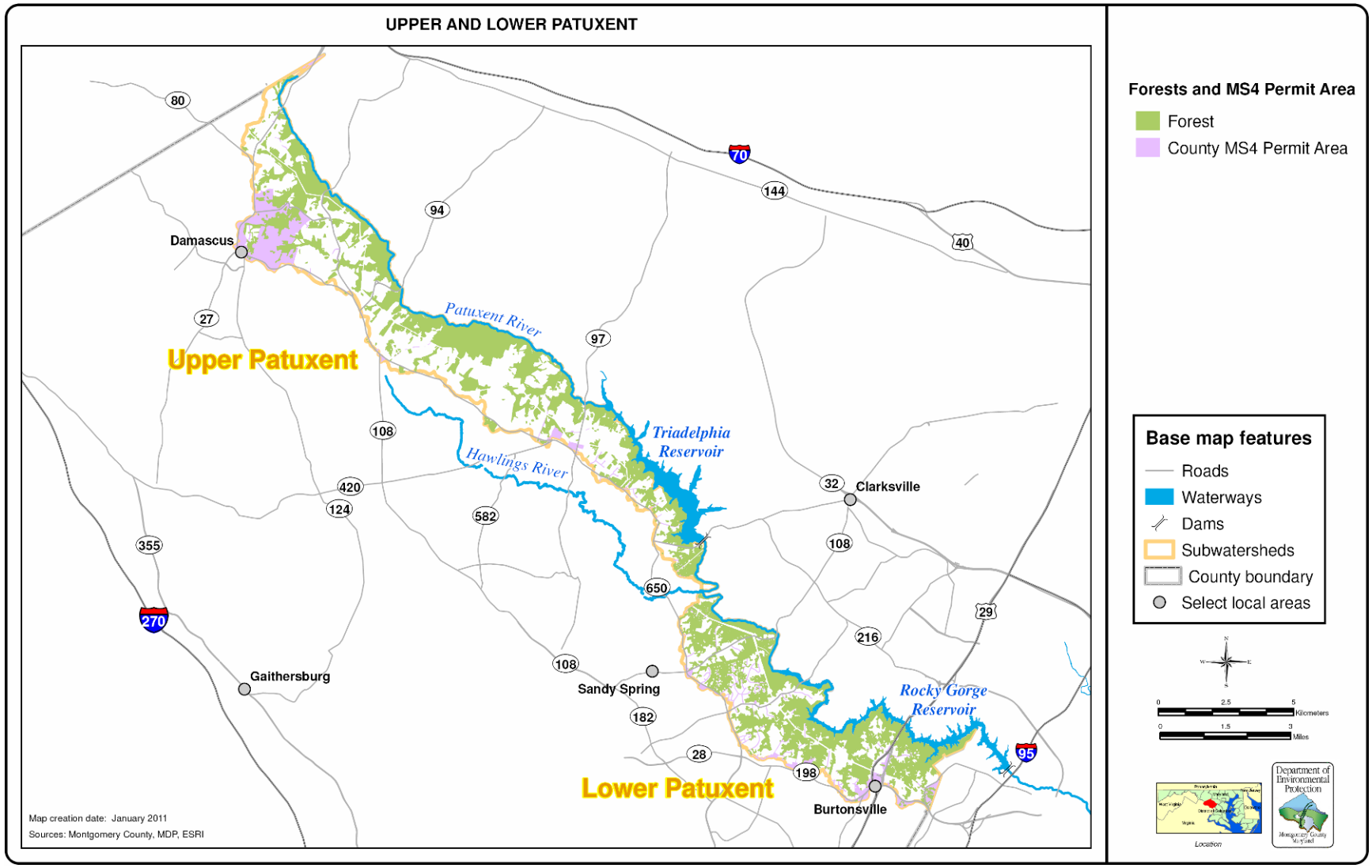

Figure 6: Extent of forest cover and MS4 permit area for the Upper and Lower Patuxent subwatersheds, 2008 Forest Cover data, Montgomery County, Maryland.

Table 5 details acres of impervious cover by type in the Lower and Upper Patuxent subwatersheds. County roads and roofs make up the majority impervious surfaces within the subwatersheds.

Table 5. Impervious cover by type for the Upper Patuxent and Lower Patuxent subwatersheds, Montgomery County, Maryland.

Major Impervious Constituents	*Lower Patuxent (acres)*	*Upper Patuxent (acres)*
Roads (acres)	158.2	170.4
County roads	75.5	46.7
Other roads	82.7	123.6
Parking Lots (acres)	64.8	59.5
County parcels (lots < 1 acre)	2.4	1.4
County parcels (lots > 1 acre)	0	2.7
Other	62.4	55.4
Roofs (acres)	114.4	81.8
County Property	2.0	1.1
Single-family residential	86.6	62.6
Public Schools	1.7	0.0
Other (not schools)	24.0	18.0
Other (acres)*	2.9	1.3
Sidewalks	0.4	0.2
Paved Courts	2.5	1.2
Total Impervious Acres	**340.1**	**312.9**

* Driveways have not been included in these impervious cover calculations.

Table 6 below details characteristics of stormwater management BMPs permitted before and after 1986 in the Upper Patuxent and Lower Patuxent subwatersheds only. Twenty-two (22) BMPs exist within the County MS4 permit area of the two subwatersheds, 14 were permitted after 1986. The majority of BMPs in the Upper and Lower Patuxent (19 of 22) lie outside the county MS4 permit area but have drainage within the MS4 permit area.

Table 6. Characteristics of BMPs (SWM BMPs) permitted before and after 1986 of the Upper Patuxent and Lower Patuxent subwatersheds, Montgomery County, Maryland. Does not include Hawlings River subwatershed.

BMP Permit Date	Number of BMPs within MS4 Permit Area	Total Drainage Area for BMPs within MS4 Permit Area (acres)[a]	Total Impervious Drainage Area (acres)	Average Drainage Area per BMP (acres)	Average Impervious Acreage Treated per BMP	Number of ESD-type BMPs / Average Impervious Acreage Treated per BMP[b]	Number of BMPs Outside of MS4 Permit Area with Part or All of Drainage within MS4 Permit Area	Total Drainage Area of BMPs Residing Outside MS4 Permit Area (acres)
Before 1986	3	2.3	1.7	0.8	0.6	0	3	499.0
After 1986	12	22.0	10	1.8	0.8	0/0	12	6.4
Year Not Specified	9	10.7	2.4	1.2	0.3	0	8	4.0
Total (all years)	24	35.0	14.1	N/A	N/A	0	23	509.4

(a) Only details drainage area of BMPs that are completely within the County MS4 permit area.
(b) Includes those BMPs categorized by county as Bioretention-type quality control.

Existing Stormwater BMPs

Figure 7 illustrates the locations of existing stormwater management devices, or "BMPs," in Upper and Lower Patuxent subwatersheds.

The Implementation Plan Guidance Document identifies three distinct "design eras," as follows:

- **Era 1: Pre-1986.** BMPs installed prior to full implementation of the Maryland Stormwater law of 1984, which typically focused on detention and peak discharge reduction
- **Era 2a: 1986 to 2002.** These practices reflect a design era where water quality was an important part of design, although water quality sizing and design standards were not as robust
- **Era 2b**: **2002 to 2009.** These practices were built to the more stringent water quality and channel protection sizing requirements and BMP design standards contained in the 2000 edition of the Maryland Stormwater Manual

As noted in Table 6, 24 BMPs exist within the Lower and Upper Patuxent subwatersheds; 3 were permitted before 1986 and are therefore candidates for retrofit. Twelve (12) BMPs were permitted after 1986 and are considered modern BMPs while 9 are of an unknown year. Table 6 also shows that the majority (23 of 24) of stormwater BMPs and the majority of BMP drainage area lie outside the MS4 permit area and only 2.3 acres within the MS4 permit area drain into BMPs permitted before 1986.

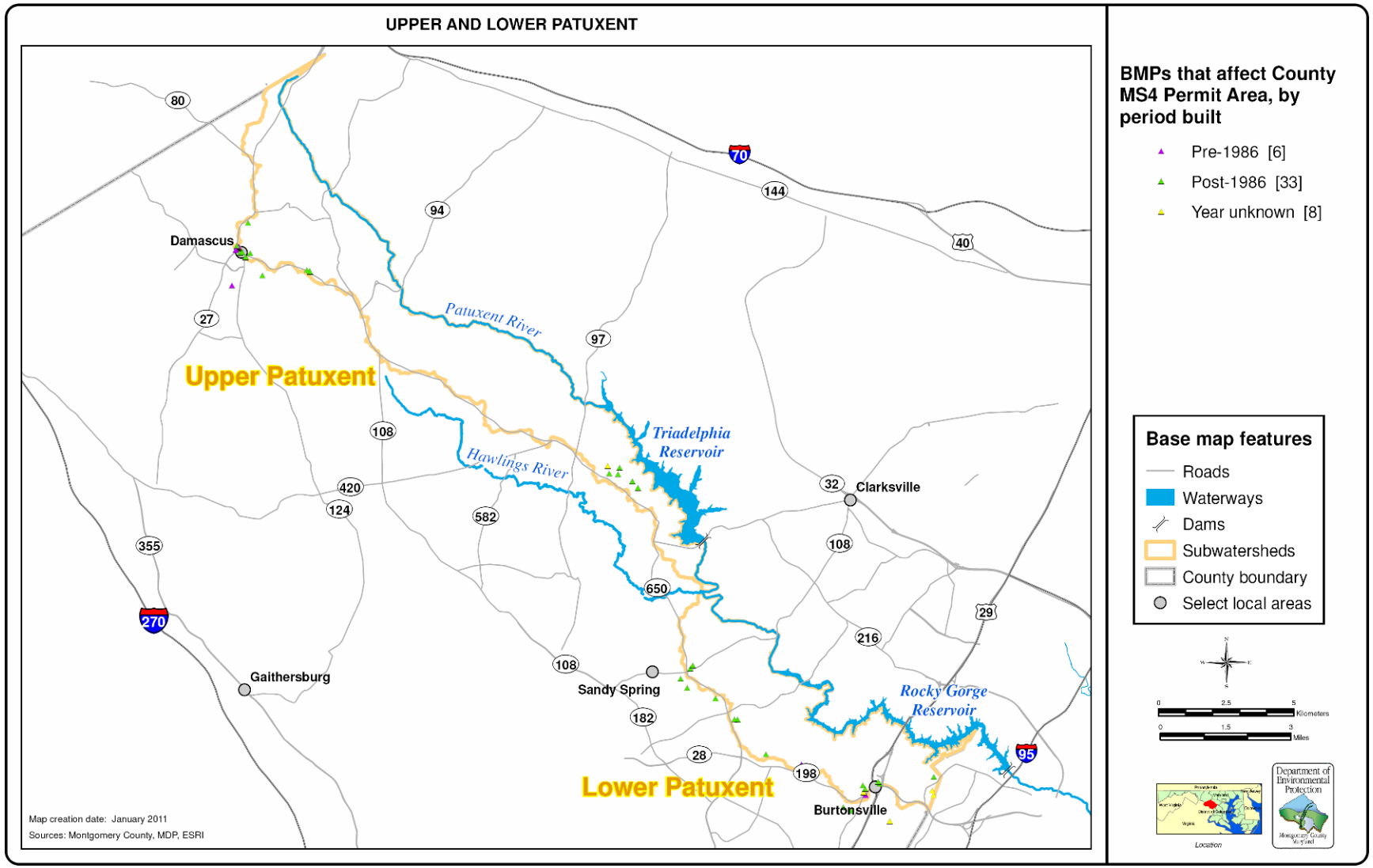

Figure 7: Stormwater BMPs (pre-1986, post 1986, and year-unknown) in the Upper Patuxent and Lower Patuxent subwatersheds with drainage areas affecting the County's MS4 permit area, Montgomery County, Maryland

Riparian Forested Buffers in Upper and Lower Patuxent Subwatersheds

Riparian forested buffers are being considered as a type of stormwater BMP for purposes of the County MS4 permit accounting system. A minimum width of 100 feet on each side of the stream will be considered to provide nutrient and pollutant reduction.

Outreach and Stewardship Strategy Education Project: To encourage habitat restoration on private property, stakeholder outreach is recommended on the important roles of riparian buffers. Implementation details are contained in the Practice Sheet entitled Riparian Reforestation Outreach and Stewardship Campaign.

Table 7 summarizes presence and absence of 100-foot forested riparian buffer on each side of the stream (as measured from the centerline of the streams and from the shoreline of the rivers). Notable is the significantly higher in percentage of unbuffered or unforested streams in the Upper Patuxent (32.7%) relative to the Lower Patuxent (14.2%).

Table 7. Forested acres and percent forest cover along 100-foot riparian buffer in the Upper and Lower Patuxent subwatersheds, Montgomery County, Maryland.

Riparian Condition	*Acres*		*Percent*	
	Lower Patuxent	*Upper Patuxent*	*Lower Patuxent*	*Upper Patuxent*
Forested	761.1	1123.8	85.8	67.3
Not Forested	126.0	545.4	14.2	32.7
TOTAL	887.1	1669.2	100.0	100.0

2.2 Upper and Lower Patuxent Desktop Analysis

Neighborhood-Scale Stormwater BMP Retrofit Opportunities for Upper and Lower Patuxent Subwatersheds

In coordination with Montgomery County DEP staff, priorities have been developed for implementation of candidate stormwater BMP retrofit projects. Figure 8 illustrates the location and priority of neighborhood-types which are grouped by Maryland Department of Planning guidelines for land-use types. Table 8 summarizes the total acreage and percentage associated with each land-use category and its relative contribution to the County's MS4 permit area.

Table 8. Stormwater BMP Retrofit Priorities in the Upper Patuxent and Lower Patuxent subwatersheds, Montgomery County, Maryland.

Stormwater BMP Retrofit Priority		***Candidate Acres in Subwatersheds (County MS4 Permit Area Only)***			***Percent in County MS4 Permit Area in Subwatersheds***	
		Upper Patuxent	***Lower Patuxent***	***Total Candidate Acres (Percentage of Total Candidate Acres)***	***Upper Patuxent***	***Lower Patuxent***
High	Areas treated by Pre-1986 Permitted BMPs	0.7	2.0	2.7 (0.5%)	0.1	0.3
Land-use Type						
Medium - a	Commercial, Industrial, and Churches	30.6	51.4	82.1 (15.5%)	2.3	9.2
Medium - b	Private schools	0.0	0.0	0.0 (<1%)	0.0	0.0
Medium - c	Apartments and Condominiums	0.0	1.0	1.0 (<1%)	0.0	0.2
Medium - d	Townhouse	0.0	0.1	0.1 (<1%)	0.0	0.0
Medium - e	High and Medium Scoring Residential Neighborhood Assessment Areas	163.2	52.9	216.1 (40.8%)	12.1	9.4
Low - a	Low Scoring Residential Neighborhood Assessment Areas	173.3	49.7	227.1 (42.9%)	13.2	8.9
Low - b	Golf courses	0.0	0.0	0.0 (0.0%)	0.0	0.0
	TOTAL	371.9 candidate acres – or 27.6% of total MS4 Permit Area	157.1 candidate acres - or 28.1% of total MS4 Permit Area	**529** candidate acres of 1906 total acres in MS4 Permit Area – or **27.8%**		

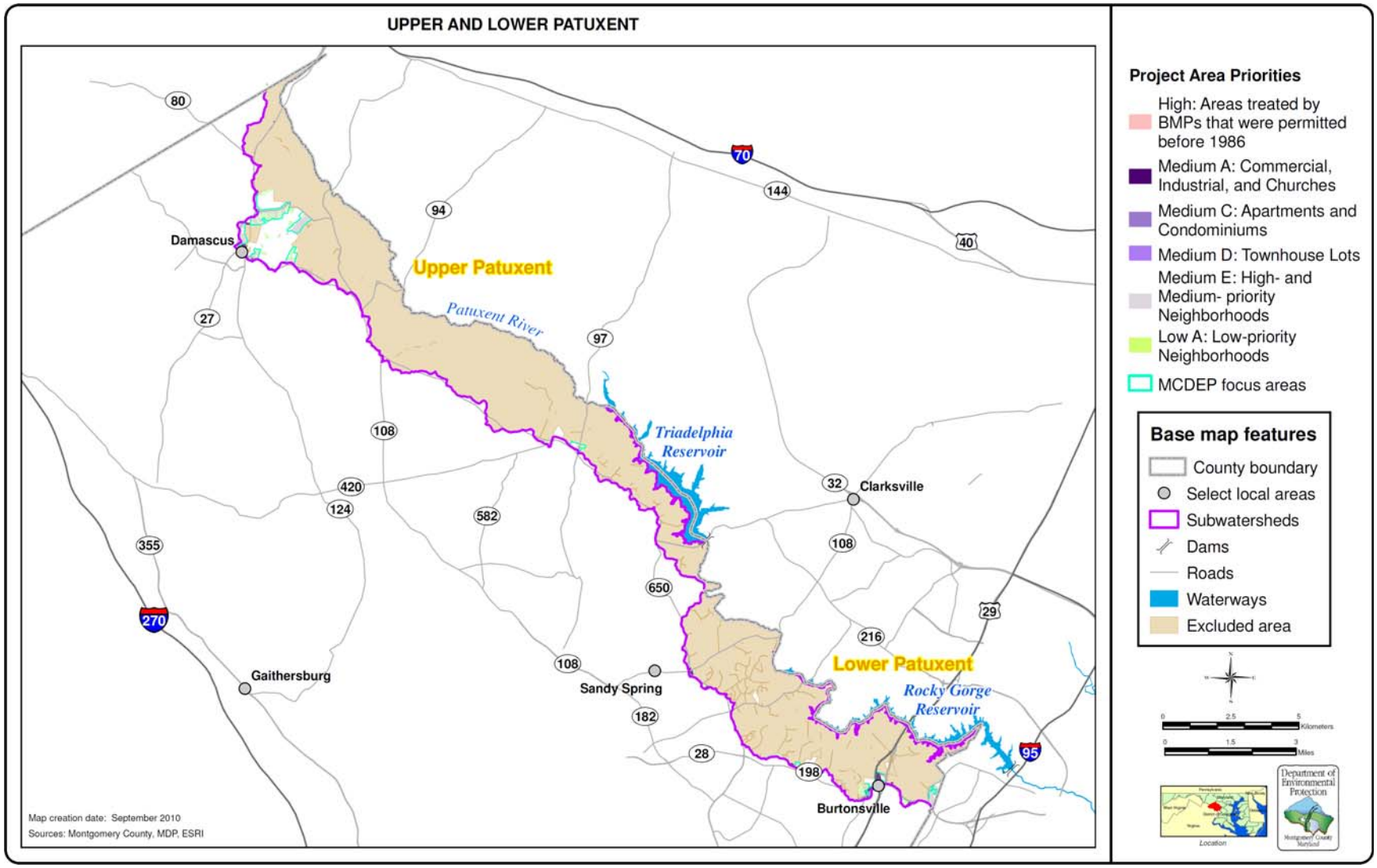

Figure 8: Project area priorities for candidate stormwater BMP retrofits in the Upper Patuxent and Lower Patuxent subwatersheds, Montgomery County, Maryland

The priorities for stormwater BMP retrofit project areas are as follows:

- **High Priority** candidate projects are modifications of or improvements to *existing BMPs*, which, in the case of Upper and Lower Patuxent, equates to 3 BMPs permitted *before* 1986, making up 2.7 acres or 0.5% of total candidate acreage for retrofit, almost all of which reside in the Lower Potomac subwatershed.

- **Medium Priority** candidate projects include the retrofit of developed privately owned parcels which have no existing stormwater management, with prioritization by particular *land-use types*.

  a) Commercial/Industrial/Churches

     Commercial and industrial properties, and some churches, tend to have large expanses of impervious surfaces in the form of parking lots and large flat roofs, with 72% imperviousness on average and similar parts forest (14.8%) and turf cover (13%). This is the highest imperviousness of any land use in the subwatershed grouping with the exception of roadways. In the case of commercial/industrial/churches, 82.1 acres or 15.5% under the MS4 permit area are not currently managed for stormwater.

  b) Private Schools

     Schools tend to have large parking lots and average 35.2% imperviousness with 50% in turf cover. Total acreage for private schools is small in the entire county and non-existent in the Upper and Lower Patuxent.

  c) Apartments and Condominiums (Multi-Family Residential)

     Average imperviousness is 44.4%, with 14.6% in forest cover and 49% as turf. This land-use category makes up only 1 candidate acre (<1%) for retrofit in the Lower Patuxent subwatershed.

  d) Townhouse Units

     This land-use type has an average of 36.8% imperviousness with 56.2% of land as turf. This land-use type makes up only 0.1 acres (<1%) of the total candidate acreage within the County's MS4 permit area.

  e) High and Medium Scoring Residential Neighborhood Assessment Areas

     These areas were determined by a desktop assessment that followed the basic approach taken in the Anacostia River Watershed Restoration Plan (USACE, 2010) to target residential areas suitable for on lot retrofitting that would potentially fit into a private residential ESD implementation program similar to the Rainscapes program. The criteria evaluated included lot size, home ownership, presence or absence of homeowners association (HOA), and presence or absence of existing BMPs. Neighborhood areas were then broken into tiers of high, medium, and low based on the points assigned to the various criteria. In the Patuxent, this land-use category equates to 163.2 and 52.9 acres in the Upper and Lower Patuxent, respectively, and a combined total of 40.8% of all available candidate acres in the two watersheds.

- **Low Priority** land-uses include low percentages of impervious and are considered the lowest priority for implementation of stormwater management retrofit. They include:

  - Low A - Low Scoring Residential Neighborhood Assessment Areas

    As described above, these are the areas that ranked low under the residential neighborhood assessment. Most such acreage exists in the Upper Patuxent Watershed (173.3 acres of 227.1 total acres). This category contains the largest percentage of candidate acres in the Upper and Lower Patuxent, at 42.9%.

  - Low B - Golf courses

    Golf courses have low imperviousness (4.5%), significant turf cover (80.7%) and forest cover (14.8%), making them a low priority for stormwater retrofits. There are no candidate acres of this land use type in the Upper or Lower Patuxent subwatersheds.

Priority Opportunities

Outreach and Stewardship Strategy Education Project:
To help watershed stakeholders understand what these retrofits are, stakeholder outreach such as installing educational signage is recommended as described in the Practice Sheet entitled Innovative Stormwater Management Outreach and Stewardship Campaign.

The priorities assigned in the desktop analysis are the best compromise between costs and benefits of potential restoration projects in the Upper and Lower Patuxent subwatersheds. Three (3) retrofit projects are available in the high priority category. The existing regional stormwater management BMPs drain 0.5% of candidate acres available for retrofit under the County's MS4 permit area in the two subwatersheds. Medium-priority candidate projects account for 56.3% of available treatable acreage in the County's MS4 permit area, primarily in the form of high and medium scoring Residential Neighborhood Assessment areas and to a lesser extent commercial & industrial land uses, as well as churches.

The low-priority category primarily comprises large private lots greater than 0.5 acres. While this land-use makes up a significant percentage (42.9%) of total candidate acres in the subwatersheds, these lots have low percentages of imperviousness per lot.

County Focus Areas

The desktop analysis, refined by first-hand knowledge provided by DEP staff who understand the historic land-use changes, planned zoning changes, planned development, status of existing stormwater BMPs, socio-political priorities, and constraints, among other factors, resulted in restoration "focus areas" as seen in Figure 8. These areas are unique to the watershed pre-assessments. These 15 focus areas include a mix of untreated land ranging from 7 to 155 acres, with an average untreated impervious surface of 80.1 acres per focus area and an average imperviousness of 22.8% per focus area across both subwatersheds. County schools are not included since these sites are being included as part of the County's public property retrofit

assessments. Table 9 summarizes the size, amount of imperviousness, and whether a focus area currently has any stormwater BMPs in place.

Table 9. Untreated acres, untreated impervious area, and percent in the total untreated acres in the focus areas of the Upper and Lower Patuxent subwatersheds, Montgomery County, Maryland

Focus Area	*Subwatershed*	*BMP Status*[(a)]	*Untreated Land Area in Focus Area (Acres)*	*Untreated Impervious Area in Focus Area (Acres)*	*Untreated Percent Impervious in Focus Area (Acres)*
1	Lower Patuxent	None[b]	9.3	1.2	13.4
2	Lower Patuxent	Pre-1986	12.6	5.4	42.6
3	Lower Patuxent	None	10.4	7.2	69.2
4	Lower Patuxent	None	36.5	23.5	64.2
5	Lower Patuxent	Year unspecified	23.9	3.5	14.8
6	Lower Patuxent	Year unspecified	60.5	5.9	9.7
		TOTAL	**153.2**	**46.7**	**38.8%**
1	Upper Patuxent	Post-1986	17.9	0.8	4.4
2	Upper Patuxent	None	8.1	0.5	5.8
3	Upper Patuxent	None	155.7	13.6	8.8
4	Upper Patuxent	None	41.7	3.6	8.8
5	Upper Patuxent	None	7.2	0.8	11.3
6	Upper Patuxent	None	38.9	3.3	8.4
7	Upper Patuxent	None	71.4	6.9	9.6
8	Upper Patuxent	None	19.5	2.0	10.1
9	Upper Patuxent	None	8.7	2.0	22.8
		TOTAL	**369.1**	**33.5**	**10.0**
	Grand Total for Both Subwatersheds		**522.3 Untreated Focus Areas acres**	**80.1 Untreated Focus Areas Impervious acres**	**22.8% Average Imperviousness across both Subwatersheds**

(a) BMP status indicates that one or more BMPs may exist in the particular focus area of the indicated BMP treatment era. Existing BMP drainage areas have been subtracted, hence specific indication of "untreated" acres in subsequent columns.

(b) "None" indicates areas that do not currently have any stormwater management in place.

3 Implementation Plan Watershed Profile

The following sections explore the restoration potential of all three subwatersheds of the Patuxent. The pre-assessment analyses conducted for the Upper and Lower Patuxent are combined with information from the Hawlings River Assessment to generate an overall Patuxent Watershed Implementation Plan.

3.1 County MS4 Land use

County MS4 land use in the watershed is displayed in Tables 10 through 12. Rural land use and forests are the dominant land use in the County MS4 permit area of the watershed grouping, covering about 1/3 of the watershed each. This is followed by low density residential, which covers 27% of the watershed grouping, on average (Table 12). The Lower Patuxent subwatershed is more developed relative to the Hawlings River and Upper Patuxent subwatershed with a lower proportion of forest land use (14%). Compared to the other two subwatersheds, the Lower Patuxent has significantly more land in agricultural and large-lot developments.

Table 10: County MS4 land use breakdown for Upper Patuxent subwatershed

Maryland Department of Planning 2002 Land Cover/Land Use	*Watershed Acres*	*Percent of Total (%)*
Low Density Residential (<1 du/acre)	303	23%
Medium Density Residential (1-4 du/acre)	65	5%
High Density Residential (>4 du/acre)	0	0%
Commercial	36	3%
Industrial	0	0%
Municipal/Institutional- Intensive[1]	14	1%
Municipal/Institutional- Extensive[2]	0	0%
Roadway[3]	47	3%
Rural[4]	503	38%
Forest[5]	367	27%
Open Water	1	0%
Bare Ground	0	0%
Total Watershed	**1,336**	100%

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

Table 11: County MS4 land use breakdown for Hawlings River and Lower Patuxent subwatershed

Maryland Department of Planning 2002 Land Cover/Land Use	*Watershed Acres*	*Percent of Total (%)*
Low Density Residential (<1 du/acre)	1,257	21%
Medium Density Residential (1-4 du/acre)	1,474	25%
High Density Residential (>4 du/acre)	62	1%
Commercial	295	5%
Industrial	1	0%
Municipal/Institutional- Intensive[1]	189	3%
Municipal/Institutional- Extensive[2]	14	0%
Roadway[3]	442	7%
Rural[4]	1,035	17%
Forest	1,181	20%
Open Water	19	0%
Bare Ground	0	0%
Total Watershed	**5,968**	**100%**

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

Table 12: County MS4 land use breakdown for Patuxent watershed

Maryland Department of Planning 2002 Land Cover/Land Use	*Watershed Acres*	*Percent of Total (%)*
Low Density Residential (<1 du/acre)	1,059	20%
Medium Density Residential (1-4 du/acre)	1,447	27%
High Density Residential (>4 du/acre)	62	1%
Commercial	219	4%
Industrial	1	0%
Municipal/Institutional- Intensive[1]	173	3%
Municipal/Institutional- Extensive[2]	13	0%
Roadway[3]	366	7%
Rural[4]	954	18%
Forest	1,100	20%
Open Water	18	0%
Bare Ground	0	0%
Total Watershed	**5,413**	**100%**

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

3.2 Existing Stormwater BMPs in County MS4 Permit Area

The County currently has 173 structural stormwater BMPs within the Patuxent Watershed MS4 permit area, each with a contributing drainage area that varies from 421 acres for a regional quality control pond at Olney Family Park to less than 0.01 acres for small, on-site BMPs. Total drainage area treated is 1298.8 acres, 336.5 of which are impervious acres. The current inventory of County BMPs was categorized according to design era and historic performance criteria. Performance metrics were used to group the BMPs into the five categories for the entire watershed grouping and for the 3 constituent watersheds, as shown in Tables 13-15. Currently, just over 6.6% of the County MS4 permit area is treated by a range of BMPs. Code 4 BMPs are defined as meeting the requirements of environmental site design (ESD). The remaining BMPs are classified according to their performance code as presented in the Guidance Document, Section 2.

Table 13: Existing Stormwater Management in the County MS4 Permit area of the Upper Patuxent subwatershed, Montgomery County, Maryland

BMP Performance Code[1]	*Count*	*Acres of Impervious Cover (IC) Treatment*	
		Drainage Area Treated	*Total IC in Drainage Area*
(4) ESD BMPs	9	6.1	2.9
(3) Effective BMPs	3	1.7	0.8
(2) Under-performing BMPs	7	12.8	3.7
(1) Non-performing BMPs	0	0	0
(0) Pretreatment & Unknown[2]	5	2.3	1.7
Total	24	22.9	9.1

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

Table 14: Existing Stormwater Management in the County MS4 permit area of the Hawlings River and Lower Patuxent subwatershed, Montgomery County, Maryland

BMP Performance Code[1]	*Count*	*Acres of Impervious Cover (IC) Treatment*	
		Drainage Area Treated	*Total IC in Drainage Area*
(4) ESD BMPs	27	100.7	28.6
(3) Effective BMPs	44	760.8	183.2
(2) Under-performing BMPs	15	20.1	4.4
(1) Non-performing BMPs	16	326.6	71.6
(0) Pretreatment & Unknown[2]	47	67.3	40
Total	149	1275.5	327.8

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

Table 15: Existing Stormwater Management in the County MS4 permit area of the Patuxent Watershed, Montgomery County, Maryland

BMP Performance Code[1]	*Count*	*Acres of Impervious Cover (IC) Treatment*	
		Drainage Area Treated	*Total IC in Drainage Area*
(4) ESD BMPs	36	107.1	31.3
(3) Effective BMPs	47	762.2	184
(2) Under-performing BMPs	22	32.8	8.4
(1) Non-performing BMPs	16	326.7	71.2
(0) Pretreatment & Unknown[2]	52	70	41.6
Total	173	1298.8	336.5

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

In addition to the structural stormwater management BMPs listed above, there is 1 completed stream restoration site within the County MS4 permit area of the Patuxent Watershed. This project restored a total length of stream equal to almost 2,746 linear feet.

3.3 Problems Facing the Patuxent Subwatersheds

The 2008 TMDL document (MDE 2008), submitted by MDE in 2007 and approved by EPA in November 2008, establishes TMDLs for the nutrient and sediment impairments in the Patuxent Reservoirs. "In summary, the TMDLs for phosphorus and sediment are intended to: 1) resolve violations of narrative criteria associated with phosphorus enrichment of Triadelphia and Rocky Gorge Reservoirs, leading to excessive algal growth; 2) resolve violations of narrative criteria associated with excess sedimentation of Triadelphia Reservoir; and 3) ensure that both Triadelphia and Rocky Gorge Reservoirs meet the interim interpretation of the non-tidal DO criteria, as applied to reservoirs." (MDE 2008)

Total Phosphorus

The 2004 Patuxent Reservoirs (Triadelphia and Rocky Gorge) Source Water Assessment (SWA) (MDE) identified current contamination threats to these two reservoirs as including point and non-point sources from transportation infrastructure, railroads, a petroleum products pipeline, agriculture, septic systems, and urban/suburban areas. The analysis indicated phosphorus as the primary contaminant of concern. Secondarily, turbidity, sediment, disinfection byproducts, iron, manganese, and protozoa (pathogens) were indicated as contaminants of concern.

Sediment

Transport of suspended solids in streams and into a reservoir decreases holding capacity and has a deleterious effect on stream and reservoir ecology by inhibiting sunlight penetration and smothering benthic organisms in stream bottoms and the reservoir floor. Increases in suspended solids in the Upper Patuxent streams and reservoirs can be the result of construction within the watershed, scour and re-suspension of bottom and floodplain sediment, and bank erosion brought on by higher peak stream flows due to the increase in impervious surfaces from

road and building construction. Cropland and animal pasture are also significant sources of suspended solids in major streams of the Patuxent Reservoirs watershed (Versar, 2004).

Biological and Habitat Conditions

The tributaries to the reservoir located in Montgomery County are classified as Use III-P (Nontidal Cold Water and Public Water Supply) upstream of the Triadelphia Reservoir, Use IV-P (Recreational Trout Waters and Public Water Supply) in the Hawlings River subwatershed and Use I-P (Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply) in downstream drainage areas.

The Patuxent Watershed includes one Tier II (high quality) designated surface water in Montgomery County. All of Maryland's current Tier II waters were designated on the basis of indices of biological integrity (MDE 2006).

During a Countywide, five-year monitoring cycle completed in 2009, 23 tributaries in the Patuxent Watershed (9 in the Upper Patuxent, 6 in the Hawlings River, 8 in the Lower Patuxent) were sampled for benthic invertebrates, fish species, and habitat metrics to assess the stream resource conditions. Results of the survey for the entire watershed and the constituent subwatersheds are detailed in Tables 16-18, summarized by both stream miles and drainage area.

The survey data can be used to classify both instream conditions and overall water quality from the watershed. Therefore, the stream miles summary can be interpreted as an indicator of the current instream resource conditions. The drainage area summary can be used to indicate the condition of streams draining from the watershed.

Currently, the majority of the stream resource conditions in the Patuxent Watershed were assessed as "Good" with similar but comparable percentages of "Excellent" and "Fair". The Hawlings River had zero stream miles in excellent condition.

Table 16: Upper Patuxent subwatershed Stream Resource Condition Survey results by stream miles and drainage area

Resource Condition	*Length (miles)*	*%*	*Area (Acres)*	*%*
Excellent	8.9	12.9	1,931.3	14.5
Good	60.0	87.1	11,418.4	85.4
Fair	0	0	0	0
Poor	0	0	0	0
Not Accessed	0	0	11.8	0.1
Total	68.9	100	13,361.5	100

Table 17: Hawlings River and Lower Patuxent subwatershed Stream Resource Condition Survey results by stream miles and drainage area

Resource Condition	*Length (miles)*	*%*	*Area (Acres)*	*%*
Excellent	6.2	4%	992.5	4%
Good	115.9	81%	20538.4	82%
Fair	20.4	14%	3663.2	15%
Poor	0	0%	0	0%
Not Accessed	0	0%	0	0%
Total	142.5	100%	25194.1	100%

Table 18: Patuxent Watershed Stream Resource Condition Survey results by stream miles and drainage area

Resource Condition	*Length (miles)*	*%*	*Area (Acres)*	*%*
Excellent	15.1	10	2,923.8	10
Good	175.9	80	31,956.8	80
Fair	20.5	10	3,663.2	10
Poor	0	0	0	0
Not Accessed	0	0	11.8	0.0
Total	211.5	100	38,555.6	100

Other Water Quality Issues

As part of its environmental enforcement program, the County tracks citizen complaints regarding water quality and illegal solid waste dumping. Table 19 summarizes the number and type of citizen complaints recorded for the Patuxent during the five year cycle from 2004 to 2009. There were 26 cases, all related to stormwater pollutant discharge except one complaint regarding petroleum. Fifteen of the 26 complaints were in the Hawlings River subwatershed alone.

Table 19: Patuxent by subwatershed recorded water quality complaints[1]

Number by Water Quality Complaint Type				
Total # of cases	***Stormwater-Pollutant Discharge***	***Surface Water-Chemical Discoloration/ Unknown***	***Surface Water-Sewage***	***Surface Water-Petroleum Product in Water***
Upper Patuxent				
5	5	0	0	0
Hawlings River and Lower Patuxent				
21	20	0	0	1
Overall Patuxent				
26	25	0	0	1

[1] From WQCases2004_2009_Locations.shp

Table 20 includes the same complaints summarized by location, and general land use type for the Watershed Grouping and by constituent watershed. The majority of complaints recorded

were in residential and commercial land uses. For some properties, there were multiple complaints filed. These locations were given 'hotspot' identification in the pollutant loading model, discussed further in section 3.

Table 20: Patuxent by subwatershed water quality complaint by zoning[1]

General Zoning Type[2]	***Acres***	***Total # of Properties***	***Acres***	***Total # of Properties***	***Acres***	***Total # of Properties***
	Upper Patuxent		Hawlings River and Lower Patuxent		Overall Patuxent	
Apartments	0	0	0	0	0	0
Residential	42.2	2	41.4	11	83.6	13
Commercial	0.9	1	9.6	5	10.5	6
Industrial	0	0	0	0	0	0
Non-Conforming	0	0	0	0	0	0
Unzoned	0	0	0	0	0	0

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

Solid waste trash dumping sites were also logged by the County to identify trash hotspots. Table 21 includes a summary of the complaint database by complaint type for the Patuxent Watershed and by constituent subwatershed. The majority of complaints were recorded as residential or public dumping. Forty-seven of the 101 complaints were in the Hawlings River subwatershed alone

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

Table 21: Patuxent by subwatershed solid waste trash dumping sites[1]

Number per Solid Waste Type				
Total # of cases	***Farm Land***	***Residential***	***Public Land***	***Dumpster***
Upper Patuxent				
17	5	3	8	1
Hawlings River and Lower Patuxent				
84	6	41	31	6
Overall Patuxent				
101	11	44	39	7

[1] From SWCases2004_2009_locations.shp

Table 22 identifies the general zoning type at the site of the complaint by subwatershed. The majority of complaints were in residential areas, followed closely by pubic land. These tables indicate a greater proportion of complaints of dumping on residential areas in the Hawlings River and Lower Patuxent. Some properties had multiple complaints.

Table 22: Patuxent by subwatershed solid waste trash dumping sites by zoning[1]

General Zoning Type[2]	***Acres***	***Total # of Properties***	***Acres***	***Total # of Properties***	***Acres***	***Total # of Properties***
	Upper Patuxent		Hawlings River and Lower Patuxent		Overall Patuxent	
Apartments	0	0			4.8	1
Residential	184.5	11	839.6	51	1024.1	62
Commercial	16.1	2	14.4	4	30.5	6
Special Exemption	0	0	104.4	1	104.4	1
Industrial	0	0	0	0	0	0
Unzoned	0	0	0	0	0	0

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

3.4 Existing Pollutant Loads and Impervious Surfaces

Existing Phosphorus and Sediment Loads per the TMDL

The 2008 TMDL document (MDE 2008), approved by EPA in November 2008, establishes TMDLs for the nutrient and sediment impairments in the Patuxent Reservoirs.

TMDL = WLA [non-stormwater point sources + regulated stormwater point sources] + LA + MOS

- WLA = waste load allocation (MS4s, WWTP and other point sources)
- LA = load allocation
- MOS = margin of safety

Available information for the Patuxent watershed allows the stormwater WLA for this analysis to be defined separately for Howard, Montgomery, and Prince George's Counties; however, these WLAs aggregate municipal and industrial stormwater, including loads from construction activity (Table 23).

Table 23: Baseline Loading Estimates for the Triadelphia (Upper Patuxent subwatershed) and Rocky Gorge (Hawlings River and Lower Patuxent subwatersheds) Reservoirs draining Montgomery County's MS4 permit area and Comparison Values from MDE

Parameter	*Date*	*Baseline Montgomery County MS4 load*	*Montgomery County WLA % Reduction*	*Target Montgomery County MS4 load*
Triadelphia				
Total Phosphorus	2007	438.4 lbs/year	15%	372.6 lbs/year
Sediment	2007	29.3 tons/year	0%	29.3 tons/year
Rocky Gorge				
Total Phosphorus	2007	4268.2 lbs/year	15.0%	3,628.0 lbs/year

Impervious Surfaces

Impervious surfaces, or cover in the Patuxent Watershed as derived from County Geographic Information Systems (GIS) is summarized in Tables 24-26, for the entire watershed and for each subwatershed. Roads account for the largest percentage of impervious cover in the watershed at just over 34%. This is followed by single-family home roofs, at 23% as shown in Table 26.

Impervious cover in the Upper Patuxent as derived from County GIS is summarized in Table 24. Roads account for the largest percentage of impervious cover in the subwatershed at just over 47.5%. This is followed by single-family home roofs, at 20.4% and private parking lots at 19.6%.

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

Impervious cover in the Hawlings River and Lower Patuxent as derived from County GIS is summarized in Table 25. Roads (32%) and Single-family home roofs (23%) account for the largest percentage of impervious cover in the subwatershed.

Table 24: County MS4 Permit Area Impervious Cover and Untreated Impervious Cover Breakdown for the Upper Patuxent subwatershed

Impervious Cover Type	*Impervious Acres*	*Watershed (%)*
1. Roads		
a. Low Density Residential[1]	1.7	1.8%
b. Other[2]	45.0	47.5%
2. Parking Lot		
a. County Small Lots (<1 acre) [3]	0.2	0.2%
b. County Large Lots (>=1 acre) [3]	1.5	1.6%
c. Private	18.5	19.6%
3. Roofs		
a. County[4]	0.7	0.8%
b. Single Family Homes[5]	19.3	20.4%
c. Other	7.6	8.1%
4. Sidewalks[6]	0.1	0.1%
5. Other		
a. Schools[7]	0.0	0.0
b. Recreational[8]	0.0	0.0
Total Impervious Acres from GIS[9]	94.7	100%

[1]All roads in RE2 or R200 property zoning.
[2]Includes County and private roads.
[3]Parking lots located in County-owned parcels derived using County_pnts from the County's PROPERTY geodatabase.
[4]Buildings located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.
[5]Buildings located on single family home parcels, derived using MDP_pnts from the County's PROPERTY geodatabase and selecting only single-family dwelling types.
[6]Sidewalks in MS4 permit area. Does not include all residential sidewalks or driveways.
[7]Impervious cover located in public school parcels, derived using pubsch points from the County's LOCATIONS geodatabase. Some overlap with other impervious.
[8] Impervious cover identified as Recreational in geodatabase. Some overlap with other impervious.
[9] Sum of all GIS impervious. Excludes overlaps in schools and recreational.

Table 25: County MS4 Permit Area Impervious Cover and Untreated Impervious Cover Breakdown for the Hawlings River and Lower Patuxent subwatershed

Impervious Cover Type	*Impervious Acres*	*Watershed (%)*
1. Roads		
a. Low Density Residential[1]	85.6	12%
b. Other[2]	234.1	32%
2. Parking Lot		
a. County Small Lots (<1 acre) [3]	6.6	1%
b. County Large Lots (>=1 acre) [3]	6.3	1%
c. Private	131	18%
3. Roofs		
a. County[4]	4.1	1%
b. Single Family Homes[5]	169.6	23%
c. Other	68.5	9%
4. Sidewalks[6]	13.8	2%
5. Other		
a. Schools[7]	6.6	1%
b. Recreational[8]	0	0%
Total Impervious Acres from GIS[9]	726.2	100%

[1]All roads in RE2 or R200 property zoning.
[2]Includes County and private roads.
[3]Parking lots located in County-owned parcels derived using County_pnts from the County's PROPERTY geodatabase.
[4]Buildings located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.
[5]Buildings located on single family home parcels, derived using MDP_pnts from the County's PROPERTY geodatabase and selecting only single-family dwelling types.
[6]Sidewalks in MS4 permit area. Does not include all residential sidewalks or driveways.
[7]Impervious cover located in public school parcels, derived using pubsch points from the County's LOCATIONS geodatabase. Some overlap with other impervious.
[8] Impervious cover identified as Recreational in geodatabase. Some overlap with other impervious.
[9] Sum of all GIS impervious. Excludes overlaps in schools and recreational.

Table 26: County MS4 Permit Area Impervious Cover and Untreated Impervious Cover Breakdown for the Patuxent Watershed

Impervious Cover Type	*Impervious Acres*	*Watershed (%)*
1. Roads		
a. Low Density Residential[1]	87.3	10.6%
b. Other[2]	279.1	34.%
2. Parking Lot		
a. County Small Lots (<1 acre) [3]	6.8	0.8%
b. County Large Lots (>=1 acre) [3]	7.8	0.9%
c. Private	149.6	18.2%
3. Roofs		
a. County[4]	4.9	0.5%
b. Single Family Homes[5]	188.9	23.0%
c. Other	76.2	9.3%
4. Sidewalks[6]	14.0	1.7%
5. Other		
a. Schools[7]	6.6	0.8%
b. Recreational[8]	0.0	0%
Total Impervious Acres from GIS[9]	821.0	100%

[1]All roads in RE2 or R200 property zoning.
[2]Includes County and private roads.
[3]Parking lots located in County-owned parcels derived using County_pnts from the County's PROPERTY geodatabase.
[4]Buildings located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.
[5]Buildings located on single family home parcels, derived using MDP_pnts from the County's PROPERTY geodatabase and selecting only single-family dwelling types.
[6]Sidewalks in MS4 permit area. Does not include all residential sidewalks or driveways.
[7]Impervious cover located in public school parcels, derived using pubsch points from the County's LOCATIONS geodatabase. Some overlap with other impervious.
[8] Impervious cover identified as Recreational in geodatabase. Some overlap with other impervious.
[9] Sum of all GIS impervious. Excludes overlaps in schools and recreational.

4 Inventory of Provisional Restoration Candidates

4.1 Types of Restoration Practices

Table 27 summarizes the specific watershed restoration practices applied to the Patuxent Watershed. The first four groups of restoration practices involve various forms of ESD. All restoration practices differ in the mode and manner by which they will be delivered in the watershed (capital budgets, water quality protection charge, regulation, etc.). Multiple delivery mechanisms are needed to implement enough watershed restoration practices to meet the stringent watershed treatment and pollutant reduction targets set forth in the County's MS4 permit and TMDLs.

Table 27: Restoration Practices Evaluated in the Watershed Implementation Plan for the Patuxent Watershed

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

Table 27: (Continued)

Description of Practice	*Application in the Patuxent Watershed*
Trash Prevention and Control - This category includes a wide range of programs and practices specially aimed at reducing trash inputs to stream, including reduce, reuse and recycle campaigns, littering and illegal dumping enforcement, dumpster management, storm drain marking, storm drain inlet devices, stream cleanups, instream BMPs to trap and remove trash, etc. These measures are in addition to any trash trapped and removed by other restoration practices which are computed separately.	Not applicable
Structural Practices	
Traditional Retrofits - This is the traditional retrofit scale where large-scale, non-ESD retrofits are constructed on larger parcels of public or private land as discovered through analysis of MCDEP BMP inventory.	New Ponds
BMP Maintenance Upgrades - Credit for improvement in current County MS4 permit cycle for major maintenance upgrades of failed stormwater practices that result in significant improvement in hydraulic function and increased treatment capacity using existing County maintenance budget. Credit can only be taken for increased load reduction due to upgrades that significantly rehabilitate BMP function from its installation baseline. (e.g., increase capacity, lengthen flow path, reduce short-circuiting and eliminate design failures).	Code 1 & 2 BMP Upgrades (see WTM3.0)
Habitat Restoration - This category includes any pollutant reduction or volume reduction that can be attributed to specific stream restoration or riparian reforestation projects planned for construction in the watershed for the County MS4 permit cycle.	Riparian Reforestation

4.2 Inventory of Previously Identified Projects

Hawlings River subwatershed

The County has developed an inventory of potential stormwater retrofits and stream restoration projects within the Hawlings River subwatershed (Charles P. Johnson and Associates and Environmental Quality Resources, 2003). The study identified and generated (1) concept designs for 12 candidate stream bank stabilization and buffer enhancement projects on 15 miles of the total 98.2 stream miles and (2) concept designs for modification of 3 existing stormwater BMPs to increase their efficacy (Figures 9, 10 and 11).

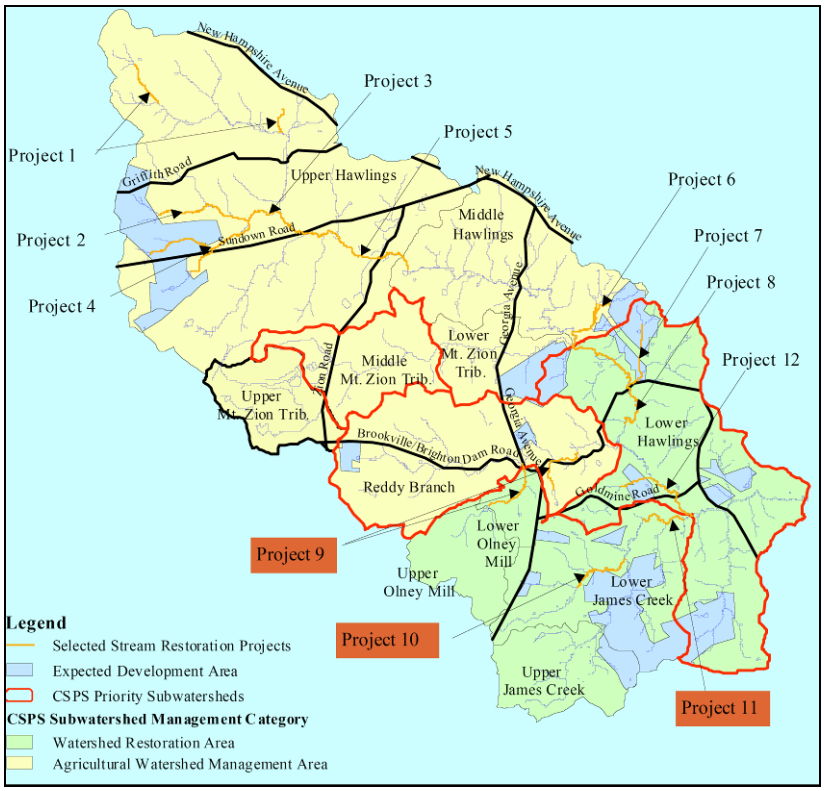

Figure 9: Twelve candidate stream bank stabilization and buffer enhancement projects in the Hawlings River subwatershed. Top 3 ranked projects are highlighted in orange. (Charles P. Johnson and Associates and Environmental Quality Resources, LLC 2003)

Number	Name	Location	Length (ft)
1	Upper Hawlings I	Upstream of Griffith Rd.	4,601
2	Upper Hawlings II	South of and generally parallel to Griffith Rd	6,293
3	Upper Hawlings III	Crosses Sundown Rd twice	10,638
4	Upper Hawlings IV	Generally parallel to Sundown Rd.	4,295
5	Upper Hawlings V	Mainstem south of Sundown Rd.	8.612
6	Middle Hawlings	Starts in Hunting Ridge subdivision	5,848
7	Lower Hawlings I	Mainstem above Brighton Dam Rd.	5,262
8	Lower Hawlings II	Mainstem and tributaries south of Brighton Dam Rd	8,410
9	Reddy Branch	Olney Mill subdivision-- Lower Olney Mill Tributary and Reddy Branch	8,303
10	Lower James Creek I	Hallowell Subdivision.	4,976
11	Lower James Creek II	Generally parallel to Gold Mine Rd.	3,528
12	Lower Hawlings III	Near Gold Mine Rd and New Hampshire Ave.	5,963

Figure 10: Twelve stream candidate restoration projects, their location and length in the Hawlings River subwatershed (Charles P. Johnson and Associates and Environmental Quality Resources, LLC 2003).

Proposed Retrofit Project	Subwatershed Location	Description
Olney Mill Family Park Pond	Upper Olney Mill	Convert pond into an extended detention facility that will provide runoff quantity control for 495 acres.
Lake Hallowell	Upper James Creek	Increase the flow released from the lake to provide greater minimum flow to the receiving stream throughout the year
Sandy Spring Meadow Dry Pond	Lower Hawlings	Convert the existing dry pond into an extended detention facility for enhanced runoff quantity and quality control for 28 acres.

Figure 11: Top 3 candidate retrofit projects identified in the Hawlings River subwatershed (Charles P. Johnson and Associates and Environmental Quality Resources, LLC 2003).

Entire Patuxent Watershed

Potential restoration strategies for the watershed set forth in this Plan were drawn from the Hawlings River subwatershed study and feedback received from the County DEP. Previously identified restoration projects identified are presented in Figure 12. Only one additional ESD project in the Upper Patuxent and one ESD project in the Lower Patuxent subwatersheds were not from the Hawlings River subwatershed study.

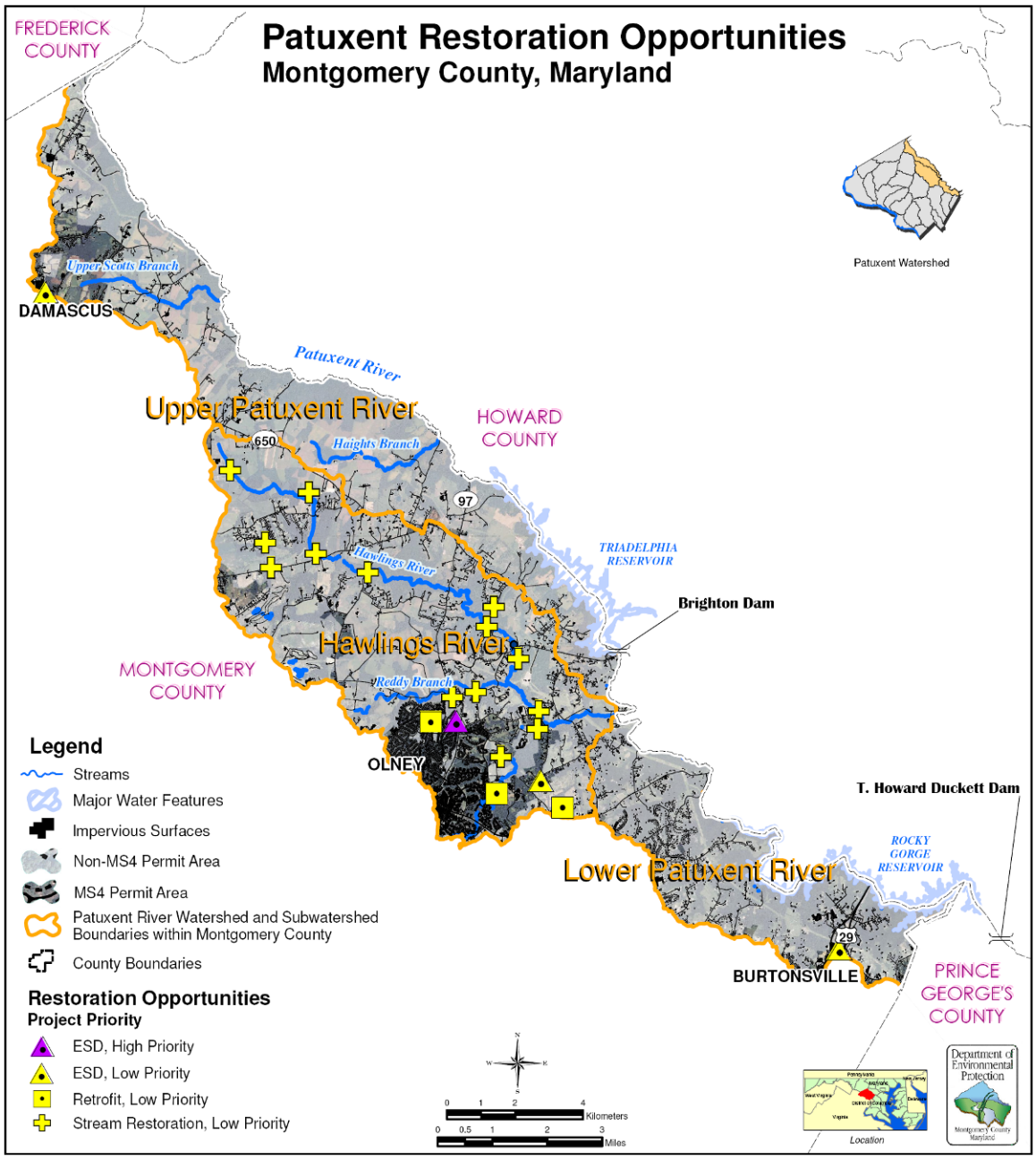

Figure 12: Patuxent watershed restoration opportunities within the County MS4 permit area.

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

5.1 Pollutant Load Tracking

The TMDLs for the nutrient total phosphorus were determined using a time-variable, two-dimensional water quality eutrophication model, CE-QUAL-W2, to simulate water quality in each reservoir. The TMDLs are based on average annual TP loads for the simulation period 1998-2003, which includes both wet and dry years, thus taking into account a variety of hydrological conditions. Chlorophyll *a* concentrations indicative of eutrophic conditions can occur at any time of year and are the cumulative result of phosphorus loadings that span seasons. Thus, although daily loads were calculated for these TMDLs, average annual TP loads are the most appropriate measure for expressing the nutrient TMDLs for Triadelphia and Rocky Gorge Reservoirs.

Similarly, the sediment TMDL for Triadelphia Reservoir, which is based on the water quality modeling performed for the nutrient TMDLs, is expressed as an average annual load in keeping with the long-term water quality goal of preserving the storage capacity of the reservoir.

5.2 Desktop Review of BMP Coverage

A desktop review of BMP coverage was used to analyze the existing BMP coverage and proposed projects inventory from the 2003 Hawlings River WRAP. This was the only subwatershed of the three in the Patuxent which had been evaluated for proposed restoration projects in its MS4 at the time of this effort.

The BMPs were classified according to their performance code as shown in Table 28. The relative performance of each practice type was based on national comparative reviews of pollutant reduction and runoff reduction performances of practices (CWP, 2007; and CWP and CSN, 2008) or performance studies on individual practices (Schueler, 1998). The composite efficiencies were also compared to recent research values and assumptions used in local models (USACE, 2008; Chesapeake Bay Program, 2008; and MDE, 2009) to further justify the performance coding. A summary of the BMP modeling assumptions are in Table 28.

Table 28: Composite Effectiveness Factor, and Pollutant Reduction by BMP Performance Code

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

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

The Watershed Treatment Model (WTM) was used to estimate pollutant sources and treatment options for the Patuxent Watershed. The spreadsheet used was an updated version of the publically available v3.1, which included an expanded runoff volume reduction component (personal correspondence, Deb Caraco, 2009). The WTM was used to track a progression of restoration strategies across the watershed and illustrate the effectiveness of each strategy in reducing pollutant loads and ultimately meeting the TMDL load reduction targets. Targeted strategies range from specific capital improvement projects identified by the County to less well defined nonstructural strategies tied to stakeholder participation and involvement. The specific layers of analysis are presented below, following the nomenclature of WTM 1.0 – WTM 5.0.

5.3 Summary of Watershed Treatment Model Scenarios

A summary of the model scenarios evaluated using the Watershed Treatment Model are provided in Table 29 below and described in more detail in the following sections.

Table 29: Summary of WTM Scenarios

Implementation Phase	*Description*
WTM Baseline Conditions	The WTM was run under existing conditions approach with the Maryland Department of Planning (MDP) year 2002 land use/land cover data and existing BMPs. A rough calibration to the MDE TMDL baseline load was conducted.
WTM 2.0 Completed as of 2009; High Priority Projects; Low Priority and Other Potential Projects	The WTM was run with a series of future management practices, which were proposed projects from the County inventory of restoration sites. These practices cover new ponds, retrofits of existing BMPs, and ESD practices from the proposed projects list determined in the WRAP.
WTM 3.0 ESD Strategies and Other Structural BMPs	The remaining inventory of reduced treatment efficiency BMPs were reviewed for retrofit opportunities and potential increased pollutant reduction efficiencies. In addition, the County's inventory for other project types that include public properties (e.g., libraries and parking lots), public schools, and open section roads available for ESD retrofits was reviewed as were areas for private property ESD retrofits.
WTM 4.0 Habitat Restoration	Other projects on public lands and other practices that are identified in Appendix B of the Guidance Document were explored
WTM 5.0 MS4 Programmatic Practices	Other MS4 programmatic practices that are identified in Appendix B of the Guidance Document were examined.

WTM 1.0 – Baseline Conditions

The WTM was run under existing conditions approach with the MDP year 2002 land use/land cover data and existing BMPs coded under "Existing Management Practices" (Tables 30-32). The baseline pollutant load was calculated and compared to the MDE-determined baseline MS4 load for phosphorus for the Patuxent Watershed and sediment for the Upper Patuxent

subwatershed. Since the data used to establish the TMDL was collected by MDE through 2003 (MDE, 2008), any BMPs with "approved" dates after 2003 were not included in this baseline calculation. However, BMPs approved after 2003 can be counted towards meeting the TMDL reduction target. The Upper Patuxent did not have any BMPs approved after 2003. The Hawlings River and Lower Patuxent Watershed a total of three BMPs approved after 2003, which are summarized in Table 33.

Table 30: Existing BMP inventory for the Upper Patuxent subwatershed

BMP Performance Category	*Count*	*Total DA (Acres)*	*Total IA (Acres)*
ESD Practices (Code 4)	9	6.1	2.9
Effective BMPS (Code 3)	3	1.7	0.8
Underperforming BMPs (Code 2)	7	12.8	3.7
Non-performing BMPs (Code 1)	0	0	0
Pretreatment BMPs (Code 0)	5	2.3	1.7

DA: Drainage Area
IA: Impervious Area

Table 31: Existing BMP inventory for the Hawlings River and Lower Patuxent subwatershed

BMP Performance Category	*Count*	*Total DA (Acres)*	*Total IA (Acres)*
ESD Practices (Code 4)	27	100.7	28.6
Effective BMPS (Code 3)	44	760.8	183.2
Underperforming BMPs (Code 2)	15	20.1	4.4
Non-performing BMPs (Code 1)	16	326.6	71.6
Pretreatment BMPs (Code 0)	47	67.3	40

DA: Drainage Area
IA: Impervious Area

Table 32: Existing BMP inventory for the Patuxent Watershed

BMP Performance Category	*Count*	*Total DA (Acres)*	*Total IA (Acres)*
ESD Practices (Code 4)	36	107.1	31.3
Effective BMPS (Code 3)	47	762.2	184
Underperforming BMPs (Code 2)	22	32.8	8.4
Non-performing BMPs (Code 1)	16	326.7	71.2
Pretreatment BMPs (Code 0)	52	70	41.6

DA: Drainage Area
IA: Impervious Area

Table 33 Existing BMPs approved after 2003, subtracted from Table 31 Inventory for the Hawlings River and Lower Patuxent subwatershed prior to calculating baseline loading for TMDL tracking

BMP Performance Category	*Count*	*Total DA (Acres)*	*Total IA (Acres)*
ESD Practices (Code 4)	2	5.8	0.7
Effective BMPS (Code 3)	0	0	0
Underperforming BMPs (Code 2)	0	0	0
Non-performing BMPs (Code 1)	0	0	0
Pretreatment BMPs (Code 0)	1	1.1	0.4

DA: Drainage Area IA: Impervious Area

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

The WTM was run with a series of future management practices, i.e., proposed projects from the County inventory of restoration sites. These practices cover new ponds, retrofits of existing BMPs, and ESD projects from the proposed projects list determined in the WRAP, as summarized in Tables 35-37. The database also includes stream restoration projects, which were not accounted for during TMDL tracking. Drainage area (DA), impervious area (IA), total length, and total cost were all determined from engineering designs or estimated based on the running average per practice values from the County database (Montgomery County DEP Restoration Sites Database, 2010). In general, the County used the following summary in Table 34 to estimate proposed impervious area and costs, where engineering costs were unavailable:

Table 34: Impervious Cover and Cost Estimates used in the Future Management Scenarios

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

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

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

Table 35: Levels of treatment: Complete, High Priority Projects, Low Priority and Other Potential in the Upper Patuxent subwatershed

Restoration Type	*Count*	*Total Cost*	*Total Length (feet)*	*Total DA (acres)*	*Total IA (acres)*
Completed Projects					
None					
High Priority Projects					
None					
Low Priority and Other Potential Projects					
ESD	1	$396,000		2.79	1.98

Table 36: Levels of treatment: Complete, High Priority Projects, Low Priority and Other Potential in the Hawlings River and Lower Patuxent subwatershed

Restoration Type	*Count*	*Total Cost*	*Total Length (feet)*	*Total DA (acres)*	*Total IA (acres)*
Completed Projects					
Stream Restoration	1	$479,293	2,746	0.0	0.0
High Priority Projects					
ESD	1	$282,000		2.0	1.4
Retrofit of Non-performing BMPs	1	$85,637		18.1	3.9
Low Priority and Other Potential Projects					
ESD	2	$910,000		5.24	4.58
Retrofit of Effective BMPs	2	$1,968,100		468.0	82.8
Stream Restoration	14	$18,609,750	74,439		

Table 37: Levels of treatment: Complete, High Priority Projects, Low Priority and Other Potential for the Entire Patuxent Watershed

Restoration Type	*Count*	*Total Cost*	*Total Length (feet)*	*Total DA (acres)*	*Total IA (acres)*
Completed Projects					
Stream Restoration	1	$479,293	2,746		
High Priority Projects					
ESD	1	$282,000		2.0	1.4
Retrofit of Non-performing BMPs	1	$85,637		18.1	3.9
Low Priority and Other Potential Projects					
ESD	3	$470,000		8.1	6.5
Retrofit of Effective BMPs	2	$1,968,100		468.0	82.8
Stream Restoration	14	$18,609,750	74,439		

The cumulative pollutant load reduction was computed and compared to the TMDL annual target for TP and sediment. The applicable target reduction in TP from the calculated MDE stormwater WLA is 15% for both reservoirs. For sediment in the Triadelphia the WLA is zero as the contribution from the MS4 to the reservoirs is negligible compared to other sources.

WTM 3.0 - ESD Strategies and Other Structural BMPs

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

a. Code 1 and 2 BMP ESD Retrofits - The remaining Code 1 and Code 2 BMP treatment area was calculated by subtracting the previously targeted retrofits from (WTM 2.0) from the total BMP area (summarized in Table 38). It was then assumed these areas were suitable for retrofits and incrementally increased the performance efficiency of Code 1 and 2 BMPs to the MEP within Future Management Practices. The cost per impervious acre estimate was based on typical County retrofits for large pond BMPs. All underperforming or non-performing BMPs are in the Hawlings River subwatershed.

Table 38: Underperforming (Code 2) and Non-performing (Code 1) BMPs targeted for retrofit in the Patuxent Watershed (all in the Hawlings River subwatershed).

Target	*Count*	*Total DA (acres)*	*Total IA (acres)*	*Cost per IA*	*Total Cost*
Total Code 2 BMPs	8	9.9	2.3		
-Previously Targeted for Retrofit	0	0	0		
Remaining Code 2 for Retrofit	**8**	**9.9**	**2.3**	**$12,000**	**$27,600**
Total Code 1 BMPs	15	320.1	68.6		
-Previously Targeted for Retrofit	-1	18.11	3.69		
Remaining Code 1 for Retrofit	**14**	**301.99**	**64.91**	**$12,000**	**$778,968**
				Total	$806,568

Tables 39 through 41 show the following parameters for the Patuxent Watershed and its constituent subwatersheds:

b. Public properties – Forty percent of the impervious cover from the aggregate area and associated imperviousness from untreated County-owned Large Parking Lots and Rooftops was assigned to future management practices as code 4 (see Table B.4 of Guidance Document, and summary in Tables 39 through 41 below). The forty percent target for restoration was based on a judgment of the maximum extent practicable considering physical constraints to ESD/LID. The unit cost estimate was based on an equal mix of new ESD retrofits for larger parking lots and rooftops.

c. Public schools – Forty percent of the impervious cover from the aggregate area and associated imperviousness and from untreated Public Schools Parcels was assigned to future management practices as code 4 (see Table B.4 of Guidance

Document, and summary in Tables 39 through 41 below). The restoration target was set similarly to part (b) above.

d. Low Density Residential (LDR) and Other County Roads - Seventy-five percent of the impervious cover from the aggregate area and associated imperviousness from RE2 and R200 roadways was assigned to future management practices as code 4 (see Table B.4 of Guidance Document, and summary in Table 39 through 41 below). The restoration target was set similarly to part (b) above. The unit cost estimation was based on an open-section road retrofit. Other County Roads were assigned a forty percent aggregate impervious cover restoration target, and the unit cost was based on a curbed road retrofit.

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

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

Thirty percent implementation of site-scale ESD projects in the targeted neighborhoods that meet criteria associated high and median priority was assumed, which equates to 49.2 acres of impervious area treatment over the entire Patuxent Watershed, and a cost of $6,494k assuming $298k per impervious acre. Figure 13 shows the priority neighborhoods in the Patuxent watershed. Table B.7 of the Guidance Document describes the basic approach used to make pollutant reduction and cost decisions.

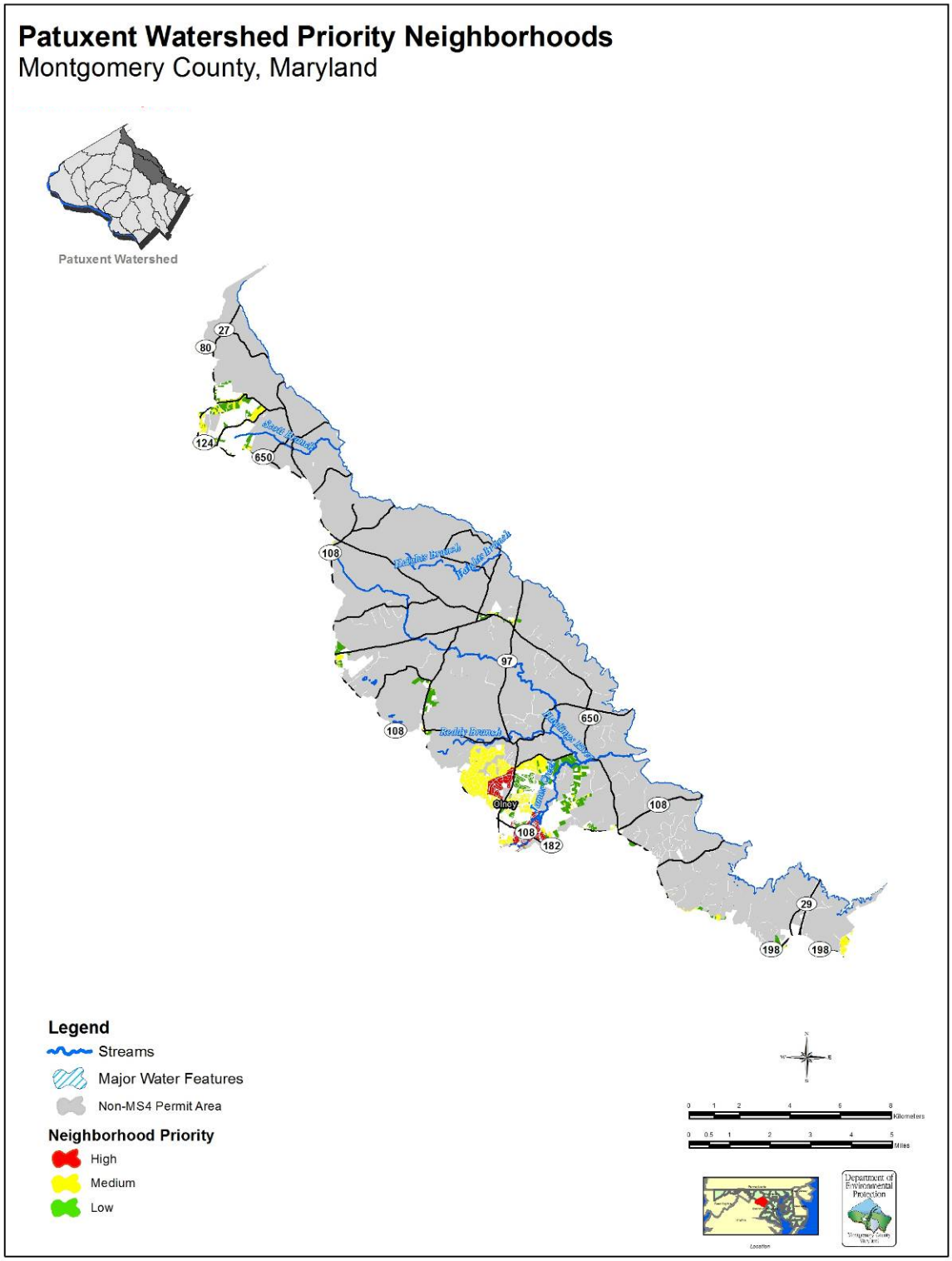

Figure 13: Priority Neighborhoods for the Patuxent Watershed

f. Non-residential Property without Adequate Treatment ESD implementation: These are comprised of commercial properties that are not currently paying into Water Quality Protection Charge (WQPC). It was assumed that forty percent of these properties will apply ESD practices to treat the impervious cover on site. This equates to 56.3 acres of impervious cover across the entire Patuxent Watershed as shown in Table 41. This area was assumed to be treated to the maximum extent practicable within the WTM.

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

Table 39: Summary of restoration potential within County owned BMPs, schools, and ESD roads options in the Upper Patuxent subwatershed

Land Cover	***Total IA***	***Restoration Potential****	***Restored IA***	***Unit Cost*** **	***Restoration Cost****
Type	Acres	%	Acres	$/Acre IA	$
County Large Parking Lots[1]	1.5	40%	0.6	$317,500	$187,071
County Roofs[2]	0.7	40%	0.3	$508,500	$152,347
Schools[3]	0.0	40%	0.0	$484,000	$0
Low Density Residential Roads[4]	1.7	75%	1.3	$137,000	$176,319
Other County Roads	45.0	40%	18.0	$200,000	$3,600,320
Priority Neighborhoods[5]	10.6	30%	3.2	$298,000	$949,696
Non-residential Property without adequate treatment	31.3	40%	12.5	$298,000	$3,732,986
Totals	**91**		**36**		**$8,798,739**

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

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

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

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

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

[4] All roads in RE2 or R200 property zoning.

[5] Rooftop area in High and Medium Priority Neighborhoods

Table 40: Summary of restoration potential within County owned BMPs, schools, and ESD roads options in the Hawlings River and Lower Patuxent subwatershed

Land Cover	***Total IA***	***Restoration Potential****	***Restored IA***	***Unit Cost*** **	***Restoration Cost****
Type	Acres	%	Acres	$/Acre IA	$
County Large Parking Lots[1]	6.3	40%	2.5	$317,500	$799,338
County Roofs[2]	4.1	40%	1.6	$508,500	$835,974
Schools[3]	6.6	40%	2.6	$484,000	$1,270,984
Low Density Residential Roads[4]	85.6	75%	64.2	$137,000	$8,788,721
Other County Roads	234.1	40%	93.2	$200,000	$18,649,200
Priority Neighborhoods[5]	137.4	30%	40.5	$ 298,000	$5,545,035
Non-residential Property without adequate treatment	109.4	40%	43.7	$ 298,000	$13,039,765
Totals	**584**		**248**		**$48,929,017**

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

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

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

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

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

[4] All roads in RE2 or R200 property zoning.

[5] Rooftop area in High and Medium Priority Neighborhoods

Table 41: Summary of restoration potential within County owned BMPs, schools, and ESD roads options in the Patuxent Watershed

Land Cover	***Total IA***	***Restoration Potential****	***Restored IA***	***Unit Cost*** **	***Restoration Cost****
Type	Acres	%	Acres	$/Acre IA	$
County Large Parking Lots[1]	7.8	40%	3.1	$317,500	$986,409
County Roofs[2]	4.9	40%	1.9	$508,500	$988,321
Schools[3]	6.6	40%	2.6	$484,000	$1,270,984
Low Density Residential Roads[4]	87.3	75%	65.4	$137,000	$8,965,040
Other County Roads	279.1	40%	111.2	$200,000	$22,249,520
Priority Neighborhoods[5]	148.0	30%	49.2	$298,000	$6,494,731
Non-residential Property without adequate treatment	140.7	40%	56.3	$298,000	$16,772,632
Totals	**674**		**290**		**$57,727,637**

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

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

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

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

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

[4] All roads in RE2 or R200 property zoning.

[5] Rooftop area in High and Medium Priority Neighborhoods

WTM 4.0 – Habitat Restoration

Other projects on public lands and other practices that are identified in Appendix B of the Guidance Document were explored. The specific order of consideration was dependant on the parameter of focus, which for the Patuxent Watershed are (1) TP loads to the two reservoirs from all three subwatersheds and (2) sediment loads to the Rocky Gorge Reservoir from the Hawlings River and Lower Patuxent subwatersheds.

a. Habitat restoration (riparian reforestation) – computed the total amount of unforested 100-ft buffer along streams and then converted land use area to forest area in Future Management Practices (see Table B.13 of the Guidance Document, and summary of areas in Tables 42-44 below). One-hundred percent implementation of riparian reforestation across the total area was assumed.

Table 42: Summary of land use categories within the 100-ft buffer area of County streams in the Upper Patuxent subwatershed

MDP 2002 Land Cover/Land Use	*Watershed*	*Total Buffer Area*	
	Acres	*Unforested Area (acres)*	*Forested Area[3] (acres)*
Low Density Residential	303	5	4
Medium Density Residential	65	0	0
High Density Residential	0	0	0
Commercial	36	0	0
Industrial	0	0	0
Municipal/Institutional	14	0	0
Total Watershed	**418[1]**	**5**	**4**
Total Cost[2]		**$103,200**	

[1] Includes areas not targeted for riparian reforestation [roadways, rural land use, forest, open water and bare ground]
[2] Assumes $20k per acre reforestation
[3] Forested area is derived from the Forest08 shapefile

Table 43: Summary of land use categories within the 100-ft buffer area of County streams in the Hawlings River and Lower Patuxent subwatershed

MDP 2002 Land Cover/Land Use	*Watershed*	*Total Buffer Area*	
	Acres	*Unforested Area (acres)*	*Forested Area[3] (acres)*
Low Density Residential	757	35	26
Medium Density Residential	1,382	74	31
High Density Residential	62	2	0
Commercial	183	3	0
Industrial	1	0	0
Municipal/Institutional	171	10	5
Total Watershed	**2,556[1]**	**124**	**62**
Total Cost[2]		**$2,450,700**	

[1] Includes areas not targeted for riparian reforestation [roadways, rural land use, forest, open water and bare ground]
[2]Assumes $20k per acre reforestation
[3] Forested area is derived from the Forest08 shapefile

Table 44: Summary of land use categories within the 100-ft buffer area of County streams in the Patuxent Watershed

MDP 2002 Land Cover/Land Use	*Watershed*	*Total Buffer Area*	
	Acres	*Unforested Area (acres)*	*Forested Area[3] (acres)*
Low Density Residential	1,059	40	30
Medium Density Residential	1,447	74	31
High Density Residential	62	2	0
Commercial	219	2	0
Industrial	1	0	0
Municipal/Institutional	185	9	4
Total Watershed	**2,973[1]**	**127**	**65**
Total Cost[2]		**$2,553,900**	

[1] Includes areas not targeted for riparian reforestation [roadways, rural land use, forest, open water and bare ground]
[2]Assumes $20k per acre reforestation
[3] Forested area is derived from the Forest08 shapefile

WTM 5.0 - Programmatic Practices

MS4 programmatic practices identified in Appendix B (Table B.8) of the Guidance Document were also examined. For the Patuxent, this was limited to proper lawn-care education. The potential reduction in load was calculated using the WTM Lawn Care Education/Future Management Practices, which requires the number of acres of lawn (estimated under Primary Sources) as a percentage of land use type. Default WTM discounts based on residential surveys assume that 80% of lawn areas are fertilized, 65% of those areas are "over-fertilized" and 70% of owners would be willing to change their behavior.

Outreach and Stewardship Strategy Education Project:
Stakeholder outreach on proper lawn care is recommended in partnership with HOAs, garden retailers, and master gardeners. Implementation details are in the Practice Sheet entitled Lawn Stewardship Outreach and Stewardship Campaign.

We assume a high fraction (0.8) of the population could be targeted with effective educational messages, which for the Patuxent, targets every household within the MS4, at a cost of $15 per household (Schueler 2005; USRM #2, Table 47). The potential load reductions from the residential education program are shown in Table 45.

Table 45: MS4 Programmatic Practices

Strategy	***Acres of Lawn***	***Potential TP Source (lbs/yr)***	***Unit Cost***	***Total Cost***
Lawn Care	3,870 (6,542 dwelling units)	140	$15 per dwelling unit	$98,130

5.4 Preliminary Results of the Sediment and Total Phosphorus Reduction Analysis

The WTM was run iteratively using a series of spreadsheets for each step outlined above. Initially, the WTM was coded with the existing land use and BMP database to calculate the baseline load. This resulted in a TP load nearly 2 times higher than the MDE baseline for TP in the Upper Patuxent subwatershed (Triadelphia Reservoir), so the baseline WTM load was adjusted to match the MDE baseline load. Since the targeted WLA was a 15% reduction from the baseline, the reduction was applied to our adjusted WTM computed baseline to establish the 373 pound/yr target for restoration efforts. The baseline load for TP in the Lower Patuxent subwatershed and Hawlings River subwatersheds (Rocky Gorge Reservoir) was less than 13% of the MDE baseline load, so the baseline WTM load was adjusted to match the MDE baseline. Since the target WLA was also a 15% reduction from the baseline, the reduction applied to our adjusted WTM baseline to establish a 3,628 pound/yr target for restoration efforts.

For TSS, the initial WTM baseline load was nearly 3 times higher than the MDE baseline for TSS in the Upper Patuxent subwatershed (Triadelphia Reservoir), so the baseline WTM load was adjusted to match the MDE baseline load.

From there, the iterative approach was used to track progress as shown in Table 46. The target WLA for TSS is already met, so no additional restoration efforts were needed to meet this TMDL; however, the overall watershed benefit of various restoration efforts relative to the baseline load were estimated.

Table 46: Preliminary Results of WTM Modeling for TP and TSS for Patuxent Watershed

Implementation Phase	***Patuxent Watershed TP Loading***	***Lower Patuxent / Rocky Gorge & Hawlings River TP Loading***	***Upper Patuxent / Triadelphia Reservoir TP Loading***	***Patuxent Watershed TSS Loading***	***Upper Patuxent / Triadelphia Reservoir TSS Loading***	***Cumulative Cost Millions $***
	% reduction from Baseline Load	*% reduction from Baseline Load*	*% reduction from Baseline Load*	*% reduction from Baseline Load*	*% reduction from Baseline Load*	
WTM Baseline Load* Adjusted to MDE Baseline Load	**0%**	**0%**	**0%**	**0%**	**0%**	$ -
WTM 2.0 Completed, High Priority Projects, Low Priority and Other Potential Projects	8%	8%	1%	8%	1%	$3.64
WTM 3.0 ESD Strategies and Other Structural BMPs	34%	34%	11%	38%	12%	$62.26
WTM 4.0 Habitat Restoration	35%	35%	11%	40%	12%	$64.81
WTM 5.0 MS4 Programmatic Practices	43%	43%	14%	40%	12%	$64.91
TMDL WLA		15%	15%		0%	

* Excludes existing BMPs approved after the TMDL was established in 2003.

The restoration strategy is further illustrated in Figures 14 and 15, where the implementation phases are shown in order with their resulting TP in comparison to the WLA goal. It is not necessary to demonstrate sediment load reduction over time as the TMDL is met immediately at WTM 2.0, as indicated in Table 46. The cost for each implementation phase is also shown.

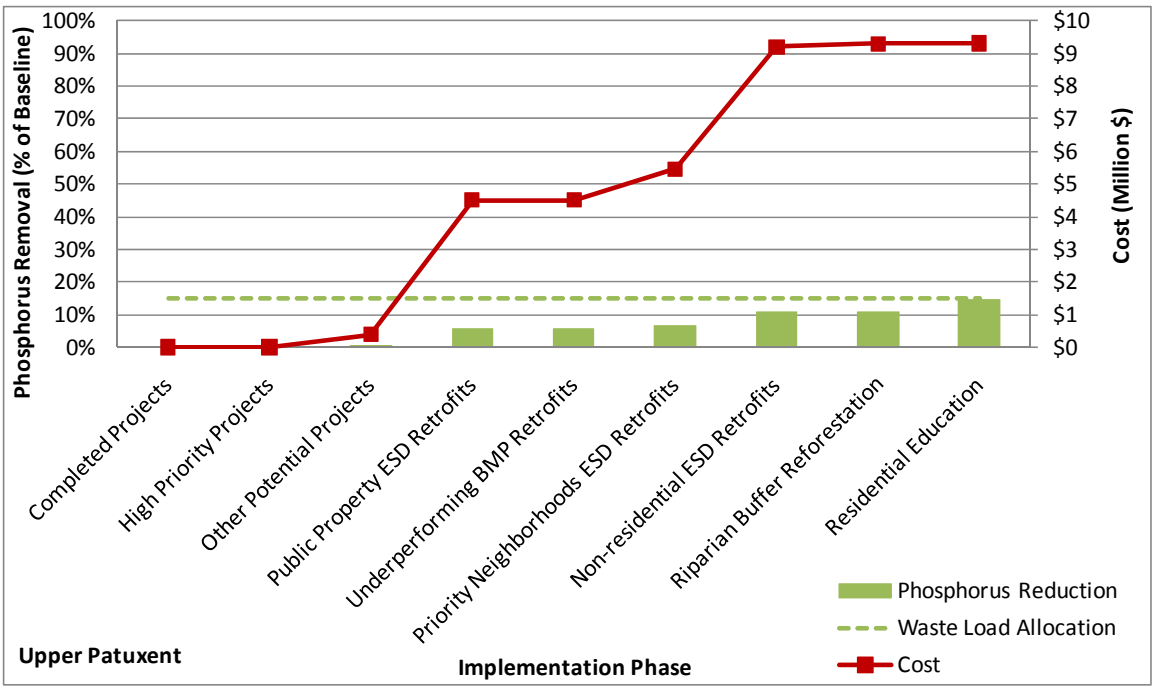

Figure 14: Cumulative reduction in total phosphorus (TP) loading over restoration practices implementation for Upper Patuxent subwatershed (Triadelphia Reservoir).

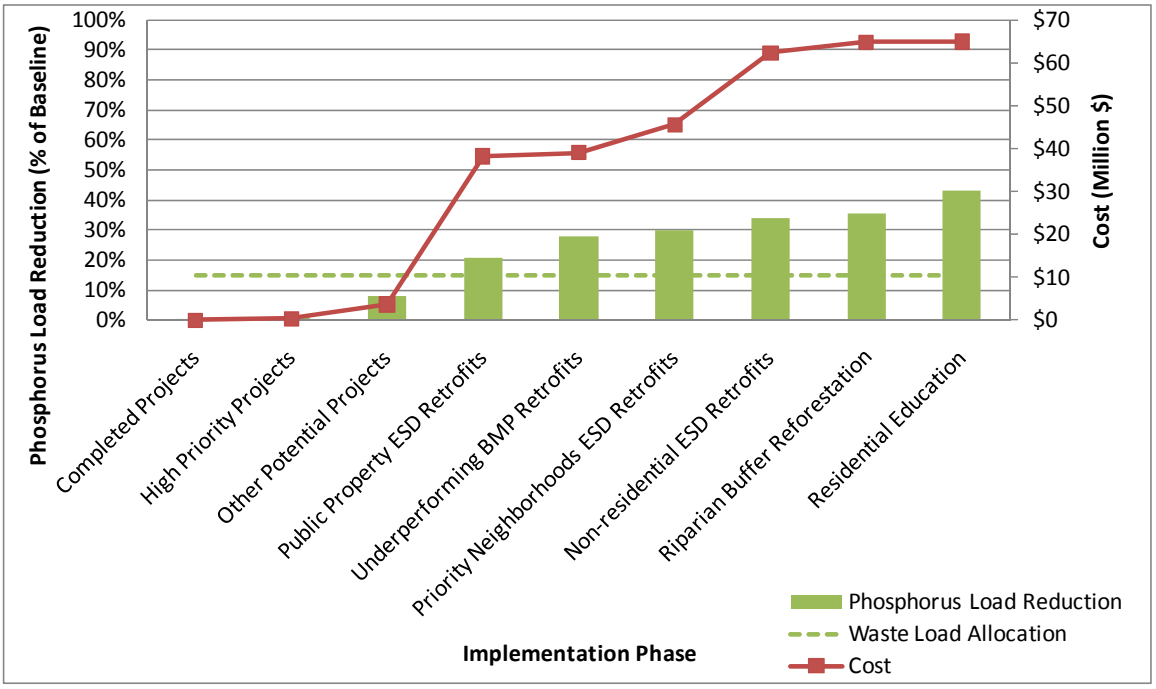

Figure 15: Cumulative reduction in TP loading over restoration practices implementation for Hawlings River and Lower Patuxent subwatersheds (Rocky Gorge Reservoir).

The most cost effective strategy for TSS reduction into the Triadelphia Reservoir from the watershed is underperforming BMPs followed by better lawn care practices and then “other potential projects”, as detailed in Table 47.

Table 47: Individual restoration strategy cost effectiveness for Total Suspended Solids (TSS) reduction in Patuxent Watershed

Rank	Restoration Strategy	TSS tons/yr	Incremental Cost Million $	Unit Cost tons/Million $
1	Underperforming BMP Retrofits	26.0	0.81	32.2
2	Lawn Care Education	0.9	0.10	9.7
3	Low Priority and Other Potential Projects	23.4	3.27	7.1
4	High Priority Projects	1.9	0.37	5.1
5	Riparian Reforestation	4.5	2.55	1.8
6	Public Property Retrofits	45.8	34.54	1.3
7	Priority Neighborhoods ESD Retrofits	6.1	6.49	0.9
8	Private, Non-residential ESD Retrofits	14.7	16.77	0.9
9	Completed Projects	0.4	0.00	0.0

The most effective strategy for reduction in TP, by far, is the implementation of better lawn care practices, followed by underperforming BMP retrofits and then “other potential projects”, as detailed in Table 48.

Note that cost-effectiveness analysis was not broken up by subwatershed.

Table 48: Individual restoration strategy cost effectiveness for Total Phosphorus (TP) reduction in Patuxent Watershed

Rank	Restoration Strategy	TP lbs/yr	Incremental Cost Million $	Unit Cost lbs/ Million $
1	Lawn Care Education	367.0	0.1	3,739.4
2	Underperforming BMP Retrofits	349.9	0.8	433.8
3	Low Priority and Other Potential Projects	352.4	3.3	107.6
4	High Priority Projects	25.2	0.4	68.5
5	Riparian Reforestation	76.2	2.6	29.8
6	Public Property Retrofits	585.4	34.5	16.9
7	Priority Neighborhoods ESD Retrofits	79.6	6.5	12.3
8	Private, Non-residential ESD Retrofits	194.1	16.8	11.6
9	Completed Projects	5.3	0.0	0.0

6 Nitrogen and Bacteria Reduction Tracking

Even though no impairments or TMDLS exist in the Patuxent Watershed related to nitrogen or bacteria at this time, the impact of restoration practices on these parameters were calculated. In general, Total Nitrogen (TN) and bacteria reduction strategies follow the strategies proposed for phosphorus and sediment, only with different efficiencies. The respective efficiencies for the various strategies and assumptions about target areas follow the Guidance Document and assumptions presented in this Plan (e.g., Table 28).

Reductions in nitrogen and bacteria loads from a baseline condition, by implementation phase, are provided in Table 49.

Table 49: Preliminary TN and Bacteria Loading Results of WTM Modeling in the Patuxent Watershed

Implementation Phase	*TN Loading*	*Bacteria Loading*	*Comments*
	% reduction from Baseline Load	*% reduction from Baseline Load*	
WTM Baseline Load	**0%**	**0%**	**Uncalibrated load using Anacostia loading rates**
WTM 2.0	0.1%	0.1%	**Completed Projects**
WTM 2.0	0.5%	0.6%	**High Priority Projects**
WTM 2.0	7.2%	7.1%	**Low Priority and Other Potential Projects**
WTM 3.0	29.6%	32.5%	**ESD Strategies**
WTM 4.0	30.6%	35.3%	**Habitat Restoration**
WTM 5.0	65.4%	38.9%	**MS4 Programmatic Practices**

Overall, the TN, bacterial loads were reduced by 65.4% and 38.9% respectively. Since the same core restoration strategies outlined for the sediment load reduction and impervious cover reduction procedures are being followed, the cost for implementation also remains generally the same.

7 Action Inventory Implementation Schedule

7.1 Patuxent Watershed Implementation Schedule

The implementation schedule summarized in Tables 50 and 51 are an action inventory matrix that identifies priorities and timeframes for implementation of the above identified watershed restoration strategies as a function of project synergies and expected funding levels countywide. During the first permit cycle (through 2015), a priority was placed on full implementation of complete, high and low priority projects. A list of the high and low priority projects is provided in Appendix A. Far fewer opportunities exist overall compared to other watersheds in the County. A limited amount of ESD on private land and stream restoration was pursued. Finally, outreach (100%) was targeted for pollutant load reduction (primarily nutrients) but not credited towards impervious cover credit. No riparian reforestation was targeted due to limited or no opportunities within the MS4 permit area. In future permit cycles, ESD on private and public land is pursued more substantially as is stream restoration. A limited amount of riparian reforestation achieves some impervious cover and pollutant load reduction.

Table 52 includes a summary of implementation goals for the 2015, 2017, 2020, 2025, and out years in order to illustrate the expected timeframe for compliance with the MS4 permit WLA. The Rocky Gorge phosphorus WLA is met easily and the Triadelphia phosphorus WLA is also met, but with a longer timeframe needed for compliance. The assumptions for the 2020 and 2025 fiscal periods were that future MS4 permits would set a similar countywide impervious goal as in the current permit (20%). The 2017 fiscal period was important for the countywide implementation strategy for meeting the Chesapeake Bay TMDL goals. The out year 2030 was an arbitrary milestone set for complete implementation of the strategies outlined in this Plan.

Table 50: Summary of Implementation Plan Schedule for the 2015 Fiscal Period, with expected level of ESD and pollutant load reductions for the Upper Patuxent and Triadelphia Reservoir

Sub-watershed	Strategies	% Complete in Permit Cycle	IC Treated (acres)	ESD (% IC)	Cost (Million $)	ESD (% Cost)	% Reduction from baseline			
							TN	TP	TSS	Bacteria
Triadelphia	Completed and High Priority Projects	100.0%	-	0%	$0	0%	-	-	-	-
	Low Priority Projects	100.0%	2	100%	$0.4	100%	0.5%	0.5%	0.6%	0.5%
	Other Potential Projects	0.0%	-	0%	$0	0%	-	-	-	-
	Public ESD Retrofits	0.0%	-	100%	$0	100%	0.0%	0.0%	0.0%	0.0%
	Private ESD Retrofits	5.0%	1	100%	$0.2	100%	0.3%	0.3%	0.3%	0.3%
	Riparian Reforestation	0.0%	-	0%	$0	0%	0.0%	0.0%	0.0%	0.0%
	Stream Restoration	0.0%	-	0%	$0	0%	-	-	-	-
	Programmatic Practices	100.0%	-	0%	$0.01	0%	23.4%	3.5%	0.0%	0.0%
	Subtotal	**7.6%**	**3**	**100.0%**	**$0.6**	**99.1%**	**24.2%**	**4.3%**	**0.9%**	**0.8%**

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

Table 51: Summary of Implementation Plan Schedule for the 2015 Fiscal Period, with expected level of ESD and pollutant load reductions for the Lower Patuxent and Hawlings River Watershed

Sub-watershed	Strategies	% Complete in Permit Cycle	IC Treated (acres)	ESD (% IC)	Cost (Million $)	ESD (% Cost)	% Reduction from baseline			
							TN	TP	TSS	Bacteria
Rocky Gorge	Completed and High Priority Projects	100.0%	5	27%	$0.4	77%	0.7%	0.7%	0.8%	0.8%
	Low Priority Projects	100.0%	5	100%	$0.9	100%	8.4%	8.2%	8.3%	8.2%
	Other Potential Projects	25.0%	-	0%	$0.5	0%	0.0%	0.0%	0.0%	0.0%
	Public ESD Retrofits	0.0%	-	100%	$0	100%	0.0%	0.0%	0.0%	0.0%
	Private ESD Retrofits	1.0%	1	100%	$0.2	100%	0.1%	0.1%	0.1%	0.1%
	Riparian Reforestation	0.0%	-	0%	$0	0%	0.0%	0.0%	0.0%	0.0%
	Stream Restoration	2.5%	-	0%	$0.5	0%	0.3%	0.2%	0.9%	0.0%
	Programmatic Practices	100.0%	-	0%	$0.1	0%	38.0%	8.2%	0.3%	4.7%
	Subtotal	**3.6%**	**11**	**64.5%**	**$3**	**54.5%**	**47.5%**	**17.4%**	**10.4%**	**13.8%**

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

Table 52: Summary of Implementation Plan schedule for the Patuxent Watershed with expected MS4 permit area WLA compliance endpoints

Sub-Watershed	Fiscal Year		2015	2017	2020	2025	2030	TMDL WLAs
Triadelphia	Impervious Treated (acres)		3	12	20	38	38	
	ESD (% Impervious)		100%	98%	97%	99%	99%	
	Cost (Million $)		1	3	5	9	9	
	ESD (% Cost)		99%	98%	98%	99%	99%	
	% Reduction from baseline	TN	24%	27%	29%	34%	34%	
		TP	4%	7%	9%	14%	14%	15%
		TSS	1%	4%	6%	12%	12%	
		Bacteria	1%	4%	6%	12%	12%	
Rocky Gorge	Impervious Treated (acres)		11	88	165	307	307	
	ESD (% Impervious)		64%	89%	90%	95%	95%	
	Cost (Million $)		3	17	40	70	75	
	ESD (% Cost)		55%	82%	64%	73%	68%	
	% Reduction from baseline	TN	47%	55%	67%	82%	85%	
		TP	17%	25%	36%	52%	53%	15%
		TSS	10%	19%	45%	70%	79%	
		Bacteria	14%	23%	32%	47%	47%	

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

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Appendix A – List of High and Low Priority ProjectsLow Priority Projects

High and Low Priority Project List –
Rocky Gorge Reservoir (Lower Patuxent & Hawlings River) Watershed

Subwatershed	**Project Type**	**Project Name**
Hawlings River	Environmental Site Design (ESD)	Longwood Community Center Ross Boddy Recreation Center
	Stormwater Pond Retrofit	Sandy Spring Meadows
Lower Patuxent River	Environmental Site Design (ESD)	Burtonsville Park & Ride

High and Low Priority Project List –
Triadelphia Reservoir (Upper Patuxent River) Watershed

Project Type	**Project Name**
Environmental Site Design (ESD)	Damascus Library