Lower Patuxent River

Watershed Assessment

June | 2016

Prepared For

Charles County

Department of Planning and

Growth Management

Watershed Protection and Restoration Program

200 Baltimore St., La Plata, MD 20646

Prepared by

KCI Technologies, Inc.

936 Ridgebrook Road

Sparks, MD 21152

ACKNOWLEDGEMENTS

The Lower Patuxent Watershed Assessment was a collaborative effort between Coastal Resources, Inc., KCI Technologies, Inc. and Charles County Department of Planning and Growth Management. The resulting report was authored by the following individuals from KCI Technologies, Inc. and Charles County.

Susanna Brellis | KCI Technologies, Inc.

Megan Crunkleton | KCI Technologies, Inc.

Colin Hill | KCI Technologies, Inc.

Bill Frost | KCI Technologies, Inc.

Michael Pieper | KCI Technologies, Inc.

James Tomlinson | KCI Technologies, Inc.

Charles Rice | Charles County P&GM

Karen Wiggen | Charles County P&GM

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

List of Acronyms

BayFAST	Bay Facility Assessment Scenario Tool
BMP	Best Management Practices
CBP	Chesapeake Bay Program
CIP	Capital Improvement Plan
EOS	Edge of Stream
EPA	U.S. Environmental Protection Agency
ESD	Environmental Site Design
FA	Future Allocation
MAST	Maryland Assessment Scenario Tool
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
SPSC	Step Pool Storm Conveyance
SW-WLA	Stormwater Wasteload Allocation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
WIP	Watershed Implementation Plan
WLA	Wasteload Allocation

1 INTRODUCTION

1.1 BACKGROUND

Charles County Department of Planning and Growth Management (PGM) has initiated a series of watershed assessments in response to requirements set forth by the Maryland Department of the Environment (MDE) in the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit (11-DP-3322 MD0068365), issued on December 26, 2014. The watershed assessments support the County's goals for healthy watersheds and natural resources, and also support progress towards satisfying several regulatory and permit requirements.

Mattawoman Creek Watershed and Lower Patuxent River Watershed (Figure 1) were selected for the 2015 watershed assessments and follow the methodologies and formats set forth in the County's Port Tobacco River Watershed plan, which was completed in September 2015 and served as a pilot assessment for the County's current assessment methods. The Mattawoman Creek Watershed assessment is reported separately (KCI, 2016). The assessments build from the planning strategies included in the County's Phase II Watershed Implementation Plan (WIP) Strategy (February 2013). The WIP describes in broad terms the County's various non-agricultural source sectors (wastewater, urban stormwater, septic), their associated TMDL load reduction targets, reduction strategies, costs of plan implementation and potential funding sources. The watershed assessments provide the next step in the planning process specifically for the urban stormwater sector regulated by the County's NPDES permit. The watershed assessments, through desktop and field assessment, identify watershed and water quality conditions and identify and prioritize specific restoration solutions to meet the County's watershed restoration goals.

1.2 WATERSHED DESCRIPTION

The Lower Patuxent River Watershed, located in northeastern Charles County, drains into the Patuxent River, which also drains directly into the Chesapeake Bay (Figure 2). The Town of Hughesville is located in the southwestern portion of the Lower Patuxent River Watershed, and Benedict is located at the easternmost extent of the watershed on the Patuxent River. Prince George's County, St. Mary's County and Calvert County also contain portions of the Lower Patuxent River Watershed. The Lower Patuxent River portion within Charles County is approximately 3 miles long with a watershed of approximately 30 square miles. Land use in the watershed is predominately forested (44%), with the remaining area devoted to developed land (37%) and agriculture (13%; MDP, 2010).

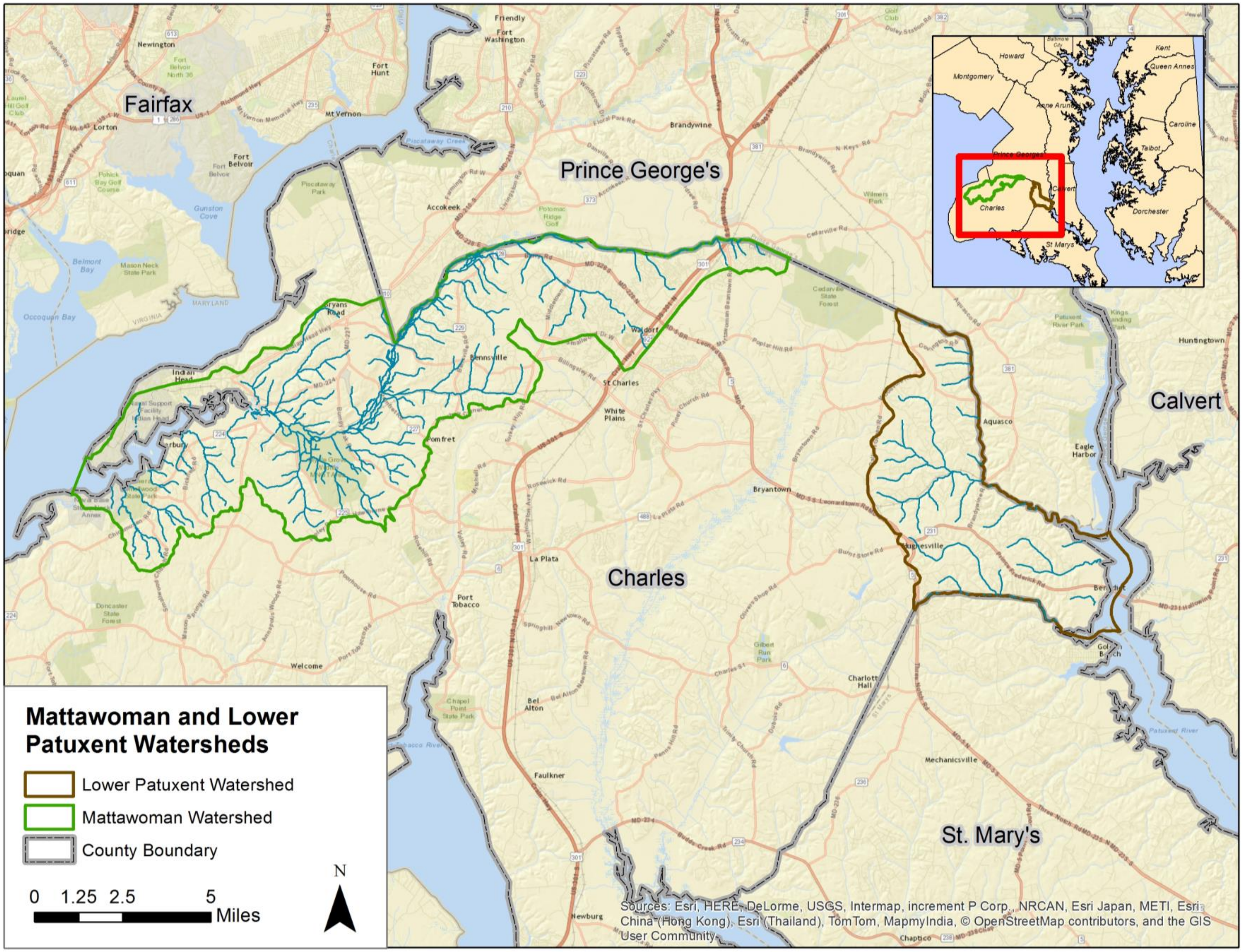


FIGURE 1: STUDY AREA LOCATION MAP

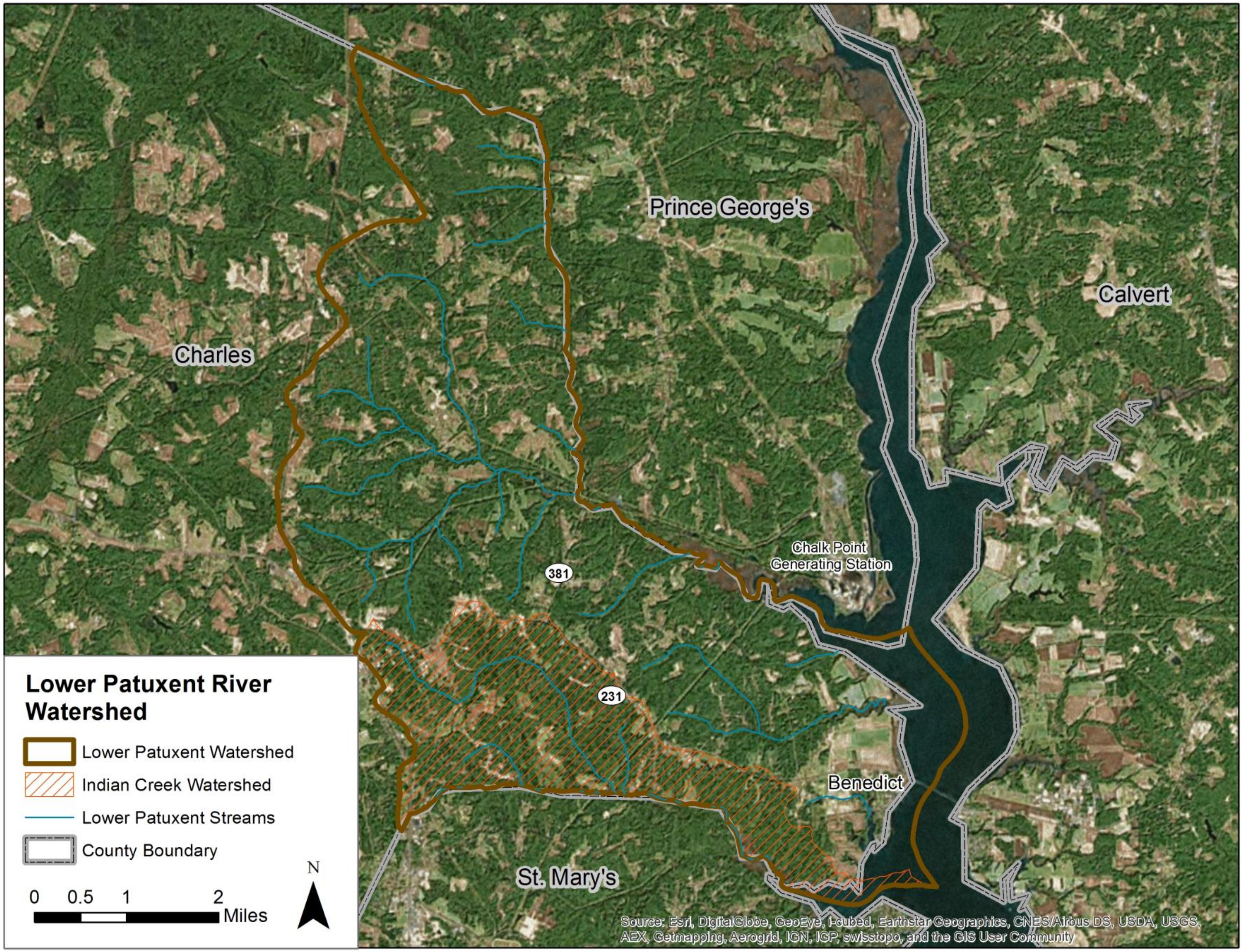


FIGURE 2: LOWER PATUXENT RIVER WATERSHED LOCATION

1.3 PREVIOUS WATERSHED STUDIES AND ASSESSMENTS

BayLand Consultants and Designers, Inc. prepared the *Benedict Properties Shoreline and Stormwater Assessment Report* (2014a) to help Charles County meet their MS4 permit and the Phase II Watershed Implementation Plan. The investigation included two parcels located in the Town of Benedict and identified opportunities for shoreline stabilization and stormwater management BMP projects. BayLand also prepared the *Feasibility Report: Shoreline Management Practices at Charles County Owned Properties* (2014b) in which they identified shoreline stabilization projects on nine Charles County owned properties. Projects from both BayLand reports are included in the analysis of this report.

1.4 GOALS

1.4.1 WATERSHED ASSESSMENTS

The County's current round of watershed assessments will satisfy section IV.E.1 of the NPDES permit to develop detailed watershed assessments for the entire County by the end of the permit term (2019) with a focus on urban stormwater sources and restoration. The following schedule of assessments is being implemented:

- Port Tobacco – completed 2015;
- Mattawoman Creek and Lower Patuxent River – completed 2016;
- Zekiah Swamp, Gilbert Run, and Wicomico River – to be complete 2016; and
- Potomac River (upper,middle, lower) and Nanjemoy Creek – to be complete 2017.

The assessments identify management strategies that support several planning goals, including:

- Implementation of restoration efforts for twenty percent of the County's impervious area;
- Meeting Chesapeake Bay Total Maximum Daily Load (TMDL) stormwater load reduction targets; and
- Meeting TMDL targets for local waterway impairments, specifically stormwater waste-load allocations (SW-WLAs).

To accomplish these goals the assessments are structured to meet the following objectives:

- Characterize current water quality conditions;
- Characterize current stream and watershed conditions;
- Identify and rank water quality problems;
- Identify and prioritize water quality improvement projects;
- Estimate pollutant load reductions achievable with implementation of the plan and develop reduction milestones towards meeting SW-WLAs.

Because the primary goal of this current study is related to the urban stormwater sector and meeting the restoration goals of the NPDES permit, watershed elements such as rare, threatened and endangered species, coastal waterways, climate impacts, etc. while extremely important, are outside of the scope of this current effort. These elements are addressed in other State and County planning efforts and the results of this study can be combined to address a wider range of watershed features.

1.4.2 Impervious Restoration

As a requirement of the NPDES MS4 Discharge Permit issued by MDE to Charles County, the County must treat 20% of remaining Countywide baseline untreated impervious acres by the end of the current permit term in December, 2019. Impervious accounting methodology is included in Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (MDE, 2014a). Untreated impervious includes those areas where stormwater practices provide less than the current Maryland standard water quality volume for runoff from 1” of rainfall. Section 6.3 of this report describes the impervious credit achieved, with specificity for the Lower Patuxent River watershed.

1.4.3 Indian Creek Bacteria TMDL

1.4.3.1 TMDL Development

The total allowable pollutant load to a waterbody consists of two categories of sources: point sources (Wasteload Allocation or WLA) which include stormwater and wastewater, and non-point sources (Load Allocation or LA) which include agricultural loads. Stormwater regulated by NPDES permits is regulated as a point source. In Maryland, MDE designates this allowable load as the stormwater wasteload allocation (SW-WLA). They may also include to other components, a Margin of Safety (MOS) which has generally been included implicitly in the analysis, and a Future Allocation (FA) which is used to account for growth in wastewater point sources and is not frequently included.

There is a local TMDL with SW-WLAs assigned to Charles County for bacteria for the Indian Creek portion of the Lower Patuxent River.

The Lower Patuxent River TMDL for bacteria was put in place in 2004, has a baseline year of 2001 and addresses fecal coliform impairments for several restricted shellfish harvesting areas (MDE, 2004). Because the only subwatershed listed in the TMDL within Charles County is Indian Creek, the discussion of the TMDL in this section refers only to the Indian Creek subwatershed.

The maximum allowable load was calculated for two conditions: the median and 90th percentile. Because the 90th percentile analysis had the most stringent reduction, it was used for the TMDL. Reductions to this level (concentrations exceeded 10% of the time) for Indian Creek, along with the six other creeks within the Lower Patuxent River Basin, will be needed for the restricted shellfish harvesting areas to meet the shellfish water quality criteria.

Review of the TMDL modeling shows that the allowable load was derived from the water quality criteria and the current load from monitoring data. As a result, the TMDL computation is based on the load calculated from measurements of bacteria concentration in the receiving water.

The baseline, allowable load, and percent reduction for all sources (LA and WLA combined) was given in the TMDL (MDE, 2004), shown in Table 1. All loads have been converted from the scientific notation for counts per day used in the TMDL to a common unit of billion MPN/day for this analysis and report.

TABLE 1: TMDL CALCULATIONS (BN MPN/DAY)

Baseline Load	Allowable Load	Req'd % Reduction
261.5	146.6	43.94%

The Indian Creek Watershed spans both Charles and St. Mary's Counties, so both jurisdictions have a responsibility to address the LA. The SW-WLA for stormwater was estimated in the TMDL by considering the urban land area in the watershed to be the regulated stormwater, and calculating the SW-WLA by pro-rating the allowable load to the urban land. As the only permitted jurisdiction in the watershed is Charles County, the County's urban land was used for the calculation. This resulted in a pro-rated percentage of 10.6% of the TMDL for the SW-WLA.

The proportion of the LA for which each jurisdiction is responsible was derived from the non-urban land use distribution, plus the unregulated St. Mary's County urban land shown in Table C-2 of the TMDL. The land use breakdown is shown in Table 2 and the pro-rated TMDL loads are shown in Table 3.

TABLE 2: INDIAN CREEK LAND USE DISTRIBUTION

Land Use	Total Area (ac)	Charles County (ac)	Charles County (%)	St. Mary's County (ac)	St. Mary's County (%)
Non-Urban	5,710.1	3,090.2	39.4%	2,619.8	33.4%
Regulated Urban	1,309.8	829.1	10.6%		0.0%
Non-regulated Urban	829.1		0.0%	1,309.8	16.7%
Total	7,849.0	3,919.4	49.9%	3,929.6	50.1%

TABLE 3: STORMWATER WASTE LOAD ALLOCATION (WLA) AND LOAD ALLOCATION (LA) (BN MPN/DAY)

	SW-WLA	LA	TMDL
Charles County	15.6	57.7	73.3
St. Mary's County	0.0	73.4	73.4
Published Total	15.6	131.1	146.7

The TMDL was written using the best available data to calculate sources of fecal coliform to the shellfish beds in seven creeks in the Lower Patuxent River basin. They are based on the following input data and are calculations of watershed loads, not the delivered loads in the TMDL calculations.

- land use
- wildlife habitat, density, and FC production per animal
- Population, septic systems, and sewer coverage
- Factors for number of dogs and FC production per dog

- Livestock census and FC production per animal

The contribution of each source to the total load was provided as a percentage, shown in Table 4.

TABLE 4: INDIAN CREEK SOURCE ASSESSMENT (BN MPN/DAY)

Source	Loading	Percent
Livestock	2,990	64.7%
Pets	594	12.9%
Human	38	0.8%
Wildlife	998	21.6%
Total	4,620	100.0%

1.4.3.1 TMDL Reduction Targets

There are several issues with the development of the TMDL that make it difficult to use in determining how much and what kind of treatment will be effective at meeting the TMDL goals. First, review of the TMDL modeling shows that the allowable load was derived from the water quality criteria and the current load from monthly monitoring data. As a result, the TMDL computation is based on instream loads calculated from measurements of concentration in the receiving water. Watershed loads, calculated from sources which are not transported and which have not undergone transformation such as die-off are required for restoration analysis. Comparison between the initial source load and therefore source load reduction cannot be drawn to the TMDL which is based on the receiving water concentration.

Second, the WLA calculation method above excerpted from the TMDL predates the current MDE guidance for developing SW-WLA implementation plans for bacteria (MDE, 2014c) which places emphasis on addressing human derived sources. With the preceding analysis, loads from all four sources are considered to be stormwater loads: livestock, human (septic systems), pets, and wildlife. The urban, or human derived, sources need to be more explicit in the model in order to calculate load reductions for the urban sector which the WLA should address.

Further analysis to isolate the urban loads making up the SW-WLA was conducted. A full description of the modeling is included in the County's overall restoration plan (KCI, 2016a) and only a brief summary is included here. Bacteria sources including human, domestic pets, wildlife, and livestock were estimated and total annual loads for the full TMDL (all sources including LA and WLA) were calculated using loading rates from current best available guidance and literature.

Refer to Table 5 for the results of the modeling and the load reduction goal used by the County to address the SW-WLA. A new baseline (2001) load was calculated (3,038 billion MPN/day). MDE's guidance on TMDL implementation stresses planning to the percent reduction, therefore the original percent reduction (43.94%) was applied to the baseline load to determine the load reduction required, 1,335 billion MPN/day. In this manner the TMDL and SW-WLA is remodeled or 'calibrated' to a new model that can more readily be used to assess load reductions from restoration planning scenarios.

TABLE 5: MODELED LOCAL TMDL BASELINE AND TARGET LOADS

	Lower Patuxent River
	Bacteria- billion MPN/day
Baseline and Target	
TMDL Baseline Year	2001
Baseline Load	3,038
Target Percent Reduction	43.94%
Modeled Target Reduction	1,335
Modeled TMDL WLA	1,703

1.4.4 Chesapeake Bay TMDL

In December, 2010, the U.S. Environmental Protection Agency, (EPA) published the Chesapeake Bay TMDL. The Bay TMDL sets limits on loading of three pollutants (nitrogen, phosphorus and sediment) delivered to the Bay from contributing segments, such as the Lower Patuxent River.

The County's MS4 permit is requiring compliance with the Chesapeake Bay TMDL for the urban stormwater sector through the use of the 20% impervious surface treatment strategy. Therefore it is expected that the 20% goal and associated credit accounting will take precedence over the Bay TMDL loading goals and crediting. While not a requirement in the County's MS4 permit, the strategies provided in this plan to meet local TMDL reduction targets have been modeled in order to calculate potential progress toward meeting the Bay TMDL nutrient and sediment reduction goals.

Charles County's Bay TMDL goal is defined at the County scale and is provided here in Table 6 with the reduction described in terms of both the loading reduction and the percent reduction. Total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) loads are measured in edge of stream (EOS) loads, which is the amount of a pollutant load transported from a source to the nearest stream. Section 6 of this report describes the reductions achieved, with more specificity for the Lower Patuxent watershed.

TABLE 6: CHARLES COUNTY BAY TMDL STORMWATER GOALS

	TN- EOS (lbs/yr)	**TP- EOS (lbs/yr)**	**TSS- EOS (lbs/yr)***
Bay TMDL Goal %	18.2%	37.7%	-
Bay TMDL Target Stormwater Reduction	42,759	7,554	-

*No target reduction for sediment. It is anticipated that by achieving the phosphorus goal, enough sediment will be removed to improve water quality.

2 WATERSHED ASSESSMENT METHODS

The following assessments were conducted throughout the Lower Patuxent River watershed:

- Upland Assessment
- Nutrient Synoptic Survey
- Stream Corridor Assessment

Property access permission letters were sent to all landowners within the target watershed with streams on their property. Passive permission was assumed through the letters, although landowners were given the opportunity to deny access to their properties. However, all of the properties targeted for assessments were able to be accessed as part of this effort.

2.1 UPLAND ASSESSMENT

KCI assessed upland pollution sources and restoration opportunities using the methodology detailed in the Center for Watershed Protection's Unified Subwatershed and Site Reconnaissance Manual (CWP, 2004). These assessments included both the Neighborhood Source Assessment (NSA) and Hotspot Site Investigations (HSI). General procedures for each type of assessment are provided in the following sections.

2.1.1 NEIGHBORHOOD SOURCE ASSESSMENT

A Neighborhood Source Assessment (NSA) reconnaissance was conducted in residential neighborhood areas to evaluate the pollution-producing behaviors. The NSA rates the potential severity and type of non-point source pollution from residential behaviors. It also provides an assessment of the influence of imperviousness for each site by providing an estimate of whether roof drainage is directed to cisterns, storm drains, impervious areas or pervious areas and the percent of driveways in the neighborhood that are impervious.

A desktop analysis was performed in which all neighborhoods in the Lower Patuxent River watershed were identified and delineated. These neighborhoods were then categorized by similar characteristics, including house type (single family, townhouse, etc.), lot size, year built, and stormwater management era. Individual neighborhoods that characterized each category were selected for field visits so the assessment was conducted in a variety of residential areas that represent the different housing types found throughout each watershed. Neighborhoods were then rated on the Pollution Severity Index as either severe, high, moderate, or none based on their potential to generate pollutants. Neighborhoods were also rated on the Restoration Opportunity Index as either high, moderate, or low based on their potential for restoration opportunities.

2.1.2 Hotspot Site Investigations

A Hotspot Site Investigation (HSI) was conducted to identify potential stormwater hotspots. Hot Spots for this plan are defined as commercial, industrial, institutional, municipal or transportation-related operations that typically produce high levels of stormwater runoff and pollutants, while presenting potential risk for spills, leaks or illicit discharges. These include gas stations, commercial car washes, vehicle and equipment maintenance facilities, and sites where pesticides, fertilizers, or industrial chemicals may be stored or used.

The HSI assessment was conducted at locations identified in the office from aerial photography and mapping layers in GIS, and was targeted towards business, commercial, and industrial sites in the urban areas of the watershed. Additionally, using available GIS layers, potential hot spot locations that received no or only partial stormwater management were prioritized. Field crews rated each hotspot on the likelihood that current activities at the site are causing stormwater runoff contamination. Appropriate follow-up actions for each hotspot, including education, retrofits, and referral for immediate enforcement were also noted.

2.2 Nutrient Synoptic Survey

2.2.1 Water Quality Sampling

Synoptic water quality sampling was performed across the Lower Patuxent River watershed. The sampling locations were selected by locating sites which represented the watershed and also had ease of access. Sites located on a stream that crossed under a road or other infrastructure were sampled upstream of the road so the structure was not directly impacting the flow and water quality. In some locations, a site was selected upstream and downstream of a confluence to show changes in the flow and water quality at the confluence. Sample collection did not occur within 24 hours after a rainfall event totaling more than 0.25 inches of precipitation. A sub-meter Trimble® GPS unit was used to navigate to each sample point. If a grab sample could not be collected at the original sampling point, the location was shifted upstream or downstream accordingly, and an additional GPS point was collected if the point was moved significantly. Sampling locations remained within the original sampling reach and were not moved downstream of a confluence that would include flow from any additional reaches. Site conditions (e.g. clarity, odor, condition of site) were recorded at each sampling site. Grab samples were collected from each site for laboratory analysis of water quality parameters. Samples were preserved on ice for transport immediately after they were collected. Three duplicate samples and one lab blank were collected for quality assurance purposes.

Environmental Testing Lab Inc.[1] completed all laboratory analysis according to standard, approved methods. A complete list of analytical parameters and methods, including detection limits, is presented in Table 7.

[1] 3430 Rockefeller Ct, Waldorf, MD 20602

TABLE 7: WATER CHEMISTRY ANALYTICAL METHODS

Parameter	Method	Detection Limit	Units
Enterococcus (E. coli)	Colilert	1	MPN/100 ml
Ortho-phosphate Phosphorus	EPA 365.1	0.01	mg/L
TKN	EPA 351.2	0.5	mg/L
Nitrate + Nitrite	EPA 353.2	0.5	mg/L
Total Nitrogen	EPA 351.2 + 353.2	1	mg/L
Total Phosphorus	EPA 365.1	0.01	mg/L

Additional water quality measurements were collected *in situ* from each sampling site. Temperature, pH, specific conductivity, and dissolved oxygen were measured with a YSI ProPlus® multiprobe, and turbidity was measured with a Hach 2100 Turbidimeter. Optical brightener (fluorescent whitening agents) samples were collected in sample bottles wrapped in aluminum foil, and analyzed in the field using a Turner Designs AquaFluor® Handheld Flurometer configured with an Optical Brightener channel, following the California EPA Surface Water Ambient Monitoring Program's SOP (Burres, 2011). The Flurometer unit has a minimum detection limit of 0.5ppm and a range of 0-30,000ppm.

2.2.2 Stream Discharge Measurement

Stream discharge measurements were performed at each sampling site in conjunction with water quality sampling in order to calculate instantaneous baseflow pollutant loads. A suitable transect, one that approximates a "U" shaped channel, was located at each site for measuring stream discharge. Transects were selected to be free of irregularities that may create backflows and cross flows. A SonTek FlowTracker® Handheld Acoustic Doppler Velocimeter was used to collect a series of approximately 10 velocity measurements at regular intervals across the wetted width of the stream to determine instantaneous discharge. The measurements collected at regular intervals included depth (to the nearest 0.5cm) and velocity (to the nearest 0.00 m/sec). Velocity was measured at 0.6 of the distance from the water surface to the bottom of the stream. Due to the difficulty of obtaining accurate discharge measurements below approximately 0.05 cfs with the flowmeter, discharge at low flow sites was obtained by measuring cross sectional area and using a float to measure velocity.

2.3 Stream Corridor Assessment

Prior to performing stream corridor assessments, approximately 3.5 miles of stream reaches were prioritized using select GIS data elements as shown in the table below. Table 8 presents the selection and exclusion factors for selecting SCA reaches. KCI used the following general criteria for prioritizing stream reaches:

Criteria for selection:

- Topography – narrow, steep stream valleys and tortuous meander
- Vicinity to high density of stormwater infrastructure (outfalls, BMPs)

- Drainage area consists of untreated or undertreated impervious surfaces

Criteria for exclusion:

- Land use- adequate forest cover, wide riparian buffers
- Low density development and agriculture

TABLE 8: SCA REACH SELECTION AND EXCLUSION FACTORS

Data Element	Factors for selection	Factors for exclusion
Topography	Narrow, steep valleys and side slopes, tortuous meanders	Flat, wide floodplains
Stormwater infrastructure (outfalls, BMPs, BMP treated areas, Stormwater by Era)	Reaches downstream of untreated or undertreated areas	Reaches downstream of treated areas
Forest Cover	Lack of riparian buffer and forest	Adequate forest cover, wide riparian buffers
Development	Higher density development	Low density development and agriculture

Field crews conducted stream field investigations using standard SCA protocols as outlined in Stream Corridor Assessment Survey: SCA Survey Protocols (Yetman, 2001). Using the same methodology as other SCA surveys will allow for the results to be incorporated into, and directly compared against, other County and State assessment datasets. Property access permission letters were sent to all landowners within the target watershed with streams on their property. All of the properties targeted for assessments were able to be accessed as part of this effort.

The field investigation consisted of a two-person team walking the stream channel and conducting a visual assessment to locate problem areas and assess their severity and correctability. The field team collected information on channel alteration, erosion, exposed utility pipes, drainage pipe outfalls, fish barriers, inadequate buffers, construction in or near the stream, trash dumping, and recorded any unusual conditions. Representative sites were selected at locations representative of each stream segment. The general physical habitat condition was assessed at the representative sites using a modified version of the EPA's Rapid Bioassessment Protocols (Barbour et al., 1999). The assessment includes qualitative ratings for ten habitat parameters as well as information on wetted width, pool, run, and riffle depths, and channel substrate.

During the field assessment points were given unique alphanumeric identifiers according to the stream reach and point type. This allowed each point to have a unique ID, for example, 001_IB001. A complete list of point types and corresponding alphanumeric identifiers used during the field assessments is included below:

- Erosion (ES)
- Exposed pipe (EP)
- Pipe outfall (PO)
- Inadequate buffer (IB)
- Fish barrier (FB)
- Trash dumping (TD)
- Channel alteration (CA)
- Unusual condition (UC)

A GPS location was recorded and a photograph was taken for each assessment point. Linear features (eroding banks, buffer impacts, and channel alteration) were documented with a GPS location at each end of the impact and a line feature was developed to better represent the full extent of the problem area. The assessment rated each feature on a 1 to 5 scale according to its severity, correctability, and accessibility; where a score of 1 is the most severe, but also the most correctible and the most accessible. The results were then compiled into a database which will be used to identify and prioritize areas for restoration actions.

In addition to the basic SCA set of impacts and assessments, KCI added an inventory of Potential BMP Locations, in which the field crew could identify up to five potential BMP types that could be implemented at any particular location. This reduced the need for additional field visits and property owner coordination. The potential BMP types included the following:

- Bioretention/raingarden
- Invasive plant control
- Livestock exclusion fencing
- Outfall stabilization
- Riparian buffer enhancement or replacement
- Stabilized crossing
- Stormwater management pond
- Streambank stabilization
- Streamside grass buffer
- Wetland creation
- Wetland restoration
- Water trough

3 WATERSHED ASSESSMENT RESULTS

3.1 UPLAND ASSESSMENT

Upland assessments including both the NSA and HSI were completed on March 19th and 20th, 2015. Field crews assessed a total of 4 neighborhoods and 1 potential hotspot in the Lower Patuxent River watershed.

3.1.1 NEIGHBORHOOD SOURCE ASSESSMENT

A total of 4 neighborhoods were assessed in the Lower Patuxent River watershed (Figures 4 and 5). General characteristics of each neighborhood are presented in Table 9. A complete record of NSA data is included in Appendix A.

TABLE 9: GENERAL CHARACTERISTICS OF NEIGHBORHOODS ASSESSED

Site ID	Neighborhood / Subdivision	LU Type	Lot Size (acres)	Age (Decade)	Curb & Gutter	% Imperv -ious	% Lawn	% Canopy
LP-1	Malcolm Rd and Regina Ave /Regina Drive	Single Fam Detached	1	1950-2015	No	30	60	40
LP-2	Leonardtown Rd and Scout Camp Road	Single Fam Detached	>1	1970-1990	No	30	45	70
LP-3	Young Rd /Celestial Ln	Single Fam Detached	>1	2000	No	10	85	20
LP-5	Benedict Ave	Single Fam Detached	1	1930-2000	No	50	40	10

All neighborhoods received a 'moderate' pollution severity rating for potential nutrient, bacteria, sediment, and oil and grease pollution (Table 10). Nutrients, bacteria, sediment, and oil and grease were the most common pollution sources identified.

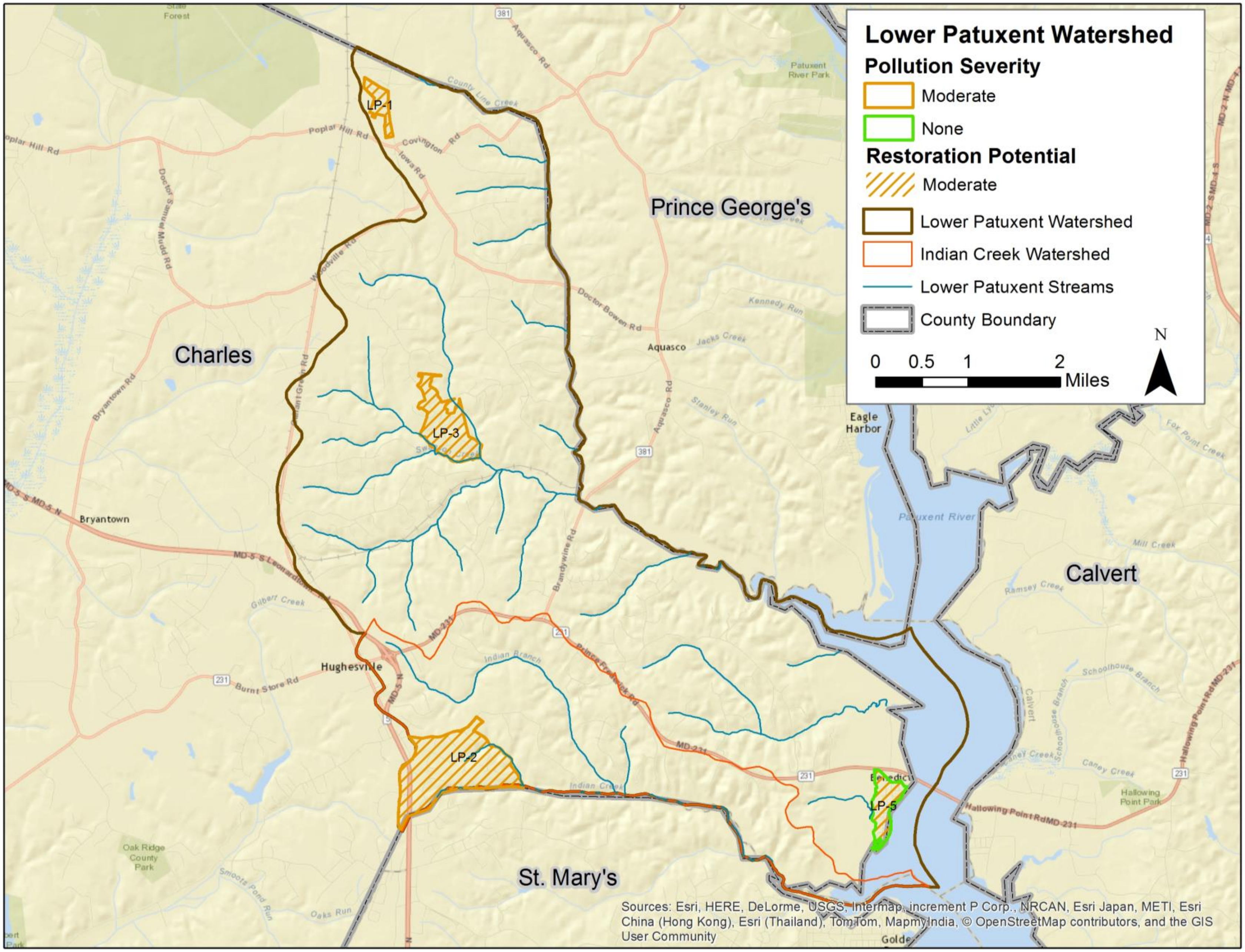


FIGURE 3: NEIGHBORHOOD SOURCE ASSESSMENT RESULTS

The restoration potential was rated as 'moderate' for all neighborhoods (Table 10). The restoration potential is based off of an index that ranks specific neighborhood features using benchmark values (e.g., less than 10% of storm drains stenciled). Depending on the feature type, if more than five features fall above or below the benchmark value, the neighborhood is considered to have a 'high' restoration potential; three to five benchmarks will have a 'moderate' restoration potential; and, a neighborhood with a 'low' restoration potential will have two or fewer benchmarks. Rain barrels, rain gardens, and conservation landscaping were the most common restoration actions recommended. Other recommended restoration measures include tree planting, and stormwater management retrofits.

TABLE 10: NEIGHBORHOOD POLLUTION SEVERITY AND RESTORATION POTENTIAL

NSA Site ID	Neighborhood / Subdivision	Pollution Severity	Pollution Sources	Restoration Potential	Potential Action
LP-1	Malcom Rd and Regina Ave/Regina Drive	Moderate	Sediment, Oil and Grease	Moderate	retrofit swales, rain gardens, rain barrels, tree planting, conservation landscaping
LP-2	Leonardtown Rd and Scout Camp Road	Moderate	Sediment, Nutrients, Bacteria	Moderate	retrofit swales, rain gardens, rain barrels, tree planting, conservation landscaping
LP-3	Young Rd/Celestial Ln	Moderate	Sediment, Nutrients	Moderate	retrofit swales, rain gardens, rain barrels, tree planting, conservation landscaping
LP-5	Benedict Ave	Moderate	Sediment, Bacteria, Oil and Grease	Moderate	rain barrels, rain gardens, conservation landscaping

3.1.2 Hotspot Site Investigations

One hotspot site in the Lower Patuxent River Watershed was investigated (Figure 4). The location, general description, and common operations (i.e., vehicle operations, outdoor materials, waste management, physical plant, turf/landscaping) of each site investigated are presented in Table 11. A complete record of HSI data is included in Appendix B.

The site was designated as a 'potential' hotspot. Recommendations at this site included a review of cleaning practices, check fueling practices near water, and the addition of a riparian buffer at the water's edge.

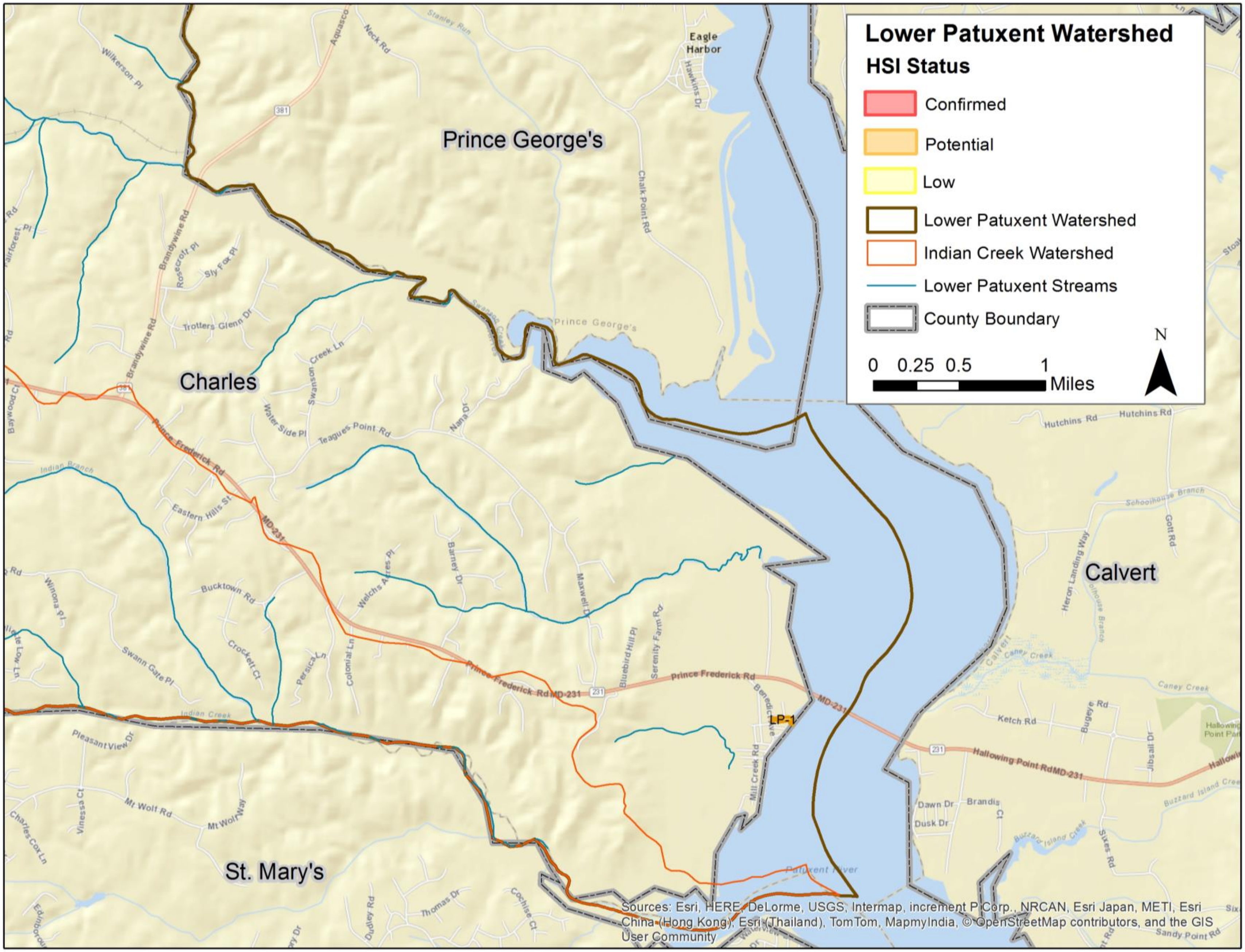


FIGURE 4: HOT SPOT INVESTIGATION RESULTS

TABLE 11: HOT SPOT INVESTIGATION LOCATIONS AND OPERATIONS

HSI Site ID	Location	Description	Vehicle Ops	Outdoor Materials	Waste Mgmt.	Physical Plant	Landscaping	HSI Status	Potential Action
LP-1	DeSoto's Landing	marina	Yes	No	Yes	Yes	Yes	Potential	Review cleaning practices, checking fueling practices near water, add buffer at water edge

3.2 Synoptic Water Quality Survey

Synoptic water quality sampling was performed across the Lower Patuxent River watershed from April 22-29, 2015. A total of 14 sites were visited (Figure 5) for water quality and discharge measurements; however, two sites were dry and no samples could be collected for water quality analysis. Synoptic sampling occurred at least 24 hours after rainfall events totaling more than 0.25 inches. The only rain event totaling more than 0.25 inches that occurred during the range of sampling dates was 0.35 inches on April 25, 2014. All sampling dates were at least 24 hours after these events (Wunderground weather station KMDHUGHE3, KMDWALDO8).

3.2.1 Stream Discharge

Discharge measurements were collected at each site in conjunction with the collection of grab samples. Results of flow measurements are shown in Table 14. Two sites had no flow present during site visits due to dry (i.e., intermittent flow) conditions. Overall, discharge values ranged from 0.02 to 9.22 cubic feet per second (cfs) for sites where samples were collected.

3.2.1 Water Quality

In situ water quality measurement results are presented in Table 14. Results of nutrients and bacteria baseflow concentrations and instantaneous load results, calculated using stream flow measurements, from water quality grab samples are presented in Figure 6 through Figure 10 and Table 15, which use color-coded nutrient ranges and ratings derived from Frink (1991; Table 12) and Southerland, et al. (2005; Table 13).

TABLE 12: NUTRIENT RANGES AND RATINGS FROM FRINK (1991)

Parameter	Baseline	Moderate	High	Excessive
Nitrate-Nitrite Concentration mg/L	<1	1 – 3	3 – 5	>5
Nitrate-Nitrite Yield kg/ha/day	<0.01	0.01 – 0.02	0.02 – 0.03	>0.03
Orthophosphate Concentration mg/L	<0.005	0.005 – 0.01	0.01 – 0.015	>0.015
Orthophosphate Yield kg/ha/day	<0.0005	0.0005 – 0.001	0.001 – 0.002	>0.002

TABLE 13: TOTAL NUTRIENT RANGES AND RATINGS FROM SOUTHERLAND ET AL., 2005. ALL UNITS IN MG/L.

Parameter	Low	Moderate	High
Total Nitrogen	< 1.5	1.5 – 7.0	>7.0
Total Phosphorus	< 0.025	0.025 – 0.070	> 0.070

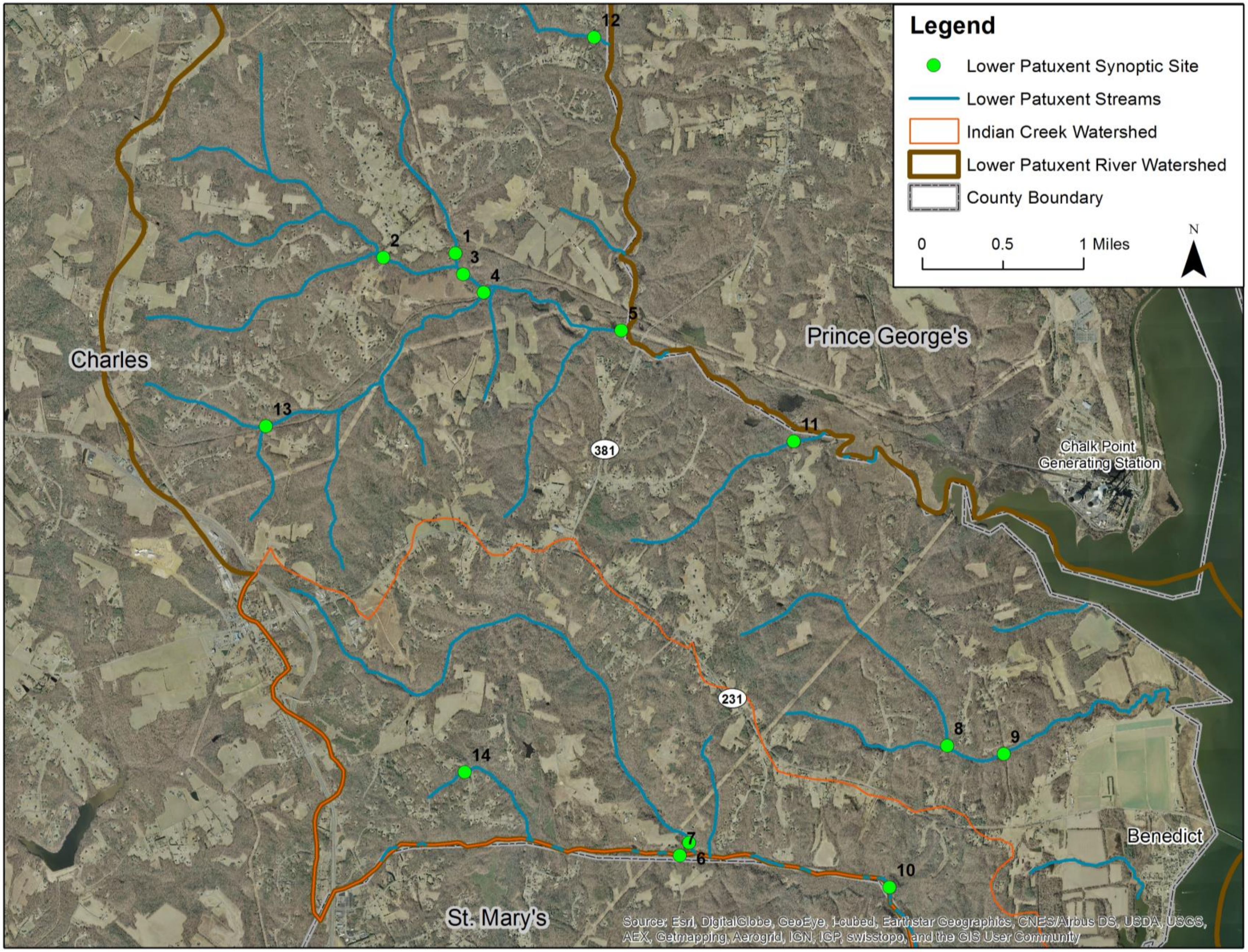


FIGURE 5: SYNOPTIC WATER QUALITY SURVEY SAMPLING LOCATIONS

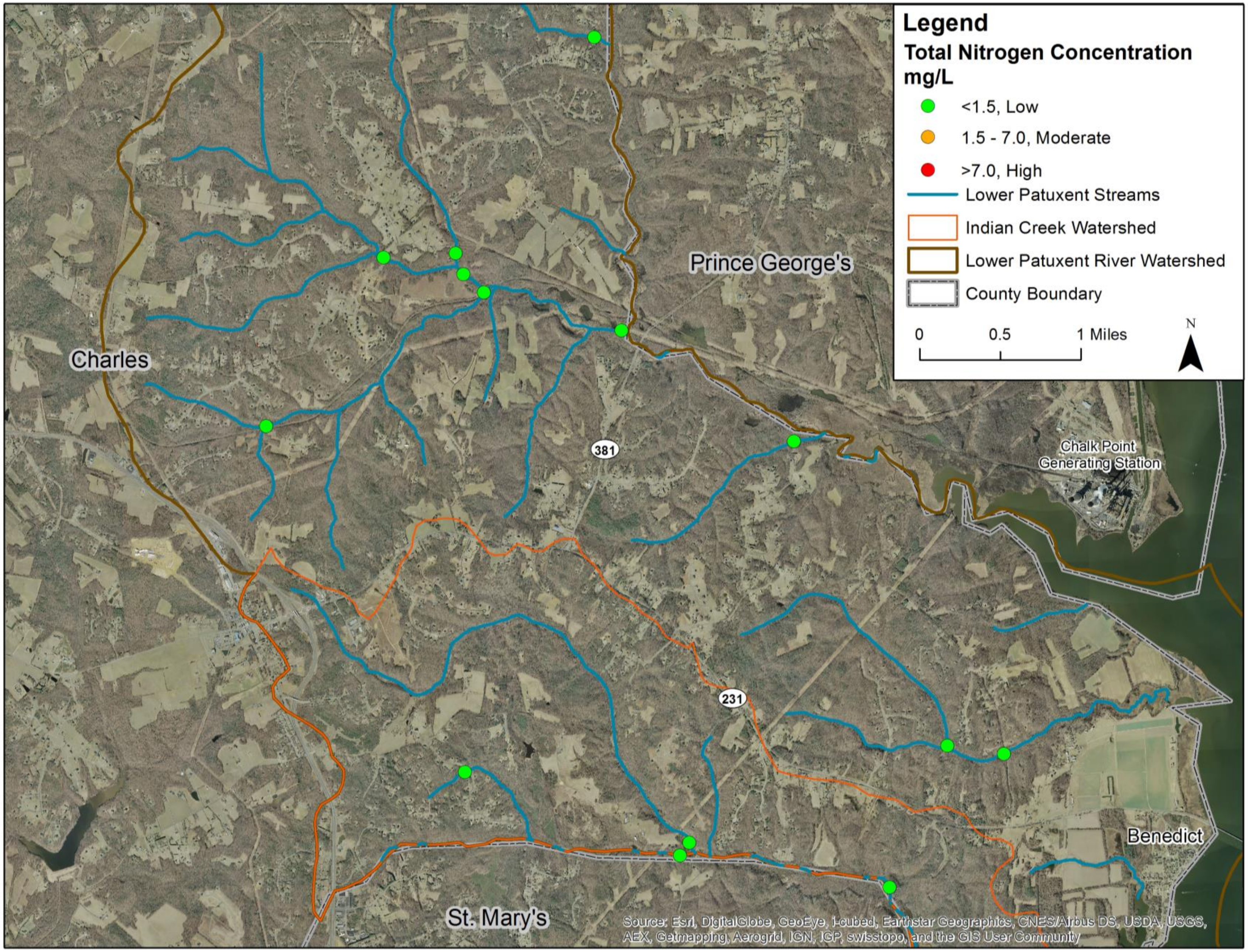


FIGURE 6: SYNOPTIC WATER QUALITY SURVEY SAMPLING RESULTS: TOTAL NITROGEN CONCENTRATION

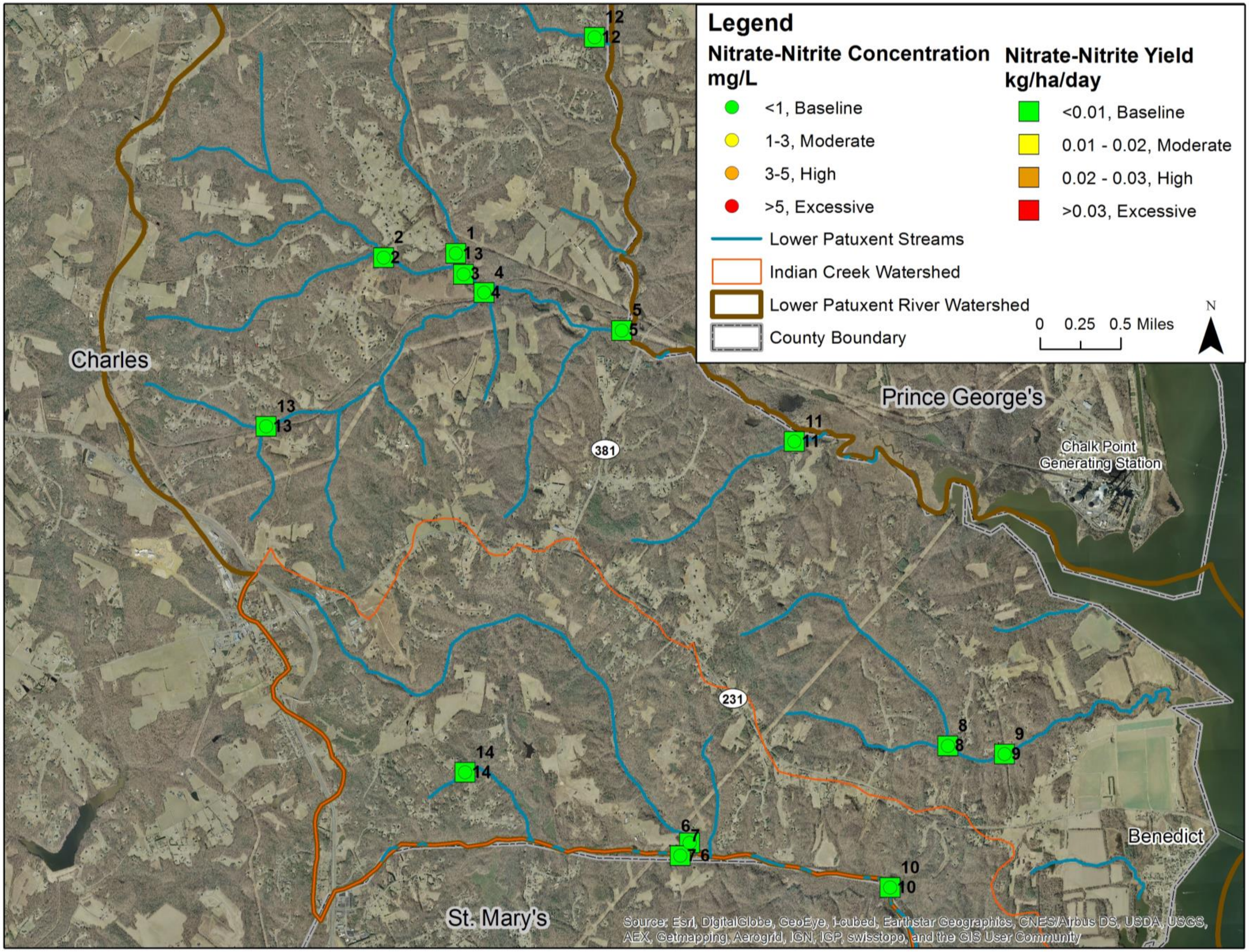


FIGURE 7: SYNOPTIC WATER QUALITY SURVEY SAMPLING RESULTS: NITRATE-NITRITE CONCENTRATION AND YIELD

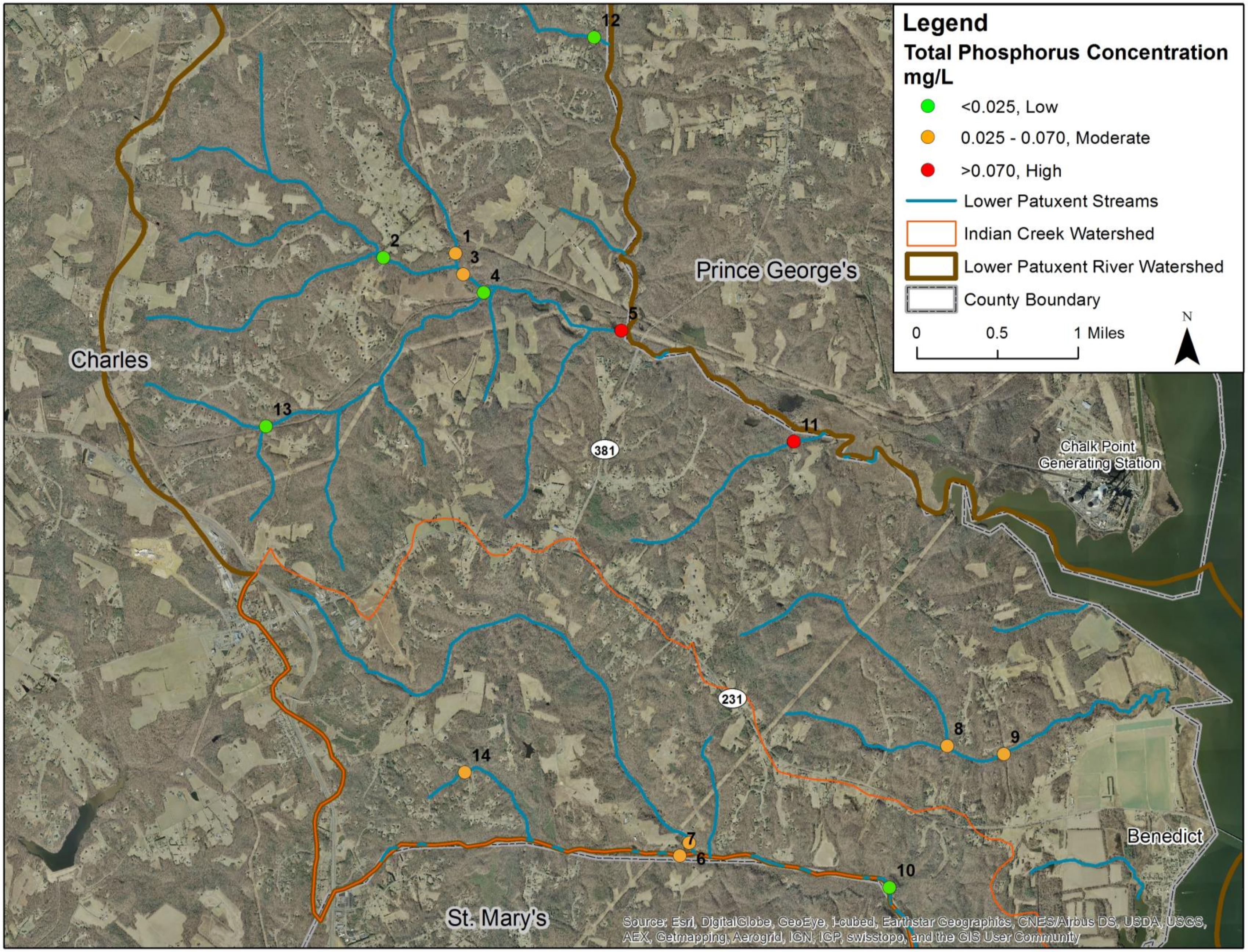


FIGURE 8: SYNOPTIC WATER QUALITY SURVEY SAMPLING RESULTS: TOTAL PHOSPHORUS CONCENTRATION

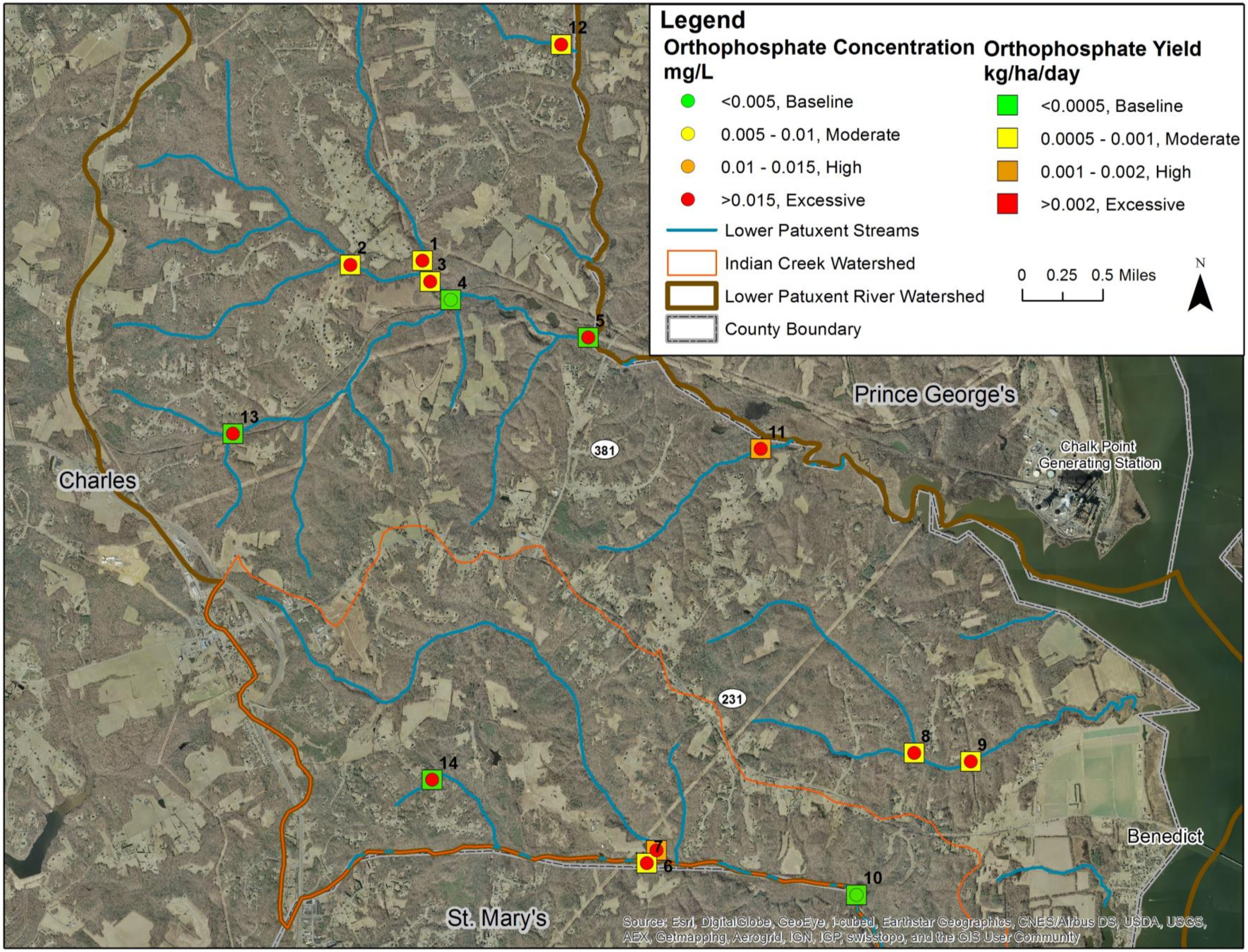


FIGURE 9: SYNOPTIC WATER QUALITY SURVEY SAMPLING RESULTS: ORTHOPHOSPHATE CONCENTRATION AND YIELD

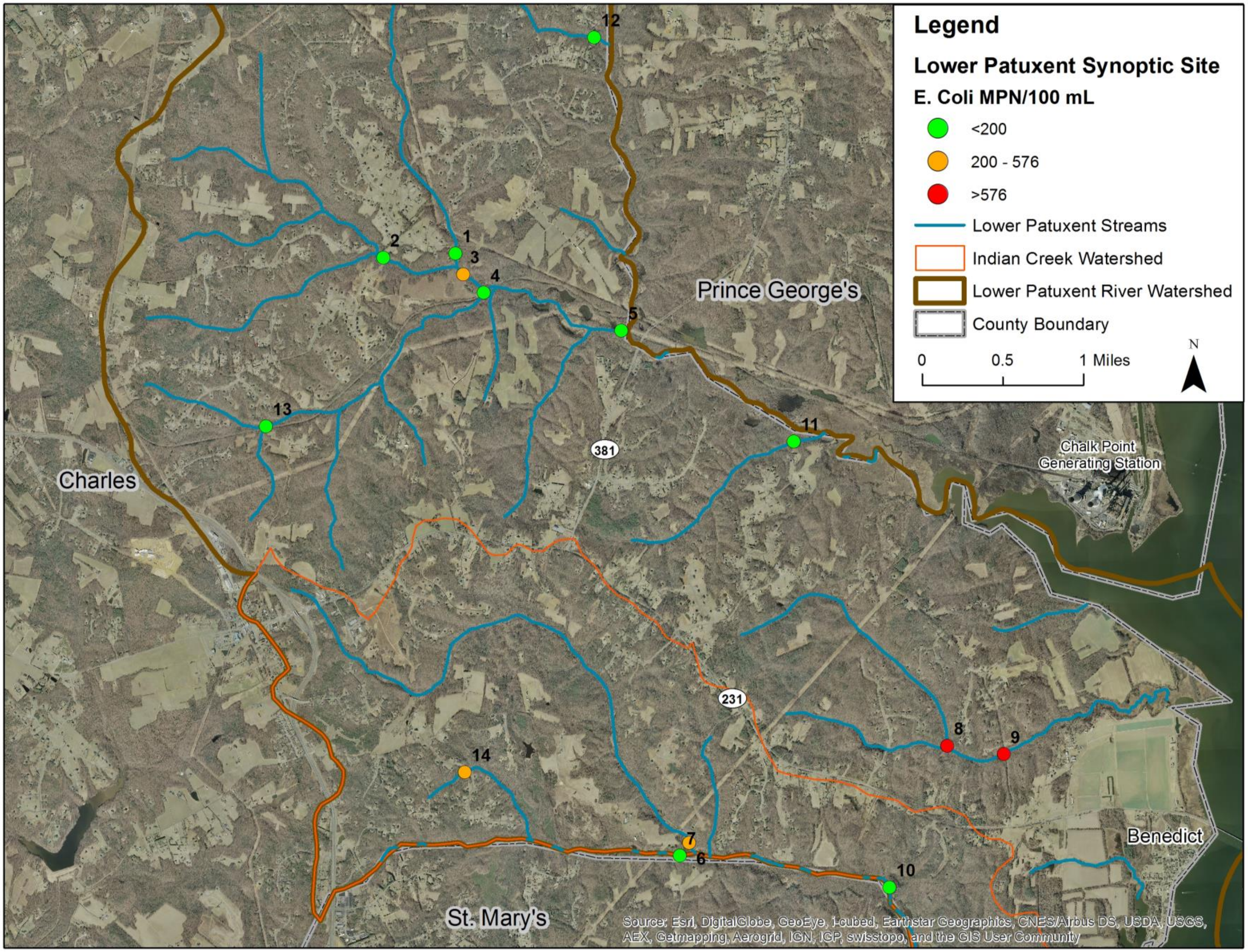


FIGURE 10: SYNOPTIC WATER QUALITY SURVEY SAMPLING RESULTS: BACTERIA

TABLE 14: STREAM DISCHARGE MEASUREMENT AND IN SITU WATER QUALITY MEASUREMENT RESULTS

Station	Date	Area (Hectares)	Area (Acres)	Discharge (cfs)	Discharge (Ls)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	Turbidity (NTU)	Optical Brightener (ppm)
LP-1	4/23/2015	720	1,779.2	4.20	118.9	10.5	6.82	11.19	116.2	6.84	1.81
LP-2	4/23/2015	720	1,779.2	4.16	117.9	9.7	6.92	11.43	117.6	3.60	1.37
LP-3	4/23/2015	1,489	3,679.4	9.22	261.2	10.6	6.90	11.22	118.4	5.56	1.77
LP-4	4/23/2015	749	1,850.8	0.00	0.0	-	-	-	-	-	-
LP-5	4/23/2015	2,668	6,592.8	0.04	1.2	16.7	**6.47**	5.26	94.3	30.50	3.81
LP-6	4/22/2015	774	1,912.6	5.81	164.5	10.8	7.10	9.20	150.9	5.17	2.02
LP-7	4/22/2015	627	1,549.3	3.70	104.7	11.1	6.94	9.79	132.6	5.93	1.66
LP-8	4/22/2015	277	684.5	1.38	39.1	13.8	**6.49**	8.59	109.9	12.10	1.69
LP-9	4/22/2015	518	1,280.0	2.94	83.2	13.0	6.54	9.55	114.8	15.00	1.40
LP-10	4/22/2015	1,831	4,524.5	0.00	0.0	-	-	-	-	-	-
LP-11	4/22/2015	262	647.4	1.63	46.3	16.0	7.11	8.85	172.2	12.50	1.50
LP-12	4/23/2015	122	301.5	0.83	23.4	12.2	6.98	10.58	135.5	4.93	0.85
LP-13	4/23/2015	256	632.6	1.67	47.1	9.3	7.14	11.73	126.8	5.90	1.60
LP-14	4/22/2015	158	390.4	0.02	0.5	11.8	6.83	10.13	115.1	4.22	1.48

Note: bold values indicate exceedances of COMAR standards or water quality thresholds

MDE has established acceptable water quality standards for each designated Stream Use Classification, which are listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality*. The non-tidal streams located in the Lower Patuxent River watershed are covered in *COMAR* in Sub-Basin 02-13-11: Patuxent River Area and are designated Use I waters. Specific designated uses for Use I streams include water contact sports, fishing, the growth and propagation of fish, agricultural water supply, and industrial water supply. The acceptable criteria for Use I waters are as follows:

- pH - 6.5 to 8.5
- DO - may not be less than 5 mg/l at any time
- Turbidity - maximum of 150 Nephelometric Turbidity Units (NTU's) and maximum monthly average of 50 NTU
- Temperature - maximum of 90°F (32°C) or ambient temperature of the surface water, whichever is greater
- E. coli – 576 MPN/100ml for *Infrequent Full Body Contact Recreation*.

For the majority of sites, *in situ* water quality parameters fell within COMAR limits for Use I streams. All sites in the Lower Patuxent Watershed were within acceptable ranges for DO levels. Two sites in the Lower Patuxent River Watershed had pH values below the minimum threshold of 6.5 SU, although pH values below 6.5 are common for streams that drain wetlands, which have naturally low pH levels. All sites were within acceptable ranges for temperature and turbidity. Although MDE does not have a water quality standard for specific conductivity, Morgan et al. (2007) have reported biological impairment thresholds in Maryland of 247 µS/cm for benthic macroinvertebrates. All sites in the Lower Patuxent Watershed were within acceptable ranges for specific conductivity with values ranging from 94.3 to 172.2 µS/cm.

Optical brighteners are whitening agents found in cleaning products such as laundry soaps and detergents, and can be found in toilet paper. Presence of optical brighteners in stream water can indicate illicit discharge of sewer systems and leaking septic tanks. The optical brightener results in the Lower Patuxent River watershed were generally inconclusive. The field fluorometer was calibrated with a 50ppm laundry detergent solution, following the California EPA Surface Water Ambient Monitoring Program's SOP (Burres, 2011). According to this method, sample measurements below 5ppm are considered negative for optical brightener. Field results ranged from 0.9 to 3.8 ppm, therefore it was concluded that none of the samples contained optical brighteners.

TABLE 15: WATER QUALITY GRAB SAMPLING RESULTS- NUTRIENT AND BACTERIA CONCENTRATIONS AND INSTANTANCEOUS LOADS

Station	Discharge (L/sec)	Ortho-P (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	E. Coli (MPN/100 ml)	Ortho-P (kg/H/day)	TKN (kg/H/day)	Nitrate-Nitrite (kg/H/day)	Total Nitrogen (kg/H/day)	Total Phosphorus (kg/H/day)
LP-1	118.9	0.060	0.25	0.25	0.5	0.04	145.5	0.00086	0.00357	0.00357	0.00713	0.00057
LP-2	117.9	0.040	0.25	0.25	0.5	0.02	161.6	0.00057	0.00354	0.00354	0.00707	0.00028
LP-3	261.2	0.050	0.25	0.25	0.5	0.04	206.4	0.00076	0.00379	0.00379	0.00758	0.00061
LP-4	-	-	-	-	-	-	-	-	-	-	-	-
LP-5	1.2	0.300	0.6	0.25	0.5	0.35	16	0.00001	0.00002	0.00001	0.00002	0.00001
LP-6	164.5	0.070	0.25	0.25	0.5	0.06	224.7	0.00129	0.00459	0.00459	0.00918	0.00110
LP-7	104.7	0.050	0.25	0.25	0.5	0.05	152.9	0.00072	0.00361	0.00361	0.00722	0.00072
LP-8	39.1	0.050	0.25	0.25	0.5	0.04	579.4	0.00061	0.00305	0.00305	0.00610	0.00049
LP-9	83.2	0.040	0.25	0.25	0.5	0.05	686.7	0.00055	0.00347	0.00347	0.00694	0.00069
LP-10	-	-	-	-	-	-	-	-	-	-	-	-
LP-11	46.3	0.120	0.25	0.25	0.5	0.13	150	0.00183	0.00381	0.00381	0.00763	0.00198
LP-12	23.4	0.040	0.25	0.25	0.5	0.02	99	0.00066	0.00415	0.00415	0.00829	0.00033
LP-13	47.1	0.030	0.25	0.25	0.5	0.01	55.6	0.00048	0.00398	0.00398	0.00796	0.00016
LP-14	0.5	0.080	0.25	0.6	0.5	0.06	461.1	0.00002	0.00007	0.00017	0.00014	0.00002

At this time, Maryland does not have specific numeric water quality criteria for nitrogen and phosphorus. To remain consistent with the Watershed Restoration Action Strategy report for Port Tobacco River Watershed (MDE, 2006b), nutrient ranges and ratings for nitrate-nitrite and orthophosphate were derived from Frink (1991) and used for comparison of water quality results (Table 12). Total nitrogen and total phosphorus concentrations were compared to those provided by the Maryland Biological Stream Survey (Southerland, et al. 2005; Table 13).

Total nitrogen concentrations were low at all sites (Figure 6 and Table 15). Baseline concentrations of nitrate/nitrite were found throughout the Lower Patuxent watershed (Figure 7 and Table 15). Instantaneous nitrate/nitrite yields were all found to have baseline ratings in all subwatersheds in the Lower Patuxent Watershed (Figure 7 and Table 15).

Total phosphorus concentrations were high in 2 subwatersheds, moderate in seven, and low in the remaining three subwatersheds (Figure 8 and Table 15). Aside from the two dry sites, excessive concentrations of orthophosphate were found in all subwatersheds, which had values ranging from 0.030 mg/L to 0.300 mg/L (Figure 9 and Table 15).

Elevated bacteria levels (*E. coli* > 576 mpn/100 ml; mpn = most probable number) were found in two subwatersheds (LP-8 and LP-9). LP-8 is located on a tributary to LP-9 and the sites are located in a forested residential area in the southeastern portion of the watershed. Three subwatersheds had levels exceeding the standard for water contact recreation of 200mpn/100 ml (Figure 10, Table 15).

In an attempt to correlate neighborhood pollution sources and water quality data from the synoptic survey, neighborhoods visited during the NSA with drainage to synoptic sites were identified. Only one synoptic point was identified as receiving majority of their drainage from a neighborhood visited during the NSA. Neighborhood LP-2, a predominantly wooded residential area, drains to synoptic site LP-14, which was found to have *E. coli* exceeding the 200mpn/100 ml water contact recreation standard and moderate total phosphorus concentrations. LP-2 was assessed to have "moderate" pollution severity; it had high forest cover, 70% disconnected downspouts, only 20% high maintenance lawns, and no stormwater management present. No obvious sources of phosphate or bacteria were found during the neighborhood assessment; however leaking septic tanks could be a source. No immediate correlation can be made between neighborhood pollution and synoptic sites.

3.3 Stream Corridor Assessment

Field crews walked approximately 1.5 miles of mapped stream channels between April 21 and 24, 2015. Figure 11 shows the stream reaches walked by field crews and the location of the representative sites for each walked reach. Inadequate buffers were the most widespread and frequent problems identified. The total number of points identified and ranked by severity in each watershed can be found in Table 16. The majority of points were categorized as severe to minor severity. No points received a rating of "very severe". A more detailed discussion of each data point type follows. A complete dataset is included as Appendix C.

TABLE 16: SCA DATA POINTS BY SEVERITY

Potential Problems	Total	Very Severe	Severe	Moderate	Low	Minor
Erosion (0.8 miles)	5	0	0	3	1	1
Buffer (0.2 miles)	3	0	3	0	0	0
Pipe Outfall	0	0	0	0	0	0
Fish Barrier	0	0	0	0	0	0
Trash	0	0	0	0	0	0
Channel Alteration	2	0	0	0	2	0
Construction	0	0	0	0	0	0
Exposed Pipe	0	0	0	0	0	0
Unusual Conditions	3	0	0	0	0	3
Total	***13***	0	3	3	3	4
Representative Sites	**2**					
Potential BMP Sites	**0**					

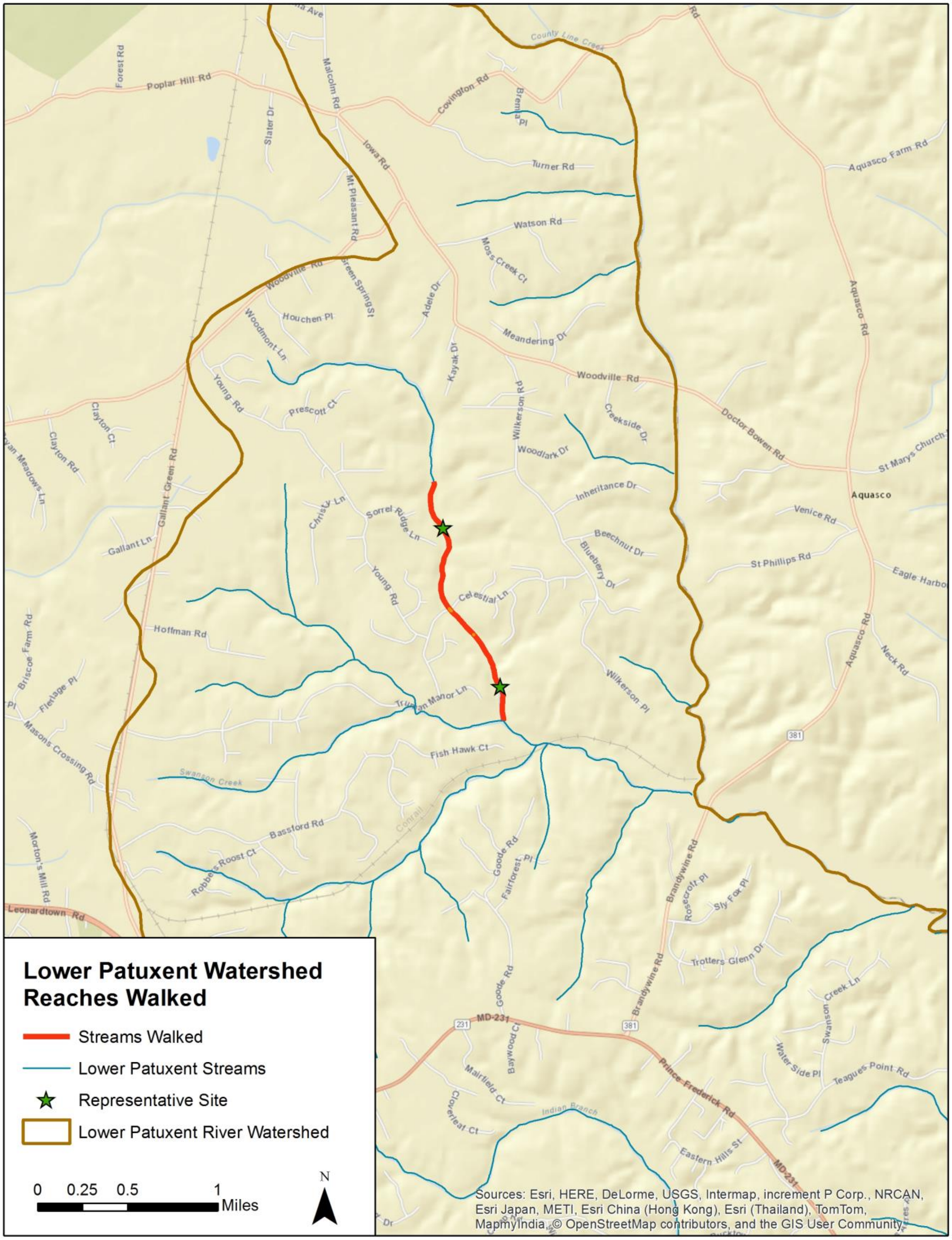


FIGURE 11: SCA REACHES WALKED AND REPRESENTATIVE SITES

Erosion Sites

Five erosion sites totaling 0.8 miles of erosion were identified. The stream erosion process was identified as both headcutting and downcutting for 100% of these sites. While collecting stream erosion data, field crews also attempted to determine the leading possible cause of erosion at each site. These potential causes included: an upstream road crossing, bends and slopes in the stream channel, upstream land use changes, and pipe outfalls. The most commonly described possible causes for erosion was landuse change upstream (80%), followed by bend at steep slope (20%). No sites presented an immediate threat to infrastructure. Locations of erosion sites can be found in Figure 13.

Inadequate Buffers

Inadequate buffers, defined as buffers less than 50 feet wide from the edge of the stream, were identified at 3 sites throughout the Lower Patuxent River Watershed totaling 0.2 miles of inadequate buffer for both right and left bank combined. All of the inadequate buffer found affected both sides of the stream channel and were a result of a power line easement. The location of reaches with inadequate buffers is displayed in Figure 13.

Pipe Outfalls

No pipe outfalls were located.

Fish Barriers

No fish barriers were located.

Channel Alteration

Channel alteration impacts were found at 2 sites, totaling approximately 112 feet in length. All channel alteration locations had a severity rating of “low”. One site was associated with a road crossing and one site was associated with rip rap stabilization efforts. Locations of channel alteration sites can be found in Figure 14.

Unusual Conditions and Trash

There were 3 unusual condition/comment points identified in the study area. All three of these sites were beaver dams with no significant impact to the stream.

No trash dumping sites were located.

In-Stream Construction

No in-stream construction was located.

Representative and Other Points

Representative points were taken at 2 locations in the Lower Patuxent River Watershed (Figure 11). Figure 12, below, presents the proportion of reaches in each assessment category for each habitat parameter, giving insight into the types of stream impacts creating the most degradation. In general, the modified qualitative RBP assessment at these sites revealed stream channels dominated by sand and gravel substrates. The stream reaches assessed generally had adequate riparian and bank vegetation buffers. Stream reaches had very little channel alternation and received "optimal" ratings. There was moderate sediment deposition throughout the study area, with reaches receiving scores of "marginal" and "suboptimal". Channel flow status was suboptimal throughout the study area. Both velocity/depth diversity and benthic substrate were found to be "suboptimal" or "marginal", with no sites receiving "optimal" ratings for these parameters. Shelter for fish and benthic substrate were both marginal throughout the study area.

Stream channel erosion is a major factor leading to impaired habitat conditions. All of the identified erosion sites were described as channel widening and downcutting processes. As the stream channels widen, the ability to effectively transport sediments (eroded bank material and from runoff over land) is reduced, leading to reduced scores for several habitat parameters including flow, velocity, embeddedness and macroinvertebrate habitat.

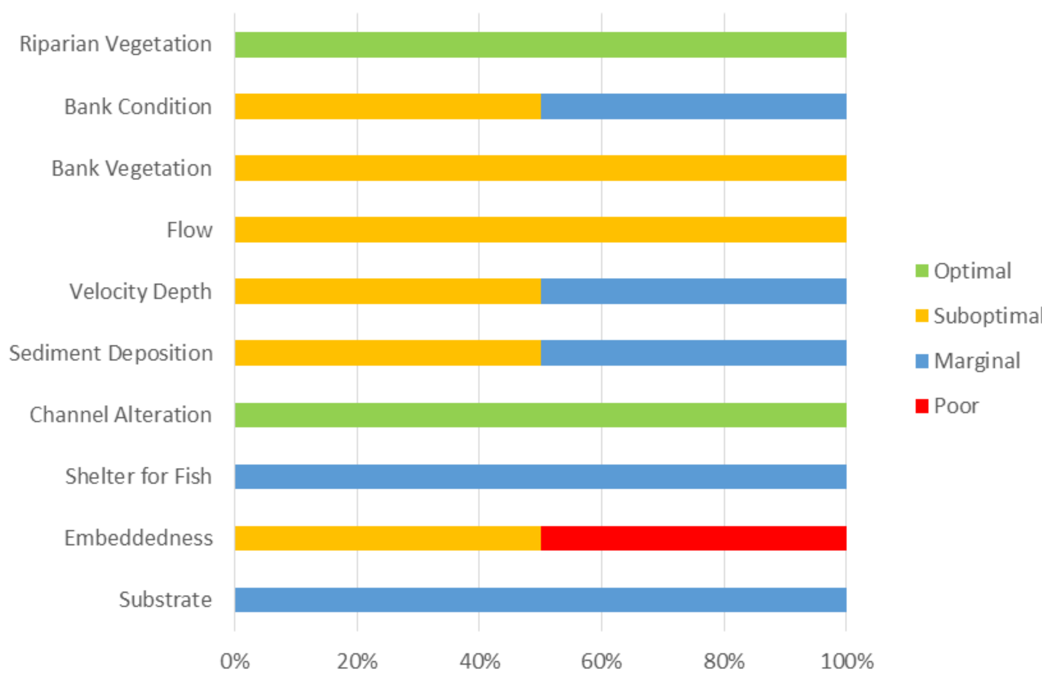


FIGURE 12: PROPORTION OF REACHES PER ASSESSMENT CATEGORY

Exposed Pipes

No exposed pipes were identified in the assessment.

Potential Improvements (BMP Locations)

No potential improvement sites were identified.

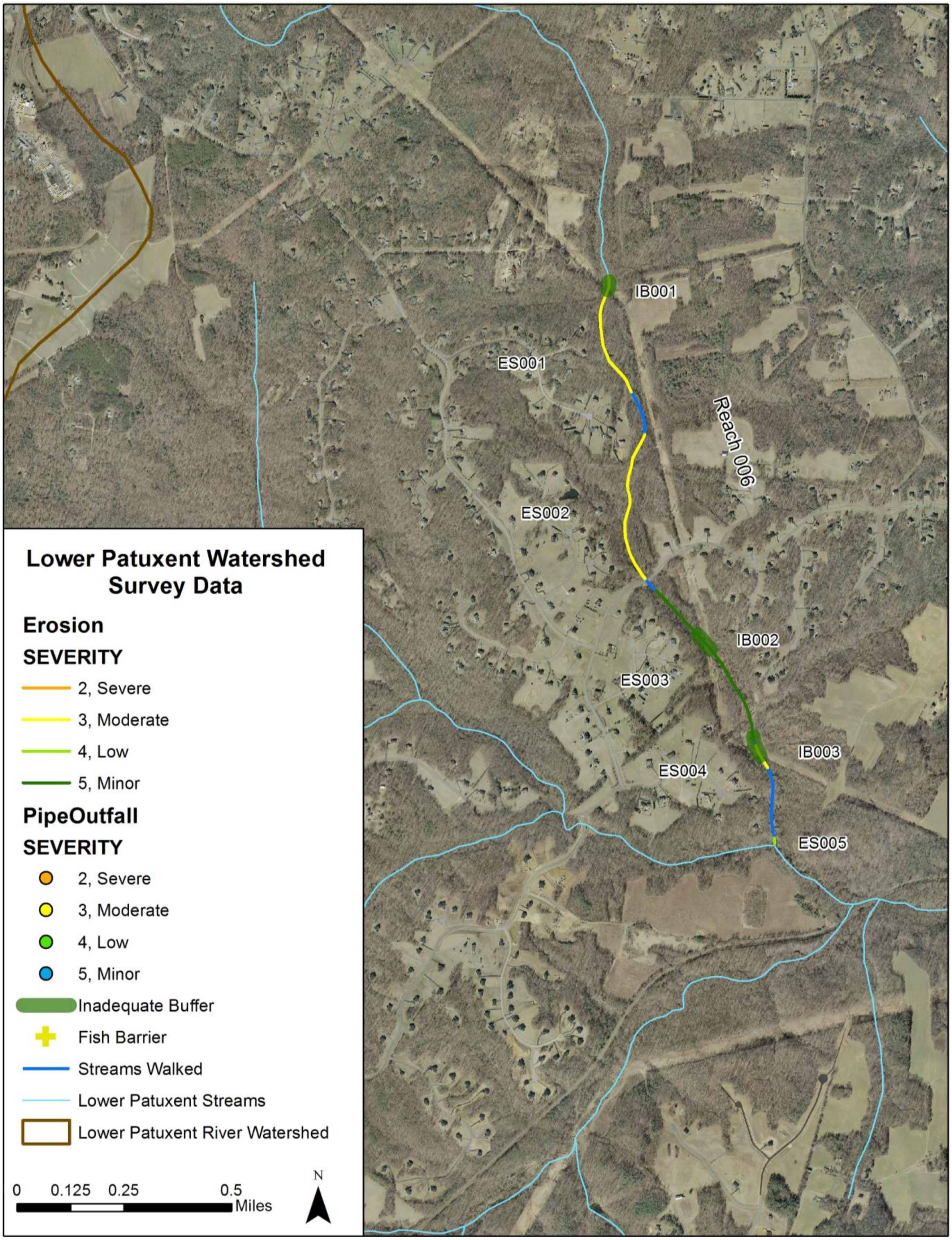


FIGURE 13: SURVEY DATA MAP: PIPE OUTFALL, EROSION, FISH BARRIER, AND INADEUQATE BUFFER SITES

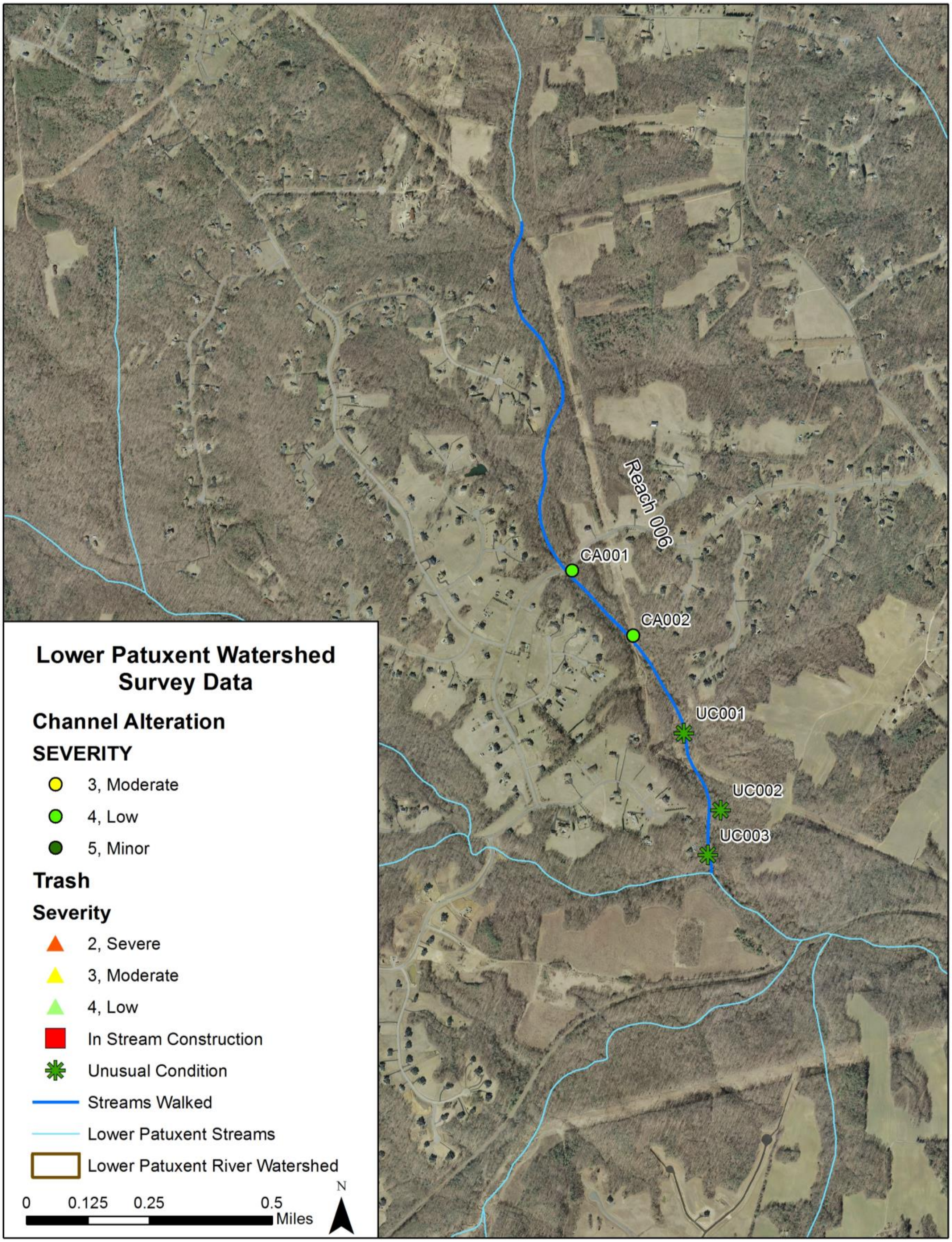


FIGURE 14: SURVEY DATA MAP: CHANNEL ALTERATION, TRASH DUMPING, IN STREAM CONSTRUCTION, AND UNUSUAL CONDITION SITES

4 Potential Water Quality Improvement Projects

Results of the desktop and field watershed assessments were compiled and the results were analyzed to determine those specific areas of impairment most in need of restoration. Restoration measures were then developed according to the type and source of impact. The following section presents the methods and results for each restoration measure type which include both structural and non-structural practices and programs:

- Stream restoration;
- Shoreline erosion control;
- Stormwater BMPs (step pool stormwater conveyance (SPSC), bioretention, wet pond);
- Reforestation;
- Environmental site design;
- Homeowner practices (rain barrels, rain gardens, downspout disconnect).

Mapping of the site specific structural practices are included in Figure 15. Tables presenting cost, load reduction, and impervious credit associated with each of the proposed projects are included in each section below. Bacteria load reductions associated with each project were not calculated since projects were not proposed in the Indian Creek watershed.

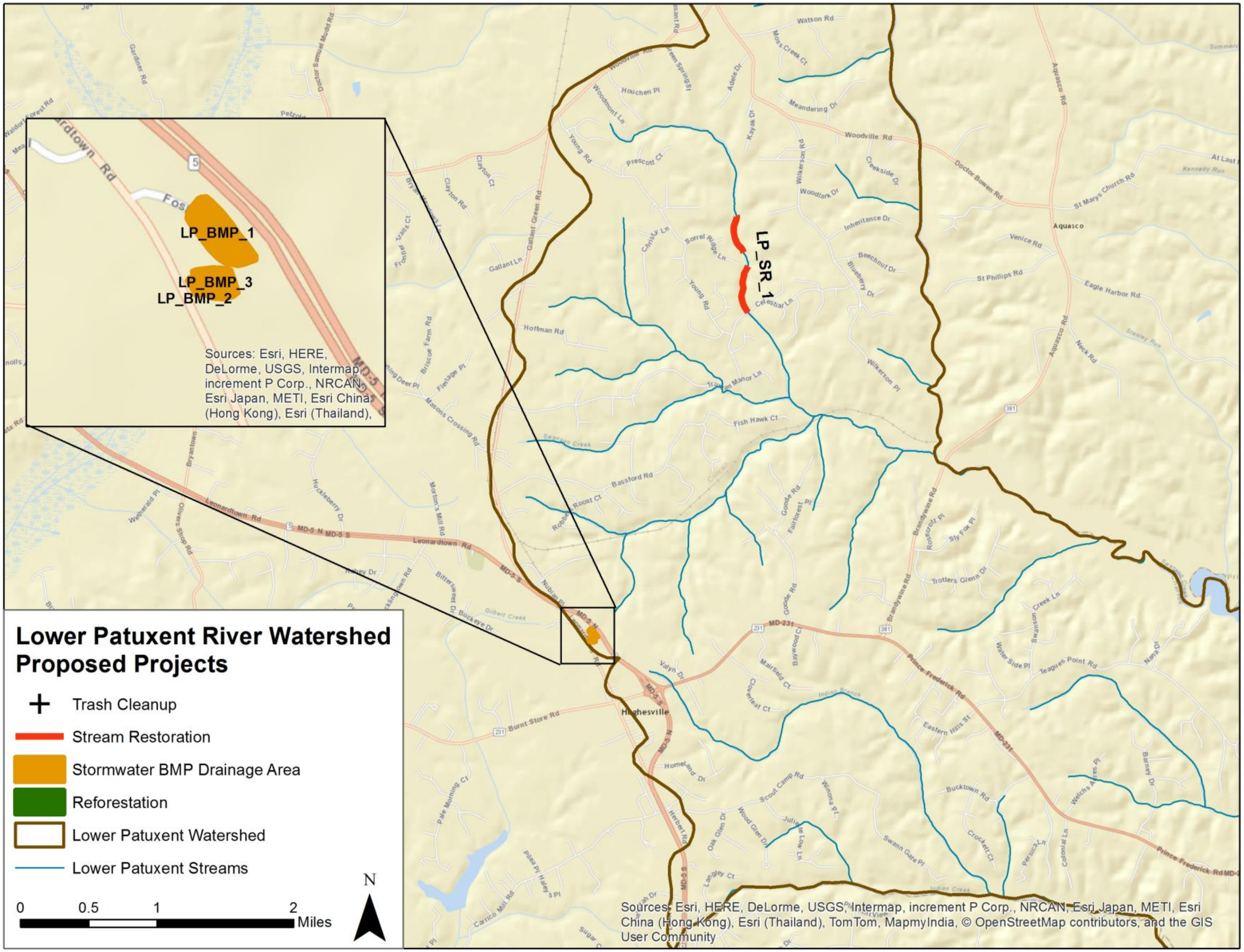


FIGURE 15: LOCATION OF POTENTIAL WATER QUALITY IMPROVEMENT PROJECTS

4.1 Stream Restoration

Stream restoration opportunities were field identified during the SCA assessment. The SCA stream segments were selected based on the surrounding land use within their drainage areas; streams receiving a high percent of impervious area were selected to better identify stream reaches in need of restoration. The current condition of streams was assessed and locations of stream erosion were identified and mapped using GPS. The assessment rated each segment of stream erosion on a 1 to 5 scale according to its severity, correctability, and accessibility; where a score of 1 is the most severe, but also the most correctible and the most accessible. Priority areas in need of stream restoration were determined using these three scores. The site ranking criteria can be found in Table 17.

TABLE 17: STREAM RESTORATION AND PIPE OUTFALL SITE RANKING CRITERIA

Priority Ranking	Scores
High	Severity = 1 or 2 AND Correctability/Access = 1 - 4
Medium	Severity = 1 or 2 AND Correctability or Access = 5, OR Severity = 3 AND Correctability/Access = 1 - 4
Low	Severity = 1 or 2 AND Correctability AND Access = 5; OR Severity = 3 AND Correctability/Access = 5; OR Severity = 4 - 5
Very Low	Severity = 4 or 5 AND Correctability/Access = 5; OR Severity = 3 AND Correctability AND Access = 5

Next, high and medium priority erosion sites were identified and combined into stream restoration projects based on proximity to other erosion sites. Pipe outfall data collected during the SCA assessment was ranked according to the same methods used for stream restoration sites (Table 17). Pipe outfalls with high and medium priority rankings would have been selected and incorporated into nearby stream restoration projects, however no medium or high priority outfalls were located in the vicinity of the stream restoration sites.

One stream restoration project was identified, with a total length of approximately 3,400 linear feet (Table 18). Impacts to the streams include stream widening and downcutting.

A unit cost estimate of $645/ft was used to estimate the initial cost of the stream restoration projects and a cost factor per impervious acre treated was used to derive the total cost over 20 years (King and Hagan, 2011). It should be noted that economy of scale is not built in to this cost estimate. Larger stream restoration projects are likely estimated to be much costlier than actual project costs may be.

Load reductions were calculated for total nitrogen, total phosphorus, and total suspended sediment for each restoration site with estimated removal efficiencies from *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014a) which are shown in
Table 19 and Table 20.

TABLE 18: STREAM RESTORATION PROJECT DESCRIPTIONS

Watershed	Restoration Site ID	SCA Reach	Length (ft)	Current Condition	Proposed Actions
Lower Patuxent River	LP_SR_1	006	3,443	Stream receives runoff from residential and agricultural properties. Channel incised with localized areas of severe bank erosion.	Stream bank and bed stabilization to repair bank erosion. Potential floodplain reconnectivity.

TABLE 19: STREAM RESTORATION REMOVAL EFFICIENCY AND IMPERVIOUS ACRE EQUIVALENT

Pounds Reduced per Linear Foot			Impervious Acre Equivalent per Linear Foot
TN	TP	TSS	
0.075	0.068	15	0.01

TABLE 20: STREAM RESTORATION COST, IMPERVIOUS CREDIT, AND LOAD REDUCTION

Watershed	Restoration Site ID	SCA Reach	Erosion length (ft)	Total Initial Cost	Total Cost Over 20 Years	Imperv-ious credit	Load Reduction (lbs/yr)		
							TN	TP	TSS
Lower Patuxent River	LP_SR_1	006	3,443	$2,220,433	$2,833,892	34.43	258.2	234.1	51,638.0
Lower Patuxent Total			3,443	$2,220,433	$2,833,892	34.43	258.2	234.1	51,638.0

4.2 Shoreline Erosion Control

Areas with significant shoreline erosion were identified using the Maryland DNR Maryland Coastal Atlas (DNR, 2015). Historic shoreline data and shoreline rate of change transects were used to search for shoreline with moderate (4 to 8 feet of erosion per year) and high (greater than 8 feet of erosion per year) erosion along the portions of Swanson Creek, Indian Creek, and Patuxent River within the Lower Patuxent Watershed and Charles County boundary. Shoreline without adequate erosion transect data was also analyzed using the historic shoreline data to identify additional areas with significant erosion issues. Areas with artificial stabilization or bulkhead were excluded from this search.

One potential shoreline erosion project was identified. The site is located on the western shore of the Patuxent River at the Prince Frederick Road bridge. Transect data shows that the area has a moderate rate of change, with 4 to 8 feet of erosion per year. Historic shoreline data shows that there was approximately 480 feet of shoreline erosion at the worst point of erosion since the mid-1800s. This site had previously been identified by Charles County as a potential shoreline erosion control project and BayLand Consultants & Designers, Inc. prepared a feasibility report for the project (BAY_LP_SEC_1). They proposed a living shoreline and large stone sills to protect the shoreline from further erosion for a length of 450 feet (BayLand, 2014b). BayLand provided a cost estimate for the erosion control project, assuming a unit cost of $500/ft based on the use of the large stone they recommended (BayLand, 2014b). BayLand was also contracted by Charles County to investigate shoreline stabilization projects on two additional parcels located in Benedict on Mill Creek (BayLand 2014a). They identified five reaches of erosion and recommended 3,016 linear feet of shoreline stabilization. These reaches are grouped into one project for the purposes of this assessment. Project load reductions were calculated with outdated removal rates in BayLand, 2014a, and as a result BAY_LP_SEC_2 load reductions were recalculated with the most up to date removal rates from Schueler and Lane, 2015 (Table 21: Shoreline Erosion Control Removal Efficiency and Impervious acre Equivalent). Cost and load reductions associated with each project are presented in Table 22. Additional costs to calculate total cost over 20 years was not provided by BayLand, therefore a 20% factor was applied to estimate the additional cost needed over time.

TABLE 21: SHORELINE EROSION CONTROL REMOVAL EFFICIENCY AND IMPERVIOUS ACRE EQUIVALENT

Pounds Reduced per Linear Foot			Impervious Acre Equivalent per Linear Foot
TN	TP	TSS	
0.075	0.068	137	0.04

TABLE 22: LOWER PATUXENT RIVER WATERSHED SHORELINE EROSION CONTROL PROJECTS

Restoration Site ID	SCA Reach	Erosion Length (ft)	Total Cost	Cost over 20 Years	Imperv-ious Credit	Load Reduction (lbs/yr)		
						TN	TP	TSS
BAY_LP_SEC_1	N/A	450	$323,438	$388,125	18.0	33.8	30.6	61,650.0
BAY_LP_SEC_2	N/A	3,016	$1,785,000	$2,142,000	120.6	226.2	205.1	413,192.0
Lower Patuxent Total		3,466	$2,108,438	$2,530,125	138.6	260.0	235.7	474,842.0

4.3 Stormwater BMPs

Sites to develop new or retrofit stormwater BMPs were identified as part of the watershed assessment and planning process. Additional sites identified in previous assessments are described in section 4.3.2. All assessments, including the resulting proposed stormwater BMPs and projected treatment, are included in the sections below.

The potential to provide stormwater management through BMP facilities throughout the Lower Patuxent watershed is relatively low due to the low impervious cover and high percentage of forest cover. Constructing a series of small BMP facilities such as bioretention adjacent to commercial parking lot and driveways is an effective way to provide stormwater management and treat high amounts of imperviousness in this watershed.

4.3.1 Watershed Assessment Stormwater BMP Analysis

A desktop analysis was performed to compile a list of potential sites for stormwater management. Results from the investigation conducted prior to the stormwater (BMP) assessment, including the neighborhood source assessment, hot spot investigation, and stream corridor assessment, were reviewed for potential concurrent stormwater management opportunities. Several of these sites were selected for additional review to assess feasibility for stormwater management through structural or ESD practices. The sites selected included neighborhoods with little to no existing stormwater management, as well as pipe outfalls requiring stabilization. A database containing geospatial information for existing Charles County stormwater facilities was also used to identify potential BMP retrofit sites.

A field visit was then conducted for each site. Sites with limited opportunity for stormwater management were noted, but not evaluated further. Sites that displayed potential for stormwater management retrofit or improvement were documented through photographs, field map annotation, and field reconnaissance forms. Existing site conditions, including ownership, existing stormwater management, site drainage, and conveyance, were recorded. Details that may not be readily available in GIS format, such as adjacent land use, access constraints, potential permitting considerations, and potential utility conflicts were also noted. Finally, a preliminary stormwater BMP proposed treatment option, purpose, and location was established for each site.

Following the field visit, the potential stormwater BMP sites were inventoried, and field information was corroborated and/or expanded upon using a variety of additional resources such as County as-built records and County spatial data. With additional supporting information, the potential sites were again queried for conditions that might eliminate the project from consideration completely.

Planning-level drainage areas were then delineated to the remaining selected potential stormwater BMP sites in ArcGIS using stormdrain shapefiles, two-foot contour data, and orthophotography, as well as field-observed drainage patterns. An impervious area layer was created by merging building, roadway, and driveway shapefiles and then clipped to each drainage area to establish the acres of impervious area draining to each site.

To determine the water quality volume (WQv) required at each retrofit site, procedures from MDE 2000 Maryland Stormwater Design Manual were used including the following equation:

$$WQv = \frac{(0.05+0.009*I)(A)}{12}$$

where:

I = Percent impervious cover
A = Drainage area (in acres)
I = Percent impervious cover

Once the MDE required water quality volume was established for each potential site, the proposed BMP type was finalized, and an estimate of the WQv provided was completed for each retrofit.

The BMP facility types that were identified include bioretention and Filterra. Table 23 below includes a brief discussion of the existing site conditions and the proposed site improvements. Table 24 contains a summary of the impervious area treated by the proposed BMP types. BMP drainage areas are displayed in Figure 15.

TABLE 23: PROPOSED SWM BMP PROJECTS

Site ID	Existing Conditions	Proposed Improvements
LP_BMP_1	An existing inlet receives water from the majority of the parking lot and a few buildings on the eastern side of the property.	Filterra
LP_BMP_2	Grass area between the roadway and the gas station building. It receives water from the driveway and half of the building. Very limited surface area.	Bioretention
LP_BMP_3	Grass area on the back of the gas station building. It receives flow from the parking lot, buildings and driveways.	Bioretention

TABLE 24: AREA TREATED BY SWM BMP PROJECTS PER TYPE

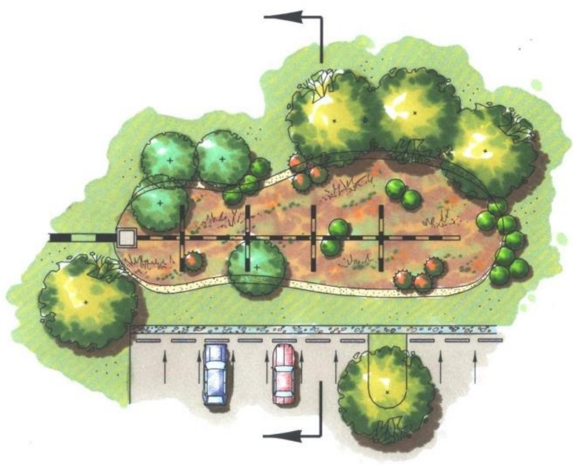
Treatment Type	Restoration Site IDs	Total Drainage Area (ac)	Impervious Area Treated (ac)
Filterra	LP_BMP_1	1.50	0.04
Bioretention	LP_BMP_2	0.08	0.07
	LP_BMP_3	0.67	0.48
Lower Patuxent Total		**2.25**	**0.59**

The following provides a general description of each of the stormwater BMP treatment types.

Bioretention

A bioretention area combines open space with SWM through the use of landscaping and permeable soils to treat runoff from parking lots and urban areas. The permeable soils filter suspended sediments and some pollutants from the runoff while the landscaping promotes evapotranspiration of the runoff and uptake of nutrients.

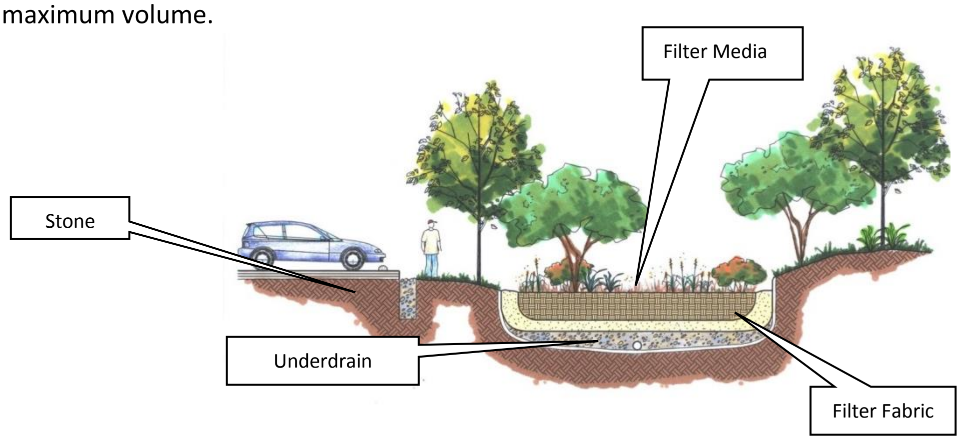
Bioretention areas generally consist of a stone diaphragm, filter fabric, filter media, landscaping, and an underdrain system. The stone diaphragm reduces the velocity of the runoff from the impervious surface that is entering the facility and also removes suspended material that may clog the filter media. The underdrain system is a perforated pipe system that collects the water that has filtered through the permeable media and transports it to a downstream open channel or connects into a nearby storm drain.



Plan view of bioretention area

The landscaping in a bioretention area is also very important. The plants chosen are native plant species that are tolerant of standing water. A wide variety of trees, shrubs, and herbaceous plants are selected for varying levels of vegetative uptake, for encouragement of various wildlife species, and for improved aesthetics. The permeable soil in the bioretention area is approximately 2.5 feet to 4 feet deep with 3 inches of mulch above it.

The ponding within the bioretention area is typically 6 inches to 12 inches. There is generally a catch basin or weir provided within the ponding area that is used for overflow when the ponding area reaches its maximum volume.



There two opportunities for bioretention in the Lower Patuxent River watershed. These sites were identified in the field and have a relatively small amount of drainage reaching them. All of these sites are located on commercial properties, adjacent to a parking lot. The drainage areas to these sites are small, but the potential bioretention areas would provide treatment for small drainage areas with high amounts of imperviousness. Obvious limitations include obtaining permission from property owners and confirming potential for utilities impacts.

Filterra

Filterra is a patented stormwater LID/ESD type treatment that has MDE approval for pollutant reduction crediting. The system is installed in the stormwater inlet. Runoff flows through the system through a curb-inlet opening and flows through a filter media which captures pollutants. There was one site identified as having potential for Filterra retrofit. This site is located on a commercial parking lot, within an existing inlet. The Filterra does not require much space to build and operate; however the water quality volume provided is relatively limited. Obvious limitations include obtaining permission from property owners and determining maintenance responsibility.

4.3.2 Additional Assessments

An additional assessment was conducted in the Lower Patuxent River watershed by BayLand Consultants & Designers, Inc. BayLand Consultants & Designers, Inc. was contracted by Charles County to conduct two assessments to identify projects to help meet the requirements of their MS4 permit and Phase II Watershed Implementation Plan. *Feasibility Report: Shoreline Management Practices at Charles County Owned Properties* (BayLand, 2014b*)* identified one shoreline stabilization project located within the Lower Patuxent River Watershed on Benedict Avenue and *Benedict Properties Shoreline and Stormwater Assessment* (BayLand, 2014a*)* identified and recommended shoreline stabilization, bioretention, and reforestation projects within the Lower Patuxent River Watershed in Benedict. Project load reductions were calculated with outdated removal rates in BayLand, 2014a, and as a result the BayLands projects were recalculated with the most up to date removal rates from Schueler and Lane, 2015. Cost estimates provided by Bayland (2014a and 2014b) are used. Impervious treatment, load reductions, and project costs are included in the cost and treatment summary in section 4.3.3.

4.3.3 Stormwater BMP Cost and Treatment Summary

Results from the stormwater BMP assessments are compiled below. Impervious acres treated, runoff depth treated, load reduction, initial costs, and total costs over 20 years are shown in Table 25. Restoration site IDs that include “LP_SWM” are from the watershed assessment. Site IDs that include “BAY-” are from the BayLand assessments.

TABLE 25: STORMWATER BMP RUNOFF DEPTH TREATED, IMPERVIOUS TREATED, LOAD REDUCTION, AND COST

KCI Projects								
Restoration Site ID	**BMP Type**	**Impervious Acres Treated**	**Runoff Depth**	**Load Reduction (lbs/yr)**			**Total Initial Costs***	**Total Costs Over 20 Years****
				TN	**TP**	**TSS**		
LP_BMP_1	Filterra	0.04	0.05	0.4	0.1	34.4	$2,448	$4,448.12
LP_BMP_2	Bioretention	0.07	1.75	0.4	0.1	25.6	$12,411	$14,446
LP_BMP_3	Bioretention	0.48	1.15	2.9	0.5	196.7	$89,086	$103,692
Subtotal		0.59	2.95	3.7	0.7	256.7	$103,945	$122,586
Level 8- Alternate Feasibility and Concept Design Projects								
BAY-BIO1	Bioretention	0.50	1.00	10.0	0.8	0.2	$35,000	$42,000
Level 8 Subtotal		0.50	1.00	10.0	0.8	0.2	$35,000	$42,000
Lower Patuxent Total		1.09	3.95	13.70	1.50	256.90	$138,945	$164,586

Load reductions for site BAY-BIO1 were calculated using updated removal rates from Schueler and Lane, 2015.

*Bioretention cost estimates from King and Hagan, 2011. Filterra costs (cost assumes maintenance is done by County) from Low Impact Development Center, Inc., 2007.

**Watershed assessment sites (projects termed: 'LP_SWM') bioretention 20 year cost estimates from King and Hagan, 2011. Total cost over 20 years was not provided for projects proposed by BayLand, therefore a 20% factor was applied to estimate to calculate the additional cost needed over time.

4.4 Reforestation

Several inadequate buffer sites were field identified during the SCA assessment performed in April 2015, however these sites were located under power lines and therefore not potential reforestation sites. GIS desktop assessment was performed to supplement the SCA identified reforestation projects. The desktop assessment focused first on the opportunity to plant riparian buffers. Using the most recent available aerial photography, stream reaches without adequate 50 foot buffer on both banks were identified. Streams within land use areas categorized as agriculture were excluded from this search. Next, tree planting opportunities larger than 0.25 (as required by MDE in *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* Guidance, 2014) acres outside of riparian areas were identified. No potential reforestation sites were identified during this GIS assessment.

BayLand Consultants & Designers, Inc. also identified a tree planting opportunity in Benedict involving a combination of reforestation on pervious and pavement removal and subsequent conversion of impervious urban to forest (BayLand, 2014a). Load reductions were calculated for total nitrogen, total phosphorus, and total suspended sediment for the site with estimated removal efficiencies from *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (Table 26; MDE, 2014a). These efficiencies assume a survival rate of 100 trees/acre or greater with at least 50% of trees having a two inch diameter or greater (4.5 feet above ground; MDE, 2014a). Cost was provided by BayLand, 2014a (Table 27).

TABLE 26: REFORESTATION BMPS EFFICIENCY AND IMPERVIOUS ACRE EQUIVALENT

BMP	Efficiency Per Acre			Impervious Acre Equivalent
	TN	TP	TSS	
Reforestation on Pervious Urban	66%	77%	57%	0.38
Impervious Urban to Forest	71%	94%	93%	1.00

TABLE 27: REFORESTATION SITE COST, IMPERVIOUS CREDIT, AND LOAD REDUCTION

Restoration Site ID	SCA Reach ID	Property type	Area (acres)	Total Initial Cost	Total Cost Over 20 Years	Impervious Credit	Load Reduction (lbs/year)		
							TN	TP	TSS
BAY_LP_TP_1	N/A	parking lot/ open space	2.25	$175,000*	N/A	1.5	19.8	2	0.5
Lower Patuxent Total			2.25	$175,000	N/A	1.5	19.8	2	0.5

*includes cost for removal of impervious surface and replacing with top soil (BayLand, 2014a)

5 PROGRAMMATIC PRACTICES

Nutrient removals from planned homeowner practices if implemented in the Lower Patuxent / Indian Creek watersheds are included in Section 5.1. The continuation and possible expansion of septic practices is discussed in Section 5.2 and the development of a pet waste program in Indian Creek for increased bacterial load reduction is discussed in Section 5.3.

5.1 HOMEOWNER PRACTICES

The implementation of homeowner practices is not only a cost effective strategy to supplement County restoration BMPs (e.g., stormwater BMPs, stream restoration, shoreline erosion control, etc.), but they also encourage the community to actively participate in cleaning up and taking ownership of the health of their watershed.

Nutrient removal from planned homeowner practices, including rainwater harvesting (i.e., rain barrels), rain gardens, and downspout disconnection, was calculated for each neighborhood assessed during the NSA reconnaissance and then projected to the watershed scale. The removal rates for 1 inch of rainfall treatment for this suite of homeowner BMPs are included in Table 28 (Goulet and Schueler, 2014). However, rainfall treatment varies based on site constraints, homeowner participation, and feasibility. Therefore, removal rates were calculated individually, by neighborhood, for each practice type based on specific site and design parameters in order to estimate total rain treatment and nutrient removal as shown in Tables 37, 38 and 39.

Impervious acre equivalencies for homeowner practices are also included in Table 28. An impervious acre equivalent assumption was applied to each homeowner practice based on the associated modeling BMP type (rain barrel: impervious surface reduction, rain garden: bioretention/rain gardens, disconnection of rooftop runoff: impervious surface reduction).

TABLE 28: REMOVAL EFFICIENCIES FOR HOMEOWNER PRACTICES

Practice	Efficiency Per Acre*		Impervious Acre Equivalent
	TN	TP	
Rain Barrel	28%	33%	0.75
Rain Garden	60%	70%	1.00
Downspout Disconnection	45%	52%	0.75

* based on treating the full 1 inch runoff

A series of assumptions were incorporated into the calculation of nutrient removal from homeowner practices, including the following:

General Assumptions

- Household participation per neighborhood:
  - Rain barrels = 30% of homes
  - Rain gardens = 10% of homes
  - Downspout Disconnections = 10% of homes
- Apartment or condominiums are not included in homeowner practices

- These practices will treat rooftop impervious area only
- Townhomes generally have 2 downspouts; Single-family homes generally have 4 downspouts – based on data collection during the NSA reconnaissance
- Total nitrogen and total phosphorus removed by each NSA neighborhood are standard removals that can be applied to additional neighborhoods identified as having similar housing densities, lot size, and forest cover in order to calculate total removal at the watershed scale.

Rain Barrel Assumptions

- Townhomes would use 1 rain barrel; Single-family homes would use 2 rain barrels
- Rain barrel capacity = 55 gal
- 50% of roof area will be treated

Rain Garden Assumptions

- Townhomes are not participating in the rain gardens strategy due to site limitations
- 50% of roof area will be treated
- Average rain garden depth = 8 in. as per Chesapeake Stormwater Network guidance (2013a)
- Engineering factor of 0.12 used to calculate Surface Area of rain garden as per Chesapeake Stormwater Network guidance (2013a)

Downspout Disconnection Assumptions

- Townhomes are not participating in the downspout disconnection strategy due to site limitations
- 1 downspout will be disconnected per single-family home
- Available pervious land measured in GIS between driveway and property line for a subset of households within each NSA neighborhood. As per Chesapeake Stormwater Network guidance, available pervious land area should be >10 feet in width with a length no less than 40 feet (2013b).
- An 'Average' infiltration ranking with an infiltration factor of 0.5 was applied to all NSA neighborhoods.

Nutrient removal and impervious credit for rain barrel, rain garden, and downspout disconnection practices for each NSA neighborhood, projection by neighborhood type, and watershed total are shown in Tables 35, 36 and 37.

Estimated costs for each homeowner practice are also included in the following tables. While some costs may be the responsibility of individual homeowners, the County is currently working with partners to subsidize costs and is in the process of securing additional funding for further support.

For the rain barrel practice, a cost of $60/barrel plus $25/fixtures and attachments was used to calculate an estimated cost of $107,100 for implementation in the Lower Patuxent watershed. The County currently covers 50% of costs for home owners who participate in the rain barrel practice. According to the University of Connecticut Cooperative Extension System, rain garden costs may vary from a minimum cost of $5/sq ft of rain garden size - $45/sq ft of rain garden size dependent on soil removal costs, soil amendments, need for a contractor, and planting size (http://nemo.uconn.edu/raingardens /calculator.htm). An initial cost estimate of $25/sq ft of rain garden size and a total cost of $746,714 is projected for implementing the rain garden practice in the Lower Patuxent watershed. An estimated cost of $10/downspout extension was used to calculate the cost of implementing the downspout disconnection practice which resulted in a total cost of $2,100 in the Lower Patuxent watershed. A grant program with Chesapeake Bay Trust and the County was initiated in FY 2016 for non-profit organizations to help alleviate practice costs in which the County provides 50% credit to the annual stormwater remediation fee for these practices.

TABLE 29: PROJECTED NUTRIENT REMOVAL AND IMPERVIOUS CREDIT FROM PLANNED RAIN BARRELS

NSA ID	Neighbor-hood Type	Average Roof Area to Treat (sq ft) for 50% of Total Area	Rainfall Depth Treated (in)	% Removal Based on Total Rain Treatment		Lbs Reduced per NSA Neighborhood		# of Similar Neighbor-hoods in Port Tobacco	Total # of Homes	Projected Lbs Reduced per Neighborhood Type		Treated Imperv-ious Acres	# of Rain Barrels Needed	Cost
				TN	TP	TN lbs/yr	TP lbs/yr			TN lbs/yr	TP lbs/yr			
LP-01	Single Family	738	0.12	27%	31%	0.5	0.1	1	26	0.9	0.2	0.3	53	$4,488
LP-02	Single Family	1,165	0.08	18%	21%	1.8	0.4	9	474	17.6	3.8	9.5	948	$80,580
LP-03	Single Family	1,334	0.07	16%	19%	0.7	0.2	3	77	2.9	0.6	1.8	154	$13,056
LP-05	Single Family	811	0.11	25%	29%	1.9	0.4	0	53	1.9	0.4	0.7	106	$8,976
								Total	**630**	**23.3**	**5.0**	**12.3**	**1,261**	**$107,100**

TABLE 30: PROJECTED NUTRIENT REMOVAL AND IMPERVIOUS CREDIT FROM PLANNED RAIN GARDENS

NSA ID	Neighbor-hood Type	Average Roof Area to Treat (sq ft) for 50% of Total Area	Rainfall Depth Treated (in)	% Removal Based on Total Rain Treatment		Lbs Reduced per NSA Neighborhood		# of Similar Neighbor -hoods in Port Tobacco	Total # of Homes	Projected Lbs Reduced per Neighborhood Type		Treated Imperv-ious Acres	Cost
				TN	TP	TN lbs/yr	TP lbs/yr			TN lbs/yr	TP lbs/yr		
LP-01	Single Family	738	1.0	60%	70%	0.3	0.1	1	9	0.7	0.1	0.1	$20,283
LP-02	Single Family	1,165	1.0	60%	70%	1.9	0.4	9	158	19.3	4.1	4.2	$575,128
LP-03	Single Family	1,334	1.0	60%	70%	0.9	0.2	3	26	3.6	0.8	0.8	$106,722
LP-05	Single Family	811	1.0	60%	70%	1.5	0.3	0	18	1.5	0.3	0.3	$44,581
								Total	**211**	**25.1**	**5.3**	**5.4**	**$746,714**

TABLE 31: PROJECTED NUTRIENT REMOVAL AND IMPERVIOUS CREDIT FROM PLANNED DOWNSPOUT DISCONNECTION

NSA ID	Neighbor-hood Type	Average Roof Area to Treat (sq ft) with one Downspout Disconnect	Rainfall Depth Treated (in)	% Removal Based on Total Rain Treatment		Lbs Reduced per NSA Neighborhood		# of Similar Neighbor-hoods in Port Tobacco	Total # of Homes	Projected Lbs Reduced per Neighborhood Type		Treated Imperv-ious Acres	# of Downspout Extensions Needed	Cost
				TN	TP	TN lbs/yr	TP lbs/yr			TN lbs/yr	TP lbs/yr			
LP-01	Single Family	369	0.5	47%	55%	0.1	0.0	1	9	0.3	0.1	0.1	9	$88
LP-02	Single Family	582	1.4	64%	75%	1.0	0.2	9	158	10.3	2.2	1.6	158	$1,580
LP-03	Single Family	667	1.0	61%	71%	0.5	0.1	3	26	1.8	0.4	0.3	26	$256
LP-05	Single Family	405	0.0	-1%	-1%	0.0	0.0	0	18	0.0	0.0	0.1	18	$176
								Total	**211**	**12.4**	**2.7**	**2.1**	**211**	**$2,100**

5.2 Septic Practices

Although septic strategies including connections, pump outs, and upgrades do not receive nutrient and sediment load reduction credits, they do receive bacteria reduction credits and count towards impervious credit and were included in the County's impervious accounting (Section 6.3). According to MDE guidance (MDE, 2014a) each septic connection achieves an impervious equivalent of 0.39 ac, each pump-out achieves an impervious acre equivalent of 0.03 ac and each septic upgrade achieves an impervious acre equivalent of 0.26 ac (Table 32). Upgrades will reduce bacteria loads by a variable amount, depending on whether the system is functional or failed, the type of upgrade, and the estimated wastewater flow to the system.

Table 33 shows bacteria reduction and impervious credit for septic connections, pump outs, and upgrades in the Charles County portion of Indian Creek in the Lower Patuxent watershed. As of Fall 2015, there were 119 septic pump outs in the Lower Patuxent watershed since 2007; and 13 upgrades in the Lower Patuxent watershed since 2014. Estimated costs of septic connections, pump outs and upgrades are $42,330/connection (LimnoTech, 2013), $117/pump out (Charles County data), (LimnoTech, 2013), and $13,000/upgrade (MDE, 2011). However, actual costs include $141,948 for septic practices in the Lower Patuxent watershed (Table 33). Total cost over 20 years for annual septic practices are also included in Table 33 and were calculated by multiplying initial costs by 20 years. The County currently administers a Bay Restoration Fund (BRF) Septic System Grant Program through the Health Department that provides financial assistance to homeowners for septic system upgrades or connections to the public sewer system (https://www.charlescountymd.gov/pgm/planning/septic-system-upgrade-assistance). The County also has a septic pump-out reimbursement program to encourage residents to use this practice (http://www.charlescountymd.gov/pgm/planning/ septic-system-pump-out-reimbursement-program).

TABLE 32: SEPTIC EFFICIENCIES AND IMPERVIOUS AREA EQUIVALENCIES

Practice	Efficiency Per Practice*			Impervious Acre Equivalent
	TN	TP	Bacteria	
Septic Pumping	0%	0%	Variable	0.03
Septic Denitrification	0%	0%	Variable	0.26
Septic Connections	0%	0%	Variable	0.39

* No credit given to septic practices for Urban MS4 source sector

TABLE 33: POLLUTANT REMOVAL AND IMPERVIOUS CREDIT FROM SEPTIC PRACTICES

Watershed	Practice	Number	Cost	Total Cost over 20 Years	Lbs Reduced / yr**			Bacteria Reduction (MPN/yr)	Impervious Credit (Ac)
					TN	TP	TSS		
Lower Patuxent River	Connection	0	$0	N/A	0.0	0.0	0.0	Variable	0.0
	Pumping*	119	$13,857	$277,130	0.0	0.0	0.0	Variable	3.6
	Denitrification	13	$128,091	N/A	0.0	0.0	0.0	Variable	3.4

* Annual practice cost over 20 years calculated by multiplying initial costs by 20 years.

** No credit given to septic practices for Urban MS4 source sector

5.3 PET WASTE

Pet waste that is not picked up can contribute nutrients and bacteria to local waterways. Simple behavior change could significantly reduce this contribution of bacteria. There are a number of outreach approaches that could be tried. Brochures or postcard mailings could be effective in informing residents of the Indian Creek watershed of the bacteria pollution problem in their watershed and opportunities for bacteria load reduction through pet waste disposal. Other methods, such as education signage and dog waste stations with bags and trash cans may not be as effective in Indian Creek due to the limited amount of parks or other public areas.

Estimated bacteria loads, potential reductions, and associated assumptions are presented in Table 34. The total number of households in Indian Creek was determined by GIS analysis of the County's tax parcel layer using the parcel description to identify residential parcels. The ratio of dogs per household, percent of owners that walk their dogs, and percent dog walkers that do not clean up after their dogs was estimated according to a survey of Chesapeake Bay residents conducted by the Center for Watershed Protection (Swann, 1999). The average fecal coliform production rate per dog estimated from Bacteria Indicator Tool User's Guide (EPA, 2000). The media awareness factor and percent willing to change are assumptions from Caraco, 2000 and are based on 8% of the households reached through brochure or postcard mailings and 60% of households willing to adopt the behavior change.

Based on implementing a targeted educational outreach program in the Indian Creek watershed a potential reduction of 30 billion MPN/day is estimated to result.

TABLE 34: INDIAN CREEK WATERSHED PET WASTE LOAD AND REDUCTION ASSUMPTIONS AND CALCULATIONS

Parameter	Assumption
Loads	
Number of residential households	268
Ratio of dogs per household	41%
Percent of owners that walk their dogs	56%
Percentage of walked dogs contributing bacteria	41%
Average fecal coliform production rate per dog	5 bn MPN/day
Total	**125 bn MPN/day**
Reduction	
Message awareness factor	40%
Percent willing to change	60%
Potential Reduction	**30 bn MPN/day** **2.2% of required TMDL reduction**

6 TREATMENT SUMMARY

6.1 EXISTING BMPS – ACTUAL IMPLEMENTATION

Charles County maintains a database of stormwater urban BMP facilities and water quality and capital improvement projects (WQIP and CIP) in addition to tracking ESD and operational practices. Current BMP implementation through 2015 in the Lower Patuxent watershed is shown in Table 35. BMP implementation for the Port Tobacco and Mattawoman watersheds can be found in the Port Tobacco Watershed Assessment (KCI, 2015) and Mattawoman Creek Watershed Assessment (KCI, 2016).

TABLE 35: CURRENT BMP IMPLEMENTATION THROUGH 2015 IN LOWER PATUXENT WATERSHED

BMP	Unit	Lower Patuxent River 2015 Current Implementation*
ESD Practices*	impervious acre	0
Inlet Cleaning	# of pipes	0
Street Sweeping	miles swept	0
Wet Pond	acres	0
Underground Storage Chamber	acres	0
Dry Swale	acres	
Filterra	acres	0
SPSC	acres	0
Rain Garden	Acres	<1
Septic Connections	# of systems participating	1
Septic Pump outs	# of systems participating	119
Septic Upgrades	# of systems participating	13

*Includes all of the County's restoration ESD BMPs through 2015.

6.2 PLANNED IMPLEMENTATION

Table 36 presents the planned implementation of BMPs described in sections 4, 5, and 6 of this report.

TABLE 36: BMP IMPLEMENTATION - PLANNED LEVELS

BMP	Unit	Lower Patuxent
Bioretention	acre	1
Created wetland	acre	0
Downspout Disconnection - Homeowner Practice	# of homes participating	210
Rain Barrels - Homeowner Practice	# of homes participating	630
Rain Gardens - Homeowner Practice	# of homes participating	210

BMP	Unit	Lower Patuxent
Dry Swale	acre	0
Filtering Practices	acre	2
Infiltration basin	acre	0
Inlet Cleaning	# of pipes	0
Organic Filter	acre	0
Pond Retrofit	acre	0
Reforestation	acres	1
Septic Connections	# of systems participating	0
Septic Pump outs	# of systems participating	0
Septic Upgrades	# of systems participating	24
Pet Waste	# of dog owners participating	6
Sheetflow to Conservation	acre	0
Shoreline Erosion Control	linear feet	3,466
Step Pool Stormwater Conveyance Systems	acre	0
Stream Restoration	linear feet	3,443
Street Sweeping	miles swept	0
Submerged Gravel Wetland	acre	0
Wet Pond	acre	0

6.3 Impervious Treatment

As a requirement of the NPDES MS4 Discharge Permit issued by MDE to Charles County on December 26, 2014, the County must treat 20% of remaining baseline untreated impervious acres by 2019. Impervious acres treated within the Lower Patuxent watershed will count towards this goal.

Table 37 shows impervious treatment achieved by planned strategies described in this report for the Lower Patuxent watershed.

TABLE 37: LOWER PATUXENT RIVER IMPERVIOUS ACCOUNTING

Impervious Accounting	Lower Patuxent River
Baseline Impervious Treatment	
Impervious Estimate	536.0 acres
Impervious Treated	207.4 acres
Impervious Treated Percent	39%
Impervious Untreated	328.6 acres
Impervious Untreated Percent	61%
Potential Impervious Treatment	
Operational Practices	0.0 acres
Septic Connections	0.0 acres

Septic Pump Outs	3.6 acres
Septic Upgrades	6.2 acres
Homeowner Practices	19.9 acres
Structural Practices	36.70 acres
Vista Retrofit Practices	0.0 acres
BayLand Structural Practices	140.6 acres
GMB Structural Practices	0.0 acres
Total Potential Impervious Treatment	**207.0 acres**
Summary of Projected Progress	
Impervious Untreated	328.6 acres
Total Potential Impervious Treatment	207.0 acres
Percent of Untreated Impervious Treated	**63%**

6.4 Local TMDL and Bay TMDL Baseline and Target Loads

6.4.1 Introduction

For local TMDLs, the modeling approach follows MDE's guidance (MDE 2014a, MDE 2014c) regarding determining whether the SW-WLA requirements have been met:

> *… it is recommended that local jurisdictions demonstrate their progress towards achieving SW-WLAs by comparing reduction percentages rather than absolute loads.*

This approach will allow the County to use its best land use and treatment data to develop baseline loads consistent with TMDL dates published on MDE's TMDL Data Center website. It is understood that the absolute loads and load reductions will vary because the modeling used to develop the TMDL is different from what is currently available, and may not be available in any case. Demonstrating progress by percent reduced will allow the County to plan for the TMDL based on the best and most accurate data available on land use, sources, loading rates, and removal efficiencies.

6.4.2 Indian Creek Bacteria TMDL

The Lower Patuxent River bacteria TMDL requires a reduction of 43.94 percent. This will require reductions in the LA by managing loads from livestock and wildlife. MDE's stormwater WLA bacteria guidance (MDE, 2014c) describes the sources to be addressed for load reduction in an implementation plan, as follows:

Sector	MS4 Source (SW-WLA)	Non-Point Source (LA)
Human	Sanitary sewer illicit discharge	Septic systems
	Sanitary sewer exfiltration	Sanitary sewer overflow (SSO)
	Homeless populations	Combined sewer overflow (CSO)
		Recreational boating
Domestic Pets	Pets, urban areas	Pets, rural areas
Wildlife	Urban wildlife	Non-urban wildlife
Livestock		Agriculture, hobby farms
		CAFOs

The implementation approach required by the permit is to meet the SW-WLA by reducing loads from the sources identified in the TMDL: domestic pets and urban wildlife. Livestock, septic systems, and other wildlife are considered non-point sources contributing to the LA and are not regulated by the NPDES permit.

If it is infeasible or impractical to meet the reduction from these sources, additional strategies that address other sectors will be explored. An alternate approach is described in MDE's bacteria TMDL guidance (MDE 2014) which states that the priority is to address human sources due to the greater health risk. Even though the TMDL does not describe any human sources that discharge through the MS4, reducing loads from non-MS4 sources such as septic systems will be an acceptable method of meeting the TMDL requirement.

SW-WLA

Domestic - Pets The planned reduction in pet waste will be accomplished through expanding existing programs to encourage dog owners to clean up after their pets. The goal is to increase awareness through a number of outreach activities targeted to residents in the Indian Creek watershed with the goal of changing the fraction of dog walkers who pick up waste from 60% to 70%.

Wildlife - Urban No programs are planned to address this source. While goose management can be a successful method of reducing bacterial loads, the watershed does not have open water locations such as ponds where the birds congregate and where management practices can be applied easily. Other wildlife species are similarly dispersed and it is not feasible to reduce the population.

LA

Human - Septic Systems Bacteria loads from working systems were not affected by any restoration programs. The projects planned for failed systems are septic system denitrification upgrades, which will bring the systems back to working status, and add additional treatment to reduce nitrogen loads significantly. Upgrades will repair failures to the septic tank structure and the drainfield, allowing the system to reduce bacteria loads as originally designed.

Wildlife - Rural No programs are planned to address this source.

Livestock No programs are planned to address this source. There are no areas of pasture where livestock have access to streams for water so off-stream watering or fencing would not reduce livestock pollution. The minimal loads from this source did not justify additional effort for pollutant load reductions.

Results

The SW-WLA could not be met with the sources discharging to the storm drain system - domestic and wildlife. However, by including septic system upgrades as a restoration strategy, the target percentage reduction from the TMDL can be met. Two upgrades before 2015 provided a small reduction in loading. Upgrades for the estimated remaining failed systems will meet more than the required WLA reduction, along with reducing the priority source from human contributions.

6.4.3 Chesapeake Bay TMDL

The County's MS4 permit is requiring compliance with the Chesapeake Bay TMDL for the urban stormwater sector through the use of the 20% impervious surface treatment strategy. Therefore it is expected that the 20% goal and associated credit accounting will take precedence over the Bay TMDL loading goals and crediting. While not a requirement in the County's MS4 permit, the strategies provided in this plan to meet local TMDL reduction targets have been modeled in order to calculate potential progress toward meeting the Bay TMDL nutrient and sediment reduction goals.

Bay TMDL baseline and calibrated target loads are presented in Table 44. Modeling terminology is defined below.

- **Calibrated 2000 Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from baseline year conditions in the Charles County MS4 source sector for each SW-WLA calibrated to MAST CBP v.5.3.2.
- **Target Percent Reductions**: Percent reductions assigned to Charles County Phase I MS4 stormwater sector (http://wlat.mde.state.md.us/ByMS4.aspx).
- **Calibrated Target Reductions:** Target reduction calibrated MAST CBP v.5.3.2 by multiplying the reduction percent published by the calibrated baseline load.
- **Calibrated TMDL WLA**: Allocated loads are calculated from the baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: Baseline – (Baseline x Target Percent Reduction); or, Baseline x (1 – Target Percent Reduction).

TABLE 38: BAY TMDL BASELINE AND TARGET LOADS

	TN- EOS (lbs/yr)	TP- EOS (lbs/yr)	TSS- EOS (lbs/yr)
Bay TMDL Baseline and Targets			
2010 Baseline Loads	235,070	20,037	5,739,174
Target Percent Reduction	18.2%	37.7%	-
Calibrated Target Reduction	42,759	7,554	-
Calibrated Bay TMDL WLA	192,311	12,483	-

6.5 Local TMDL and Bay TMDL Expected Load Reductions

This section provides a summary of pollutant load treatment from current and planned BMP implementation throughout the Lower Patuxent watershed towards the County's local TMDL and Bay TMDL goals, including the restoration BMPs implemented through 2015 (presented in Section 6.1) and planned implementation (Section 6.2). Table 39 presents local TMDL progress and planned reductions and Table 40 presents Bay TMDL progress and planned reductions.

As described in Section 1, the goal of this watershed assessment is to ensure that there is enough treatment throughout the watershed, the third of a series of watershed assessments, so that the Charles County Bay TMDL goals are achieved. Progress and planned reductions from the County's other watershed assessments, Port Tobacco River Watershed Assessment (KCI, 2015) and Mattawoman Creek Watershed Assessment (KCI, 2016) are also included. Descriptions of the reductions are described below. It is important to note that loads for the Town of LaPlata are not included in baseline, progress, or planning loads for Countywide results as LaPlata is not considered part of the County's MS4 permit. Since LaPlata is located in the Port Tobacco and Zekiah Swamp watersheds, loads were disaggregated from both watersheds based on land area proportion for Countywide results. Planned accounting and modeling terminology is described below.

- **Restoration Reduction**: Load reductions from restoration BMPs with a built date after the baseline to 2015.
- **Restoration Reduction Percent**: The percent difference of the baseline load and the restoration reduction.
- **Reduction Remaining for Treatment**: The difference between the calibrated TMDL target reduction and restoration reduction.
- **Reduction Percent Remaining**: The difference between the Target Percent Reduction and Restoration Reduction Percent. This is the percent reduction left to be treated.
- **Planned Reductions**: The sum of loads treated by planned projects.
- **Reduction (Progress + Planned)**: The sum of loads treated from restoration BMPs with a built date after the baseline to 2015 (i.e., 2015 Progress Reductions) and Planned Reductions.
- **Reduction Percent (Progress + Planned)**: The percent difference of the baseline load and the Reduction (Progress + Planned).
- **Reduction Remaining for Treatment**: The difference between the calibrated target reduction and the Reduction (Progress + Planned).

TABLE 39: LOCAL TMDL PROGRESS AND PLANNED REDUCTIONS

	Lower Patuxent River
	Modeled Bacteria Loads MPN/day
Baseline and Target	
TMDL Baseline Year	2001
Baseline Load	3,038
Target Percent Reduction	43.94%
Target Reduction	1,335
TMDL WLA	1,703
2015 Progress Reductions	
Restoration Reduction (from baseline to 2015)	64
Restoration Reduction Percent	4.8%
Reduction Remaining for Treatment	1,271
Planned Reduction	

Planned Reductions	1,579
Totals	
Reduction (Progress + Planned)	1,643
Reduction Percent (Progress + Planned)	123.1%
Reduction Remaining for Treatment	0

TABLE 40: BAY TMDL PROGRESS AND PLANNED REDUCTIONS

	TN- EOS (lbs/yr)	**TP- EOS (lbs/yr)**	**TSS*- EOS (lbs/yr)**
Bay TMDL Baseline and Targets			
2010 Baseline Loads	235,070	20,037	5,739,174
Target Percent Reduction	18.2%	37.7%	-
Calibrated Target Reduction	42,759	7,554	-
Calibrated Bay TMDL WLA	192,311	12,483	-
2015 Progress Reductions			
Restoration Reductions (from 2010 to 2015)	1,768	637	178,707
Port Tobacco	*103*	*37*	*11,151*
Mattawoman	*1,665*	*600*	*167,556*
Lower Patuxent	-	-	-
Planned Reductions			
Planned Reductions	16,535	4,925	1,915,136
Port Tobacco	*8,435*	*2,391*	*855,663*
Mattawoman	*7,549*	*2,061*	*532,736*
Lower Patuxent	*552*	*473*	*526,737*
Totals			
Reduction (Progress + Planned)	18,616	5,630	2,124,939
Reduction Percent (Progress + Planned)	7.9%	28.1%	-
Reduction Remaining for Treatment	24,144	1,924	**-**

Loads outside of the Town of LaPlata.

*No target reduction for sediment. It is anticipated that by achieving the phosphorus goal, enough sediment will be removed to improve water quality.

6.6 Cost Summary

A summary of project costs by project category is provided in (Table 41). Costs for restoration projects include the planning, design, surveying, environmental permitting, agency review, and construction costs and were estimated using a variety of sources.

King and Hagan (2011) cost estimates were used for many restoration project types, including stream restoration and all stormwater management projects, except Filterra, which was calculated with estimates from Low Impact Development Center, Inc. (2007) with the assumption that the County will perform maintenance activities. Cost estimates from the *Feasibility Report: Shoreline Management Practices at Charles County Owned Properties* (BayLand, 2014b) and *Benedict Properties Shoreline and Stormwater Assessment* (BayLand 2014a) were used for the shoreline erosion control projects. Cost per rain barrel was assumed to be $85. Rain gardens were assumed to be $25/ sq ft of rain garden and an estimated cost of $10/ downspout extension was used to calculate costs for downspout disconnection. While some costs of these homeowner practices may be the responsibility of individual homeowners, the County is currently working with partners to subsidize costs and is in the process of securing additional funding for further support.

TABLE 41: SUMMARY RESTORATION PROJECT COSTS

	Total Initial Cost	Cost Over 20 Years
Stream Restoration	$2,220,433	$2,833,892
Shoreline Erosion Control (Bayland- Level 3)	$2,108,438	$2,530,125
Stormwater Management	$103,945	$122,587
Stormwater Management (Bayland- Level 8)	$35,000	$42,000
Reforestation (Bayland- Level 8)	$175,000	$42,905
Homeowner Practices	$855,914	
Septic Practices	$312,000	$277,130
Pet Waste	$5,000	Variable
Total	**$5,640,676**	**$5,848,638**

- Additional costs to calculate total cost over 20 years not provided for BayLand. A 20% factor was applied to estimate the additional cost needed over time.
- Annual practices cost over 20 years calculated by multiplying initial costs by 20 years. Annual practices include septic pump outs, but not upgrades. Cost over 20 years for annual practices does not account for inflation.

7 PRIORITIZATION

A complete description of the prioritization methods is included in Appendix D. This section provides a brief summary of the method and presents the results. The prioritization involved a matrix made up of a series of parameters, or metrics, which evaluated each project and allowed for discrimination between the facilities. There are three categories of metrics, project benefits, project constraints, and project costs. Metrics were selected using a pairwise comparison by the project team by comparing pairs of metrics to evaluate which has greater importance. From this analysis, the weight of each chosen metric was calculated. Next, the projects were scored for each metric. Quantitative metrics were scored based on results of the preliminary design and cost estimates (e.g. impervious area treated, pollutant removal). Other metrics were scored more qualitatively based on professional judgment and assessment of each project site (e.g. access constraints, public visibility/education/outreach). Each project was ranked based on the total score and the final prioritization was determined. The final prioritized list of projects is presented in Table 42 and Table 43. BayLand sites were not included in the prioritization.

TABLE 42: LOWER PATUXENT RIVER WATERSHED PRIORITIZATION RANKING BY PROJECT TYPE

Project ID	Project Type	Benefits Rank	Constraints Rank	Cost Rank	Total Score	Final Rank
LP_SR_1	Stream Restoration	2	4	1	7	1.5
LP_BMP_1	Filterra	4	2	2	8	3.5
LP_BMP_2	Bioretention	3	2	3	8	3.5
LP_BMP_3	Bioretention	1	2	4	7	1.5

TABLE 43: LOWER PATUXENT RIVER WATERSHED PRIORITIZATION FINAL RANKING

Project ID	Project Type	Final Rank
LP_SR_1	Stream Restoration	1.5
LP_BMP_3	Bioretention	1.5
LP_BMP_1	Filterra	3.5
LP_BMP_2	Bioretention	3.5

The project prioritization results provide a starting point for the County's planning process of project implementation. Table 43 present the potential projects listed by final ranking. The highest ranked projects (lower final rank numbers) in general provide the greatest benefits with the least constraints and project costs, relative to all other potential projects. These projects should be first priority to achieve the greatest load reductions to meet Bay restoration goals.

As noted in Section 6, the planned projects summarized above will have an implementation target of 2025 to align with Bay restoration goals. Feasibility studies of the planned strategies may reveal that some existing structures identified for retrofitting or enhancement or that new restoration strategies may not be feasible candidates for future projects and may be eliminated from consideration. The County will take an adaptive management approach and will reevaluate treatment needs as feasibility studies progress. The County will continue to track the overall effectiveness of the various BMP strategies and will adapt the suite of solutions based on the results. In addition, new technologies are continuously evaluated to determine if the new technologies allow more efficient or effective pollution control.

Support, cooperation, and participation from the citizens of Charles County are very important for the successful implementation of restoration projects, especially homeowner practices. Treatment in the Lower Patuxent River watershed is imperative for Bay restoration by providing the load reductions presented in Section 6.4.3.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

BayLand Consultants and Designers, Inc. 2014a. Benedict Properties Shoreline and Stormwater Assessment. Hanover, MD.

BayLand Consultants and Designers, Inc. 2014b. Feasibility Report: Shoreline Management Practices at Charles County Owned Properties. Hanover, MD.

Burres, E. 2011. Standard Operating Procedure (SOP) 3.4.1.4. Measuring Optic Brighteners in Ambient Water Samples Using a Fluorometer. California EPA Surface Water Ambient Monitoring Program. http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/3414.pdf

Caraco, D. 2001. The Watershed Treatment Model. Version 3.0. Prepared by the Center for Watershed Protection, Ellicott City, MD. Prepared for the Office of Wetlands, Oceans, and Watersheds, U.S. Environmental Protection Agency, Washington, D.C.

Center for Watershed Protection. 2004. Unified Subwatershed and Site Reconnaissance: A User's Manual. Version 1.0. Prepared by the Center for Watershed Protection, Ellicott City, MD. Prepared for the Office of Water Management, U.S. Environmental Protection Agency, Washington, D.C. http://fosc.org/PDF/UrbanWatershedRestorationManual11.pdf

Chesapeake Stormwater Network. 2013a. Homeowner Guide for a More Bay-Friendly Property. Chesapeake Stormwater Network, Ellicott City, MD. http://chesapeakestormwater.net/2013/04/homeowner-bmp-guide/

Chesapeake Stormwater Network. 2013b. Virginia Stormwater Design Specification No.1 – Rooftop (Impervious Surface) Disconnection. Chesapeake Stormwater Network, Ellicott City, MD. http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2012/01/VA_BMP_Spec_No_1_DISCONNECTION_FINAL_Draft_v2-0_01012013.pdf

Frink, C.R. 1991. Estimating Nutrient Exports to Estuaries. Journal of Environmental Quality, v. 20(4), p. 717-724

Goulet, N. and T. Schueler. 2014. Background on the Crediting Protocols for Nutrient Reduction Associated with Installation of Homeowner BMPs. Urban Stormwater Work Group. http://chesapeakestormwater.net/wp-content/uploads/downloads/2014/03/USWG-MEMO-ON-HOMEOWNER-BMP-CREDITING12312013.pdf

KCI Technologies, Inc. 2015. Port Tobacco River Watershed Assessment. Prepared for the Charles County Department of Planning and Growth Management by KCI Technologies, Inc. Sparks, Maryland.

KCI Technologies, Inc. 2016. Mattawoman Creek Watershed Assessment. Prepared for the Charles County Department of Planning and Growth Management by KCI Technologies, Inc. Sparks, Maryland.

KCI Technologies, Inc. 2016a. Charles County Stormwater Restoration Plan (Draft May 2016). Prepared for the Charles County Department of Planning and Growth Management by KCI Technologies, Inc. Sparks, Maryland.

King, D. and P. Hagan. 2011. Costs of Stormwater Management Practices in Maryland Counties. University of Maryland Center for Environmental Science. Solomons, MD. https://www.mwcog.org/uploads/committee-documents/kl1fWF1d20111107094620.pdf

LimnoTech. 2013. Charles County Phase II Watershed Implementation Plan Strategy. http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Documents/FINAL_PhaseII_Report_Docs/Final_County_WIP_Narratives/Charles_WIPII_2013.pdf

Low Impact Development Center, Inc., 2007. LID Urban Design Tools. Tree Box Filter: Costs. http://www.lid-stormwater.net/treeboxfilter_costs.htm

Maryland Assessment Scenario Tool (MAST). 2015. Commonly used Chesapeake Bay Program BMP names crosswalk. http://www.mastonline.org/Documentation.aspx

Maryland Department of the Environment (MDE). 2004. Total Maximum Daily Loads for Island Creek, Town Creek, Trent Hall Creek, St. Thomas Creek, Harper and Pearson Creeks, Goose Creek, and Indian Creek and a Water Quality Analysis for Battle Creek of Fecal Coliform for Restricted Shellfish Harvesting Areas in the Lower Patuxent River Basin in Calvert, Charles, and St. Mary's Counties, Maryland. Maryland Department of the Environment Technical and Regulatory Services Administration, Baltimore, MD. http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_lowerpax1_fc.aspx

Maryland Department of the Environment (MDE). 2006b. Report on Nutrient Synoptic Survey in the Port Tobacco River Watershed, Charles County Maryland, March, 2005 as part of a Watershed Restoration Action Strategy. Maryland Department of the Environment Technical and Regulatory Services Administration, Baltimore, MD.

Maryland Department of the Environment (MDE). 2011. Final Report of the Task Force on Sustainable Growth and Wastewater Disposal. Baltimore, MD. http://www.mdp.state.md.us/pdf/yourpart/septicstf/septicstf-finalreport.pdf

Maryland Department of the Environment (MDE). 2012. Maryland's Phase II Watershed Implementation Plan for the Chesapeake Bay TMDL. Maryland Department of the Environment, Baltimore, MD. http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/FINAL_PhaseII_WIPDocument_Main.aspx

Maryland Department of the Environment (MDE). 2014a. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Guidance for National Pollutant Discharge Elimination System Stormwater Permits. Maryland Department of the Environment, Baltimore, MD. http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20MS4%20Guidance%20August%2018%202014.pdf

Maryland Department of the Environment (MDE). 2014b. Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment Total Maximum Daily Loads. Maryland Department of the Environment. June 2014. Baltimore, MD. http://www.mastonline.org/include/MAST_Guidance_Local_TMDLs_2014.pdf

Maryland Department of the Environment (MDE). 2014c. Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads. Maryland Department of the Environment. May 2014. Baltimore, MD. http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Documents/Bacteria%20Implementation%20Plan%20Guidance_051414_clean.pdf

Maryland Department of the Environment. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26- Department of the Environment. 26.08.02 Water Quality. http://www.dsd.state.md.us/comar/SubtitleSearch.aspx?search=26.08.02.

Maryland Department of Natural Resources (DNR). 2015. Maryland's Coastal Atlas. http://gisapps.dnr.state.md.us/coastalatlas/iMap-master/basicviewer/index.html

Maryland Department of Planning (MDP). 2010. Land Use/Land Cover for Maryland. http://www.mdp.state.md.us/OurWork/landuse.shtml

Morgan R.P., K.M. Kline, and S.F. Cushman. 2007. Relationships among nutrients, chloride, and biological indices in urban Maryland streams. Urban Ecosystems 10:153-177

Schueler, T. and C. Lane. 2015. Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects. Chesapeake Stormwater Network, Ellicott City, MD. http://www.chesapeakebay.net/documents/Final_CBP_Approved_Expert_Panel_Report_on_Stormwater_Retrofits--_short.pdf

Southerland, M.T., L. Erb. G.M. Rogers, R.P. Morgan, K. Eshelman, M.J. Kline, K. Kline, S.A. Stranko, P.F. Kazyak, J. Killian, J. Ladell, J. Thompson. 2005. Maryland Biological Stream Survey 2000-2004 Volume 14: Stressors Affecting Maryland Streams. DNR-12-0305-0100. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-05-11.

Swann, C. 1999. A Survey of Residential Nutrient Behaviors in the Chesapeake Bay. Widener Burrows, Inc. Chesapeake Research Consortium. Center for Watershed Protection. Ellicott City, MD. https://cfpub.epa.gov/npstbx/files/UNEP_all.pdf

US EPA, Office of Water (2000). Bacteria Indicator Tool User's Guide. EPA-823-B-01-003.

Yetman, Kenneth T., 2001. Stream Corridor Assessment Survey: Survey Protocols. Maryland Department of Natural Resources: Watershed Restoration Division: Annapolis, MD. http://dnr2.maryland.gov/streams/Publications/SCAProtocols.pdf

APPENDIX A – NEIGHBORHOOD SOURCE ASSESSMENT DATA

Site ID	Watershed	Date	Assessed by	Neighborhood / Subdivision / Streets	Area (acres)	HOA	LU Type	Lot Size (acres)	Age (Decade)	% with Garages	% with Basement	Sewer Service
LP-1	Lower Patuxent	3/20/2015	SB/LW	Malcom Rd and Regina Ave/Regina Drive	53.0	No	Single Fam Detached	1	1950-2015	0	10	No
LP-2	Lower Patuxent	3/20/2015	SB/LW	Leonardtown Rd and Scout Camp Road	487.0	Unknown	Single Fam Detached	>1	1970-1990	100	100	No
LP-3	Lower Patuxent	3/20/2015	SB/LW	Young Rd/Celestial Ln	205.0	Unknown	Single Fam Detached	>1	2000	100	80	No
LP-5	Lower Patuxent	3/20/2015	SB/LW	Benedict Ave	104.0	No	Single Fam Detached	1	1930-2000	20	0	No

Site ID	Infill Index	% Imper-vious Cover	% Lawn	% Land-scaped	% Bare Soil	% Forest Canopy	Land Cover Comments	% Non-target Irrigation	% High Lawn Mgmt	% Medium Lawn Mgmt	% Low Lawn Mgmt
LP-1	<5%	30	60	10	0	40	large portion lawn, forested in back yard	0		10	90
LP-2	No Evidence	30	45	20	5	70	mostly forested lots, lawns and landscaping around houses	0	20	60	20
LP-3	No Evidence	10	85	5	0	20	large portion lawn, forested in back yard	0	50	50	
LP-5	No Evidence	50	40	10	0	10	mixed, some with only lawns, and some with forested back yard	0		20	80

Site ID	Lawn Maintenance Comments	% Lots w/ Outdoor Pools	No. of Outdoor Pools	% Yards with Trash	% Impervious driveways, parking	Driveway Condition	% Clean Driveways	Sidewalks	Sidewalk Condition	% Clean Sidewalks	Distance, sidewalk to street	Pet Waste	Curb / Gutter
LP-1		0	0	20	90	Breaking up	60	No				No	No
LP-2	mixed- lawns with trees generally low management	20	7	10	100	Clean	100	No				No	No
LP-3	large uniform lawns	20	10	0	100	Clean	100	no				No	No
LP-5		1	1	20	90	Clean	90	No				No	No

Site ID	Curb / Gutter Condition	% Gutters not clean	% Down-spouts to SD / SS	% Down-spouts to IA	% Down-spouts to Pervious	% Down-spouts to Rain Barrels	Lawn Area D/S of Leader	Downspout Comments	SD Inlets
LP-1			0	20	80	0	Yes	some to driveway	No
LP-2			0	30	70	0	Yes	some to driveway	No
LP-3			0	50	50	0	Yes	downspouts half to driveways, half to lawn	No
LP-5			0	20	80	0	Yes	some downspouts to driveways	No

Site ID	% Inlets Marked	Inlet Condition	Catch Basin Inspected	Basin ID	SW Pond	Pond Over-grown	Pond Surf Area	Common Open Space	Pet Waste	Dumping	Buffers Present	Buffer Encroach-ment	Pollution Severity	Pollution Severity Score	Restoration Index
LP-1			No		No			No					Moderate	1	Moderate
LP-2			No		No			Yes	No	No	No		Moderate	4	Moderate
LP-3			No		No			No					Moderate	4	Moderate
LP-5			No		No			No					None	0	Moderate

Site ID	Pollution Sources	Potential Action	Notes
LP-1	Sediment, Oil and Grease	retrofit swales, rain gardens, rain barrels, tree planting, conservation landscaping	
LP-2	Sediment, Nutrients, Bacteria	retrofit swales, rain gardens, rain barrels, tree planting, conservation landscaping	
LP-3	Sediment, Nutrients	retrofit swales, rain gardens, rain barrels, tree planting, conservation landscaping	
LP-5	Sediment, Bacteria, Oil and Grease	rain barrels, rain gardens, conservation landscaping	

APPENDIX B – HOT SPOT INVESTIGATION DATA

Site ID	Watershed	Date	Assessed by	Site Name	Category	NPDES Status	Operation Description	Vehicle Operations	Vehicle Types	No. of Vehicles	Vehicle Activities
LP-1	Lower Patuxent	3/20/2015	SB/LW	DeSoto's Landing	commercial	unregulated	marina	Yes	Boats	40	Maint/Fuel/ Wash/ Store

Site ID	Vehicle Storage	Vehicle Runoff Div Method	Spills / Leakage	Notes	Uncovered Fueling	Connected Fueling	Notes	Outdoor Washing	Wash Discharge to Storm Drain	Notes	Outdoor Materials	Loading	Stored Outside
LP-1	Yes	Yes	No	boats	Yes	No	fueling area at dock at water	Yes	No	potentially washing very close to water	No		

Site ID	Material Description	Storage Area	Connected Storage	Staining	No Cover	Liquid Storage Contain-ment	Labels Missing	Waste Mgmt	Type	Dumpster	Dumpster	Connected	Div Methods Lacking
LP-1								Yes	Garbage		good condition	No	

Site ID	Notes	Physical Plant	Building Age	Building Condition	Discharge to MS4	Parking Lot Age	Parking Lot Condition	Parking Lot Condition	Parking Lot Material	Down-spouts to IA	Down-spouts to MS4	Notes	Stains to MS4	Turf/Land-scaping
LP-1		Yes	1970s	Clean	No	1970s	Breaking up	pot holes in gravel	Gravel	Yes	No	downspouts to gravel parking lot	No	Yes

Site ID	% Forest Canopy	% Lawn	% Land-scaped	% Bare Soil	Turf Mgmt	% Non-target Irrigation	Drain to MS4	Organics on IA	Notes	MS4	SWM Practices	SWM Practices	Private SD	Gutter Sediment	Gutter Organics	Gutter Litter	Catch Basin Inspected	Basin ID
LP-1	10	10	2	10	Low	0	No			No								

Site ID	Inlet Condition	Hotspot Status	Potential Action	Notes
LP-1		Potential	review cleaning practices, checking fueling practices near water, add buffer at water edge	

APPENDIX C – STREAM CORRIDOR ASSESSMENT DATA

Inadequate Buffer

SUBWATERSHED	SITE ID	FIELD DATE	PHOTO	BANK	UNSHADED	WIDTH LEFT	WIDTH RIGHT	LENGTH LEFT	LENGTH RIGHT	LAND USE LEFT	LAND USE RIGHT	RECENTLY ESTABLISHED	LIVESTOCK	SEVERITY	CORRECTABILITY	ACCESS	WETLAND
Lower Patuxent	006_IB001	4/24/2015	LP_R006_IB001.jpg	Both	Both	0	0	107	107	POWERLINES	POWERLINES	NO	NO	2	5	4	5
Lower Patuxent	006_IB002	4/24/2015	LP_R006_IB002.jpg	Both	Both	0	0	123	246	POWERLINES	POWERLINES	NO	NO	2	4	3	3
Lower Patuxent	006_IB003	4/24/2015	LP_R006_IB003.jpg	Both	Both	0	0	256	256	POWERLINES	POWERLINES	NO	NO	2	4	3	3

SCA Scoring: Severity (1 = Most Severe, 5 = Minor); Correctability (1 = Minor/Easy, 5 = Major/Difficult); Accessibility (1 = Easily Accessible, 5 = Difficult to Access)

Channel Alteration

SUBWATERSHED	SITE ID	FIELD DATE	PHOTO	TYPE	BOTTOM WIDTH	LENGTH (FT)	PERENNIAL	SEDIMENTATION	VEG IN CHANNEL	ROAD CROSSING	LENGTH (FT)	SEVERITY	CORRECTABILITY	ACCESS
Lower Patuxent	006_CA001	4/24/2015	LP_R006_CA001.jpg	ROAD CROSSING	6	100	YES	YES	NO	YES	100	4	4	1
Lower Patuxent	006_CA002	4/24/2015	LP_R006_CA002.jpg	RIP RAP	8	10	YES	NO	YES	NO	12	4	4	3

SCA Scoring: Severity (1 = Most Severe, 5 = Minor); Correctability (1 = Minor/Easy, 5 = Major/Difficult); Accessibility (1 = Easily Accessible, 5 = Difficult to Access)

Erosion Site

SUBWATERSHED	SITE ID	FIELD DATE	PHOTO	TYPE	POSSIBLE CAUSE	LENGTH LEFT (FT)	LENGTH RIGHT (FT)	HEIGHT (FT)	LAND USE LEFT	LAND USE RIGHT	INFRASTRUCE THREATENED?	SEVERITY	CORRECTABILITY	ACCESS	STREAM	TYPEDESC	CAUSEDES
Lower Patuxent	006_ES001	4/24/2015	LP_R006_ES001_1.jpg, LP_R006_ES001_2.jpg, "_3.jpg	WIDENING, DOWNCUTTING	BEND AT STEEP SLOPE	0	1548	6	FOREST	FOREST	NO	3	4	4			
Lower Patuxent	006_ES002	4/24/2015	LP_R006_ES002.jpg	WIDENING, DOWNCUTTING	LAND USE CHANGE UPSTREAM	474	474	3	FOREST	FOREST	NO	3	4	3			
Lower Patuxent	006_ES003	4/24/2015	LP_R006_ES003_1.jpg, LP_R006_ES003_2.jpg	WIDENING, DOWNCUTTING	LAND USE CHANGE UPSTREAM	0	1336	2	FOREST	FOREST	NO	5	5	4			
Lower Patuxent	006_ES004	4/24/2015	LP_R006_ES004_1.jpg, LP_R006_ES004_2.jpg	WIDENING, DOWNCUTTING	LAND USE CHANGE UPSTREAM	125	109	2	FOREST	FOREST	NO	3	4	4			
Lower Patuxent	006_ES005	4/24/2015	LP_R006_ES005.jpg	WIDENING, DOWNCUTTING	LAND USE CHANGE UPSTREAM	78	78	3	FOREST	FOREST	NO	4	5	4		2ft headcut in channel	

SCA Scoring: Severity (1 = Most Severe, 5 = Minor); Correctability (1 = Minor/Easy, 5 = Major/Difficult); Accessibility (1 = Easily Accessible, 5 = Difficult to Access)

Representative Site

SUBWATERSHED	SITE ID	FIELD DATE	PHOTO	SUBSTRATE	EMBEDDEDNESS	SHELTER FOR FISH	CHANNEL ALTERATION	SEDIMENT DEPOSITION	VELOCITY DEPTH	FLOW	VEGETATION	BANK CONDITION	RIPARIAN VEGETATION	RIFFLE WIDTH (IN)	RUN WIDTH (IN)	POOL WIDTH (IN)	RIFFLE DEPTH (IN)	RUN DEPTH (IN)	POOL DEPTH (IN)	BOTTOM TYPE
Lower Patuxent	006_RE001	4/24/2015	LP_R006_RE001_US.jpg, LP_R006_RE001_DS.jpg	Marginal	Suboptimal	Marginal	Optimal	Suboptimal	Suboptimal	Suboptimal	Suboptimal	Marginal	Optimal	72	84	96	3	5	10	GRAVEL
Lower Patuxent	006_RE002	4/24/2015	LP_R006_RE002_US.jpg, LP_R006_RE002_DS.jpg	Marginal	Poor	Marginal	Optimal	Marginal	Marginal	Suboptimal	Suboptimal	Suboptimal	Optimal	96	108	120	3	6	10	SAND

Habitat Assessment Rankings (in order from worst to best condition) - Poor, Marginal, Suboptimal, Optimal

Unusual Condition

SUBWATERSHED	SITE ID	PHOTO	FIELD DATE	COMMENT	SEVERITY	CORRECTABILITY	ACCESS
Lower Patuxent	006_UC001	LP_R006_UC001.jpg	4/24/2015	BEAVER DAM, NO REAL IMPACT	5	5	5
Lower Patuxent	006_UC002	LP_R006_UC002.jpg	4/24/2015	BEAVER DAM, NO REAL IMPACT	5	5	5
Lower Patuxent	006_UC003	LP_R006_UC003.jpg	4/24/2015	BREACHED BEAVER DAM, NO SIGNIFICANT IMPACT	5	5	3

SCA Scoring: Severity (1 = Most Severe, 5 = Minor); Correctability (1 = Minor/Easy, 5 = Major/Difficult); Accessibility (1 = Easily Accessible, 5 = Difficult to Access)

APPENDIX D – PRIORITIZATION METHODS

Project Prioritization Methods

To support County environmental manager's resource allocation decision making process, a prioritization was developed for the Lower Patuxent River watershed projects identified in this report. The results indicate which projects are the most beneficial and cost effective relative to the set of projects identified.

The prioritization involved a matrix made up of a series of parameters, or metrics, which evaluated each proposed project and allowed for discrimination between the projects. Each metric was scored for each project, either qualitatively or quantitatively as appropriate. Weighting factors were applied to metrics that were deemed the most critical, and the sum of the weighted scores determined the highest priority projects to implement.

The approach included scoring and ranking of the project benefits, constraints and costs. Including factors of feasibility and cost is necessary because the potential exists for the most beneficial project to also be relatively less feasible. It might be the most expensive project, have limited access, utility conflicts, or require disturbance to natural resources.

The following describes the methods used.

Metric Evaluation

The prioritization uses a series of metrics, or indicators, that describe various attributes of a project. A series of candidate metrics was developed for each of the three categories: Benefits, Constraints, and Cost. Metrics evaluated by the project team are listed in Table 1 with a brief description of each.

Table 1: Candidate Prioritization Metrics

Metric	Description
Project Benefits	
Quantity Control	Level of quantity control (cfs/ac)
Water Quality Treatment	Rainfall Depth Treated (in)
Pollutant Removal	TN, TP, and TSS removed (lb) based on modeling
Groundwater Recharge	Amount of recharge based on level of expected infiltration
Channel Protection	Based on proposed level of quantity control and downstream stability
Channel Stabilization	Level of channel stabilization provided will be dependent on channel condition and type of project
Water/Stream Temperature	Does project reduce receiving water temperature?
Instream Habitat Improvement	Does project provide or improve instream habitat?
Riparian Habitat Improvement	Does project provide or improve riparian habitat?
Wetland Habitat Improvement	Does project provide or improve wetland habitat?
Fish Passage	Does project reduce or eliminate barriers to fish passage?
Public Visibility/Education/Outreach	Is project in close proximity to public places?
Community Aesthetic Improvement	Does the project improve community appearance?
Public Safety Improvement	Is there a public safety issue that is addressed by the project?
Combined Benefit	Are there multiple projects in close proximity that together provide a larger cumulative benefit?
Impervious Area Treated	Area of impervious surface treated (acres)
Proximity to MS4	Does the project receive MS4 drainage?
Project Constraints	

Metric	Description
Access	Are there constraints to access – mature trees, infrastructure, steep slopes?
Permitting	Are there significant permitting issues – wetland/forest disturbance?
Maintenance Requirements	What is the level of maintenance involved – frequency, expense, equipment?
Ownership	Is ownership of the parcels involved held publicly or privately? Are private owners cooperative?
Adjacent Land Use	Are adjacent properties compatible with the type of potential project?
Design/Construction	Do the site layout, topography, elevations allow for a design that maximizes benefit and is constructible?
Public Safety	Does the project create a public safety hazard?
Existing Utility Conflicts	Are there existing underground or overhear utilities conflicting with the design? Are the private or public?
Fish Passage	Does the project introduce or make worse a barrier to fish passage?
Project Cost	
Total Life Cycle Cost	Total life cycle cost of the project
Cost per Impervious Area Treated	Total cost of the project divided by the impervious area treated, dollars per acre
Cost per Pollutant Removed	Total cost of the project divided by the amount of pollutant removed, dollars per lb of TP, TN, TSS

Candidate metrics were evaluated for inclusion based on the following attributes:

Duplication. Selected metrics are not duplicative of one another. Results of the prioritization can be skewed if two or more metrics are evaluating very similar project factors.

Project Goals and Objectives. Selected metrics are linked to the overall project goal and objectives. The primary goals of the current projects are to maximize impervious surface treatment and pollutant removal, therefore metrics linked to those goals would be important to include. Secondary goals include items such as habitat improvement and stream channel protection. The linkage to project goals is also accounted for in the metric weighting which is described below.

Relative Management Importance. The suite of candidate metrics was evaluated by County resource managers to determine the factors that were most important to them. To evaluate the suite, a pairwise comparison was used. Results of the comparison were also used to derive the metric weights.

Each metric was analyzed by the project team by comparing pairs of metrics to evaluate which has greater importance. The project team included representatives from Charles County Department of Planning and Growth Management. Each metric is evaluated individually against all of the other metrics and the evaluator selects one by one, which metric has greater importance. The results are tabulated for each metric category (benefits, constraints, costs). Metrics with the greatest number of selections represent those that were felt overall to be the most important. Results are presented in Figures 1-3.

Figure 1: Project Benefits Metric

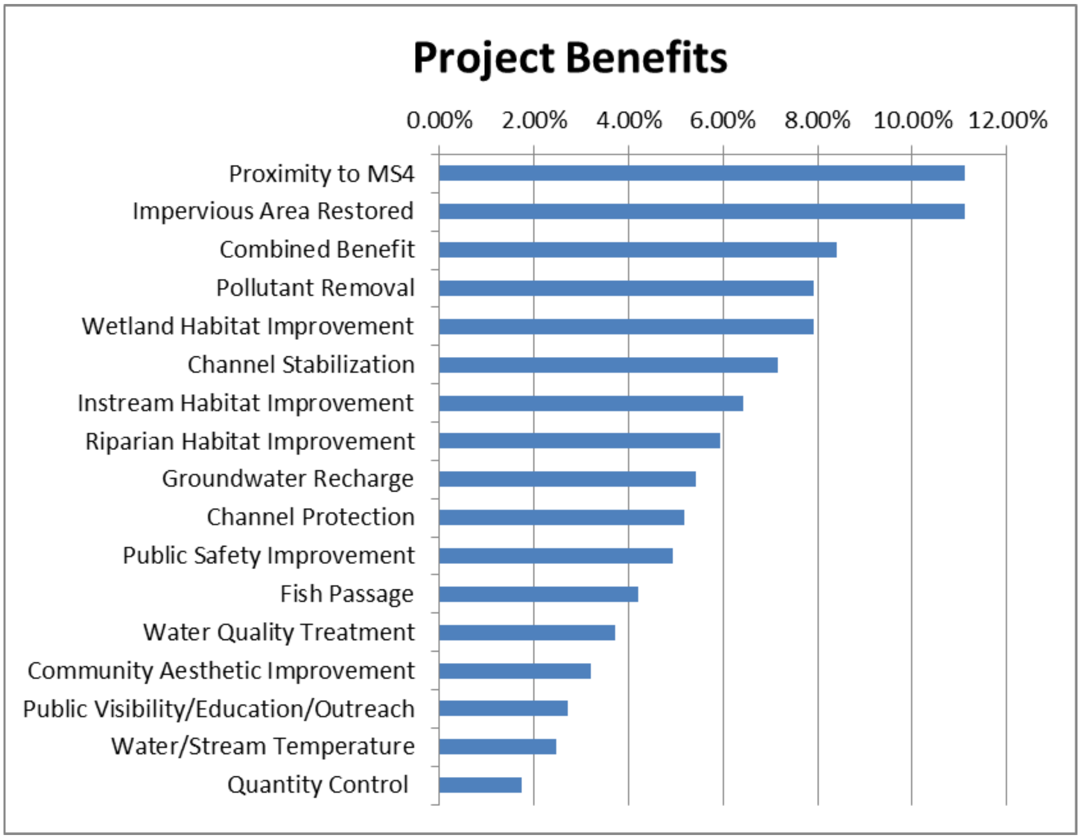


Figure 2: Project Constraints Metric Weights

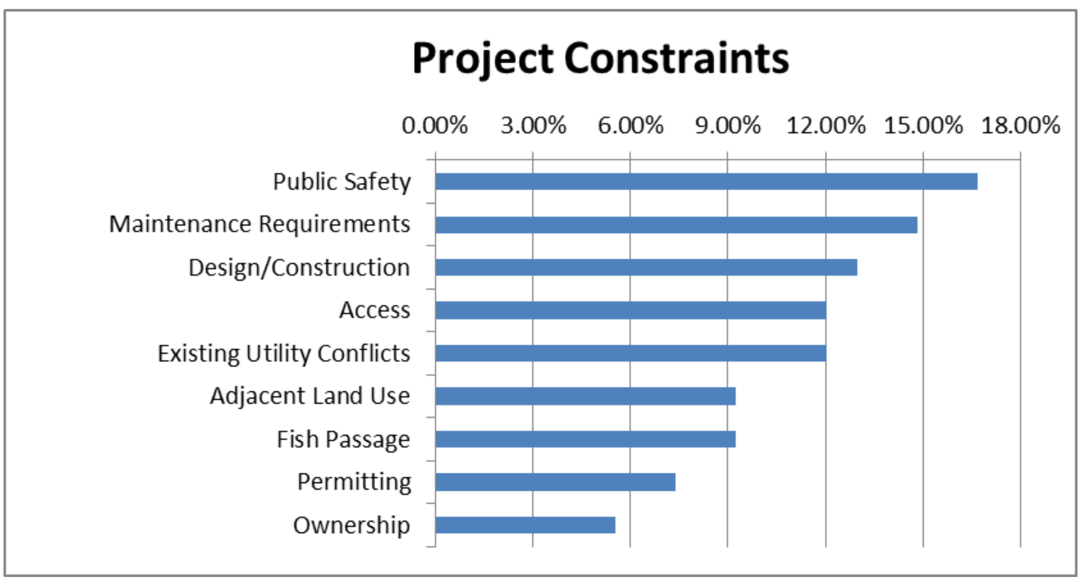
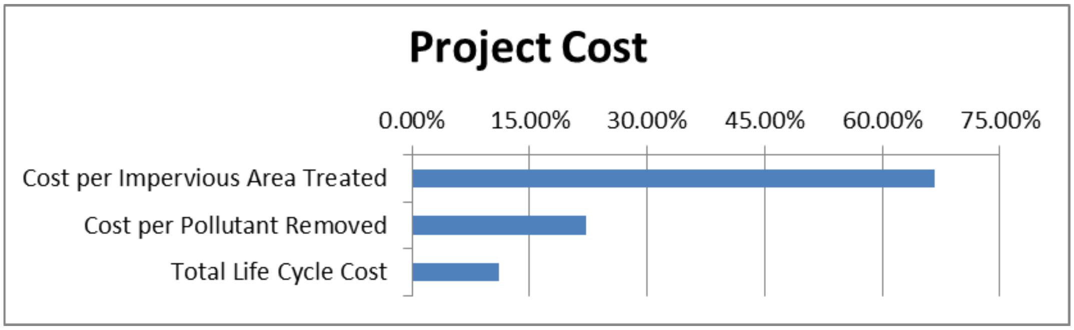


Figure 3: Project Cost Metric Weights



Metric Selection Results

Based on the evaluation described above, a final list of selected metrics was derived. Selected metrics are listed below in order of importance by category. Two constraint metrics (fish passage and public safety) and two benefits metrics (quantity control and public safety improvement) were not used due to their lack of discrimination potential between projects.

Project benefit:

- proximity to MS4
- impervious area treated
- combined benefit
- pollutant removal
- wetland habitat improvement
- channel stabilization
- instream habitat improvement
- riparian habitat improvement
- groundwater recharge
- channel protection
- fish passage
- water quality treatment
- community aesthetics improvement
- public visibility/education/outreach
- water/stream temperature

Project constraint:

- maintenance requirements
- design/construction
- access
- existing utility conflicts
- adjacent land use
- permitting
- ownership

Project cost:

- cost per impervious acre treated
- cost per pollutant removed
- total life cycle cost

Metric Weighting Factors

Weighting factors were developed and applied to allow resource managers to impart the relative importance of the selected metrics into the prioritization. For example, if pollutant load reduction is far more critical in selection versus impervious surface treatment, then it would be more highly weighted. Weights were developed within each of the three categories (benefit, constraints, and cost). Results of the pairwise comparison were totaled and the proportion of the result for each metric of the total was used as the final weight (Table 2).

Table 2: Weighting Factor Results

Metric	Final Weight
Proximity to MS4	11.17%
Impervious Area Restored	11.17%
Combined Benefit	8.44%
Pollutant Removal	7.94%
Wetland Habitat Improvement	7.94%
Channel Stabilization	7.20%
Instream Habitat Improvement	6.45%
Riparian Habitat Improvement	5.96%
Groundwater Recharge	5.46%
Channel Protection	5.21%
Public Safety Improvement	4.96%
Fish Passage	4.22%
Water Quality Treatment	3.72%
Community Aesthetic Improvement	3.23%
Public Visibility/Education/Outreach	2.73%
Water/Stream Temperature	2.48%
Quantity Control	1.74%
Total	100%
Public Safety	16.67%
Maintenance Requirements	14.81%
Design/Construction	12.96%
Access	12.04%

Metric	Final Weight
Existing Utility Conflicts	12.04%
Adjacent Land Use	9.26%
Fish Passage	9.26%
Permitting	7.41%
Ownership	5.56%
Total	100%
Cost per Impervious Area Treated	66.67%
Cost per Pollutant Removed	22.22%
Total Life Cycle Cost	11.11%
Total	100%

Scoring

Quantitative metrics were scored based on results of the preliminary design and cost estimates (e.g. impervious area treated, pollutant removal). Other metrics were scored more qualitatively based on professional judgment and assessment of each project site (e.g. access constraints, public visibility/education/outreach).

Each project was assigned a score between 1 and 5 for each metric. Projects evaluated to have the most benefit received a score of 5, and those with the least benefit were given a score of 1. Constraints were evaluated in a similar fashion such that projects with more constraints were scored a 1, and those with the least were given a score of 5.

Project Benefits

Proximity to MS4 and impervious acres restored were both given the highest weight. Proximity to MS4 scores were determined based on the proximity of the site to MS4 drainage. Areas receiving MS4 drainage received the highest scores and projects in agricultural land use received lower scores. Impervious acres restored scores were calculated by ranking the projects by impervious acres restored and then calculating the corresponding score.

Combined benefit scores were calculated based on the number of projects within close proximity. Clustered projects received higher scores than isolated projects.

Pollutant removal scores were calculated by using the modeled total nitrogen, phosphorus, and sediment load reduction to rank each project. The ranking was then used to calculate a score for each project.

Wetland, riparian, and in-stream habitat scores were calculated based on the habitat benefit from each project. Generally, stream restoration projects received higher scores in these categories. Projects near or within wetlands got a higher wetland habitat score. Stream restoration and SPSC projects that would have tree planting associated with the project received higher scores for riparian habitat. All stream restoration projects received the highest score of 5 for in-stream habitat.

Channel stabilization was scored based on the type of project and level of increased channel stabilization anticipated. Stream restoration and SPSC projects were given scores of 5 and 4, respectively, however all other projects have no potential increased channel stability and were given scores of 1.

Groundwater recharge was calculated for the stormwater management projects and scores were calculated based on these values. No other project type would provide groundwater recharge.

Projects that would provide an increase in channel protection received higher scores than those not providing additional channel protection.

Each project was scored according to the potential improvement to public safety that the project would achieve. No projects were found to have any associated public safety improvement aspects and all projects received a score of 1.

Projects that would address fish passage issues received higher scores for the fish passage metric. While no stream restoration site specifically had a fish passage issue identified, stream restoration projects should generally improve fish passage, therefore stream restoration projects were all given scores of 2, while all other projects received scores of 1.

Water quality treatment scores were calculated by ranking the projects by rainfall depth treated and then calculating the corresponding score.

Community aesthetic improvement scores were calculated based on the anticipated improvement of community appearance. Projects such as trash cleanups, stream restoration, and reforestation in highly visible areas received higher scores. Stormwater management projects were scored based on the project type and anticipated appearance of the facility and associated plantings.

Public visibility/education/outreach scores were calculated based on the project's proximity to public areas that could provide educational opportunities for the community.

Water/stream temperature was scored based on project type. Stream restoration projects received higher scores if tree planting would be associated with the project. All reforestation projects received the highest score of 5. Stormwater management projects generally received moderate scores with the exception of the wet ponds, which would provide no benefit to water temperature.

Projects were scored according to their potential for quantity control (cfs/acre). No projects were found to have associated quantity control benefits and all projects received a score of 1.

Project Constraints

Design and construction constraints, such as site layout, topography, and elevations, were analyzed for each project. Projects that were identified as having steep slopes, nearby infrastructure, or other design and construction constraints received lower scores.

The degree of maintenance required for each project was estimated. Biorentention and infiltration basin projects generally require more maintenance and received lower scores, while trash cleanups, reforestation, and stream restoration projects generally require less maintenance and received higher scores.

Existing utility conflicts were assessed and scored. Majority of the projects did not have utility conflicts, however some sites were found to have underground and overhead electric, cable or telephone lines and subsequently received lower scores in this metric.

Ease of access was analyzed for each site. The presence of paved access roads or trails, or proximity to existing roads or parking lots was considered and scored accordingly.

Permitting requirements was evaluated for each project. Stream restoration projects generally require extra permitting and received lower scores than the projects such as reforestation and trash cleanups.

Site ownership was identified and scored. Projects on private property received lower scores than those on public property.

Lastly, adjacent land use was determined and scored. Adjacent properties with land use not compatible with the project type received lower scores.

Project Costs

Project costs were calculated and ranked for each project in three categories: life cycle cost, cost per pollutant reduced, and cost per impervious area. Scores were calculated for each category and then averaged for the final project cost score.

Results

Weighting factors were applied to the scores for each metric. Total scores were then summed for each project for both the benefit and constraint categories and the projects ranked within each category. Projects were also ranked according to the cost metrics, including total project cost, cost per pollutant removed, and cost per impervious acre treated. A ranking for each metric category was assigned based on the results. The final ranking incorporates the results of the category rankings. The final prioritized lists of projects for the Lower Patuxent River watershed are presented in Table 3. Projects listed by final rank are presented in Table 4.

Table 3: Lower Patuxent River Prioritization Ranking by Project Type

Project ID	Project Type	Benefits Rank	Constraints Rank	Cost Rank	Total Score	Final Rank
LP_SR_1	Stream Restoration	2	4	1	7	1.5
LP_BMP_1	Filterra	4	2	2	8	3.5
LP_BMP_2	Bioretention	3	2	3	8	3.5
LP_BMP_3	Bioretention	1	2	4	7	1.5

Table 4: Lower Patuxent River Prioritization Final Ranking

Project ID	Project Type	Final Rank
LP_SR_1	Stream Restoration	1.5
LP_BMP_3	Bioretention	1.5
LP_BMP_1	Filterra	3.5
LP_BMP_2	Bioretention	3.5

Note: Lowest numerical value for each rank category is the highest ranked project

APPENDIX E – PUBLIC COMMENTS

Charles County solicited public review and comment of the draft Watershed Assessments (Port Tobacco, Mattawoman, and Lower Patuxent watersheds) through a public meeting and review period. A public meeting was held at the Charles County government location in La Plata Maryland on May 9, 2016. The meeting included presentations of the County's completed watershed assessments and a presentation on the draft Restoration Plan. Questions and answer sessions followed each of the presentations. A 30-day public review period followed the meeting with questions and comments due to the County on June 9, 2016. The documents for review were available on the County's website.

A summary of the questions and comments received regarding the Watershed Assessments, and the County's response to the comment, are included in this appendix. Comments on the Restoration Plan are included as an Appendix to Restoration Plan report.

Public Meeting Comment Summary: Watershed Assessments 5/9/2016

Questions related to the presentation on the County's Watershed assessments:

1) Q: What sites were rated severe during the Stream Corridor Assessment for the Mattawoman Watershed?
   A: The following numbers of sites were rated 'severe'
   a. 1 erosion
   b. 8 buffer
   c. 1 pipe outfall
   d. 1 trash
   e. 1 construction

2) Q: Where were the Stream Corridor Assessments conducted?
   A: The following were completed:
   a. Field crews assessed 8 miles in Port Tobacco and identified 5 miles of erosion
   b. Field crews assessed 8 miles in Mattawoman Creek and identified 1.4 miles of erosion
   c. Field crews assessed 3.5 miles in Lower Patuxent and identified 0.8 miles of erosion

3) Q: Does Port Tobacco have a stormwater component?
   A: Port Tobacco does not have a stormwater waste load allocation, therefore there is no MS4 urban stormwater treatment required to meet a TMDL.

4) Q: Stormwater that goes into the wastewater treatment plant, how is that allocated?
   A: Charles County does not have combined sewer, so stormwater is not directed to the treatment plant. The wastewater sector has separate goals from the urban sector for TMDL compliance.

5) Q: Can you explain downspout disconnection?
   A: Downspouts are normally directed to an impervious surface such that runoff from rooftops will flow into and through stormwater systems. We want to direct the flow to a lawn, breaking up the path, and keeping the flow and related pollutants out of the stormwater system.

6) Q: In the Mattawoman will the high levels of orthophosphate be taken care of in the restoration plan and can the results be explained more?
   A: The County has added more detail related to the orthophosphate levels in the watershed assessment.

7) Q: Will there be more presentations on sources of pollutants other than stormwater? How do we deal with other sources of pollutants in Mattawoman Creek, which are moving targets?
A: As the TMDLs have been coming out, the other sectors area also having informational meetings to find solutions. TMDLs have a load from the baseline year that we need to reduce, and the State is developing Accounting for Growth policies and stormwater management regulations to address loads from new growth since the baseline year. There is some residual pollutant after stormwater controls are implemented, so the Accounting for Growth policies are to address the residual.

8) Q: Regarding step pool conveyance systems which can take down quite a bit of forest, do any of the proposed retrofits take down forest for this type of stormwater management? Charles County should design into the plan, not to take down forest for restoration projects.
A: KCI always avoids taking out excessive trees and if absolutely necessary it would be limited to edge trees, not forests. During site feasibility evaluations the size of the project, slopes, utilities, and tree removal are evaluated. Impacts to trees are part of a project selection and prioritization process and are avoided whenever possible.

9) Q: Forest is the best way to manage stormwater. As a part of the counterbalance to this plan, forest retention should be encouraged as a first priority for decision makers, because then stormwater doesn't have to be paid for by the taxpayers. Counties could recommend forest retention be in the plan, so that MDE might credit this practice. Is there any way to encourage forest retention?
A: Forest retention is a good strategy to limit future impacts and additional pollutant loads; however MDE does not currently give restoration credit for forest retention for impervious treatment or for TMDL compliance therefore forest retention is not included as a strategy.

10) Q: Are upstream areas fixed in storm restoration? It may not make sense to complete a stream restoration project without also treating the upstream areas.
A: The County looks to combine upstream stormwater treatment with stream restoration whenever possible. During site selections the County's consultants look into combined projects but it is not always feasible. Ownership and cost become a factor, the County typically has more access to stream valley corridors than multiple, private upstream properties. The goal with adding upstream management is to reduce the stormwater flow to lower the shear stress (erosion potential) in the stream so that a softer approach with more focus on the biological components can be used in the restoration. Update sizing of channel to its current flow regime can help bring habitat functions back.

Public Comment Period Summary: Watershed Assessments 5/9/2016-6/6/2016

Mattawoman Watershed Society Letter dated June 9, 2016

These comments were intended for the Mattawoman Creek Watershed Assessment but were also applicable to the Lower Patuxent River Watershed Assessment.

Comment: A table of abbreviations in the [plan] would be extremely helpful. For example EOS and NTP are never formally defined.

Response: Added a table of abbreviations and defined EOS.

Comment: If a reference has an online link, providing it would be helpful.

Response: Added online links where available.

Comment: On p. 37, the units for 247 µS/cm are incorrectly given as µg/l.[1] The county or consultant might be interested in MWS monthly data on conductance. For example, on April 3, 2016, 7 of 20 sites exhibited conductance greater than 247 µS/cm.

Explain the meaning and significance Optical Brightners, and the concentrations given in Table 10.

Response: Fixed units. Added explanation of optical brightener significance and results.

Comment: Explain the likely outcomes of stream restoration when the upstream catchment is not retrofitted with measures to address the cause of the stream degradation. Provide the scientific backing for this practice.

Response: As noted above in response to a similar public meeting question, the County looks to combine upstream stormwater treatment with stream restoration whenever possible. During site selections the County's consultants look into combined projects but it is not always feasible. Ownership and cost become a factor, the County typically has more access to stream valley corridors than multiple, private upstream properties. The goal with adding upstream management is to reduce the stormwater flow to lower the shear stress (erosion potential) in the stream so that a softer approach with more focus on the biological components can be used in the restoration. Update sizing of channel to its current flow regime can help bring habitat functions back. A project can still be successful when the upstream catchment is not retrofitted. Many Counties in Maryland have used this approach with good success, particularly with outcomes related to channel stability, infrastructure protection and public safety, and pollutant loading reduction. Biological outcomes are tougher to meet with this approach, however the restored channel is typically in a very degraded biological state at the outset.

MDE has accepted stream restoration as an important tool for meeting MS4 impervious surface goals and TMDL requirements. The Chesapeake Bay Program's Urban Stormwater Workgroup published the Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. The document details the types of approved projects and protocols for crediting impervious treatment and pollutant removal. The document also includes an extensive list of References Cited, which includes much of the current scientific literature on the subject.
http://www.chesapeakebay.net/documents/Stream_Panel_Report_Final_08282014_Appendices_A_G.pdf

The Bay Program has also published a fact sheet with useful stream restoration information.
http://www.chesapeakebay.net/documents/U4._Urban_Stream_Restoration_Fact_Sheet_in_Chesapeake_Bay_Watershed.pdf