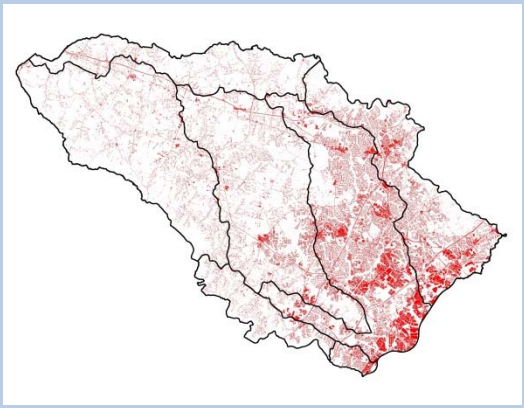
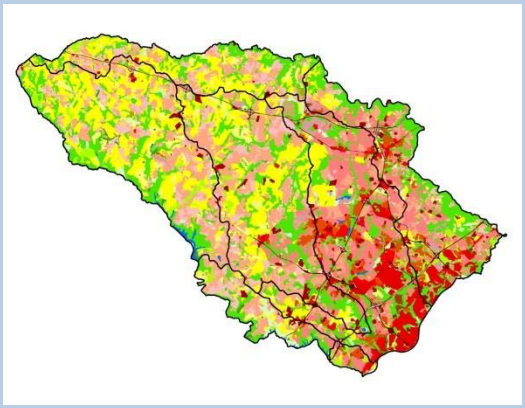
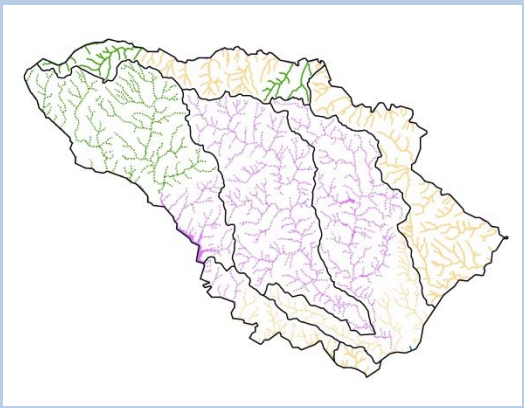
COUNTYWIDE IMPLEMENTATION STRATEGY

TMDL AND IMPERVIOUS SURFACE RESTORATION PLAN

HOWARD COUNTY, MARYLAND

UPDATED DECEMBER 2017

COUNTYWIDE IMPLEMENTATION STRATEGY

DECEMBER 2017

PREPARED FOR

HOWARD COUNTY, MARYLAND
STORMWATER MANAGEMENT DIVISION
DEPARTMENT OF PUBLIC WORKS
6751 COLUMBIA GATEWAY DRIVE, SUITE 514
COLUMBIA, MD 21046-3143

PREPARED BY

KCI TECHNOLOGIES, INC.
936 RIDGEBROOK ROAD
SPARKS, MD 21152

WITH SUPPORT FROM

MCCORMICK TAYLOR, INC.
509 S. EXETER STREET, 4TH FLOOR
BALTIMORE, MD 21202

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This watershed restoration plan was completed as a collaborative effort between the following partners:

Howard County Stormwater Management Division

KCI Technologies, Inc.

McCormick Taylor, Inc.

The report was authored by the following individuals from KCI Technologies, Inc.:

Megan Crunkleton

Mike Pieper

Bill Frost, P.E.

Database support and GIS analyses were provided by McCormick Taylor, Inc.:

Joe Knieriem

County staff providing expertise, oversight, and review include:

Christine Lowe, P.E.

Mark Richmond, P.E.

Michele Monde, P.E.

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For more information pertaining to the CIS, please contact:

Mark S. Richmond, Chief
Stormwater Management Division
Howard County Department of Public Works
6751 Columbia Gateway Drive, Suite 514
Columbia, MD 21046
410-313-6413
msrichmond@howardcountymd.gov

And visit us on the web:
http://www.howardcountymd.gov/swm.htm

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List of Acronyms

AFG	Accounting for Growth
BACI	Before-After Control-Impact
BayFAST	Bay Facility Assessment Scenario Tool
BMP	Best Management Practices
BSID	Biological Stressor Identification Studies
CA	Columbia Association
CBP	Chesapeake Bay Program
CIP	Capital Improvement Plan
CIS	Countywide Implementation Strategy
CWA	Clean Water Act
DEL	Delivered
DRP	Department of Recreation and Parks
EOS	Edge of Stream
EPA	U.S. Environmental Protection Agency
ESD	Environmental Site Design
LULC	Land use / Land cover
MAST	Maryland Assessment Scenario Tool
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PSU	Primary Sampling Unit
SHA	State Highway Administration
SPSC	Step Pool Storm Conveyance
SSO	Sanitary Sewer Overflow
SWMD	Stormwater Management Division
SW to MEP	Stormwater to the Maximum Extent Practicable
SW-WLA	Stormwater Wasteload Allocation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey
WIP	Watershed Implementation Plan
WLA	Wasteload Allocation
WQA	Water Quality Assessment
WWTP	Wastewater treatment plant
WSSC	Washington Sanitary Sewer Commission

Executive Summary

On December 18, 2014, Howard County received a new National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit (11-DP-3318, MD0068322) from the Maryland Department of the Environment (MDE) that includes requirements for watershed restoration activities, specifically preparation of a restoration plan within the first year of the permit term (Section IV.E.2). To address this requirement, Howard County has developed this Countywide Implementation Strategy (CIS) that:

- Demonstrates ways to meet the Total Maximum Daily Load (TMDL) Stormwater Wasteload Allocations (SW-WLAs) approved by U.S. Environmental Protection Agency (EPA)
- Illustrates a strategy to provide additional stormwater runoff management for impervious acres equal to 20% of the impervious area for which runoff is not currently managed to the Maximum Extent Practicable (MEP)
- Educates and involves residents, businesses, and stakeholders in achieving measurable water quality improvements
- Establishes a reporting framework for annual reporting under the County's MS4 permit
- Provides an evaluation and adaptive management process for developing actions to be taken if permit requirements are not met
- Identifies the funding needed to implement the CIS

In addition to these requirements, the County must develop watershed assessments for each watershed in the County before the end of the permit term in December 2019. The County has completed all major watershed assessments with the completion of the Little Patuxent and Middle Patuxent watersheds in December 2015 and all remaining watersheds (Brighton Dam, Patapsco River Lower North Branch, Patuxent River Upper, Rocky Gorge Dam, and South Branch Patapsco River) assessed in 2016. These assessments, which provide visual characterization, identification of water quality issues and prioritized solutions, are the foundation on which this CIS has been and will be developed.

As required by the permit, the CIS includes a schedule of activities, provides dates for meeting the SW-WLAs, presents cost estimates for projects and programs, describes the County's monitoring and progress evaluation frameworks, including adaptive management, and includes public participation elements.

Impervious Surface Restoration

As a requirement of PART IV.E.2.a of the County's NPDES MS4 permit, the County must conduct an impervious area assessment to define the restoration efforts required under the permit and restore 20% of countywide baseline untreated impervious acres by 2019, the end of the current permit term. The CIS includes the County's impervious accounting to determine the levels of treated, untreated and partially treated impervious surface under County MS4 jurisdiction and presents the County's impervious surface baseline and 20% restoration goal. The total County MS4 Impervious Area, or the area under Howard County jurisdiction, is 15,226.4 acres. The difference between this value and the total impervious area of 17,728.0 is impervious surfaces under other ownership (state lands) and portions regulated by other NPDES permits (MSHA and industrial sites). The impervious baseline treated area is 2,944.7 acres and the untreated area is 12,281.7 acres; however the County is using MDE's approved baseline of 12,299.2. Applying the 20% factor to the untreated area yields a 20% restoration target of 2,459.8 acres.

As instructed by MDE, MS4 jurisdictions may apply restoration credit to the current permit term from projects completed after the expiration date of the previous permit term. Therefore restoration projects implemented following June 20, 2010 are considered restoration, while restoration projects implemented before June 20, 2010 are credited to the baseline. The results indicate that the County has completed 1,433.5 impervious acres of restoration to apply to its 20% goal, leaving 1,026.4 acres of impervious restoration to be completed by the end of the permit term in December, 2019.

The CIS, with a full accounting of current progress and the projects and programs recommended and planned, would result in a total restoration of 2,107.5, or 17.2% of the untreated baseline within the current permit term. The County anticipates that because of the over 400 acres added to the restoration target with MDE's approved baseline, and based on resource and timing constraints related to program funding and project execution such as permitting and private property owner coordination, that the 20% target will likely not be met by the end of the permit term. The County is moving forward with MDE's baseline value, but plans to re-address several elements of the baseline accounting in the year 4 recalculation. Several of these items are detailed in section 1.2.3 of this CIS. The County will re-evaluate overall impervious restoration progress at the end of FY18 but expects to use nutrient trading with the Little Patuxent Water Reclamation Plant to trade in time for the final 352 acres of treatment (based on current projections). See sections 4 and 5 for details.

Local TMDLs

As a requirement of section PART IV.E.2.b of the County's NPDES MS4 permit, the County must develop restoration plans by December 2015 for each SW-WLA approved by EPA prior to the effective date of the permit. There are currently eight final approved TMDLs within Howard County with either an individual or aggregate SW-WLA (ES Table 1). Several County TMDL watersheds fall within neighboring counties; however, SW-WLAs assigned to jurisdictions outside of Howard County's Phase I MS4, which may also include, Phase II jurisdictions, Maryland State Highway Administration, and other NPDES regulated stormwater are not the responsibility of Howard County and are not addressed in the CIS.

The following describes TMDLs that are not addressed in the CIS:

- Approved TMDL (September 19, 2017) for polychlorinated biphenyls (PCBs) in the Patuxent River. This TMDL will have a separate plan developed in 2018.
- Centennial Lake sediment and phosphorus TMDLs (approved April 2002) do not have SW-WLAs assigned to the Howard County MS4 source sector
- Lower segment of the Patuxent River Upper bacteria TMDL (approved August 2011) does not have a SW-WLA assigned to the Howard County MS4 source sector
- Triadelphia Reservoir sediment TMDL (approved November 2008), which does have a SW-WLA for Howard County Phase I MS4, requires a 0% reduction in baseline sediment loads with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008).
- Patuxent River Upper (Cash Lake) mercury TMDL (approved March 2011), which is listed in Attachment B of the County's current permit, is located wholly within Prince George's County, therefore Howard County is not responsible for this TMDL
- South Branch Patapsco does not have a local TMDL, but it is included in the analysis since it, with the Patapsco River Lower North Branch, makes up the Baltimore Harbor watershed.
- The Middle Patuxent watershed does not have a TMDL.

The CIS presents disaggregated and calibrated baseline loads for each SW-WLA to calculate the load reduction required from the baseline value. Based on MDE guidance, growth in the stormwater load since the TMDL baseline year was not accounted for in the analysis. Local TMDLs are considered met, from a planning perspective, when the load reductions associated with 2017 restoration progress coupled with the planned restoration load reductions included in the CIS exceed the load reduction required. Some TMDLs are estimated to be exceeded by a wide margin because removals per pollutant type are not achieved at the same rate. TN removal rates are low compared to TP and TSS on a per project basis. This impacts watersheds with multiple TMDLs and nested watersheds (Baltimore Harbor).

ES Table 1. Howard County Local TMDL Summary

Watershed Name	Watershed Number	WLA Type	Pollutant	Baseline Year	MDE Published Reduction	CIS Planned Reduction
Patapsco River Lower North Branch[1]	02130906	Individual	Sediment	2005	10.0%	81.8%
		Aggregate	Bacteria	2003	75.0%	90.1%
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906	Aggregate	Nitrogen	1995	15.0%	15.1%
	02130908					
	02130906	Aggregate	Phosphorus	1995	15.0%	132.2%
	02130908					
Patuxent River Upper	02131104	Individual	Sediment	2005	11.4%	26.7%
Little Patuxent River	02131105	Individual	Sediment	2005	48.1%	52.1%
Rocky Gorge Reservoir	02131107	Aggregate	Phosphorus	2000	15.0%	18.6%
Triadelphia Reservoir (Brighton Dam)	02131108	Aggregate	Phosphorus	2000	15.0%	22.6%
		Aggregate	Sediment	2000	0%	--

[1]Bacteria TMDL applies only to subwatershed PAT0148

Chesapeake Bay TMDL

The Chesapeake Bay TMDL, established by the EPA (EPA, 2010), sets pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. While not a requirement in the County's NPDES MS4 permit, strategies provided in this plan to meet local TMDL reduction targets and impervious restoration treatment are modeled against the Bay TMDL goals in order to calculate progress. The County's MS4 permit requires compliance with the Chesapeake Bay TMDL for the stormwater sector through the use of the 20% impervious surface restoration strategy rather than through the use of calculating and tracking nutrient reductions; however the Bay TMDL nutrient reductions have been tabulated in the CIS for general comparison.

Management Measures

Management measures to reduce pollutant loads and restore impervious surfaces include structural stormwater Best Management Practices (BMPs), alternate practices, and also non-structural County based and homeowner-implemented programs. The major project types accounted for in the CIS towards the reduction goals are presented in section 4. These include projects currently identified in the County's FY18, FY19, FY20 Capital Improvement Plan (CIP) list, potential project sites identified with

concept plans developed in the 2015 watershed assessments in the Little and Middle Patuxent, and concept plans developed in the 2016 assessment of the County's remaining watersheds.

Cost and Schedule

The cost of implementing the CIS to meet the stated goals has been estimated. It is important to note that the costs represent planning level estimates for use in high level forecast budgeting with many assumptions made. The cost estimates provided in the CIS will likely adjust as the County progresses with implementation of its program.

The total cost to implement all practices described in this plan is $167,885,317. This total cost includes all SWM Division CIP restoration BMPs ($158,095,317) along with costs from additional practices (i.e., rain barrels, septic pump-outs and upgrades, street sweeping, inlet cleaning and Howard EcoWorks) from FY17 – FY19 ($2,415,000) as well as costs from FY21 – FY29 ($7,425,000) needed to fulfill the local TMDL targets by FY29.

ES Table 2. Fiscal Year Schedule of SWM Division CIP Project Implementation and Cost

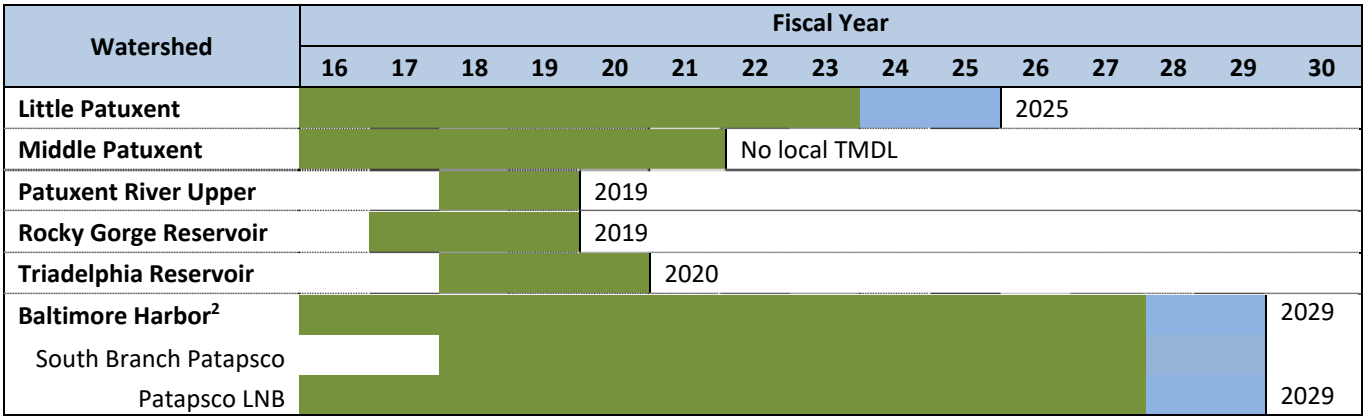
Fiscal Year	Number of Planned Projects to Meet the 20% Restoration Requirement[1]	Total Cost to Meet the 20% Restoration Requirement[1]	Number of Additional Planned Projects to Complete the TMDL Goals[2]	Total Additional Cost to Complete the TMDL Goals[2]
2018	24	$16,103,189		
2019	21	$10,542,539		
2020	12	$9,882,839		
2021			17	$15,400,615
2022			20	$15,396,791
2023			19	$14,646,142
2024			21	$16,070,676
2025			21	$15,763,623
2026			20	$15,012,974
2027			20	$15,012,974
2028			19	$14,262,325
2029				
Total	**57**	**$36,529,197**	**152**	**$121,566,120**

[1] Values for FY18 through FY20 meet the 20% restoration requirement and also provide a portion of the nutrient and sediment load reductions required toward meeting the local and Bay TMDL goals.

[2] Values for FY21 through FY2027 provide the additional nutrient and sediment load reductions required toward meeting the local and Bay TMDL goals..

Implementation of the CIS and will meet the local TMDL-required reductions by the end dates indicated in the following figure, ES Figure 1.

ES Figure 1. Implementation Schedule with End Dates Indicated[1]



[1] Primary project funding period is shown in green, additional implementation period for each TMDL are in blue.
[2] Baltimore Harbor TMDL includes the South Branch Patapsco and Patapsco Lower North Branch watersheds. There is no local TMDL specifically for the South Branch Patapsco.

Adaptive Management

The CIS is an important first step; however, the MS4 permit calls for an iterative and adaptive plan for implementation. The County will monitor implementation progress on a regular basis and will report progress, load reductions achieved, and impervious surface reductions to MDE with the NPDES annual report and at required milestone intervals. The County will review the CIS annually and make plan adaptations based on the results. If new methods of stormwater treatment are identified, or better approaches to source control are found, the plans can be extended and updated to take these changes into account. Similarly, if some elements of the plans are not as successful as expected, adaptations and improvements will be incorporated in future updates. Plans may also change if pollutant removal crediting methods are modified in the future.

1 Introduction

1.1 Background and Purpose

Howard County continues to implement significant controls on stormwater discharges under its National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) discharge permit and other Clean Water Act (CWA) requirements. In addition, the County has programs supporting watershed restoration and environmental sustainability that include (1) protection of water resources, (2) public outreach, (3) new investment in stormwater management, and (4) preparation of this countywide implementation strategy.

On December 18, 2014, Howard County received a new National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit (11-DP-3318, MD0068322) from the Maryland Department of the Environment (MDE) that includes requirements for watershed restoration activities, specifically preparation of a restoration plan within the first year of the permit term (Section IV.E.2). To address this requirement, Howard County has developed this Countywide Implementation Strategy (CIS) that:

- Demonstrates ways to meet the Total Maximum Daily Load (TMDL) Stormwater Wasteload Allocations (SW-WLAs) approved by U.S. Environmental Protection Agency
- Illustrates a strategy to provide additional stormwater runoff management on impervious acres equal to 20% of the impervious area for which runoff is not currently managed to the Maximum Extent Practicable (MEP)
- Educates and involves residents, businesses, and stakeholders in achieving measurable water quality improvements
- Establishes a reporting framework for annual reporting under the County's MS4 permit
- Provides an evaluation and adaptive management process for developing actions to be taken if permit requirements are not met
- Identifies the funding needed to implement the CIS

It is noted that the CIS is an important step; however, the MS4 permit calls for an iterative and adaptive plan for implementation. If new methods of stormwater treatment are identified, or better approaches to source control are found, the plans can be extended and updated to take the changes into account. Similarly, if some elements of the plans are not as successful as expected, adaptations and improvements will be incorporated in future updates. Plans may also change if pollutant removal crediting methods are modified in the future.

CIS Revision – December 2017

This document represents the second version of the CIS submitted by Howard County to MDE. Version 1 of the CIS was submitted to MDE on December 18, 2015. The County received comments from MDE on May 28, 2016 and met with MDE to discuss the comments on June 23, 2016. This revised version of the CIS addresses the following:

- Calculates impervious baseline following revised methodology (i.e., use of County's 2002 planimetric impervious layer data set as the primary base layer) and provides greater detail of methodology in an added Appendix 1.
- Per MDE guidance, the County accounts impervious restoration credit from projects implemented after the expiration date of the previous permit term (June 20, 2010).
- Removes County Lakes and pre-1985 BMPs from impervious baseline calculations.

- Clarifies pollutant load reduction modeling.
- Calculates progress reductions through FY17.
- Calculates planned reductions and costs with a revised set of planned projects based on the County's updated CIP list.
- Calculates pollutant load reductions from street sweeping efforts using a mass loading approach
- Re-calculates baseline, target, and progress loads and planned load reductions for the Patapsco River Lower North Branch local bacteria TMDL following a subwatershed approach; and provides greater detail on the methodology used to address this local TMDL.
- Introduces Nutrient Credit Trading as a viable, allowable, and potentially necessary option for impervious surface restoration.

1.1.1 Howard County MS4 Permit

Section 402(p) of the Clean Water Act required the EPA to add MS4 discharges to the NPDES permit program. In 2002, EPA directed permit writers to include WLA requirements in NPDES permits, including those for MS4 discharges. Howard County is one of five medium jurisdictions in Maryland that is regulated by a NPDES MS4 Discharge Permit (Section 402(p) of the Water Quality Act of 1987 and NPDES Permit Application Regulations for Storm Water Discharges of November 16, 1990). Howard County's first permit went into effect on April 17, 1995 and the County received its fourth permit on December 18, 2014 (11-DP-3318, MD0068322). This fourth permit includes the following new requirements related to Restoration Plans, impervious surface treatment, and TMDLs among others.

Permit Requirements

One objective of this plan is to meet the County's MS4 NPDES permit requirement to restore 20% of the County's impervious surface area that has not already been restored to the MEP per permit section PART IV.E.2.a. Another objective is to develop restoration plans for local TMDLs, specifically each stormwater Waste Load Allocation (WLA) approved by EPA, prior to the effective date of the permit, per permit section PART IV.E.2.b. Plans must be developed within the first year of permit issuance. Howard County's final permit was issued on December 18, 2014 therefore the restoration plans must be complete by December 17, 2015.

The following specific permit sections and language apply:

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

a. Within one year of permit issuance, Howard County shall submit an impervious surface area assessment consistent with the methods described in the MDE document "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits" (MDE, June 2011 or subsequent versions). Upon approval by MDE, this impervious surface area assessment shall serve as the baseline for the restoration efforts required in this permit.

By the end of this permit term, Howard County shall commence and complete the implementation of restoration efforts for twenty percent of the County's impervious surface area consistent with the methodology described in the MDE document cited in PART IV.E.2.a. that has not already been restored to the MEP. Equivalent acres restored of impervious surfaces, through new retrofits or the retrofit of pre-2002 structural BMPs [Best Management Practices], shall be

based upon the treatment of the WQv criteria and associated list of practices defined in the 2000 Maryland Stormwater Design Manual. For alternate BMPs, the basis for calculation of equivalent impervious acres restored is based upon the pollutant loads from forested cover.

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

   i. *Include the final date for meeting applicable WLAs and a detailed schedule for implementing all structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs;*
   ii. *Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;*
   iii. *Evaluate and track the implementation of restoration plans through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs; and*
   iv. *Develop an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the County's watershed assessments.*

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

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

In addition to the standard permit conditions described above, the County is also required to address additional programmatic conditions specific to the Chesapeake Bay TMDL as outlined below:

PART VI. Special Programmatic Conditions
A. Chesapeake Bay Restoration by 2025

A Chesapeake Bay TMDL has been developed by the EPA for the six Bay States (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and the District of Columbia. The TMDL describes the level of effort that will be necessary for meeting water quality criteria and restoring Chesapeake Bay.

This permit is requiring compliance with the Chesapeake Bay TMDL through the use of a strategy that calls for the restoration of twenty percent of previously developed impervious land with little or no controls within this five year permit term as described in Maryland's Watershed Implementation Plan. The TMDL is an aggregate of nonpoint sources or the load allocation (LA), and point sources or WLA, and a margin of safety. The State is required to issue NPDES permits to point source discharges that are consistent with the assumptions of any applicable TMDL, including those approved subsequent to permit issuance.

Urban stormwater is defined in the CWA as a point source discharge and will subsequently be a part of Maryland's WLA. The NPDES stormwater permits can play a significant role in regulating pollutants from Maryland's urban sector and in the development of Chesapeake Bay Watershed Implementation Plans. Therefore, Maryland's NPDES stormwater permits issued to Howard County and other municipalities will require coordination with MDE's Watershed Implementation Plan and be used as the regulatory backbone for controlling urban pollutants toward meeting the Chesapeake Bay TMDL by 2025.

The strategies and plans included in this CIS establish the steps that Howard County is taking to fulfill its new MS4 permit requirements.

1.1.2 MS4 Permit Coverage

MDE considers the MS4 Permit for Howard County to be the entire county with the exception of lands which have their own NPDES stormwater permits (Figure 1) including federal lands, state highway lands, and other state lands. NPDES regulated industrial facilities are also excluded from the County's permit coverage. MDE notes that the inclusion of private and non-urban land in the MS4 permit is based on the rationale that stormwater management for private property in Maryland is locally administered for plan approval, inspection, and enforcement, and that these facilities are inherently a part of a locality's storm drain system. The County's SW-WLA responsibilities are only for those areas included in the MS4 area.

It is important to note that the vast majority of lands in the MS4 area are privately owned residential units (as shown in Table 6 of Section 2.2.1 Land Use/Land Cover). Approximately one-half of these residential units are single family detached units with the remainder evenly split between single family attached (townhouses) and apartments. An increase of about one-third in residential units is projected by 2030 (Howard County, 2012a). The large magnitude of land not within the County's control greatly increases the difficulty of meeting the impervious acre and TMDL targets. Further, it is imperative that this CIS address advocacy of best management practices (BMPs) on private residential properties to meet impervious cover treatment and TMDL pollutant load reduction targets. The cooperation of all private property owners will be an important factor in the County meeting these targets.

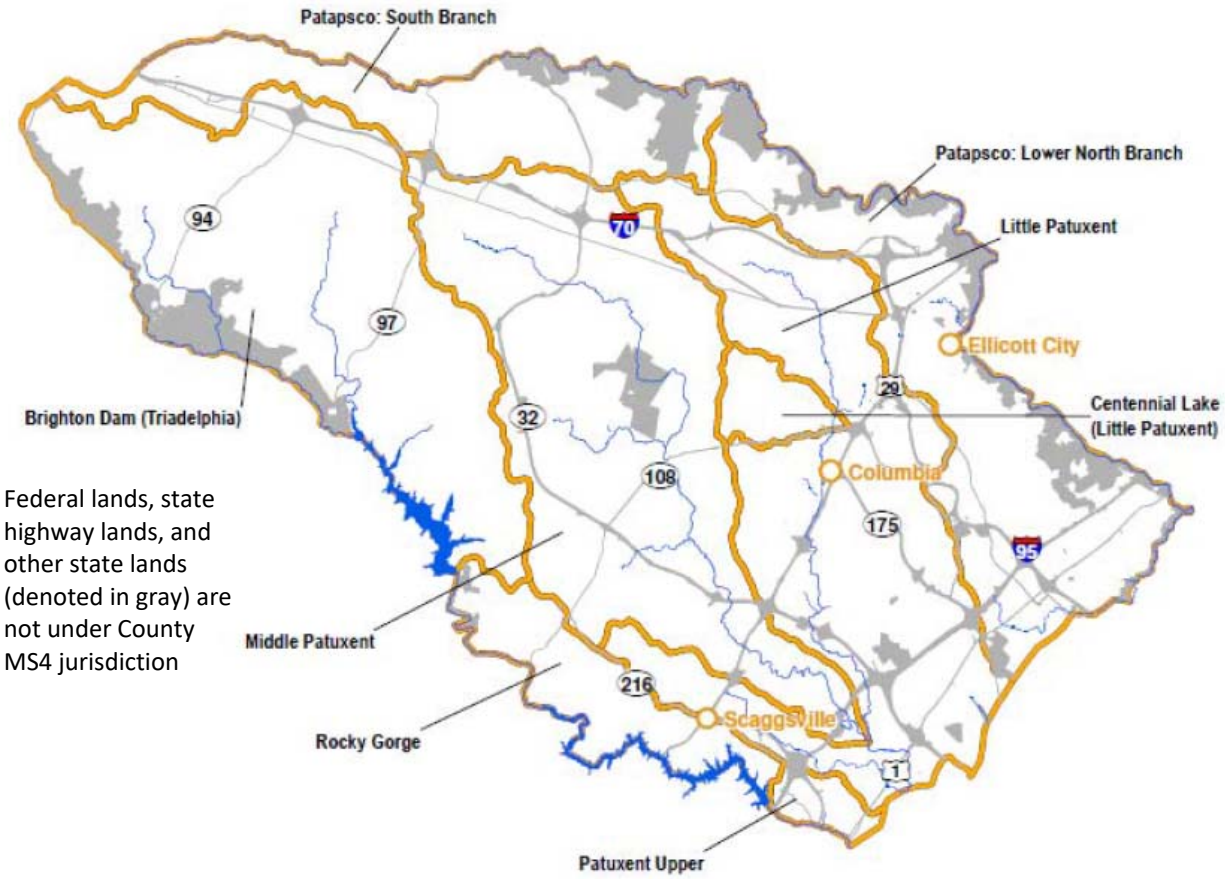


Figure 1. County Watershed and MS4 Permit Area

1.2 TMDL Allocations and Impervious Restoration Targets

1.2.1 Local TMDLs

Under the Federal Clean Water Act (CWA), the State of Maryland is required to assess and report on the quality of waters throughout the state. Where Maryland's water quality standards are not fully met, Section 303(d) of the CWA requires the state to list these water bodies as impaired waters. States are then required to estimate the maximum allowable pollutant load, or TMDL, that the listed water body can receive and still meet water quality standards.

Howard County has several watersheds where an EPA-approved quantitative assessment study (the TMDL) has established pollutant loading limits for waterbodies. These loading limits represent a maximum amount of a pollutant that the water body can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant (e.g., point sources or nonpoint sources). Pollutant loads from point and nonpoint sources must be reduced by implementing a variety of control measures. Responsibility for TMDL reductions is divided among various contributing jurisdictions within the area draining to the water body. The TMDL loading targets, or allocations, are also divided among the pollution source categories, which in this case includes non-point sources (termed load allocation or LA) and point sources (termed waste load allocation or WLA). The WLA consists of loads attributable to regulated process water or wastewater treatment and to regulated stormwater. For the purposes of the TMDL and consistent with implementation of the NPDES MS4 permit, stormwater runoff from MS4 areas is considered a point source contribution.

As a requirement of section PART IV.E.2.b of the NPDES MS4 Discharge Permit issued by MDE to Howard County, the County must develop restoration plans for each SW-WLA that were approved by EPA prior to the effective date of the permit. This applies to all current local TMDLs as well as any new TMDLs approved by EPA during the permit period. Such new TMDLs could be developed for any watersheds in the County that have listed water quality impairments as shown in Table 1. Several County TMDL watersheds fall within neighboring counties; however, SW-WLAs assigned to jurisdictions outside of Howard County's Phase I MS4, which may also include, Phase II jurisdictions, Maryland State Highway Administration, and other NPDES regulated stormwater are not the responsibility of Howard County and are not addressed in the CIS.

The following describes TMDLs that are not addressed in the CIS:

- Approved TMDL (September 19, 2017) for polychlorinated biphenyls (PCBs) in the Patuxent River. This TMDL will have a separate plan developed in 2018.
- Centennial Lake sediment and phosphorus TMDLs (approved April 2002) do not have SW-WLAs assigned to the Howard County MS4 source sector.
- Lower segment of the Patuxent River Upper bacteria TMDL (approved August 2011) does not have a SW-WLA assigned to the Howard County MS4 source sector.
- Triadelphia Reservoir sediment TMDL (approved November 2008), which does have a SW-WLA for Howard County Phase I MS4, requires a 0% reduction in baseline sediment loads with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008).
- Patuxent River Upper (Cash Lake) mercury TMDL (approved March 2011), which is listed in Attachment B of the County's current permit, is located wholly within Prince George's County, therefore Howard County is not responsible for this TMDL.

- South Branch Patapsco does not have a local TMDL, but it is included in the analysis since it, with the Patapsco River Lower North Branch, makes up the Baltimore Harbor watershed.
- The Middle Patuxent watershed does not have a TMDL.

The following statuses shown in Table 1 correspond to the following categories used by MDE to describe water quality impairment listings (MDE, 2015a):

- WQA – Category 2; waters meeting the standards for which they have been assessed based on a completed Water Quality Assessment (WQA)
- Insufficient data – Category 3; waters that have insufficient data or information to determine whether any water quality standard is being attained
- TMDL developed – Category 4a; waters that are still impaired by have a TMDL developed that establishes pollutant loading limits designed to bring the water body back into compliance.
- Impaired – Category 5; water bodies that may require a TMDL

Table 1. MDE Water Quality Impairment Listings and Status for Howard County

Impairment	Applicable Segment	Status	Approval Date
PCB in fish Tissue	Patapsco LNB	Insufficient data	
Chlorides	Patapsco LNB	Impaired	
Sulfates	Patapsco LNB	Impaired	
Heavy Metals	Patapsco LNB	WQA	January 2005
Phosphorus	Patapsco LNB	WQA	September 2009
Escherichia coli	**Patapsco LNB**	**TMDL developed**	**December 2009**
Sediment	**Patapsco LNB**	**TMDL developed**	**September 2009**
Escherichia coli	S Branch Patapsco	Insufficient data	
Biological	S Branch Patapsco	Impaired	
Nitrogen/Phosphorus	**Baltimore Harbor**	**TMDL developed**	**December 2007**
Chlorides	Little Patuxent	Impaired	
Escherichia coli	Little Patuxent	Insufficient data	
Phosphorus	Little Patuxent	WQA	March 2010
Cadmium	Little Patuxent	WQA	July 2009
Sediment	**Little Patuxent**	**TMDL developed**	**September 2011**
Sediment	Little Patuxent-Centennial	TMDL completed	April 2002
Phosphorus	Little Patuxent-Centennial	TMDL completed	April 2002
Sediment	Middle Patuxent	WQA	December 2010
Zinc	Middle Patuxent	WQA	July 2009
Nitrogen/Phosphorus	Middle Patuxent	WQA	February 2007
Nitrogen/Phosphorus	Patuxent R. Upper	WQA	February 2007
PCB	**Patuxent R. meso and oligohaline**	**TMDL developed**	**September 2017**
Escherichia coli	Patuxent R. Upper - lower segment	TMDL completed	August 2011
Escherichia coli	Patuxent R. Upper - upper segment	Insufficient data	
Sediment	**Patuxent R. Upper**	**TMDL developed**	**September 2011**
Biological	Patuxent R. Upper	Impaired	
Phosphorus	**Patuxent R. Upper – Brighton**	**TMDL developed**	**November 2008**
Sediment	**Patuxent R. Upper – Brighton**	**TMDL developed**	**November 2008**

Impairment	Applicable Segment	Status	Approval Date
Biological	Patuxent R. Upper – Rocky Gorge	Impaired	
Mercury	Patuxent R. Upper – Rocky Gorge	Impaired	
Phosphorus	**Patuxent R. Upper – Rocky Gorge**	**TMDL developed**	**November 2008**

Final approved TMDLs within Howard County with either an individual or aggregate SW-WLA, shown in bold text
Source: Maryland's Final 2014 Integrated Report of Surface Water Quality (MDE, 2015a)

There are currently eight final approved TMDLs within Howard County with either an individual or aggregate SW-WLA, shown in bold text in Table 1 above and also shown in Figure 2. Although there are sediment and phosphorus TMDLs completed for Centennial Lake (approved April 2002) and a bacteria TMDL completed for the lower segment of the Patuxent River Upper (approved August 2011), they do not have SW-WLAs assigned to the Howard County MS4 source sector and are therefore not included in the CIS.

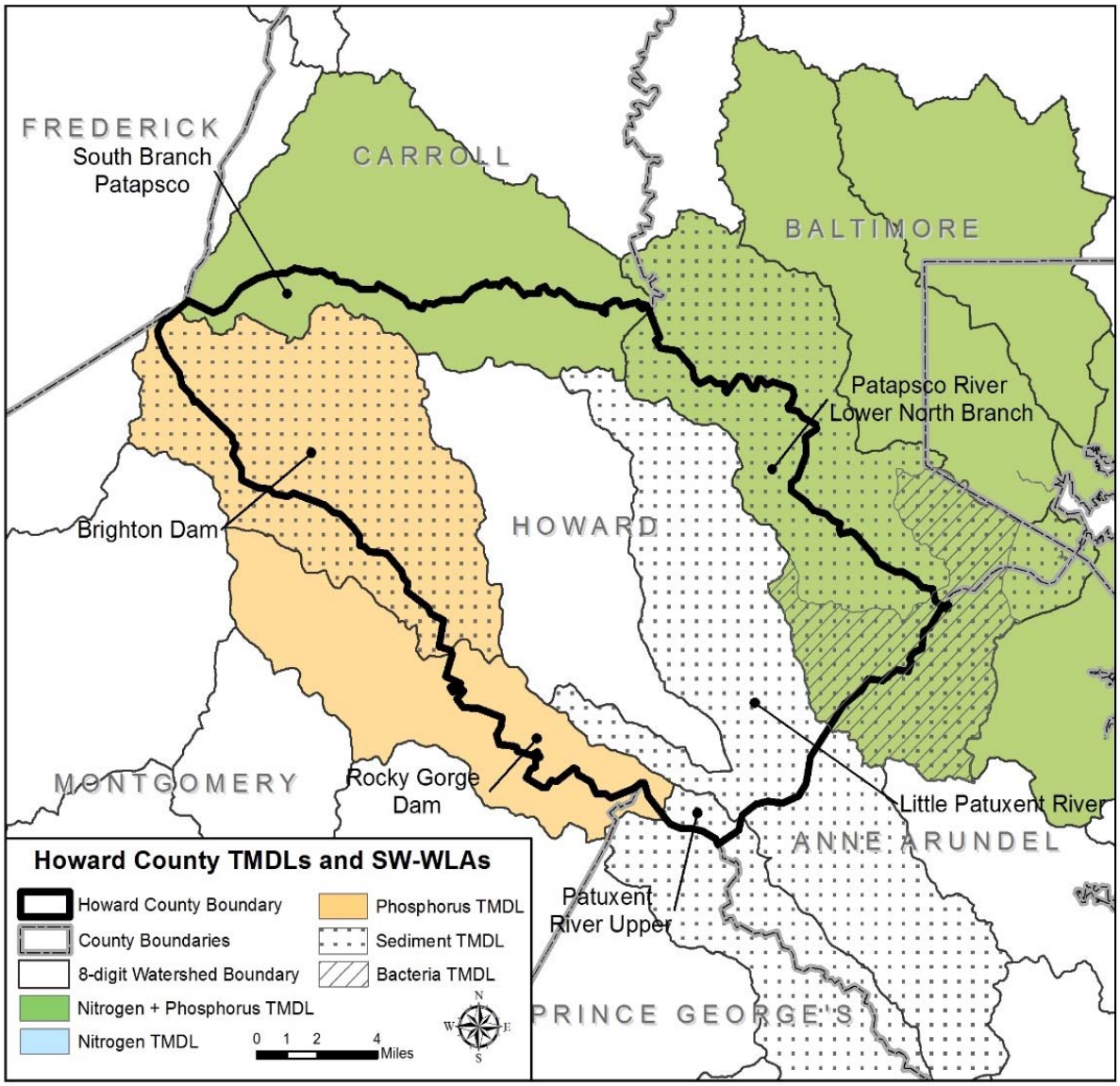


Figure 2. Howard County Local TMDLs with SW-WLAs

This CIS only addresses loads allocated to Howard County NPDES regulated stormwater point source. Howard County local TMDLs with SW-WLAs assigned to the County MS4 are listed in Table 3. It is important to note that the Triadelphia Reservoir (Brighton Dam) sediment TMDL requires 0% reduction with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008). Therefore, the Triadelphia Reservoir sediment local TMDL is not addressed further in the CIS. Additional SW-WLAs assigned to Maryland State Highway Administration and other NPDES regulated stormwater are not the responsibility of Howard County and will not be addressed in this plan.

All nutrient (i.e., total nitrogen [TN] or total phosphorus [TP]) and total suspended solids (TSS), or sediment, local TMDL SW-WLAs are for edge of stream annual loads (EOS-lbs/yr). An EOS load is the amount of a pollutant load that is transported from a source to the nearest stream annually.

Reduction Target Derivation

In order to derive the County MS4-specific SW-WLA load reduction targets, MDE's published baseline values for each TMDL need to be *disaggregated* and *calibrated* before the percent reduction is applied to calculate the load reduction required. There two procedures are described here in summary form, and in more detail in Appendix 1, followed by a more detailed description of how the methods were applied to the various watersheds.

Disaggregation

Some SW-WLAs are developed by MDE as an aggregate load including load contributions from multiple jurisdictions. Aggregate values must be first disaggregated to determine the portion of the load that each jurisdiction is responsible for. To date, Howard County has six aggregate SW-WLAs and three individual SW-WLAs (refer to Appendix 1 for the full listing). There are two methods used in the CIS for disaggregating loads; the first method uses the proportion of County urban land to total urban land in the watershed to partition out the County's baseline load, and the second method uses the BayFAST (Bay Facility Assessment Scenario Tool) model to calculate the baseline load.

Calibration

Howard County's TMDLs were developed by MDE at different periods in time using a variety of models. In order to use current models such as MAST (Maryland Assessment Scenario Tool), which is based on the current version of the Chesapeake Bay Model (v5.3.2), for analysis of load reductions, the baseline load needs to be translated or "calibrated" from the model used to develop the TMDL to the current model. According to the MDE guidance document *Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs* (MDE, 2014b), Section I, baseline nutrient and sediment loads and SW-WLAs must be calibrated to the model used to calculate load reductions:

Because all of Maryland's approved local nutrient and sediment TMDLs were developed using watershed models other than MAST [Maryland Assessment Scenario Tool], the baseline and target loads from these TMDLs need to be translated into MAST loadings. This adjustment is required to account for potential differences between models. This is a two-step process that involves 1) creating a MAST scenario that replicates the baseline year of the TMDL, and 2) applying the load reduction percentage from the TMDL to the MAST loading for the baseline year.

Bacteria Baseline Loads and SW-WLAs

Unlike TMDLs for nutrients and sediment, MDE's bacteria TMDLs were not prepared using a watershed model. All loads discussed in the bacteria TMDLs are based on monitoring in the impaired waterbody. Fate and transport from the watershed are not accounted for, including the quantity of bacteria from various sources in the watershed, die-off (or growth) in transit to the waterbody, potential sequestering and resuspension from bottom sediments, or other factors. For this analysis, all loads and load reductions have been calculated based on the delivered loads reported in the TMDL.

For the Patapsco Lower North Branch TMDL (MDE, 2009a), MDE has included Bacterial Source Tracking (BST), to estimate the source of the bacteria by matching DNA or RNA with a library of samples from known species. BST has been used to categorize the fraction of bacteria coming from four general sources: humans, domestic pets, wildlife, or livestock. It is important to note that BST is performed on samples from the impaired waterbody, and thus the estimate of the fraction from each source is for the watershed as a whole, not from particular locations, jurisdictions, or permittees.

Table 4.9.1 (MDE, 2009a) shows that the only sources for the SW-WLA regulated by the County's MS4 permit are domestic pets and urban wildlife. All human and livestock sources are considered to be part of the unregulated load allocation (LA). The TMDL does not call for any bacteria reductions from urban wildlife. For these reasons, the County's TMDL analysis and required reductions only focus on domestic pet sources.

In section 4.7, the TMDL discusses two scenarios: the Maximum Practicable Reduction (MPR) and the target reduction. MPR is based on reductions for each of the four source categories. Human sources potentially have the highest risk of causing disease, so the maximum reduction was set at 95%. The domestic pet reduction was based on an estimated success of education and outreach programs, set at 75%. The livestock target, also 75%, was based on the level of sediment reductions from agricultural BMPs. Wildlife reductions were assumed to be 0%.

The target reduction is based on MDE's requirement to determine a TMDL which will meet water quality standards. This analysis removed the practicality constraints, with a maximum allowable reduction of 98% for all sources. The resulting reduction requirements were higher than the MPR in one subwatershed for Patapsco Lower North Branch.

In the TMDL documents, MDE has recognized that "…the goal of meeting water quality standards may require very high reductions that are not achievable with current technologies and management practices. … In cases where such high reductions are required to meet standards, it is expected that the first stage of implementation will be to carry out the MPR scenario." (MDE, 2009a). For this reason, the County has chosen to meet the MPR in the CIS. Appendix 1 shows the calculations made to determine the MPR.

The TMDL is spatially broken down into five subwatersheds of the Patapsco Lower North Branch watershed based on the locations of five monitoring stations used to measure bacteria levels along the Patapsco River. Water monitoring results from the most upstream subwatershed (PAT0347) did not meet bacteria standards. BST analysis showed that the only source for PAT0347 that required a TMDL was human loads, which come from wastewater and septic systems and are not included in the SW-WLA. Because the loads are part of the wastewater sector, they do not need to be addressed as part of MS4 permit compliance. The three monitoring stations located in the middle of the watershed (PAT0285sub, PAT0222sub, and PAT0176sub) were found to be meeting water quality bacteria criteria

and therefore no TMDL was assigned and no reductions are required. The most downstream subwatershed (PAT0148) did not meet standards. As described above, the sources for PAT0148sub with a TMDL were domestic, human, and livestock. Of these three, only the domestic loads are part of the MS4 sector and are subject to this permit.

Based on the subwatershed scale structure of the TMDL, and per MDE's comments on the County's Draft CIS, Howard County's SW-WLA requirements for the stormwater sector under their MS4 NPDES permit only requires improvements in one subwatershed: PAT0148sub. This subwatershed is located in Howard, Anne Arundel, and Baltimore Counties and in Baltimore City (Figure 3). In addition there are other major landowners that do not fall under the County's MS4 jurisdiction including State Highway Administration (SHA), state properties including state park areas, and industrial properties with their own separate NPDES permits. In order to determine Howard County's specific responsibility, watershed loads must be disaggregated from the areas under other jurisdiction to estimate the load generated in the area served only by the County's MS4. This has been performed with a spatial analysis according to the procedure published by MDE (MDE 2015b). The spatial analysis included the following steps:

- Digitize subwatershed boundary.
- Intersect subwatershed with county boundaries and determine Howard County area.
- Determine that the County's land area is 100% urban and subject to the MS4 permit.
- Intersect County portion of subwatershed with permittee jurisdiction
- Multiply County MS4 percent of watershed against MPR required reduction

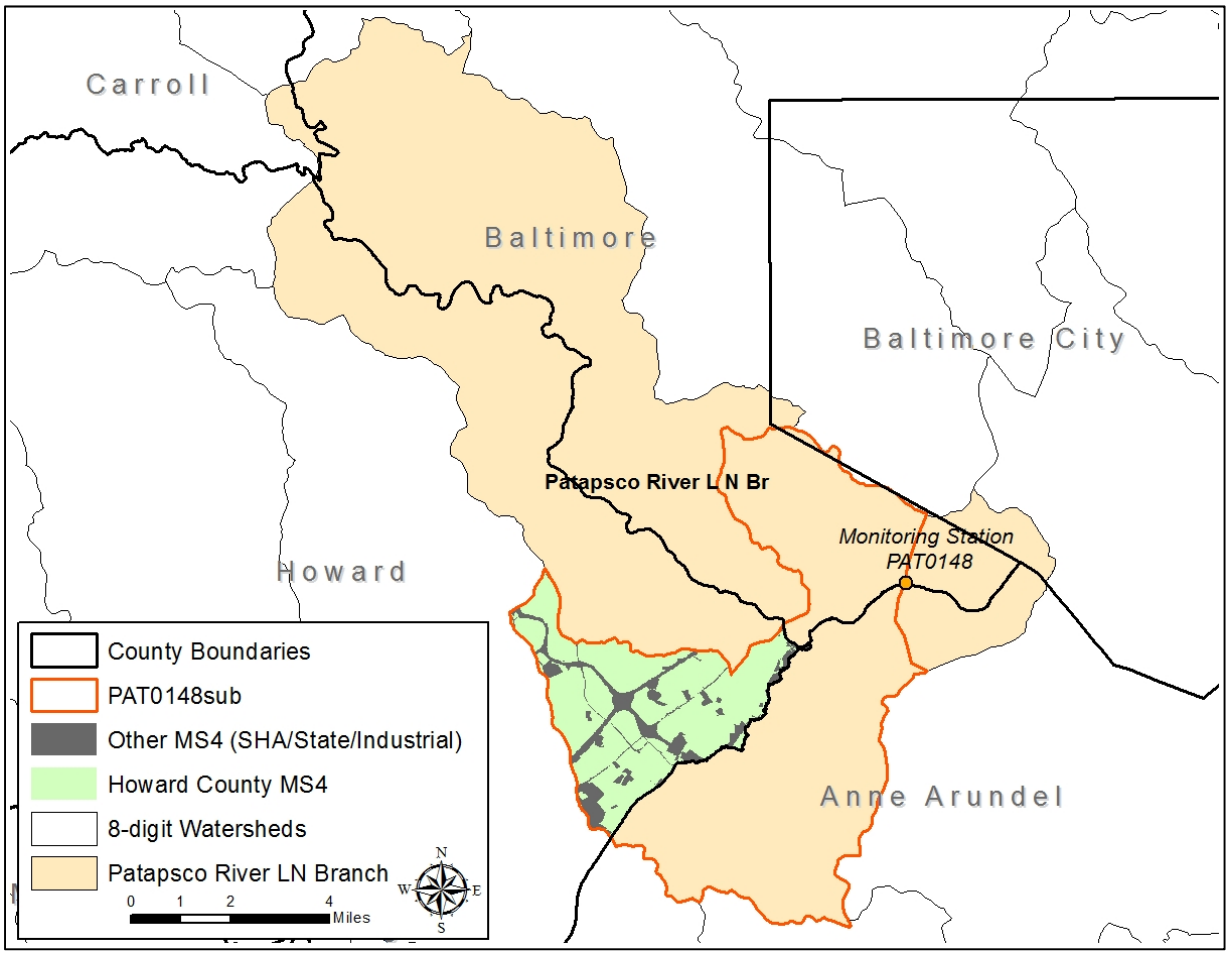


Figure 3. Subwatershed PAT0148sub used for Patapsco River Lower North Branch Bacteria Local TMDL

Based on the analysis, Howard County's MS4 makes up 24.3% of the PAT0148sub subwatershed (Table 2). The total subwatershed area is 42.60 sq mi. Of that, 12.56 sq mi is within the County's boundaries. 2.21 sq mi is land that is not under the County's MS4 jurisdiction, which leaves 10.35 sq mi, or 24.3% of the subwatershed subject to the MS4 permit.

The domestic source baseline load, TMDL target load, and required reduction calculated from MDE 2009a were disaggregated using the Countys 24.3% responsibility to give a required reduction of 16,370 billion MPN/yr.

Table 2. Spatial Analysis for Howard County MS4 Bacterial TMDL Disaggregation

PAT0148sub	Total	AA+BC+BA	HO	Non-MS4	HO MS4
(sq mi)	42.60	30.04	12.56	2.21	10.35
(%)	100.0%	70.5%	29.5%	5.2%	24.3%
Baseline	89,836	63,349	26,487	4,661	21,826
TMDL	22,459	15,837	6,622	1,165	5,457
Required Reduction	67,377	47,512	19,865	3,495	**16,370**

The load reduction calculated from disaggregating the bacteria SW-WLA following MDE Guidance stated above is the target for the Patapsco River Lower North Branch bacteria local TMDL. This value is presented in bold in Table 2.

More detailed comparison of the results of the disaggregation and calibration process per watershed is included in Appendix 1.

Disaggregating and Calibrating Nutrient and Sediment Baseline Loads and SW-WLAs

Local TMDL baseline loads for nutrients and sediments were disaggregated and calibrated in BayFAST (Bay Facility Assessment Scenario Tool). BayFAST allows users to specify the watershed and jurisdiction to model; therefore the results include only Howard County MS4 baseline loads and do not include other municipalities. The results then represent the disaggregated portion of the baseline load.

The baseline model includes County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. BayFAST functions similarly to (MAST); which is described further in Section 3.2: Modeling Approach of this plan, however BayFAST allows users to delineate facility boundaries (e.g., watershed, parcel, drainage area) and alter land use information within the delineated boundary depending on the model year. A table displaying Howard County nutrient and sediment local TMDLs with baseline loads and SW-WLAs calibrated to BayFAST is included in Appendix 1. The general calibration procedure is as follows:

1. For each local TMDL, a facility boundary for the 8-digit TMDL watershed within Howard County borders was delineated within BayFAST.
2. All default land use acreages were deleted and regulated pervious and impervious acres were replaced with MAST Local Base County Phase I MS4 urban pervious and impervious acres using the Compare Scenario tool in MAST for the respective baseline year for each local TMDL. This approach inherently disaggregates County MS4 loads from the rest of the NPDES regulated area within the watershed.
3. County BMPs installed prior to the TMDL baseline year were then added to the model.
4. The reduction percentage published in the TMDL document was then applied to the calibrated baseline loads modeled in BayFAST to calculate a calibrated reduction in EOS-lbs/yr.
5. A calibrated SW-WLA was calculated by subtracting the calibrated reduction from the BayFAST baseline load.

Calibrated load reductions calculated based on TMDL percent reductions and baseline loads modeled in BayFAST using Howard County Phase I MS4 baseline pervious and impervious land use and baseline treatment are the target reductions used in the CIS for nutrient and sediment local TMDLs. These values are presented in bold in Table 3.

More detailed comparison of the results of the disaggregation and calibration process per watershed is included in Appendix 1.

Table 3. Disaggregated and Calibrated Local TMDL SW-WLAs and Load Reductions

Watershed Name	Watershed Number	Baseline Year	Pollutant	Unit	Reduction %[1]	Baseline Loads[2]	Load Reductions[3]	WLA[4]
Patapsco River Lower North Branch	02130906	2005	Sediment	EOS-lbs/yr	10%	6,123,442	**612,344**	5,511,098
		2003	Bacteria	Billion MPN/yr	75%	21,826	**16,370**	5,457
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906	1995	Nitrogen	EOS-lbs/yr	15%	81,058	**16,059**	91,000
	02130908					26,001		
	02130906	1995	Phosphorus	EOS-lbs/yr	15%	5,530	**982**	5,564
	02130908					1,016		
Patuxent River Upper	02131104	2005	Sediment	EOS-lbs/yr	11.40%	145,902	**16,633**	129,269
Little Patuxent River	02131105	2005	Sediment	EOS-lbs/yr	48.10%	10,346,821	**4,976,821**	5,370,000
Rocky Gorge Reservoir	02131107	2000	Phosphorus	EOS-lbs/yr	15%	861	**129**	732
Triadelphia Reservoir (Brighton Dam)[5]	02131108	2000	Phosphorus	EOS-lbs/yr	15%	2,654	**398**	2,256
		2000	Sediment	EOS-lbs/yr	0%	1,844,103	**0**	1,844,103

Target load reductions used in the CIS shown in bold text.

1) Nutrient and Sediment Local TMDLs: Published Reduction % from the MDE TMDL Data Center SW-WLAs for County Storm Sewer Systems in Howard County. Bacteria Local TMDL: Reduction % is based on required reduction from Domestic sources in the PAT0148sub subwatershed.
2) Nutrient and Sediment Local TMDLs: Baseline loads modeled in BayFAST using County BMPs installed prior to the TMDL baseline year on top of baseline land use background load. Additional load reductions from Howard County lakes installed prior to the baseline year and rooftop/non-rooftop disconnects were included outside of BayFAST. Bacteria Local TMDL: Disaggregated baseline loads were calculated by multiplying the MDE published aggregate WLA for Domestic sources by the percentage of Howard County MS4 land within the urban NPDES land area of the PAT0148sub subwatershed.
3) Nutrient and Sediment Local TMDLs: Calibrated reductions calculated by applying the MDE published percent reduction to the BayFAST calibrated baseline loads. Bacteria Local TMDL: Disaggregated load reductions were calculated from the disaggregate WLA and reduction % using the following equation: (Disaggregated WLA / (1 - Reduction %)) - Disaggregated WLA
4) Nutrient and Sediment Local TMDLs: Calibrated WLAs calculated by subtracting the calibrated reduction from the BayFAST calibrated baseline load. Bacteria Local TMDL: Disaggregated WLAs were calculated by multiplying MDE published aggregate WLA for Domestic sources by the percentage of Howard County MS4 land within the urban NPDES land area of the PAT0148sub subwatershed.
5) The Triadelphia Reservoir (Brighton Dam) sediment TMDL requires 0% reduction with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008). Therefore, the Triadelphia Reservoir sediment local TMDL is not addressed further in the CIS.
6) See Appendix 1 for more detailed information on the disaggregation of aggregate SW-WLAs and calibration of nutrient and sediment SW-WLAs.

1.2.2 Chesapeake Bay TMDL

The Chesapeake Bay TMDL, established by the EPA (EPA, 2010), sets pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. Total limits set in the Bay TMDL for the states of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia are "185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year—a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment" (EPA, 2010). The TMDL also sets "rigorous accountability measures" for state compliance.

The County's MS4 permit is requiring compliance with the Chesapeake Bay TMDL through the use of the 20% impervious surface treatment strategy, as described in greater detail in the following section. 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.

Table 4 provides a concise summary of Howard County's portions of target edge of stream (EOS) and delivered (DEL) reductions towards the Chesapeake Bay TMDL and 2010 baseline and 2025 allocated loads. These terms and dates are used throughout the plan and explained in more detail in the following sections. They are presented here to assist the reader in understanding the definitions of each, how they were derived, and to provide an overall summary demonstrating the percent reduction required through full implementation of this plan. Planned loads and percent reduction achieved through this plan are discussed in Section 4: Expected Load Reductions and Impervious Treatment.

- **TN, TP, TSS:** Total Nitrogen, Total Phosphorus, Total Suspended Sediment. As specified in the Bay TMDL, if the phosphorus target is met, the sediment target will be met.
- **EOS lbs/yr and DEL lbs/yr:** An EOS load is the amount of a pollutant load that is transported from a source to the nearest stream annually while a DEL load is the amount of a pollutant load that is transported to the tidal waters of the Chesapeake Bay annually. DEL loads are generally less than EOS loads due to losses during transport from streams to the Bay.
- **Calibrated 2010 Baseline Load**: Baseline levels (i.e., land use loads with baseline BMPs) from 2010 conditions in the Howard County MS4 source sector using the Maryland Assessment Scenario Tool (MAST) Chesapeake Bay Program Phase 5.3.2 (CBP P5.3.2) model. Baseline loads were used to calibrate the Bay TMDL nitrogen and phosphorus SW-WLAs.
- **Target Percent Reduction**: Percent reductions assigned to Howard County Phase I MS4 stormwater sector (http://wlat.mde.state.md.us/ByMS4.aspx). If TP target is met, TSS target will be met.
- **Calibrated Target Reduction:** Target reduction calibrated to MAST CBP v.5.3.2 by multiplying the reduction percent published by the 2010 baseline load. If TP target is met, TSS target will be met.
- **Calibrated TMDL WLA**: Allocated loads are calculated from the 2010 baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: 2010 Baseline – (2010 Baseline x Target Percent Reduction); or, 2010 Baseline x (1 – Target Percent Reduction).

Table 4. Howard County Chesapeake Bay TMDL Baseline and Target Loads

Baseline and Target	TN-EOS lbs/yr	TN-DEL lbs/yr	TP-EOS lbs/yr	TP-DEL lbs/yr	TSS-EOS lbs/yr	TSS-DEL lbs/yr
Calibrated 2010 Baseline Load	566,350	319,997	27,609	14,300	26,344,338	20,262,457
Target Percent Reduction	11.98%	12.00%	20.72%	19.74%	-	-
Calibrated Target Reduction	67,849	38,400	5,721	2,823	-	-
Calibrated Bay TMDL WLA	498,501	281,597	21,889	11,477	-	-

1.2.3 Impervious Restoration

As a requirement of section PART IV.E.2.a of the NPDES MS4 Discharge Permit issued by MDE to Howard County, the County must conduct an impervious area assessment to define the restoration efforts required under the permit to restore 20% of remaining Countywide baseline impervious acres not already restored to the MEP. The restoration is required to be complete by 2019, the end of the current permit term.

The first step in this process is to determine the County's MS4 area of jurisdiction and the baseline impervious surface area that is treated, untreated, and partially treated. The County's GIS 2002 planimetric impervious layer was used as the basis for the analysis. Based on Maryland Stormwater regulations, development occurring after 2002 included requirements for treating the full water quality volume (WQv), therefore impervious surfaces developed after 2002 are considered fully treated and can be extracted from the analysis. Using this layer in combination with limited treatment from BMPs existing in 2002 that also can be credited with WQv treatment, the amount of untreated impervious surfaces was obtained and the 20% then applied. Existing BMPs include structural stormwater BMPs and other treatment including rooftop and non-rooftop impervious surface disconnects, septic system upgrades, and rain barrels.

Impervious restoration conducted after the expiration date of the previous permit term are considered restoration credit for the current permit term. Therefore, restoration projects implemented following June 20, 2010 are considered restoration and restoration projects implemented before June 20, 2010 are credited to the baseline.

Impervious accounting methodology and results are provided in Appendix 2 with results at the watershed and County scale presented in Table 5. Howard County submitted the report (*Howard County Impervious Accounting: Methods and Results*) to MDE with the FY16 annual report in December of 2016 to detail the process and baseline results. MDE reviewed the document and provided their comment and an approved baseline. Appendix 2 details the County's original methods, the items approved by MDE and the final results. It is noted that due to minor discrepancies and likely rounding issues, MDE's baseline untreated value of 12,299.2 is slightly different from the County's 12,281.7. The County is using the MDE value for developing the 20% restoration target (Table 5).

Note that although there are no required restoration targets at the watershed scale, some calculations are made at that level to assist in planning and targeting restoration practices to areas with the greatest need.

Table 5. Impervious Accounting Results per Watershed

	Brighton Dam	Little Patuxent River	Middle Patuxent River	Patapsco River L N Br	Patuxent River Upper	Rocky Gorge Dam	South Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
Total Impervious Area[1]	**1,511.9**	**8,145.6**	**2,953.9**	**3,611.2**	**372.6**	**471.0**	**661.8**	**17,728.0**
County MS4 Impervious Area	**1,378.5**	**7,080.1**	**2,506.9**	**2,971.4**	**311.0**	**426.2**	**552.2**	**15,226.4**
1985 - 2002 Stormwater BMPs	43.6	659.5	228.2	436.5	64.6	21.0	9.0	1,462.5
New Development	*18.8*	*458.5*	*181.6*	*357.2*	*63.6*	*19.8*	*7.4*	*1,106.8*
Redevelopment	*23.8*	*195.6*	*27.8*	*64.7*	*1.0*	*0.6*	*0.0*	*313.5*
Restoration	*1.0*	*5.5*	*18.8*	*14.6*	*0.0*	*0.6*	*1.7*	*42.2*
2002 - 6/20/2010 Stormwater BMPs[2]	10.2	175.9	102.3	69.0	1.1	9.4	39.2	407.1
New Development	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Redevelopment	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Restoration before 6/21/2010	*10.2*	*175.9*	*102.3*	*69.0*	*1.1*	*9.4*	*39.2*	*407.1*
Rooftop Disconnect	55.7	163.5	64.7	44.7	5.5	12.9	20.7	367.5
Non-Rooftop Disconnect	176.2	147.8	168.5	88.6	7.8	42.7	75.7	707.3
Rain Barrels	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2
Impervious Baseline Treated	**285.7**	**1,146.8**	**563.7**	**638.8**	**79.0**	**86.0**	**144.6**	**2,944.7**
Impervious Baseline Untreated	**1,092.7**	**5,933.3**	**1,943.2**	**2,332.6**	**232.0**	**340.2**	**407.6**	**12,281.7**
MDE Approved Values								
MDE Approved Baseline								**12,299.2**
20% Restoration Target[3]								**2,459.8**

1) Howard County's GIS 2002 planimetric impervious layer was used as the basis for the impervious accounting
2) Impervious restoration conducted after the expiration date of the previous permit term are considered restoration credit for the current permit term. Restoration projects implemented before June 20, 2010 are credited to the baseline.
3) Baseline and 20% target are MDE's approved values and differ slightly from those calculated by the County.

1.2.3.1 Alternative Impervious Reduction Strategies

Howard County is currently researching and / or conducting the following opportunities which may contribute to a better understanding of the County's existing impervious surface responsibilities and existing treatment practices and programs that will support a more accurate recalculation of the County's impervious baseline in year four (2018) of the current MS4 permit term. Results of these efforts will be reported on in annual report 23 in December 2018, if not sooner.

Revision of MS4 Area

The County is currently evaluating a revision to the MS4 area to specify more accurately the areas that drain to County stormwater infrastructure and are owned and operated by the County. Land draining to County stormwater systems including ditches, swales, inlets, stormwater BMPs etc. can be considered part of the MS4; however areas draining directly to receiving waters bypassing County systems may be excluded. Further, properties and systems that are not County owned; specifically, in developments constructed prior to 1980 in which drainage systems were not deeded over to the County would also be excluded. As stated in the definition of the MS4, the County is responsible for land that is "owned and maintained" by the County. As a result, depending on property ownership verification, the County may seek to remove these areas from the MS4.

Redevelopment Treatment

The County will determine and account for any County developments, projects, or roadways where redevelopment credits were included in the project.

Grass Swale Inventory

Existing grass swales provide treatment of water through side slope, horizontal slope, and flow depth parameters. The County is currently investigating swales that are captured on the shoulder and median of open section roadways. Swales and flows are initially identified using LiDAR and the prospective swale and treated drainage area are analyzed and confirmed by an H&H engineer. Confirmed swales are assessed in the field to confirm presence, location, bottom material, and side slope and depth via cross section.

Treatment Determination (Pre-1985 BMPs)

The County will start a pilot program using a subset of specific BMP types to determine treatment levels provided by existing stormwater BMPs built prior to 1985. The assumption is that many facilities such as dry detention ponds or extended detention ponds may in fact be treating sufficient volumes to be creditable facilities. Drainage area verification, plan research, and field inspection will be conducted to calculate the water quality volume (RS volume). Once the drainage area and RS volume are verified and calculated, the Pe can be computed. The County will analyze the results of the pilot to weigh the feasibility of the targeted approach in an effort to quantify additional existing treatment.

BMP Drainage Area POI

Howard County is currently transitioning its stormwater BMP management and accounting system to the point of investigation or POI framework. The method accounts for smaller dispersed BMPs built under MDE's Environmental Site Design (ESD) guidance as required by the Stormwater Management Act of 2007. The POI method accounts for nested BMPs and provides an accounting framework for impervious area treatment. Full implementation of the POI method will impact many County processes including delineation of BMP drainage areas, BMP inspections, impervious treatment and credit accounting, and even selection of future restoration sites. A pilot area consisting of approximately 650

BMPs was completed in 2017 and additional implementation is planned for 2018. Changes to drainage areas and impervious areas treated for BMPs existing pre-2002 in the baseline period will impact the County's baseline accounting and restoration target.

Treatment Provided by Inline Facilities

Howard County is piloting a study of inline water bodies or ponds to determine their feasibility to be upgraded to fully functional and creditable water quality treatment. The goal is to determine how closely the existing construction of the facilities meet current design criteria for stormwater management facilities and recommend potential improvements to close any gaps. If the facilities can be brought into compliance with existing design criteria, then the County will claim restoration credit against the impervious area restoration requirements.

Self-Converted Wetland Ponds

Baltimore County completed a study in 2016 demonstrating the pollutant removal capabilities of stormwater ponds that have transitioned over time to have wetland conditions within the facility (self-converted wetlands). These facilities were found to have removal efficiencies on par with wet ponds and shallow marsh type systems. Howard County is unsure currently if Baltimore County will pursue additional treatment credits for the ponds monitored in the study or if a modified BMP type 'self-converted wetland' will be developed. If modifications are made Howard County may determine the application of the method to its facilities.

Nutrient Credit Trading

If impervious surface restoration goals are not met by the end of the County's current permit, Howard County intends to use nutrient credit trading to maintain MS4 NPDES compliance. The trading program, as detailed in Chapter 11 of the Maryland Water Quality Trading Program (COMAR Title 26, Subtitle 08 Water Pollution) defines the programs and allows Howard County to trade wastewater sector nutrient reductions (TN and TP) at the Little Patuxent Water Reclamation Plant for impervious surface restoration. A more detailed description of the trading scenario is provided in sections 4 and 5 of this plan.

1.3 Restoration Plan Elements and Structure

This plan is developed within the context of on-going watershed management planning, restoration, and resource protection being conducted by Howard County. As of 2016, watershed assessments have been completed for the entire County, as shown in the bulleted list below. Information synthesized and incorporated into this plan draws upon the sources listed below with updates and additions where necessary to meet the specific goals of the SW-WLAs and impervious restoration goals. The TMDL analyses and reports developed by MDE are also referenced. These primary sources include:

- General watershed restoration assessments and strategies (WRASs) and stream corridor assessments (SCAs) for:
  - Little Patuxent (Howard County, 2002; MDNR, 2001)
  - Middle Patuxent (MDNR, 2002)
  - Lower Patapsco and Deep Run (Howard County 2006; MDNR, 2005)
  - Patuxent reservoirs (WSSC, 2012)

- Specific watershed plans with restoration projects:
  - Deep Run and Tiber-Hudson (U.S. Army Corps of Engineers, Baltimore District, 1999)

  - Cherry Creek (Howard County, 2002)
  - Centennial Lake and Wilde Lake in Little Patuxent (CWP and Tetra Tech, 2005)
  - Sucker Branch and Rockburn Branch in Lower Patapsco (CWP and Tetra Tech, 2006)
  - Downtown Columbia (Howard County, 2010)
  - Lake Elkhorn in Little Patuxent (Versar, Inc., 2009)
  - Upper Little Patuxent (KCI Technologies, Inc., 2009)
  - Tiber-Hudson Subwatershed Restoration Action Plan (CWP, 2013)
  - Little Patuxent (KCI Technologies, Inc., 2015; Versar, Inc., 2015)
  - Middle Patuxent (Versar, Inc., 2015; McCormick Taylor, 2015; BioHabitats, 2015)
  - Patapsco River – South Branch and Lower North Branch (KCI Technologies, Inc., 2016; Straughan Environmental, Inc., 2016; McCormick Taylor, 2016; BioHabitats, 2016)
  - Patuxent River – Brighton Dam, Rocky Gorge Dam, and Patuxent River Upper (KCI Technologies, Inc., 2016; Straughan Environmental, Inc., 2016; McCormick Taylor, 2016; BioHabitats, 2016)

- TMDL Documents:
  - Total Maximum Daily Loads of Nitrogen and Phosphorus for the Baltimore Harbor in Anne Arundel, Baltimore, Carroll and Howard Counties and Baltimore City, Maryland (MDE, 2006)
  - Total Maximum Daily Loads of Phosphorus and Sediments for Triadelphia Reservoir (Brighton Dam) and Total Maximum Daily Loads of Phosphorus for Rocky Gorge Reservoir, Howard, Montgomery, and Prince George's Counties, Maryland (MDE, 2008)
  - Total Maximum Daily Loads of Fecal Bacteria for the Patapsco River Lower North Branch Basin in Anne Arundel, Baltimore, Carroll, and Howard Counties, and Baltimore City, Maryland (MDE, 2009a)
  - Total Maximum Daily Load of Sediment in the Little Patuxent River Watershed, Howard and Anne Arundel Counties, Maryland (MDE, 2011a)
  - Total Maximum Daily Load of Sediment in the Patapsco River Lower North Branch Watershed, Baltimore City and Baltimore, Howard, Carroll and Anne Arundel Counties, Maryland (MDE, 2011b)
  - Total Maximum Daily Load of Sediment in the Patuxent River Upper Watershed, Anne Arundel, Howard and Prince George's Counties, Maryland (MDE, 2011c)

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

- General Guidance for Developing a Stormwater Wasteload Allocation (SW-WLA) Implementation Plan (MDE, October 2014)
- Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs (MDE, June 2014)
- Guidance for Developing Stormwater Wasteload Allocation Implementation Plans for Nutrient and Sediment Total Maximum Daily Loads (MDE, November 2014)
- Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads (MDE, May 2014)

- Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (MDE, August 2014)

The CIS has been prepared in general accordance with the EPA's nine essential elements for watershed planning. These elements, commonly called the "a through i criteria" are important for the creation of thorough, robust, and meaningful watershed plans and incorporation of these elements is of particular importance when seeking implementation funding.

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

a. An identification of the causes and sources that will need to be controlled to achieve the load reductions estimated in the plan and to achieve any other watershed goals identified in the plan, as discussed in item (b) immediately below. (Section 2)

b. An estimate of the load reductions and impervious treatment expected for the management measures described under paragraph (c) below, recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time. (Section 4)

c. A description of the management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above as well as to achieve other watershed goals identified in the plan, and an identification of the critical areas in which those measures will be needed to implement this plan. (Section 3)

d. An estimate of the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. (Section 5)

e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the recommended management measures. (Section 6)

f. A schedule for implementing the management measures identified in this plan that is reasonably expeditious. (Section 7)

g. A description of interim, measurable milestones for determining whether management measures or other control actions are being implemented. (Section 7)

h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised. (Section 8)

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above. (Section 9)

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

2 Causes and Sources of Impairment

2.1 Impairments

Sources of water quality impairments vary across the landscape. The most common impairments in the urban environment are nutrients (nitrogen and phosphorus), sediment, bacteria, and impairment to the biological condition of streams. Impairments can have different implications for management. Impairments that cause a water body to not meet its designated use require the responsible jurisdiction to address the impairment to enable that water body to meet its designated use once again. The mechanism for this in Maryland is through the development and implementation of TMDLs.

2.1.1 Water Quality

Use Designations

Use classes for Maryland streams are defined in the Code of Maryland Regulations (COMAR) 26.08.02.02. For each use class there are several designated uses. Use Class I has the following designated uses: growth and propagation of fish (not trout), other aquatic life and wildlife; water contact sports; leisure activities involving direct contact with surface water; fishing; agricultural water supply; and industrial water supply. Use Class II contains all of the designated uses of Use Class I with the addition of: propagation and harvesting of shellfish; seasonal migratory fish spawning and nursery use; seasonal shallow-water submerged aquatic vegetation use; open-water fish and shellfish use; and seasonal deep-channel refuge use. Use Class II refers to tidal waters, none of which are located within Howard County. Use Class III contains all of the designated uses of Use Class I with the addition of the growth and propagation of trout. Use Class IV contains all of the designated uses of Use Class I and is also capable of supporting adult trout for a put-and-take fishery. Use classes with the '-P' suffix contain all of the designated uses of the use class with the addition of public water supply. Therefore, Use Class III-P has the designated uses of Use Class I with the addition of growth and propagation of trout, and public water supply.

The spatial extent for stream and impoundment use classes is defined in COMAR 26.08.02.08. A map of stream and impoundment use class for Howard County is presented in Figure 4. Use Class I streams within Howard County are defined as: Patuxent River and tributaries not designated Use Class I-P, III, III-P, Iv, or IV-P; Patapsco River Lower North Branch not designated Use Class IV; and Patapsco River South Branch not designated Use Class III or Use Class IV. Use Class I-P streams within Howard County are Little Patuxent River and all tributaries Upstream of Old Forge Bridge except those designated as Use Class IV-P, and Patuxent River and all tributaries upstream of Rocky Gorge Dam except those designated as Use Class III-P or Use Class IV-P. There are no Use Class II streams in Howard County. Use Class III streams in Howard County are Patapsco River South Branch and all tributaries upstream of the confluence with Gillis Falls, unnamed tributary to South Branch Patapsco River at Henryton, and unnamed tributary to South Branch Patapsco River at Marriottsville. Use Class III-P streams in Howard County include Patuxent River and all tributaries upstream of Triadelphia Reservoir. Use Class IV streams in Howard County include Patapsco River Lower North Branch mainstem, and South Branch Patapsco River mainstem downstream of the confluence with Gillis Falls. Use Class IV-P streams in Howard County include Little Patuxent and Middle Patuxent Rivers and all tributaries upstream of U.S. Route 1, and Patuxent River and all tributaries between Rocky Gorge Reservoir and Triadelphia Reservoir including those flowing into Triadelphia Reservoir. All impoundments in Howard County (Centennial Lake, Lake Elkhorn, Lake Kittamaqundi, Triadelphia Reservoir, and Wilde Lake) are listed at Use Class IV-P with the exception of Rocky Gorge Reservoir which is Use Class I-P.

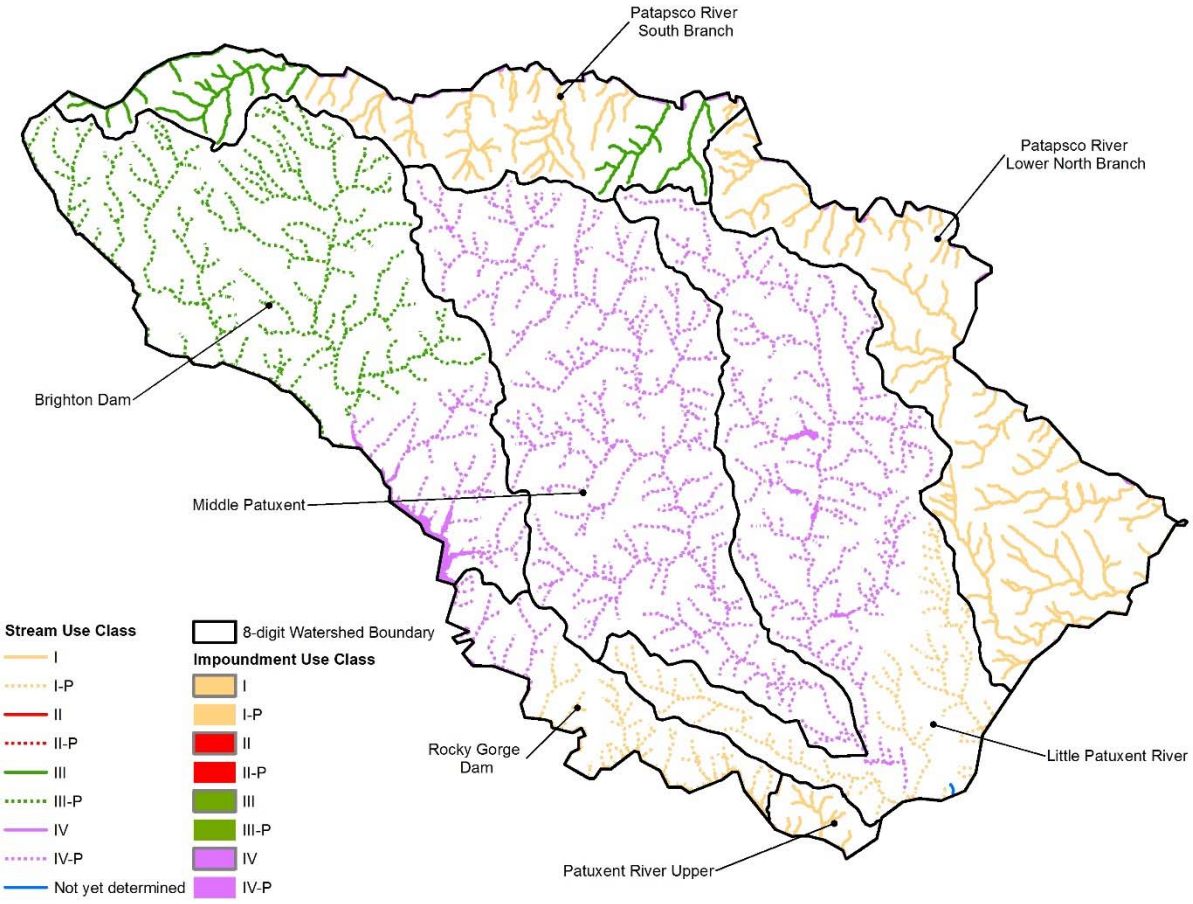


Figure 4. Howard County Stream and Impoundment Designated Use Classes

303(d) Impairments

According to Maryland's final 2014 list of impaired waters (MDE, 2015a), several segments within Howard County are listed for water quality impairments as previously discussed in Section 1.1.2 and shown in Table 1. Howard County contains ten Category 4a stream segments which include those waters that are not meeting their use designation but for which a TMDL has been developed to address impairments. Category 4a waters include five watersheds listed for sediment, three watersheds listed for phosphorus, and two watersheds listed for bacteria. Category 5 waters, which include those waters that are not meeting their use designation and require a TMDL, include three watersheds listed for an unknown pollutant (i.e., cause unknown), two watersheds listed for chlorides, one watershed listed for sulfates, and a final watershed listed for mercury in fish tissue.

2.1.2 Biological Impairments

The condition of Howard County's watersheds, as indicated by Benthic Index of Biotic Integrity (BIBI) scores, is shown in the following map of County stream monitoring results (Figure 5). While stream conditions vary across the county, degradation is more common where the urban area is more dense or older. This reflects, in part, the history of urban and suburban development prior to effective stormwater management regulations. Stream condition is generally better in the more rural parts of the

county, but stream degradation still occurs in these areas as a likely result of large lot development and legacy agricultural impacts. By reducing the adverse effects of stormwater runoff throughout the county, this CIS should improve the condition of County streams and watersheds over time.

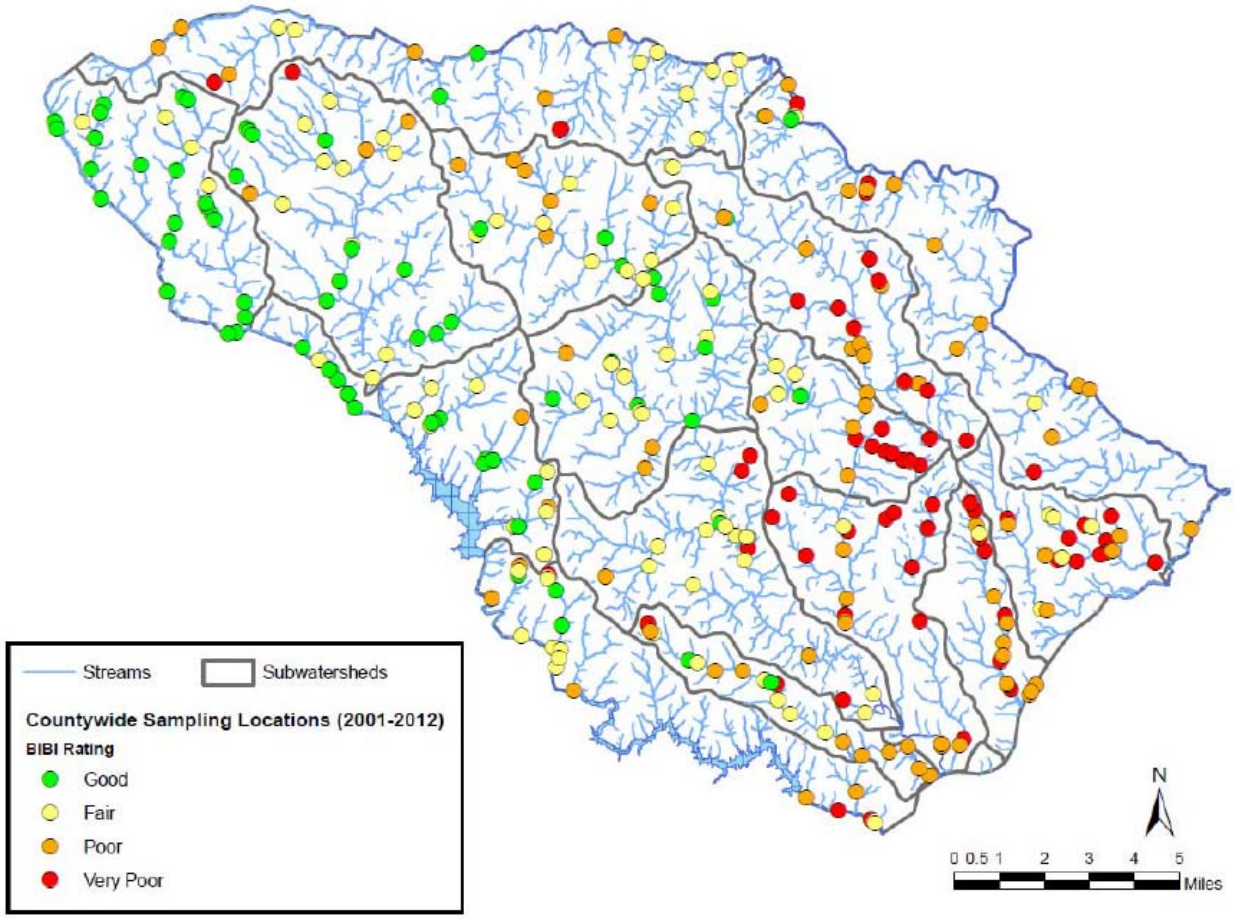


Figure 5. Condition of Howard County streams as indicated by sampling of benthic macroinvertebrate communities at random locations (2001 - 2012)

Recent countywide bioassessment results are available for 2013 and 2014. 2013 sampling took place in the Little Patuxent watershed, comprised of Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds. During 2014, sampling was conducted in the Upper Middle Patuxent, Middle Middle Patuxent, and Lower Middle Patuxent subwatersheds which combined make up the Middle Patuxent watershed.

Results from 2013 sampling (Rogers et al., 2013) indicate that stream biological condition in the Little Patuxent watershed is poor, with the mean BIBI score of the three subwatersheds ranging from 'Poor' to 'Very Poor'. Stream habitat mean scores for all three subwatersheds were in the 'Partially Supporting' or 'Not Supporting' category for the RBP habitat assessment and 'Degraded' for the Maryland PHI habitat assessment. *In situ* water quality results were within COMAR standards excepting two sites, both in the Upper Little Patuxent subwatershed, which had pH values below the codified threshold value of 6.5.

2014 sampling (Rogers et al., 2014) results indicate that all three subwatersheds had mean BIBI scores in the 'Fair' category. Stream habitat mean scores for all three subwatersheds were in the 'Partially Supporting' category for the RBP habitat assessment and 'Degraded' or 'Partially Degraded' for the Maryland PHI habitat assessment. *In situ* water quality results were within COMAR standards excepting two sites, one in the Upper Middle Patuxent and one in the Middle Middle Patuxent subwatersheds, which had pH values below the codified threshold value of 6.5.

2.2 Sources

Approved TMDLs exist for three pollutants in Howard County: nutrients, both nitrogen and phosphorus; sediment; and bacteria.

Nutrients are a pollutant of concern as an overabundance can cause algal blooms. Nitrogen is the limiting nutrient in the Chesapeake Bay, with high levels of nitrogen leading to algal blooms which cause decreased water clarity and light attenuation in the bay, as well as rob the bay of dissolved oxygen as algal blooms die and decompose at the bottom of the water column. Phosphorus is the limiting nutrient in freshwater systems and can lead to algal blooms in lakes and reservoirs with the same impacts as algal blooms in the Chesapeake Bay but also can have an impact on drinking water if the bloom occurs in a reservoir that is used as a water source for municipal drinking water. Both Rocky Gorge and Triadelphia Reservoirs are part of the Washington Suburban Sanitary Commission's (WSSC) drinking water system. Sources of nutrients include agricultural runoff, urban stormwater, municipal wastewater treatment plants, phosphorus bound to sediments supplied to the system, and discharge from upstream impoundments.

Another pollutant of concern is sediments. Sediments consist of particles of weathered rock or soils which make it into streams and are carried downstream to end up in the Chesapeake Bay. Fine sediments in suspension can cloud the water, blocking out light needed for aquatic vegetation to grow, and can accumulate on the bottom of streams, lakes, and the Bay smothering aquatic invertebrates, underwater grasses, and shellfish. Sediments can also help transport nutrients as much of the phosphorus which travels downstream is bound to sediments. Sources of sediments include erosion of poorly buffered agricultural land, instream erosion of stream banks and the stream bed, urban stormwater, shoreline erosion, and as a natural process of rivers and streams.

Bacteria are another pollutant of concern. Bacteria in the water can create a human health hazard and require water contact restrictions in streams, rivers, lakes, and the bay. Bacteria come from multiple sources, which can be classified as either human, domestic pets, livestock, or wildlife. The most common sources of human-specific bacteria are sanitary sewer overflows (SSO), leaking sewer infrastructure, illicit connections, or failed septic systems. Bacteria can originate from pet waste that is not disposed of properly. Livestock are another source of bacteria, especially agricultural feeding operations. Finally, bacteria can come from wildlife living in the watershed, in both urban and forested areas.

Nutrients

Approved TMDLs for nutrients exist for three watersheds in Howard County. Those watersheds are Baltimore Harbor (both nitrogen and phosphorus), Rocky Gorge Reservoir (phosphorus), and Triadelphia Reservoir (phosphorus).

The two largest sources of nitrogen to the Baltimore Harbor as identified in the Baltimore Harbor Nutrient TMDL (MDE, 2006) are municipal and industrial point sources (71%), and urban stormwater (12%). The two largest sources of phosphorus to the Baltimore Harbor from the Baltimore Harbor Nutrient TMDL (MDE, 2006) are municipal and industrial point sources (58%), and urban stormwater (29%). As of 2006, there were two municipal wastewater treatment plants (WWTP) in the watershed (Patapsco WWTP, and Cox Creek WWTP) as well as five industrial wastewater treatment plants.

The Rocky Gorge Reservoir TMDL document identifies the two largest sources of phosphorus as Triadelphia (34%) and cropland (24%).

The two largest sources of phosphorus to Triadelphia Reservoir are cropland (50%) and scour (28%). Scour is sediment delivered to the reservoir that was eroded from stream banks or from the stream bed.

Sediment

Approved TMDLs for sediment exist for four watersheds in Howard County. Those watersheds are Little Patuxent River, Patapsco River Lower North Branch, Patuxent River Upper, and Triadelphia Reservoir.

The sediment TMDL document for Little Patuxent River lists the largest sources of sediment as urban land (67.9%) and cropland (14.4%; MDE, 2011a). The Biological Stressor Identification analysis (BSID) completed by MDE for the Little Patuxent River found that biological impairment is due in part to sediment/flow related stressors; that increased runoff from impervious sources in the urban environment has altered the hydrology and resulted in increased sediment from instream erosion, adversely affecting the instream biological communities.

The sediment TMDL document for Patapsco River Lower North Branch lists the largest sources of sediment as urban land (68.4%) and cropland (16.9%; MDE, 2011b). The BSID analysis completed by MDE for the Patapsco River Lower North Branch found that biological impairment is due in part to sediment/flow related stressors; that increased runoff from impervious sources in the urban environment has altered the hydrology and resulted in increased sediment from instream erosion, adversely affecting the instream biological communities.

The sediment TMDL document for Patuxent River Upper Watershed lists the largest sources of sediment as urban land (42.0%) and cropland (41.0%) (MDE, 2011c). The Biological Stressor Identification analysis (BSID) completed by MDE for the Patuxent River Upper Watershed found that biological impairment is likely due to sediment/flow related stressors; that increased runoff from impervious sources in the urban environment has altered the hydrology and resulted in increased sediment from instream erosion, adversely affecting the instream biological communities.

The TMDL for sediment in Triadelphia Reservoir identified cropland (54%) and scour (38%) as the two largest sources of sediment in that watershed (MDE, 2008). The scour source accounts for instream erosion as the source of sediment input to the reservoir.

Bacteria

Only one watershed in Howard County has an approved TMDL for bacteria: the Patapsco River Lower North Branch. The TMDL (MDE, 2009a) was prepared using monitoring data from five stations on the mainstem of the river, and calculated WLAs and reductions relative to the monitored instream loads. As such, the TMDL addresses delivered loads rather than watershed loads at the source.

Bacteria sources were identified using bacteria source tracking (BST) analysis. For the 8-digit watershed, the results categorized the probable sources as livestock (11%), human (22%), domestic pets (22%) and wildlife (46%). BST has been used to categorize the fraction of bacteria coming from four general sources: humans, domestic pets, wildlife, or livestock. It is important to note that BST is performed on samples from the impaired waterbody, and thus the estimate of the fraction from each source is for the watershed as a whole, not from particular locations, jurisdictions, or permittees.

The TMDL showed that the only sources for the SW-WLA regulated by the County's MS4 permit are domestic pets and wildlife. All human and livestock sources are considered to be part of the unregulated LA. For this reason, the County's TMDL analysis only focuses on domestic pet sources.

2.2.1 Land Use/Land Cover

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

Land use / land cover (LULC) data from Maryland Department of Planning (MDP, 2010) is presented in Figure 6. Data presented in the figure and tables below were used to characterize the County and show potential pollution sources. These LULC data were not used in the calculations of loads and load reduction, which were based instead on the land-river segment scale from the Chesapeake Bay Program Partnership Watershed Model.

Existing Land Use/Land Cover

According to 2010 LULC data (Table 6), the largest category in Howard County is urban, or developed, land (50.3%) followed by forested land (26.1%) and agriculture (22.3%). Developed land largely consists of residential (low-density 17.7%, medium-density 10.1%), and large lot subdivisions (large lot agriculture 4.6%, large lot forest 3.9%). Residential areas as a total make up 39.2% of the County.

Land use / land cover data are summarized by watershed in Table 7. The watershed in Howard County with the largest percentage of urban land is Little Patuxent River (68.9%) followed by Patuxent River Upper (63.2%) and Patapsco River Lower North Branch (57.7%). The watershed with the least amount of urban land is Brighton Dam (34.5%), followed by South Branch Patapsco River (35.8%), Rocky Gorge Dam (47.1%), and Middle Patuxent River (48.7%). Patapsco River Lower North Branch (34.4%) and Rocky Gorge Dam (34.1%) are the watersheds with the largest portion of forested land. Brighton Dam (37.5%) and South Branch Patapsco River (36.1%) are the watersheds with the largest amount of agricultural lands.

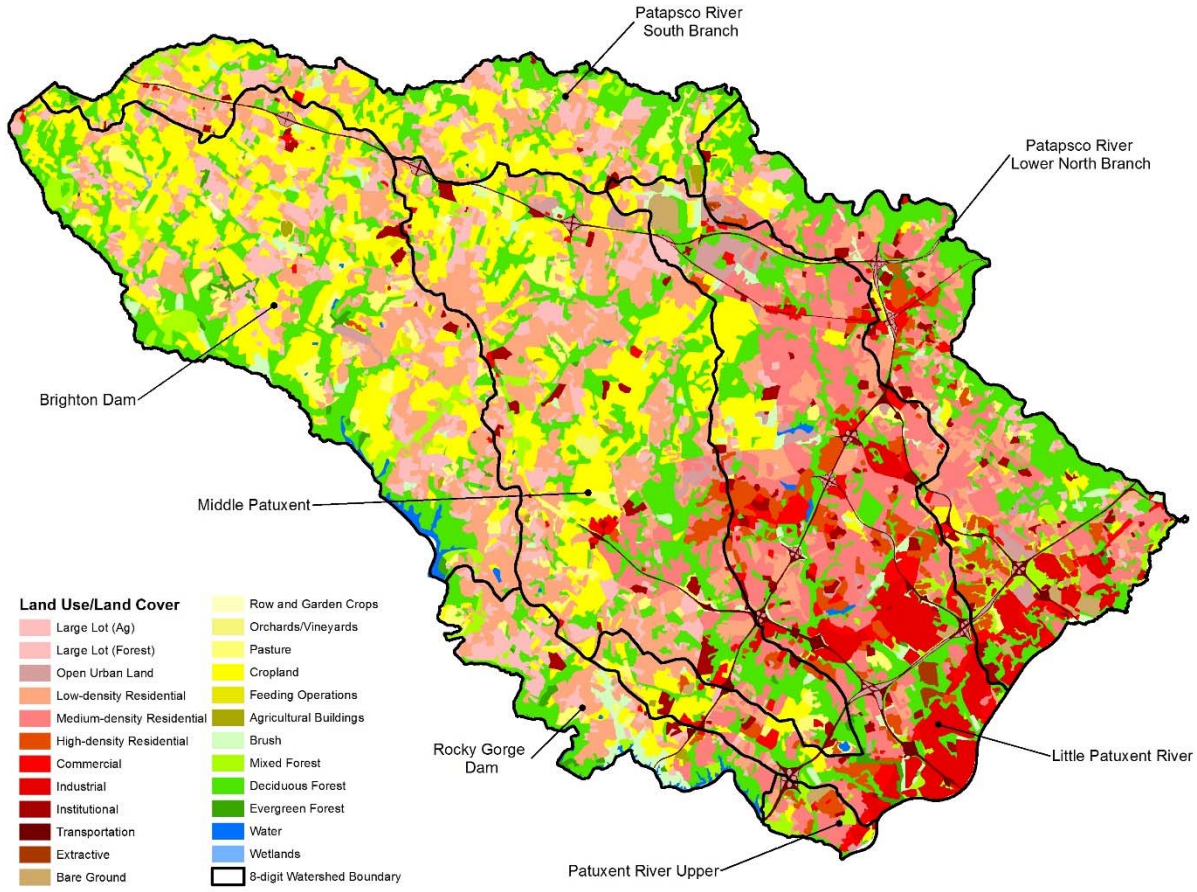


Figure 6. Countywide Land Use/Land Cover (MDP, 2010)

Table 6. Countywide Land Use/Land Cover (MDP, 2010)

Land Use / Land Cover	Acres	Percent
Urban	**81,575.6**	**50.3**
Large lot subdivision (agriculture)	7,437.0	4.6
Large lot subdivision (forest)	6,394.9	3.9
Low-density residential	28,644.9	17.7
Medium-density residential	16,285.4	10.1
High-density residential	4,829.4	3.0
Open urban land	2,978.5	1.8
Commercial	4,070.1	2.5
Industrial	5,077.6	3.1
Institutional	3,269.1	2.0
Extractive	224.3	0.1
Transportation	2,364.2	1.5
Agriculture	**36,174.7**	**22.3**
Cropland	30,051.9	18.5
Pasture	5,331.6	3.3
Orchards/vineyards/horticulture	337.7	0.2
Row and garden crops	57.6	0.0
Feeding operations	126.9	0.1
Agricultural building	269.1	0.2
Forest	**42,231.7**	**26.1**
Deciduous forest	34,139.0	21.1
Evergreen forest	906.8	0.6
Mixed forest	4,148.1	2.6
Brush	3,037.8	1.9
Water	**1,003.6**	**0.6**
Other	**1,049.9**	**0.6**
Wetlands	29.5	0.0
Bare ground	1,020.4	0.6
Total	**162,035.5**	**100.0**

Table 7. Land Use/Land Cover (MDP, 2010) and Impervious Cover (2013) by Watershed

Watershed	Urban		Agriculture		Forest		Water		Other		Imperviousness	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Brighton Dam	12,730.2	34.5	13,864.0	37.5	9,815.9	26.6	488.9	1.3	23.5	0.1	1,830.1	5.0
Little Patuxent River	26,178.5	68.9	3,382.6	8.9	7,774.8	20.5	140.9	0.4	541.5	1.4	9,139.7	24.0
Middle Patuxent River	18,067.5	48.7	10,305.0	27.8	8,595.2	23.2	42.3	0.1	63.4	0.2	3,410.9	9.2
Patapsco River Lower North Branch	13,988.1	57.7	1,593.7	6.6	8,340.0	34.4	0.0	0.0	310.2	1.3	4,424.8	18.3
Patuxent River Upper	1,090.9	63.2	70.7	4.1	478.3	27.7	0.0	0.0	86.0	5.0	439.7	25.5
Rocky Gorge Dam	3,771.0	47.1	1,167.5	14.6	2,729.4	34.1	328.0	4.1	10.6	0.1	584.8	7.3
South Branch Patapsco River	5,749.5	35.8	5,791.1	36.1	4,498.2	28.0	3.6	0.0	14.8	0.1	744.3	4.6

2.2.2 Impervious Surfaces

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

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

Figure 7 shows the distribution of impervious cover within the County using the County's 2013 planimetric impervious surface spatial data. Note that these impervious values are used to demonstrate potential pollution sources, and are not the data used to generate the County's baseline. Table 7 presents a summary of the countywide impervious cover totals by watershed; Table 8 presents a summary of impervious cover totals by each NPDES source sector by watershed; and Table 9 shows the breakdown of impervious cover into individual impervious surface types (e.g., buildings and roads).

The total impervious surface acreage for Howard County is 20,574.5 acres, or 12.7% of the county (Howard County 2013 impervious GIS data). Little Patuxent River is the watershed with the most impervious acres at 9,139.7, or 24.0% of total watershed area, while Upper Patuxent River has the largest percentage of imperviousness at 25.5%, or 439.7 acres out of a total 1,725.9 acres (Table 7). The watershed with the lowest impervious percentage is South Branch Patapsco at 4.6%. Table 8 presents percent impervious cover by watershed and NPDES source sector. The majority of the County's impervious cover is within the County MS4 Phase I source sector (89%) with some impervious cover owned by Maryland State Highway Administration (10%), other State-owned property (1%), and some regulated industrial facilities (0.4%).

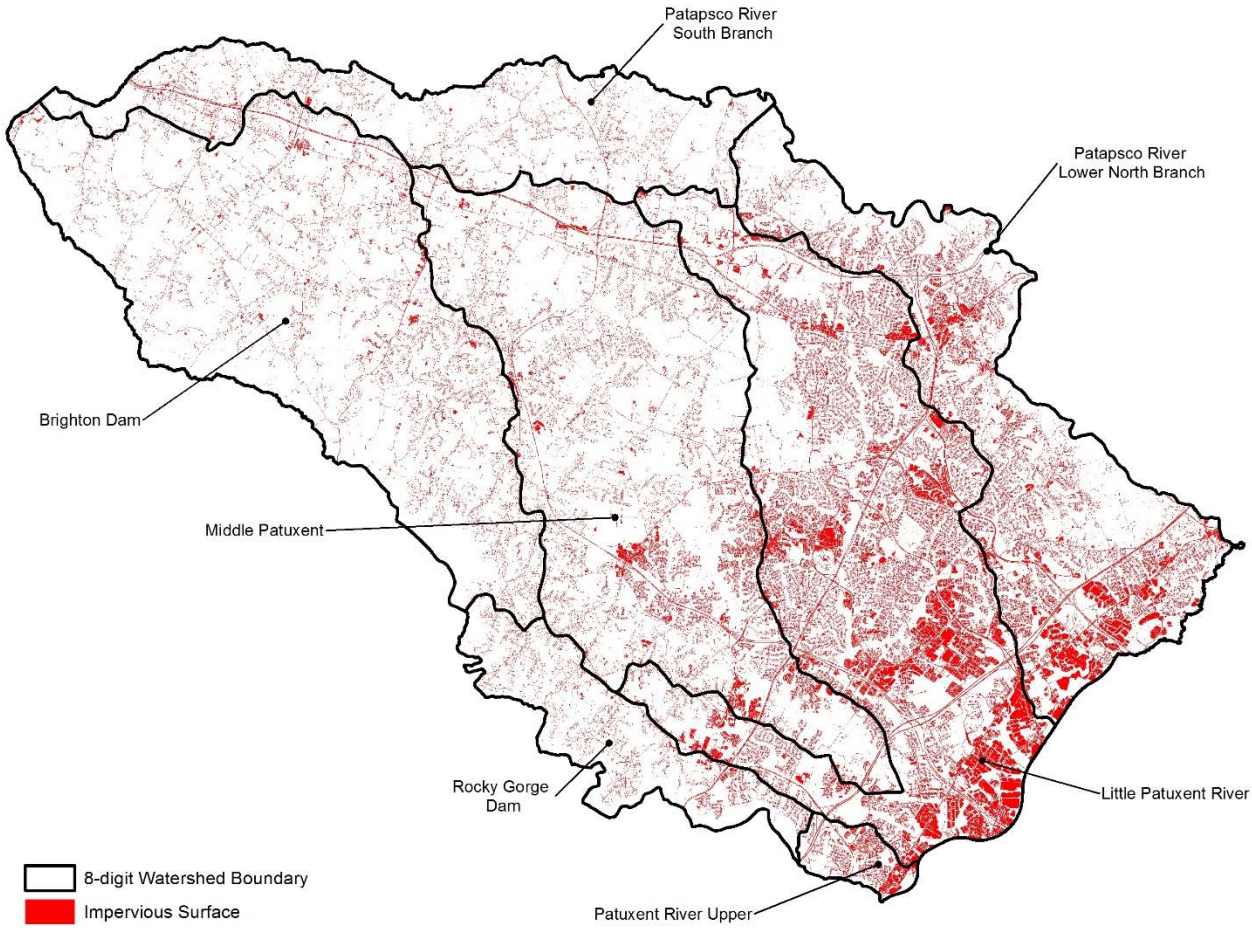


Figure 7. Distribution of impervious cover within Howard County (Howard County 2013 impervious GIS data)

Table 8. Percent Impervious Cover by Watershed and NDPES Source Sector (Howard County 2013 impervious GIS data)

Watershed Name	Total Impervious Acres	City Phase I MS4	County Phase I MS4	County Phase II MS4	Federal Property	Municipal Phase II MS4	Regulated Industrial Facility	SHA Phase I/II MS4	State Property
Brighton Dam	1,830.1	0%	92%	0%	0%	0%	0%	7%	1%
Little Patuxent River	9,139.7	0%	90%	0%	0%	0%	0%	9%	1%
Middle Patuxent River	3,410.9	0%	88%	0%	0%	0%	0%	12%	0%
Patapsco Lower North Branch	4,424.8	0%	87%	0%	0%	0%	1%	10%	2%
Patuxent River Upper	439.7	0%	87%	0%	0%	0%	0%	13%	0%
Rocky Gorge Dam	584.8	0%	91%	0%	0%	0%	0%	9%	0%
South Branch Patapsco	744.3	0%	85%	0%	0%	0%	0%	14%	2%
Countywide Total	**20,574.5**	**0%**	**89%**	**0%**	**0%**	**0%**	**0.4%**	**10%**	**1%**

Table 9. Area and Percent of each Impervious Type within the MS4 for Howard County (Howard County 2013 impervious GIS data)

Type Impervious	Total Impervious Acres	Percent of Total Impervious in County
Bridge Decks	12.6	0.1%
Buildings	6,003.1	32.8%
Driveway Paved	2,952.4	16.2%
Driveway Unpaved	572.9	3.1%
Parking Lots Paved	3,857.5	21.1%
Parking Lots Unpaved	412.8	2.3%
Roads Paved	4,129.3	22.6%
Roads Unpaved	41.4	0.2%
Sidewalks Major	65.8	0.4%
Sidewalks Minor	29.8	0.2%
Trails and Pathways	199.1	1.1%
Total	18,276.7	100.0%

2.3 Anticipated Growth

Future urban sector growth and the anticipated increase in urban loads that may result are expected to be controlled by two elements: stormwater management to the MEP that is required with new development, and anticipated "Accounting for Growth" policies. This CIS is developed to treat the reduction required from the initial baseline year load, calibrated to the current Bay model. Based on coordination with MDE, TMDL restoration planning should focus on the untreated and undertreated areas associated with the urban footprint at the time of the TMDL baseline. Future loads and loads potentially added to the urban sector since the baseline year to present are not accounted for here as they are addressed under other programs. MDE has requested in restoration plan development guidance (MDE, 2014d) that jurisdictions begin estimating potential additional loads, therefore estimates are included in section 2.3.2.

2.3.1 Offsetting Loads from Future Growth

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

Maryland's 2007 Stormwater Management Act went into effect in October of 2007, with resulting changes to COMAR and the 2000 Maryland Stormwater Design Manual in May of 2009. The most significant changes relative to watershed planning are in regard to implementation of ESD. The 2007 Act defines ESD as "using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources."

The following section discusses projected land use loads with the application of stormwater BMPs to the maximum extent practicable (SW to the MEP). TMDL modeling efforts to estimate future loads include the application of SW to the MEP to represent ESD treatment for new development in the watershed. SW to the MEP will control 50%, 60%, 90%, and 70% of nitrogen, phosphorus, sediment and bacteria loads, respectively, for new development.

Anticipated "Accounting for Growth" policies will address the residual load (TN: 50%, TP: 40%, TSS: 10%, and bacteria: 30%) that is potentially uncontrolled by development-based stormwater controls. As required by the State's Watershed Implementation Plan (Bay Restoration Plan) Maryland is developing an Accounting for Growth (AFG) policy that will address the expected increase in the State's pollution load from increases in population growth and new development. While not currently a fully formed policy, the State's plan, as of the *Final Report of the Workgroup on Accounting for Growth in Maryland* (August 2013) focuses on two elements: 1) the strategic allotment of nutrients loads to large wastewater treatment plants, upgraded to the best available technology; and 2) the requirement that all other new loads must be offset by securing pollution credits.

2.3.2 Estimates of Future Growth

As stated in the MDE guidance document General Guidance for Developing a Stormwater Wasteload Allocation (SW-WLA) Implementation Plan, Section 1.h. (MDE, 2014d):

New urban areas that have been developed since TMDL allocations were set imply loads beyond the original SW-WLA (i.e., additional urban footprint within a watershed). This can confound the process of accounting for load reductions to meet the allocations. MDE is working to develop methods to deal with this issue. However, MDE is also recommending that within the SW-WLA implementation plans, local jurisdictions estimate this potential new urban load as the next step in a longer-term process to address the issue.

To estimate increases in loads over time, an analysis was completed using a combination of MAST modeled loads and projected loading estimates in addition to estimates based on recent growth patterns. The estimates were completed at the Countywide scale (i.e., sum of all watersheds) and for local TMDL watersheds. The average percent change in County Phase I MS4 urban land use acres (impervious and pervious acres) was calculated as the average percent change observed between MAST land use acres from 2010 through 2015. There was a 1.7% Countywide increase in County Phase I MS4 urban land use acres observed between 2010 and 2015 (Table 10) while average percent change ranged from 1.1% (Patuxent River Upper) to 2.9% (Rocky Gorge Reservoir) for land use acres in local TMDL watersheds (Table 13).

The pace of growth in loads is consistent with growth projections outlined in Howard County's Water Resources Element (WRE) (Howard County, 2010). The WRE is built upon General Plan 2000, a 20-year plan; however, the growth projections of the WRE extend beyond 2020 to the year 2030. The WRE anticipates the same general pace of growth between 2020 and 2030 as in the original 20-year plan between 2000 and 2020. The WRE also acknowledges that the pace may slow as developable land becomes more scarce in the out years approaching 2030. The time period used to assess current growth in loads is 2010 to 2015, which should then be representative of growth for the CIS planning period out to 2025.

Projected TN, TP, and TSS EOS and DEL loads were calculated by applying the average percent change observed between MAST loading results for County Phase I MS4 urban land (impervious and pervious acres) from 2010 through 2015 to loads of the previous year by watershed and Countywide. Since bacteria loading is not available in MAST, the average percent change in bacteria loads in the Patapsco River Lower North Branch was derived using the 2005 MS4 disaggregated baseline load and estimated 2015 loads, which was calculated by applying a bacteria loading rate to 2015 MAST County Phase I MS4 urban land. The average percent change in bacteria loads was then applied to the loads of the previous year.

Howard County average percent change in County Phase I MS4 background pollutant loads are shown in Table 11 which ranges from 1.4% to 1.7%. Average percent change in County Phase I MS4 background loads for watersheds with listed local TMDL pollutants are shown in Table 13 with ranges from 1.1% (Little Patuxent River) to 2.7% (Rocky Gorge Reservoir). In this manner, a 1.7% annual increase in TSS-EOS Countywide loads and a 2.7% annual increase in TP-EOS loads in Rocky Gorge Reservoir would be expected from 2015 to 2025 if development were to occur at the same rate and be implemented without BMPs. Because new development will implement BMPs under Maryland's stormwater regulations, the resultant loading increases were reduced by 50% for TN, 60% for TP, and 90% for TSS based on the MAST removal rates for nutrients and sediment treated by stormwater treatment to the maximum extent practicable (SW to the MEP). Bacteria loading increases were reduced by 70% based on a conservative average reduction rate for bacterial removal by structural BMPs. Projected loading with application of SW to the MEP was incorporated in both Bay and local TMDL modeling and is shown in

Table 12 and Table 13. These additional loads are cumulative since 2015; for example, 2017 additional land use loads consists of additional loads for 2016 growth and 2017 growth.

Table 10. Howard County Average Percent Change in County Phase I MS4 Urban Land Use Acres

County Phase I MS4 Urban Land Use Acres	
2010	63,289
2015	68,683
Average % Change	1.7%

Table 11. Howard County Average Percent Change in County Phase I MS4 Background Pollutant Loads

No BMP County Phase I MS4 Urban Land Use Loads	TN EOS-lbs/yr	TN DEL-lbs/yr	TP EOS-lbs/yr	TP DEL-lbs/yr	TSS EOS-lbs/yr	TSS DEL-lbs/yr
2010	656,081	379,207	36,726	19,835	38,960,095	31,474,608
2015	712,312	406,667	39,682	21,272	42,038,356	33,746,443
Average % Change	1.7%	1.4%	1.6%	1.4%	1.6%	1.4%

Table 12. Additional Estimated Future Loads for Howard County Bay TMDL

Additional Land Use Loads - With SW to MEP	TN EOS-lbs/yr	TN DEL-lbs/yr	TP EOS-lbs/yr	TP DEL-lbs/yr	TSS EOS-lbs/yr	TSS DEL-lbs/yr
2017 Estimate	12,210	5,890	511	247	132,859	97,433
2019 Estimate	24,420	11,780	1,022	493	265,718	194,865
2025 Estimate	61,050	29,449	2,555	1,233	664,295	487,163

Additional loads are cumulative since 2015

Table 13. Nutrient, Sediment, and Bacteria Local TMDLs – Estimated Future Increases in Land Use and Pollutant Loads

County Phase I MS4 Urban Land Use Acres	Baltimore Harbor	Little Patuxent River	Patapsco River Lower North Branch	Patuxent River Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)
2010	15,255	24,893	12,918	1,146	2,057	7,624
2015	16,507	26,336	13,870	1,207	2,352	8,709
Average % Change	1.6%	1.2%	1.5%	1.1%	2.9%	2.8%

No BMP County Phase I MS4 Urban Land Use Loads	TN EOS-lbs/yr	TP EOS-lbs/yr	TSS EOS-lbs/yr	TSS EOS-lbs/yr	Bacteria MPN/100 mL/yr	TSS EOS-lbs/yr	TP EOS-lbs/yr	TP EOS-lbs/yr
2010*	131,274	8,666	16,117,115	9,051,056	60,282	286,799	1,061	3,721
2015	142,760	9,352	17,015,519	9,728,170	70,457	302,996	1,204	4,205
Average % Change	1.7%	1.6%	1.1%	1.5%	1.4%	1.1%	2.7%	2.6%

Additional Land Use Loads - With SW to MEP	TN EOS-lbs/yr	TP EOS-lbs/yr	TSS EOS-lbs/yr	TSS EOS-lbs/yr	Bacteria MPN/100 mL/yr	TSS EOS-lbs/yr	TP EOS-lbs/yr	TP EOS-lbs/yr
2017 Estimate	2,498	118	37,939	29,111	610	684	26	87
2019 Estimate	4,997	237	75,879	58,222	1,220	1,369	52	175
2025 Estimate	12,491	592	189,697	145,554	3,051	3,422	131	437

*2005 MS4 baseline disaggregated load used to calculate bacteria load growth.

3 Management Measures

Best management practices (BMPs) are either already implemented or are planned for implementation to achieve and maintain the local TMDL load reductions and impervious surface treatment. This section serves to describe the watershed planning process, types of BMPs, and management measures being implemented throughout the County. Load reductions and impervious treatment that result from these measures (Criterion b) are discussed in the following section, Section 4: Expected Load Reductions and Impervious Treatment.

3.1 County Planning Process

The following sections describe Howard County's current watershed-based planning process which includes watershed assessment and implementation.

3.1.1 Watershed Assessments

Howard County initiated its current watershed assessment approach in the Spring of 2015 with assessments in the Middle Patuxent and Little Patuxent watersheds. Howard County's Stormwater Management Division utilized four teams of consultant contractors to assess the watersheds that were divided into four study area planning units – Northern Middle Patuxent, Southern Middle Patuxent, Northern Little Patuxent, and Southern Little Patuxent. The remaining County watersheds were assessed in the Spring of 2016 and included two subwatersheds of the Patapsco River (South Branch and Lower North Branch) and three subwatersheds of the Patuxent River (Brighton Dam, Rocky Gorge Dam, and Patuxent River Upper). Table 14 lists the watershed groupings used in the assessments.

Table 14. 2015 and 2016 Completed Watershed Assessment Areas

Watershed	Study Area	Included County Watersheds
Middle Patuxent	Northern Middle Patuxent (NMP)	Upper Middle Patuxent Dorsey Run
	Southern Middle Patuxent (SMP)	Lower Middle Patuxent Hammond Branch (part of Lower Little Patuxent)
Little Patuxent	Northern Little Patuxent (NLP)	Upper Little Patuxent Centennial Lake (part of Middle Little Patuxent)
	Southern Little Patuxent (SLP)	Middle Little Patuxent (except for Centennial Lake) Lower Little Patuxent
Patapsco River	Patapsco River South Branch (SBP)	Patapsco River South Branch
	Patapsco River Lower North Branch (LNB)	Patapsco River Lower North A Patapsco River Lower North B
Patuxent River	Brighton Dam (BRD)	Upper Brighton Dam Lower Brighton Dam Cattail Creek
	Patuxent River Upper (PRU)	Patuxent River Upper
	Rocky Gorge Dam (RGD)	Rocky Gorge Dam

The primary goal of the assessments was to identify impacted, untreated and degraded areas in need of treatment and restoration. A desktop analysis was first conducted to identify those areas that had the highest potential for both impairment and restoration. The evaluation included land use, previous stream assessment results, impervious surface data, stormdrain network mapping, existing citizen erosion and/or drainage complaints, and location and type of existing BMPs. The types of assessments were categorized into several groups based on the type of facility / landform to be assessed and the resulting type of project. The numbers of the various assessments from each watershed study are included in Table 15 and Table 16. A total of 693 sites were assigned to the consultant teams in 2015 and 390 sites in 2016, where stream miles walked were considered one site for accounting purposes.

Several sites (86) were also identified from the previous watershed studies listed in Section 1.3. These sites were added to the list during the 2015 watershed assessments but were more limited in scope to include a desktop assessment, with field visits when needed, to update the assessment information for these previously documented sites. The total, combining the field and desktop assessments, was 779 sites in 2015 (Table 15).

Table 15. 2015 Watershed Assessment Numbers of Sites Assessed per Project Type

Impairment / Project Type	Middle Patuxent	Little Patuxent	Total
Convert Existing BMPs	76	84	160
Opportunities for new BMPs for untreated impervious areas	79	128	207
Potential stream restoration (stream miles)	39	39	78
Potential Tree planting sites	26	20	46
Outfall Stabilization	70	132	202
SubTotal Field Assessment Sites[1]	***290***	***403***	***693***
Desktop Assessment	24	62	86
Total Sites (miles) Assessed[1]	***314***	***465***	***779***

[1] Each stream mile counted as one 'site' for accounting purposes

Table 16. 2016 Watershed Assessment Numbers of Sites Assessed per Project Type

Impairment / Project Type	Patapsco Watersheds		Patuxent Watersheds			Total
	Patapsco LN Br	South Br Patapsco	Brighton Dam	Rocky Gorge	Patuxent River Upper	
Convert Existing BMPs	48	1	9	3	4	65
Opportunities for new BMPs for untreated impervious areas	40	0	11	1	1	53
Potential stream restoration (stream miles)	34	13	3	1	3	54
Potential Tree planting sites	36	20	22	8	2	88
Outfall Stabilization	106	11	4	0	9	130
Total Sites (miles) Assessed[1]	***264***	***45***	***49***	***13***	***19***	***390***

[1] Each stream mile counted as one 'site' for accounting purposes

Once the field assessment was complete, the results from each site were evaluated and prioritized with narrative ratings of "high", "medium" and "low" priorities for further development of concept plans to identify the specific issue and a potential solution for each site. The concept plans describe the site conditions, land ownership, benefits expected from completion of the project including calculation of pollutant removal and impervious treatment credits, and any perceived constraints to project implementation including access, tree removal, and conflicts with existing infrastructure or utilities. A planning level cost estimate was derived for each project which included construction, design, survey, permitting and contingency.

The results of the 2015 and 2016 assessments are two prioritized lists of 148 and 180, respectively, high and medium priority projects with completed concept plans that are ready to move into the next phases of implementation. A summary of the 2015 and 2016 projects by type is included in Table 17.

Table 17. 2015 and 2016 Watershed Assessments Summary of Potential Project Sites

Watershed	Project Category and Type	Number of Project Sites	Treated Area (ac)	Project Length (ft)
Little Patuxent	**BMP Conversion**	**12**	**200.3**	
	Extended Detention Structure, Wet	1	4.7	
	Retention Pond (Wet Pond)	5	90.0	
	Sand Filter	1	11.1	
	Shallow Marsh	1	9.0	
	Shallow Wetland	1	53.1	
	Submerged Gravel Wetlands	3	32.4	
	New BMP	**10**	**46.1**	
	Bioretention	2	6.9	
	Perimeter (Sand) Filter	2	4.0	
	Retention Pond (Wet Pond)	4	25.4	
	Underground Filter	2	9.9	
	Outfall	**18**	**134.9**	**2,547.1**
	Outfall Stabilization	13	31.5	1,808.6
	Step Pool Storm Conveyance	5	103.4	738.4
	Stream Restoration	**32**		**62,028.0**
	Stream Restoration	32		62,028.0
	Tree Planting	**14**	**45.9**	
	Planting Trees or Forestation on Pervious Urban	14	45.9	
Middle Patuxent	**BMP Conversion**	**8**	**110.3**	
	Micropool Extended Detention Pond	3	46.8	
	Sand Filter	3	23.3	
	Shallow Wetland	1	27.6	
	Swale	1	12.6	
	Outfall	**8**	**36.4**	**1,938.2**

Watershed	Project Category and Type	Number of Project Sites	Treated Area (ac)	Project Length (ft)
	Outfall Stabilization	6		1,527.1
	Step Pool Storm Conveyance	2	36.4	411.2
	Stream Restoration	**28**		**58,623.2**
	Stream Restoration	28		58,623.2
	Tree Planting	**18**	**129.4**	
	Planting Trees or Forestation on Pervious Urban	18	129.4	
2015 Watershed Assessment Grand Total		**148**	**703.4**	**125,136.4**
Brighton Dam	**BMP Conversion**	**4**	**109.9**	
	Bioretention	2	16.3	
	Infiltration Basin	1	3.7	
	Retention Pond (Wet Pond)	1	90.0	
	New BMP	**7**	**4.9**	
	Bioretention	1	2.1	
	Infiltration Trench	1	0.8	
	Rain Garden	2	0.3	
	Bioswale	3	1.8	
	Outfall	**1**	**22.6**	**118.0**
	Step Pool Storm Conveyance	1	22.6	118.0
	Stream Restoration	**6**		**5,565.0**
	Stream Restoration	6		5,565.0
	Tree Planting	**1**	**3.6**	
	Planting Trees or Forestation on Pervious Urban	1	3.6	
Patapsco Lower North Branch	**BMP Conversion**	**41**	**981.3**	
	Created Wetland	1	14.5	
	Infiltration Basin	2	22.8	
	Micropool Extended Detention Pond	6	96.2	
	Retention Pond (Wet Pond)	30	793.8	
	Shallow Marsh	1	23.8	
	Step Pool Storm Conveyance	1	30.3	

Watershed	Project Category and Type	Number of Project Sites	Treated Area (ac)	Project Length (ft)
	New BMP	**12**	**32.3**	
	Bioretention	2	3.6	
	Infiltration Trench	2	6.3	
	Retention Pond (Wet Pond)	1	3.1	
	Step Pool Storm Conveyance	1	6.8	
	Underground Filter	3	7.7	
	Bioswale	3	4.7	
	Outfall	**23**	**164.1**	**2,641.0**
	Outfall Stabilization	6		199.0
	Step Pool Storm Conveyance	17	164.1	2,442.0
	Stream Restoration	**44**		**71,053.0**
	Stream Restoration	44		71,053.0
	Tree Planting	**10**	**12.7**	
	Planting Trees or Forestation on Pervious Urban	10	12.7	
Patuxent River Upper	**BMP Conversion**	**2**	**25.7**	
	Bioretention	1	8.7	
	Retention Pond (Wet Pond)	1	17.1	
	New BMP	**1**	**3.2**	
	Micro-Bioretention	1	3.2	
	Outfall	**3**	**11.6**	**725.0**
	Step Pool Storm Conveyance	3	11.6	725.0
	Stream Restoration	**4**		**4,850.0**
	Stream Restoration	4		4,850.0
Rocky Gorge Dam	**Stream Restoration**	**4**		**3,974.0**
	Stream Restoration	4		3,974.0
	Tree Planting	**2**	**17.2**	
	Planting Trees or Forestation on Pervious Urban	2	17.2	

Watershed	Project Category and Type	Number of Project Sites	Treated Area (ac)	Project Length (ft)
South Branch Patapsco	**Outfall**	**2**	**2.1**	**220.0**
	Outfall Stabilization	1		110.0
	Step Pool Storm Conveyance	1	2.1	110.0
	Stream Restoration	**11**		**17,003.0**
	Stream Restoration	11		17,003.0
	Tree Planting	**2**	**27.3**	
	Planting Trees or Forestation on Pervious Urban	2	27.3	
2016 Watershed Assessment Grand Total		**180**	**1,418.5**	**106,149.0**

Projects are selected by the County to move forward in the planning process largely based on restoration needs. For example, because there is currently no SW-WLA for Middle Patuxent, and no TMDL anticipated in the near future, it is proposed to limit the implementation of those projects proposed for the Middle Patuxent and focus efforts in watersheds with a local TMDL; which, requires greater restoration to reach pollutant reduction targets.

3.1.2 Project Implementation

Howard County has an implementation process in place through several on-going high-capacity on-call contracts. The first is the Stormwater and Watershed Management Evaluation, Design services contract. The County has four engineering firms on this on-call contract to complete the assessment, design and engineering, permitting, construction phase and monitoring elements of structural stormwater BMP and retrofit projects including all of the project types identified in the current round of watershed assessments. The County has an associated on-call contract for construction, which includes six construction firms. Projects are completed by assigning a firm from each contract to a project site.

3.2 Modeling Approach

A combination of models was used for baseline, progress, and planned pollutant load modeling for Bay and local TMDLs. They are described below. Each BMP provides impervious surface restoration as well as a reduction for nitrogen, phosphorus, and sediment, along with other pollutants.

Section 3.3 presents the suite of practices the County uses for current implementation and/or plans to use to address local TMDL and impervious restoration permit requirements. Section 8 presents information on how progress toward load reductions will be evaluated and how management plans will be adapted on an on-going basis.

MAST and BayFAST

The baseline pollutant loads (i.e., nitrogen, phosphorus, and sediment) for the Bay TMDL were determined using MAST, which calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model. MAST, created by Devereux Environmental Consulting for

MDE, is a web-based pollutant load estimating tool that streamlines environmental planning. Users specify a geographic area (e.g., County, watershed) and then select BMPs to apply on that area. MAST builds the scenario and provides estimates of pollutant load reductions and allows users to understand which BMPs provide the greatest load reduction benefit and the extent to which these BMPs can be implemented. Based on the scenario outputs, users can refine their BMP choices in their planning. MAST facilitates an iterative process to determine if TMDL allocations are met. Scenarios may be compared to each other, to TMDL allocations, or to the amount of pollutants reduced by current BMP implementation.

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

The baseline pollutant loads for nutrient and sediment local TMDLs were determined using BayFAST (Bay Facility Assessment Scenario Tool). BayFAST functions similarly to MAST but allows users to delineate facility boundaries (e.g., watershed, parcel, drainage area) and alter land use information within the delineated boundary depending on the model year.

Baseline loads were created by modeling baseline BMPs (i.e., install date before baseline year) on top of a No Action scenario with land use loads corresponding to the TMDL baseline year. Both the Watershed Model and MAST/BayFAST provide loads at two different scales: Edge-of-Stream (EOS) and Delivered (DEL). Delivered loads show reductions based on in-stream processes, such as nutrient uptake by algae or other aquatic life. Local TMDL plans focus on reducing load on the land, so EOS estimates are more appropriate and were used for nutrient and sediment modeling analysis.

Scenarios modeled using MAST or BayFAST are described in more detail below.

Bay TMDL

Baseline: Bay TMDL baseline loads were calibrated in MAST by modeling BMPs installed prior to and including June 30, 2010. This baseline model was set to the Howard County geographic area with BMPs entered at the 8-digit watershed level using “2010 revised” Initial Conditions and “2010 Loads” Processed Water Base Data background land use data in MAST. Additional load reductions, calculated outside of MAST, were subtracted from the 2010 baseline scenario MAST loads including load reductions from non-rooftop and rooftop disconnects and rain barrels installed prior to FY 2011. Load reductions for non-rooftop and rooftop disconnects were calculated by applying treated impervious area by removal rates for ESD practices (MDE, 2014c). Load reductions for rain barrels were calculated by applying treated rooftop area by removal rates for runoff reduction (RR) practices (see Table 18).

Local TMDLs

Baseline: Local TMDL baseline loads were calibrated in BayFAST by modeling BMPs installed prior to the TMDL baseline year on top of baseline land use background loads for each local TMDL watershed. Facility boundaries were delineated in BayFAST according to each local TMDL watershed and land use acres within the facility boundary were replaced with land use data corresponding to each local TMDL baseline year. Local TMDL baseline scenario loads are provided in MAST; however, the functionality to edit

baseline BMPs in the scenarios is not available. Modeling baseline loads in BayFAST ensures all of the County's baseline BMPs are included as there may have been some changes in data since the latest scenario builder data submitted for inclusion in MAST public progress scenarios.

Removal Rate Curve Equations

Pollutant load reductions for progress (i.e., post TMDL Baseline through 6/30/2017) and planned projects were calculated using revised removal rate curve equations for runoff reduction (RR) and stormwater treatment (ST) practices prepared by Chesapeake Stormwater Network (Schueler and Lane, 2015). Reductions are calculated based on rainfall treatment, whether noted in project concepts or as an assumption of 1-inch treatment, and removal efficiencies per RR and ST practice (Table 18).

Table 18. Runoff Reduction and Stormwater Treatment Practices Removal Rate Reductions

Practice	Rainfall Treatment	Nitrogen Reduction	Phosphorus Reduction	Sediment Reduction
Runoff Reduction (RR)	1"	60%	70%	75%
Stormwater Treatment (ST)	1"	35%	55%	70%

Bacteria Modeling

Bacteria loads and reductions were modeled with spreadsheet analysis. Because of the high variability in loading, sources which are difficult to identify or quantify, unknown processes of die-off or growth, and lack of data, more sophisticated approaches were not judged to provide a significantly better estimate of loads or reductions to justify the additional effort.

Two types of treatment were modeled. The first was conventional structural stormwater management. For these facilities, removal rates were derived from the International Stormwater BMP Database, supplemented with other sources. No bacteria removal rates were found for some of the approved BMPs, including rooftop disconnection, permeable pavement, stream restoration, outfall stabilization, tree planting, or vegetated open channels. As a result, these types of practices were not credited for bacteria treatment.

Structural Stormwater Management. Bacteria loads from diffuse sources to the MS4 were calculated using a single annual loading rate for all types of land use multiplied by the land area. The loading rate was calculated for the County's portion of PAT0148sub as follows:

Watershed Name	Sub-watershed	Calculated Disaggregated County MS4 Baseline Load (bn MPN/yr)	County MS4 Area (ac)	Loading Rate (bn MPN/yr)
Patapsco River Lower North Branch	PAT0148sub	21,826	6,624	**3.30**

For example, restoration progress between 2003 and 2017 from structural SWM was achieved for only three BMP types which had both treated area and bacteria reduction capability:

BMP Type	Units	Qty	Load @ 3.30	Redux Rate	Reduction (bn MPN/yr)
Bioretention	Drainage acres	103.23	340.7	70%	238
Dry Detention Ponds	Drainage acres	1.00	3.3	66%	2
Wet Ponds or Wetlands	Drainage acres	20.97	69.2	95%	66
				Total	**306**

Non-structural Measures. The second type of treatment modeled was load reductions for non-structural measures, specifically pet waste management. Calculations for load reductions were made using algorithms and default parameters from the Watershed Treatment Model (Caraco, 2001). The approach uses an estimate of the number of dogs in the watershed, the number walked and not picked up after, and the annual bacteria load per dog. The calculation assumes that the entire baseline domestic load is based on pet waste from dogs which are walked but the waste is not cleaned up.

The calculations are shown in Table 19. The TMDL is met if the County increases the percent of dog walkers who pick up after their pets from 60% to 70%.

Table 19. Bacteria Load Reductions from Non-structural Measures

Parameter	Unit	Value	Source
Number of dogs			
Households	number	10,927	Residential parcels in the County MS4 area of PAT0148sub
Dogs/household	percent	40%	Caraco, 2001
Dogs/County MS4 in PAT148sub	number	4,371	10,927 x 0.40
Number of dogs contributing bacteria			
% walkers	percent	50%	Caraco, 2001
# of dogs walked	number	2,186	4,371 x 0.50
% owners that do not clean up	percent	40%	Caraco, 2001
Dogs contributing pet waste	number	874	2,186 x 0.40
Bacteria contribution per dog			
Baseline Bacteria	bn MPN/yr	21,826	TMDL analysis – BL bacteria
Baseline Bacteria / dog	bn MPN/yr	25	21,826 / 874
Restoration analysis			
Required Reduction	bn MPN/yr	16,370	TMDL analysis
# of dogs to be cleaned up	number	655	16,370 / 25
Total # of dogs to be cleaned up	percent	1,529	874 + 655
Final % of owners that clean up	percent	**70%**	1,529 / 2,186

3.3 Best Management Practices

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

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

The recommended practices are also consistent with those proposed in the County's Phase II Watershed Implementation Plan (WIP) for the Chesapeake Bay TMDL and in the County's comprehensive watershed planning efforts. Exceptions to this are dry ponds which include dry detention ponds and dry extended detention ponds. These practices are typically not considered for future implementation; however, there are many existing facilities that are still actively treating runoff throughout the County so they are described here as well. The practices include:

- **Bioretention** — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. Rain gardens may be engineered to perform as a bioretention.
- **Bioswales** —An open channel conveyance that functions similarly to bioretention. Unlike other open channel designs, there is additional treatment through filter media and infiltration into the soil.
- **Dry Detention Ponds** – Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow. MAST modeling includes hydrodynamic structures in this category. These devices are designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.
- **Dry Extended Detention Ponds** - Depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. They are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, allowing additional wet sedimentation to improve treatment effectiveness.
- **Impervious Surface Reduction** - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Disconnection of rooftop and non-rooftop runoff, rainwater harvesting (e.g., rain barrels), and sheetflow to conservation areas are credited as impervious surface reduction.
- **Infiltration** — A depression or trench to form a shallow basin where sediment is trapped and stormwater infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil; they are not constructed on poor soils, such as C and D soil types. Yearly inspections to determine if the basin

or trench is still infiltrating runoff are planned. Dry wells, infiltration basins, infiltration trenches, and landscaped infiltration are all examples of this practice type.

- **Outfall Enhancement with Step Pool Storm Conveyance (SPSC)** – The SPSC is designed to stabilize outfalls and provide water quality treatment through pool, subsurface flow, and vegetative uptake. The retrofits promote infiltration and reduce stormwater velocities. This strategy is modeled in MAST as SW to the MEP. Bacteria reductions for this practice are modeled as a sand filter.
- **Outfall Stabilization (without SPSC)** – Outfall stabilization is the repair of localized areas of erosion below a storm drain outfall. These practices receive a maximum credit of 2 acres per project as per MDE Guidance. Credit is provided in the form of 0.01 impervious reduction equivalents of 0.01 acre per linear foot of outfall stabilization. No direct pollutant reduction credits are appropriated.
- **Permeable Pavement -** Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.
- **Stream Restoration -** Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.
- **Stormwater Retrofits –** Howard County plans to construct a variety of retrofits throughout the County. Stormwater retrofits may include converting dry ponds, dry extended detention ponds, or wet extended detention ponds into wet pond structures, wetlands, infiltration basins, or decommissioning the pond entirely to install SPSC (step pool storm conveyance).
- **Urban Filtering** - Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.
- **Urban Tree Plantings** - Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting
- **Vegetated Open Channels** - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.
- **Wet ponds or wetlands** — A water impoundment structure that intercepts stormwater runoff then releases it at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached pollutants. Until 2002 in Maryland, these practices were generally designed to meet water quantity, not water quality objectives. There is little or no vegetation within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal, but phosphorus and sediment are reduced.

Along with the standard set of structural BMPs listed above, treatment will also be provided through alternative and non-structural measures including the following strategies that are performed through the programs listed below:

Impervious Surface Disconnects

Howard County has developed a process to account for existing disconnections of impervious surfaces from both rooftop and non-rooftop sources. The County's method involves GIS analysis and field verification of a percentage of credited sites and follows the disconnection methods outlined in the Maryland Stormwater Design Manual. The methodology for rooftop and non-rooftops disconnects has been reviewed and approved by MDE.

Currently the County is accounting for these disconnections as baseline treatment; however the County is investigating use of the treatment as restoration and may present data and rationale to MDE at a later date with proposed revisions to the baseline and restoration accounting, which would reduce the County's overall restoration requirement.

Rooftop Runoff disconnection treats runoff of residential downspouts by directing the water to pervious areas with relatively low slope. This slows the water and allows it to be infiltrated into the soil. The main functions of this method are to reduce runoff velocity, decrease erosion, and therefore reduce the amount of pollutants reaching local waterways. Some residential areas built previous to 2000 meet the criteria for the rooftop runoff disconnection credit.

Non-rooftop disconnection credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). Sites that are graded to promote overland vegetative filtering may receive a non-rooftop disconnection credit.

Specific details of the methods can be found in Technical Memoranda entitled *Howard County Rooftop Disconnection Analysis,* (McCormick Taylor, 2015a), and *Howard County Non-rooftop Disconnection Analysis*, (McCormick Taylor, 2015b). A summary of the criteria and included here.

According to Chapter 5 of the *Maryland Stormwater Design Manual*, to receive credit for disconnection, the follow criteria must be met:

Rooftop Runoff Disconnection Credit Criteria

- In residential development applications, disconnections will only be credited for lot sizes greater than 6,000 square feet.
- The length of the "disconnection" shall be 75 feet or greater.
- Dry wells, french drains, rain gardens, or other similar storage devices may be utilized to compensate for areas with disconnection lengths less than 75 feet.
- The entire vegetative "disconnection" shall be on an average slope of 5% or less.
- Rooftop cannot be within a designated hotspot.
- Disconnection shall cause no basement seepage.
- The contributing area of rooftop to each disconnected discharge shall be 500 square feet or less.
- The disconnection must drain continuously through a vegetated channel, swale, or through a filter strip to the property line or BMP.
- For those rooftops draining directly to a buffer, only the rooftop disconnection credit or the buffer credit may be used, not both.

Non-Rooftop Runoff Disconnection Credit Criteria

- Runoff cannot come from a designated hotspot.

- The maximum contributing impervious flow path length shall be 75 feet.
- The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or BMP.
- The length of the "disconnection" must be equal to or greater than the contributing length.
- The entire vegetative "disconnection" shall be on an average slope of 5% or less.
- The surface impervious area to any one discharge location cannot exceed 1,000 sq. ft.
- Disconnections are encouraged on relatively permeable soils (HSG's A and B).
- If the site cannot meet the required disconnect length, a spreading device, such as a french drain, rain garden, gravel trench or other storage device may be needed for compensation.
- For those areas draining directly to a buffer, only the non-rooftop disconnection credit or the stream buffer credit can be used, not both.

Impervious surfaces located within existing stormwater BMP drainage areas were removed from the analysis so as to not double count the impervious treatment credited.

Enhanced IDDE

Howard County is piloting a program in fall 2017 collecting water quality grab samples from discharging outfalls inspected for the IDDE program. Nutrient loads identified and remediated can be credited.

Street Sweeping

Street sweeping is a source control operational program that the County has managed since 1996 to reduce pollutant loads. According to MDE's guidance document (2014a), mechanical street sweeping credits can be tabulated using a mass loading approach based on the relationship between tons of material physically removed and lbs of pollutant per ton of material. Rates used in the calculations are: TN = 3.5 lbs/ton, TP = 1.4 lbs/ton, and TSS = 420 lbs/ton. Impervious credits are calculated as 0.40 equivalent acres treated per ton of material collected.

Currently, the County uses mechanical broom sweepers (MBS) to sweep roads with curbs and gutters four times each year and records the tons collected through street sweeping efforts. Tons collected are then prorated by watershed using the proportion of roads swept throughout each watershed to total County road length. FY17 road length and tons swept listed per watershed are shown Section 4.1. Since the County recorded tons swept, pollutant reductions were calculated based on a mass loading approach and represent the actual amount of pollutants removed from the County in FY17 by street sweeping. For impervious restoration credit and pollutant load reduction calculations the County is using an average of the tons/yr from the last five years, which currently is FY13 to FY17. A new five year average will be computed each year to determine the current credits and reductions.

Inlet and Pipe Cleaning

Howard County's Bureau of Highways conducts clean-outs of catch basins, inlets, stormdrain systems and outfall pipes. This is an annual practice that is repeated each year to maintain the credit. FY17 is the first year that the County has maintained adequate records to tabulate results, with date, location, and volume of material collected. According to MDE's guidance document (2014a), this practice (also termed storm drain vacuuming) is credited on a mass loading basis using the same equivalents used as for street sweeping: TN = 3.5 lbs/ton, TP = 1.4 lbs/ton, and TSS = 420 lbs/ton. Impervious credits are calculated as 0.40 equivalent acres treated per ton of material collected.

Septic Systems

Septic system maintenance (pump-outs), upgrades and waste water treatment plant connections are methods to reduce impacts from septic systems, especially for nitrogen as septic systems can be a major contributor of nitrogen. Credits for TN, TP and TSS for septic system maintenance are not given for the urban stormwater sector. Pollution removal credits to the County for septic maintenance would fall under the waste water sector and are therefore not accounted for in the CIS which focuses on the stormwater sector.

Credit for impervious surface restoration, however, is available for three septic system activities. Septic pump-outs, that are part of a regular septic system maintenance program, provide 0.03 equivalent acres of restoration when a system is maintained and verified annually. Septic upgrades to install enhanced septic denitrification technologies result in a permanent credit of 0.26 equivalent acres for each upgrade completed. Additionally, 0.39 equivalent acres would be credited for each septic system connected to a WWTP.

Howard County maintains data on the number of septic upgrades on an annual basis, completed largely through the Bay Restoration Fund (BRF) grant program. In total 231 upgrades were completed between FY11 and FY17. Replacement or upgrades of failed septic systems are also an alternative for reducing bacteria in a watershed, although, it addresses the LA and not the WLA of a TMDL. Each upgrade reduces bacteria loads by approximately 2 billion MPN/100mL/yr.

Howard County in 2017 compiled septic pump-out data based on septage hauling and disposal records and manifests. Approximately 7,000 unique units were pumped between FY13 and FY17 based on the compiled data. Because Howard County watersheds are not located within the Chesapeake Bay Critical Area, a rolling five year period is being used for septic pump-out crediting. In 2017 Howard County implemented a septic maintenance rebate program, called Septic Savers, led by the Office of Community Sustainability with assistance from Department of Public Works and the Health Department. This program was created to encourage and help document the number of septic pump-outs completed per year. The County will pay for a third of the pump-outs to start. Pump-outs are credited for impervious surface treatment at a rate of 0.03 equivalent acres for every unit participating. The practice is considered an annual credit that needs to be maintained with regular annual pump-out. Septics programs are discussed further in Sections 4, 5, and 7.

Forest Conservation/Reforestation Program

This program began in 1996 and provides developers, who do not have the room to do their forest conservation "on-site", the option to pay a fee-in-lieu to the County. A portion of this fee is passed on to the Department of Recreation & Parks, Natural Resources Division to perform the mitigation. The Department, which manages over 8,000 acres, determines where the trees are most needed. The County's first priority is planting and enhancing riparian forest buffers.

Stream ReLeaf

The Stream ReLeaf Program was initiated by the Howard County Stormwater Management Division (Department of Public Works) in 2003 as part of the implementation of the Little Patuxent River Watershed Restoration Action Strategy. The Program has grown and expanded in scope significantly over the years, and is now managed by the Natural Resources Division of the Department of Recreation and Parks.

Stream ReLeaf is a program designed to enhance riparian (stream) buffers by providing free native trees and shrubs to homeowners. The homeowner commits to planting the trees and shrubs on their property and the County delivers the requested plants. Requirements for the program are as follows: the area that the homeowner is willing to plant must be within 75 feet of a stream (rights of ways are not eligible); and the homeowner must commit to planting at least 12 trees.

Pet Waste Management

The Bark Ranger Program. In the summer of 2013, the Park Rangers of Howard County Recreation and Parks implemented a new program to address loads from domestic animals. "Bark Ranger" encourages patrons to clean up after their pets, more specifically dogs, and to use a leash while visiting Howard County parks. Dog feces not picked up is unsightly, negatively impacts ground and surface water, and attracts rodents. Currently the program has 1,400 participants signed up for the program.

Nutrients, sediment, and bacteria can be modeled as a load reduction BMP using parameters for the number of owners who clean up along with a calculation of the delivered load per dog. Forecasts of program expansion can be estimated with data from surveys that estimate the number of dogs in a watershed, and a proportion of dog owners willing to change their behavior.

Pet Waste Outreach / Education. Pet waste outreach programs include education efforts which increase public recognition about the water quality and health problems from consequences of dog waste. They may also include more active approaches including establishing dog parks and providing bags and disposal facilities in residential common areas.

A number of jurisdictions have established outreach programs that include these activities and more. A comprehensive outreach plan would include developing partnerships with pet stores, veterinarians, pet rescue organizations, and others. These partners could assist in disseminating information to dog owners targeted to the affected watersheds.

Specific outreach materials could include the following:

- Inserts in HOA newsletters
- Presentations at community meetings
- Posters at neighborhood stores
- Door hangers in targeted neighborhoods
- Giveaways for dog owners
- Signs and brochures at pet stores and other partner organizations
- Public service announcements on radio and television
- Website information

Pet waste stations are a form of outreach that can be targeted at specific locations where a problem is identified. These stations include a bag dispenser and receptacle for disposal. Their benefit is not only education, but reduction of pet waste on site by making it easier for dog walkers to clean up.

Potential locations include:

- Common areas of apartment complexes and subdivisions
- Open space adjacent to partner organizations
- Walking trails
- County parks

Costs are highly variable and depend on how intensive the outreach program becomes. Montgomery County MD implemented a multi-year program of partnerships, sponsors, outreach, education, signs, and pet waste stations for $240,500. Costs of individual items can vary as well. For example, pet waste stations have been reported to cost in the range of $60 to $200 each. A more accurate estimate will depend on the first steps of program planning.

Wildlife Management

The following two programs are in place in the County. These are presented for supplemental and informational purposes only. These programs have the capability to reduce bacteria loads related to the non-point source load allocation in the 8-digit watershed; however, load reductions from urban wildlife are not required by the TMDL, and therefore reductions from these programs have not been calculated and have not been applied to meeting the SW-WLA.

Canada Goose Management Program. Dealing with high population levels of resident Canada geese, mallards and illegally released domestic waterfowl is an ongoing problem on Recreation and Parks lands. The County currently treats goose nests at Centennial Lake and Font Hill under a federal permit that allows eggs to be coated with vegetable oil to prevent hatching. In addition to nest treatment, the Department continues to address this issue through an integrated approach that includes public education, habitat modification, behavior modification, and population reduction.

Deer Population Management in Howard County Parks. Managed deer hunts take place on prescheduled dates from October until February and are a response to continuing damage to trees, shrubs and groundcover in the parks from deer browsing. Without management, the current trends will continue causing degradation of forest shrubs and ground cover layers. Long-term forest health will also be impacted since replacement of mature canopy trees would be reduced or eliminated through destruction of seedling stock. These impacts have been documented on these properties, and are well confirmed in scientific literature.

Rain Barrel Program

Howard County continues to provide residents with free barrels through the County's Rain Barrel Program. Predrilled rain barrels are available free of charge to residents who attend seminars at the Alpha Ridge landfill. Residents purchase the hardware needed and Master Gardeners provide free instruction on how to assemble the rain barrels. A total of 586 rain barrels have been given away within the past four years. Pollutant reduction for existing rain barrels are modeled as an ESD micro scale practice using the impervious surface reduction BMP type in MAST. Credit for future planned implementation is given for pollutant reduction using land use loading rates with treatment percentages following removal curves in MDE guidance (MDE, 2014c). Impervious surface treatment is based on the square feet and inches of rainfall treated per rain barrel, with a 0.75 factor applied relating rain barrels to impervious surface treatment (Goulet and Schueler, 2014).

Rain Gardens

For the past two years, the County has provided funding for the Howard EcoWorks (formerly the READY program). Led by the Alliance for the Chesapeake Bay, People Acting Together in Howard (PATH), Parks and People Foundation, and the University of Maryland Extension Service, Howard EcoWorks teaches young adults about environmental issues, trains them to build water quality projects, asks them to give presentations throughout the community, and has them install local projects. This program uses college students and community associations to create rain gardens and other stormwater enhancements at

churches, schools and open space areas. The County assists by excavating areas where the rain gardens are to be installed for an eight-week period during the summer.

The measured effectiveness and impervious equivalency for each of these practices may be found in Table 20 and Table 21.

Table 20. Typical Pollutant Reductions from Structural and Non-Structural BMPs

BMP	Nitrogen	Phosphorus	Sediment	Bacteria
Bioretention A/B soils	70%	75%	80%	70%
Bioretention C/D soils	25%	45%	55%	70%
Bioswales	70%	75%	80%	-5%
Dry Detention Ponds	5%	10%	10%	66%
Dry Extended Detention Ponds	20%	20%	60%	60%
Impervious Surface Reduction[1]	-	-	-	-
Infiltration w/ sand, veg.	85%	85%	95%	90%
Infiltration w/o sand, veg.	80%	85%	95%	90%
Outfall Enhancement with SPSC[2]	50%	60%	90%	70%
Permeable Pavement w/ sand, veg.	80%	80%	85%	-
Permeable Pavement w/o sand, veg.	75%	80%	85%	-
Septic Systems (pumping, upgrades, connections)[3]	0%	0%	0%	1.9 billion MPN/ 100mL each
Stream Restoration (lbs/linear ft)[4]	0.075	0.068	44.88	-
Street Sweeping (lbs/ton)	3.5	1.4	420	-
Inlet and Pipe Cleaning (lbs/ton)	3.5	1.4	420	-
Urban Filtering	40%	60%	80%	60%
Urban Tree Plantings*	-	-	-	-
Vegetated Open Channels	45%	45%	70%	-
Wet Ponds or Wetlands	20%	45%	60%	95%

Sources: MDE, 2014c; MAST documentation; International SW BMP Database, Watershed Treatment Model

1) Calculated as a land use change to a lower loading land use

2) Outfall enhancement with SPSC modeled as SW to the MEP in MAST for nutrients and sediment and as sand filters for bacteria

3) No pollutant removal credit given for septics for the stormwater sector. Bacteria reductions for upgrades and connections, not pumping.

4) Interim rates shown. Stream restoration projects as of 2015 now use Protocols 1-3 of the Bay Program's Expert Panel recommendations (CBP, 2014).

Table 21. Impervious Acre Equivalent for Structural and Non-Structural BMPs

BMP	Treatment Unit	Impervious Acre Equivalent*
Bioretention A/B soils	WQv (provided)/WQv (required)	1.00
Bioretention C/D soils	WQv (provided)/WQv (required)	1.00
Bioswales	WQv (provided)/WQv (required)	1.00
Dry Detention Ponds	WQv (provided)/WQv (required)	0.00
Dry Extended Detention Ponds	WQv (provided)/WQv (required)	0.00
Impervious Surface Reduction	Per acre disconnected or removed	0.75
Infiltration	WQv (provided)/WQv (required)	1.00

BMP	Treatment Unit	Impervious Acre Equivalent*
Outfall Stabilization	WQv (provided)/WQv (required)	0.01
Permeable Pavement	WQv (provided)/WQv (required)	0.75
Rain barrel	WQv (provided)/WQv (required)	0.75
Septic pump-outs	Per unit (annual practice)	0.03
Septic Upgrades (denitrification)	Per unit	0.26
Step Pool Storm Conveyance (SPSC)	WQv (provided)/WQv (required)	1.00
Stream Restoration	Linear foot	0.01
Street Sweeping	Dry ton removed	0.40
Inlet and Pipe Cleaning	Dry ton removed	0.40
Urban Filtering	WQv (provided)/WQv (required)	1.00
Urban Tree Plantings	Acres planted	0.38
Vegetated Open Channels	WQv (provided)/WQv (required)	1.00
Wet Ponds or Wetlands	WQv (provided)/WQv (required)	1.00

Source: MDE, 2014c

*Assuming full 1-inch rainfall treatment, full WQv is provided. Acres of impervious in BMP drainage area is multiplied by the equivalent acres to determine credited acres

4 Expected Load Reductions and Impervious Treatment

4.1 2017 Progress – Actual Implementation

Howard County maintains an extensive geodatabase of urban stormwater BMP facilities and water quality improvement projects. Current BMP implementation through June 30, 2017 is shown in Table 22. The treatment provided through current BMP implementation towards the County's local TMDL, impervious treatment, and Bay TMDL goals are shown in the sections below.

4.1.1 Local TMDLs

2017 Progress results are shown in Table 23 with modeling terminology defined below. This modeling terminology is also used in Table 24, which presents Chesapeake Bay TMDL 2017 Progress results.

- **Calibrated Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from baseline year conditions in the Howard County MS4 source sector for each SW-WLA calibrated to BayFAST CBP v.5.3.2. Baseline years vary by local TMDL (as presented in Table 23). Patapsco River Lower North Branch bacteria baseline disaggregated according to County MS4 urban land area within the watershed.
- **Target Percent Reductions**: Percent reductions assigned to Howard County Phase I MS4 stormwater sector (http://wlat.mde.state.md.us/ByMS4.aspx).
- **Calibrated Target Reductions:** Target reduction calibrated to BayFAST CBP v.5.3.2 by multiplying the reduction percent published by the calibrated baseline load. Patapsco River Lower North Branch bacteria load reduction disaggregated according to County MS4 urban land area within the watershed.
- **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). Patapsco River Lower North Branch bacteria WLA disaggregated according to County MS4 urban land area within the watershed.

- **Restoration Reduction**: Load reductions from restoration BMPs with a built date after the baseline to 2017.
- **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.

Progress as of 2017 is good across the watersheds. Baltimore Harbor, which encompasses Patapsco River Lower North Branch, and South Branch Patapsco, has achieved 5.5% TN reduction or approximately 37% of the goal and 14.2% reduction for TP, very close to the 15.0% goal. The Patuxent River is showing a 32.8% TSS reduction on a goal of 48.1%. The Patapsco River Lower North Branch appears to have achieved the TSS goal as of FY17 progress, exceeding the 10% goal by 1%; however work still remains on the bacteria loading with only 1.4% treated. Sediment reduction in the Patuxent River Upper is at 66% of the goal with only 3.9% reduction remaining. Rocky Gorge and Triadelphia Reservoir are at 60% and 40% of their 15% TP reductions respectively.

Table 22. Current BMP Implementation through 2017

		Baltimore Harbor[1]		Little Patuxent River		Patapsco River Lower North Branch - Sediment		Patapsco River Lower North Branch - Bacteria		Patuxent River Upper		Rocky Gorge Reservoir		Brighton Dam	
BMP	Unit	1995 Baseline	Restoration	2005 Baseline	Restoration	2005 Baseline	Restoration	2003 Baseline[2]	Restoration[3]	2005 Baseline	Restoration	2000 Baseline	Restoration	2000 Baseline	Restoration
Bioretention	DA acres	9.7	26.6	50.0	53.7	63.8	25.9	n/a	103.2	1.0		12.1	0.2	3.0	10.1
Bioswale	DA acres	5.0		81.2	0.3	32.5		n/a				107.8		5.0	
Dry Detention Ponds[4]	DA acres	1,097.5		3,432.4	32.0	1,702.6		n/a	1.0	224.4		19.0		95.1	
Extended Dry Detention Ponds[4]	DA acres	354.5	27.4	1,062.0	68.9	910.6	27.4	n/a		172.9				47.3	
Impervious Surface Reduction	DA acres	0.02	0.2	0.02	46.2	0.02	0.2	n/a	0.5					0.01	
Infiltration w/ sand, veg.	DA acres	41.4		115.1	47.8	133.5		n/a		1.3				25.0	
Infiltration w/o sand, veg.	DA acres	254.4		198.3	0.3	298.3		n/a		18.9		18.4		136.0	
Lakes	DA acres	292.5		6,792.4		292.5		n/a							
Non-Rooftop Disconnect	Impervious acres	164.3		147.8		88.6		n/a		7.8		42.7		176.2	
Outfall Enhancement w/ SPSC	DA acres		9.7		69.3		9.7	n/a							
Outfall Stabilization	Linear feet		170.7				170.7	n/a	35.9						
Permeable Pavement w/o sand, veg.	DA acres		0.4		0.2		0.4	n/a							
Rain Barrels	No. of barrels		227.0		461.0		203.0	n/a			18.0		25.0		62.0
Rooftop Disconnect	Impervious acres	65.3		163.5		44.7		n/a		5.5		12.9		55.7	
Septic Connections	No. of units				4.0			n/a							
Septic Upgrades	No. of units		22.0		24.0		10.0	n/a					10.0		54.0
Storm Drain Vacuuming	Tons removed							n/a	3.6						
Stream Restoration	Linear feet		1,557.1	959.0	23,318.2		1,557.1	n/a	1,353.5		100.0		321.0		
Street Sweeping[5]	Tons swept		193.4		374.5		173.7	n/a	5.7		17.6		40.0		44.7
Urban Filtering	DA acres	5.7	9.2	32.7	10.0	40.2	9.2	n/a		0.2					
Urban Tree Plantings	Acres planted		336.7	85.3	44.4	38.9	154.0	n/a	37.7		0.4	1.1	26.1	13.8	439.8
Vegetated Open Channels	DA acres			0.4				n/a							
Wet Ponds or Wetlands	DA acres	930.5	40.7	3,412.5	553.2	1,800.6	40.7	n/a	21.0	254.2		155.3		506.1	

1) Baltimore Harbor includes BMPs located within Patapsco River Lower North and South Branch Patapsco watersheds
2) 2003 bacteria baseline loads for Patapsco River Lower North Branch local TMDL were calculated from disaggregation of the TMDL for Howard County's portion of the subwatershed PAT0148. See Section 1.2.1 for details.
3) All restoration practices in the watershed are included, however reductions are only calculated for those practices with bacteria reduction efficiencies listed in Table 20.
4) Dry detention ponds and extended dry detention ponds do not contribute to restoration load reductions
5) Street sweeping is an annual practice but averaged over a 5-yr period. Tons swept represent FY13-FY17 results.

Table 23. Local TMDL 2017 Progress Reductions Achieved

	Baltimore Harbor		Little Patuxent River	Patapsco River Lower North Branch		Patuxent River Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)
	TN- EOS lbs	TP- EOS lbs	TSS- EOS lbs	TSS- EOS lbs	Billion MPN/yr	TSS- EOS lbs	TP- EOS lbs	TP- EOS lbs
Baseline Loads and Target Reductions								
TMDL Baseline Year	1995	1995	2005	2005	2003	2005	2000	2000
Calibrated Baseline Load	107,059	6,546	10,346,821	6,123,442	21,826	145,902	861	2,654
Target Percent Reduction	15.0%	15.0%	48.1%	10.0%	75.0%	11.4%	15.0%	15.0%
Calibrated Target Reduction	16,059	982	4,976,821	612,344	16,370	16,633	129	398
Calibrated TMDL WLA	91,000	5,564	5,370,000	5,511,098	5,457	129,269	732	2,256
2017 Progress Reductions								
Restoration Reduction (from baseline to 2017)	5,912	929	3,398,711	671,611	306	10,965	78	158
Restoration Reduction Percent	5.5%	14.2%	32.8%	11.0%	1.4%	7.5%	9.0%	6.0%
Reduction Remaining for Treatment	10,147	52	1,578,110	-59,267	16,064	5,668	52	240
Reduction Percent Remaining	9.5%	0.8%	15.3%	-1.0%	73.6%	3.9%	6.0%	9.0%

4.1.2 Chesapeake Bay TMDL

2017 Progress results are shown in Table 24. As mentioned in previous plan sections, Howard County is meeting its Bay TMDL responsibilities through the 20% impervious surface restoration; therefore the Bay TMDL targets and reductions shown here are for informational purposes only.

Table 24. Bay TMDL 2016 Progress Reductions Achieved

	TN-EOS lbs/yr	TN-DEL lbs/yr	TP-EOS lbs/yr	TP-DEL lbs/yr	TSS-EOS lbs/yr	TSS-DEL lbs/yr
Baseline Loads and Target Reductions						
Calibrated 2010 Baseline Load	566,350	319,997	27,609	14,300	26,344,338	20,262,457
Target Percent Reduction	11.98%	12.00%	20.72%	19.74%	-	-
Calibrated Target Reduction	67,849	38,400	5,721	2,823	-	-
Calibrated Bay TMDL WLA	498,501	281,597	21,889	11,477	-	-
2017 Progress Reductions						
Restoration Reductions (from baseline through FY17)	17,493	9,987	4,686	2,512	4,208,666	3,378,522
Restoration Reduction Percent	3.1%	3.1%	17.0%	17.6%	16.0%	16.7%
Reduction Remaining for Treatment	50,356	28,413	1,035	311	-	-
Reduction Percent Remaining	8.9%	8.9%	3.7%	2.2%	-	-

4.1.3 Impervious Restoration

2017 Progress results are shown in Table 25. The table builds on the impervious accounting information included in Table 5 in previous sections, but adds the restoration progress completed between June 20, 2010 and June 30, 2017. Results are provided at the watershed level for informational purposes only and to aid in planning and targeting future restoration efforts, the 20% requirement is to be met at the County scale, not at the watershed scale. Credits are divided between 'permanent' credits for installation of facilities or restoration practices (street sweeping, pond retrofit etc.) versus annual practices that are accounted for each year. **The results indicate that the County has 1,433.5 impervious acres of restoration to apply to its 20% goal, leaving 1,026.4 acres of impervious restoration to be completed by the end of the permit term in December, 2019.**

Table 25. Impervious Restoration 2017 Progress per Watershed

	Brighton Dam	Little Patuxent River	Middle Patuxent River	Patapsco River L N Branch	Patuxent River Upper	Rocky Gorge Dam	South Branch Patapsco	Countywide
Impervious Baseline Untreated								**12,299.2**
20% Restoration Target								**2,459.8**
Impervious Restoration and FY16 Progress (Impervious Credit Acres, 6/20/2010 through FY16)								
Restoration BMPs	70.1	355.5	187.3	54.2	0.04	2.7	6.2	676.0
Septic Connections								2.0
Septic Upgrades								43.4
FY16 Subtotal	**70.1**	**355.5**	**187.3**	**54.2**	**0.0**	**2.7**	**6.2**	**721.4**
Impervious Restoration FY17 Credits (Impervious Credit Acres, 7/1/2016 to 6/30/2017)								
Stormwater BMP	0.5	63.5	14.7	12.9		0.3		91.7
Stream Restoration		31.1	1.0	53.3				85.4
Outfall Stabilization		3.5	0.9	4.1				8.4
Tree Planting	0.5	0.1	0.7	0.6		0.1		2.1
Septic Connections								2.3
Septic Upgrades								16.6
FY17 Subtotal	**0.9**	**98.2**	**17.3**	**70.9**	**0.0**	**0.4**	**0.0**	**206.6**
FY17 Progress	**71.1**	**453.7**	**204.6**	**125.0**	**0.0**	**3.1**	**6.2**	**928.0**
Impervious Restoration Annual Credit Practices as of FY17 (6/30/2017)								
Inlet and Pipe Cleaning (annual)	0.0	22.1	1.0	9.6	1.0	1.0	0.0	34.6
Street Sweeping (annual)								293.0
Septic Pump-outs (5 yr period)								177.8
FY17 Subtotal (annual credits)	**0.0**	**22.1**	**1.0**	**9.6**	**1.0**	**1.0**	**0.0**	**505.5**
Total Impervious Restoration FY17 Progress - All Credits								
Total Impervious Restoration	**71.1**	**475.8**	**205.6**	**134.6**	**1.0**	**4.1**	**6.2**	**1,433.5**
% Impervious Treated								**11.7%**
Remaining Restoration								**1,026.4**

4.2 Planned Implementation

A large majority of the planned projects and programs include structural practices to be implemented by Howard County DPW. In addition several non-structural programs are included.

Structural Practices

Table 26 displays planned levels of implementation including FY18, FY19 and FY20 planned projects, project concepts developed in 2015 and 2016 as a result of watershed assessments throughout the County, and additional pending projects needed to meet the goals. Appendix 3 includes a list of currently identified projects for the FY18-FY20. The number of projects and provided treatment were estimated for pending concepts using concepts developed from the 2015 and 2016 watershed assessments. Using the distribution of number of projects for each BMP type (i.e., BMP conversion, new BMP, outfall stabilization, stream restoration, and tree planting), the average amount of treatment provided in drainage area or linear feet was calculated. Average impervious credit and TN, TP, and TSS reductions were calculated from the average amount of treatment per project. Pending projects were distributed based on local TMDL requirements and progress achieved from current BMP implementation. Refer to the appendices of each watershed assessment report for information on individual project concepts.

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

Non-Structural and Homeowner Practices

In addition to these structural BMPs, several non-structural programs are emphasized including rain barrels, septic systems, and street sweeping / inlet pipe cleaning. Treatment credits for these programs are included for impervious surfaces in Table 30.

Rain barrels are planned to be installed at a rate of 100 per year, a slightly conservative estimate based on an average rain barrel installation rate of approximately 135 per year over the period from 2010 to 2015.

Septic upgrades to denitrification systems are also planned at a rate of 30 per year based on an average rate of 33 per year from FY11 to FY17. It is expected that Howard County's Septic Savers program will continue to yield approximately 170 credit acres each year using the previous rolling 5-year timespan for crediting. Septic connections are performed at a slower pace and are expected to yield 2 credit acres over the next 3-year period.

Street sweeping and inlet cleaning are expected to continue at the current pace (300 and 30 credit acres respectively); however increased emphasis on inlet cleaning in particular may occur due to the cost effectiveness of the practice.

Table 26. BMP Implementation - Planned Levels for Howard County

		BMP Conversion (ac)	New BMP (ac)	Outfall Stabilization (lf)	Stream Restoration (lf)	Urban Tree Plantings (ac)	Total Number of Projects
Countywide							
FY18 Credit Year	# of Projects	4	3	4	13	0	24
	Area or Length Treated	18.9	27.7	0	22,922	0	
FY19 Credit Year	# of Projects	3	4	1	13	0	21
	Area or Length Treated	27.0	53.8	200.0	17,512	0	
FY20 Credit Year	# of Projects	5	0	0	7	0	12
	Area or Length Treated	131.2	0.0	0.0	8480	0.0	
2015 Concepts - Inventory	# of Projects	3	3	1	8	5	20
	Area or Length Treated	88.2	23.8	196.8	16,394.6	27.3	
2016 Concepts - Inventory	# of Projects	39	10	43	50	12	136
	Area or Length Treated	954.2	26.0	2861.0	80,768.0	39.9	
Additional Projects	# of Projects	6	0	0	5	0	11
	Area or Length Treated	149.2	0.0	0.0	15,564.9	0.0	
Total	# of Projects	60	20	49	96	17	224
	Area or Length Treated	1,237.5	131.3	3,257.8	153,161.5	67.2	

4.2.1 Local TMDLs

Table 27 displays local TMDL loads with current and planned BMP practices. Planned accounting and modeling terminology is described below. This terminology is also used in Table 28, which presents Chesapeake Bay TMDL Planned results.

- **Planned Reductions**: The sum of loads treated by FY18-FY20 planned projects, project concepts developed in 2015 and 2016 as a result of watershed assessments, and pending concepts.
- **Reduction (Current + Planned)**: The sum of loads treated from restoration BMPs with a built date after the baseline to 2017 (i.e., 2017 Progress Reductions) and Planned Reductions.
- **Reduction Percent (Current + Planned)**: The percent difference of the baseline load and the Reduction (Current + Planned).
- **Reduction Remaining for Treatment**: The difference between the calibrated TMDL WLA target reduction and the Reduction (Current + Planned). A negative number means the target reduction is exceeded by the plan.

Table 27 below represents the progress that would be made once planned reductions from projects in Table 26 above are implemented. With this level of implementation all local TMDLs would be met (see Figure 8). Some TMDLs are far exceeded because removals per pollutant type are not achieved at the same rate. TN removal rates are relatively low compared to TP and TSS on a per project basis. Therefore the number of projects needed to meet the Baltimore Harbor TN reduction goal resulted in overachieving on the TP reduction, and the TSS reduction in the Patapsco River LNB which is nested in the Baltimore Harbor watershed.

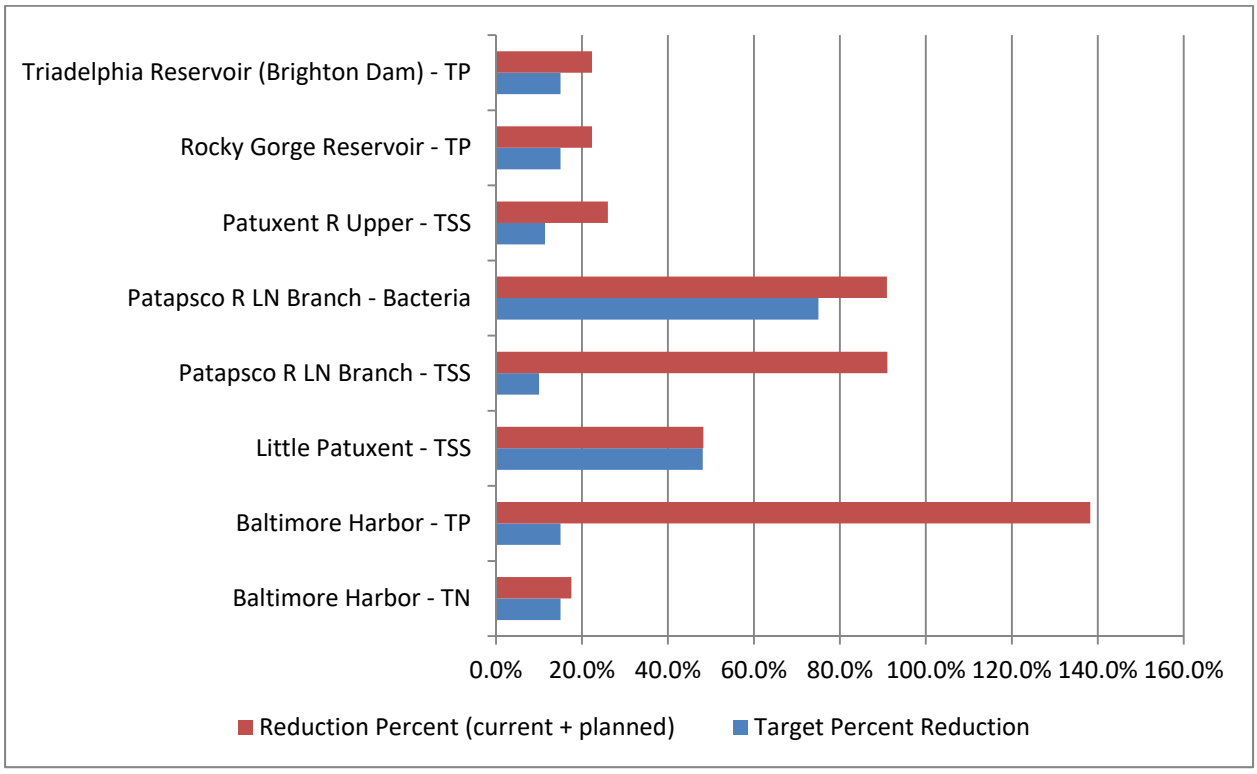


Figure 8. Percent reduction required and planned per watershed

Table 27. Local TMDL Reductions with Planned Implementation

	Baltimore Harbor		Little Patuxent	Patapsco R LN Branch		Patuxent R Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)
	TN-EOS lbs/yr	TP-EOS lbs/yr	TSS-EOS lbs/yr	TSS-EOS lbs/yr	Bacteria MPN/100mL/yr	TSS-EOS lbs/yr	TP-EOS lbs/yr	TP-EOS lbs/yr
Reduction Targets								
TMDL Baseline Year	1995	1995	2005	2005	2003	2005	2000	2000
Baseline Load	107,059	6,546	10,346,821	6,123,442	21,826	145,902	861	2,654
Target Percent Reduction	15.0%	15.0%	48.1%	10.0%	75.0%	11.4%	15.0%	15.0%
Calibrated Target Reduction	16,059	982	4,976,821	612,344	16,370	16,633	129	398
Calibrated TMDL WLA	91,000	5,564	5,370,000	5,511,098	5,457	129,269	732	2,256
Current Reductions – 2017 Progress								
Restoration Reductions (from baseline to present)	5,912	929	3,398,711	671,611	304	10,965	78	158
Restoration BMPs	*5,235*	*659*	*3,241,404*	*598,662*	*304*	*4,526*	*29*	*104*
Street Sweeping	*677*	*271*	*157,307*	*72,949*	*0*	*6,439*	*49*	*55*
Restoration Reduction Percent	5.5%	14.2%	32.8%	11.0%	1.4%	7.5%	9.0%	6.0%
Reduction Remaining	10,147	52	1,578,110	-59,267	16,066	5,668	52	240
Reduction Percent Remaining	9.5%	0.8%	15.3%	-1.0%	73.6%	3.9%	6.0%	9.0%
Planned Reductions								
Planned Reductions	12,857	8,121	1,594,324	4,903,764	19,545	27,000	115	435
FY18 Credit Year	*860*	*740*	*63,080*	*495,466*	*-*	*-*		*435*
FY19 Credit Year	*781*	*589*	*273,259*	*409,554*	*31*	*27,000*	*57*	*-*
FY20 Credit Year	*552*	*305*	*206,664*	*232,547*				
2015 Concepts - Inventory	*-*	*-*	*1,051,321*	*-*	*-*	*-*	*-*	*-*
2016 Concepts - Inventory	*9,620*	*5,887*	*-*	*3,510,962*	*2,864*	*-*	*57*	*-*
Additional Placeholder Projects	*1,044*	*601*	*-*	*255,234*	*280*	*-*	*-*	*-*
Pet Waste					*16,370*			

	Baltimore Harbor		Little Patuxent	Patapsco R LN Branch		Patuxent R Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)
	TN-EOS lbs/yr	TP-EOS lbs/yr	TSS-EOS lbs/yr	TSS-EOS lbs/yr	Bacteria MPN/100mL/yr	TSS-EOS lbs/yr	TP-EOS lbs/yr	TP-EOS lbs/yr
Restoration Reduction Percent	12.0%	124.1%	15.4%	80.1%	89.5%	18.5%	13.3%	16.4%
Totals (Current + Planned)								
Reduction (current + planned)	18,769	9,051	4,993,034	5,575,374	19,849	37,965	192	593
Reduction Percent (current + planned)	17.5%	138.3%	48.3%	91.0%	90.9%	26.0%	22.3%	22.4%
Planned Load	88,290	-2,505	5,353,787	548,068	1,977	107,937	669	2,061
Reduction Remaining for Treatment	-2,710	-8,069	-16,214	-4,963,030	-3,480	-21,332	-63	-195

4.2.2 Chesapeake Bay TMDL

Table 28 represents the progress towards the Bay TMDL reduction targets that would be made by 2025 once planned reductions from projects in Table 26 are implemented. Howard County's stormwater sector is required by its MS4 NPDES permit to meet the Bay TMDL requirements by completion of the 20% impervious surface restoration; however the Bay TMDL nutrient reductions have been tabulated here for general comparison. While the 20% goal is required by 2019, the Bay TMDL timeline is 2025, therefore it was determined that providing the reductions with implementation through 2025 would be most useful. With implementation of the projects and programs in the CIS the Bay TN reductions would not be met, but the TP reductions would be met. Based on accepted Bay TMDL accounting protocol, TSS is assumed to be met as the TP goal is met because the two parameters are closely related. Howard County's local TMDLs are largely TP and TSS, with only one TN TMDL. As described above, BMPs generally reduce TP and TSS at a higher rate than TN, therefore the local TMDLs required fewer BMPs to meet the TP and TSS goals than it would have if more TN TMDLs were in place.

Table 28. Bay TMDL Reductions with Planned Implementation

	TN-EOS lbs/yr	TN-DEL lbs/yr	TP-EOS lbs/yr	TP-DEL lbs/yr	TSS-EOS lbs/yr	TSS-DEL lbs/yr
Baseline and Targets						
Calibrated 2010 Baseline Load	566,350	319,997	27,609	14,300	26,344,338	20,262,457
Target Percent Reduction	11.98%	12.00%	20.72%	19.74%	-	-
Calibrated Target Reduction	67,849	38,400	5,721	2,823	-	-
Calibrated Bay TMDL WLA	498,501	281,597	21,889	11,477	-	-
2017 Progress Reductions						
Restoration Reductions	17,493	9,987	4,686	2,512	4,208,666	3,378,522
Restoration Reduction Percent	3.1%	3.1%	17.0%	17.6%	16.0%	16.7%
Reduction Remaining	50,356	28,413	1,035	311	-	-
Reduction Percent Remaining	8.9%	8.9%	3.7%	2.2%	-	-
Planned Reductions						
Planned Reductions	17,265	9,857	10,953	5,872	7,649,381	6,140,569
FY18 Credit Year	*2,253*	*1,286*	*1,634*	*876*	*1,071,547*	*860,188*
FY19 Credit Year	*1,419*	*810*	*1,100*	*590*	*754,712*	*605,847*
FY20 Credit Year	*1,074*	*613*	*632*	*339*	*461,712*	*370,641*
2015 Concepts - Inventory	*1,940*	*1,108*	*1,177*	*631*	*812,628*	*652,340*
2016 Concepts - Inventory	*9,534*	*5,443*	*5,810*	*3,114*	*4,230,456*	*3,396,014*
Additional Placeholder Projects	*1,044*	*596*	*601*	*322*	*318,327*	*255,538*
Planned Reduction Percent	3.0%	3.1%	39.7%	41.1%	29.0%	30.3%
Total Reductions (Current + Planned)						
Reduction (current + planned)	34,758	19,844	15,639	8,384	11,858,047	9,519,090
Reduction Percent (current + planned)	6.1%	6.2%	56.6%	58.6%	45.0%	47.0%
Planned Load	33,091	18,556	-9,919	-5,561	-	-
Reduction Remaining for Treatment	5.8%	5.8%	-35.9%	-38.9%	-	-

4.2.3 Impervious Restoration by 2019

Impervious surface restoration for 20% of the baseline untreated impervious surface acres by the end of the County's permit term. Implementation of the practices described above and included in Table 26 coupled with FY17 restoration progress will achieve 2,107.5 acres, or 17.2% of the untreated baseline. As detailed in Section 5 below, this level of restoration is dependent on the County's financial resources and the time necessary to implement such a large number of projects and programs. In addition, the County's approved 20% restoration goal, per MDE's review in April 2017, was determined to be over 400 acres larger than previously calculated. As such the County is projecting to be approximately 350 acres short of the restoration goal. Based on these constraints and the progress made to date, the County does not anticipate being able to meet the impervious surface restoration goals in the end of the permit term.

If impervious surface restoration goals are not met by the end of the County's current permit, Howard County intends to use nutrient credit trading to maintain MS4 NPDES compliance. The trading program, as detailed in Chapter 11 of the Maryland Water Quality Trading Program (COMAR Title 26, Subtitle 08 Water Pollution) defines the programs and allows Howard County to trade wastewater sector nutrient reductions (TN and TP) at the Little Patuxent Water Reclamation Plant for impervious surface restoration. These trades are done 'in time' in that they are not permanent and would need to be made up in the County's next permit term, which is currently in draft form and will include making up the credit and likely have some additional restoration required, accounted for by impervious restoration, nutrient load reductions or a combination.

Table 29 below presents the available nutrients that can be traded in time between the wastewater sector and the urban MS4 sector. The results of the last four years are shown to display the reliability of the credits. The nutrient loading is well below the allowable limit each year as a factor of high level performance at the plant, not a factor of the plant operating below permitted flow capacity. The plant is achieving treatment below the required maximum concentrations of 4.0 mg/l for TN and 0.3 mg/l for TP.

Based on urban sector loading rates for Howard County of 12.26 lb/ac/yr TN and 1.62 lb/ac/yr the County would need 4,382 lbs of credit using TN, which amounts to 3.2% of the available TN credits to achieve the 352 acres of impervious restoration expected to remain. Using TP the County would need 572 lbs of TP, or 18.0% of the available credits for the same 352 acres.

Howard County will reevaluate progress at the end of FY18 and make a determination as to whether credit trading will be used. The current understanding is that a permit modification would need to be requested in early 2019 such that trading can be added to the County's MS4 permit before the end of the term in December 2019.

Table 29. Little Patuxent Plant Available Nutrient Trading Credits

	TN	TP
Permitted Maximum Load (lbs)	309,715	23,358
2014		
2014 Annual Flow (MGD)	7,382.75	7,382.75
Max Load Based on Annual Flow (lbs)	246,289	18,472
2014 Actual Discharged Load (lbs)	116,726	16,176

Amount Below Limit (lbs)	129,563	2,296
2015		
2015 Annual Flow (MGD)	7,256.29	7,256.29
Max Load Based on Annual Flow (lbs)	242,070	18,155
2015 Actual Discharged Load (lbs)	107,788	14,324
Amount Below Limit (lbs)	134,282	3,831
2016		
2016 Annual Flow (MGD)	7106.11	7106.11
Max Load Based on Annual Flow (lbs)	235,131	17,733
2016 Actual Discharged Load (lbs)	93,952	14,665
Amount Below Limit (lbs)	141,179	3,068
2017		
2017 Annual Flow (MGD)	6,354	6,354
Max Load Based on Annual Flow (lbs)	210,795	15,897
2017 Actual Discharged Load (lbs)	73,848	12,720
Amount Below Limit (lbs)	136,947	3,177

Table 30. Planned Impervious Restoration

	Brighton Dam	Little Patuxent	Middle Patuxent	Patapsco LNB	Patuxent Upper	Rocky Gorge Dam	S Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
Impervious Baseline Untreated								**12,299.2**
20% Restoration Target								**2,459.8**
Impervious Restoration FY17 Progress (Impervious Credit Acres)								
Total Impervious Restoration	**71.1**	**475.8**	**205.6**	**134.6**	**1.0**	**4.1**	**6.2**	**1,433.5**
% Impervious Treated								**11.7%**
Restoration Remaining								**1,026.4**
Planned Impervious Restoration FY18 - FY20 (Impervious Credit Acres)								
Total Restoration BMPs	64.0	210.5	62.0	263.4	18.0	8.4	0.0	626.3
FY18 Credit Year	*64.0*	*50.0*	*51.8*	*120.8*				*286.6*
FY19 Credit Year		*82.6*	*5.2*	*109.7*	*6.0*	*8.4*		*211.9*
FY20 Credit Year		*77.9*	*5.0*	*32.9*	*12.0*			*127.8*
Rain Barrels	0.04	0.30	0.09	0.13	0.01	0.02	0.61	1.2
Septic Connections								2.0
Septic Upgrades								30.0
Total Planned Permanent								**659.5**
Inlet and Pipe Cleaning (annual)								50.0
Street Sweeping (annual)								300.0
Septic Pump-outs (5 yr period)								170.0
Total Planned Annual								**520.0**
Total Planned Impervious Restoration	**64.0**	**210.8**	**62.1**	**263.5**	**18.0**	**8.4**	**0.6**	**977.5**

Total Impervious Restoration to FY20 (Impervious Credit Acres)	
FY17 Progress	928.0
FY18-2020 Planned Permanent	659.5
FY20 Planned Annual	520.0
Projects to Cover Remaining IA	0.0
Total Impervious Restoration	2,107.5
% Impervious Treated	17.2%

5 Technical and Financial Assistance Needs

This section details the technical and financial factors required for successful implementation of the planned recommendations.

5.1 Technical Requirements

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

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

A streamlined environmental review and permitting process for County MS4 restoration projects related to NPDES MS4 impervious restoration and TMDL treatment projects is now in place. At the federal level, the recent Regional General Permit for Chesapeake Bay TMDL Activities, effective July 1, 2015 should serve to streamline the permitting process as it related to US Army Corps of Engineers review and approval. Together these permitting factors, are intended should allow for faster and more efficient implementation of projects.

Howard County also emphasizes the on-going process by MDE and the Chesapeake Bay Program, specifically in the Water Quality Goal Implementation Team and the related Urban Stormwater Workgroup, Watershed Technical Workgroup, and the Best Management Practices (BMP) Verification Committee to provide for sound BMP reduction rates and credit accounting and to continue to facilitate review and approval of BMPs not currently credited.

Technical assistance for Public Participation and Education and for Monitoring will also be necessary to fully implement and track progress towards meeting the goals of the local TMDL. These elements are discussed in Sections 6 and 9 of this plan.

5.2 Financial Needs

The cost of implementing the CIS to meet the stated goals has been estimated. It is important to note that the costs represent planning level estimates for use in high level forecast budgeting with many assumptions made. The cost estimates provided here focus on the capital costs associated with implementing the projects described in previous sections. The following presents the methods used to derive the cost estimates per project type with summaries of costs for full implementation at the watershed and County scale.

5.2.1 Project Cost Estimates – Watershed Assessment

Cost estimates used in development of the CIS for structural projects were largely derived during the 2015 watershed assessments completed for the Little and Middle Patuxent watersheds and refined in 2016 during the Patapsco and Patuxent assessments. Estimates were made during the Concept Plan development stage for each project selected for a concept. Costs were created for each project individually based on an itemized planning level cost estimate. Line item costs were derived with County and consultant input based on many years of project implementation in Howard County and were used consistently among the contractors developing the concept plans. Cost estimates included each of the following items:

- Construction Costs – listed per item needed (e.g. excavation, structures, rip-rap, sand fill, risers, trees) listed with unit costs, quantity needed (cubic yards, linear feet, each, lump sum), and extended cost and totaled for a total Construction Cost.
- Engineering and Management – including engineering, design, site topographic and property survey, required state and federal permitting and environmental clearance, geotechnical evaluations, and construction management and oversight all summed for a total Design Cost.
- Contingency – due to the many unknown site factors at the early concept stage, a 30% contingency was added to the total construction and design cost.
- Total Project Cost – includes the total of the Construction, Design, and Contingency items.

Costs not included are pre- and post-construction monitoring and life cycle costs for inspection and maintenance. These will be estimated in later planning stages. Cost estimate templates varied between project types to include the items specific to that type. Project types include: stormwater BMP conversions, new stormwater BMPs, stream restoration, outfall stabilization, outfall stabilization with step-pool stormwater conveyance (SPSC) and tree planting.

5.2.2 CIS Cost Estimate

The CIS cost estimate is broken in two planning phases. The first phase includes the next three years of planning – FY18-FY20. It is noted that at this time, the three year CIP forecast aligns with the final three years of project implementation for impervious surface restoration. The County's end of permit date is December 2019 is mid-way through FY20; therefore the FY20 period is included in the impervious restoration planning horizon. The next three years is the period for which the County has CIP plans in place and is able to forecast with some level of certainty the specific projects to be executed and when the design and constructions funds will be needed based on project schedule.

Howard County's CIP budget for FY19 is projected to be $10.5 million for project execution and $10 million for maintenance. The FY20 budget includes $12.1 million for projects and $8 million for maintenance. The CIS includes projects slated for funding, which includes both design and construction,

for FY19 to maximize the $10.5 million. Projects slated for funding in FY20 are still evolving and the list will undoubtedly changes moving forward as projects move from planning stages to encumber funds and move into design. Currently projects in the CIP track are slated to use close to $9.9 million in funds. Projects will move from inventory lists to planned lists as they are selected and the full $12.1 million will be utilized.

Planning for the period beyond the permit term is more closely linked to fulfilling the County's TMDL requirements. This is the second planning phase. Because the planning for this period is four or more years away estimates using average cost per project and per credit were used to make planning level total cost estimates per year.

Future projects that come from the 'inventory' of watershed assessment Concept Plans have fully developed cost estimates based on the specific project elements. For projects that arise from drainage complaints or other sources, cost estimates developed for the 2015 and 2016 concept plans were used to extrapolate to the few projects with gaps in cost estimates. For each project type, average costs were derived on a "per project" basis from the 2015 and 2016 data (including 328 projects). These results are included in Table 31. For example the average cost for a BMP conversion is $589,796 for an average project drainage area of 21.3 acres. The costs per project unit (per acre for stormwater BMP, per linear foot for streams and outfalls, and per acres planted) are also presented.

Table 31. Average Cost Per Project Type

BMP Type	Number of Projects	Unit	Amount	Estimated Cost	Cost per Unit (acres or lf)
BMP Conversion	67	DA acres	21.3	$589,796	$27,677
New BMP	30	DA acres	2.9	$411,139	$142,756
Outfall Stabilization	26	Linear Feet	140.2	$217,823	$1,554
Outfall - SPSC	29	Linear Feet	156.7	$373,083	$2,381
Stream Restoration	129	Linear feet	1,729.4	$1,371,505	$793
Tree Planting	47	Acres Planted	5.0	$219,519	$43,729

To aid in the planning process, costs per project type per impervious acre treated and per pound of pollutant removed were developed from the same watershed assessment concept plan cost estimate data (Table 32). In this manner, planners can determine which projects would be expected to perform the best on a $/lb or $/impervious acre basis and then use those projects to develop more efficient and cost effective plans. Outfall stabilization projects do not currently receive pollutant removal credit; therefore this project type is not expected to be recommended in future assessments. The strategy will likely still be used when an SPSC is not feasible or when a site specifically needs a more basic structural solution in response to infrastructure protection or citizen complaint needs.

Table 32. Project Cost per Removal and Credit

BMP Type	Cost Per Removal / Credit				
	Impervious Credit ($/ac)	TN ($/lb)	TP ($/lb)	TSS ($/lb)	Bacteria[1] ($/MPN/100ml)
BMP Conversion	$77,809	$8,034	$66,719	$47	$6,321
New BMP	$229,686	$26,907	$207,646	$173	$56,475
Outfall Stabilization	$165,017	NA	NA	NA	NA
Outfall - SPSC	$117,692	$10,219	$98,180	$72	NA
Stream Restoration	$79,461	$11,357	$12,526	$19	NA
Tree Planting	$114,931	$6,660	$195,999	$240	NA

[1] Bacteria data calculated from 2016 Patapsco River Lower North Branch project concepts, only

Other practices included in the cost estimation include the homeowner related practices and County programs that the County supports financially including rain barrels, septic pump-out rebate program, septic upgrades, and street sweeping. The cost of these measures is included in Table 33.

In February 2017, Howard County implemented its own septic maintenance rebate program, called Septic Savers, led by the Office of Community Sustainability with assistance from Department of Public Works and the Health Department. This program was created to encourage and help document the number of septic pump-outs completed per year. The County estimates that with 50% participation within the approximately 18,000 septic systems located County-wide, that a significant reduction in pollutants, and an equivalent credit for impervious surface treatment will be achieved. The County issues $100 rebates to new and returning residents; which is approximately 40% of the average cost to pump a septic tank in Howard County. OCS will notify participants every 3 years that it may be time to pump their septic tanks once again; which they will also be eligible for an additional $100 rebate at this time. A budget of $100,000 was allocated from the Watershed Projection Fund for use in FY17 to begin Septic Savers. A maximum of 1,000 participants can participate in FY17 with this level of funding with a maximum of 30 impervious credit acres. Assuming a 3-year program beginning in FY17 with approximately 1,000 new participants each year, final participation of 9,000 units at 0.03 equivalent acres would provide 270 acres of credit towards the impervious restoration goal with a total cost of $900,000 through FY19 and a cost per impervious acre of $3,333. A cumulative cost of $1,000,000 would support the program from FY20 through FY29. Costs for septic upgrades are paid for through the Bay Restoration Fund with an average cost of $14,143 per project; so there are no direct costs to the County.

Howard County continues to provide residents with free rain barrels through the County's Rain Barrel Program. Predrilled rain barrels are available free of charge to residents who attend seminars at the Alpha Ridge landfill. Residents purchase the hardware needed and the Master Gardeners provide free instruction on how to assemble the rain barrels. A total of 586 rain barrels were given away from 2013-2017. For this analysis, the costs to the County of the rain barrels are estimated at $50 each with a total of $5,000 per year. It is anticipated that this program will continue for an extended period, however the yearly costs are only shown through FY19 Table 33 in addition to a cumulative cost of providing 100 rain barrels per year from FY20 through FY29.

Street sweeping is an annual practice that costs the County approximately $400,000 annually following the implementation level completed in FY17. Annual costs are projected to remain constant with an implementation cost of $1,200,000 for FY18 through FY20 and cumulative cost of $3,600,000 to maintain the current level of implementation of the street sweeping program from FY21 through FY29 (Table 33).

As mentioned in section 3.3, the County has provided funding for Howard EcoWorks for the past several years and plans to continue providing funding. The County provided $500,000 for HowardEcoWorks in FY17 and is planning to support the program with $450,000 for FY18 activities and $400,000 in FY19 with lesser amounts over time as the program becomes more self-sufficient. Given the varying amount of funding provided by the County, an average annual cost of $200,000 was estimated for FY18 through FY29 in Table 33.

Table 33. Supplemental Practices Cost Estimate

Program	FY18	FY19	FY20	Cumulative / Total FY18 – FY20	Cumulative / Total FY21 – FY29
Septic Pump-Outs					
Units participating	3,000	3,000	3,000	9,000	
County Cost[1]	$100,000	$100,000	$100,000	$300,000	$900,000
Impervious Credit	90	90	90	270	
Septic Upgrades					
Units participating	30	30	30	90	
County Cost[2]	$0	$0	$0	$0	$0
Impervious Credit	7.8	7.8	7.8	23	
Rain Barrels					
New Units participating / year	100	100	100	300	
Cost	$5,000	$5,000	$5,000	$15,000	$45,000
Street Sweeping[3]					
Cost	$400,000	$400,000	$400,000	$1,200,000	$3,600,000
Impervious Credit	300	300	300	300	
Inlet Cleaning					
Cost	$120,000	$120,000	$120,000	$360,000	$1,080,000
Impervious Credit	50	50	50	50	
Howard EcoWorks					
County Cost	$450,000	$200,000	$200,000	$850,000	$1,800,000
			Total Cost	**$2,365,000**	**$7,425,000**

[1]County provides $100/unit up to 1,000 units per year. Other costs will be paid for by septic unit owner.
[2]Cost paid for through Bay Restoration Fund (average cost of $14,143 per project). No direct cost to the County.
[3]Street sweeping is an annual practice that will continue at FY16 progress rate.

5.2.3 Cost Summary

The total projected cost to implement the County's Capital Improvement Plan (CIP) projects described in this plan is $167,885,317. The estimates per year and per watershed are shown in Figure 9 and Table 34.

For the near term period through FY20 costs are placed in the year the funding is needed based on design and construction schedules. This detailed method is more difficult to apply in the period from FY21 to FY29, therefore cost estimates in that period is more linked to the year a project is completed. Costs are generally placed in the fiscal year in which the construction costs are expected to be incurred and when the project will be largely complete.

For the purposes of this CIS, the costs of these projects focuses on the specific implementation costs associated with engineering, permitting, and construction. County operational costs such as additional County staff to manage the work, additional inspections, maintenance, etc., have not been included. These costs will be developed and factored into future County budgeting.

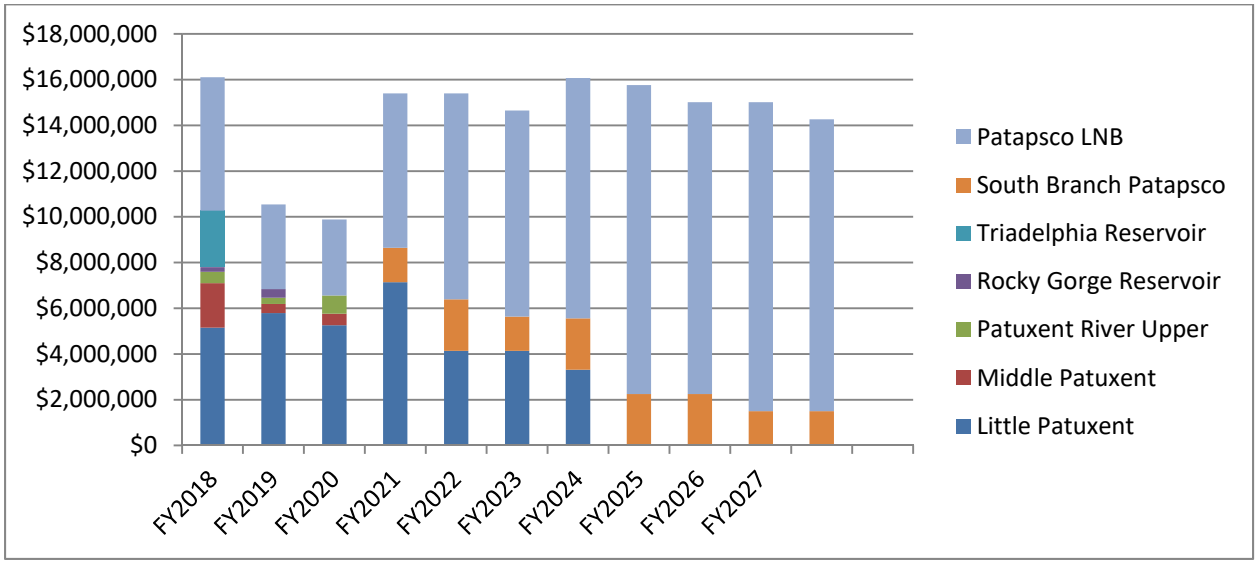


Figure 9. Cost per Fiscal Year per Watershed for SWM Division CIP Restoration BMPs

In summary, the total cost to implement all practices described in this plan is $167,885,317. This total cost includes all SWM Division CIP restoration BMPs ($158,095,317) along with costs from additional practices (i.e., rain barrels, septic pump-outs and upgrades, street sweeping, inlet cleaning and HowardEcoWorks) from FY17 – FY19 ($2,415,000) as well as costs from FY21 – FY29 ($7,425,000) needed to fulfill the local TMDL targets by FY29.

Table 34. Cost Summary of SWM Division CIP Restoration BMPs per Fiscal Year NTP

						Baltimore Harbor		
Watershed	**Little Patuxent**	**Middle Patuxent**	**Patuxent River Upper**	**Rocky Gorge Reservoir**	**Triadelphia Reservoir**	**South Branch Patapsco**	**Patapsco LNB**	**Total**
Local TMDL Target Year	**2025**	**NA**	**2019**	**2019**	**2020**	**2029**		
FY18	$5,150,018	$1,949,503	$497,993	$200,000	$2,471,000		$5,835,305	$16,103,819
FY19	$5,788,001	$400,000	$270,000	$379,800			$3,704,738	$10,542,539
FY20	$5,258,248	$500,000	$800,000				$3,324,591	$9,882,839
FY21	$7,143,480					$1,501,297	$6,755,838	$15,400,615
FY22	$4,137,061					$2,251,946	$9,007,784	$15,396,791
FY23	$4,137,061					$1,501,297	$9,007,784	$14,646,142
FY24	$3,309,649					$2,251,946	$10,509,082	$16,070,676
FY25						$2,251,946	$13,511,676	$15,763,623
FY26						$2,251,946	$12,761,028	$15,012,974
FY27						$1,501,297	$13,511,676	$15,012,974
FY28						$1,501,297	$12,761,028	$14,262,325
FY29								
Total	$34,923,517	$2,849,503	$1,567,993	$579,800	$2,471,000	$15,012,974	$100,690,531	$158,095,317

*Total cost is lower than the total cost of all SWM Division CIP restoration BMPs ($185,233,826) because some design costs are not included (i.e., any prior to FY17).

6 Public Participation / Education

Howard County's MS4 permit requires a significant increase in effective public outreach and community stewardship. Such public involvement is necessary for the CIS to achieve its restoration goals. The following describes the public involvement strategy being used to gather input for the CIS and a summary of education and outreach programs.

6.1 CIS and Watershed Assessment Public Participation

Development of the 2015 and 2016 watershed assessments and preparation of the CIS are done with public input gathered through a combination of public review and comment periods and through a series of public meetings. The draft watershed assessment reports for the Little Patuxent and Middle Patuxent watersheds and this draft CIS were posted on the County's stormwater management division website in December 2015 for a 30-day public review and comment period. Comments received will be taken into consideration and modifications to the assessments and CIS will be made where appropriate.

A series of public meetings were held in the summer of 2015 and in early to mid-December to disseminate information on the County's watershed planning and restoration program and to specifically introduce the goals, methods and results of the assessments and CIS.

Four meetings were held from June 17 to June 30, 2015 at locations in each of the four planning areas. The meetings focused on the preliminary watershed assessment results.

- Southern Middle Patuxent Watershed – June 17, 2015 @ Robinson Nature Center
- Northern Little Patuxent Watershed – June 22, 2015 @ Dunloggin Middle School
- Southern Little Patuxent Watershed – June 24, 2015 @ Hammond High School
- Northern Middle Patuxent Watershed – June 30, 2015 @ Folly Quarter Middle School

Four meetings were held from December 2 to December 10, 2015 at locations in each of the four planning areas. The meetings included the final assessment results and introduced the CIS.

- Northern Middle Patuxent – Dec. 2, 2015 @ Gary J. Arthur Community Center
- Southern Little Patuxent – Dec. 3, 2015 @ North Laurel Community Center
- Southern Middle Patuxent – Dec. 9, 2015 @ Robinson Nature Center
- Northern Little Patuxent – Dec. 10, 2015 @ Howard Community College

In addition to the public meetings throughout 2015, the County also held a series of public meetings that focused on the watershed assessments accomplished in 2016.

Three meetings were held from June 21 to June 28, 2016 at locations throughout the Patuxent River and Patapsco River planning areas. The meetings focused on the preliminary watershed assessment results.

- Rocky Gorge Dam and Patuxent River Upper – June 21, 2016 @ North Laurel Community Center
- Patapsco River Lower North Branch – June 23, 2016 @ Roger Carter Community Center
- Patapsco River South Branch and Brighton Dam – June 28, 2016 @ Gary J. Arthur Community Center

Two meetings were held on January 23 and January 26, 2017 at locations in both the Patuxent River and Patapsco River planning areas. The meetings included the final assessment results and updates to the CIS.

- Patuxent River – January 23, 2017 @ Gary J. Arthur Community Center
- Patapsco River – January 26, 2017 @ Roger Carter Community Center

The meetings included presentations of the planning documents and opportunities for questions. Maps and copies of the planning documents were present for participants to review in person. County staff and consultants who completed the field assessment and concept plan development were present to answer questions and to describe assessment results from any specific location that a property owner or interested individual might be concerned about.

6.2 Program Summary

Public education and outreach occurs throughout the County and is conducted by various agencies. Current programs include information about stormwater runoff, stormwater infrastructure maintenance, water conservation, trash reduction and recycling, lawn care management, and programs that provide a mechanism for reporting suspected illicit discharges and spills. New to the MS4 permit is the requirement to develop and implement, within one year, a public education and outreach program to reduce littering and increase recycling, which includes:

- Educating the public on the importance of reducing, reusing, and recycling
- Disseminating information by using signs, articles, and other media outlets
- Promoting educational programs in schools, businesses, community associations, etc.

The County is required to evaluate annually and report on the effectiveness of the education programs (e.g., in terms of personnel and financial resources). The following programs are good examples of the programs currently being implemented throughout the County. Refer to the County's NPDES Annual Report (Howard County, 2014 and 2015) for a complete list of all programs currently being implemented.

6.2.1 Stormwater Management Division (SWMD) Education Programs

School Outreach

The SWMD continues to provide workshops to the schools and businesses in Howard County. Schools participate in County-sponsored programs and workshops designed to increase their awareness of water quality issues.

Other Educational Outreach Initiatives

The SWMD as well as Department of Recreation and Parks (DRP) staff speak at the Howard County Legacy Leadership Institute for the Environment (HoLLIE), Master Gardener training events, and are part of the Howard County Watershed Forum. The result of the forum was the first Howard County Watershed Steward Academy class in 2012 and annual classes since 2012. The result of all of these efforts is to create a more educated County citizen who will contribute to the improvement of water quality in Howard County and in the Chesapeake Bay.

6.2.2 Recycling Division Programs

The County's Recycling Division distributes recycling and waste reduction literature to households and businesses and provides outreach materials through local libraries, public buildings, events, and the County's website: www.HowardCountyRecycles.org. The County's recycling rate more than doubles the State's mandated annual rate of 20 percent. The County has also instituted apartment and special event based recycling programs.

Outreach to Business Communities

The Business Recycling Program has been providing technical support to the Howard County Chamber of Commerce business collection co-op.

Outreach to Students and Schools

The County is maintaining its presence in schools that has been established over the past four years. The County's Recycling Coordinators distribute school recycling information through school programs, brochures, and lunchroom recycling posters. The County also administers programs ranging from individual classroom talks and short lunchroom presentations to school-wide assemblies for students as young as 2 years old.

6.2.3 Department of Recreation and Parks (DRP) Programs

Stream and Pond Cleanup Program

Since 1996, the Department has actively recruited volunteers and tracked their efforts removing trash and other debris from Howard County's waterways. To date, the County has had 2,376 people spend 5,161 hours cleaning the County's waterways.

Howard County GreenFest

For six years, the County has hosted an annual Green Fest which features many exhibits and vendors dealing with tree plantings, energy efficient home improvements, rain barrels, gardening and composting, document shredding, Goodwill donations, Nike Reuse-a-Shoe collection, Bikes for the World collection, as well as live bird and reptile displays. Other features include the County's recycling program and community tree planting programs as well as many community groups focused on environmental awareness. SWMD attends to promote water quality and illicit discharge reduction.

Robinson Nature Center

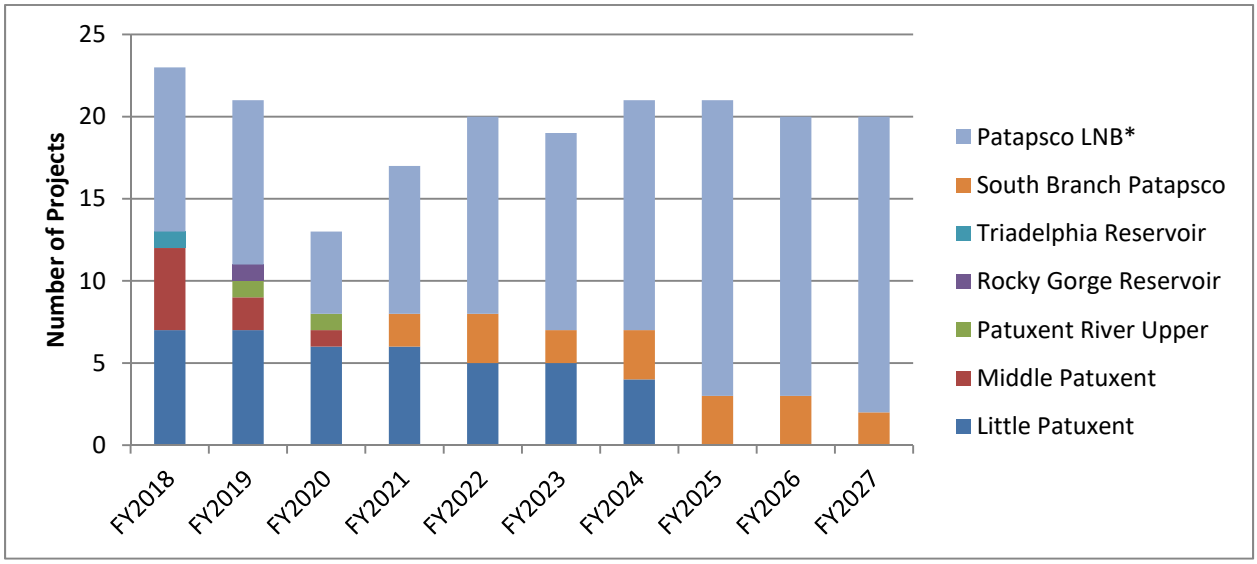
The Robinson Nature Center, in operation since September 2011, serves as a model of innovative water conservation methods and officially received its LEED Platinum certification by the USGBC in 2012. Using the building as a teaching tool, the Robinson Nature Center educates the public about green technologies, sustainability, environmental stewardship and techniques that can help reduce stormwater runoff, as well as reducing water and energy consumption. In addition to using the building's features, including porous pavement, bioretention, native landscaping, and a green roof, to educate the public, Robinson Nature Center offers informal and formal educational opportunities that help educate the public about Howard County's connection to the Chesapeake Bay and about the LEED certification program. Robinson Nature Center partners with local and regional groups to promote programs that recycle organic materials for uses consistent with mitigating stormwater runoff and sediment discharge. Robinson also offers professional development opportunities to teachers that allow them to bring water conservation and stewardship issues back to the classroom.

7 Implementation Schedule and Milestones

This section presents the estimated timeline for working towards the impervious treatment and load reduction targets. The prescribed end-date for treating 20% of the baseline untreated impervious cover is the end of the 5-year cycle of the new MS4 permit, December 2019. As described in previous sections, the County anticipates being near 17% restoration at the end of the permit based on current projections. The possibility of using nutrient credit trading in time will be evaluated at the end of FY18 based on progress going into the final phases of implementation.

The timeline for meeting the nitrogen and phosphorus reduction targets in the Chesapeake Bay TMDL is 2025 with 70% progress by 2017 per the Phase II Watershed Implementation Plan (WIP). The County's NPDES permit however requires that the County's stormwater portion of the Bay TMDL will be met through the 20% impervious treatment goal, therefore the County's stormwater sector is focused on the 20% target and is not specifically scheduling its urban MS4 sector to the 2017 and 2025 milestone dates.

The number of projects to be initiated per year and per watershed are presented in Figure 10 and Table 36. The program seeks to even out the level of effort across the planning period with an average of approximately 20 projects being completed each year.



*Patapsco Lower North Branch sediment local TMDL target year also 2029

Figure 10. SWM Division CIP Project Implementation by Fiscal Year and Watershed

Table 35 presents the anticipated average project duration used for scheduling. Project completion will be preceded by approximately two-years of site specific assessment, design and permitting. Some projects, stream restoration for example, will likely be followed by a set number of years of monitoring.

Table 35. Anticipated Average Project Duration in Months

BMP	Project Type	Design	Construction	Total
Ponds (New and Conversions)	BMP Conversion	12	6	18
Smaller ESD Type Practices (New) (Bioretention, Sand Filter etc.)	New BMP	12	6	18

BMP	Project Type	Design	Construction	Total
Stream Restoration	Stream Restoration	14	6	20
Outfall Stabilization	Outfall	14	6	20
SPSC		14	6	20
Tree Planting	Tree Planting	3	1	4

The schedule is developed such that the year a project is anticipated to be initiated (i.e., design) is the year it is indicated on the schedule in Table 36. Projects slated for the FY18 and FY19 time periods include projects already in development and on County CIP lists. They also include some projects identified in the 2015 and 2016 watershed assessments. A focus is on the Little Patuxent between FY17 and FY20 since a large percentage of untreated County impervious is located in the watershed, and many projects are already identified with concept plans developed and ready to move into design stages. Little and Middle Patuxent projects are generally slated first since concepts have been developed prior to the concepts developed from 2016 watershed assessments. Concepts developed from watershed assessments completed in 2016 identify the list of potential projects for the remainder of County watersheds; therefore these projects are generally scheduled for later stages of the program.

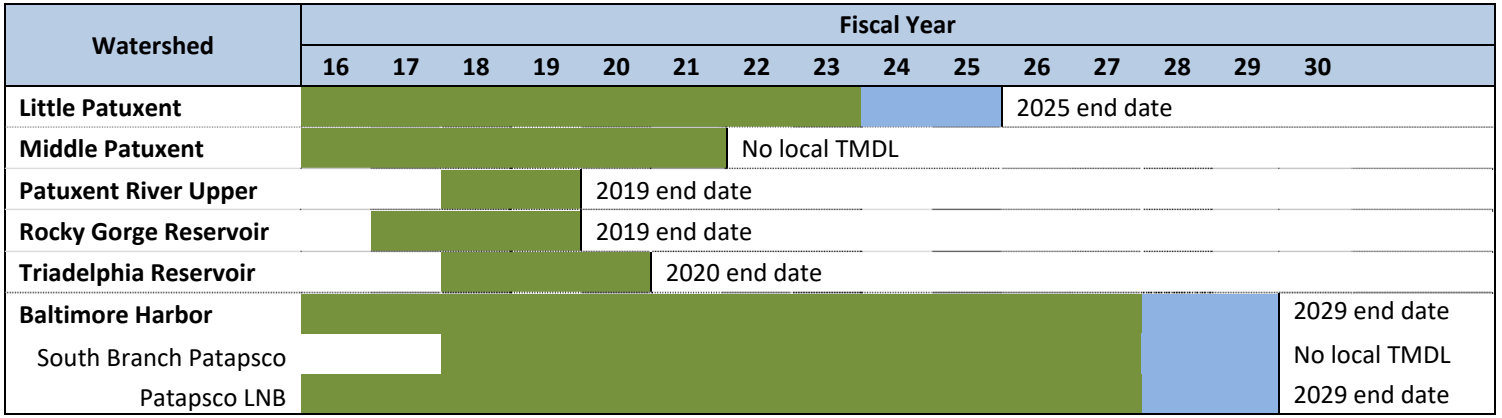
Figure 11 below indicates the general planning level schedule for project implementation. Local TMDL SW-WLA completion is indicated on the same figure with 'end dates' noted for each local TMDL. Larger, more challenging local TMDLs in the Little Patuxent (sediment), Patapsco River LNB (sediment and bacteria) and the Baltimore Harbor (nitrogen and phosphorus) are given a 2-year additional period to allow for project implementation. No local TMDLs are currently in place for the Middle Patuxent or South Branch Patapsco.

Table 36. Project Implementation List Per Year and Watershed

						Baltimore Harbor		
Watershed	**Little Patuxent**	**Middle Patuxent**	**Patuxent River Upper**	**Rocky Gorge Reservoir**	**Triadelphia Reservoir**	**South Branch Patapsco**	**Patapsco LNB***	**Total**
Target Year	**2025**	**NA**	**2019**	**2019**	**2020**	**2029**		
FY18	7	5			1		10	23
FY19	7	2	1	1			10	21
FY20	6	1	1				5	13
FY21	6					2	9	17
FY22	5					3	12	20
FY23	5					2	12	19
FY24	4					3	14	21
FY25						3	18	21
FY26						3	17	20
FY27						2	18	20
FY28						2	17	19
FY29								
Total	40	8	2	1	1	20	142	214

*Patapsco Lower North Branch sediment local TMDL target year also FY29

Figure 11. Implementation Schedule



Primary project funding period is shown in green. Additional implementation period in blue. Baltimore Harbor TMDL includes the South Branch Patapsco and Patapsco Lower North Branch watersheds.

8 Load Reduction Evaluation Criteria

Adaptive management is a critical component of achieving and maintaining the local TMDLs, Bay TMDL, and this restoration plan. The milestones proposed in Section 7 will be used to reevaluate against progress and will be revised, if necessary, to ensure that Howard County continues to maintain TMDL requirements. Progress evaluation will be measured through three approaches: tracking implementation of management measures, estimating load reductions through modeling, and tracking overall program success through long term monitoring.

8.1 Tracking Implementation of Management Measures

Implementation will be measured by determining whether the targets for implementation shown in previous sections are maintained according to the schedule presented. Howard County has developed an NPDES Geodatabase that manage a comprehensive system for adding and tracking projects and accounting for new programs.

Feasibility studies of the planned strategies may reveal that some existing structures or sites identified for retrofitting or enhancement may not be feasible candidates for future projects and may be eliminated from consideration. Since many restoration projects will need to be done on private property, lack of approval by private property owners may also impact the number and types of projects that can be accomplished. The County will take an adaptive management approach and will reevaluate treatment needs as feasibility studies progress. The County will continue to track the overall effectiveness of the various BMP strategies and will adapt the suite of solutions based on the results. In addition, new technologies are continuously evaluated to determine if the new technologies allow more efficient or effective pollution control.

Two-Year Milestone Reporting

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

Milestones are reported in two forms: Programmatic and BMP Implementation. Programmatic milestones identify the anticipated establishment or enhancement of the institutional means that support and enable implementation. Examples of Programmatic milestones, which are submitted by the County to MDE, include projected funding, enhancement of existing programs and resources, and the establishment of new programs and studies. The milestone period for Programmatic covers two calendar years – for example, the period for 2014 -2015 is from January 1, 2014 through December 31, 2015. BMP Implementation milestones are a quantitative account of various types of restoration activities (e.g., structural BMPs, stream restoration, maintenance efforts), which have geo-located coordinates. The period for BMP implementation milestones differs from the Programmatic milestones period and covers two state fiscal years – for example, the period for 2014 – 2015 is from July 1, 2013 through June 30, 2015. Planned BMP Implementation milestones reported to MDE include the action (e.g., BMP type), proposed restoration over the 2-year milestone period (e.g., area treated, length restored), actual rate of implementation over 1 year, and percent progress. The County's Annual NPDES MS4 report and associated geodatabase serve as an annual report on BMP milestone implementation.

Annual NPDES Reporting

As a requirement of the NPDES permit, the County must submit annually a progress report demonstrating the implementation of the NPDES stormwater program based on the fiscal year. If the County's annual report does not demonstrate compliance with their permit and show progress toward meeting WLAs, the County must implement BMP and program modifications within 12 months.
The annual report includes the following – items in bold font directly relate to elements of the load reduction evaluation criteria:

- The status of implementing the components of the stormwater management program that are established as permit conditions including:
  - i. Source Identification
  - **ii. Stormwater Management**
  - iii. Erosion and Sediment Control
  - iv. Illicit Discharge Detection and Elimination
  - v. Litter and Floatables
  - vi. Property Management and Maintenance
  - vii. Public Education
  - viii. Watershed Assessment
  - **ix. Restoration Plans**
  - **x. TMDL Compliance**
  - xi. Assessment of Controls; and,
  - xii. Program Funding
- **A narrative summary describing the results and analyses of data, including monitoring data that is accumulated throughout the reporting year**
- Expenditures for the reporting period and the proposed budget for the upcoming year
- A summary describing the number and nature of enforcement actions, inspections, and public education programs
- **The identification of water quality improvements and documentation of attainment and/or progress toward attainment of benchmarks and applicable WLAs developed under EPA approved TMDLs; and,**
- **The identification of any proposed changes to the County's program when WLAs are not being met**
- Attachment A – The County is required to complete a database containing the following information:
  - i. Storm drain system mapping
  - **ii. Urban BMP locations**
  - iii. Impervious surfaces
  - **iv. Water quality improvement project locations**
  - **v. Monitoring site locations**
  - **vi. Chemical monitoring results**
  - **vii. Pollutant load reductions**
  - **viii. Biological and habitat monitoring**
  - ix. Illicit discharge detection and elimination activities
  - x. Erosion and sediment control, and **stormwater program information**
  - xi. Grading permit information
  - xii. Fiscal analyses – cost of NPDES related implementation

8.2 Estimating Load Reductions

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

Table 37 shows annual planned load reductions and percent reduction for each local TMDL. The County will use these values as annual target load reductions and will measure progress against the cumulative load reductions and percent reductions.

Table 37. Local TMDL Annual Pollutant Load Reduction Targets

Watershed		Baltimore Harbor				Little Patuxent		Patapsco R LN Branch				Patuxent R Upper		Rocky Gorge Reservoir		Triadelphia Reservoir (Brighton Dam)	
Target Year		2029				2025		2029				2019		2019		2020	
Pollutant		TN-EOS lbs/yr		TP-EOS lbs/yr		TSS-EOS lbs/yr		TSS-EOS lbs/yr		Bacteria MPN/100mL/yr		TSS-EOS lbs/yr		TP-EOS lbs/yr		TP-EOS lbs/yr	
Unit		Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative[1]	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
FY17	Reduced	-	5,912	-	929	-	3,398,711	-	671,611	-	304	-	10,965	-	78	-	158
	% Reduced	-	5.5%	-	14.2%	-	32.8%	-	11.0%	-	1.4%	-	7.5%	-	9.1%	-	6.0%
FY18	Reduced	860	6,772	740	1,669	63,080	3,461,791	495,466	1,167,077	-	304	-	10,965	-	78	435	**593**
	% Reduced	0.8%	6.3%	11.3%	25.5%	0.6%	33.5%	8.1%	19.1%	-	0.1%	-	8.2%	-	9.8%	16.4%	**22.4%**
FY19	Reduced	781	7,553	589	2,258	273,259	3,735,050	409,554	1,576,631	16,401	16,705	27,000	**37,965**	115	**193**		
	% Reduced	0.7%	7.1%	9.0%	34.5%	2.6%	36.1%	6.7%	25.7%	75.1%	76.5%	18.5%	**26.0%**	13.4%	**22.4%**		
FY20	Reduced	552	8,105	305	2,563	206,664	3,941,714	232,547	1,809,178	16,642	16,977						
	% Reduced	0.5%	7.6%	4.7%	39.2%	2.0%	38.1%	3.8%	29.5%	76.3%	77.8%						
FY21	Reduced	1,523	9,628	927	3,490	350,440	4,292,155	538,028	2,347,206	16,726	17,334						
	% Reduced	1.4%	9.0%	14.2%	53.3%	3.4%	41.5%	8.8%	38.3%	76.6%	79.4%						
FY22	Reduced	1,523	11,152	927	4,417	350,440	4,642,595	538,028	2,885,234	16,726	17,690						
	% Reduced	1.4%	10.4%	14.2%	67.5%	3.4%	44.9%	8.8%	47.1%	76.6%	81.1%						
FY23	Reduced	1,523	12,675	927	5,344	350,440	**4,993,035**	538,028	3,423,262	16,768	18,088						
	% Reduced	1.4%	11.8%	14.2%	81.6%	3.4%	**48.3%**	8.8%	55.9%	76.8%	82.9%						
FY24	Reduced	1,523	14,199	927	6,270			538,028	3,961,290	16,810	18,529						
	% Reduced	1.4%	13.3%	14.2%	95.8%			8.8%	64.7%	77.0%	84.9%						
FY25	Reduced	1,523	15,722	927	7,197			538,028	4,499,318	16,810	18,969						
	% Reduced	1.4%	14.7%	14.2%	109.9%			8.8%	73.5%	77.0%	86.9%						
FY26	Reduced	1,523	17,246	927	8,124			538,028	5,037,346	16,831	19,430						
	% Reduced	1.4%	16.1%	14.2%	124.1%			8.8%	82.3%	77.1%	89.0%						
FY27[2]	Reduced	1,523	**18,769**	927	**9,051**			538,028	**5,575,374**	16,789	**19,849**						
	% Reduced	1.4%	**17.5%**	14.2%	**138.3%**			8.8%	**91.0%**	76.9%	**90.9%**						
FY28	Reduced																
	% Reduced																
FY29	Reduced																
	% Reduced																

[1] Pet waste is an annual BMP which must be hit every year to count towards bacteria credit.

[2] Projects initiated in FY27 may not be complete until FY28 or FY29; therefore, credit will not be received until completion of the project.

8.3 Tracking Overall Program Success through Monitoring

Overall program success will be evaluated using trends identified through a long term monitoring program such as that described below in Section 9: Monitoring. TMDL compliance status will be evaluated to determine if the CIS needs to be updated. If it is found during the evaluation of BMP implementation and load reductions that the milestone targets are no longer being met, a revision of the plan may be necessary.

8.4 Best Management Practices Inspection and Maintenance

Implementing the 2000 Maryland Stormwater Design Manual and providing applicable feedback to MDE on programmatic problems is a condition of the current NPDES permit, MDE has updated the Design Manual per the requirements set forth by the Stormwater Management Act of 2007. The County is now implementing the current version of the Design Manual, including the 2009 revision for ESD, and providing feedback on that version as necessary.

The County performs preventative maintenance inspections of all County, Board of Education, and private SWM facilities on a triennial basis. In addition, there are also individual residential ESD BMPs (e.g., rain gardens, rain barrels, etc.), which are being inspected triennially. The 2009 ESD revision has led to a large influx of facilities needing to be inspected.

Inspectors follow the requirements outlined in the County's Storm Water Management Facility Inspection and Maintenance Procedures (Howard County, 2012b). The general procedure for the inspection of privately maintained facilities is to use the owner information in the BMP database developed by the County to give prior notification to the BMP owners of the County's intent to inspect their facility; perform the inspection; provide the owner a complete record of the results of the inspection, including deficiencies that need to be repaired; then follow up with the owner to ensure the necessary repairs are made within a reasonable time frame. The County has developed an extensive component to the BMP database to allow tracking of the inspection and maintenance process in detail for each BMP inspected.

9 Monitoring

Official monitoring for impairment status is the responsibility of the State; however the County utilizes a variety of monitoring programs to ensure progress towards its NPDES responsibilities and TMDL progress.

The new MS4 permit emphasizes the need to monitor progress toward meeting permit requirements and apply adaptive management as necessary. Specifically, the County is expected to implement a back-up plan for additional restoration if required pollutant reductions are not met. The additional BMPs available beyond the projects and programs presented in the CIS (i.e., BMPs above the TMDL target) provide this back-up inventory of projects that could be implemented if necessary. In each watershed assessment, BMPs in excess of the minimum number needed to meet restoration requirements may be developed to provide this back-up plan.

The approach for tracking progress toward meeting regulatory and programmatic targets should include a combination of the County's NPDES geodatabase, updated progress models using MAST, and

monitoring of the reductions in stressors and improvements in stream conditions that result from project implementation.

Physical monitoring reflects the realities of monitoring restoration (Southerland, 2012), wherein (1) monitoring the design, construction, and maintenance of BMPs or other restoration projects is relatively easy; while (2) monitoring the performance of these projects, in terms of reducing stressors, is more difficult (owing to technical and cost factors); and, (3) in terms of stream condition, is often much harder (owing to confounding factors and time lags). Most problematic is monitoring to capture water quality improvements associated with programmatic restoration measures, such as increased outreach, enhanced enforcement, or adopting new legislation or regulation. Documenting improvements associated with these types of approaches are better addressed as part of public outreach and stewardship.

The 2010 Chesapeake and Coastal Bays Trust Fund Water Quality Monitoring Strategy (Trust Fund Evaluation Workgroup, 2010) recognizes that intensive monitoring of BMP performance, while effective, is not practical on a large scale. The Strategy recommends that sampling of larger receiving waters be done only when a 30% reduction in nutrient or sediment loads from one or more BMPs are expected; otherwise, monitoring should be done as close to the implementation site as possible. The Strategy concludes that these monitoring challenges underscore the need for an adaptive management approach that draws upon existing sampling networks and institutional partnerships and recognizes issues related to the local budget and funding cycle. As one of the major recipients of Trust Fund monies, Howard County is already advanced in conducting monitoring under this Strategy.

An approach for Howard County to augment its tracking of restoration project implementation could be:

- Stream condition monitoring on a time scale where improvements are likely to occur (including biological community metrics beyond narratives of excellent, good, fair, and poor)
- BMP performance monitoring on the spatial scale where changes in stressors are expected to be measurable

Stream condition changes are unlikely to be detected over short time periods and, therefore, would only be evaluated after 5-10 years. Reductions in stressors from effective BMPs may be measurable over periods of 1-5 years, but are unlikely to be detected over large spatial scales in less than 10 years.

The County has a history of both extensive monitoring to address stream condition and intensive monitoring to address BMP performance. It is not practical to expand the intensive monitoring effort commensurate with the many-fold increase in project implementation. Therefore, the County may evaluate its combined, existing monitoring effort and, if necessary, consider reallocation and augmentation to most efficiently track progress toward meeting the targets of the MS4 Permit.

Where appropriate, monitoring by the State or others (including volunteer citizens) may contribute to providing a more complete picture of restoration progress (e.g., toward Chesapeake Bay TMDL targets). As described above, it is important not to encourage unrealistic expectations for observing stream condition improvements over large geographic scales or over short time periods.

9.1 Current Howard County Monitoring

The County currently conducts monitoring in the following three areas:

- **Countywide stream resource monitoring**. Although not required by its MS4 permit, the County has conducted biological monitoring since 2001. The Howard County Biological Monitoring and Assessment Program has been sampling about 150 stream sites every five years (generally 10 sites in each of three watersheds each year). Monitoring includes benthic macroinvertebrate sampling, in-situ water quality monitoring, physical habitat assessment, and a basic geomorphic assessment at each site. In the first two five-year rounds, sites were selected randomly within watersheds or primary sampling units (PSUs); in the third round that began in 2011, two sites are re-sampled from the first round and two sites are re-sampled from the second round, while the remaining six sites are selected at random. This partial replacement methodology is optimal for both status assessment and trend detection. This countywide monitoring provides an excellent baseline for ecological stream conditions that should improve with the implementation of restoration projects.

  Stormwater Design Manual monitoring. After MDE finalized the Maryland 2000 Stormwater Management Design Manual, and as a requirement of the County's MS4 Permit at the time, Howard County undertook physical stream monitoring in the Hammond Branch watershed to determine the effectiveness of stormwater management practices being applied to new development for stream channel protection. After ten years of monitoring in the Hammond Branch Tributary Watershed, the County provided adequate data and requested and was given permission by MDE to discontinue monitoring at this location and initiate monitoring in another developing watershed.

  In 2011, Howard County (in conjunction with MDE) replaced monitoring at the Hammond Branch site with monitoring of an unnamed tributary to Red Hill Branch, a tributary of the Upper Little Patuxent (hereafter called Rumsey Run). Given the evolution of stormwater regulations following Maryland's Stormwater Management Act of 2007, the monitoring at Rumsey Run is designed to differentiate between the effects of Environmental Site Design treatment of runoff ("green stormwater infrastructure") and the effects of no or traditional stormwater treatment ("gray stormwater infrastructure") on stream channel stability. Monitoring includes the survey of approximately 4,000 linear feet of stream channel, cross-sectional surveys, and pebble counts. In addition, four maximum-level gauges are monitored within Rumsey Run to support hydraulics and hydrology modeling. Continuous flow monitoring at outfalls representative of different stormwater infrastructures was added in 2013.

- **Discharge characterization and restoration monitoring**. Previously, Howard County intensively monitored the water chemistry, biology, and stream physical condition on the Font Hill Tributary to the Little Patuxent River, to meet the discharge characterization requirements of their MS4 Permit. After completion of a watershed plan for the Centennial Lake and Wilde Lake watersheds in 2005, this monitoring was moved to these two watersheds, but discontinued in the Centennial Lake watershed in 2009. The monitoring effort was shifted to the Red Hill Branch subwatershed of the Upper Little Patuxent watershed after the watershed plan was completed.

  Monitoring in the Wilde Lake watershed includes biological, geomorphic, and water quality assessments. Synoptic (one-time) chemical, physical, and biological sampling is conducted throughout the watershed to determine if the restoration efforts outlined in the Centennial and Wilde Lake Watershed Restoration Plan are reducing pollutant loading and increasing the health of the lake and streams. Biological monitoring began in 2006 and is conducted at five sites per

year. It includes the collection and analysis of the benthic macroinvertebrate community, assessment of the physical habitat, and instream water quality sampling. Geomorphic assessment also began in 2006 and includes the annual survey of four channel cross-sections, particle size analysis, and longitudinal profile of three reaches. The County also maintains and operates an automated sampler to evaluate stormwater quality at a site located on the main channel draining to Wilde Lake. The sampling station includes a probe for continuous instream water quality monitoring, continuous flow monitoring, and a refrigerated unit for collection of stormwater samples. Continuous flow measurements are used to estimate annual and seasonal pollutant loads and for the calibration of watershed assessment models.

Monitoring in the Red Hill Branch subwatershed includes biological, geomorphic, and water quality evaluations to assess the effectiveness of restoration efforts identified in the Upper Little Patuxent Watershed Management Plan. Monitoring was initiated in late 2009 with geomorphic assessments, and in early spring of 2010 with biological assessments, continuous discharge, baseflow and stormflow water quality, and sediment sampling. Biological monitoring includes the collection and analysis of the macroinvertebrate community, physical habitat assessments, and measurements of in-situ water chemistry. Biological assessments include annual sampling at three sites located at the downstream end of the major drainage areas within the Red Hill Branch subwatershed, as well as a fourth control site located in an adjacent watershed. Beginning in 2011, the Maryland Biological Stream Survey is supplementing this monitoring with annual fish assessments during the summer. Geomorphic assessments are conducted at two locations within Red Hill Branch and at a third control site in an adjacent watershed; these include the annual survey of channel cross sections, particle size analysis, and a longitudinal profile of three reaches. Other monitoring techniques include assessments of bed and bank stability through bank pin and scour chain measurements and channel facies mapping, as well as bulk bar sieve samples.

Howard County also conducts baseflow and stormflow water quality monitoring at five stations associated with three restoration projects in the Red Hill Branch watershed. The Bramhope study area consists of two sites, one upstream and one downstream of a stream restoration project. The Salterforth study area consists of two sites, one upstream and one downstream of a dry extended detention basin retrofit. The third study area is located within Meadowbrook Park near the downstream extent of the subwatershed and consists of a single monitoring station to monitor changes in water quality resulting from the combined restoration treatments throughout the subwatershed. An automated sampler includes a probe for continuous instream water quality monitoring, continuous flow monitoring, and a refrigerated unit for collection of stormwater samples. Continuous discharge, baseflow, and stormflow water quality are monitored to determine the pollutant loading and removal rates. Innovative techniques to assess bedload and suspended sediment during storm flows include pit trap and siphon samplers. DNR is also conducting flow monitoring upstream and downstream of the Bramhope stream restoration project to enable calculation of pollutant loads. Pre-restoration monitoring began in 2010; post-restoration and retrofit monitoring for both Bramhope and Salterforth began in 2012.

Howard County is also conducting restoration monitoring at Dorsey Hall in the Red Hill Branch and Plumtree Branch subwatersheds and for restoration projects located in and around Turf Valley in the upper portions of the Little Patuxent watershed. Dorsey monitoring includes base and stormflow water chemistry, sediment, geomorphological assessment, biological sampling,

habitat assessment and continuous discharge. Turf Valley monitoring is limited to biological, physical habitat, and in situ water quality evaluations.

There is additional water quality and flow monitoring being conducted at USGS stream gages in Howard County (Figure 12), as follows:

- **Water quality and flow monitoring at USGS gages**. In 2012, the U.S. Geological Survey (USGS) operated ten 10 stream gages within Howard County watersheds in coordination with Howard County, Columbia Association (CA), State Highway Administration (SHA), Washington Sanitary Sewer Commission (WSSC), Maryland Geological Survey, American Rivers, and National Oceanographic and Atmospheric Administration (NOAA). Three of the stations are on the Patapsco River to document the effects of dam removal and may be terminated at some point. The Little Patuxent stations above Wilde Lake and Lake Elkhorn are new and do not have stream discharge ratings developed, yet. The full list of USGS gages is given below with data at http://waterdata.usgs.gov/md/nwis/current/?type=flow.

    - USGS 01591400 CATTAIL CREEK NEAR GLENWOOD, MD (starting 1944, funded by WSSC)
    - USGS 01591610 PATUXENT RIVER BELOW BRIGHTON DAM NEAR BRIGHTON, MD (starting 1983, funded by WSSC)
    - USGS 01592500 PATUXENT RIV NEAR LAUREL, MD (starting 1944, funded by WSSC)
    - USGS 01593370 L PAX RIV TRIB ABOVE WILDE LAKE AT COLUMBIA, MD (starting Oct 2012, funded by CA)
    - USGS 01593450 L PAX RIV TRIB ABOVE LAKE ELKHORN NR GUILFORD, MD (starting Oct 2012, funded by CA)
    - USGS 01593500 LITTLE PATUXENT RIVER AT GUILFORD, MD (starting 1932, funded by SHA)
    - USGS 01594000 LITTLE PATUXENT RIVER AT SAVAGE, MD (starting 1939, funded by Howard County Bureau of Utilities)
    - USGS 01589000 PATAPSCO RIVER AT HOLLOFIELD, MD (May 1944 to January 1992, March 1994 to September 1995, January 2000 to September 2004, April 2010 to current year; funded by Maryland Geological Survey)
    - USGS 01589025 PATAPSCO RIVER NEAR CATONSVILLE, MD (starting Oct. 2010, funded by American Rivers and NOAA)
    - USGS 01589035 PATAPSCO RIVER NEAR ELKRIDGE, MD (starting Oct. 2010, funded by American Rivers and NOAA)

These gages help the County monitor (1) pollutant loadings being carried across jurisdictions, (2) changes associated with stream restoration and stormwater retrofits, and (3) effects of development in upstream watersheds. This supports other monitoring by providing information on both upstream contributing and downstream cumulative conditions.

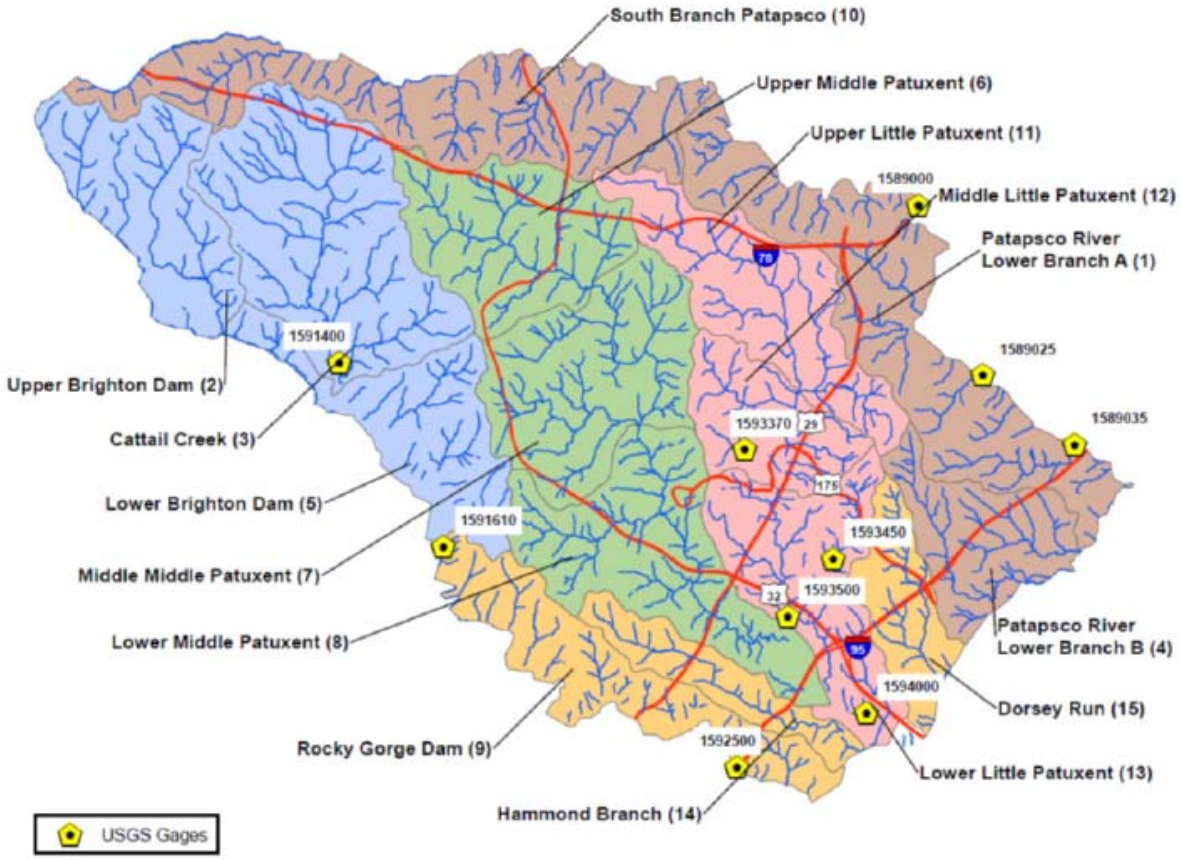


Figure 12. Locations of the 10 USGS stream gages operating within Howard County watersheds during 2012.

9.2 Recommended Monitoring to Track Implementation Progress

Applying the adaptive management approach, the County will consider whether to reallocate and augment its current monitoring program, including the possibility of incorporating the following two components:

1. **Stream resource sampling** of stream benthic macroinvertebrates, water quality, and physical habitat should continue using the partial-replacement design instituted in 2012. Under this design, four of the 10 sites sampled in each watershed would be repeats of sites sampled in Round 1 (2001-2005) and Round 2 (2006-2010), while the remaining six sites would be new random sites. To provide the best trend detection for changes in each watershed resulting from restoration efforts, these four sites per watershed should remain fixed in perpetuity. For the purposes of monitoring improvements to Howard County watersheds resulting from implementation of the new MS4 Permit and Chesapeake Bay WIP, years 2000-2010 can be viewed as baseline stream conditions. Each watershed and site could be evaluated after each 5-year sampling with comparisons to the random and sentinel (fixed, annual) site Maryland Biological Stream Survey (MBSS) monitoring conducted by the State, to control for weather or other confounding factors. Where possible, the results from fish and salamander sampling conducted by the MBSS could be incorporated into the trend evaluations.

Indicators of significant changes in the composite stream condition scores based on indices of biotic integrity or more sensitive community-based analyses), are the ultimate measure of restoration success. Select measures of changes in both biological communities and physical habitat will be evaluated to detect more immediate changes related to reductions in specific stressors. For a headwaters site, the selected monitoring parameters would directly represent the project goals and anticipated environmental benefits to measure success. For example, the Maryland Biological Stressor Identification Process (MDE, 2009b; Southerland et al., 2007) has identified the following variables as significantly correlated with sediment (flow/sediment) and nutrient (energy) stressors to be addressed with restoration projects:

- Flow/Sediment effects: Benthic Tolerant Species, bank stability index, embeddedness, epifaunal substrate condition, instream habitat condition

- Energy effects: Hilsenhoff Biotic Index, shading, dissolved oxygen, dissolved organic carbon, total nitrogen, ammonia-NH3, total phosphorus

Each of these metric scores or other measures of community change could be evaluated, in addition to the composite stream condition scores, to potentially track improvements resulting from reductions in sediment and nutrients, respectively. The biological metrics—Benthic Tolerant Species and Hilsenhoff Biotic Index—alone may prove to be useful indicators. Additional biological metrics taken from the literature (e.g., specific intolerant taxa) will also be considered.

2. **Intensive restoration performance monitoring** of flow and pollutant transport in representative subwatersheds may be extrapolated countywide. This monitoring may use statistically robust, before-after-control-impact (BACI) designs where the maximum number of restoration projects will be implemented. GIS data describing the interplay of land use and stream network would be collected from these subwatersheds and benchmarked to the monitoring results, so that the performance could be extrapolated to similar areas throughout the County. Creating representative subwatershed restorations for each combination of land use type and stormwater solution is critical to this approach.

   Currently, Howard County is conducting BMP performance monitoring in two subwatersheds and the Columbia Association may institute similar monitoring in a third subwatershed as follows:

   a. Wilde Lake watershed contains an older residential community near the center of Columbia and predates stormwater controls. Monitoring since 2006 occurs along several reaches within the subwatershed and encompasses three stream restorations, two SWM retrofits, and two bioretentions. A new USGS gage was installed in October 2011 at a downstream point in this subwatershed.

   b. Red Hill Branch watershed has a mixed-age community outside of Columbia and variable stormwater controls. Monitoring since 2009 includes BACI designs for a stream restoration and a stormwater retrofit. The Rumsey Run geomorphic assessment of newer infiltration BMPs drains to the most downstream monitoring station in Red Hill Branch. A volunteer rain garden program has also been initiated within the subwatershed.

c. Lake Elkhorn watershed is not currently monitored, but a new USGS gage was installed in October 2011 at a downstream point in this subwatershed. Eighteen restoration projects, ranging from stream restoration to SWM retrofits to bioretentions, are planned for Lake Elkhorn watershed, some of which already have been completed.

Each of these monitoring efforts will contribute to extrapolation of restoration performance results countywide. As new restoration projects are constructed, they could be clustered in at least two other subwatersheds with different characteristics to improve the extrapolations to other land uses.

3. **Bacteria Monitoring** Howard County is investigating use of a monitoring program to track bacteria concentrations in the Patapsco Lower North Branch watershed, specifically the PAT0148 subwatershed. Long-term bacteria monitoring along with implementation of pet waste programs will document changes in bacteria levels coinciding with participation in the pet waste pick-up strategy.

The most important aspect of these restoration performance monitoring efforts is the inclusion of a statistically rigorous design with proper controls (spatially, using upstream and downstream sites or paired watersheds; and temporally, with monitoring before and after a restoration event). It will be important to use sampling methods with the least variability and clearest signal. Currently, the Trust Fund program is developing standard geomorphic and water quality methods that are being informed by the monitoring done in Howard County. It is possible that the lessons of intensive monitoring in Red Hill Branch will identify redundant methods that can be eliminated from future monitoring.

It is also possible that emerging technologies will allow continuous recording of water chemistry that was previously unaffordable. For example, optical dissolved oxygen probes do not need regular calibration and can be installed in streams to provide information on diurnal changes. Unexplained low dissolved oxygen conditions may reflect high algal or microbial levels related to nutrient enrichment. Initially, the County could sample a small number of sites associated with restoration efforts, moving the equipment periodically to increase coverage.

Lastly, Howard County may use the continuous flow monitoring of USGS gages for current and future monitoring within the county. Co-locating water quality monitoring with these gages or using them as an indicator of cumulative flows from comparable subwatersheds would increase the value of monitoring data, especially for calculating pollutant loads. Fortunately, USGS gages have recently been installed in the Wilde Lake and Lake Elkhorn subwatersheds. Since all three current monitoring efforts are in the Little Patuxent watershed, extrapolation watershed-wide can make use of the downstream USGS gage at Savage. The USGS gage on Cattail Creek offers an opportunity to monitor clustered restoration projects in western Howard County.

In summary, Howard County monitoring efforts to document stream changes associated with restoration efforts may incorporate the following framework and methods.

- Continue to use sentinel (fixed) sites for trend monitoring of stream conditions

- Use existing monitoring networks (such as the countywide and Maryland Department of Natural Resources Maryland Biological Stream Surveys (MDNR MBSS) stream resource monitoring) to provide baselines and adjust for confounding effects such as precipitation and unusual weather
- Leverage the intensive monitoring of restoration performance in subwatersheds such as Wilde Lake, Red Hill
- When needed, identify the best additional sites to conduct restoration monitoring in subwatersheds with different land uses such as commercial and high-density developments
- Use statistically robust before-after-control-impact (BACI) designs, latest affordable sampling methods, and co-location with USGS gages to optimize the power to detect changes associated with restoration efforts

The type of monitoring described above would be compliant with current NPDES permit conditions and would seek to draw conclusions to specific management questions to assist the County in making informed decisions. To that end, the County will attempt to balance cost, availability of resources, private property owner approvals, and other factors to determine the final monitoring strategies implemented.

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Appendix 1: Disaggregation and Calibration of Howard County Local TMDL SW-WLAs

Disaggregation of Aggregate WLAs

Some SW-WLAs are developed by MDE as an aggregate load including load contributions from multiple jurisdictions. In order to determine Howard County's portion of the load, the aggregate SW-WLA must be disaggregated based on the percentage of Howard County's MS4 regulated urban land area within the TMDL watershed. To date, Howard County is responsible for six aggregate SW-WLAs and three individual SW-WLAs. Aggregate WLAs were disaggregated following steps outlined in MDE's TMDL Stormwater Toolkit (MDE, 2015b). The proportion of Howard County MS4 urban land area to total urban land area, including other jurisdictions, within the 8-digit watershed boundaries was calculated. Urban land use categories from Maryland Department of Planning 2010 land use data (MDP, 2010) were used to define each jurisdiction's urban area. The percentage of Howard County MS4 urban land area was then applied to the aggregate SW-WLA published in the local TMDL document. Local TMDLs with individual SW-WLAs require a specified percent reduction of pollutant loads from baseline levels to achieve the target SW-WLA and no disaggregation is necessary. Table 1 displays Howard County local TMDLs with aggregate SW-WLAs disaggregated.

The load reduction calculated from disaggregating the bacteria SW-WLA following MDE Guidance stated above is the target for the Patapsco River Lower North Branch bacteria local TMDL. This value is presented in bold in the Calculated Disaggregated County MS4 Reduction column of Table 1.

Calibrating Nutrient and Sediment Baseline Loads and WLAs

According to the MDE guidance document *Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs* (MDE, 2014b), Section I, baseline loads and WLAs must be calibrated to the model used to calculate load reductions:

Because all of Maryland's approved local nutrient and sediment TMDLs were developed using watershed models other than MAST [Maryland Assessment Scenario Tool], the baseline and target loads from these TMDLs need to be translated into MAST loadings. This adjustment is required to account for potential differences between models. This is a two-step process that involves 1) creating a MAST scenario that replicates the baseline year of the TMDL, and 2) applying the load reduction percentage from the TMDL to the MAST loading for the baseline year.

Local TMDL baseline loads for nutrients and sediments were calibrated in BayFAST (Bay Facility Assessment Scenario Tool) by modeling County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. BayFAST functions similarly to Maryland Assessment Scenario Tool (MAST); which is described further in Section 3.2: Modeling Approach of this plan, however BayFAST allows users to delineate facility boundaries (e.g., watershed, parcel, drainage area) and alter land use information within the delineated boundary depending on the model year. The general calibration procedure is as follows:

1. For each local TMDL, a facility boundary for the 8-digit TMDL watershed within Howard County borders was delineated within BayFAST.
2. All default land use acreages were deleted and regulated pervious and impervious acres were replaced with MAST Local Base County Phase I MS4 urban pervious and impervious acres using the Compare Scenario tool in MAST for the respective baseline year for each local TMDL. This approach inherently disaggregates County MS4 loads from the rest of the NPDES regulated area within the watershed.
3. County BMPs installed prior to the TMDL baseline year were then added to the model.

4. The reduction percentage published in the TMDL document was then applied to the calibrated baseline loads modeled in BayFAST to calculate a calibrated reduction in EOS-lbs/yr.
5. A calibrated WLA was calculated by subtracting the calibrated reduction from the BayFAST baseline load.

Aggregate nutrient and sediment SW-WLAs are inherently disaggregated through this approach. Therefore, disaggregated loads calculated using the proportion of Howard County MS4 urban land (as described in the Disaggregation of Aggregate SW-WLAs section above) were not used in the CIS. Additionally, because bacteria load reductions are not modeled using BayFAST or MAST, aggregate bacteria SW-WLAs were disaggregated but not calibrated.

Calibrated load reductions calculated based on TMDL percent reductions and baseline loads modeled in BayFAST using Howard County Phase I MS4 baseline pervious and impervious land use and baseline treatment are the target reductions used in the CIS for nutrient and sediment local TMDLs. These values are presented in bold in Table 2.

Calibrating Bacteria Baseline Loads and WLAs

Unlike TMDLs for nutrients and sediment, MDE's bacteria TMDLs were not prepared using a watershed model. All loads discussed in the bacteria TMDLs are based on monitoring in the impaired waterbody. Fate and transport from the watershed are not accounted for, including the quantity of bacteria from various sources in the watershed, die-off (or growth) in transit to the waterbody, potential sequestering and resuspension from bottom sediments, or other factors.

For the Patapsco Lower North Branch TMDL, MDE has included Bacterial Source Tracking (BST), to estimate the source of the bacteria by matching DNA or RNA with a library of samples from known species. BST has been used to categorize the fraction of bacteria coming from four general sources: humans, domestic pets, wildlife, or livestock. It is important to note that BST is performed on samples from the impaired waterbody, and thus the estimate of the fraction from each source is for the watershed as a whole, not from particular locations, jurisdictions, or permittees.

Table 4.9.1 shows that the only sources for the SW-WLA regulated by the County's MS4 permit are domestic pets and wildlife. All human and livestock sources are considered to be part of the unregulated LA. For this reason, the County's TMDL analysis only focuses on domestic sources.

In section 4.7, the TMDL discusses two scenarios: the Maximum Practicable Reduction (MPR) and the target reduction. MPR is based on reductions for each of the four source categories. Human sources potentially have the highest risk of causing disease, so the maximum reduction was set at 95%. The domestic pet reduction was based on an estimated success of education and outreach programs, set at 75%. The livestock target, also 75%, was based on the level of sediment reductions from agricultural BMPs. Wildlife reductions were assumed to be 0%.
The target reduction is based on MDE's requirement to determine a TMDL which will meet water quality standards. This analysis removed the practicality constraints, with a maximum allowable reduction of 98% for all sources. The resulting reduction requirements were higher than the MPR one subwatershed for Patapsco Lower North Branch.

In the TMDL documents, MDE has recognized that "…the goal of meeting water quality standards may require very high reductions that are not achievable with current technologies and management

practices. … In cases where such high reductions are required to meet standards, it is expected that the first stage of implementation will be to carry out the MPR scenario." (MDE, 2009). For this reason, the County has chosen to meet the MPR in the CIS.

The following tables show the calculations for the County's MPR:

Baseline (TMDL Table 4.7.1)

	Domestic	Human	Livestock	Wildlife	Target
PAT03471	209,080	153,371	126,719	552,503	1,041,673
PAT0285sub	86,526	74,154	35,401	162,746	358,827
PAT0222sub	93,102	76,095	36,756	138,911	344,864
PAT0176sub	36,596	37,625	28,997	82,355	185,573
PAT0148sub	89,836	143,286	42,047	159,828	434,997
	515,140	484,531	269,920	1,096,343	2,365,934

MPR Percent Reduction (TMDL Table 4.7.3)

	Domestic	Human	Livestock	Wildlife	Target
PAT03471	0.0%	87.4%	0.0%	0.0%	12.9%
PAT0285sub	0.0%	0.0%	0.0%	0.0%	0.0%
PAT0222sub	0.0%	0.0%	0.0%	0.0%	0.0%
PAT0176sub	0.0%	0.0%	0.0%	0.0%	0.0%
PAT0148sub	75.0%	95.0%	75.0%	0.0%	54.0%

MPR TMDL (Derived from Baseline and Table 4.7.3)

	Domestic	Human	Livestock	Wildlife	Target
PAT03471	209,080	19,325	126,719	552,503	907,627
PAT0285sub	86,526	74,154	35,401	162,746	358,827
PAT0222sub	93,102	76,095	36,756	138,911	344,864
PAT0176sub	36,596	37,625	28,997	82,355	185,573
PAT0148sub	22,459	7,164	10,512	159,828	190,723
	447,763	214,363	238,385	1,096,343	1,987,614

MPR Reduction (Baseline minus MPR TMDL)

	Domestic	Human	Livestock	Wildlife	Target
PAT03471	0	134,046	0	0	134,046
PAT0285sub	0	0	0	0	0
PAT0222sub	0	0	0	0	0
PAT0176sub	0	0	0	0	0
PAT0148sub	67,377	136,122	31,535	0	235,034
	67,377	270,168	31,535	0	369,080

Per MDE's comments on the Draft CIS, the County is only required to focus improvements in one subwatershed: PAT0148sub. The loads presented above are for the entire 8-digit watershed. In order to determine the County's responsibility, they must be disaggregated to estimate the load generated in the

area served by the MS4. This has been performed with a spatial analysis according to the procedure published by MDE (CITATION NEEDED). The spatial analysis included the following steps:

- Digitize subwatershed boundary.
- Intersect subwatershed with county boundaries and determine Howard County area.
- Intersect County portion of subwatershed with permittee jurisdiction
- Multiply County MS4 percent of watershed against MPR required reduction

Spatial Analysis for HoCo Disaggregation

PAT0148sub	Total	AA+BC+BA	HO	Non-MS4	HO MS4
(sq mi)	42.60	30.04	12.56	2.21	10.35
(%)	100.0%	70.5%	29.5%	5.2%	24.3%
Baseline	89,836	63,349	26,487	4,661	21,826
TMDL	22,459	15,837	6,622	1,165	5,457
Required Reduction	67,377	47,512	19,865	3,495	**16,370**

Table 1. Howard County Local TMDLs with SW-WLAs. Aggregate SW-WLAs Disaggregated Following MDE Guidance

Watershed Name	Watershed Number 8-digit	WLA Type	Baseline Model[1]	Pollutant	Units	MDE Published WLA[2]	MDE Published Reduction %[2]	Watershed Howard County MS4 Urban Land Area (ac)[3]	Watershed Total Urban NPDES Land Area (ac)[4]	% of County MS4 Land Area[5]	Calculated Disag-gregated County MS4 WLA[6]	Calculated Disag-gregated County MS4 Reduction[7]	Calculated Disag-gregated County MS4 Baseline Load
Patapsco River Lower North Branch	02130906	Individual	CBP WM P5	Sediment	tons/yr	2,634.30	10%	-	-	-	-	-	-
		Aggregate	N/A	Bacteria	billion MPN/yr	89,386.0	75.0%	8,038.4	27,264.0	24.3%	5,457	**16,370**	21,826
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906	Aggregate	HSPF, CH3D, CE-QUAL_ICM, sediment flux	Nitrogen	lbs/yr	79,659.0	15%	18,099.87	53,483.69	33.8%	26,958.1	4,757.3	31,715.4
	02130908												
	02130906	Aggregate		Phosphorus	lbs/yr	8,622.0	15%	18,099.87	53,483.69	33.8%	2,917.8	514.9	3,432.8
	02130908												
Patuxent River Upper	02131104	Individual	CBP WM P5.2	Sediment	tons/yr	579.8	11.4%	-	-	-	-	-	-
Little Patuxent River	02131105	Individual	CBP WM P5.2	Sediment	tons/yr	3,609.3	48.1%	-	-	-	-	-	-
Rocky Gorge Reservoir	02131107	Aggregate	CE-QUAL-W2	Phosphorus	lbs/yr	1,512.0	15%	3,457.01	14,734.75	23.5%	354.7	62.6	417.3
Triadelphia Reservoir (Brighton Dam)	02131108	Aggregate	CE-QUAL-W2	Phosphorus	lbs/yr	4,672.0	15%	12,467.78	14,707.93	84.8%	3,960.4	698.9	4,659.3
		Aggregate	CE-QUAL-W2	Sediment	tons/yr	354.0	0%				300.1	0.0	300.1

Target load reductions used in the CIS shown in bold text.
SW-WLA disaggregation method: MDE TMDL Stormwater Toolkit (http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Pages/TMDLStormwaterToolkit.aspx)

1) Baseline model used to create the TMDL. Chesapeake Bay Program Watershed Model Phase (CBP WM P); Hydrological Simulation Program Fortran (HSPF); Curvilinear Hydrodynamic in Three Dimensions (CH3D); Corps of Engineers-Water Quality-Integrated Compartment Model (CE-QUAL-ICM), Corps of Engineers-Water Quality-and Hydrodynamic model in 2D (CE-QUAL-W2)
2) Published WLA and Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Howard County. Value for bacteria is for domestic loads in PAT0148sub subwatershed only. Bacteria reduction has been calculated for Howard County MS4, domestic loads, PAT0148sub subwatershed.
3) MDP 2010 LULC urban land area within Howard County NPDES MS4 Phase I/II source sector in watershed. Value for bacteria is for PAT0148sub subwatershed.
4) MDP 2010 LULC urban land area within total NPDES source sectors in watershed. All land in PAT0148sub subwatershed is urban MS4.
5) The percent of County MS4 land area was calculated by dividing the total County MS4 urban land area with the total urban NPDES source sector land area of the 8-digit watershed area (MDP, 2010). Bacteria values are for PAT0148sub subwatershed.
6) Disaggregated WLAs were calculated by multiplying MDE published aggregate WLAs by the percentage of County MS4 land within the urban NPDES land area of the 8-digit watershed. Bacteria is based on domestic loads in PAT0148sub.
7) Disaggregated reductions were calculated from the disaggregate WLA and reduction % using the following equation: (Disaggregated WLA / (1 - Reduction %)) - Disaggregated WLA

Table 2. Disaggregated and Calibrated Nutrient and Sediment Local TMDL SW-WLAs and Load Reductions

Watershed Name	Watershed Number	Baseline Year	Pollutant	MDE Published Reduction %[1]	Baseline Acres (MAST Local TMDL Base Year)[2]		Baseline Loads EOS-lbs/yr[3]	Reduction EOS-lbs/yr[4]	WLA EOS-lbs/yr[5]
					County Phase I MS4 Impervious	County Phase I MS4 Pervious			
Patapsco River Lower North Branch	02130906	2005	Sediment	10%	3,049	8,461	6,123,442	**612,344**	5,511,098
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906	1995	Nitrogen	15%	2,773	7,776	81,058	**16,059**	91,000
	02130908				371	1,816	26,001		
	02130906	1995	Phosphorus	15%	2,773	7,776	5,530	**982**	5,564
	02130908				371	1,816	1,016		
Patuxent River Upper	02131104	2005	Sediment	11.40%	247	942	145,902	**16,633**	129,269
Little Patuxent River	02131105	2005	Sediment	48.10%	6,189	18,189	10,346,821	**4,976,821**	5,370,000
Rocky Gorge Reservoir	02131107	2000	Phosphorus	15%	291	1,517	861	**129**	732
Triadelphia Reservoir (Brighton Dam)[6]	02131108	2000	Phosphorus	15%	869	4,859	2,654	**398**	2,256
		2000	Sediment	0%			1,844,103	**0**	1,844,103

Target load reductions used in the CIS shown in bold text.

1) Published Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Howard County
2) County Phase I MS4 urban impervious and pervious acres for the TMDL baseline year. A query was run using the MAST Compare Scenario tool based on local TMDL watershed split by County and Local Base year. Local TMDL base data prior to 2000 is unavailable in MAST; therefore, 2000 County Phase I MS4 urban impervious and pervious acres were used in the Baltimore Harbor baseline model (baseline year = 1995).
3) Baseline loads modeled in BayFAST using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. Modeled 10/22/2015. Additional load reductions from Howard County lakes installed prior to the baseline year and rooftop/non-rooftop disconnects were included outside of BayFAST.
4) Calibrated reductions calculated by applying the MDE published percent reduction to the BayFAST calibrated baseline loads.
5) Calibrated WLAs calculated by subtracting the calibrated reduction from the BayFAST calibrated baseline load.
6) The Triadelphia Reservoir (Brighton Dam) sediment TMDL requires 0% reduction with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008). Therefore, the Triadelphia Reservoir sediment local TMDL is not addressed further in the CIS.

Comparison of Published, Disaggregated, and Calibrated SW-WLAs

- Baltimore Harbor – Nitrogen and Phosphorus: The Baltimore Harbor nutrient TMDL requires a 15% reduction of 1995 baseline nitrogen and phosphorus loads and includes Patapsco River Lower North Branch and South Branch Patapsco watersheds. This local TMDL has aggregate SW-WLAs for the NPDES stormwater sector for nitrogen and phosphorus – 79,659 TN EOS-lbs/yr and 8,622 TP EOS-lbs/yr as published in the TMDL document (MDE, 2006). Disaggregated nutrient SW-WLAs (26,958 TN EOS-lbs/yr and 2,918 TP EOS-lbs/yr) are much lower than nutrient SW-WLAs calibrated to BayFAST (91,000 TN EOS-lbs/yr and 5,564 TP EOS-lbs/yr) due to differences in the baseline model used to calculate the original aggregate WLA. Models included the following: a watershed model Hydrological Simulation Program Fortran (HSPF), a hydrodynamic model (Curvilinear Hydrodynamic in Three Dimensions (CH3D), a water quality model (Corps of Engineers-Water Quality-Integrated Compartment Model (CE-QUAL-ICM), and a sediment flux model. When calibrating nitrogen and phosphorus baseline loads using BayFAST (CBP WM P5.3.2), 1995 baseline land use information (i.e., Howard County Phase I MS4 impervious and pervious acres) was unavailable and 2000 land use information was used in the model. The differences between models and 1995/2000 land use background loads may have increased the calibrated SW-WLAs when compared to the disaggregated SW-WLAs resulting from the disaggregation of the original aggregate SW-WLA.

- Little Patuxent River – Sediment: The Little Patuxent River sediment TMDL requires a 48.1% reduction of 2005 baseline loads. This local TMDL has an individual SW-WLA assigned to the Howard County MS4 Phase I urban sector of 7,218,600 EOS-lbs/yr (3,609 tons/yr) as published in the TMDL document (MDE, 2011a). There is a 26% difference in the SW-WLA calibrated in BayFAST (5,370,000 EOS-lbs/yr) likely due to changes between the baseline model (CBP WM P5.2) and the current model (CBP WM P5.3.2).

- Patapsco River Lower North Branch – Sediment: The Patapsco River Lower North Branch sediment TMDL requires a 10% reduction of 2005 baseline loads. This local TMDL has an individual SW-WLA assigned to the Howard County MS4 Phase I urban sector of 5,268,600 EOS-lbs/yr (2,634.4 tons/yr) as published in the TMDL document (MDE, 2011b). There is a 5% difference in the SW-WLA calibrated to BayFAST (5,511,098 EOS-lbs/yr) likely due to slight differences between the baseline model (CBP WM P5) and the current model (CBP WM P5.3.2).

- Patapsco River Lower North Branch – Bacteria: The Patapsco River Lower North Branch bacteria TMDL requires a 13.4% reduction of 2003 baseline loads. However, the County only has a SW-WLA in one subwatershed: PAT0148sub. This subwatershed has an aggregate target of 89,836 billion MPN/yr for domestic sources, the only ones contributing to the NPDES stormwater sector as published in the TMDL document (MDE, 2009a). This bacteria load, disaggregated to the Howard County MS4 Phase I urban sector resulted in a WLA of 5,457 billion MPN/yr. This disaggregated WLA accounts for 24.3% of the aggregate WLA, which is the percentage of Howard County's NDPES MS4 urban land area within the total NPDES urban land area of the subwatershed.

- Patuxent River Upper – Sediment: The Patuxent River Upper sediment TMDL requires an 11.4% reduction of 2005 baseline loads. This local TMDL has an individual SW-WLA assigned to the Howard County MS4 Phase I urban sector of 1,159,600 EOS-lbs/yr (579.8 tons/yr) as published in the TMDL document (MDE, 2011c). However, the calibrated SW-WLA modeled in BayFAST

resulted in a load approximately ten times less than the published individual SW-WLA (129,269 EOS-lbs/yr). In addition to differences between the baseline model (CBP WM P5.2) and the current model (CBP WM P5.3.2), differences in Howard County Phase I MS4 urban land area may also be attributing to the difference in WLA. As discussed in the section above, *Calibrating Nutrient and Sediment Baseline Loads and WLAs*, MAST Local Base land use for Howard County Phase I MS4 urban impervious and pervious acres were used to calibrate TMDL baseline loads. MAST shows 247 impervious acres and 942 pervious acres for 2005 Upper Patuxent Howard County Phase I MS4; therefore, a SW-WLA of 129,269 EOS-lbs/yr (calibrated SW-WLA) is much more reasonable for this area than a SW-WLA of 1,159,000 EOS-lbs/yr (published individual SW-WLA).

- Rocky Gorge Reservoir – Phosphorus: The Rocky Gorge Reservoir phosphorus TMDL requires a 15% reduction of 2000 baseline loads. This local TMDL has an aggregate SW-WLA for the NPDES stormwater sector of 1,512 EOS-lbs/yr as published in the TMDL document (MDE, 2008). Sediment SW-WLA disaggregated to the Howard County MS4 Phase I urban sector resulted in a WLA of 354.7 EOS-lbs/yr. This disaggregated WLA accounts for 23.5% of the aggregate WLA, which is the percentage of Howard County's NDPES MS4 urban land area within the total NPDES urban land area of the watershed. There is a 106% difference in the SW-WLA calibrated to BayFAST (732.0 EOS-lbs/yr) when compared to the disaggregated SW-WLA likely due to differences between the baseline model used to calculate the aggregated SW-WLA (CE-QUAL-W2) and the current model (CBP WM P5.3.2).

- Triadelphia Reservoir (Brighton Dam) – Phosphorus and Sediment: The Triadelphia Reservoir TMDL requires a 15% reduction of 2000 baseline phosphorus loads. Sediment is also listed in this TMDL; however, the Howard County MS4 Phase I urban sector requires a 0% reduction in baseline sediment loads and will not be addressed further in the CIS. An aggregate phosphorus SW-WLA for the NPDES stormwater sector of 4,672 EOS-lbs/yr is published in the TMDL document (MDE, 2008). Phosphorus SW-WLA disaggregated to the Howard County MS4 Phase I urban sector resulted in a WLA of 3,960 EOS-lbs/yr. This disaggregated WLA accounts for 84.8% of the aggregate WLA, which is the percentage of Howard County's NPDES MS4 urban land area within the total NPDES urban land area of the watershed. There is a 43% difference in the SW-WLA calibrated to BayFAST (2,256 EOS-lbs/yr) when compared to the disaggregated SW-WLA likely due to differences between the baseline model used to calculate the aggregated SW-WLA (CE-QUAL-W2) and the current model (CBP WM P5.3.2).

Appendix 2: Howard County Impervious Accounting: Methods and Results

HOWARD COUNTY IMPERVIOUS ACCOUTING: METHODS AND RESULTS

December 2016

Updated December 2017

Prepared for:

Howard County

Department of Public Works

Bureau of Environmental Services

Stormwater Management Division

NPDES Watershed Management Program

Prepared by:

KCI Technologies, Inc.

And

McCormick Taylor, Inc.

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Introduction

As a requirement of section PART IV.E.2.a of the NPDES MS4 Discharge Permit issued by MDE to Howard County, the County must conduct an impervious area assessment to define the restoration efforts required under the permit to restore 20% of remaining Countywide baseline impervious acres not already restored to the MEP. The restoration is required to be complete by 2019, the end of the current permit term.

Howard County conducted the impervious accounting analysis and reported on the methods and results in the Countywide Implementation Strategy (CIS) completed in December 2015 and submitted to MDE with the County's NPDES annual report (AR20).

Based on MDE's comments on the County's methodology, a change in the date cutoff for determining restoration projects credited towards baseline reduction versus restoration, additional County data resources being further prepared, and basic progress completed during FY2016, Howard County has completed a full update to their impervious accounting, and determination of their baseline untreated impervious surfaces and the associated 20% restoration target. In light of these major changes, this memorandum was developed to describe the methods and results of the County's accounting.

MDE reviewed the County's impervious area assessment submitted on December 17, 2016 and provided comments and an approved impervious area baseline on April 13, 2017. Revisions to the County's impervious baseline accounting are provided and discussed in Section 5. Currently the County is moving forward with the 20% restoration based on the MDE approved baseline and associated 20% target; however the County continues to determine reductions to its baseline and will prepare a recalculated impervious baseline in year four of the current MS4 permit term.

Methodology Overview

The first step in this process is to determine the County's MS4 area of jurisdiction and the baseline impervious surface area that is treated, untreated, and partially treated. The County's GIS 2002 planimetric impervious layer was used as the basis for the analysis. Based on Maryland Stormwater regulations, development occurring after 2002 included requirements for treating the full water quality volume (WQv), therefore impervious surfaces developed after 2002 are considered fully treated and can be extracted from the analysis. Using this layer in combination with limited treatment from BMPs existing in 2002 that also can be credited with WQv treatment, the amount of untreated impervious surfaces was obtained and the 20% then applied. Existing BMPs include structural stormwater BMPs and other treatment including rooftop and non-rooftop impervious surface disconnects, septic system upgrades, rain barrels, and Howard County lakes.

Impervious restoration conducted after the expiration date of the previous permit term are considered restoration credit for the current permit term. Therefore, restoration projects implemented following June 20, 2010 are considered restoration and restoration projects implemented before June 20, 2010 are credited to the baseline.

Impervious accounting methodology is provided here with results at the watershed and County scale. Although there are no required restoration targets at the watershed scale, the calculations were made at that level to assist in planning and targeting restoration practices to areas with the greatest need.

1. 2002 Impervious Surface Layer Development

1.1 Source Data

The following source data were used to develop the Howard County 2002 impervious surface layer:

2002 Planimetric Data:

- Roads (Polygons)
- Parking Lots (Polygons)
- Buildings – Major (Polygons)
- Buildings – Minor (Polygons)
- Driveways (Lines)
- Sidewalks (Lines)
- Trails (Lines)

2006 Planimetric Data:

- Driveways (Polygons)

Ownership Data:

- State Highway Administration (SHA) Right-of-Way
- Howard County Parcels

BMPs from adjacent jurisdictions:

- SHA TMDL Database – Extract of BMP facilities whose footprint or drainage area are in Howard County

1.2 Impervious Layer Development

The following steps were used to develop a countywide impervious surface layer for Howard County that represents the 2002 condition.

1. Conversion of polyline data to polygon

Several of the planimetric layers developed in 2002 were polyline features. In order to incorporate these data in the countywide impervious polygon layer, they needed to be converted to polygon data.

a. Sidewalks and Trails:

The sidewalk and trail layers were buffered by 1.5 feet, creating three foot wide polygon features.

b. *Driveways:*

2006 was the first year that Howard County captured driveways as polygon features. In 2002, only the driveway outlines were captured as polyline features. A select by location was performed to identify which 2006 driveway polygons intersected with the 2002 driveway polylines. A two-foot buffer was applied to ensure any minor updates to feature geometry didn't affect the selection. Any intersecting features from the 2006 polygon layer were extracted as the 2002 driveway polygon layer.

2. Impervious layer creation and topology review

All polygon planimetric layers were merged into a single polygon impervious surface feature class. To ensure no overlaps existed amongst the 2002 planimetric layers, overlapping areas were erased from each planimetric layer using the ArcGIS Erase tool before being merged into the final feature class.

3. Impervious Ownership Identification

The County sought to spatially identify impervious area owned and managed by the County, as well as the impervious area owned by SHA, other state agencies, managed under industrial SW-12 permits, or treated by a SHA BMP. Table 1 below summarizes the total acreages of each impervious category. Below is a description of how each category was identified spatially.

a. *SHA right-of-way (SHA):*

SHA's latest right-of-way layer was unioned with the impervious surface layer. All areas within SHA right-of-way except driveway features were coded as SHA.

b. *State owned (State):*

Using Howard County's parcel layer, parcels owned by State agencies were identified and extracted as State owned parcels. These state owned parcels were unioned with the impervious surface layer. All areas within these parcels were coded as State owned. Table 2 below shows the full list of parcel owner names used for the state owned parcels.

c. *Industrial SW-12 permitted areas (Industrial):*

Howard County made a request to MDE for all SW-12 permit holders within the county. Using the provided list of owners and addresses, the County compiled a list of parcels that would be considered managed under a separate SW-12 permit. These SW-12 parcels were unioned with the impervious surface layer. All areas within these parcels were coded as industrial. When plans were available, they were reviewed and only those impervious areas identified in the plan were coded as industrial. Table 3 below shows the full list of parcel owner names used for the Industrial SW-12 permitted areas.

d. *SHA TMDL Database (SHA BMP DA):*

Using a database of BMPs and their drainage areas, these drainage areas were unioned with the impervious surface layer. All areas within these parcels were coded as SHA BMP DA. All areas treated by SHA BMPs were within SHA's right-of-way, so no additional County impervious was excluded due to SHA BMPs.

Table 1: Impervious Category Acreage

Impervious Category	Total Acreage
County	15227.70975
Industrial	419.869023
SHA	1878.307556
SHA BMP DA	19.357428
State	184.28835

Table 2: State Owned Parcels

Owner	Impervious Acres
BOARD OF PUBLIC WORKS STATE OF MD TO THE USE OF CORRECTIONAL SERVICE	0.23190
COM DEV ADMIN MD DEPT OF HOUSING & COM DEV	3.31463
DEPARTMENT OF FOREST & PARKS ST MD	4.49643
MARYLAND DEPT OF TRANSPORTATION STATE RAILROAD ADMINISTRATION	1.81200
MARYLAND FOOD CENTER AUTHORITY THE C/O DONALD DARNALL	30.87993
MARYLAND FOOD CTR AUTHORITY THE	19.20083
MARYLAND ST DEPT PUBLIC SAFETY & CORRECTIONAL SERVICES MD ST POLICE	1.45462
ST OF MD BOARD OF PUBLIC WORKS C/O CSX TRANSPORTATION INC	0.04642
ST OF MD DEPART NAT RESOURCES C/O LYMAN W HAMLIN	0.00156
ST OF MD DEPT FOREST & PARKS	2.84407
ST OF MD DEPT FOREST & PARKS FORESTS & PARKS	0.65843
ST OF MD DEPT NATURAL RESOUCES	0.48614
ST OF MD DEPT NATURAL RESOUCES STATE OFFICE BLDG	0.04156
ST OF MD DEPT OF CORRECTIONS C/O CSX TRANSPORTATION INC	6.18769
ST OF MD DEPT OF FORESTS & PARKS	1.50177
ST OF MD DEPT OF FORESTS & PK	0.18713
ST OF MD DEPT OF FORESTS & PK C/O ALLAN SLEVY	0.08598
ST OF MD DEPT OF FORESTS & PKS	1.11686
ST OF MD DEPT OF FORESTS AND PARKS	0.52828
ST OF MD DEPT OF NAT RES	0.74281
ST OF MD DEPT OF NAT RES C/O GEORGE E RAMSEY 3RD	0.08432
ST OF MD DEPT OF NAT RESOURCE STATE OFFICE BLDG	0.00526
ST OF MD DEPT OF NATRL RESOURCES % JAMES B COULTER SEC	0.24508
ST OF MD DEPT OF NATURAL RESOURCES	0.06997
STATE HIGHWAT ADMINISTRATION DEPARTMENT OF TRANSPORTATION	0.25643
STATE HIGHWAY AD DEPT OF TRANS	0.00219
STATE HIGHWAY ADM DEPT OF TRANS	0.25586
STATE HIGHWAY ADMINISTRATION	1.10864
STATE HIGHWAY ADMINISTRATION ATTN NORMAN GABRIEL	0.00948

Owner	Impervious Acres
STATE HIGHWAY ADMINISTRATION DEPT OF TRANSPORTATION	1.02037
STATE HIGHWAY ADMINISTRATION DEPT OF TRANSPOTATION	0.48250
STATE HIGHWAY ADMINISTRATION DEPT TRANSPORATION	0.06631
STATE HIGHWAY ADMINISTRATION OFFICE OF REAL ESTATE	0.00002
STATE OF MARYLAND	0.32818
STATE OF MARYLAND ATTN MDNG-AG-FI	3.11087
STATE OF MARYLAND C/O JEAN COLBURN	0.48189
STATE OF MARYLAND C/O MVA ATTN LIZY KANNARKAT	1.11055
STATE OF MARYLAND C/O PATAPSCO VALLEY ST PARK	14.53704
STATE OF MARYLAND C/O PATAPSCO VALLEY ST PK	0.00002
STATE OF MARYLAND C/O PATAPSCO VALLEY STATE PARK	0.21847
STATE OF MARYLAND COMMISSION OF MD	3.05920
STATE OF MARYLAND DEAPT OF NATURAL RESOURCES	0.21750
STATE OF MARYLAND DEPARTMENT FORESTS & PARKS	0.03236
STATE OF MARYLAND DEPARTMENT OF GENERAL SERVICES	0.85539
STATE OF MARYLAND DEPARTMENT OF NATURAL RESOURCES	0.06631
STATE OF MARYLAND DEPARTMENTS OF FORESTS AND PARKS	0.02046
STATE OF MARYLAND DEPT FORESTS & PARKS	0.31585
STATE OF MARYLAND DEPT GEN SER C/O RECORDS CTR WAREHOUSE	3.35647
STATE OF MARYLAND DEPT NATL RESOURCES	0.64909
STATE OF MARYLAND DEPT NATURAL RESOURCES	0.69779
STATE OF MARYLAND DEPT OF FOREST & PARKS	0.02137
STATE OF MARYLAND DEPT OF FORESTRY	0.06747
STATE OF MARYLAND DEPT OF FORESTS & PARKS	2.73433
STATE OF MARYLAND DEPT OF FORESTS AND PARKS	0.01531
STATE OF MARYLAND DEPT OF GENERAL SERVICES	4.67289
STATE OF MARYLAND DEPT OF HEALTH AND MENTAL HYGIENE	10.47646
STATE OF MARYLAND DEPT OF NATL RES	0.31916
STATE OF MARYLAND DEPT OF NATL RESOURCES	0.25017
STATE OF MARYLAND DEPT OF NATURAL RESOURCES	8.33944
STATE OF MARYLAND DEPT OF NATURAL RESOURSES	0.00004
STATE OF MARYLAND DEPT OF TRANSPORTATION	0.08267
STATE OF MARYLAND DEPT STATE HIGHWAY ADMINISTRATION	0.03074
STATE OF MARYLAND DEPT TRANS	0.02596
STATE OF MARYLAND DHMH ARC OF HOWARD COUNTY	0.09096
STATE OF MARYLAND HIGHWAY ADMIN DAYTON MAINTENANCE SHOP	0.00006
STATE OF MARYLAND HIGHWAY ADMINISTRATION	0.03061
STATE OF MARYLAND HUGH THOMAS WILDLIFE FARM	0.73667
STATE OF MARYLAND PATUXENT INST FIANCE OFFICE	13.31327
STATE OF MARYLAND PATUXENT INST FINANCE OFFICE	0.70466

Owner	Impervious Acres
STATE OF MARYLAND ST HWY ADMIN DEPT OF TRANSPORTATION	0.02374
STATE OF MARYLAND STATE HIGHWAY ADMINISTRATION	0.44749
STATE OF MARYLAND STATE HIGHWAY ADMINST DEPT TRANSPR	0.02262
STATE OF MARYLAND THE SHA	0.00005
STATE OF MARYLAND THE STATE HIGHWAY ADMINISTRATION	0.00209
STATE OF MARYLAND THE STATE HIGHWAY ADMINISTRATION THE	0.11161
STATE OF MARYLAND TO THE USE OF DEPT OF NATURAL RES	1.36811
STATE OF MARYLAND TO THE USE OF DEPT OF NATURAL RESOURCES	0.02935
STATE OF MARYLAND UNI MD EXPERIMENTAL FARM	9.61155
STATE OF MD	0.05553
STATE OF MD BD OF PUBLIC WORKS MARYLAND SCHOOL OF THE DEAF	7.68507
STATE OF MD DEPT NAT RESOURCES	0.00234
STATE OF MD DEPT OF FOREST & PARKS	1.13457
STATE OF MD DEPT OF MD ST POLICE	6.07513
STATE OF MD DEPT OF NAT'L	0.26952
STATE OF MD DEPT OF NATL RESOURSES	0.04508
STATE OF MD DEPT OF PUBLIC SAFETY	0.10679
STATE OF MD DEPT OF STATE POLICE	0.10741
STATE OF MD DEPT PUBLIC SAFETY CORRECTIONAL SERVICE	0.67856
STATE OF MD ST BD OF PRISON CONT	0.16516
STATE OF MD STATE HIGHWAY ADMINST DEPARTMENT OF TRANSPORTATION	0.03335
STATE OF MD STATE RDS COMM	0.00284
STATE OF MD STATE ROADS COMM	0.00037
STATE RAILROAD ADMIN C/O MASS TRANSIT ADMIN	1.81586
STATE RAILROAD ADMINISTRATION DEPT OF TRANSPORTATION	3.47464
STATE ROADS COMM OF MD	0.00610
STATE ROADS COMMISION OF MARYLAND	0.00007
STATE ROADS COMMISSION	0.04277
STATE ROADS COMMISSION OF MARYLAND	0.32901
STATE ROADS COMMISSION OF MD	0.24647
Total	**184.28835**

Table 3: Industrial Permit Properties

Owner	Impervious Acres
9041 CHEVROLET DRIVE LLC	0.40261
95-10 DEVELOPMENT LC	7.344491
A. DUIE PYLE	6.601121
AMB SHERWICK LLC	3.498989

Owner	Impervious Acres
BALTIMORE AUTO RECYCLING INC	0.284282
BARDALE COMPANY AN ILLINOIS CORP	2.929382
BELTS CORPORATION	6.872849
CABOT III-MD1WII LLC	1.892936
CALTON JOHN R JR	0.799288
CHASE LIMITED PARTNERSHIP	1.750222
CONCRETE PIPE & PRECAST LLC	2.93896
CSX TRANSPORTATION	113.736122
DANIELS C R	6.488117
DISTRIBUTION FUNDING TRUST II	14.011044
DOBBIN ROAD FLUIDICS LLC	4.6867
DORSEY RUN LIMITED PARTNERSHIP	1.516341
DYNA AJ LLC	0.077111
EDYS GRAND ICE CREAM	9.319043
ENTERPRISES J R	3.028467
FEDEX FREIGHT INC	5.097206
FP 6310 HILLSIDE CENTER LLC	0.028117
FRP DORSEY LLC	3.272662
GENTRY FAMILY REALTY LP	2.56621
GPT ELKRIDGE TERMINAL OWNER LLC	4.36518
HOCK/BAVAR STAYTON JOINT	7.674936
JOHNS HOPKINS UNIV	68.926578
KIT KAT ROAD PARTNERS LLC	2.408578
MARYLAND & VIRGINIA BUSINESS TRUST	10.869655
MARYLAND RECYCLE COMPANY	0.404687
MAYER BROS INC	0.216855
MERRITT 068 LLC	15.908062
N A INC	3.437494
NOAH AARON CORPORATION	0.110662
OLD GUILFORD ROAD LLC	0.388697
OLD JESSUP ROAD PLANT LLC	0.073992
ORIOLE JUNCTION LLC	0.382742
OVERNITE TRANSPORTATION CO	16.15404
POTOMAC ABATEMENT HOLDING LIMITED	0.803602
PRESTON COURT LIMITED PARTNERSHIP	1.643443
PROLOGIS DEVELOPMENT SERVICES INC	4.992881
SAN TOMAS LIMITED PARTNERSHIP	14.236579
SAVCON LLC	0.103908
SD PROPERTY DEVELOPMENT LLC	0.150777
SEQUA CORPORATION	6.881551

Owner	Impervious Acres
SNOWDEN FIRST LLC	7.649514
SPECTOR FAMILY LLC	5.034467
SPIRIT MASTER FUNDING III LLC	0.088081
STATE OF MARYLAND HIGHWAY ADMIN	5.123211
TCAM CORE PROPERTY FUND OPERATING	5.661563
THE HOWARD RESEARCH & DEVELOPMENT	0.01905
TROY HILL CORPORATE CTR III LLC	6.932804
TROY HILL I LLC	22.572216
TROY HILL II LLC	3.759445
UNITED STATES POSTAL SERVICE	1.460667
WASHINGTON WILBERT	0.789237
XYZ LLC	1.501601
Total	**419.869025**

2. Baseline and Restoration Impervious Credit Calculations

Impervious credit for baseline and restoration BMPs was calculated following MDE Guidance *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014). Impervious equivalency for structural and non-structural BMPs are presented in Table 4. BMPs installed before 6/20/2010 are considered baseline treatment and impervious credit was taken off of the County's impervious baseline. Impervious credit from restoration BMPs installed after 6/20/2010 (i.e., 6/21/2010 through current reporting year, 6/30/2016) were applied towards the County's restoration target.

Table 4: Impervious Acre Equivalent for Structural and Non-Structural BMPs

BMP	Treatment Unit	Impervious Acre Equivalent*
Bioretention A/B soils	WQv (provided)/WQv (required)	1.00
Bioretention C/D soils	WQv (provided)/WQv (required)	1.00
Bioswales	WQv (provided)/WQv (required)	1.00
Dry Detention Ponds	WQv (provided)/WQv (required)	0.00
Dry Extended Detention Ponds	WQv (provided)/WQv (required)	0.00
Impervious Surface Reduction	Per acre disconnected or removed	0.75
Infiltration	WQv (provided)/WQv (required)	1.00
Outfall Stabilization	WQv (provided)/WQv (required)	0.01
Permeable Pavement	WQv (provided)/WQv (required)	0.75
Rain barrel	WQv (provided)/WQv (required)	0.75
Septic connections	Per unit	0.39
Septic pump-outs	Per unit (annual practice)	0.03
Septic Upgrades (denitrification)	Per unit	0.26
Step Pool Storm Conveyance (SPSC)	WQv (provided)/WQv (required)	1.00

BMP	Treatment Unit	Impervious Acre Equivalent*
Stream Restoration	Linear foot	0.01
Street Sweeping	Dry ton removed	0.40
Urban Filtering	WQv (provided)/WQv (required)	1.00
Urban Tree Plantings	Acres planted	0.38
Vegetated Open Channels	WQv (provided)/WQv (required)	1.00
Wet Ponds or Wetlands	WQv (provided)/WQv (required)	1.00

Source: MDE, 2014

*Assuming full 1-inch rainfall treatment, full WQv is provided. Acres of impervious in BMP drainage area is multiplied by the equivalent acres to determine credited acres

3. Draft Impervious Baseline Analysis

The County's approach to calculating impervious baseline credit is as follows:

3.1 Stormwater BMPs

Stormwater BMPs, trees, and pavement removal from Howard County's database were categorized based on the following categories:

a. Pre-1985 Stormwater:

Sum of impervious credit for BMPs coded as New Development and Redevelopment (no Restoration BMPs) with a Built Date before 1/1/1985. Excluded BMPs coded as XDPD, XDED, and XOGS which include dry pond, extended detention dry pond, and oil grit separator BMP types. Table 5 presents the BMP types with a Built Date before 1/1/1985 that were included in baseline credit calculations. Table 6 presents BMP types excluded from baseline credit calculations.

Table 5: Pre-1985 SW BMP Types in Howard County database Included in Baseline Credit Calculations

BMP Type	BMP Name
FBIO	Bioretention
ITRN	Infiltration trench
MSWG	Grass swale
ODSW	Dry Swale
PWED	Wet extended detention pond
PWET	Wet pond
UGS	Underground detention

Table 6: Pre-1985 SW BMP Types in Howard County database Excluded from Baseline Credit Calculations

BMP Type	BMP Name
XDED	Dry extended detention pond
XDPD	Dry pond

BMP Type	BMP Name
XOGS	Oil grit separator
XOTH	Other practice

b. 1985 - 2002 Stormwater:

Sum of impervious credit for BMPs coded as New Development, Redevelopment, or Restoration with a Built Date between 1/1/1985 and 1/1/2002. Impervious credit for BMPs coded XDED (extended detention dry ponds) were calculated with an assumed PE of 0.5. Excluded BMPs coded XDPD and XOGS which include dry pond and oil grit separator BMP types. Table 7 presents the BMP types with a Built Date between 1/1/1985 and 1/1/2002 that were included in baseline credit calculations. Table 8 presents BMP types excluded from baseline credit calculations.

Table 7: 1985 - 2002 SW BMP Types in Howard County database Included Baseline Credit Calculations

BMP Type	BMP Name
AGRE	Green roof
ARTF	Reinforced Turf
FBIO	Bioretention
FPU	Tree planting
FSND	Surface sand filter
FUND	Underground sand filter
IBAS	Infiltration basin
ITRN	Infiltration trench
MIDW	Dry well
MMBR	Micro-bioretention
ODSW	Dry swale
PWED	Wet extended detention pond
PWET	Wet pond
UGS	Underground detention
WSHW	Shallow marsh
XDED*	Dry extended detention pond

*Assumed PE of 0.5 applied for XDED BMPs

Table 8: 1985 - 2002 SW BMP Types in Howard County database Excluded from Baseline Credit Calculations

BMP Type	BMP Name
XDPD	Dry pond
XOGS	Oil grit separator
XOTH	Other practice

c. 2002 – 6/20/2010 Stormwater:

Sum of impervious credit for BMPs coded as Restoration with a Built Date between 1/1/2002 and 6/20/2010. Table 9 presents the BMP types with a Built Date between 1/1/2002 and 6/20/2010 that were included in baseline credit calculations.

Table 9: 1/1/2002 – 6/20/2010 SW BMP Types in Howard County database Included in Baseline Credit Calculations

BMP Type	BMP Name
FPU	Tree planting
MSWG	Grass swale
MSWW	Wet swale
PMED	Micropool extended detention pond
PWED	Wet extended detention pond
PWET	Wet pond
STRE	Stream restoration
WPWS	Pond/wetland system
WSHW	Shallow marsh

3.2 Howard County Lakes

Howard County has accounted for several County lakes that are providing substantial stormwater retention and treatment. The initial evaluation targeted nine facilities with high levels of impervious area. Two of these sites have undergone retrofit and are meeting standard stormwater pond criteria for crediting therefore they have been dropped from this analysis. Centennial Lake was also identified as a potential source of existing treatment, however based on comments from MDE that the current 303(d) listing and TMDLs developed for Centennial Lake for phosphorus and sediment, that including the lake would not be reasonable. Currently there are six facilities under analysis and the County does plan to investigate other similar facilities to determine their potential for credit.

The lakes included in the current analysis are listed in Tables 10, 11 and 12. These facilities for the most part were built before current stormwater design criteria were in place, and all but one was built before WQv criteria was developed. While these facilities were not designed specifically as stormwater treatment structures, the permanent pool volumes afforded at each site appear suitably sized to adequately treat stormwater runoff from upstream impervious surfaces.

There were several factors applied to reduce the chances for erroneously inflating the crediting.

- WQv Required – Calculated using current impervious values to account for the full current volume.
- Impervious Credits – Calculated using 2002 impervious surfaces so as not to apply credit to newer development
- Double Counting – Areas treated by other BMPs were extracted from the area credited so as not to double count the credit
- County Jurisdiction – Credit was only applied to County impervious area within the drainage area.

The following describes the data and computations:

Impervious Acres and Pervious Acres

Impervious County acres and pervious County acres within the lake drainage area reflect current conditions. This would ensure that the WQv required would not be underestimated..

Impervious Area Not Treated by Other Existing BMPs

This is the difference between the total impervious area within the lake drainage area and the impervious area treated by other BMPs within the lake drainage area, so essentially what is leftover and potentially treated by the lake.

Percent Impervious

Percent impervious from data provided in the original plans. If information was available, actual percent impervious was used.

Required WQv and Provided WQv

Computations for Provided WQv were based on the data provided in the original plans regarding storage volume and permanent pool. With regular maintenance, the initial plan volumes have been retained. WQv required for each site were calculated using MDE's unified stormwater sizing criteria:

$$WQv = [(P)(Rv)(A)] / 12$$

Where: P = rainfall depth in inches and is equal to 1.0"
Rv = volumetric runoff coefficient (0.05 + 0.009(I)
A = area in acres
I = percent impervious cover

Current levels of impervious surfaces were used to calculate the WQv required.

Runoff Depth

For runoff depth, divided Provided WQv by Required WQv. If PE <2.6, used actual calculated PE value. If PE > 2.6, used 2.6 as max.

Impervious Credit

Impervious area not treated by other existing BMPs (i.e., impervious difference) was used to calculate impervious acre credit and ensure there is no double counting credit for BMPs within the lake drainage area. Equation used to calculate impervious acre credit derived from Table 3. Impervious Acre Credit for Treatment Above and Below 1" of Rainfall (MDE Guidance document, 2014)

- If Runoff Depth = 1: Impervious difference x Runoff Depth
- If Runoff Depth < 1: Impervious difference x Runoff Depth
- If Runoff Depth >1: =(1*Impervious difference)+(((Runoff depth-1)*0.25)*Impervious difference)

Table 10: Howard County Lakes

Lake	Watershed	Built Date
Lake Elkhorn	02131105	1/1/1986
Lake Kittamaqundi	02131105	8/2/1989
Montgomery Meadows	02130906	7/14/1992
Wilde Lake	02131105	7/18/1993
Waverly Woods	02130906	4/20/2001
Lang Beach (Jackson Pond)	02131105	10/20/2008

Table 11: Lake Water Quality Volume Required Calculation

Lake	Drainage Area (ac)	Current Pervious Area within Lake DA (ac)	Current Impervious Area within Lake DA (ac)	Current % Impervious	Required WQv (ac-ft)
Lake Elkhorn	2,222.5	1,611.6	610.9	27.5%	55.1
Lake Kittamaqundi	1,335.6	930.3	405.2	30.3%	36.0
Montgomery Meadows	292.5	230.2	62.3	21.3%	5.9
Wilde Lake	1,011.5	758.4	253.1	25.0%	23.2
Waverly Woods	403.9	324.7	79.2	19.6%	7.6
Lang Beach (Jackson Pond)	193.7	145.5	48.1	24.9%	4.4

Table 12: Lake Impervious Credit Calculation

Lake	Required WQv (ac-ft)	Provided WQv (ac-ft)	Runoff Depth Treated (Prov. / Req)	2002 County Impervious Area Not Treated by Other Existing BMPs	Imp. Credit
Lake Elkhorn	55.1	203.0	2.6	344.64	482.5
Lake Kittamaqundi	36.0	161.3	2.6	302.40	423.4
Montgomery Meadows	5.9	8.75	1.3	45.55	51.2
Wilde Lake	23.2	110.0	2.6	232.82	325.9
Waverly Woods	7.6	14.0	1.1	36.94	44.3
Lang Beach (Jackson Pond)	4.4	16.9	2.6	44.55	62.4

3.3 Rooftop Disconnect

Impervious credit for impervious total acres disconnected. Refer to *Howard County Rooftop Disconnection Analysis* for details (McCormick Taylor, 2015a).

3.4 Non-Rooftop Disconnect

Impervious credit for impervious total disconnected with credit range >25 sq. ft. Excluded impervious credit with credit range <25 sq. ft. Refer to *Howard County Non-Rooftop Disconnection Analysis* for details (McCormick Taylor, 2015b).

3.5 Rain Barrels

An impervious acre equivalency of 0.75 applied based on Scenario Builder BMP crosswalk relating rain barrels to impervious surface reduction practices. This equivalency was applied to rooftop area treated through FY2010 (corresponding to 6/20/2010 baseline date).

3.6 Impervious Baseline Results

Howard County's impervious baseline accounting is presented in Table 13. Countywide, the total County MS4 Impervious Area, or the area under Howard County jurisdiction, is 15,226 acres. The difference between this value and the total impervious area of 17,728 acres is impervious area under other ownership (state lands) and areas regulated by other NPDES permits (MSHA and industrial sites). Existing treatment is broken down by era between new development, redevelopment, and restoration for informational purposes only. The impervious baseline treated area is 5,064.7 acres and the untreated area is 10,161.7 acres. Applying the 20% factor to the untreated area yields a 20% restoration target of 2,032.3 acres.

Table 13: Baseline Impervious Accounting Results Summary

	Brighton Dam	Little Patuxent	Middle Patuxent	Patapsco LNB	Patuxent Upper	Rocky Gorge Dam	S Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
Total Impervious Area	**1,511.9**	**8,145.6**	**2,953.9**	**3,611.2**	**372.6**	**471.0**	**661.8**	**17,728.0**
County MS4 Impervious Area	**1,378.5**	**7,080.1**	**2,506.9**	**2,971.4**	**311.0**	**426.2**	**552.2**	**15,226.4**
Pre-1985 Stormwater BMPs	4.2	718.8	10.3	13.4	0.0	0.0	0.0	746.7
New Development	4.2	648.1	5.9	3.7	0.0	0.0	0.0	661.9
Redevelopment	0.0	70.7	4.4	9.7	0.0	0.0	0.0	84.8
Restoration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985 - 2002 Stormwater BMPs	43.6	659.5	228.2	436.5	64.6	21.0	9.0	1,462.5
New Development	18.8	458.5	181.6	357.2	63.6	19.8	7.4	1,106.8
Redevelopment	23.8	195.6	27.8	64.7	1.0	0.6	0.0	313.5
Restoration	1.0	5.5	18.8	14.6	0.0	0.6	1.7	42.2
2002 - 6/20/2010 Stormwater BMPs	8.6	161.1	102.3	69.0	1.1	9.4	39.2	390.8
New Development	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Redevelopment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Restoration before 6/21/2010	8.6	161.1	102.3	69.0	1.1	9.4	39.2	390.8
Howard County Lakes	0.0	1,294.2	0.0	95.5	0.0	0.0	0.0	1,389.7
Rooftop Disconnect	55.7	163.5	64.7	44.7	5.5	12.9	20.7	367.5
Non-Rooftop Disconnect	176.2	147.8	168.5	88.6	7.8	42.7	75.7	707.3
Rain Barrels	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2
Impervious Baseline Treated	**288.3**	**3,145.0**	**574.0**	**747.8**	**79.0**	**86.0**	**144.6**	**5,064.7**
Impervious Baseline Untreated	**1,090.2**	**3,935.1**	**1,932.9**	**2,223.7**	**232.0**	**340.2**	**407.6**	**10,161.7**
20% Restoration Target	**218.0**	**787.0**	**386.6**	**444.7**	**46.4**	**68.0**	**81.5**	**2,032.3**

4. Draft Impervious Restoration Analysis

The County's approach to calculating impervious restoration credit is as follows:

4.1 Stormwater BMPs

Impervious restoration for stormwater BMPs, trees, streams, and pavement removal from Howard County's database is calculated as the sum of impervious credit for BMPs coded as Restoration with a Built Date after 6/20/2010. Table 14 presents the BMP types with a Built Date after 6/20/2010 that were included in restoration credit calculations.

Table 14: SW BMP Types Installed after 6/20/2010 in Howard County database Included in Restoration Credit Calculations

BMP Type	BMP Name
APRP	Permeable Pavement
FBIO	Bioretention
FPU	Tree planting
FSND	Surface sand filter
IBAS	Infiltration basin
IMPP	Impervious Surface Elimination (to Pervious)
MIDW	Dry well
MMBR	Micro-bioretention
MRNG	Rain Gardens
MRWH	Rainwater Harvesting
MSWB	Bioswale
ODSW	Dry Swale
OUT	Outfall stabilization
PWED	Wet extended detention pond
PWET	Wet pond
SPSC	Outfall stabilization - SPSC
STRE	Stream restoration
WEDW	Extended detention shallow wetland
WPWS	Pond/wetland system
WSHW	Shallow marsh
XDED	Dry extended detention pond

4.2 Rain Barrels

An impervious acre equivalency of 0.75 applied based on Scenario Builder BMP crosswalk relating rain barrels to impervious surface reduction practices. This equivalency was applied to rooftop area treated after FY2010.

4.3 Septic Connections

An impervious acre equivalency of 0.39 was used for septic upgrades based on MDE Guidance *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014). This equivalency was applied to number of septic unit connections after FY2010.

4.4 Septic Upgrades

An impervious acre equivalency of 0.26 was used for septic upgrades based on MDE Guidance (MDE, 2014). This equivalency was applied to number of septic unit upgrades after FY2010.

4.5 Street Sweeping

Howard County collected 930.7 tons through their street sweeping program in FY16. Tons swept in FY16 were prorated by 8-digit watershed based on the proportion of total County street sweeping route length per watershed. Applied impervious acre equivalency of 0.40 based on MDE Guidance (MDE, 2014) to calculate impervious restoration credit. Because street sweeping is an annual practice, only credit for FY16 efforts was included as impervious restoration.

4.6 Impervious Restoration Results

A summary of the current (end of FY16) impervious restoration progress is presented in Table 15. The County has achieved credits for restoring 1,027.7 acres and has 1,004.6 acres remaining to treat by the end of 2019.

Table 15: Restoration Impervious Accounting Results Summary - Draft

	Brighton Dam	Little Patuxent	Middle Patuxent	Patapsco LNB	Patuxent Upper	Rocky Gorge Dam	S Branch Patapsco	County wide
Impervious Baseline and Target (Impervious Credit Acres)								
Total Impervious Area	**1,511.9**	**8,145.6**	**2,953.9**	**3,611.2**	**372.6**	**471.0**	**661.8**	**17,728.0**
County MS4 Impervious Area	**1,378.5**	**7,080.1**	**2,506.9**	**2,971.4**	**311.0**	**426.2**	**552.2**	**15,226.4**
Impervious Baseline Treated	**288.3**	**3,145.0**	**574.0**	**747.8**	**79.0**	**86.0**	**144.6**	**5,064.7**
Impervious Baseline Untreated	**1,090.2**	**3,935.1**	**1,932.9**	**2,223.7**	**232.0**	**340.2**	**407.6**	**10,161.7**
20% Restoration Target	**218.0**	**787.0**	**386.6**	**444.7**	**46.4**	**68.0**	**81.5**	**2,032.3**
Impervious Restoration and 2016 Progress (Impervious Credit Acres)								
Restoration BMPs Completed after 6/20/2010	69.7	327.8	149.3	50.3	0.0	3.9	7.3	608.3
Rain Barrels	0.08	0.59	0.20	0.26	0.03	0.03	0.03	1.2
Septic Connections	0.00	1.56	0.78	0.00	0.00	0.00	0.00	2.3
Septic Upgrades	14.0	6.2	15.1	2.6	0.0	2.6	3.1	43.7
Street Sweeping	17.9	172.1	70.3	79.8	7.0	16.0	9.1	372.3
Total Impervious Restoration	**101.7**	**508.3**	**235.6**	**133.0**	**7.1**	**22.5**	**19.5**	**1,027.7**
% Impervious Treated	**9.3%**	**12.9%**	**12.2%**	**6.0%**	**3.1%**	**6.6%**	**4.8%**	**10.1%**

5. Final Approved Results

MDE reviewed the County's impervious area assessment submitted on December 17, 2016 and provided comments and an approved impervious area baseline of 12,299 acres on April 13, 2017. In their response, MDE confirmed that the County may submit a revised baseline as part of the fourth year permit renewal application. Based on the County's approved impervious area baseline of 12,299 acres, the County's restoration requirement this permit term, as provided by MDE, is 2,459.8 acres.

MDE approved the County's approach to calculating the following:

- Total impervious area in Howard County
- Deduction for State Highway Administration (SHA) MS4
- Deduction for SHA BMP drainage area
- Deduction for industrial operations covered under the 12-SW permit
- Deduction for State facilities with their own MS4
- Deduction for acres treated or restored with 1985-2002 Stormwater BMPs
- Deduction for restored acres from 2002 – 6/20/2010 Stormwater BMPs
- Deduction for areas treated with rooftop disconnects
- Deduction for areas treated with non-rooftop disconnects
- Deduction for areas treated with rain barrels.

At this time, MDE did not approve the deduction of 746.7 acres for pre-1985 stormwater BMPs stating that supporting policy data is missing. MDE also did not approve the deduction of 1,389.7 acres of treatment from Howard County lakes stating that the lakes are not constructed for water quality treatment and do not meet the performance criteria found in the 2000 Maryland Stormwater Design Manual. As a result, Howard County has removed treatment from pre-1985 stormwater BMPs and treatment from Howard County lakes from the impervious baseline. MDE offered the County with the opportunity to provide documentation such as plans, reports, or some further analysis to support treatment from pre-1985 stormwater BMPs and data on upstream and downstream conditions around the lakes to support treatment from County lakes.

The County's impervious accounting baseline and 20% restoration target, as approved by MDE, is presented in Table 16.

Between the time of submitting the impervious area assessment for MDE review in December 2016 and the updated version of this document, two restoration projects built between 2002 and 6/20/2010, one in Brighton Dam and another in Little Patuxent, were identified and added to the treated baseline. The net difference accounts for 16.3 acres treated and is carried through Table 17. The inclusion of the additional projects result in a revised baseline of 12,282 acres with a restoration requirement for this permit term of 2,456 acres.

Table 16: Baseline Impervious Accounting Approved by MDE

	Brighton Dam	Little Patuxent	Middle Patuxent	Patapsco LNB	Patuxent Upper	Rocky Gorge Dam	S Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
Total Impervious Area	**1,511.9**	**8,145.6**	**2,953.9**	**3,611.2**	**372.6**	**471.0**	**661.8**	**17,728.0**
County MS4 Impervious Area	**1,378.5**	**7,080.1**	**2,506.9**	**2,971.4**	**311.0**	**426.2**	**552.2**	**15,226.4**
1985 - 2002 Stormwater BMPs	43.6	659.5	228.2	436.5	64.6	21.0	9.0	1,462.5
New Development	18.8	458.5	181.6	357.2	63.6	19.8	7.4	1,106.8
Redevelopment	23.8	195.6	27.8	64.7	1.0	0.6	0.0	313.5
Restoration	1.0	5.5	18.8	14.6	0.0	0.6	1.7	42.2
2002 - 6/20/2010 Stormwater BMPs	8.6	161.1	102.3	69.0	1.1	9.4	39.2	390.8
New Development	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Redevelopment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Restoration before 6/21/2010	8.6	161.1	102.3	69.0	1.1	9.4	39.2	390.8
Rooftop Disconnect	55.7	163.5	64.7	44.7	5.5	12.9	20.7	367.5
Non-Rooftop Disconnect	176.2	147.8	168.5	88.6	7.8	42.7	75.7	707.3
Rain Barrels	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2
Impervious Baseline Treated	**284.1**	**1,132.0**	**563.7**	**638.8**	**79.0**	**86.0**	**144.6**	**2,928.3**
Impervious Baseline Untreated	**1,094.4**	**5,948.1**	**1,943.2**	**2,332.6**	**232.0**	**340.2**	**407.6**	**12,298.1**
20% Restoration Target	**218.9**	**1,189.6**	**388.6**	**466.5**	**46.4**	**68.0**	**81.5**	**2,459.6**

Table 17: Revised Baseline Impervious Accounting

	Brighton Dam	Little Patuxent	Middle Patuxent	Patapsco LNB	Patuxent Upper	Rocky Gorge Dam	S Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
Total Impervious Area	**1,511.9**	**8,145.6**	**2,953.9**	**3,611.2**	**372.6**	**471.0**	**661.8**	**17,728.0**
County MS4 Impervious Area	**1,378.5**	**7,080.1**	**2,506.9**	**2,971.4**	**311.0**	**426.2**	**552.2**	**15,226.4**
1985 - 2002 Stormwater BMPs	43.6	659.5	228.2	436.5	64.6	21.0	9.0	1,462.5
New Development	18.8	458.5	181.6	357.2	63.6	19.8	7.4	1,106.8
Redevelopment	23.8	195.6	27.8	64.7	1.0	0.6	0.0	313.5
Restoration	1.0	5.5	18.8	14.6	0.0	0.6	1.7	42.2
2002 - 6/20/2010 Stormwater BMPs	10.2	175.9	102.3	69.0	1.1	9.4	39.2	407.1
New Development	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Redevelopment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Restoration before 6/21/2010	10.2	175.9	102.3	69.0	1.1	9.4	39.2	407.1
Rooftop Disconnect	55.7	163.5	64.7	44.7	5.5	12.9	20.7	367.5
Non-Rooftop Disconnect	176.2	147.8	168.5	88.6	7.8	42.7	75.7	707.3
Rain Barrels	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2
Impervious Baseline Treated	**285.7**	**1,146.8**	**563.7**	**638.8**	**79.0**	**86.0**	**144.6**	**2,944.7**
Impervious Baseline Untreated	**1,092.7**	**5,933.3**	**1,943.2**	**2,332.6**	**232.0**	**340.2**	**407.6**	**12,281.7**
20% Restoration Target	**218.5**	**1,186.7**	**388.6**	**466.5**	**46.4**	**68.0**	**81.5**	**2,456.3**

6. References

Maryland Department of the Environment (MDE) 2014. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated – Guidance for National Pollutant Discharge Elimination System Stormwater Permits. Maryland Department of the Environment. August 2014. Baltimore, MD.

McCormick Taylor. 2015a. Howard County Rooftop Disconnection Analysis. Prepared by McCormick Taylor, Inc., Baltimore, MD for Howard County, Department of Public Works, Stormwater Management Division, Columbia, MD.

McCormick Taylor. 2015b. Howard County Non-rooftop Disconnection Analysis. Prepared by McCormick Taylor, Inc., Baltimore, MD for Howard County, Department of Public Works, Stormwater Management Division, Columbia, MD.

Appendix 3: Potential Project List FY18/FY19/FY20

Note: Project Planning List as of December 2017, subject to change.

Project Name	Proposed BMP Type	Watershed	Projected Impervious Credit	FY Funding Year - Design	Estimated Cost - Design	FY Funding Year - Construction	Estimated Cost - Construction
Ashton Woods (F90-011)	New BMP	Patapsco LN Branch	5.0	PF	PF	FY19	$500,000
Beech Creek	Pond Repair	Little Patuxent	25.1	PF	PF	FY18	$500,000
Brentwood Manor - Gatewood Drive	Sand Filter	Little Patuxent	3.3	FY18	$66,719	FY19	$300,000
Brentwood Manor (DOR-SR-F906/DOR-SR-F907)	Stream Restoration	Little Patuxent	20.4	FY18	$65,799	FY19	$800,000
Churchill Way Outfall Stabilization	Outfall Stabilization	Middle Patuxent	2.0	PF	PF	FY18	$149,503
Columbia Medical Campus	Submerged Gravel Wetlands	Little Patuxent	8.0	FY19	$90,000	FY20	$500,000
Country Meadows	New BMP	Little Patuxent	5.0	PF	PF	FY18	$1,200,000
Courthouse	New BMP	Patapsco LN Branch	2.0	PF	PF	FY18	$800,000
Cradlerock Way	Step Pool Storm Conveyance	Little Patuxent	2.3	PF	PF	FY18	$106,160
Diversified Lane	New BMP	Patapsco LN Branch	8.5	PF	PF	FY19	$800,000
Dobbin Road Commercial Center	Retention Pond (Wet Pond)	Little Patuxent	9.4	FY20	$90,000	FY21	$437,359
Ducketts Lane	Stream Restoration	Patapsco LN Branch	33.2	PF	PF	FY19	$277,144
Ellicott City Parking Lot D Water Quality Enhancements	New BMP	Patapsco LN Branch	8.0	PF	PF	FY19	$137,594
Ellicott View Pond - Opti	Wet Pond	Patapsco LN Branch	4.9	FY18	$152,980	FY19	$200,000
Font Hill Stream Restoration	Stream Restoration	Little Patuxent	20.0	FY18	$350,000	FY19	$2,950,000
George Howard Building Parking Lot	Bioretention	Patapsco LN Branch	2.0	PF	PF	FY18	$800,000
Golden Coin Court	Retention Pond (Wet Pond)	Little Patuxent	9.9	FY19	$90,000	FY20	$227,240
Governor Martin	Outfall Stabilization	Patapsco LN Branch	4.0	PF	PF	FY18	$500,000
Gwynn Park Drive	Stream Restoration	Little Patuxent	5.0	FY19	$150,000	FY20	$500,000
Heritage Woods Retrofit	Wet Pond	Little Patuxent	2.0	PF	PF	FY18	$600,000
Kesting Court	Extended Detention Pond - Wetland	Patapsco LN Branch	4.0	FY19	$90,000	FY20	$242,090
Kings Meade	Sand Filter	Middle Patuxent	3.2	PF	PF	FY19	$300,000
Longview Drive (9509) Stream Restoration	Stream Restoration	Little Patuxent	4.5	PF	PF	FY18	$700,000
Mellen Court Stream Restoration and Outfall Stabilization	Stream Restoration	Little Patuxent	28.0	PF	PF	FY20	$950,000
Mink Hollow - Stream	Stream Restoration	Rocky Gorge Dam	8.4	FY18	$200,000	FY19	$379,800
North Laurel Community Center	Stream Restoration	Patuxent River Upper	12.0	FY18	$226,985	FY20	$800,000
North Laurel Industrial Park	Stream Restoration	Patuxent River Upper	6.0	FY18	$271,008	FY19	$270,000
Nuetzel Stream	Stream Restoration	Little Patuxent	1.0	FY20	$271,008	FY21	$783,996
Old Annapolis Road	Retention Pond (Wet Pond)	Little Patuxent	14.5	FY20	$90,000	FY21	$428,480
Park Drive	Stream Restoration	Patapsco LN Branch	5.0	PF	PF	FY18	$500,000
Patapsco Park Estates Repair and Retrofit	Extended Detention Structure, Wet	Patapsco LN Branch	5.0	FY18	$90,000	FY20	$277,165
Patrick Farm	Stream Restoration	Brighton Dam	64.0	PF	PF	FY18	$2,471,000
Phelps Luck Stream	Stream Restoration	Little Patuxent	5.0	FY19	$150,000	FY20	$500,000
Plum Spring Lane (NLP-SR-F99a)	Stream Restoration	Little Patuxent	22.0	FY19	$200,000	FY20	$800,000
Quaker Mill Court	New BMP	Patapsco LN Branch	5.0	FY15	$83,387	FY18	$900,000
Red Hill Way Phase 2	Stream Restoration	Little Patuxent	4.5	PF	PF	FY18	$184,152
Route 40 N (NLP-SR-F555b; Frederick Road - South)	Stream Restoration	Little Patuxent	14.0	PF	PF	FY18	$900,000
Route 40 S (NLP-SR-F555a; Frederick Road - North)	Stream Restoration	Little Patuxent	13.0	PF	PF	FY18	$800,000
Sante Fe Court	Stream Restoration	Little Patuxent	10.7	FY20	$180,000	FY21	$783,996
SHA Study A	Stream Restoration	Little Patuxent	17.3	FY20	$200,000	FY21	$700,000
SHA Study B	Stream Restoration	Little Patuxent	17.3	FY20	$200,000	FY21	$700,000
Sucker Branch Concept B	Stream Restoration	Patapsco LN Branch	8.2	PF	PF	FY18	$370,350
Sucker Branch Concept E	Stream Restoration	Patapsco LN Branch	4.2	PF	PF	FY18	$186,750
Sucker Branch	Stream Restoration	Patapsco LN Branch	20.0	PF	PF	FY20	$1,500,000

Note: Project Planning List as of December 2017, subject to change.

Project Name	Proposed BMP Type	Watershed	Projected Impervious Credit	FY Funding Year - Design	Estimated Cost - Design	FY Funding Year - Construction	Estimated Cost - Construction
Sunny Field Court A/B	Stream Restoration	Patapsco LN Branch	20.1	FY18	$249,821	FY19	$1,700,000
Sweet Hours Stream Repair	Stream Restoration	Middle Patuxent	5.0	FY19	$100,000	FY20	$500,000
Timbers of Troy Golf Course	Stream Restoration	Patapsco LN Branch	15.6	PF	PF	FY18	$900,000
Willow Bend Court	Stream Restoration	Little Patuxent	7.0	PF	PF	FY19	$658,001
Windy Knolls	Stream Restoration	Middle Patuxent	20.0	PF	PF	FY18	$1,800,000
Wood Creek	Stream Restoration	Little Patuxent	5.0	FY18	$177,188	FY19	$400,000
Woodcrest Drive	Micropool Extended Detention Pond	Patapsco LN Branch	4.2	FY18	$145,112	FY20	$414,336
Woodcrest Drive	Stream Restoration	Patapsco LN Branch	19.8	FY18	$240,292	FY20	$891,000
LPR - Woodland Rd (Utilities) Build	Stream Restoration	Little Patuxent	12.0	PF	PF	FY20	$750,000

PF = Previously Funded, funded prior to the FY18-FY20 period