FREDERICK COUNTY STORMWATER RESTORATION PLAN

DECEMBER 2021

Drone Imagery of Green Hill Manor, Adamstown
Installation of the gravel wetland March, 15, 2020

Contents

Tables

Figures

ACKNOWLEDGEMENTS

This Restoration Plan is a product of several decades of cumulative planning and restoration efforts on the part of Frederick County Government staff, community partners, and consultants. The Plan is a collaborative project between Staff, consultants, and subject matter experts. Shannon Moore wrote the original version of this plan that serves as the template for the continued updates to the document.

Rhonda Hughes and Brittany Pjura, from KCI Technologies, Inc. (KCI), worked with Jeremy Joiner and Donald Dorsey, Frederick County, to update the geodatabase of completed, programmed, and identified stormwater projects and summarize progress by BMP type, status, and date to meet several specific needs for TMDL and impervious area restoration plans.

Megan Crunkleton (KCI) modeled nutrient and sediment local TMDL scenarios in MDE's TMDL Implementation Progress and Planning Tool (TIPP). Susanna Brellis (KCI) modeled nutrient Bay TMDL scenarios in the Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST) and assisted with TIPP modeling and QC.

Bill Frost (KCI), Danielle DePalo (KCI), and Olivia Devereux rewrote the Watershed Treatment Model (WTM) specifically for bacteria to simplify data entry and modeling for five scenarios. Breanne Ensor (KCI) completed the bacteria modeling update for FY21. Mike Pieper (KCI) provided project management as well as technical assistance. Susanna, Megan, Breanne, and Mike updated the projects, text, tables, and figures from the previous Restoration Plan for this report.

Project oversight, guidance, and reviews were provided by Donald Dorsey, Jeremy Joiner, and Shannon Moore of Frederick County OSER.

ACRONYMS AND ABBREVIATIONS

BMP: Best Management Practice
BRF: Chesapeake Bay Restoration Fund
BST: Bacteria Source Tracking
CAA: Clean Air Act
CFU: Colony Forming Units
CBP: Chesapeake Bay Program
CBWM: Chesapeake Bay Watershed Model
E.coli: Escheria coli
FIB: Fecal Indicator Bacteria
MDE: Maryland Department of the Environment
MEP: Maximum Extent Practicable
MFSG: Municipal and Financial Services Group
MPN: Most Probable Number
MPR: Maximum Practicable Reduction
MS4: Municipal Separate Storm Sewer System
NPDES: National Pollutant Discharge Elimination System
OSER: Office of Sustainability and Environmental Resources
P3: Public-Private Partnership
Plan: Frederick County Stormwater Restoration Plan. Includes Impervious Cover Restoration Plan, 12 local TMDL and 2 Chesapeake Bay TMDL Restoration Plans.
SSO: Sanitary Sewer Overflow
Stormwater Accounting Guidance: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* document by MDE
TIPP: TMDL Implementation Progress Planning Tool
TMDL: Total Maximum Daily Load
WIP: Watershed Implementation Plan
WTM: Watershed Treatment Model
WWTP: Wastewater Treatment Plant

EXECUTIVE SUMMARY

This Frederick County Stormwater Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the County's Impervious Cover Restoration Plan and Total Maximum Daily Load (TMDL) Restoration Plans. The Restoration Plan addresses twelve TMDLs for local waterways, two for the Chesapeake Bay, and an impervious surface restoration requirement. This current December 2021 update of the Plan demonstrates that Frederick County Government is on track to meet the restoration efforts required under its current permit and has a long-term plan to address its portion of stormwater wasteload allocations for all TMDLs in Frederick County. Compliance with the Chesapeake Bay TMDL is regulated in the permit through the use of the 20% impervious surface treatment strategy. While not a requirement in the County's MS4 permit, restoration strategies to meet local TMDL reduction targets and impervious restoration treatment were also modeled against the Bay TMDL goals in order to calculate progress in reducing pollutant loads. These results were provided for information purposes only.

Frederick County's Restoration Plan uses a multi-pronged approach that includes multiple stormwater practice types. These stormwater practices include volumetric practices such as bioretention and pond retrofits, as well as alternative practices for stormwater including riparian buffer planting and stream restoration. Best Management Practices (BMPs) used are predominantly from Maryland Department of the Environment's (MDE) *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2020 Accounting Guidance) (MDE, 2020) which was the most recent guidance available at the time of updating this restoration Plan. This document describes how treated impervious acres and nutrient and sediment removal efficiencies are accounted for. To assess whether nutrient and sediment local TMDL goals were met, these practices were modeled using MDE's TMDL Implementation Progress and Planning (TIPP) spreadsheet tool which was provided and requested to be used, if possible, by MDE on June 9, 2021. Frederick County utilized the TIPP for the first time in FY21 and the tool calculates pollutant load reductions based on the data entry of existing, programmed, and identified BMPs that are maintained in the County's NPDES geodatabase. The TIPP was developed by MDE for use by MS4 jurisdictions for local TMDL modeling and planning. The Chesapeake Bay Program's (CBP) Chesapeake Assessment Scenario Tool (CAST) was used to estimate load reductions applied towards the Chesapeake Bay TMDL and since CAST was developed specifically for Bay-scale modeling for the Bay TMDL pollutants it was determined to be the most appropriate Bay TMDL modeling tool. Both the TIPP spreadsheet tool and CAST use methods associated with Phase 6 of the Bay Model, which is consistent with the MDE 2020 Accounting Guidance used in the updated Restoration Plan. Based on our understanding, the MDE 2020 Accounting Guidance is the draft version of the final MDE 2021 Accounting Guidance, published on November 5, 2021. The County acknowledges the newer guidance and will be updating the Restoration Plan next Fiscal Year (2022) to align with the final November 2021 updated guidance.

Progress towards *E. coli* TMDL loads and reductions were determined using a modified version of the Watershed Treatment Model version 2013. Structural stormwater treatment was summarized from the County database, supplemented with literature values and Sanitary Sewer Overflow (SSO) loads and reductions calculated by the County's Division of Water and Sewer Utilities , formerly known as Division of Utilities and Solid Waste Management until the September 2020 division reorganization, for secondary sources of bacteria.

A summary of assessment methods and major historical updates to the impervious accounting and restoration plan are as follows:

- Frederick County submitted an Impervious Surface Area Assessment of its MS4 Discharge permit with its first Annual Report under the new permit (Frederick County, 2015).

- The baseline in the previous permit was derived using the Simple Method (Schueler, 1987); which applied impervious cover coefficients to land use/land cover (LU/LC) maps from Maryland Department of Planning. This method has been replaced by the use of planimetric data, where actual impervious areas are digitized from aerial survey.
- Frederick County submitted its Fiscal Year 2018 Annual Report in December 2018 as its fourth annual report submission for this permit term. At the MDE's request Frederick County included in this report submission a revised impervious surface cover assessment. MDE provided comments on this annual report submission on July 12, 2019. In its comments, MDE states that it cannot approve the County's revised impervious cover assessment because the County's baseline update did not have adequate documentation to definitively identify the impervious acreages treated by various BMPs in the County's rooftop and non-rooftop disconnect analyses.
- Frederick County notes that the revisions to the rooftop and non-rooftop analyses included in the County's impervious cover resubmission and reported in the 2018 Annual Report Appendix O: Impervious Accounting Memo and geodatabase, were conducted in the expanded MS4 Boundary. However, the update to the Boundary area was not provided for in Appendices P and Q, Rooftop Disconnect Protocol and Non-Rooftop Disconnect Protocol. Essentially, the revised impervious cover assessment was conducted correctly, but the protocol document language detailing the new extent was not updated when submitted with the 2018 Annual Report.
- MDE noted in its August 23, 2019 memo, which tentatively approved the County's Financial Assurance Plan, that approval of the impervious area analysis was still pending. The County updated the impervious cover restoration plan as well as two technical memos for rooftop and non-rooftop disconnect studies and submitted them to MDE on September 30, 2019. Frederick County staff met with MDE on October 24th where it was decided by MDE that the impervious cover analysis was pending approval of the non-rooftop disconnect study. A field visit was planned to review the study findings with MDE; however, McCormick Taylor in reviewing for the field meeting discovered a significant error in its work for the rooftop and non-rooftop studies. The wrong projection file that caused the county's restoration obligation to be underestimated by 711 acres. The impervious cover assessment was conducted using the correct boundary and by the correct protocol but with an error in the projection which caused the discrepancy. The County worked with the consultants to correct the error.
- Apart from the rooftop and non-rooftop disconnection issue, MDE did not take issue with the County's methodology for the revised submission or its results, which was the same MDE-approved methodology MDE used with substantially similar results. In some instances, Frederick County had access to better source data, which resulted in slightly different numbers than what MDE calculated from its analysis; the small differences are outlined in the methodologies section. Frederick County respectfully submitted additional clarity in how it developed its impervious baseline by adhering to the methods outlined by Maryland Department of the Environment (MDE).
- MDE's regulations for the Maryland Water Quality Trading Program became effective on July 16, 2018. MDE updated its Draft Maryland Trading and Offset Policy and Guidance Manual Chesapeake Bay Watershed (MDE 2017) in April 2017. Trading requirements for MS4 communities are also laid out in MDE's 2014 Accounting Guidance and updated in MDE's 2020 Accounting Guidance (MDE SW 2014; MDE 2020). Frederick County's MS4 permit went through a major modification in order to use trading and was finalized on November 8, 2019. The County used MDE's trading program to generate 708.1 acres of credits from its wastewater treatment plant (WWTP) at Ballenger McKinney in 2020. This plant's permit was recently reissued and includes trading. The County modified its plant's permit with MDE upon reissuance to include the option to generate credits.

- Based on the analysis provided in the Impervious Cover Restoration Plan, Rooftop and Non-Rooftop Disconnect Studies, Sheet flow to Conservation protocol submitted in December 2019, and the Field Review Memo of the Non-Rooftop disconnect submitted on February 14, 2020 and accompanying Appendices, Frederick County used MDE's guidance and comments to determine there are 13,396 total impervious acres within its boundary, of which 678 acres are treated with BMPs, 403 impervious acres are treated through rooftop disconnect, 2,259 impervious acres are treated through non-rooftop disconnect, 38 acres are treated through sheetflow to conservation areas, 51 acres are treated through existing grass swales, and 64 acres are treated by draining to Maryland State Highway Administration BMPs from the Frederick County MS4 area. This leaves the County with 9,903 untreated impervious acres. Based on the 20% restoration requirement, Frederick County will need to treat 1,981 impervious acres to meet its MS4 Permit Restoration requirement. This information is presented in Table ES-1.

Table ES-1: Frederick County Impervious Accounting (as of 12/29/2019)

Impervious Accounting Areas	Area (ac)
Total Impervious area within MS4 Permit Area	13,396
Treated Impervious	(-678)
Rooftop Disconnect	(-403)
Non Rooftop Disconnect	(-2,259)
Existing Grass Swales Districts 3-6	(-51)
SHA Treated County Impervious	(-64)
Sheetflow to Conservation Area	(-38)
Treated Baseline	(-3,493)
Untreated Baseline	9,903
Restoration Goal (20% of untreated baseline)	**1,981**

- MDE's draft comments provided on April 6, 2020 approved the 1,981 impervious acre restoration goal for Frederick County; which included the Rooftop Disconnect memo, the Non-Rooftop Disconnect memo, the Existing Water Quality Grass Swale Identification Protocol and the Sheetflow to Conservation Protocol submitted by the County as part of the 2019 Annual Report.
- On December 29, 2020, Frederick County submitted its FY20 Annual Report which included three restoration projects completed during FY20, which increased the County's implementation to 1,272.93 impervious acres restored from its 20% restoration goal of 1,981 acres. Frederick County utilized Section VII. Water Quality Trading of the MDE's 2020 Accounting Guidance document to translate the 708.1 acres of impervious acres into Equivalent Nutrient Credits and bought these from the County's Ballenger McKinney treatment plant.
- The County coordinated nutrient trading with MDE once the Discharge Monitoring Report (DMRs) were certified on March 10, 2021.
- The County requested from MDE to purchase nutrient credits in the form of 17,356 Nitrogen and 123,533 TSS credits from the County's Ballenger-McKinney Wastewater Treatment Plant on April 2, 2021 which would satisfy the County's permit obligations of 708.1 acres in nutrient trading as well as MDEs requirements for the trade.
- The County submitted their Maximum Extent Practicable or "MEP" analysis to MDE in Summer of 2021 and by September 2021 no further questions were asked by MDE to the County.

- On December 1, 2021, The County reached out to MDE for confirmation on trades and learned from Nicole Christ that MDE neglected to process the requested trades that were requested by email on April 2, 2021. As such, the County requested a status update and found out from Ms. Christ that the request was accidentally overlooked. She followed up by email on December 1, 2021 that the trades were fully executed. The trades appear on the Water Quality Trade registry, https://mde.maryland.gov/programs/Water/WQT/Documents/MDE_REGISTER_WEB.xlsx.
- Since the last reporting period Frederick County has implemented additional projects and previously planted reforestation areas now meet the 2-inch diameter at breast height requirement. Table ES-2 below provides the updated impervious restoration credit by project type.

Table ES-2: Complete Impervious Restoration Credit by Type (December 29, 2014-June 30, 2021)

BMP Type	Total
Stormwater	
Micro-Bioretention (MMBR)	2.74
Rainwater Harvesting (MRWH)	0.05
Bioretention (FBIO)	1.70
Wet Extended Detention (PWED)	265.72
Wet Pond (PWET)	54.74
Sand Filter (FSND)	9.47
Stream Restoration	569.54
Outfall Stabilization	63.46
Tree Planting	216.23
Septic Denitrification	69.2
Septic Connections to WWTP	4.52
Septic Pumping	249.26
Vacuum Street Sweeping[1]	100.07
Redevelopment Restoration	8.59
Nutrient Trading	365.74
Total	**1,981.03**

1 Annual practice averages credit over 5 years

- Utilizing Section VII. Water Quality Trading of the November 2021 Accounting Guidance, Frederick County calculated the amount of credits that will need to be bought through the Water Quality Trading Program for the 365.74 impervious acre equivalent need. Per Equation 14 found in Section VII. Water Quality Trading, of the November 2021 Accounting Guidance, the County can purchase credits through the Water Quality Trading Program in varying amounts per nutrient to fulfill this obligation. As shown in table ES-3 below, a purchase of 4,827 Nitrogen credits would fulfill this obligation; as well would a purchase of 489 Phosphorous credits or 1,559,654 TSS credits. As provided for in the Accounting Guidance, Frederick County could also purchase excess amounts of a singular credit in lieu of acquiring another; allowing for a multitude of credit purchasing options.

- Based on current restoration projects statuses and the MDE November 2021 Accounting Guidance, Frederick County proposes to purchase the remaining required nutrient trading credits from the Ballenger McKinney treatment plant in Frederick County to remain in compliance for this reporting term. The County will coordinate nutrient trading with MDE once the Discharge Monitoring Report (DMRs) are certified in 2022.

Table ES-3: Nutrient Trading Credit Conversions per November 2021 Accounting Guidance

Nutrient	Impervious Acre Credits To Be Acquired	Translation into EOS Load Reductions (lbs at EOS)	Frederick County EOS-EOT Conversion Factor	Calculated Equivalent WQTP Nutrient Credits (lbs/yr)
Total N	365.74	18.08	0.73	4,827
Total P	365.74	2.23	0.60	489
TSS	365.74	8,046	0.53	1,559,654

- Restoration numbers will necessarily adjust due to implementation schedules for future projects and other unforeseen issues; future versions of the plan will reflect any needed changes.
- The twelve local TMDLs addressed in this document are shown in Table ES-4 and Figure ES-1 below. The TMDLs address impairments from phosphorus, sediment and *E. coli*. Each TMDL's SW-WLA for Frederick County Government's MS4 has its own TMDL Restoration Plan within this Stormwater Restoration Plan. Due to the miniscule amount of PCB in the Patuxent TMDL in the Mt. Airy region, the permit states that PCBs were too low to detect; therefore we do not have a PCB TMDL and are not responsible for a TMDL plan for this pollutant in this watershed.
- MDE's TMDL Implementation Progress and Planning (TIPP) spreadsheet tool was utilized for the first time in FY21 to model baseline, progress, and planned (proposed/identified/potential) scenarios for the County nutrient and sediment local TMDLs. Baseline loads and required load reductions increased substantially because of the change in modeling methods. Planned completion dates have been adjusted, as needed, to achieve the new targets (Table ES-4).

Table ES-4: Local TMDL Pollutant Load Planned Percent Reductions by Watershed

Watershed	MDE Published Reduction	Bacteria Reduction Human / Domestic	County Planned Reduction	Planned % of Goal Achieved	Planned Completion Date
Catoctin Creek TP	11.0%		25.6%	232.3%	2030
Catoctin Creek TSS	49.1%		49.1%	100.0%	2041
Double Pipe Creek EC	98.8%	56.3%	65.9%	117.0%	2028
Double Pipe Creek TP	73.0%		73.3%	100.3%	2029
Double Pipe Creek TSS	46.8%		235.6%	503.4%	2023
Lower Monocacy River EC	92.5%	45.3%	51.1%	112.8%	2047
Lower Monocacy River TP	28.0%		41.4%	147.8%	2072
Lower Monocacy River TSS	60.8%		60.9%	100.1%	2089
Potomac River Montgomery Co. TSS[1]	36.2%		--	--	--
Upper Monocacy River EC	97.0%	48.5%	54.4%	112.1%	2030
Upper Monocacy River TP	4.0%		23.6%	589.6%	2024
Upper Monocacy River TSS	49.0%		49.0%	100.0%	2049

(1) MDP Land use shows no urban area in County portion of this watershed.

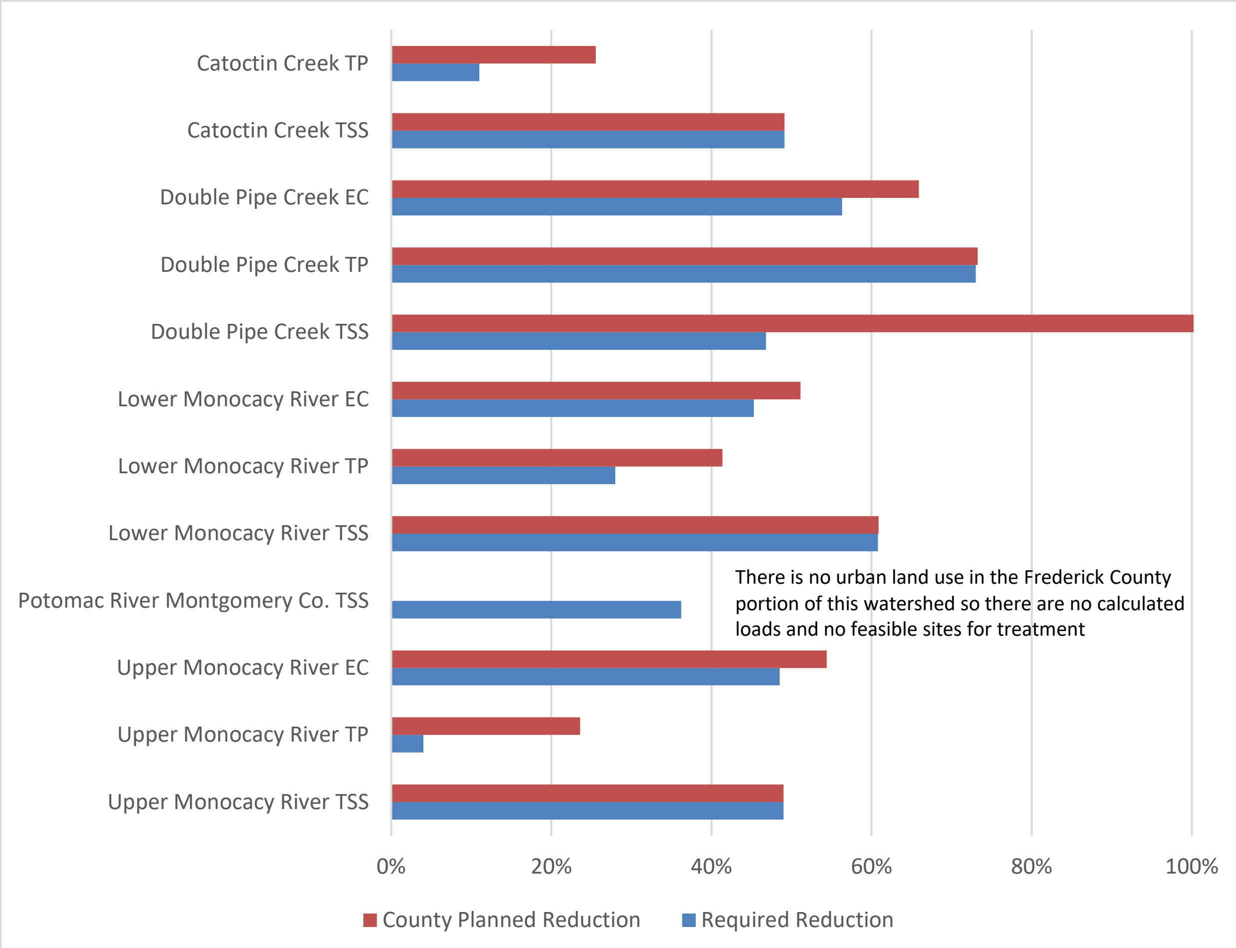


Figure ES-1: TMDL Pollutant Load Percent Reduction

This Frederick County Stormwater Restoration Plan continues to satisfy the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and TMDL Restoration Plans. Based on the updated 2021 planning analysis using the TIPP model, the Plan will take a cumulative 68 years from the date of the current report to address all TMDL requirements, and will cost a cumulative amount of $342,534,254 (Table ES-5). This represents a significant increase in BMP implementation needed to achieve target reductions when compared to the completion cost and timeframe resulting from previous modeling. The Restoration Plan also meets TMDL pollutant removal targets for all 12 local TMDLs, as shown in Table ES-4. Pollutant reductions for the Chesapeake Bay TMDL have been compared with MDE's suggested targets. The projects and programs proposed in this plan will provide 120.5% of the amount of phosphorus targeted and 65.2% for nitrogen in the Phase II Watershed Implementation Plan (WIP) for the Chesapeake Bay. The Phase III WIP was published on August 23, 2019 and will be included in the Restoration Plan when the new MS4 permit becomes effective.

Table ES-5: TMDL Restoration Timeline and Cost Estimate

Scenario	Begin Date	Complete Date	Duration (Years)	Cost
Completed	3/11/2007	6/30/2021	14.3	$32,132,613
Programmed	7/1/2021	6/30/2027	6.0	$30,387,518
Identified	7/1/2021	6/30/2028	7.0	$23,945,230
Potential	7/1/2025	6/30/2089	64.0	$288,201,506
Total from Report Date[1]			**68.0**	**$342,534,254**
[1] Duration from Report (7/1/2021) to end of Potential tier (6/30/2089)				

This document relies on currently accepted practices to meet the pollutant and impervious cover restoration requirements that are required by the MS4 permit and MDE's Accounting Guidance; however, additional alternatives and efficiencies could be considered in the future in order to meet the County's goals. The question should be asked: what is the most cost-effective way to reduce the pollutants in the local and Bay TMDLs? The answer to that will likely include a number of key concepts:

1. Reduction of atmospheric deposition of nitrogen: the Chesapeake Bay TMDL 2010 baselines from EPA included atmospheric deposition reductions from nitrogen due to portions of the Clean Air Act that were implemented. Future actions, such as the low sulfur fuels standard, were not included. Future versions of EPA allocations will likely show additional reductions from expanded implementation of the Clean Air Act (CAA) and other air rules.

   Maryland applied NOx reductions from its own Clean Cars Act and Healthy Air Act to open water, as no BMPs currently exist for this land use; however, if the reductions occur across the land they should be more evenly distributed. There should be a mechanism to allow jurisdictions to count their atmospheric NOx reductions towards the Bay. Consideration should also be given for BMPs that the County implements to reduce atmospheric pollution, such as the conversion of its bus fleet to all-electric.

   Thus far, the County has purchased nine electric buses. Related to that, the County has installed 10 bus charging stations and has provided the infrastructure for an additional 10 charging stations. More charging stations are planned for a future transit facility expansion. The County has also installed five charging stations for its hybrid fleet passenger cars.

   In 2019, the County installed a solar array at the Reichs Ford Road Landfill that will generate enough renewable energy to supply about 20% of the County's general electric usage for buildings. The array is expected to produce more than 3 ½ million kilowatt hours of electricity a year. Through a net metering agreement, electricity generated by the solar array is transferred to Potomac Edison's power grid. The County then offsets power costs at designated County facilities, including the bus charging stations.

   On December 19, 2018, County Executive Jan Gardner held a ground-breaking ceremony for a solar PV project. This major sustainability project saw the construction of a nearly 2 million kilowatt-hour photovoltaic solar array on 4.9 acres of vacant land to provide low-cost renewable energy to the Ballenger-McKinney WWTP. This facility is expected to go online imminently.

   The State's Greenhouse Gas Reduction Act plan (MDE 2030 GGRA Plan 2021) and the Climate and Energy Action Plan by the Metropolitan Washington Council of Governments have many elements that would reduce NOx and nitrogen deposition to the Bay. Frederick County Government is currently working on a mitigation strategy for greenhouse gases from internal operations and plans to initiate a community-wide strategy in 2022.

2. Large scale (Baywide or statewide) education and management programs for pet waste and urban fertilization could provide a cost-effective way of reducing pollution that is not clearly addressed in the Stormwater Accounting Guidance.

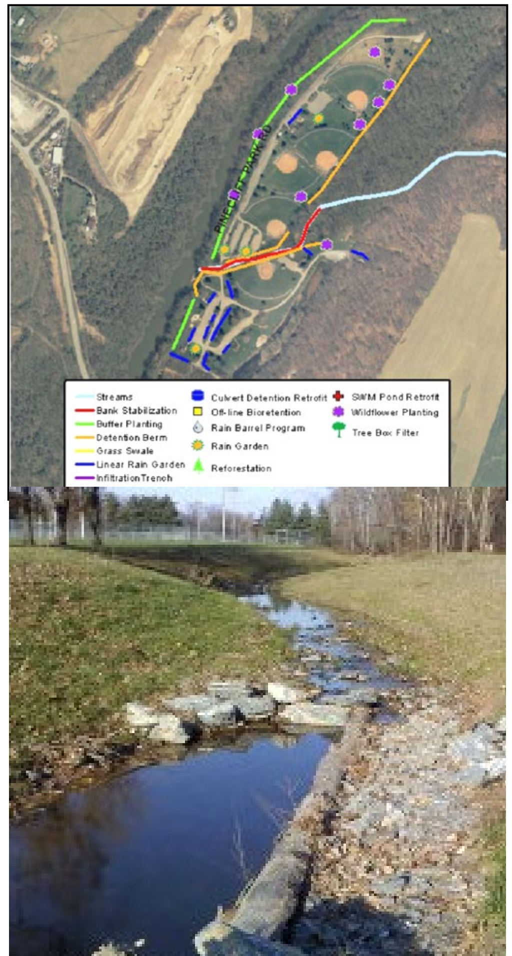
3. Public procurement is designed to protect the public's interests but also has a great deal of overhead; to reduce the cost per acre estimated for this plan, multiple options should be considered:
    a. Grant issuances: Several jurisdictions have issued RFPs asking for bids on the most cost-effective pollutant and impervious area reductions. Others have worked with the Chesapeake Bay Trust to issue grant opportunities that the Trust manages for a minimum amount of overhead. In both options, the public procurement will be reduced and private and non-profit entities can compete on a price basis. Frederick County has looked into grant solicitations and has found they generally do not perform well in terms of price or accountability.
    b. Public-Private Partnerships: A longer-term relationship model for Public-Private Partnerships (P3s) exists. Essentially the private partner implements the restoration and maintenance efforts and is responsible for specific performance metrics like cost per acre restored or pound of pollutant reduced. The partner can provide long-term financing. The County pays the private partner through bonds or another revenue source. Frederick County has reviewed several existing P3 contracts with other jurisdictions and have not found at this time that they would save the county money.

INTRODUCTION

Ballenger Creek Stream Restoration Time Series

PLAN REQUIREMENTS

This Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and TMDL Restoration Plans. The Restoration Plan addresses twelve TMDLs for local waterways, two for the Chesapeake Bay, and a 20% impervious surface restoration requirement. The TMDLs address impairments from nitrogen, phosphorus, sediment and *E. coli*.



Pinecliff Park Stream Restoration

This Plan should be viewed as a planning document that is subject to the County's review and revision in future years consistent with adaptive management, which is a cornerstone of any good water quality program. Adaptive management means that the Plan's estimated dates and costs for completion of various projects may change over time, and that projects may be substituted based on lessons learned as implementation progresses.

This plan assumes certain removal efficiencies for BMPs as a part of the development of the plans. For example, better information on BMP effectiveness or new treatment approaches will be considered for future updates of the plan. Finally, the County's ability to implement milestone actions depends on approval and funding from the local governing body in future years.

IMPERVIOUS COVER RESTORATION PLAN REQUIREMENTS

Part IV.E.2.a of the permit describes the requirement for the Impervious Cover Restoration Plan:

> *"by the end of this permit term, Frederick 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, 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."*

By December 29, 2019, Frederick County was required to restore 20% of the County's impervious surface within the MS4 that is not treated to the Maximum Extent Practicable (MEP). It used standards and methods from MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2014 Accounting Guidance) (MDE, 2014) for calculating the County's baseline untreated impervious area and the 20% restoration target. Projects after December 29, 2019 use

Accounting Guidance dated June, 2020 (MDE 2020 Accounting Guidance) as described in more detail in later sections.

TOTAL MAXIMUM DAILY LOAD RESTORATION PLAN REQUIREMENTS

Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant, measured in mass per day, which a water body can receive while still meeting state water quality standards and designated uses. TMDLs are comprised of two main elements. The first is a Wasteload Allocation (WLA), which includes point sources with a permitted discharge such as wastewater or that include National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4)-regulated urban stormwater permits. The other component is a Load Allocation (LA), which includes nonpoint sources such as loads from agriculture, forest, and non-regulated urban areas.

As a requirement of PART IV.E.2.b of the Permit, issued by MDE to Frederick County, the County must develop restoration plans for each Stormwater Wasteload Allocation (SW-WLA) approved by the Environmental Protection Agency (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. There are currently 12 final approved local TMDLs within Frederick County with either an individual or aggregate SW-WLA, shown in the table below. This Restoration Plan identifies management actions and practices that will address the portions of the SW-WLAs attributable to the County's MS4 for these 12 local TMDLs. Due to the miniscule amount of PCB in the Patuxent TMDL in the Mt. Airy region, the permit states that PCBs were too low to detect; therefore we do not have a PCB TMDL and are not responsible for a TMDL plan for this pollutant in this watershed. This Restoration Plan does not account for MDE's Phase III WIP, which was published on August 23, 2019. It is anticipated that elements of the Phase III WIP will be incorporated into the County's forthcoming MS4 permit renewal, expected in 2022.

Table 6: Frederick County Local TMDLs with SW-WLAs

Segment	Impairment	Allocation Type	Baseline Year
Catoctin Creek	Phosphorus	Individual	2009
Catoctin Creek	Sediment	Aggregate	2000
Double Pipe Creek	Phosphorus	Individual	2009
Double Pipe Creek	Sediment	Aggregate	2000
Double Pipe Creek	*Escherichia coli*	Aggregate	2004
Lower Monocacy River	Phosphorus	Individual	2009
Lower Monocacy River	Sediment	Aggregate	2000
Lower Monocacy River	*Escherichia coli*	Aggregate	2004
Potomac River Montgomery County	Sediment	Individual	2005
Upper Monocacy River	Phosphorus	Individual	2009
Upper Monocacy River	Sediment	Aggregate	2000
Upper Monocacy River	*Escherichia coli*	Aggregate	2004

The permit language states that the TMDL restoration plans must 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." The final date presented in this document is for the completion of all Potential projects, sufficient to meet pollutant load reductions for all TMDLs.
- "detailed cost estimates for individual projects, programs, controls, and plan implementation".

- "monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs."
- "Development of "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."

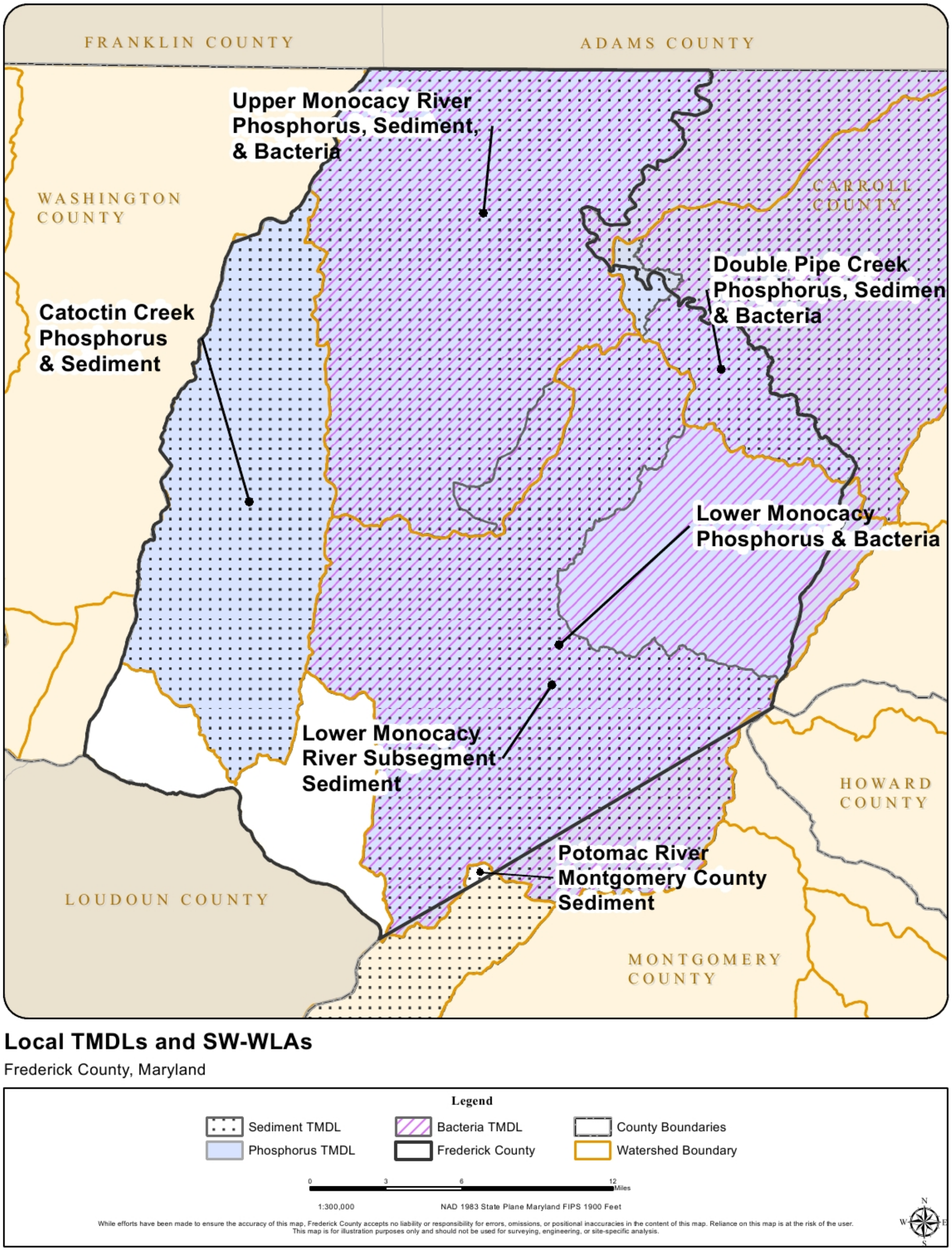


Figure 2: Frederick County Local TMDLs

RESTORATION TIERS

The County developed its Restoration Plan using the following tiers and definitions:

Figure 3: Restoration Tiers

- **Baseline:** reflects the pollutant loading, impervious surface, and projects in the ground at the time the TMDL or impervious surface goal was established (2000/2005 for sediment TMDLs; 2009 for phosphorus TMDLs; 2010 for nitrogen and phosphorus in the Bay; and 2004 for *E. coli* TMDLs). In the case of the Impervious Cover Restoration Plan, the baseline is the end date of the previous MS4 permit, March 11, 2007. These projects in the Baseline do not count as pollutant reductions in any restoration scenario. Instead they are part of the baseline load.
- **Completed:** These projects apply to restoration. They have been completed between the baseline date and June 30, 2021, the end of the reporting period for this Restoration Plan. The projects have been inspected and verified to ensure that they meet MDE's requirements. A project-by-project list for the **Completed** scenario is included in Appendix 1.
- **Programmed:** These projects are under contract or funded and have a proposed completion date on or after July 1, 2021. A project list for the **Programmed** scenario is included in Appendix 2. Projects are scheduled for completion by June 30, 2027. Note that these dates are not static and that they shift each year based on the year being reported as complete and as the program's planning is updated.
- **Identified:** These projects were identified in a Watershed Management Plan or other planning document and will be updated in future Restoration Plans as new assessments become available. These projects have engineering estimates of treated drainage areas including pervious and impervious acres. They are flagged with a geodatabase status of "proposed" and a have a completion date after June 30, 2021 and before June 30, 2028. These projects are shown in Appendix 3.
- **Potential:** These projects were selected using best available information on costs per BMP, available land or other treatment, and a level of implementation which will meet TMDL requirements. In general, the most cost-effective BMPs implemented by the county (Stream Restoration, Riparian Forest Buffers, and Forest Planting) are selected. They will be completed after June 30, 2025 and before June 30, 2089. More detail on **Potential** projects is given in Appendix 4.

SCENARIO NESTING

Many of the BMPs used to meet this plan can be used in more than one TMDL. For example, a programmed 113.7 acres of pond retrofits in the Villages of Urbana used to meet the impervious restoration goal will also be used towards the sediment and phosphorus TMDLs for the Lower Monocacy as well as the nitrogen and phosphorus reductions for the Chesapeake Bay TMDL. These scenarios nest partly or fully inside of each other; the same projects are used to meet each of them because BMPs are duplicated among TMDLs. In most instances, the schedules and costs for meeting the TMDLs are summarized by watershed and not for each of multiple TMDLs in the same watershed. Because of scenario nesting, some TMDL pollutants are overtreated and exceed reduction requirements because another listed TMDL pollutant required greater implementation to meet the target.

The TMDL Restoration Plans and Impervious Cover Restoration Plan have nested relationships. The Chesapeake Bay nitrogen and phosphorus TMDLs contain the BMPs for all Local TMDLs, and the Impervious Cover Restoration Plan. The *E. coli* TMDLs include all BMPs from local TMDLs. The local phosphorus TMDL Restoration Plans include BMPs for all local sediment TMDL Restoration Plans.

WATER QUALITY MODELS AND DELIVERY RATIOS

Reductions of nitrogen, phosphorus and sediment for stormwater BMPs had previously been modeled using a customized geodatabase script using loading rates and pollutant removal efficiencies based on Chesapeake Bay Model version 5.3.2 and MDE SW 2014 parameters. In 2021, MDE released their TMDL Implementation Progress and Planning (TIPP) tool which is a local TMDL modeling spreadsheet based on Chesapeake Bay Watershed Model Phase 6. This spreadsheet model was used to model baseline, FY21, progress, and planned scenarios for all of the local TMDLs. Reductions of bacteria are modeled in the Watershed Treatment Model (WTM) (Caraco, 2013). All of these models contain parameters for calculating pollutant loads from land use, and in the case of WTM, from a number of secondary sources. They also allow the user to predict reductions of pollutants by inputting scenarios with a suite of treatment alternates. The models calculate pollutant reductions based on the amount of treatment and pollutant reduction factors based on the level of treatment.

Pollutant loadings in this plan are expressed in terms of Edge of Stream (EOS) Loads or Edge of Tide (EOT) Loads. EOS loads apply to local waterways and are used for local TMDLs for Phosphorus, Sediment and *E. coli*. EOT loads estimate the attenuated load that makes its way to the mainstem of the Chesapeake Bay. EOT loads are obtained by subtracting the percentage of the EOS load that is attenuated prior to reaching the Bay and are used for Bay TMDL calculations. These calculations are performed in the models based on loading rates derived from the Chesapeake Bay model.

BEST MANAGEMENT PRACTICES USED

The plans in this document include stormwater BMPs accepted in MDE's 2014 and updated 2020 (draft) and 2021 (final) Accounting Guidance documents. Guidance includes stormwater retrofit projects such as wet pond or wetland conversions and new bioretention facilities as well as alternative practices such as tree planting or stream restoration. Practices in are measured in terms of impervious acres treated and in reductions of nitrogen, phosphorus, and sediment. Pollutant removal efficiencies for these practices in this plan are drawn from MDE's 2020 Accounting Guidance, which also addresses impervious acre equivalencies specific to Maryland. Our understanding is, the MDE 2020 Accounting Guidance is the draft version of the final MDE 2021 Accounting Guidance, published on November 5, 2021. The County will be updating the Restoration Plan next Fiscal Year (2022) to align with the November 2021 updated guidance.

As stated earlier, a single practice may give impervious acre credit towards the impervious cover restoration goals and pollutant reductions for multiple TMDLs. Some practices in MDE's Accounting Guidance give credit for impervious surface reduction but not pollutant reductions because the pollutant reductions are credited to another sector; these additional practices include septic system pumping, upgrades, and conversion to sewer. For the *E. coli* portions of the TMDL, BMP efficiencies from the 2013 Watershed Treatment Model (WTM) for many of the same stormwater practices are used; these efficiencies will be revised if better numbers are found in the literature. The WTM also calculates *E. coli* reductions from management programs such as pet waste education and septic system outreach.

More detailed information on management practices, including removal rates for each practice is provided in Appendix 5. The plan also includes credits from water quality trading as described in the Restoration Efforts for 20% of the County's Impervious Surface Area section of the Impervious Cover Restoration Plan.

IMPLEMENTATION MODELING TRANSLATION

Frederick County's TMDLs were developed by MDE at different periods in time using a variety of models. In order to use a currently available model for analysis, the reduction targets and loads need to be translated from the model used to develop the TMDL to the current model.

BASELINE MODELING

Baseline loads for each TMDL watershed are based on GIS overlays of the TMDL boundary, the County's MS4 jurisdiction, impervious cover derived from planimetric mapping, and urban land use delineated in MDP's land use/land cover files, and loading rates from two sources, depending on the TMDL:

- TMDL boundaries were downloaded from the MDE TMDL Data Center
- Frederick County's MS4 jurisdiction boundary was delineated by starting with the County boundary, then successively identifying other stormwater permittees and deleting their property. These included Federal lands, State lands, State and local Phase II permittees, MDOT SHA Phase I land, and industrial stormwater permittees.
- The County mapped impervious cover using aerial orthoimagery in 2005, with a subsequent update in 2014.
- MDP mapped land cover statewide in 2002 and 2010. Urban land use includes all codes beginning with 1. Baseline loads do not include land coded 2x (agriculture), 4x (forest), 50 (water), 60 wetlands), 73 (barren), or 241-242 (agriculture). This approach which models loads from urban pervious and impervious developed land use is consistent with the Chesapeake Bay Watershed Model (CBWM) and aligns with land use categories modeled in the baseline scenario of the TIPP.
- Loading rate sources and loads are described in the Nutrient/Sediment and *E. Coli* TMDL sections which follow.

Each TMDL has a baseline year, and the GIS overlays were used in the closest approximation, shown in Table 7.

Table 7: GIS Data Used for Baseline Modeling

TMDL	Baseline Year	MDP Land Cover	Frederick Impervious Cover
Sediment	2000	2005	2005
	2005	2005	2005
Phosphorus	2009	2014	2014
Chesapeake Bay Nitrogen, Phosphorus, and Sediment	2010	2014	2014
E. Coli	2004	2005	2005

The baseline model includes County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.

1. County BMPs installed prior to the TMDL baseline year were added to the model.
2. The reduction percentage published in the TMDL document was then applied to the modeled baseline loads to calculate a translated reduction in Edge-of-Stream (EOS) lbs/yr for local TMDLs and Edge-of-Tide (EOT) lbs/yr for the Bay TMDL.
3. A translated SW-WLA was calculated by subtracting the translated reduction from the modeled baseline load.

RESTORATION MODELING

Translated load reductions calculated based on TMDL percent reductions and baseline loads modeled using land use loading rates will be the target reductions used for TMDL compliance for the Bay TMDL and all local TMDLs.

Reductions for stormwater treatment have been modeled using MDE's TIPP. These include all ESD BMPs, all Structural BMPs, and Alternative BMPs.

Reductions for operational BMPs including street sweeping, catch basin cleaning, storm drain vacuuming, and septic system improvements are also modeled in the TIPP and have been determined using current data from County agencies working with these programs. Load reductions for each type of BMP are based on MDE's 2020 Accounting Guidance, (MDE, 2020).

IMPERVIOUS COVER RESTORATION PLAN

Catoctin Creek Nature Center Green Roof

IMPERVIOUS COVER BASELINE

Section PART IV.E.2.a of the NPDES MS4 Discharge Permit issued by MDE to Frederick County states that "within one year of permit issuance, Frederick 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, 2014). Upon approval by MDE, this impervious surface area assessment shall serve as the baseline for the restoration efforts required in this permit."

The baseline in the previous permit was derived using the Simple Method (Schueler, 1987); which applied impervious cover coefficients to land use/land cover (LU/LC) maps from Maryland Department of Planning. This method has been replaced by the use of planimetric data, where actual impervious areas are digitized from aerial survey.

Frederick County submitted its Fiscal Year 2018 Annual Report in December 2018 as its fourth annual report submission for the current permit term. At MDE's request Frederick County included in this report submission a revised impervious surface cover assessment. MDE provided comments on this annual report submission on July 12, 2019.

In its comments, MDE stated that it could not approve the County's revised impervious cover assessment because the County's baseline update did not have adequate documentation to definitively identify the impervious acreages treated by various BMPs in the County's rooftop and non-rooftop disconnect analyses.

Frederick County noted that the revisions to the rooftop and non-rooftop analyses included in the County's impervious cover resubmission, and reported in the 2018 Annual Report Appendix O: Impervious Accounting Memo and geodatabase, were conducted in the expanded MS4 Boundary. However, the update to the Boundary area was not provided for in Appendices with the FY19 report, Rooftop Disconnect Protocol and Non-Rooftop Disconnect Protocol. Essentially, the revised impervious cover assessment was conducted correctly, but the protocol document language detailing the new extent was not updated when submitted with the 2018 Annual Report.

MDE noted in its August 23, 2019 memo, which tentatively approved the County's Financial Assurance Plan, that approval of the impervious cover assessment was still pending. The County updated the impervious cover assessment as well as two technical memos for rooftop and non-rooftop disconnect studies and submitted them to MDE on September 30, 2019. Frederick County staff met with MDE on October 24th where it was decided by MDE that the impervious cover analysis was pending approval of the non-rooftop disconnect study. A field visit was planned to review the study findings with MDE; however, McCormick Taylor, in reviewing for the field meeting, discovered a significant error the rooftop and non-rooftop studies. The wrong projection file was used, causing the county's restoration obligation to be underestimated by 711 acres. The impervious cover assessment was conducted using the correct boundary and by the correct protocol but with an error in the projection which caused the discrepancy. The County has been working to review the work with the consultants as well as any impacts this error may have created with other studies, and to redouble efforts to look for baseline reduction credits in MDE-approved protocols.

Apart from the rooftop and non-rooftop disconnection issue, MDE did not take issue with the County's methodology for the revised submission or its results, which is the same MDE-approved methodology MDE used with substantially similar results. In some instances, Frederick County had access to better source data, which resulted in slightly different numbers than what MDE calculated from its analysis. Frederick County respectfully submitted additional clarity in how it developed its impervious baseline by adhering to the methods outlined by MDE.

Based on the analysis provided in the Impervious Cover Restoration Plan, Rooftop and Non-Rooftop Disconnect Studies, Sheet flow to Conservation protocol submitted in December 2019, and the Field Review Memo of the Non-

Rooftop disconnect submitted on February 14, 2020 and accompanying Appendices, Frederick County used MDE's guidance and comments to determine there are 13,396 total impervious acres within its boundary, of which 678 acres are treated with BMPs, 403 impervious acres are treated through rooftop disconnect, 2,259 impervious acres are treated through non-rooftop disconnect, 38 acres are treated through sheetflow to conservation areas, 51 acres are treated through existing grass swales and 64 acres are treated by draining to Maryland State Highway Administration BMPs from the Frederick County MS4 area. This leaves the County with 9,903 untreated impervious acres. Based on the 20% restoration requirement, Frederick County will need to treat 1,981 impervious acres to meet its MS4 Permit Restoration requirement. A summary table detailing the impervious area assessment and credit is included as Table 8 below.

MDE's draft comments provided on April 6, 2020 approved the 1,981 impervious acre restoration goal for Frederick County; which included the Rooftop Disconnect memo, the Non-Rooftop Disconnect memo, the Existing Water Quality Grass Swale Identification Protocol and the Sheetflow to Conservation Protocol submitted as part of the 2019 Annual Report. In addition to the draft comments provided by MDE in April 2020, the County received a letter from MDE on July 1, 2021 stating that the Department accepted the County's 2020 Annual Report and confirmed that the County met the 20% restoration requirement (i.e., 1,981 acres).

Table 8 shows the current figures on baseline untreated area, restoration from projects and programs established prior to the baseline, and a calculation of the impervious restoration requirement.

Table 8: Frederick County Impervious Accounting (12/29/2019)

Impervious Accounting Areas	Area (ac)
Total Impervious area within MS4 Permit Area	13,396
Treated Impervious	(-678)
Rooftop Disconnect	(-403)
Non Rooftop Disconnect	(-2,259)
Existing Grass Swales Districts 3-6	(-51)
SHA Treated County Impervious	(-64)
Sheetflow to Conservation Area	(-38)
Treated Baseline	(-3,493)
Untreated Baseline	9,903
Restoration Goal (20% of untreated baseline)	**1,981**
Completed as of 12/29/2019	1,273
Nutrient Trading	708
Total Restored	**1,981**

RESTORATION EFFORTS FOR 20% OF THE COUNTY'S IMPERVIOUS SURFACE AREA

Sources of the acres restored come from the **Completed** restoration tier where the completion date is between March 11, 2007 and June 30,2021, the end date of the current permit. Restoration projects from the **Completed** scenario built prior to December 30, 2014 are allowed in the Impervious Cover Restoration Plan crediting per MDE because they were executed after March 11, 2007, the ending date of the previous permit.

Where there is sufficient information, Frederick County is including alternative BMPs in its restoration plan. These include, but are not limited to, street sweeping, outfall stabilization, and a variety of septic system credits along with tree planting and stream restoration. Septic pumping was added to the plan based on locations extracted from documents acquired from septic maintenance companies as well as the County's new Septic Program Rebate

Program. The County reviewed the applicable documents, digitized each address where the septic pumping occurred, and calculated impervious acre equivalency per MDE's 2014 and 2020 Accounting Guidance.

Restoration projects are updated from the legislative reporting in the updates to the County's Financial Assurance Plan (FAP) and Watershed Protection and Restoration Plan (WPRP) reports that are submitted to MDE in December of 2020. Previous County FAPs were submitted to MDE on July 1, 2016, December 21, 2018, June 28, 2019, and April 30, 2020; and the previous update to the WPRP report was dated December 28, 2020 as required by the County's MS4 Permit requirements.

On December 29, 2021, Frederick County has continued to implement additional projects since its FY20 Annual Report. Those projects and continued preliminary maintenance and inspections of previously planted reforestation areas now meet the 2 inch diameter at breast height requirement have assisted the County in reducing its Water Quality Trades. Table 9 below provides the updated impervious restoration credit by project type.

Table 9: Complete Impervious Restoration Credit by Type (December 29, 2014-June 30, 2021)

BMP Type	Total
Stormwater	
Micro-Bioretention (MMBR)	2.74
Rainwater Harvesting (MRWH)	0.05
Bioretention (FBIO)	1.70
Wet Extended Detention (PWED)	265.72
Wet Pond (PWET)	54.74
Sand Filter (FSND)	9.47
Stream Restoration	569.54
Outfall Stabilization	63.46
Tree Planting	216.23
Septic Denitrification	69.2
Septic Connections to WWTP	4.52
Septic Pumping	249.26
Vacuum Street Sweeping[1]	100.07
Redevelopment Restoration	8.59
Nutrient Trading	365.74
Total	**1,981.03**

1 Annual practice averages credit over 5 years

Utilizing Section VII. Water Quality Trading of the November 2021 Accounting Guidance, Frederick County calculated the amount of credits that will need to be bought through the Water Quality Trading Program for the 365.74 impervious acre equivalent need. Per Equation 14 found in Section VII. Water Quality Trading, of the November 2021 Accounting Guidance, the County can purchase credits through the Water Quality Trading Program in varying amounts per nutrient to fulfill this obligation. As shown in table ES-3 below, a purchase of 4,827 Nitrogen credits would fulfill this obligation; as well would a purchase of 489 Phosphorous credits or 1,559,654 TSS credits. As provided for in the Accounting Guidance, Frederick County could also purchase excess amounts of a singular credit in lieu of acquiring another; allowing for a multitude of credit purchasing options.

Based on current restoration projects statuses and the MDE November 2021 Accounting Guidance, Frederick County proposes to purchase the remaining required nutrient trading credits from the Ballenger McKinney treatment plant in Frederick County to remain in compliance for this reporting term. The County will coordinate nutrient trading with MDE once the Discharge Monitoring Report (DMRs) are certified in 2022.

Table 10: Nutrient Trading Credit Conversions per November 2021 Accounting Guidance

Nutrient	Impervious Acre Credits To Be Acquired	Translation into EOS Load Reductions (lbs at EOS)	Frederick County EOS-EOT Conversion Factor	Calculated Equivalent WQTP Nutrient Credits (lbs/yr)
Total N	365.74	18.08	0.73	4,827
Total P	365.74	2.23	0.60	489
TSS	365.74	8,046	0.53	1,559,654

Restoration numbers will necessarily adjust due to implementation schedules for future projects and other unforeseen issues; future versions of the plan will reflect any needed changes.

The twelve local TMDLs addressed in this document are shown in Table ES-4 and Figure ES-1 below. The TMDLs address impairments from phosphorus, sediment and *E. coli*. Each TMDL's SW-WLA for Frederick County Government's MS4 has its own TMDL Restoration Plan within this Stormwater Restoration Plan. Due to the miniscule amount of PCB in the Patuxent TMDL in the Mt. Airy region, the permit states that PCBs were too low to detect; therefore we do not have a PCB TMDL and are not responsible for a TMDL plan for this pollutant in this watershed.

NUTRIENT AND SEDIMENT TOTAL MAXIMUM DAILY LOADS

Windsor Knolls Middle School Tree Planting and Wetland Enhancement

OVERVIEW

The Chesapeake Bay and many local waterways have been listed as impaired due to excessive nitrogen, phosphorus, and sediment. The two nutrients, nitrogen and phosphorus, cause eutrophication by fueling algal blooms that consume dissolved oxygen (DO) needed for other organisms. Sediment causes greater turbidity, blocking sunlight needed for submerged aquatic vegetation (SAV) and reducing this critical habitat for many of the Bay's species.

Degraded habitats in turn reduce biodiversity, which then causes an imbalance in the ecosystem and removes many ecosystem services provided by those organisms. Rich biodiversity keeps all trophic levels intact, supporting fisheries and downstream. Sources of nutrient and sediment impairment have been identified by many different organizations and are discussed below.

Sources of these three pollutants include point sources, such as municipal wastewater facilities, industrial discharge facilities, and NPDES permitted stormwater discharges. Nonpoint sources include agriculture and forest runoff, septic systems, and erosion of streambanks and shorelines. (EPA 2010). Specific sources of each pollutant are described below.

SOURCES OF IMPAIRMENT

NITROGEN

Nitrogen is commonly a limiting nutrient in saltwater systems; organisms in both fresh and saltwater systems grow most effectively when the soluble nitrogen is found in a ratio of 16:1 relative to phosphorus. As an estuary, the Chesapeake Bay is limited by both nitrogen and phosphorus depending on salinity in different parts of the Bay.

Nitrogen makes up 70 percent of the atmosphere. As a gas, it is inert, but when transformed (fixed) into the reactive forms of nitrate or ammonium it becomes biologically available. Nitrogen fixation can occur naturally, but most reactive nitrogen is man-made, through combustion of fossil fuels, or manufacture of fertilizer. (EPA 2009).

Sources of nitrogen impairment to the Chesapeake Bay include the following (Eney, 2009):

- Manure, emissions and chemical fertilizers from farmland and animal operations (36 percent)
- Nitrogen oxide emissions from vehicles, industries, and electric utilities (27 percent)
- Human waste treated and discharged from municipal wastewater treatment plants and wastewater discharged from industrial facilities (20 percent)
- Chemical fertilizers applied to lawns, golf courses and other developed lands (11 percent)
- Septic systems that treat household wastewater and discharge effluent to groundwater in the Bay watershed (5 percent)

PHOSPHORUS

Phosphorus in streams and other waterbodies is found in both dissolved and particulate forms. The only biologically available form is orthophosphate, which is in solution. Most forms bind to soil; as a result, it is associated with sediment deposition. This means that freshwater systems, and phosphorus-limited Bay regions, can expect greater phosphorus related algal growth during times of heavy sediment transport. Because phosphorus is less likely to be found in dissolved form, loads may take longer to reach receiving waters, making it more difficult to estimate the effects without long-term monitoring data.

Sources of phosphorus impairment to the Chesapeake Bay include the following (Eney, 2009):

- Manure and chemical fertilizers from farms (45 percent)
- Runoff from developed cities, towns and suburbs, as well as legacy sediments from streams (31 percent)
- Municipal and industrial wastewater (21 percent)

SEDIMENT

Sediment is recognized as one of the most important pollutants to control because it can carry many other harmful substances, such as PCBs, bacteria, or minerals that effect pH. Sediment as a pollutant generally refers to Suspended Solids (SS). The EPA defines SS as mainly inorganic particles consisting of clay and silt less than 0.250 mm in size. While nitrogen and phosphorus contribute to eutrophication via providing nutrients for algal growth, sediment contributes to surface water degradation in local waterways and the Bay, both. Increased sediment deposition changes stream geomorphology, and can also smother bottom-dwelling organisms and make it more difficult for them to feed or filter water.

Sources of sediment impairment to the Chesapeake Bay include the following (Eney, 2009):

- Erosion and runoff from agriculture (60 percent)
- Urban and suburban runoff, construction activity, and in-stream sediment (19 percent)
- Natural sources (21 percent)

CHESAPEAKE BAY (FREDERICK COUNTY) TMDL PLANS BY WATERSHED

The Chesapeake Bay TMDLs, established by the EPA (EPA, 2010), set pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. These TMDLs, required under the Clean Water Act, were in response to the slow progress by states within the watershed to limit their pollutants to levels which meet water quality standards in the Bay and its tidal tributaries. 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.

Compliance with the Chesapeake Bay TMDL is regulated in the permit through the use of the 20% impervious surface treatment strategy as described in greater detail in the previous section. While not a requirement in the County’s MS4 permit, restoration strategies to meet local TMDL reduction targets and impervious restoration treatment were also modeled against the Bay TMDL goals in order to calculate progress. The results below are shown for information purposes only. This plan reflects the goals of the Phase II WIP. The Phase III WIP was released in August 2019 and will be incorporated into the County’s next MS4 permit. The County will address those elements in the Restoration Plan when the new MS4 permit becomes effective.

SW-WLAS AND TRANSLATION

Table 11 provides a concise summary of Frederick County's portions of target edge of tide (EOT) reductions towards the Chesapeake Bay TMDL and 2010 baseline and 2025 allocated loads.

- **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.
- **EOT lbs/yr:** A EOT load is the amount of pollutant that is transported to the tidal waters of the Chesapeake Bay. EOT loads are generally less than edge of stream (EOS) loads due to losses during transport from streams to the Bay.
- **Translated 2010 Baseline Load**: Baseline levels (i.e., land use loads with baseline BMPs) from 2010 conditions in the Frederick County MS4 source sector using modeling results from CAST-2019. Baseline loads were used to translate the Bay TMDL nitrogen and phosphorus SW-WLAs.
- **Target Percent Reduction**: Percent reductions assigned to Frederick County Phase I MS4 stormwater sector (MDE TMDL Data Center). If TP target is met, TSS target will be met.
- **Translated Target Reduction:** Target reduction translated by multiplying the reduction percent published by the 2010 baseline load. If TP target is met, TSS target will be met.
- **Translated TMDL WLA**: Allocated loads are calculated from the 2010 baseline levels, translated as described above, using the following calculation: 2010 Baseline – (2010 Baseline x Target Percent Reduction); or, 2010 Baseline x (1 – Target Percent Reduction).

Table 11: Frederick County Chesapeake Bay TMDL Baseline and Target Loads

Baseline and Target	TN-EOT lbs/yr	TP-EOT lbs/yr
Translated Baseline Load	769,812	56,487
Target Percent Reduction	10.9%	20.7%
Translated Target Reduction	83,910	11,693
Translated Bay TMDL WLA	685,902	44,795

The amount of treatment in progress and proposed to address the Bay TMDL is shown in Table 12 through Table 14 and reflected in Figure 4 and Figure 5. Detailed Chesapeake Bay scenarios are shown in Appendix 6.

Table 12: Cumulative Restoration Treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	129.52	217.40	346.92
Grass Swale	0.30	0.97	1.27
Sand Filters	50.90	94.60	145.50
Wet Pond	28.07	73.22	101.29
Submerged Gravel Wetland	464.80	863.10	1,327.9
Wet Pond Retrofit	1,722.43	4,077.01	5,799.44
Streams (LF)	0.00	0.00	263,453
Rainwater Harvesting	0.05	0.00	0.05
Tree Planting	0.00	690.98	690.98
Riparian Buffer	0.00	1,803.62	1,803.62

NITROGEN TMDL

Table 13: Reductions by Scenario for Chesapeake Bay Nitrogen TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	769,812	0.0%
Complete	5,679	5,679	764,133	6.8%
Programmed	4,705	10,384	759,428	12.4%
Identified	983	11,367	758,445	13.5%
Potential	43,321	54,689	715,123	65.2%
Translated Reduction	83,910			

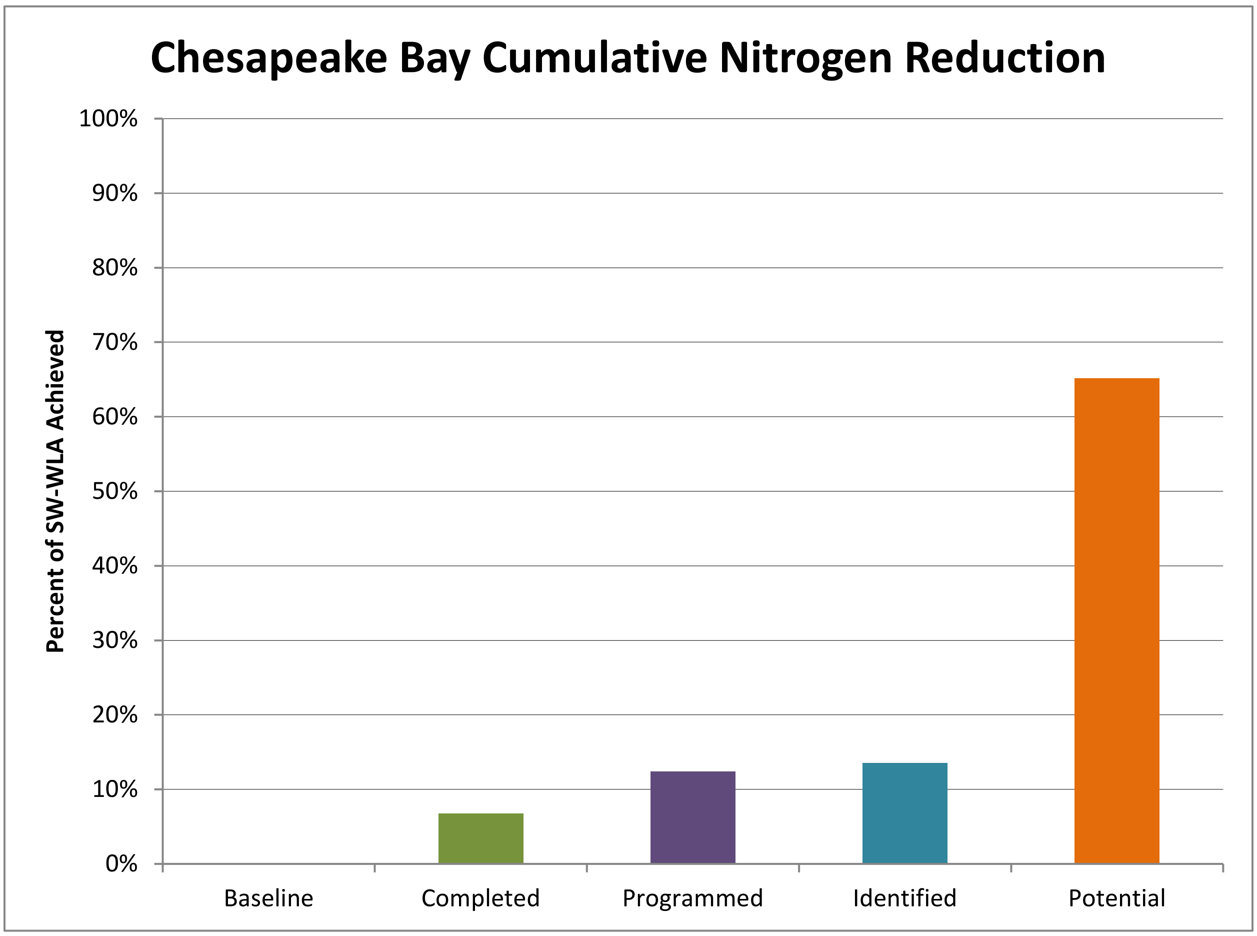


Figure 4: Chesapeake Bay Cumulative Nitrogen Reductions (Percent)

PHOSPHORUS TMDL

Table 14: Reductions by Scenario for Chesapeake Bay Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	0	0	56,487	0.0%
Complete	1,189	1,189	55,298	10.2%
Programmed	837	2,026	54,461	17.3%
Identified	584	2,610	53,877	22.3%
Potential	11,484	14,094	42,393	120.5%
Translated Reduction	11,693			

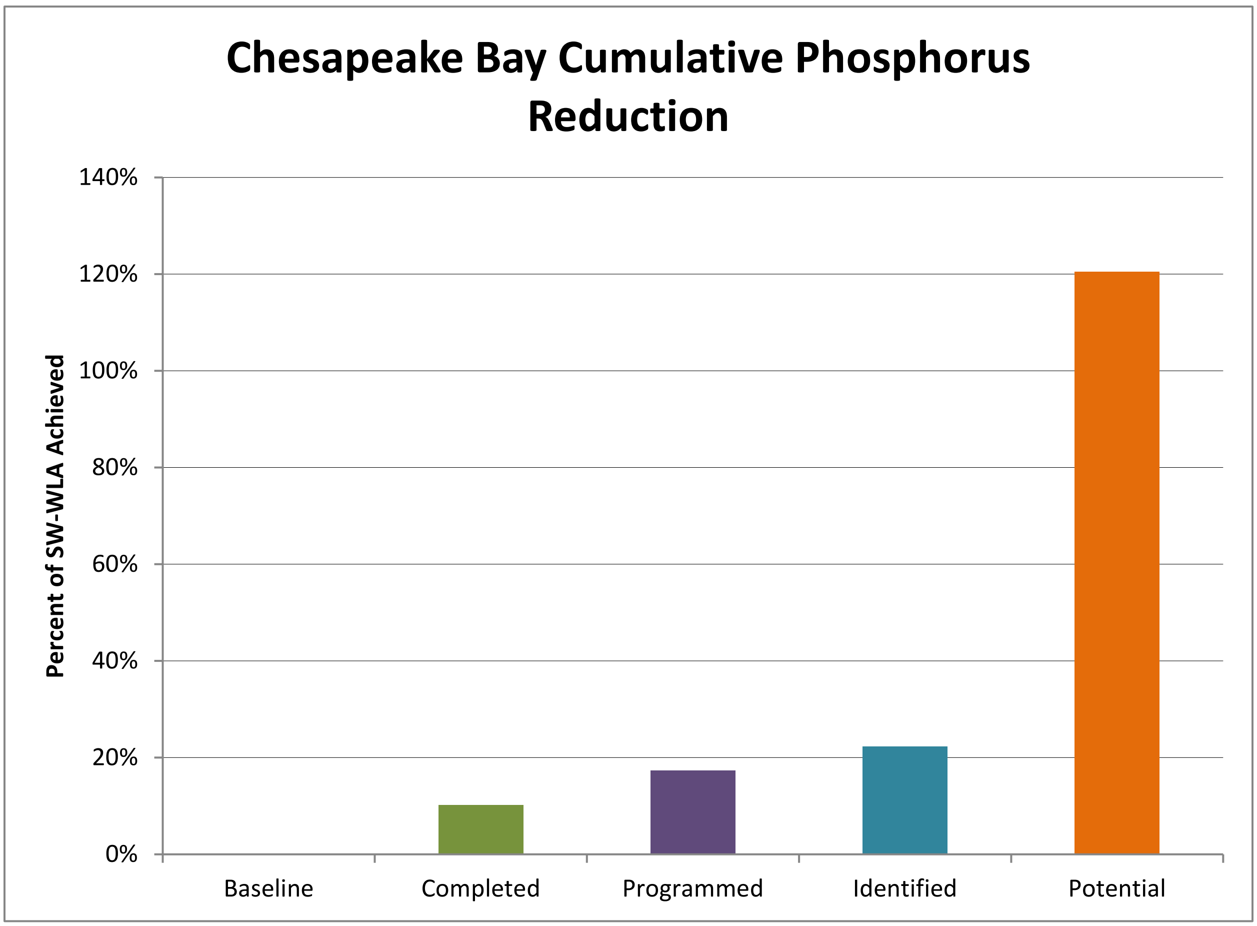


Figure 5: Chesapeake Bay Cumulative Phosphorus Reductions (Percent)

LOCAL NUTRIENT AND SEDIMENT PLANS BY WATERSHED

In order to derive the County MS4-specific SW-WLA load reduction targets, the implementation models used to determine compliance need to be translated to TMDL goals using MDE's published reduction percentages for each TMDL. The procedure is described below.

TRANSLATION

Table 15 provides a concise summary of Frederick County's portions of target edge of stream (EOS) reductions towards the nutrient and sediment local TMDLs

- **TN, TP, TSS:** Total Nitrogen, Total Phosphorus, Total Suspended Sediment.
- **EOS lbs/yr:** An EOS load is the amount of pollutant that is transported from a source to the nearest stream while a EOT load is the amount of pollutant that is transported to the tidal waters of the Chesapeake Bay. EOT loads are generally less than EOS loads due to losses during transport from streams to the Bay.
- **MDE Published Reduction**: Percent reductions assigned to Frederick County Phase I MS4 stormwater sector (MDE TMDL Data Center).
- **Translated Baseline Load**: Baseline levels (i.e., land use loads with baseline BMPs) from baseline year conditions in the Frederick County MS4 source sector using modeling results from the TIPP.
- **Translated Target Reduction:** Target reduction translated by multiplying the reduction percent published by the baseline load.

Table 15: Translated Nutrient and Sediment Local TMDL SW-WLAs and Target Load Reductions

Watershed Name	Watershed Number	Baseline Year	Pollutant[1]	MDE Published Reduction Percent[2]	Baseline Impervious Area[3]	Baseline Pervious Area[3]	Translated Baseline Load[4]	Translated Reduction[5]
Catoctin Creek	02140305	2009	Phosphorus	11.0%	1,032	8,357	13,886	**1,527**
		2000	Sediment	49.1%	880	7,666	22,864,764	**11,226,599**
Double Pipe Creek	02140304	2009	Phosphorus	73.0%	103	887	1,213	**886**
		2000	Sediment	46.8%	65	629	1,171,514	**548,269**
Lower Monocacy River[5]	02140302	2009	Phosphorus	28.0%	5,407	24,212	43,746	**12,249**
		2000	Sediment	60.8%	4,677	23,355	86,466,215	**52,571,459**
Potomac River Montgomery County	02140202	2005	Sediment	36.2%	0	0	0	**0**
Upper Monocacy River	02140303	2009	Phosphorus	4.0%	1,262	8,340	14,741	**590**
		2000	Sediment	49.0%	1,105	8,006	21,600,212	**10,584,104**

Target reduction loads used for TMDL compliance shown in bold text.

1) The county does not have reduction requirements for PCBs due to the miniscule amount of PCB present.
Published Reduction Percent from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Frederick County
2) County MS4 urban impervious and pervious acres for the TMDL baseline year. This is determined based on GIS overlays of MDP mapped land cover, impervious cover aerial orthoimagery, and Frederick County's MS4 jurisdiction boundary.
3) Baseline loads modeled using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.
4) Translated reductions calculated by applying the MDE published percent reduction to the translated baseline loads.
5) The Lake Linganore watershed is listed under a separate phosphorus and sediment TMDL and is not included in this analysis.

LOWER MONOCACY WATERSHED

SEDIMENT TMDL

The Baseline year for the Lower Monocacy Sediment TMDL was 2000. The TMDL requires a 60.8% reduction from baseline. Based on the load reduction results of the TIPP model, it is estimated that the Lower Monocacy watershed will need the following cumulative treatment through the Potential tier, as shown in Table 16 below, to meet the reduction target.

Table 16: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	104.07	190.85	294.92
Grass Swale	0.30	0.97	1.27
Sand Filters	38.60	71.70	110.30
Wet Pond	17.68	14.12	31.80
Submerged Gravel Wetlands	422.50	784.70	1,207.20
Pond Retrofit	1,082.56	2,238.5	3,321.06
Streams (LF)	0.00	0.00	167,149
Rainwater Harvesting	0.05	0.00	0.05
Tree Planting	0.00	463.74	463.74
Riparian Buffer	0.00	1,037.94	1,037.94

Detail on treatment for each restoration tier for Lower Monocacy sediment are in Appendix 7. Table 17 shows the translated load reductions for each of the restoration tiers, also shown in Figure 6. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the sediment TMDL will be met in 2089.

Table 17: Reductions by Scenario for Lower Monocacy Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	86,466,215	0.0%
Complete	2,319,622	2,319,622	84,146,593	4.4%
Programmed	795,976	3,115,598	83,350,617	5.9%
Identified	592,516	3,708,114	82,758,101	7.1%
Potential	48,920,988	52,629,102	33,837,113	100.1%
Translated Reduction	52,571,459			

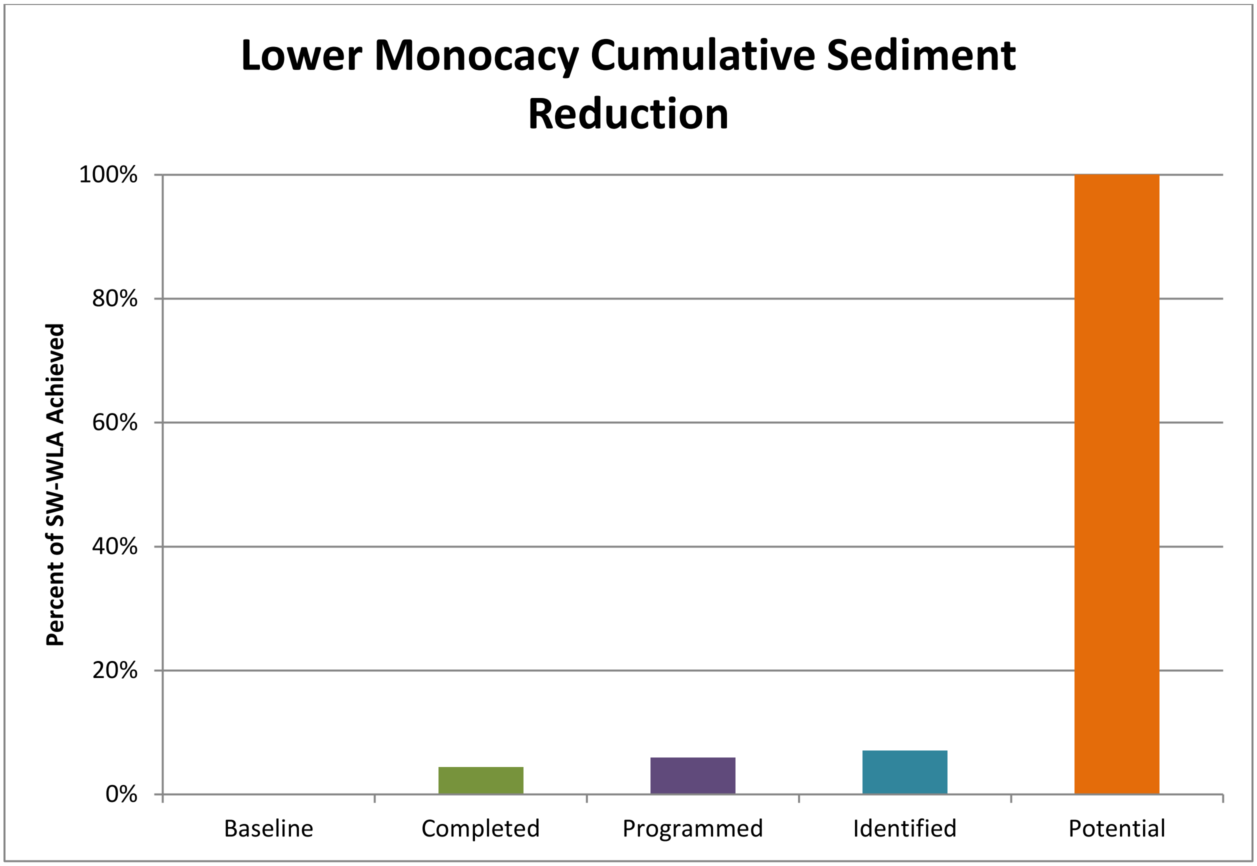


Figure 6: Lower Monocacy Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL

The Baseline year for the Lower Monocacy phosphorus TMDL was 2009. The TMDL requires a 28.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 18 below.

Table 18: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	**Impervious**	**Pervious**	**Total**
Bioretention	101.77	189.65	291.42
Grass Swale	0.30	0.97	1.27
Sand Filters	38.60	71.70	110.3
Wet Pond	28.07	73.22	101.29
Submerged Gravel Wetlands	422.5	784.7	1,207.2
Pond Retrofit	1,228.53	2,609.31	3,837.84
Streams (LF)	0.00	0.00	173,603.00
Rainwater Harvesting	0.05	0.00	0.05
Tree Planting	0.00	489.55	489.55
Riparian Buffer	0.00	1,206.05	1,206.05

Detail on treatment for each restoration tier for Lower Monocacy phosphorus are in Appendix 8. Table 19 shows the translated load reductions for each of the restoration tiers, also shown in Figure 7. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the phosphorus TMDL will be met in 2072. The BMPs and associated reductions presented in Table 18 and Table 19, respectively, show overtreatment of phosphorus due to the implementation required to meet sediment TMDL requirements in the Lower Monocacy watershed.

Table 19: Reductions by Scenario for Lower Monocacy Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	43,746	0.0%
Complete	1,321	1,321	42,425	10.8%
Programmed	501	1,822	41,925	14.9%
Identified	809	2,631	41,116	21.5%
Potential	15,471	18,102	25,644	147.8%
Translated Reduction	**12,249**			

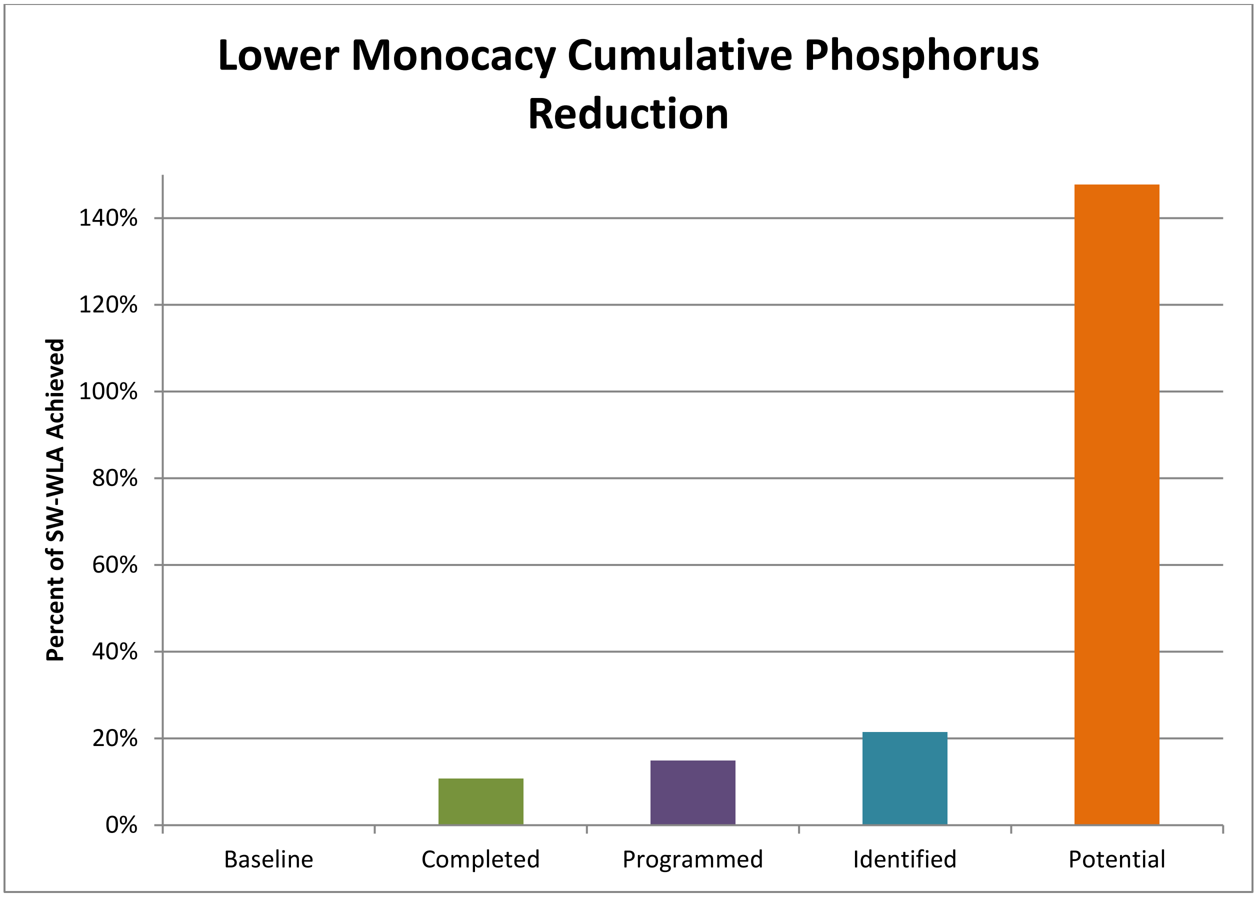


Figure 7: Lower Monocacy Cumulative Phosphorus Reductions (Percent)

SEDIMENT TMDL

The Baseline year for the Upper Monocacy Sediment TMDL was 2000. The TMDL requires a 60.8% reduction from baseline. Based on the load reduction results of the TIPP model, it is estimated that the Upper Monocacy watershed will need the following cumulative treatment through the Potential tier, as shown in Table 20 below, to meet the reduction target.

Table 20: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	27.75	27.75	55.50
Sand Filters	4.60	8.60	13.20
Submerged Gravel Wetland	21.10	39.20	60.40
Pond Retrofit	219.31	421.58	640.89
Streams (LF)	0.00	0.00	34,684.50
Tree Planting	0.00	85.27	85.27
Riparian Buffer	0.00	250.88	250.88

Detail on treatment for each restoration tier for Upper Monocacy sediment are in Appendix 9. Table 21 shows the translated load reductions for each of the restoration tiers, also shown in Figure 8. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the Sediment TMDL will be met in 2049.

Table 21: Reductions by Scenario for Upper Monocacy Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	21,600,212	0.0%
Complete	1,037,444	1,037,444	20,562,768	9.8%
Programmed	682,661	1,720,105	19,880,107	16.3%
Identified	0	1,720,105	19,880,107	16.3%
Potential	8,866,854	10,586,959	11,013,253	100.0%
Translated Reduction	10,584,104			

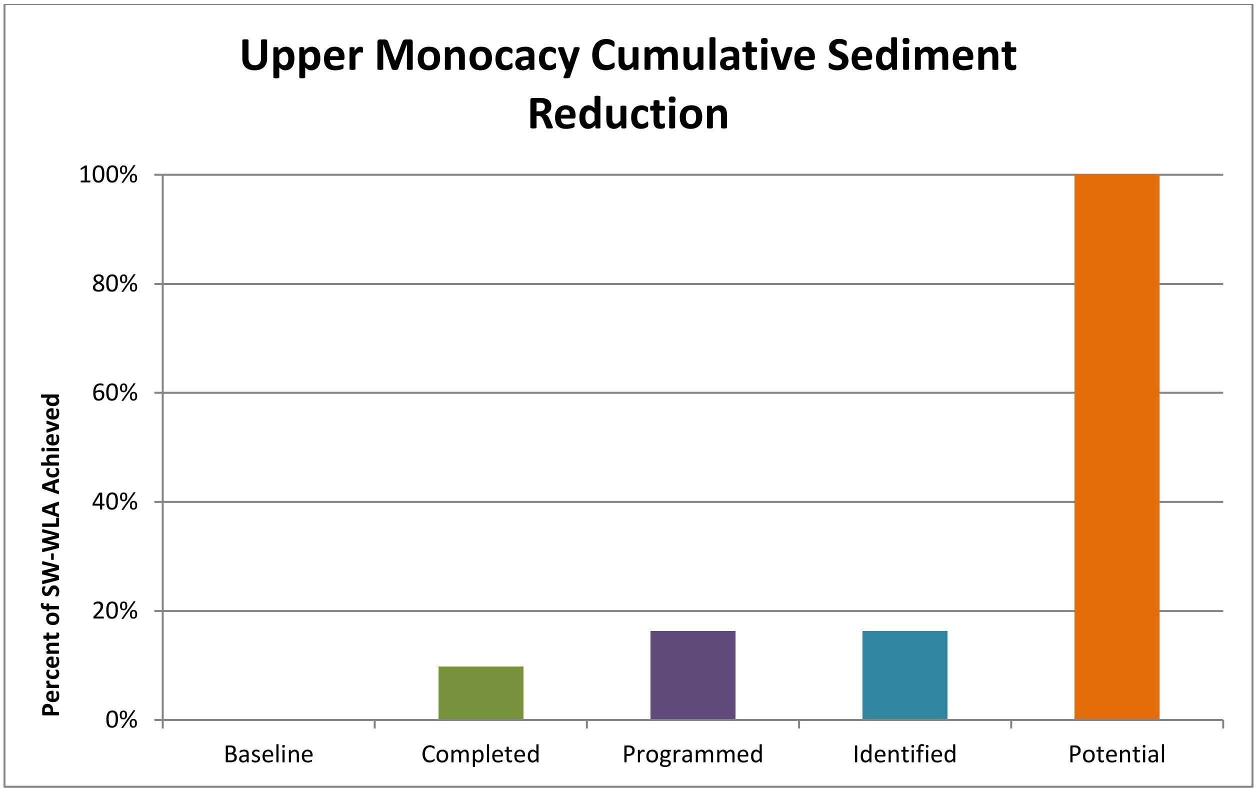


Figure 8: Upper Monocacy Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL

The Baseline year for the Upper Monocacy phosphorus TMDL was 2009. The TMDL requires a 4.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 22 below.

Table 22: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	27.75	27.75	55.50
Sand Filters	4.60	8.60	13.20
Submerged Gravel Wetland	21.10	39.20	60.40
Pond Retrofit	219.31	421.58	640.89
Streams (LF)	0.00	0.00	34,684.50
Tree Planting	0.00	85.27	85.27
Riparian Buffer	0.00	250.37	250.37

Detail on treatment for each restoration tier for Upper Monocacy phosphorus are in Appendix 10. Table 23 shows the translated load reductions for each of the restoration tiers, also shown in Figure 9. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the Phosphorus TMDL will be met in 2024. The BMPs and associated reductions presented in Table 22 and Table 23, respectively, show overtreatment of phosphorus dur to the implementation required to meet sediment TMDL reduction requirements in the Upper Monocacy watershed.

Table 23: Reductions by Scenario for Upper Monocacy Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	14,741	0.0%
Complete	332	332	14,409	56.4%
Programmed	242	575	14,167	97.4%
Identified	0	575	14,167	97.4%
Potential	2,902	3,476	11,265	589.6%
Translated Reduction	590			

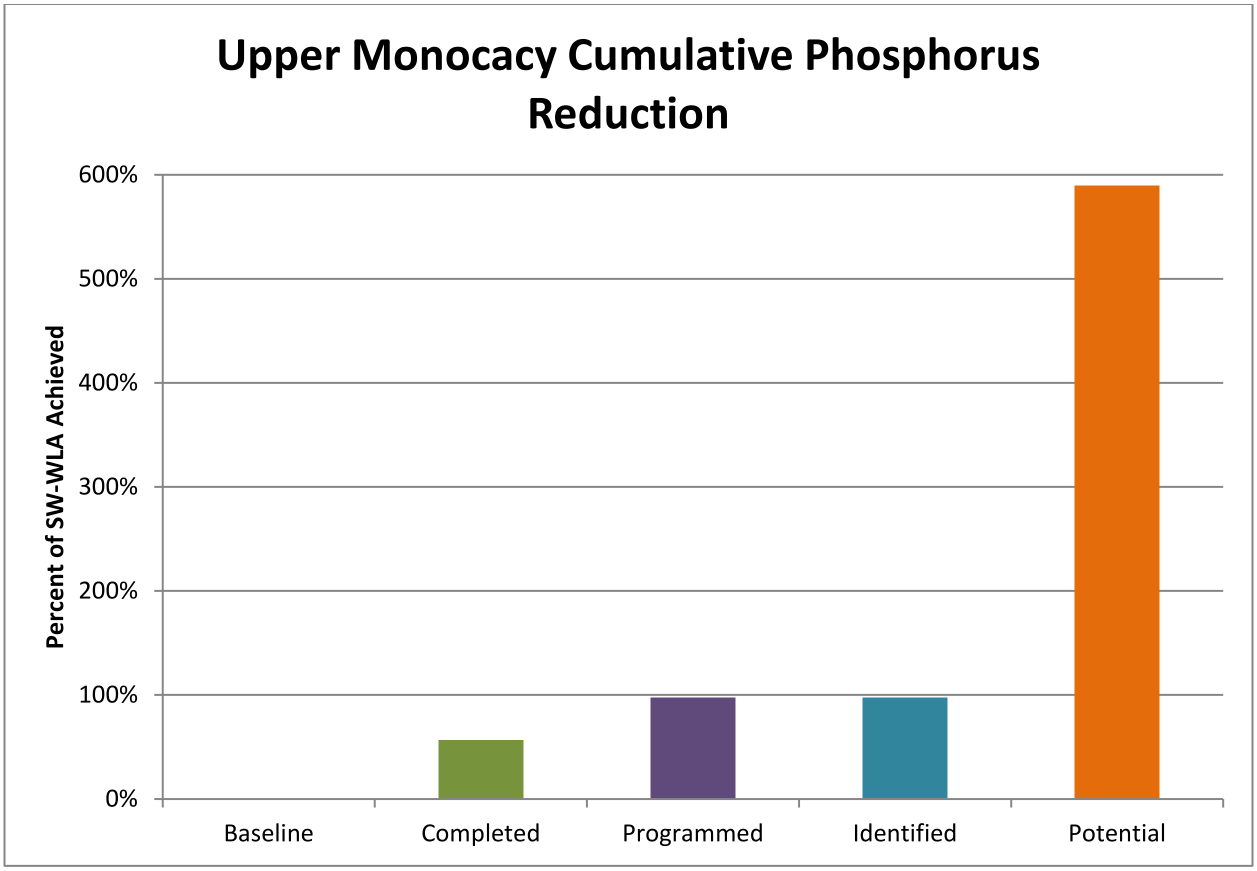


Figure 9: Upper Monocacy Cumulative Phosphorus Reductions (Percent)

SEDIMENT TMDL

The Baseline year for the Catoctin Creek Sediment TMDL was 2000. The TMDL requires a 49.1% reduction from baseline. Based on the load reduction results of the TIPP model, it is estimated that the Catoctin Creek watershed will need the following cumulative treatment through the Potential tier, as shown in Table 24 below, to meet the reduction target.

Table 24: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Sand Filters	7.70	14.30	22.10
Submerged Gravel Wetland	21.10	39.20	60.40
Pond Retrofit	194.85	685.76	880.61
Streams (LF)	0.00	0.00	38,593.50
Tree Planting	0.00	76.26	76.26
Riparian Buffer	0.00	214.12	214.12

Detail on treatment for each restoration tier for Upper Monocacy sediment are in Appendix 11. Table 25 shows the translated load reductions for each of the restoration tiers, also shown in Figure 10. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the sediment TMDL will be met in 2041.

Table 25: Reductions by Scenario for Catoctin Creek Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	22,864,764	0.0%
Complete	368,688	368,688	22,496,077	3.3%
Programmed	486,455	855,143	22,009,621	7.6%
Identified	1,176,939	2,032,082	20,832,682	18.1%
Potential	9,199,284	11,231,366	11,633,398	100.0%
Translated Reduction	11,226,599			

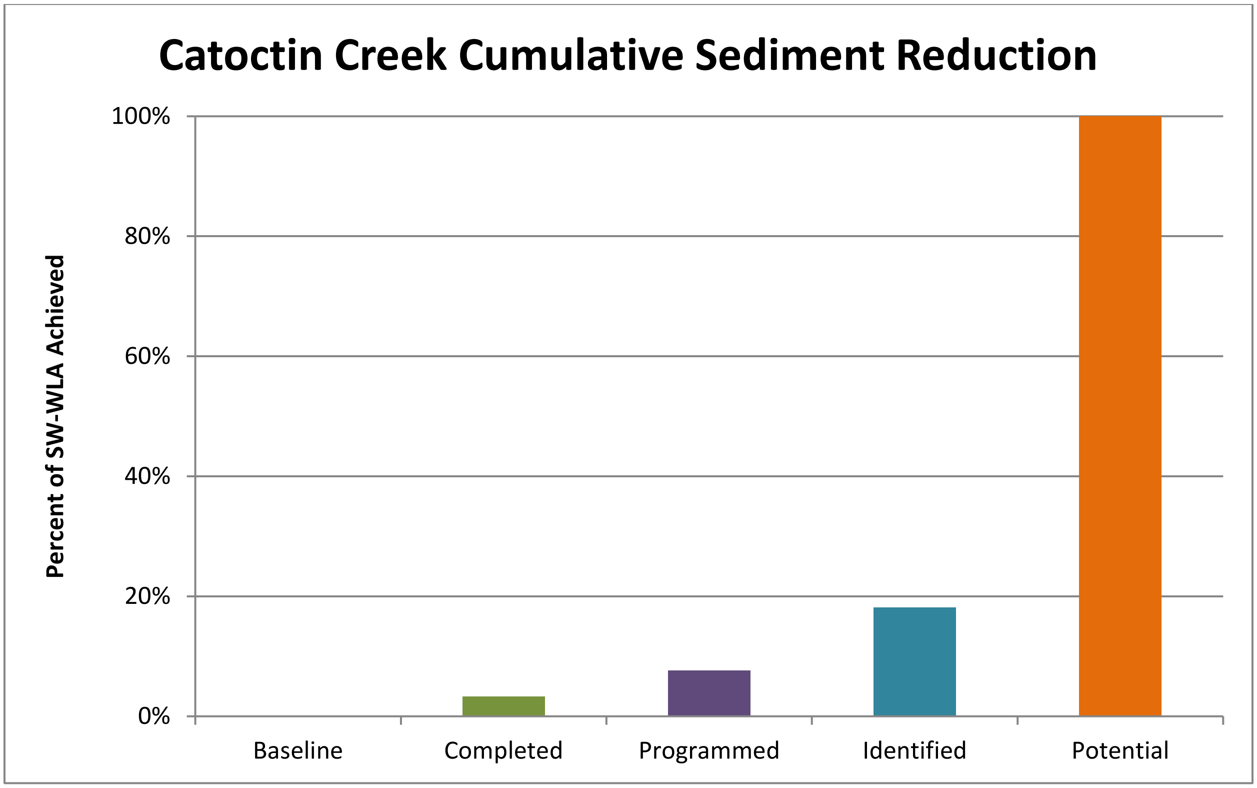


Figure 10: Catoctin Creek Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL

The Baseline year for the Catoctin Creek phosphorus TMDL was 2009. The TMDL requires an 11.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 26 below.

Table 26: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Sand Filters	7.70	14.30	22.10
Submerged Gravel Wetland	21.10	39.20	60.40
Pond Retrofit	194.85	685.76	880.61
Streams (LF)	0.00	0.00	38,593.50
Tree Planting	0.00	73.54	73.54
Riparian Buffer	0.00	214.12	214.12

Detail on treatment for each restoration tier for Catoctin Creek phosphorus are in Appendix 12. Table 27 shows the translated load reductions for each of the restoration tiers, also shown in Figure 11. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the phosphorus TMDL will be met in 2030. The BMPs and associated reductions presented in Table 26 and Table 27, respectively, show overtreatment of phosphorus due to the implementation required to meet sediment TMDL reduction requirements in the Catoctin Creek watershed.

Table 27: Reductions by Scenario for Catoctin Creek Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	13,886	0.0%
Complete	164	164	13,722	10.7%
Programmed	255	419	13,467	27.4%
Identified	351	770	13,116	50.4%
Potential	2,778	3,549	10,337	232.3%
Translated Reduction	1,528			

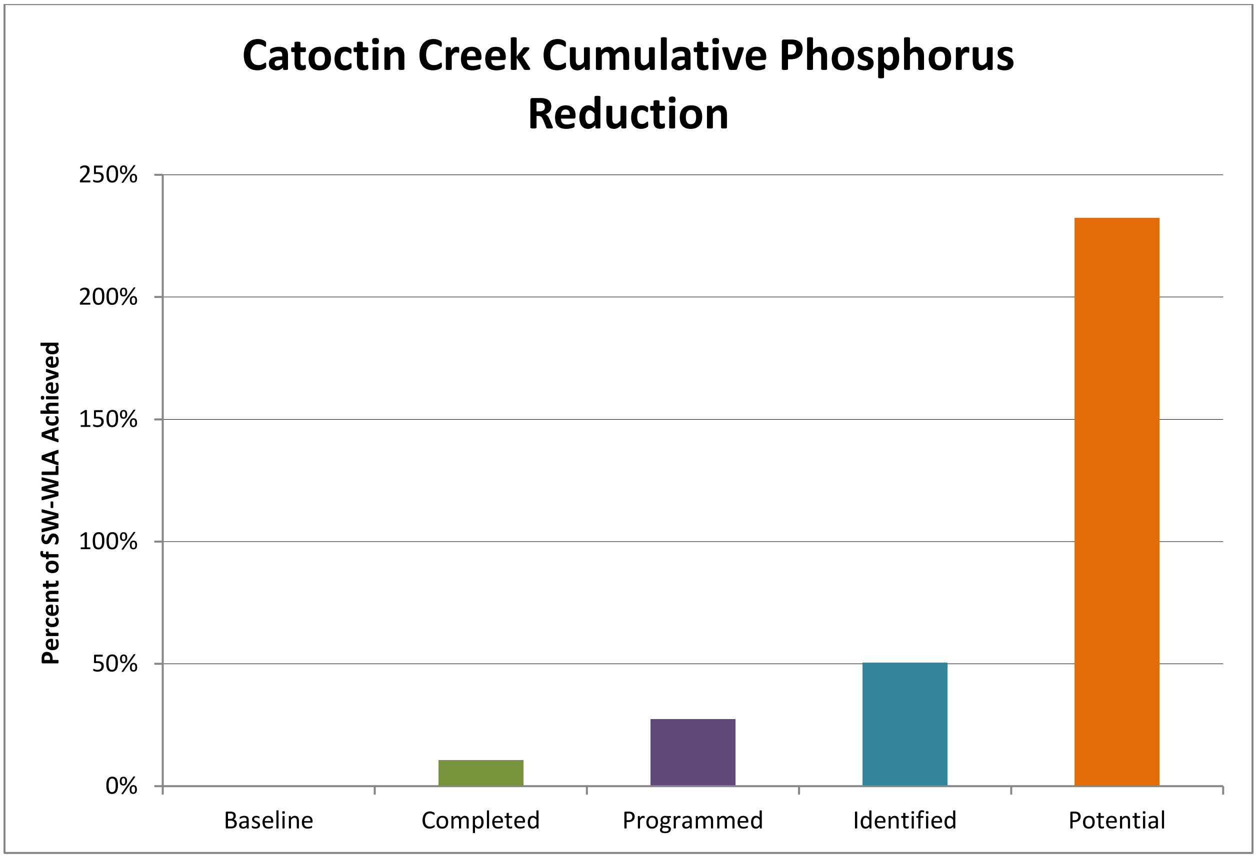


Figure 11: Catoctin Creek Cumulative Phosphorus Reductions (Percent)

SEDIMENT TMDL:

The Baseline year for the Double Pipe Creek Sediment TMDL was 2000. The TMDL requires a 46.8% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 28 below.

Table 28: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	**Impervious**	**Pervious**	**Total**
Streams (LF)	0.00	0.00	10,355
Tree Planting	0.00	25.33	25.33
Riparian Buffer	0.00	96.35	96.35

Detail on treatment for each restoration tier for Double Pipe Creek sediment are in Appendix 13. Table 29 shows the translated load reductions for each of the restoration tiers, also shown in Figure 12. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the sediment TMDL will be met in 2023. The BMPs and associated reductions presented in Table 28 and Table 29, respectively, show overtreatment of sediment due to the implementation required to meet phosphorus reduction requirements in the Double Pipe Creek watershed.

Table 29: Reductions by Scenario for Double Pipe Creek Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	1,171,514	0.0%
Complete	366,617	366,617	804,897	66.9%
Programmed	898,719	1,265,336	-93,822	230.8%
Identified	0	1,265,336	-93,822	230.8%
Potential	1,494,893	2,760,229	-1,588,715	503.4%
Translated Reduction	**548,269**			

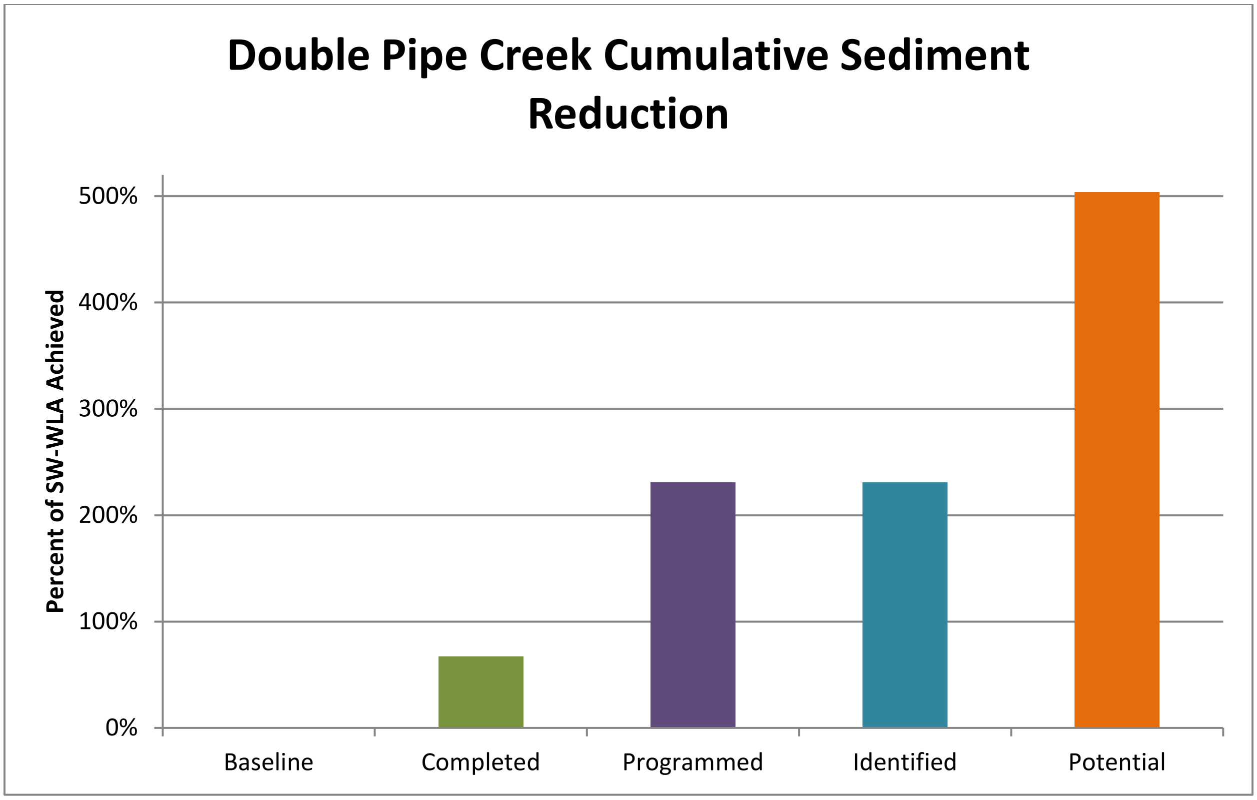


Figure 12: Double Pipe Creek Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL:

The Baseline year for the Double Pipe Creek phosphorus TMDL was 2009. The TMDL requires a 73.0% reduction from baseline. Based on the load reduction results of the TIPP model, it is estimated that the Double Pipe Creek watershed will need the following cumulative treatment through the Potential tier, as shown in Table 30 below, to meet the reduction target.

Table 30: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Streams (LF)	0.00	0.00	10,355
Tree Planting	0.00	25.33	25.33
Riparian Buffer	0.00	96.35	96.35

Detail on treatment for each restoration tier for Double Pipe Creek phosphorus are in Appendix 14. Table 31 shows the translated load reductions for each of the restoration tiers, also shown in Figure 13. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the phosphorus TMDL will be met in 2029.

Table 31: Reductions by Scenario for Double Pipe Creek Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Goal Achieved
Baseline	-	-	1,213	0.0%
Complete	105	105	1,108	11.9%
Programmed	266	371	842	41.9%
Identified	0	371	842	41.9%
Potential	517	889	324	100.3%
Translated Reduction	886			

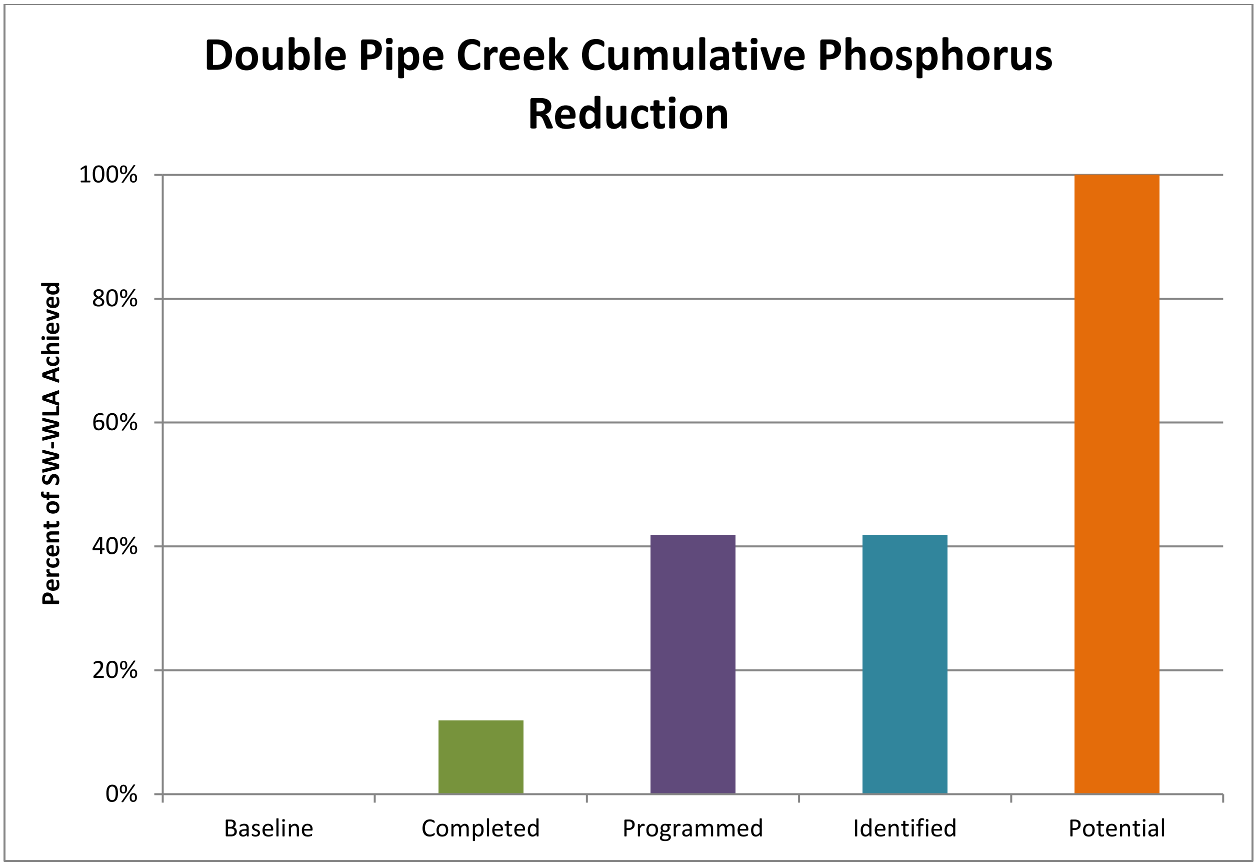


Figure 13: Double Pipe Creek Cumulative Phosphorus Reductions (Percent)

POTOMAC DIRECT (MONTGOMERY COUNTY) WATERSHED

SEDIMENT TMDL:

The Baseline year for the Potomac Direct Sediment TMDL was 2005. The TMDL requires a 36.2% reduction from baseline. However, the County is not proposing restoration measures at this time.

The Maryland Department of Planning (MDP) GIS land use layer from 2010 was used to delineate urban areas for baseline load calculations. The analysis showed no urban area in the County's portion of this small watershed, which was confirmed through review of digital aerial imagery. As a result, with the more detailed data and modeling available for this Plan, there are no calculated loads and no feasible sites for treatment.

LOCAL SEDIMENT AND PHOSPHORUS CONCLUSION

The nine local sediment and phosphorus TMDLs addressed in this document are shown in the table below. Each TMDL's SW-WLA for Frederick County Government's MS4 is met by this Plan. Figure 14 shows a comparison between the required and achieved reduction as modeled in the TIPP expressed as a percent.

Table 32: Local Phosphorus and Sediment TMDLs with Translated SW-WLAs and Reductions Achieved

Watershed Name	Pollutant	Translated Baseline Load EOS-lbs/yr	Translated WLA EOS-lbs/yr	Translated Reduction Required EOS-lbs/yr	Translated Reduction Achieved EOS-lbs/yr	% of Goal Achieved
Catoctin Creek	Phosphorus	13,886	12,359	1,528	3,549	232.3%
	Sediment	22,864,764	11,638,165	11,226,599	11,231,366	100.0%
Double Pipe Creek	Phosphorus	1,213	328	886	889	100.3%
	Sediment	1,171,514	623,246	548,269	2,760,299	503.4%
Lower Monocacy River	Phosphorus	43,746	31,497	12,249	18,102	147.8%
	Sediment	86,466,215	33,894,756	52,571,459	52,629,102	100.1%
Potomac River Montgomery County	Sediment	0	0	0	0	N/A
Upper Monocacy River	Phosphorus	14,741	14,151	590	3,476	589.6%
	Sediment	21,600,212	11,016,108	10,584,104	10,586,959	100.0%

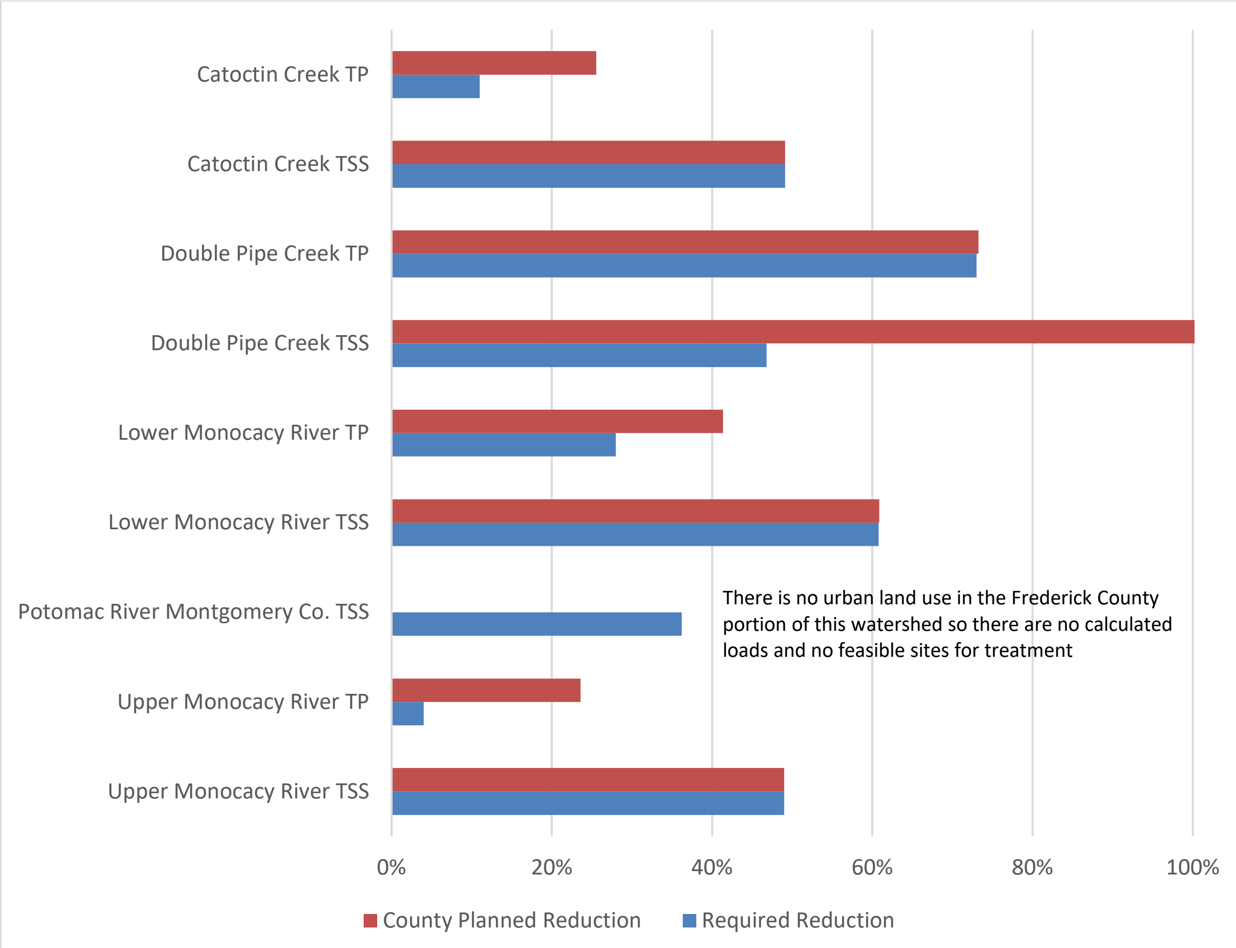


Figure 14: Phosphorus and Sediment Percent reduction required and planned per watershed

ESCHERICHIA COLI TMDL RESTORATION PLANS

Septic Tank Replacement with Denitrification

E. COLI AS A SOURCE OF IMPAIRMENT

E. coli is a single celled bacteria that falls into a class of fecal coliform bacteria, which is a subclass of total coliform bacteria. Originating in the excrement of warm-blooded animals, some strains of *E. coli* pose a risk for "body-contact recreation, for consumption of molluscan bivalves (shellfish), and for drinking water. Excessive amounts of fecal bacteria in surface water used for recreation are known to indicate an increased risk of pathogen-induced illness to humans. Infections due to pathogen-contaminated recreation waters include gastrointestinal respiratory, eye, ear, nose, throat, and skin diseases (MDE LM 2009)." Per MDE, the key priority for plans to reduce *E. coli* is to "address human sources due to the greater health risk". (MDE Bacteria 2014)

For the TMDL analysis, "Bacteria source tracking (BST) was used to identify the relative contributions from various sources of bacteria to in-stream water samples…Sources are defined as domestic (pets and human associated animals), human (human waste), livestock (agricultural animals), and wildlife (mammals and waterfowl). To identify sources, samples are collected within the watershed from known fecal sources, and the patterns of antibiotic resistance of these known sources are compared to isolates of unknown bacteria from ambient water samples." (MDE DP 2009)

SOURCES OF IMPAIRMENT AND CONTROL

The graphic below is from Byappanahalli (2012). According to the graphic, "sources of enterococci in water bodies (blue arrows) as well as sinks where enterococci are immobilized (yellow arrow) and areas of flux, in which enterococci can transition from a reservoir to the water column and vice versa (green arrows). Fluxes act as secondary sources or sinks depending upon the conditions."

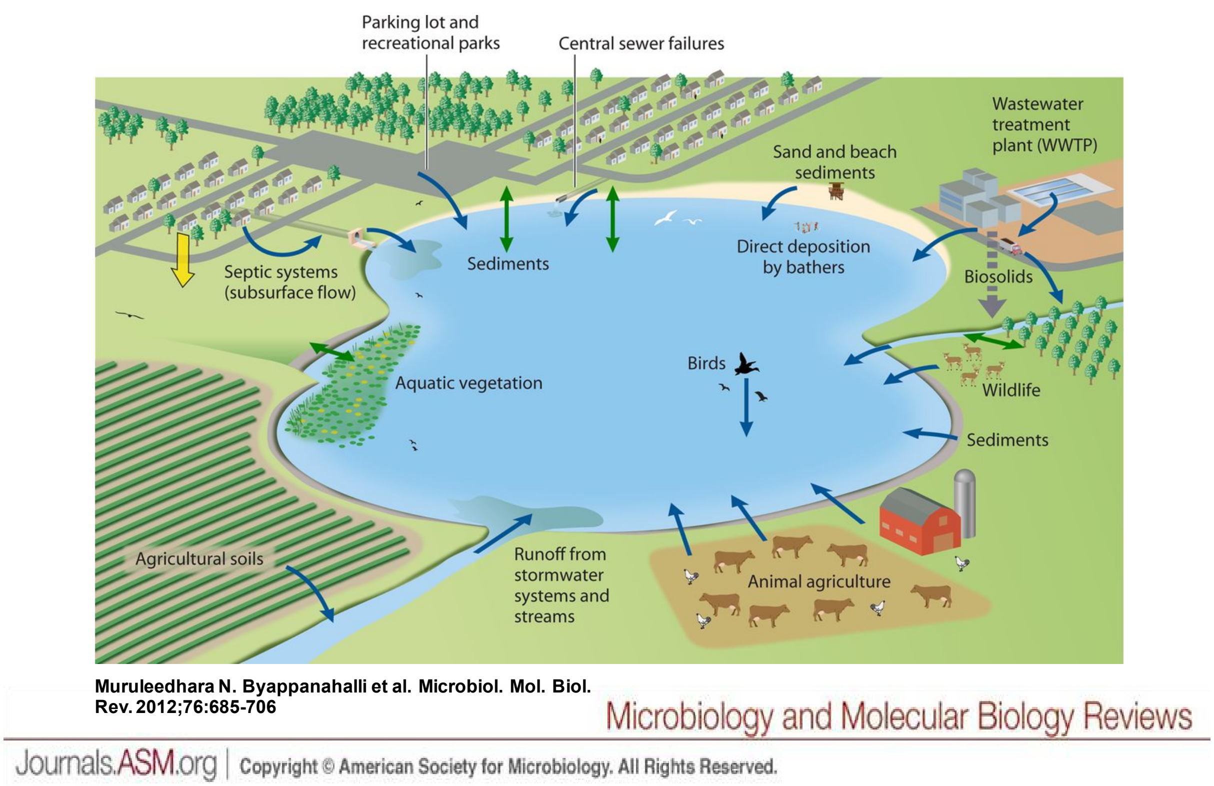


Figure 15: Sources and Sinks of *E. coli* from Byappanahalli 2012

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.

As can be seen in Figure 15: Sources and Sinks of *E. coli* from Byappanahalli 2012, stormwater runoff is a significant pathway, conveying bacteria from many of these sources to the waterbody, including pet waste, livestock manure, wildlife droppings and SSOs. Dry weather contamination comes from wastewater sources: septic systems and sewers and direct deposition. Livestock which are allowed access to water in streams can be a major source of direct manure deposits.

TMDL GOALS

Similar to nutrient and sediment TMDLs, the *E. coli* TMDLs assign a WLA which must be met for compliance. *E. coli* TMDLs have also been given a Maximum Practicable Reduction (MPR) which acknowledges the fact that it may not be possible to reduce some of the loads due to loading naturally occurring in the environment or high load reductions required to meet the WLA.

The MPR targets are established for each of the bacteria sources, as follows:

Table 33: MPR Targets by Bacteria Source

Max Practicable Reduction per Source	Human	Domestic	Livestock	Wildlife
	95%	75%	75%	0%
Rationale	(a) Direct source inputs. (b) Human pathogens more prevalent in humans than animals. (c) Enteric viral diseases spread from human to human	Target goal reflects uncertainty in effectiveness of urban BMPs and is also based on best professional judgment	Target goal based on sediment reductions from BMPs and best professional judgment	No programmatic approaches for wildlife reduction to meet water quality standards. Waters contaminated by wild animal wastes offer a public health risk that is orders of magnitude less than that associated with human waste.

The discussion of treatment and reductions achieved that follow will include both the WLA and MPR where appropriate.

TRANSLATION

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.

Implementation modeling and translation were performed using a revised version of the Watershed Treatment Model (Caraco, 2013) that allowed for modeling of all scenario tiers in one Excel workbook and only modeled bacteria. Inputs for loads were organized by Primary Sources, which are calculations of runoff loads by land use type and area within the watershed, and Secondary Sources, which calculated sewage-related loads.

PRIMARY SOURCES

The model uses a variation of the Simple Method (Schueler, 1987) to calculate loads from urban areas. The Simple Method requires area and percent impervious for each land use to calculate annual runoff, and an Event Mean Concentration (EMC) to calculate loads. Loads were calculated using EMCs reported in the National Stormwater Quality Database (NSQD) (Pitt et al., 2004). EMCs used in the model are shown in Table 34, which also cross-references land use categories from MDP and the NSQD.

Table 34: EMCs Used for Modeling

MDP Land Use	MDP LU Codes	NSQD Land Use	EMC (MPN/100 mL)
Residential	11,12,13,191,192	Residential	8,345
Open Urban	18	Open Space	7,200
Commercial / Institutional	14,16	Commercial (1)	4,300
Roadway	80	Freeways	1,700

SECONDARY SOURCES

Secondary sources are pollutant sources that cannot be calculated based on land use information alone. The sources used in the model included potential urban bacteria sources, such as septic systems, CSOs SSOs, and illicit discharges. County GIS data on miles of sanitary sewer, sewered and unsewered areas, and residential parcels were used to develop input data.

TRANSLATED SW-WLAS AND REDUCTION TARGETS

In order to help pinpoint sources, Bacteria Source Tracking (BST) was included in each of the TMDLs to identify relative contributions from various sources of bacteria to in-stream water samples. BST uses DNA, RNA, or patterns of antibiotic resistance to categorize the fraction of bacteria coming from the four general sources described above: humans, domestic pets, wildlife, or livestock for the watershed as a whole. Consistent with MDE guidance (MDE, 2014) the two sources which addressed in this plan are human and domestic. Livestock sources are treated by agricultural BMPs, which are not included in treatment for the MS4. Similarly, wildlife sources (other than urban wildlife) are not treated by BMPs or management measures associated with the MS4.

In all three of the bacteria TMDLs, two reduction percentages are shown: the Maximum Practicable Reduction (MPR) and the target reduction for the SW-WLA. 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%.

Translated load reductions calculated based on TMDL percent reductions and baseline loads modeled as described above will be the target reductions used for TMDL compliance local TMDLs. These values are presented in bold in the Translated Reduction column of Table 35, which provides a concise summary of Frederick County's portions of target loads and reductions for the three *E. coli* TMDLs.

- **MDE Published Reduction**: Percent reductions assigned to Frederick County Phase I MS4 stormwater sector from MDE Data Center (http://wlat.mde.state.md.us/ByMS4.aspx). Based on meeting Water Quality Standards (WQS).
- **MDE Published MPR:** Percent reduction based on MPR.
- **MDE Published Human and Domestic BST:** Percent of TMDL load which was determined to be from these sources based on BST analysis.
- **Target BST WLA Reduction:** Calculated from published reductions: Published Reduction x BST Human-Domestic).
- **Target BST WLA Reduction:** Calculated from published reductions: Published MPR Reduction x BST Human-Domestic).
- **Translated Baseline Load**: Baseline loads (i.e., loads with baseline BMPs) from land use runoff loads modeled in WTM, along with secondary loads from septic systems, SSOs, and illicit discharges. Loads from domestic pets and urban wildlife are included in runoff loads from urban land. Baseline loads were used to translate the target reductions for the SW-WLA and MPR.
- **Translated BST WLA Reduction:** Target reduction translated by multiplying the product of the published reduction percent and the BST percentage for human and domestic sources by the translated baseline load.
- **Translated MPR WLA Reduction**: Target reduction translated by multiplying the product of the MPR reduction percent and the BST percentage for human and domestic sources by the translated baseline load.

Table 35: Translated *E. coli* Local TMDL Target Load Reductions

Watershed Name	Baseline Year	MDE Published Reduction Percent[1]	MDE Published MPR Percent[2]	MDE Published Human and Domestic BST Percent[2]	Target BST WLA Reduction Percent[4]	Target BST MPR Reduction Percent[4]	Translated Baseline Load bn MPN/yr[3]	Translated BST WLA Reduction bn MPN/yr[4]	Translated BST MPR Reduction bn MPN/yr[4]
Double Pipe Creek	2004	98.80%	80.80%	57.00%	56.32%	**46.06%**	57,383	32,317	**26,429**
Lower Monocacy River	2004	92.50%	76.06%	49.00%	45.33%	**37.27%**	4,462,423	2,022,593	**1,663,118**
Upper Monocacy River	2004	97.00%	85.30%	50.00%	48.50%	**42.65%**	1,148,495	557,020	**489,833**

Target reduction loads used for TMDL compliance shown in bold text.

1) Published Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Frederick County
2) Published MPR % and BST% from TMDLs for each watershed.
3) Baseline loads modeled in WTM using County BMPs installed prior to the TMDL baseline year on top of baseline runoff loads from MDP urban land use and secondary sources.
4) Translated reductions calculated by applying the product of the BST Human/Domestic percent and the MDE published percent reduction to the WTM translated baseline loads.

DOUBLE PIPE CREEK WATERSHED

MDE completed monitoring of Double Pipe Creek in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the portion of the watershed in Frederick County, sections of Little Pipe Creek and Sam's Creek watersheds, has been designated as Use IV-P (Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply). MDE developed a TMDL for *E. coli* in Double Pipe Creek in 2009 (MDE DP 2009) which was approved by EPA in 2009. The portion of Double Pipe Creek that is in Frederick County is rural, with its main stormwater inputs from roads and rural residences. There are no sewer lines in this portion of the watershed. BST monitoring "was conducted at six stations throughout the Double Pipe Creek watershed, where 12 samples (one per month) were collected. To determine the MPR for the SW-WLA, a weighted calculation was performed. Bacteria sources by percent from the BST study included in the TMDL are shown in the graph below.

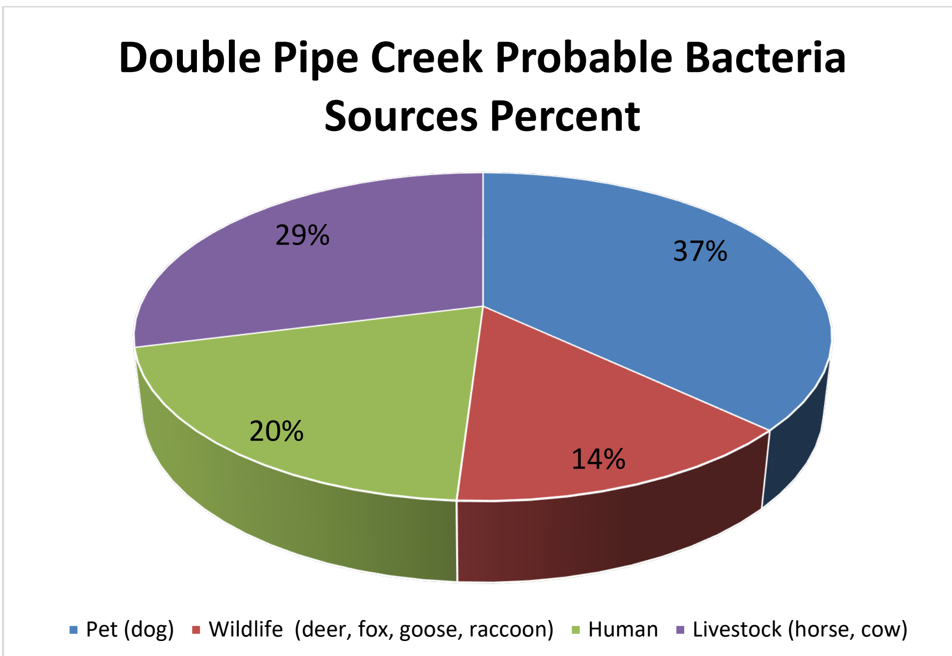


Figure 16: Double Pipe Probable Bacteria Sources Present

Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR, provided in MDE DP 2009.

Table 36: MPR Percent Derivation for Double Pipe Creek based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	6,568.6	80.8%
Domestic	75%	3,075.9	
Wildlife	0%	930.1	
Livestock	75%	0.0	

To work towards addressing the loads for the MPR and SW-WLA targets, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs per the restoration tiers described in the Introduction. The cumulative treatment from Completed to Potential is shown in Table 37 and Table 38. Detail on the amount of treatment modeled in each scenario is provided in Appendix 17.

Table 37: Cumulative restoration treatment in the Double Pipe Creek watershed

	Total Restoration (ac except as noted)		
BMP Type	IA	Pervious	DA
Bioretention	0.00	0.00	0.00
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	0.00	0.00	0.00
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	10,355.00
Tree Planting	0.00	39.68	39.68
Riparian Buffer	0.00	96.35	96.35

Table 38: Cumulative restoration treatment for alternative bacteria BMPs in the Double Pipe Creek watershed

Alternative BMPs	Total Restoration	
Pet Waste Education	32	households
Street Sweeping	0	
Impervious Disconnection	0	
Illicit Connection Removal	0%	remediated
SSO Repairs	0%	remediated
Septic System Pumping	115	systems
Septic System Repair	4	systems
Septic System Upgrade	6	systems
Septic System Retirement	0	systems

Table 39 shows the translated SW-SWA and MPR targets along with the reductions needed to meet them. The results of the improvement scenarios are also shown in Figure 17.

Table 39: Reductions by Scenario for Double Pipe Creek Bacteria TMDL (bn MPN/yr)

Scenario	Scenario Reduction	Cumulative Reduction	Load	% of Reqd Reduction	% of MPR Reduction
Baseline	0	0	57,385	0.0%	0.0%
Complete	2,054	2,054	55,330	6.4%	7.8%
Programmed	4,252	6,306	51,079	19.5%	23.9%
Identified	3,940	10,246	47,139	31.7%	38.8%
Potential	27,572	37,818	19,567	117.0%	143.1%
Translated Required BST WLA Reduction		32,317			
Translated Required BST MPR Reduction		26,429			

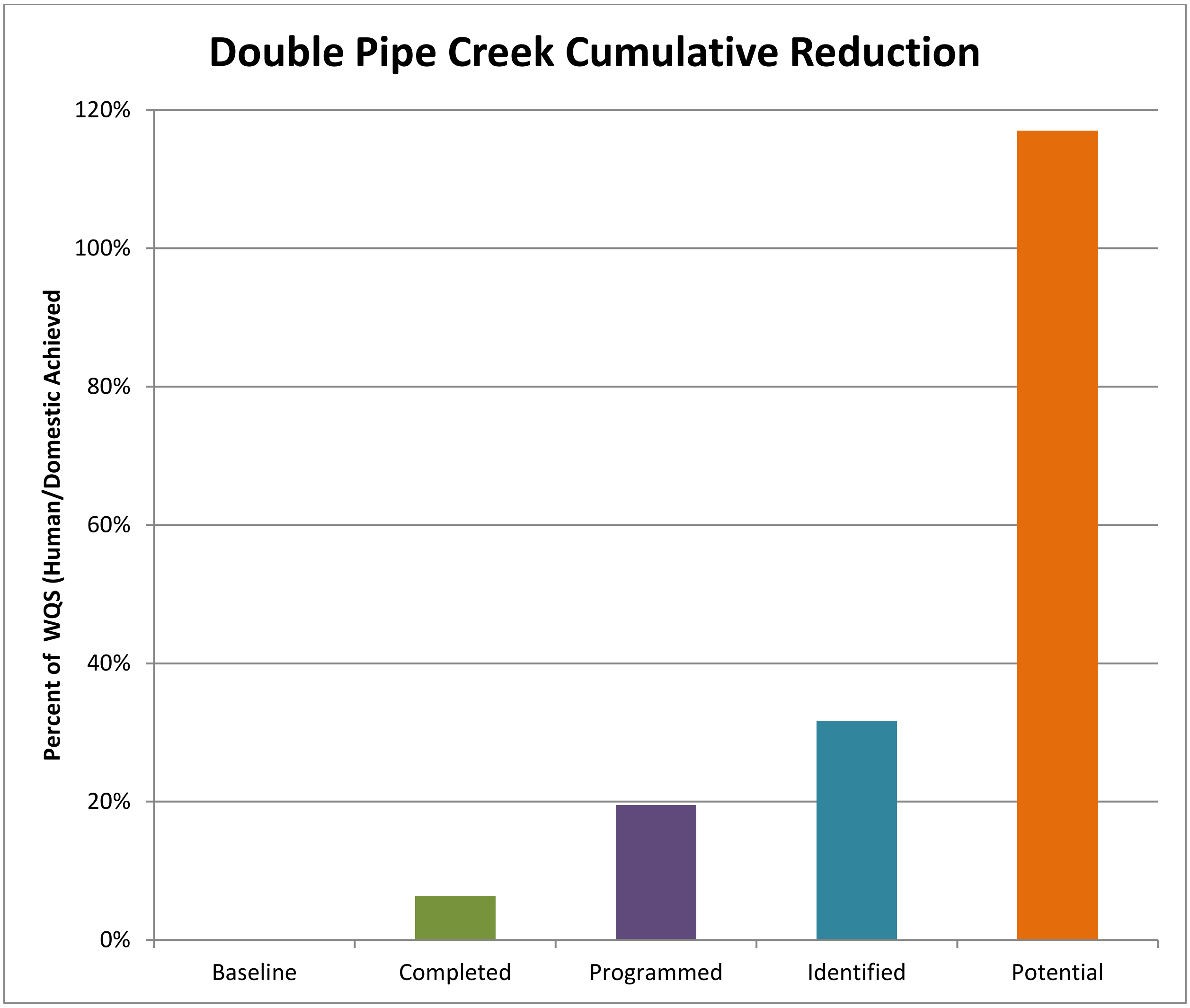


Figure 17: Double Pipe Creek Cumulative Reduction (Percent of SW-WLA)

Both the MPR and the WLA targets for human/domestic sources will be met with the Potential treatment tier. The County will take an Adaptive Management approach to this TMDL, focusing on remediating human sources of bacteria first, implementing structural BMPs according to the schedule, and monitoring the results to determine if additional treatment will be necessary.

LOWER MONOCACY WATERSHED

MDE completed monitoring of Lower Monocacy in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the Lower Monocacy River upstream of US Route 40 and the tributary Israel Creek are designated as Water Use IV-P (Recreational Trout Waters and Public Water Supply). Downstream of US Route 40, the Lower Monocacy River has a Use I-P designation (Water Contact Recreation, Protection of Aquatic Life and Public Water Supply). Other tributaries such as Carroll Creek, Rocky Fountain Run, Little Bennett Creek, Furnace Branch, Ballenger Creek and Bear Branch are designated as Use III-P water bodies (Non-tidal Cold Water and Public Water Supply).

MDE developed a TMDL for *E. coli* in the Lower Monocacy in 2009 (50D ELM 2009) which was approved by EPA in 2009. The portion of the Lower Monocacy watershed that is in Frederick County covers the city of Frederick and the towns of Walkersville, Woodsboro, and Mount Airy. The watershed's main stormwater inputs are from roads and residences. There are 311.1 miles of sanitary sewer in this portion of the watershed, and only 3% of the dwelling units are unsewered. During development of the TMDL, Bacterial Source Tracking monitoring was conducted at nine stations throughout the Lower Monocacy watershed, and 12 samples (one per month) were collected throughout the duration of one year. Two stations in the Upper Monocacy River basin were included in the TMDL analysis to determine the TMDL for the portion of land not accounted for in the Upper Monocacy TMDL.

To determine the MPR for the SW-WLA, a weighted calculation was performed. Bacteria sources by percent from the BST study included in the TMDL (50D ELM 2009) are shown in the graph below.

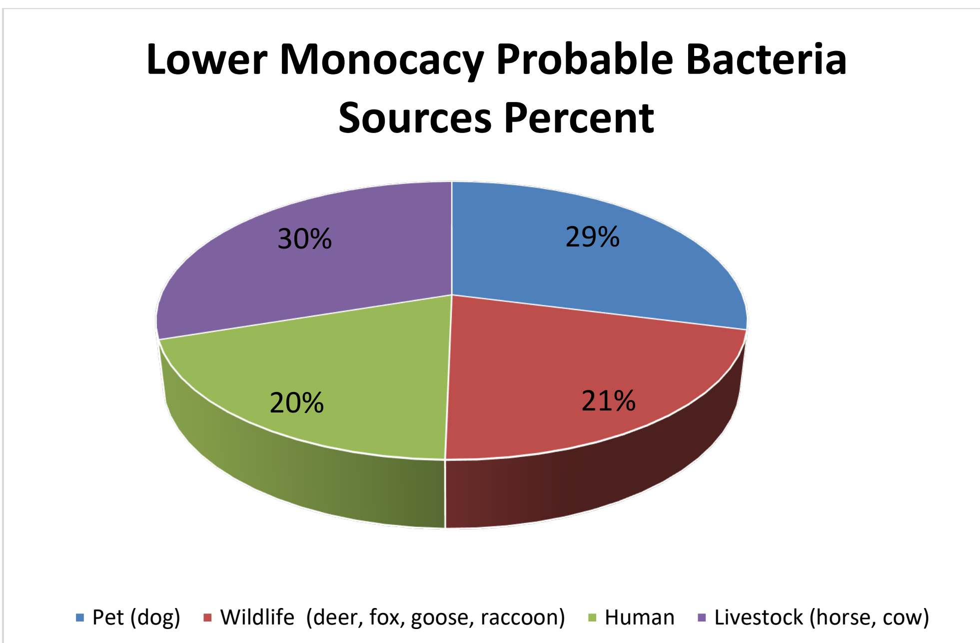


Figure 18: Lower Monocacy Probable Bacteria Sources Present

Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR.

Table 40: MPR Percent Derivation for Lower Monocacy based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted MPR	SW-WLA
Human	95%	2,652.4	76.06%	
Domestic	75%	3,900.4		
Wildlife	0%	606.4		
Livestock	75%	0		

To work towards addressing the loads for the MPR and SW-WLA targets, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs of the revised Watershed Treatment Model per the restoration tiers described in the Introduction. The cumulative treatment from Completed to Potential is shown in Table 41 and Table 42. Detail on the amount of treatment modeled in each scenario is provided in Appendix 18.

Table 41: Cumulative restoration treatment in the Lower Monocacy watershed

	Total Restoration (ac except as noted)		
BMP Type	**IA**	**Pervious**	**DA**
Bioretention	70.97	129.25	200.22
Dry Swale	0.00	0.00	0.00
Filters	498.72	914.52	1,413.24
Grass Channel	0.30	0.97	1.27
Infiltration	0.00	0.00	0.00
Wet Pond	1,038.83	2,231.27	3,270.10
Wetland	0.00	0.00	0.00
Submerged Gravel Wetland	550.65	1,081.04	1,631.69
Rainwater Harvesting	0.05	0.00	0.05
Streams (LF)	0.00	0.00	155,882.00
Tree Planting	0.00	797.34	797.34
Riparian Buffer	0.00	1,147.64	1,147.64

Table 42: Cumulative restoration treatment for alternative bacteria BMPs in the Lower Monocacy watershed

Alternative BMPs	Total Restoration	
Pet Waste Education	2,648	households
Street Sweeping	0	
Impervious Disconnection	0	
Illicit Connection Removal	0%	remediated
SSO Repairs	0%	remediated
Septic System Pumping	5,207	systems
Septic System Repair	7,648	systems
Septic System Upgrade	98	systems
Septic System Retirement	12	systems

Table 43 shows the translated SW-SWA and MPR targets along with the reductions needed to meet them. The results of the improvement scenarios are also shown in Figure 19.

Table 43: Reductions by Scenario for Lower Monocacy Bacteria TMDL (bn MPN/yr)

Scenario	Scenario Reduction	Cumulative Reduction	Load	% of Reqd Reduction	% of MPR Reduction
Baseline	249,862	249,862	4,462,423	12.4%	15.0%
Complete	280,188	280,188	4,182,235	13.9%	16.8%
Programmed	91,379	371,567	4,090,856	18.4%	22.3%
Identified	789,167	1,160,734	3,301,689	57.4%	69.8%
Potential	1,120,504	2,281,238	2,181,184	112.8%	137.2%
Translated Required BST WLA Reduction		2,022,593			
Translated Required BST MPR Reduction		1,663,118			

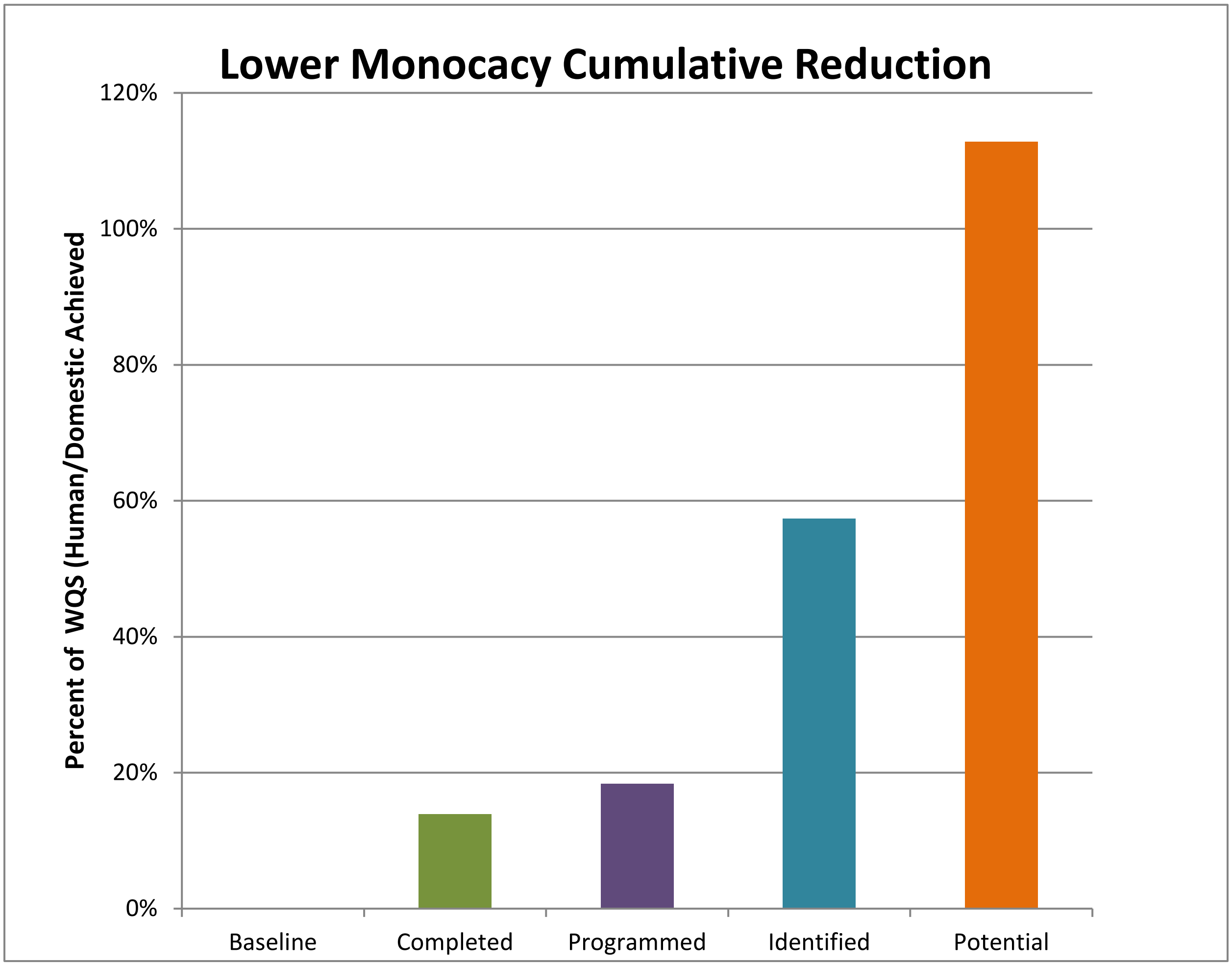


Figure 19: Lower Monocacy Cumulative Reduction (Percent of SW-WLA)

Both the MPR and the SW-WLA are met with the potential tier of treatment. The approach for this TMDL will be to work towards Adaptive Management. The initial focus will be on the most effective measures which remediate human sources of bacteria first, implementing structural BMPs which will treat phosphorus and sediment along with bacteria, and monitoring the results to determine if additional treatment will be necessary.

UPPER MONOCACY WATERSHED

MDE completed monitoring of the Upper Monocacy in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the mainstream Upper Monocacy River, portions of tributaries Toms Creek and Piney Creek, and the tributary Double Pipe Creek are designated Use IV-P water bodies (Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply). Use III-P (Water Contact Recreation, Protection of Aquatic Life, Non-tidal Cold Water and Public Water Supply) is designated to the remaining tributaries in MD, which are Tuscarora Creek, Fishing Creek, Hunting Creek, and Owens Creek.

MDE developed a TMDL for *E. coli* in the Upper Monocacy in 2009 (MDE UM 2009) which was approved by EPA in 2009. The portion of the Upper Monocacy watershed that is in Frederick County is mostly rural, with its main stormwater inputs from roads and rural residences. There are 101.3 miles of sanitary sewer lines in this portion of the watershed, and 33% of dwelling units are unsewered. Bacterial Source Tracking monitoring was conducted once a month for a year (total of 12 times) at nine MDE monitoring stations in the Upper Monocacy watershed. Two additional stations were used to determine the loadings coming from Double Pipe Creek.

To determine the MPR for the SW-WLA, a weighted calculation was performed. Bacteria sources by percent from the BST study included in the TMDL (MDE UM 2009) are shown in the graph below.

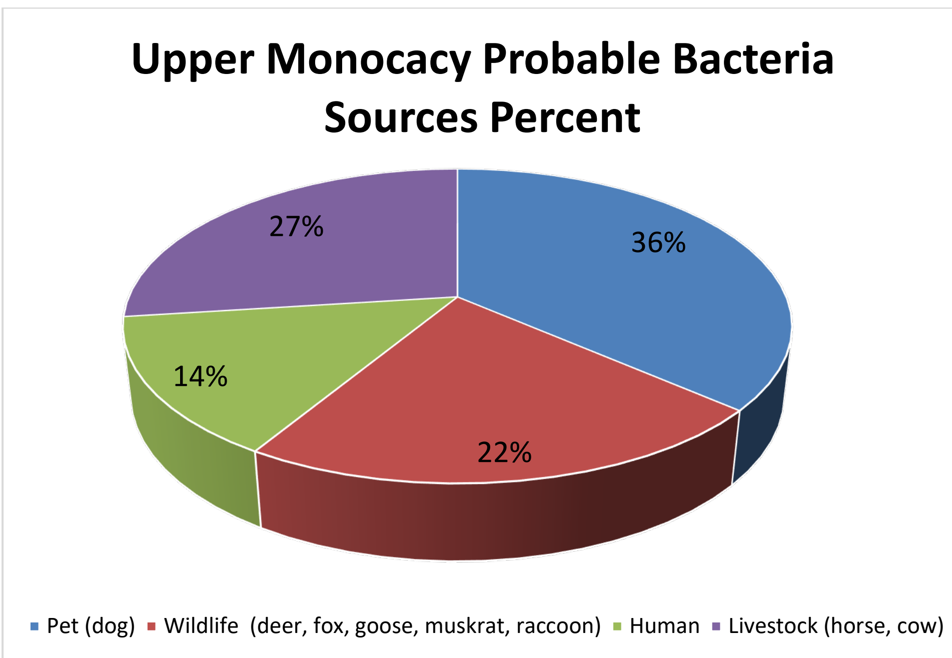


Figure 20: Upper Monocacy Probable Bacteria Sources Present

Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR.

Table 44: MPR Percent Derivation for Upper Monocacy based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	3,368.2	85.3%
Domestic	75%	943.5	
Wildlife	0%	267.6	
Livestock	75%	0	

To work towards addressing the loads for the MPR and SW-WLA targets, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs of the WTM per the restoration tiers described in the Introduction. Detail on the amount of treatment modeled in each scenario is provided in Appendix 19.

Table 45: Cumulative restoration treatment in the Upper Monocacy watershed

	Total Restoration (ac except as noted)		
BMP Type	**IA**	**Pervious**	**DA**
Bioretention	27.75	27.75	55.50
Dry Swale	0.00	0.00	0.00
Filters	110.10	204.40	314.50
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	182.61	353.48	536.09
Wetland	0.00	0.00	0.00
Submerged Gravel Wetland	73.40	136.20	209.60
Streams (LF)	0.00	0.00	31,450.50
Tree Planting	0.00	91.61	91.61
Riparian Buffer	0.00	153.34	153.34

Table 46: Cumulative restoration treatment for alternative bacteria BMPs in the Upper Monocacy watershed

Alternative BMPs	Total Restoration	
Pet Waste Education	600	households
Street Sweeping	0	
Impervious Disconnection	0	
Illicit Connection Removal	0%	remediated
SSO Repairs	100%	remediated
Septic System Pumping	1,721	systems
Septic System Repair	1,956	systems
Septic System Upgrade	97	systems
Septic System Retirement	1	systems

Table 47 shows the translated SW-SWA and MPR targets along with the reductions needed to meet them. The results of the improvement scenarios are also shown in Figure 21.

Table 47: Reductions by Scenario for Upper Monocacy Bacteria TMDL (bn MPN/yr)

Scenario	Scenario Reduction	Cumulative Reduction	Load	% of Reqd Reduction	% of MPR Reduction
Baseline	65,414	65,414	1,148,495	11.7%	13.4%
Complete	32,186	32,186	1,116,309	5.8%	6.6%
Programmed	26,170	58,356	1,090,139	10.5%	11.9%
Identified	243,287	301,643	846,852	54.2%	61.6%
Potential	322,743	624,386	524,109	112.1%	127.4%
Translated Required BST WLA Reduction		557,020			
Translated Required BST MPR Reduction		489,993			

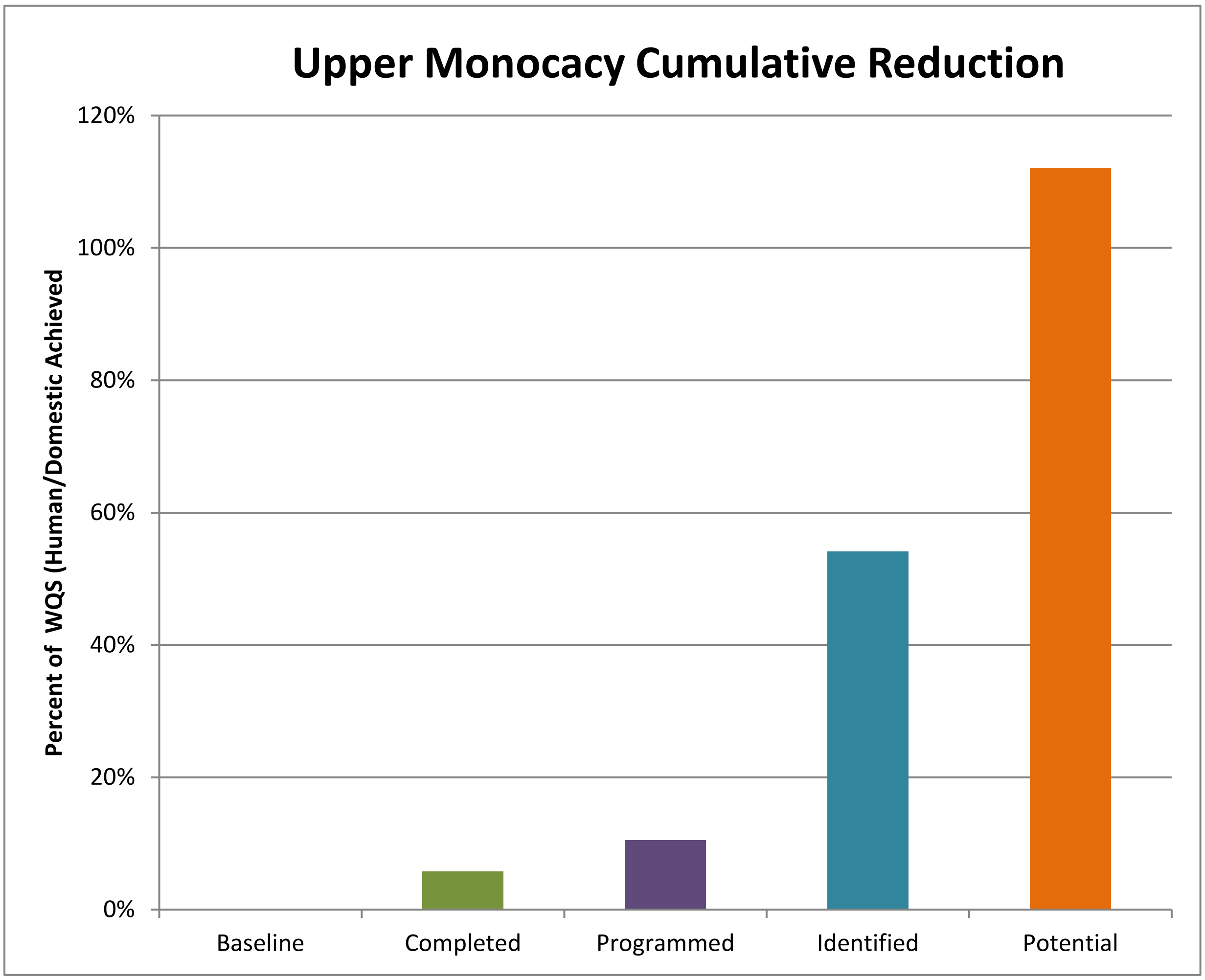


Figure 21: Upper Monocacy Cumulative Reduction in Percent of SW-WLA

Both the MPR and the SW-WLA are met with the proposed treatment. The County's approach for this TMDL will be to work towards Adaptive Management. The initial focus will be on the most effective measures which remediate human sources of bacteria first, implementing structural BMPs which will treat phosphorus and sediment along with bacteria, and monitoring the results to determine if additional treatment will be necessary.

MONITORING AND EVALUATION

With direction from Hood College and the Chesapeake Bay Foundation, the County selected sites for *E. coli* testing in Summer 2016. The chosen sites were based on areas with suspect septic tank locations as determined by the Health Department and other areas of potential and confirmed high counts of bacteria. CBF published the Frederick County data at http://www.cbf.org/issues/polluted-runoff/rainfall-revelations/2016-bacteria-testing-maryland-data.html. A map of sampling sites and 2016 data are shown below:

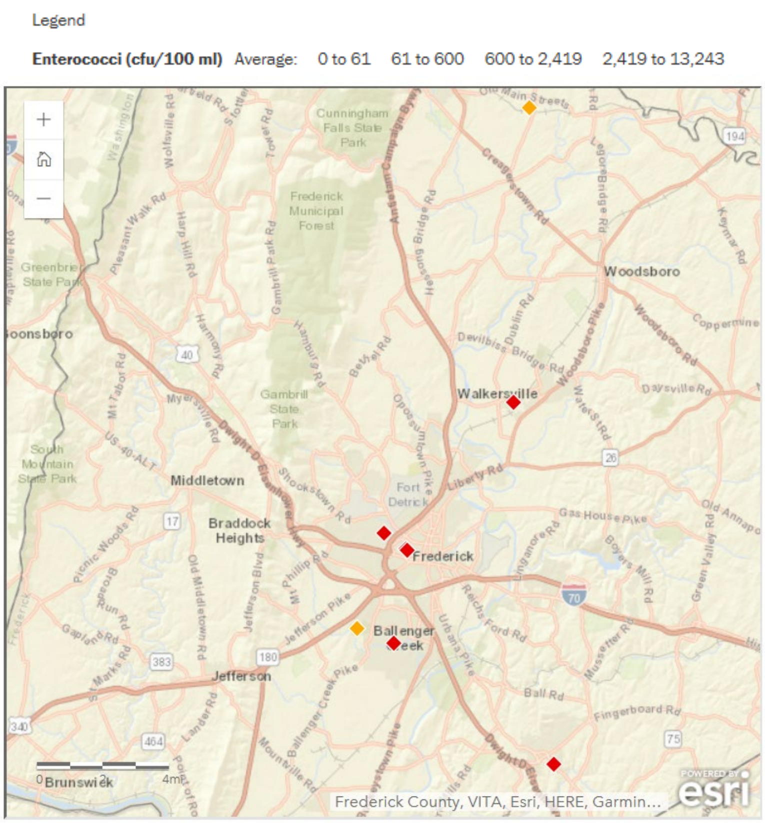


Figure 22: *E. Coli* Sampling Sites

Table 48: 2016 *E. coli* Sampling Results

2016 Water Sampling Data - MD (enterococci bacteria)

	14-Jun	16-Jun	23-Jun	27-Jun	5-Jul	11-Jul	8-Aug	16-Aug
Ballenger Creek - Ballenger Creek Park	308	8,100	2,000	280	1,100	230	324	394
Ballenger Creek - BC Elementary School	400	16,400	2,300	515	3,600	663	1,840	2,000
Carroll Creek - Frederick City	620	14,680	8,000	340	2,200	460	930	161
Glade Run - Walkersville	3,200	19,800	3,900	2,500	2,325	920	650	
Merryvale Creek - Frederick City	2,120	4,800	4,700	4,800	4,800	1,640	1,720	5,050
Owens Creek - Loys Station Park	840	6,400	3,200	560	2,050	1,005	1,070	
Peter Pan Run - Urbana	240	3,680	2,400	260	13,300	450	1,762	372
Rock Creek - Frederick City	1,120	16,300	8,350	630	2,500	1,040	1,482	400

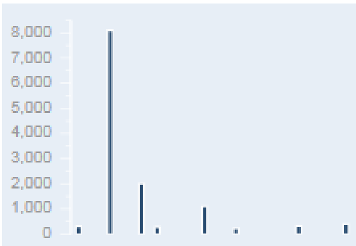
Key

Red values	= Enterococci bacteria counts greater than 61 cfu/100 ml in fresh water. At the time of sampling the site was not healthy for "moderate" bathing use, according to EPA standards. Readings above 151 cfu are not suitable for any bathing or "full body contact." More on the EPA standards.
Red values	(underlined and italicized) = Enterococci bacteria counts greater than the 2,419 maximum detection limit for analysis performed that day.
Light blue background	= .5 inches or more of rainfall at least 24 hours before collecting water samples

In 2018, Frederick County received a draft publication from MDE that contained proposed monitoring requirements for the next NPDES MS4 permit. Staff circulated this for review by KCI and compiled comments, which were submitted back to MDE.

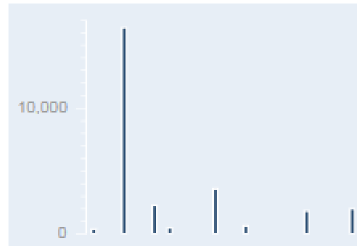
Ballenger Creek - Ballenger Creek Park

Average Enterococci Levels
All Samples: 1,592.00 cfu/100ml
Wet Weather: 2,899.00 cfu/100ml
Dry Weather: 286.00 cfu/100ml



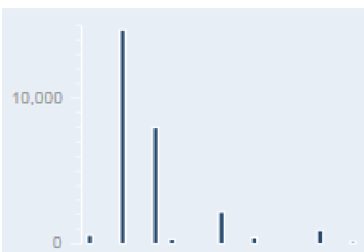
Ballenger Creek - BC Elementary School

Average Enterococci Levels
All Samples: 3,465.00 cfu/100ml
Wet Weather: 6,075.00 cfu/100ml
Dry Weather: 855.00 cfu/100ml



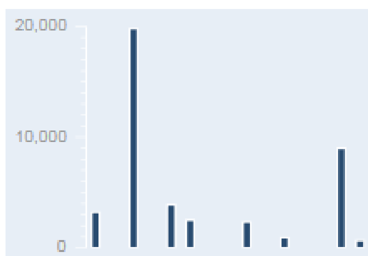
Carroll Creek - Frederick City

Average Enterococci Levels
All Samples: 3,424.00 cfu/100ml
Wet Weather: 6,260.00 cfu/100ml
Dry Weather: 588.00 cfu/100ml



Glade Run - Walkersville

Average Enterococci Levels
All Samples: 4,756.00 cfu/100ml
Wet Weather: 8,675.00 cfu/100ml
Dry Weather: 1,818.00 cfu/100ml

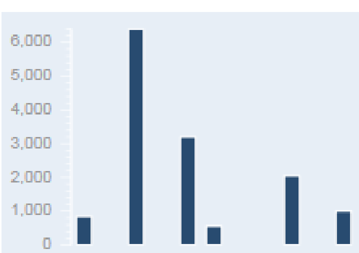


Merryvale Creek - Frederick City

Average Enterococci Levels
All Samples: 3,704.00 cfu/100ml
Wet Weather: 4,838.00 cfu/100ml
Dry Weather: 2,570.00 cfu/100ml

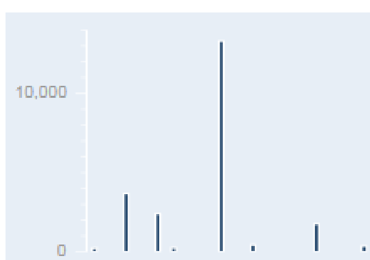
Owens Creek - Loys Station Park

Average Enterococci Levels
All Samples: 2,161.00 cfu/100ml
Wet Weather: 3,883.00 cfu/100ml
Dry Weather: 869.00 cfu/100ml



Peter Pan Run - Urbana

Average Enterococci Levels
All Samples: 2,808.00 cfu/100ml
Wet Weather: 4,938.00 cfu/100ml
Dry Weather: 678.00 cfu/100ml



Rock Creek - Frederick City

Average Enterococci Levels
All Samples: 3,970.00 cfu/100ml
Wet Weather: 6,888.00 cfu/100ml
Dry Weather: 1,053.00 cfu/100ml

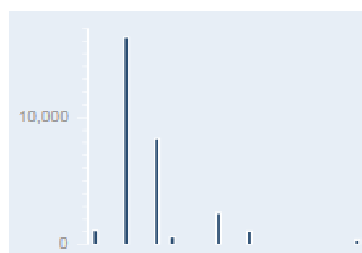


Figure 23: 2016 *E. Coli* Sampling Results

BACTERIA CONCLUSION

For all three *E. Coli* TMDLs, the SW-WLAs and MPRs could be met at the completion of the Potential Tier projects. All three restoration plans relied on remediating human sources of bacteria by 100% through elimination of SSOs, repair of all failing septic systems, identification of leaking sewers, and/or cross-connections through the IDDE program.

All watersheds used a multi-pronged approach that included volumetric practices for stormwater such as bioswales and pond retrofits, as well as alternative BMP practices including riparian buffer expansion and tree planting that also contribute to reductions in nutrient and sediment TMDLs. Outreach programs for pet waste management and septic system maintenance were also proposed.

SUMMARY PROJECTS, COSTS AND TIMEFRAMES FOR ALL PLANS

Point of Rocks Stream Restoration Project

METHODS

This section provides an estimate of the cost of implementing both the Impervious Cover Restoration Plan and TMDL Restoration Plans to meet the stated goals. 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.

PROJECTS BY RESTORATION TIER

Figure 24: Restoration Tiers

As stated earlier in this document, Restoration Tiers include **Baseline**, **Completed**, **Programmed**, **Identified**, and **Potential** scenarios. **Baseline** for impervious surfaces and TMDLs are restoration projects implemented prior to the baseline year. **Completed** projects, in terms of impervious restoration were finished after March 11, 2007, the expiration date of the previous permit and were considered complete for the current permit by December 29, 2019, and for this reporting year up to June 30, 2021. For TMDLs, the Completed projects are those completed after the baseline year and up to June 30, 2021. **Programmed** projects are programmed into the County's Capital Improvement Program and other programs and have funding and schedules. The rest will be complete by 6/30/2027. **Identified** projects can be found in Watershed Management Plans, Restoration and Retrofit Assessments, Stormwater Master Plans, and other documents completed by Frederick County Government and its partners and consultants to identify watershed restoration opportunities. They are not yet funded or scheduled as individual projects, though they may have proposed CIP funds in aggregate. They will be completed by 6/30/2028. **Potential** Projects are hypothetical projects based on the most cost-effective BMP types and acres of available land and will finish after June 30, 2025.

SOURCES FOR COST ESTIMATES

Cost estimates for structural BMPs come from the following sources:

- **Completed** CIP project costs are used where available. When completed costs are not available, Brown and Caldwell's 2014 *Technical Memo 1* (B&C 2014) is used. This study was prepared under contract to AquaLaw, Frederick County's outside legal counsel on stormwater matters, as part of a review of the County's MEP Analysis. (B&C 2014). Brown and Caldwell made recommendations on costs based on The King and Hagan study (2011) and adjusted dollars of some practices based on their experience with contracting projects in Maryland. They also adjusted cost estimates to FY2017 as the midpoint of the permit.
- **Programmed** and **Identified** estimates come from the proposed CIP budget. These represent engineering cost estimates at a 10-30% design phase. Tree planting and easement acquisition program costs come from information on County reforestation projects.
- **Potential** scenarios use costs derived as described below.

Cost estimates for operational BMPs have been derived from these sources described below.

- Management program costs for *E. coli* are absorbed by the operating budget for the NPDES MS4 permit.
- Costs for denitrification systems are taken from the Bay Restoration Fund and are estimated at $13,800 per system (personal communication by email with Kristin Mielcarek on 1/13/2015).
- Costs for septic upgrades to sewer are estimated from Anne Arundel County (URS ESA 2016) at $50,000.

Costs not included are pre- and post-construction monitoring and operational costs such as additional County staff to manage the work, conduct inspections, enforcement, or maintenance, and similar activities. These costs will be developed in future planning stages and factored into the County's budgeting.

COST ESTIMATING PROCEDURE FOR POTENTIAL PROJECTS

The County's recent history with restoration projects and preparation of their Capital Improvement Plan (CIP) were used as the basis for project costs for potential projects where siting and concept design have not yet been undertaken.

The County previously gathered typical size and cost for each project using B&C (2014). However, as the County's BMP database becomes more robust it is best to use information from projects that are more recently built and planned within the County. Therefore, for each project type, a typical size and project cost (i.e. average by BMP type) was used from the County's completed and planned (programmed/identified) project information stored in their geodatabase, see Table 49. The number of projects proposed in the Potential tier, multiplied by the project cost, gave the estimated cost for these projects, also shown in Table 49.

Table 49: Potential Tier Project Costs

BMP Type	Average Project Size[1]	Unit	Total Cost per Project
Stormwater Pond Retrofit	52.4	DA	$709,086
Bioretention	9.5	DA	$192,785
Submerged Gravel Wetlands	60.4	DA	$1,256,584
Surface Sand Filter	4.4	DA	$244,005
Stream Restoration	1,078.2	LF	$882,496
Riparian Forest Planting	7.4	acre planted	$76,498
Forest Planting	3.2	acre planted	$59,322

[1]Applied a 35/65 impervious/turf assumption for all stormwater BMPs. The TIPP also assumes a PE = 1"

Potential projects have been identified by determining the level of treatment required to meet the pollutant load reduction for each of the local TMDLs.

TIMEFRAME ESTIMATES

Timeframes for the plan are based on the following by Restoration Tier:

- **Baseline:** reflects the pollutant loading, impervious surface, and projects in the ground at the time the TMDL or impervious surface goal was established (2000/2005 for sediment TMDLs; 2009 for phosphorus TMDLs; 2010 for nitrogen and phosphorus in the Bay; and 2004 for *E. coli* TMDLs). In the case of the Impervious Cover Restoration Plan, the baseline is the end date of the previous MS4 permit, March 11, 2007.
- **Completed:** Completed between the baseline date and June 30, 2021, the end of the reporting period for this Restoration Plan.
- **Programmed:** Funded and scheduled projects that are funded and scheduled to be completed after July 1, 2021 until June 30, 2027.
- The **Identified** timeframe for completion begins July 1, 2021, and ends when the currently identified projects are completed, on or before June 30, 2028.
- The **Potential** timeframe begins when the last **Identified** project is completed on June 30, 2025 and goes on until all projects required to meet all TMDLs have been implemented on June 30, 2089.

As part of its *Technical Memorandum No. 1: Report on Frederick County Data Review Findings* (2014), Brown and Caldwell provided timeframe estimates per project type per phase based on its experience managing public procurement contracts in the state of Maryland. When County-specific project type timeframes are not available, these project phases are used to determine the length of project phases in the **Identified** and **Potential** Restoration Tiers.

This generic schedule translates to the following project start dates beginning Fiscal Year 2021 after the end of the current permit cycle. All **Identified** and **Potential** projects were projected into this schedule as a starting point. Schedules for these tiers are governed by projected capital budgets.

COMPLETED, PROGRAMMED, AND IDENTIFIED PROJECTS, BUDGETS AND TIMEFRAMES

378 **Completed** projects are included in Appendix 1. Estimated costs for the 378 completed projects and budgets through FY21 are $32,132,613. Based on the County's latest Financial Assurance Plan for FY20, funding is $8,413,244 for FY21 as reflected in Table 50. These BMPs were completed between March 11, 2007 and June 30, 2021.

Programmed projects are budgeted into the programmed five-year Capital Improvement Program based on engineering cost estimates. Table 50 includes a $31,584,756 budget for the Programmed Scenario. These projects are to be completed by June 30, 2027. There are also **Identified** projects in this budget estimate where the projects are coming from a pooled fund to be completed by FY2028 but have not yet been disaggregated as separate projects.

Municipal and Financial Services Group (MFSG) was hired by the County's legal counsel, AquaLaw, PLC to "review cost data and timeframes used by the County to estimate and project the financial impact on customers to implement 20% impervious surface restoration requirements anticipated in the upcoming permit reissuance." (MFSG 2014). From an analysis of stormwater remediation fees across the country, MFSG determined that the County should escalate its total Fiscal Year 2015 budget 15% to include Operating and Capital per year for each year of the permit. The MS4's Programmed CIP costs in the previous permit follow this guidance. Future years are based on a Maximum Extent Practicable Analysis completed in 2021 at the request of MDE.

As seen in Appendix 2, costs in FY2021 dollars for the 89 projects in the five year permit Capital Improvement Project Budget and other projects are $30,387,518. Table 50 shows operating and capital expenditures by funding source. The table was prepared for the County's Financial Assurance Plan.

Table 50: Projected annual and 5-year costs to meet the impervious surface restoration plan requirements

DESCRIPTION	CURRENT YEAR FY 2020	PROJECTED YEAR 1 FY 2021	PROJECTED YEAR 2 FY 2022	PROJECTED YEAR 3 FY 2023	PROJECTED YEAR 4 FY 2024	PROJECTED YEAR 5 FY 2025	TOTAL COSTS
Operating Expenditures (costs)							
Street Sweeping Program	$9,450	$31,946	$32,905	$33,892	$34,909	$35,956	$179,058
Inlet Cleaning	$0	$0	$0	$0	$0	$0	$0
Support of Capital Projects	$577,028	$456,781	$686,003	$706,583	$727,781	$749,614	$3,903,790
Debt Service Payment	$322,367	$569,973	$637,808	$638,034	$1,984,393	$1,984,372	$6,136,948
Other (please stipulate program expenditure)*	-	-	-	-	-	-	$0
Capital Expenditures (costs)							
General Fund (Paygo)	$3,181,950	$1,415,000	$180,000	$180,000	$1,919,544	$2,359,570	$9,236,064
WPR Fund (Paygo)	$0	$0	$0	$0	$0	$0	$0
Debt Service	$3,863,449	$4,915,543	$6,087,401	$5,379,702	$5,104,779	$4,005,830	$29,356,704
Grants & Partnerships	$400,000	$530,000	$130,000	$130,000	$130,000	$130,000	$1,450,000
Other (Partnership Funds Non-County)*	-	$494,000	$173,926	-	-	-	$667,926
Subtotal Operation and Paygo:	$4,090,795	$2,967,701	$1,710,642	$1,558,510	$4,666,626	$5,129,512	$20,123,786
Total Expenditures:	**$8,354,244**	**$8,413,244**	**$7,928,043**	**$7,068,212**	**$9,901,405**	**$9,265,342**	**$50,930,490**
						Total ISRP costs except debt service:	**$44,793,542**
						Compare ISRP costs (except debt service) / total ISRP proposed actions:	**98%**

1 Table data from revised 12/29/2020 FAP.
2 Support of Capital Project equals Assessments + CIP operating budget impacts
3 General Fund Paygo –estimates are from approved FY2021 CIP. Future years after FY2021 subject to approvals.
4 Estimates provided by Finance Division
5 Other Septic Denitrification from Chesapeake Bay Restoration Fund (BRF) Grant goes to Canaan Valley Institute.

IDENTIFIED PROJECTS, COSTS AND TIMEFRAMES

Identified projects were compiled from existing planning documents. These projects have engineering estimates of treated drainage areas including pervious and impervious acres. They will be completed by June 30, 2028. Some are included in the proposed CIP in Table 50 as funds for projects to be awarded by FY2023. The studies used to develop the Identified scenario tier are listed below. Full bibliographies are in the References section.

- Upper Monocacy River WRAS, (Schultz et al. 2008)
- Lower Monocacy River WRAS, (Schultz and Moore, 2004)
- An Assessment of Stream Restoration and Stormwater Management Retrofit Opportunities in Lower Bush Creek Watershed, completed in August 2003 (Perot, Morris et al., 2003)
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Ballenger Creek Watershed, completed August 2005 (Perot, Morris et al., 2005)
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Linganore Creek Watershed, completed June 2006 (Perot, Morris et al., 2006)
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed, completed April 2009 (Stribling et al., 2009).
- Final Report Watershed Assessment of Ballenger Creek, completed January 2001 (Roth et al., 2001a)
- Watershed Assessment of Lower Bush Creek, completed March 2001 (Roth et al., 2001b)
- Watershed Assessment of Lower Linganore Creek, completed in June 2002 (Perot, Morris et al., 2002)
- Bennett Creek Watershed Assessment, completed March 2008 (Stribling et al., 2008)
- Upper Monocacy Watershed Assessment
- Lower Monocacy Watershed Assessment
- Ballenger Creek Stormwater Master Plan
- Little Hunting Creek Watershed Assessment and Restoration Concept Report
- County-owned Stormwater Management Best Practices Retrofit Assessment, and
- Point of Rocks Storm Drain Analysis
- Potomac River Direct Watershed Study (May 2019)
- Catoctin Creek Watershed Study (May 2019)
- Double Pipe Creek Watershed Study (May 2019)
- Spring Ridge HOA Feasibility Study (May 2020)
- County-owned New BMP Assessment Frederick County, MD (June 2020)

This scenario includes 25 projects consisting of stream restoration and new wet ponds and retrofits at a cost of $23,945,230. At current funding projections, this scenario would require about 7 years to complete. Identified projects are in Appendix 3.

POTENTIAL PROJECTS, COSTS AND TIMEFRAMES

The **Potential** tier has been defined by the level of treatment rather than project by project. An estimated number of projects has been derived based on average area treated or length of stream restoration for past County projects. Using this factor, along with the amount of treatment proposed, gives a total of 700 projects (Table 51), split among pond retrofits, bioretention, sand filters, submerged gravel wetlands, stream restoration, forest planting, and riparian buffers. A summary of potential projects which would assist the County in meeting its targeted TMDL goals is shown in Appendix 4 for each watershed.

Table 51: Number of Projects and Cost Estimate for Potential Tier

BMP Type	No of Projects	Cost per Project	Total Cost
Bioretention	30	$192,785	$5,783,539
Sand Filters	33	$244,005	$8,052,176
Wet Pond Retrofit	55	$709,086	$38,999,738
Submerged Gravel Wetlands	22	$1,256,584	$27,644,856
Stream Restoration	208	$882,496	$183,559,205
Forest Planting	161	$59,322	$9,550,859
Riparian Buffer	191	$76,498	$14,611,134
	700		**$288,201,506**

Project costs and funding for the **Potential** tier was used as the basis for the timeline for meeting each of the local TMDLs. The plan has been developed to optimize completion of TMDLs with smaller requirements first, while continuing to implement projects for the more resource intensive TMDLs. The plan is based on an average funding level of $4.5MM per year. Funding from FY2021 to FY2022 is earmarked for Programmed and Identified projects; therefore, the start date for **Potential** projects, with the exception of Double Pipe Creek, is the beginning of FY2026. Results of the analysis through FY2089 are shown in Table 52. Based on the load reduction results of the TIPP model and cost data from previously completed and current programmed and identified planned County restoration projects, it is estimated that the cost for **Potential** projects needed to meet all local TMDL reduction targets is $288,201,596. This plan will be continuously re-evaluated to ensure that the modeling is as accurate as possible and that the most cost-effective strategies are being implemented.

Table 52: Potential Tier Funding Timeline through FY2089 (in $000)

	Fiscal Year	Catoctin Creek	Double Pipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy	Total per Year
Total Potential Cost		$34,004	$5,551	$211,490	$0	$37,157	$288,202
Forecast Completion		**2041**	**2029**	**2089**	**n/a**	**2049**	
	FY2026	$2,125	$1,388	$493		$494	$4,500
	FY2027	$2,125	$1,388	$493		$494	$4,500
	FY2028	$2,125	$1,388	$493		$494	$4,500
	FY2029	$2,125	$1,388	$493		$494	$4,500
	FY2030 – FY2041	$2,125		$616		$1,759	$4,500
	FY2042 – FY2049			$2,741		$1,759	$4,500
	FY2050 – FY2088			$4,500			$4,500
	FY2089			$4,702			$4,702

Projects that treat sediment also treat phosphorus and to some extent, *E. coli*. As can be seen in Table ES-1 and Figure 3, in general, in watersheds with TMDLs for these pollutants, if the sediment targets are met, they will be overtreated for other impairments. Because of the nested nature of projects to treat different TMDLs in the same watershed, it was not feasible to determine which of the **Potential** tier projects would be applicable to which pollutant. As a first approximation of determining end dates for the *E. coli* TMDLs, the duration to meet these TMDLs was pro-rated by the amount of overtreatment, shown in Table 53. This analysis will be revisited in subsequent Restoration Plans to develop an estimated completion based on project implementation. For the easier to treat phosphorus or sediment TMDLs, a separate TIPP was used to determine the suite of potential BMPs needed to achieve 100% of the required reduction. This method excludes the overtreatment that is needed in the same watershed for the harder to treat TMDL. This estimated mix of BMPs was aligned against the potential tier funding timeline presented in Table 52 to determine an approximated end date, shown in Table 53.

Table 53: Summary of TMDL completion for Sediment, Phosphorus, and *E. Coli* TMDLS

	Catoctin Creek	Double Pipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy
Pollutant	Sediment	Sediment	Sediment	Sediment	Sediment
Beginning Year	2020	2022	2020	--	2021
Years to Complete	21	1	69	--	28
Completion Year	**2041**	**2023**	**2089**	**--**	**2049**
Pollutant	Phosphorus	Phosphorus	Phosphorus	--	Phosphorus
Years to Complete	10	7	52	--	3
Completion Year	**2030**	**2029**	**2072**	**--**	**2024**
Pollutant	--	*E. Coli*	*E. Coli*	--	*E. Coli*
Years to Complete	--	6	22	--	9
Completion Year	--	**2028**	**2047**	--	**2030**

CONCLUSION

This Frederick County Stormwater Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and TMDL Restoration Plans. Based on the load reduction results of the TIPP model and the estimated costs, full implementation of the Plan is projected to take 68 years from the date of this report to address TMDL requirements, and will cost $342,534,254 which includes the Programmed, Identified, and Potential planning tiers. The Restoration Plan also meets TMDL pollutant removal targets for all 12 local TMDL as shown in Table 54.

Table 54: Local TMDL Pollutant Load Percent Reductions by Watershed

Watershed	MDE Published Reduction	Bacteria Reduction Human / Domestic	County Planned Reduction	% of Goal Achieved	Completion Date
Catoctin Creek TP	11.0%		25.6%	232.3%	2030
Catoctin Creek TSS	49.1%		49.1%	100.0%	2041
Double Pipe Creek EC	98.8%	56.3%	65.9%	117.0%	2028
Double Pipe Creek TP	73.0%		73.3%	100.3%	2029
Double Pipe Creek TSS	46.8%		235.6%	503.4%	2023
Lower Monocacy River EC	92.5%	45.3%	51.1%	112.8%	2047
Lower Monocacy River TP	28.0%		41.4%	147.8%	2072
Lower Monocacy River TSS	60.8%		60.9%	100.1%	2089
Potomac River Montgomery Co. TSS[1]	36.2%		--	--	--
Upper Monocacy River EC	97.0%	48.5%	54.4%	112.1%	2030
Upper Monocacy River TP	4.0%		23.6%	589.6%	2024
Upper Monocacy River TSS	49.0%		49.0%	100.0%	2049

(1) MDP Land use shows no urban area in County portion of this watershed.

REFERENCES

Tree Planting at Canal Run, Spring 2018

Brown and Caldwell (2014). *Technical Memorandum No. 1: Report on Frederick County Data Review Findings*. Prepared for AquaLaw. September 26, 2014.

Byappanahalli et al. (2012). *Enterococci in the Environment*. Microbiol. Mol. Biol. Rev. December 2012 vol. 76 no. 4 685-706.

Caraco, Deb (2013). *Watershed Treatment Model (WTM) 2013 Documentation*. Center for Watershed Protection, Ellicott City, MD, June 2013.

Dewberry (2015). *County-owned SWM BMP Retrofit Assessment*. Dewberry, Frederick MD, July 2015.

Eney, Lindsay (2009). *Question of the Week: What Are the Main Sources of Pollution to the Bay*? Chesapeake Bay Program, Annapolis, MD. https://www.chesapeakebay.net/news/blog/question_of_the_week_what_are_the_main_sources_of_pollution_to_the_bay

King, Dennis, and Patrick-Hagan (2011) *Costs of Stormwater Management Practices in Maryland Counties*. University of Maryland Center for Environmental Science. 2011.

Maryland Department of the Environment (MDE 2021 Guidance). *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated.* November 2021 FINAL.

Maryland Department of the Environment (MDE). TMDL Implementation Progress and Planning Tool (TIPP). Version 11/12/2021; https://mde.maryland.gov/programs/Water/TMDL/DataCenter/Pages/TMDLStormwaterImplementation.aspx

Maryland Department of the Environment (MDE 2020 Guidance). *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated.* June 2020 DRAFT.

Maryland Department of the Environment (MDE 2014 Guidance). *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated.* August 2014.

Maryland Department of the Environment (MDE Basis 2014). *Basis for Final Determination to Issue Frederick County's National Pollutant Discharge Elimination System, Municipal Separate storm Sewer System Permit (MD0068357 11-DP-3321)*, December 23, 2014.

Maryland Department of the Environment (MDE Trading 2017). *Draft Maryland Trading and Offset Policy and Guidance Manual Chesapeake Bay Watershed*. April 2017.

Maryland Department of the Environment (MDE Bacteria 2014). *Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads. Final*. May 2014.

Maryland Department of the Environment (MDE 2030 GGRA Plan 2021). *The Greenhouse Gas Emissions Reduction Act.* February 2021.

Frederick County Office of Sustainability and Environmental Resources (2015). *National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System Discharge Permit: Permit Number MD0068357 2015 Annual Report*. Frederick County Community Development Division. December 30, 2015. (MDE Permit 2015)

Maryland Department of the Environment (MDE DP 2009). *Total Maximum Daily Loads of Fecal Bacteria for the Double Pipe Creek Basin in Carroll and Frederick Counties, Maryland*. October 2009. EPA Approval Date: December 3, 2009.

Maryland Department of the Environment (MDE LM 2009). *Total Maximum Daily Loads of Fecal Bacteria for the Lower Monocacy River Basin in Carroll, Frederick, and Montgomery Counties, Maryland*. October 2009. EPA Approval Date: December 3, 2009.

Maryland Department of the Environment (MDE UM 2009). *Total Maximum Daily Loads of Fecal Bacteria for the Upper Monocacy River Basin Frederick and Carroll Counties, Maryland*. August 2009. EPA Approval Date: December 3, 2009.

Maryland Department of the Environment (2016). *TMDL Data Center*. Retrieved from http://www.mde.maryland.gov/programs/Water/TMDL/DataCenter/Pages/index.aspx. Last retrieved on May 24, 2016.

Maryland Department of Planning (2010). *Land Use / Land Cover* https://planning.maryland.gov/Pages/OurProducts/DownloadFiles.aspx

Municipal and Financial Services Group (2014). *Frederick County, Maryland MS4 Permit Implementation Cost Analysis Final Technical Memorandum*. September 16, 2014.

Perot, Morris et al. (2005). *An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Ballenger Creek Watershed, Frederick County, Maryland*. Prepared for Frederick County Division of Public Works. Versar, Inc. August 2005.

Perot, Morris et al. (2003). *An Assessment of Stream Restoration and Stormwater Management Retrofit Opportunities in Lower Bush Creek Watershed, Frederick County, Maryland*. Prepared for Frederick County Division of Public Works. Versar, Inc. August 2003.

Perot, Morris et al. (2002) *Watershed Assessment of Lower Linganore Creek Frederick County, Maryland*. Prepared for Frederick County Division of Public Works. Versar, Inc. June 2002.

Perot, Morris et al. (2006) *An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Linganore Creek Watershed, Frederick County, MD*. Prepared for Frederick County Division of Public Works. Versar, Inc. June 2006.

Roth, Nancy et al. (2001a) *Final Report Watershed Assessment of Ballenger Creek Frederick County, Maryland*. Prepared for Frederick County Division of Public Works. Versar, Inc. January 2001.

Roth, Nancy et al. (2001b) *Watershed Assessment of Lower Bush Creek*, Frederick County, Maryland. Prepared for Frederick County Division of Public Works. Versar, Inc. March 2001.

Schueler, Thomas R. (1987). *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Governments, Washington, DC.

Schultz, Kay and Shannon Moore (2004). *Lower Monocacy River Watershed Restoration Action Strategy Frederick County, Maryland Final Report.* In consultation with Lower Monocacy WRAS Steering Committee. Frederick County, Maryland. May 2004

Schultz, Kay Jessica Hunicke and Shannon Moore (2008). *Upper Monocacy River Watershed Restoration Action Strategy Frederick County, Maryland Final Report*. In consultation with Lower Monocacy WRAS Steering Committee. Frederick County, Maryland. July 2008

Stribling, Sam et al. (2008) *Bennett Creek Watershed Assessment*, Prepared for Frederick County Division of Public Works. Tetra Tech. March 2008.

Stribling, Sam et al. (2009) *An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed, Frederick County, Maryland*, Prepared for Frederick County Division of Public Works. Tetra Tech. April 2009.

URS ESA. (2016). *Draft Total Maximum Daily Load Restoration Plan for Bacteria for Public Comment*. Prepared for Anne Arundel County Department of Public Works.

U.S. Environmental Protection Agency (2010). *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment*. Annapolis, MD: US Environmental Protection Agency, Chesapeake Bay Program Office.

US Environmental Protection Agency (2009) *An Urgent Call to Action - Report of the State-EPA Nutrient Innovations Task Group*. US EPA, Washington, DC, August 2009. https://www.epa.gov/sites/production/files/documents/nitgreport.pdf

APPENDIX 1: COMPLETED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

Specific actions and expenditures that the county or municipality implemented in prior Fiscal Years to meet its impervious surface restoration plan requirements. Data includes capital projects completed as of June 30, 2021.

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Englandtowne Stream Restoration	STRE	A	21.90	$633,254	2014
Pine Cliff Stream Stabilization	STRE	A	30.00	$427,657	2010
Ballenger Stream Restoration	STRE	A	18.15	$406,986	2007
Old National Pike Park -	FPU	A	1.83	1/1/2011	2011
Holly Hills Country Club	FPU	A	5.79	$191,070	2007
Holly Hills HOA - Urban	FPU	A	0.44	$14,520	2007
Worthington Manor Golf C	FPU	A	3.47	$104,100	2011
Urbana Community Park -	FPU	A	0.90	$29,700	2009
Pinecliff Park - Riparia	FPU	A	0.28	$26,070	2012
Pinecliff Park - Urban F	FPU	A	0.51	$27,000	2010
Urbana Middle School - T	FPU	A	0.46	$15,180	2009
Spring Ridge Elementary	FPU	A	1.05	$34,650	2013
New Market Middle School	FPU	A	1.22	$40,260	2012
Wolfsville Elementary Sc	FPU	A	0.41	$13,530	2010
Deer Crossing Elementary	FPU	A	1.09	$35,970	2013
Utica Park - Urban Fores	FPU	A	0.29	$9,570	2007
Valley Elementary School	FPU	A	0.79	$26,070	2009
Urbana Elementary School	FPU	A	0.13	$4,290	2011
Mountain Village HOA - U	FPU	A	1.22	$40,260	2014
Crestwood Middle School	FPU	A	0.79	$26,070	2013
Monocacy Elementary Scho	FPU	A	0.19	$1,320	2014
Ballenger Creek Elementa	FPU	A	0.58	$19,140	2007
Orchard Grove Elementary	FPU	A	0.32	$10,560	2013
Windsor Knolls Middle Sc	FPU	A	3.29	$75,240	2011
Windsor Knolls Middle Sc	FPU	A	1.41	$75,240	2011
Phase I Ltl Hunting Creek Stream Restoration	STRE	A	3.98	$280,000	2020
Point of Rocks MS4 Stream Restoration - Phase I	STRE	A	96.50	$4,546,941	2019
Bar T Stream Restoration	STRE	A	43.53	$30,000	2019
Bar T RSC South	STRE	A	10.50	$30,000	2019
Bar T RSC North	STRE	A	103.93	$30,000	2020
CRL - (Site 7, ID-8411)	FPU	A	0.96	$12,221	2021

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
CRL - (Site 7, ID-8411)	FPU	A	5.68	$230,668	2021
CRL - (Site 9, ID-8445)	FPU	A	14.92	$263,315	2021
CRL - (Site 18, ID-8522) 6	FPU	A	10.78	$61,892	2021
CRL - (Site 17, ID-8521) 1	FPU	A	1.94	$61,892	2021
CRL - (Site 17, ID-8521) 2	FPU	A	4.61	$32,172	2021
CRL - (Site 1, ID-8255)	FPU	A	2.52	$416,293	2021
CRL - (Site 15, ID-8515)	FPU	A	38.61	$91,743	2021
CRL - (Site 19, ID-8523)	FPU	A	3.82	$40,308	2021
CRL - (Site 8, ID-8431)	FPU	A	2.42	$21,464	2021
Catoctin Creek Nature Center	FPU	A	5.67	$21,464	2021
Catoctin Creek Nature Center	FPU	A	1.10	$21,464	2021
Catoctin Creek Nature Center	FPU	A	3.62	$21,464	2021
Catoctin Creek Nature Center	FPU	A	4.97	$21,464	2021
Catoctin Creek Nature Center	FPU	A	2.45	$39,761	2021
Monocacy River Park behind DUSWM	FPU	A	11.51	$263,315	2021
CRL - (Site 18, ID-8522) 7	FPU	A	0.03	$61,892	2021
CRL - (Site 17, ID-8521) 3	FPU	A	8.64	$99,436	2021
Englandtowne Retrofit Pr	FPU	A	0.28	$18,787	2014
Clearview - Retrofit	PWET	S	5.60	$377,764	2019
Fountaindale South - Shallow Marsh Basin - Retrofit	PWET	S	18.75	$1,739,652	2019
Tranquility - Retrofit	PWET	S	4.64	$429,880	2019
Roundtree - Section 2 ED Pond - Retrofit	PWED	S	12.42	$847,110	2019
Villages of Urbana, Village V, Sec. K3, Pond "L" - Retrofit	PWED	S	7.10	$159,016	2019
FC - Englandtowne SWM - Retrofit	PWED	S	11.83	$584,645	2017
Villages of Urbana, Village 1, Pond F - Retrofit	PWED	S	4.60	$159,016	2019
Villages of Urbana, Village I, Pond G - Retrofit	PWED	S	4.94	$159,016	2019
Villages of Urbana, Village I, Pond B - Retrofit	PWED	S	9.05	$159,016	2019
Villages of Urbana, Sec. M - 5, Pond 'C' - Retrofit	PWED	S	14.53	$159,016	2019
Villages of Urbana, Sec. K - 2, Pond 'J' - Retrofit	PWED	S	11.28	$159,016	2019
Villages of Urbana, Sec. M-8, Pond M1 - Retrofit	PWED	S	10.98	$159,016	2019
Villages of Urbana, Section K4, Pond 'FF' - Retrofit	PWED	S	2.64	$159,016	2019

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Villages of Urbana, Section M-10, SWM Pond 'R' - Retrofit	PWED	S	15.31	$159,016	2019
Villages of Urbana, SWM Pond 'S' - Retrofit	FSND	S	1.95	$159,016	2019
Dudrow Business Park, SWM Pond #3 (Toys-R-Us Facility) - Retrofit	PWED	S	99.62	$2,235,000	2019
Villages of Urbana, SWM Pond A1 - Retrofit	PWED	S	4.44	$159,016	2019
Villages of Urbana, Pond 'N' - Retrofit	PWED	S	6.04	$159,016	2019
Green Hill Manor - SWM Pond #2 - Retrofit	PWET	S	19.06	$1,375,705	2019
Urbana Highlands, Sec. P3 - SWM Pond 'PB' - Retrofit	PWED	S	20.56	$159,016	2019
Urbana Highlands, Sec. P4 - SWM Pond 'PC' - Retrofit	PWED	S	4.68	$159,016	2019
Urbana Highlands, Sec. P3 - SWM Pond 'PA' - Retrofit	PWED	S	15.98	$159,016	2019
FC - TransIT - BMP B - Retrofit	FSND	S	3.13	$160,000	2019
FC - Health Department Dry Pond - Retrofit	FSND	S	4.39	$295,000	2020
OSER - Urbana High School - Bioretentions & Rain Gardens	MMBR	E	2.07	$249,069	2007
OSER - Cooperative Extension Building - WQI - 1 Filterra	MMBR	E	0.30	$148,810	2019
OSER - Urbana Community Park - Bioretention	FBIO	S	1.70	$11,440	2013
Law Enforcement Complex - BMP A - Retrofit	PWED	S	9.72	$423,799	2019
Trout Unlimited Stream Restoration	STRE	A	27.75	$624,375	2013
Little Tuscarora Creek	STRE	A	45.00	$1,012,500	2015
Bethel Road Site 1 Stream Stabilization	OUT	A	0.43	$9,675	2017
Bill Moxley Road Site 9	OUT	A	0.66	$14,850	2017
Bill Moxley Road Site Culvert	OUT	A	0.33	$7,425	2017
Black Ankle Road	OUT	A	0.61	$13,725	2017
Black Ankel Road Site 2 Culvert	STRE	A	4.20	$94,500	2017
Catholic Church Road	OUT	A	0.42	$9,450	2017
Jesse Smith Road	STRE	A	6.45	$145,125	2017
Kemptown Elementary Scho	FPU	A	0.17	$5,100	2011
Urbana High School - Tre	FPU	A	0.15	$4,500	2009
Middletown High School -	FPU	A	0.24	$7,200	2009

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
FC - Highway Ops - SWM4 (Highway Shop) Retrofit	PWET	S	6.69	$460,912	2019
OSER - Cooperative Extension Building - Microbioretention	MMBR	E	0.08	$148,810	2019
OSER - Cooperative Extension Building - Rain Tank 1A/1B	MRWH	E	0.03	$148,810	2019
OSER - Cooperative Extension Buiding - Rain Tank 2	MRWH	E	0.02	$148,810	2019
OSER - Cooperative Extension Building - WQI - 2 Filterra	MMBR	E	0.29	$148,810	2019
Yeagertown Road	STRE	A	4.38	$98,550	2014
Beaver Dam Creek Stream Restoration	STRE	A	43.50	$978,750	2015
Manor at Holly Hills, Ijamsville Road	STRE	A	4.05	$91,125	2014
9129 Baltimore Rd	OUT	A	0.18	$4,050	2018
Prices Distillery Road and Haines intersection, 3A	OUT	A	0.12	$2,700	2012
4338 Prices Distillery Rd	OUT	A	0.09	$2,025	2015
9401 Baltimore Rd	OUT	A	0.36	$8,100	2018
Prices Distillery Road and Haines intersection, 3B	OUT	A	0.12	$2,700	2012
4830 Ijamsville Rd	OUT	A	0.28	$6,188	2017
Prices Distillery Rad, Site 1 outlet	OUT	A	0.10	$2,250	2012
Prices Distillery Road, 1/2 mi N of Rt 75	OUT	A	0.16	$3,600	2013
Prices Distillery Road, Site 3	OUT	A	0.18	$4,050	2012
Willow Tree Drive South and Feldspar Road Intersect	OUT	A	0.20	$4,500	2012
Feldspar Road, 250' west of Willow Tree Drive South	OUT	A	0.57	$12,825	2016
Willow Tree Drive South, .14 mi so of US-40A	OUT	A	0.27	$5,963	2012
9013 Geisbert Rd	OUT	A	0.60	$13,500	2018
FR Highway Operations Oak Hill Road	OUT	A	0.14	$3,150	2013
Ramsburg Road	OUT	A	0.94	$21,150	2014
Pleasant View Road Site 12; 2.3 mi off MD 28	OUT	A	0.81	$18,225	2017
Pleasant View Road Site 1	OUT	A	0.69	$15,525	2017
Pleasant View Road Site 2; .4 miles off of MD 28	OUT	A	0.15	$3,375	2017
Elmer Derr - Site 3	OUT	A	0.05	$1,013	2013
East Mountain Road	OUT	A	0.07	$1,575	2013

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Fr Co Hwy/Mount Zion Road Site 1-3	STRE	A	7.80	$175,500	2018
FR Highway Operations-Hollow Road	OUT	A	0.28	$6,300	2014
Prices Distillery Road, 1/2 mi N of Rt 75	OUT	A	0.12	$2,700	2013
Prices Distillery Road, Site 4	OUT	A	0.45	$10,125	2012
0.5 mi from MD 550 on Penterra Manor Lane	OUT	A	0.19	$4,275	2017
Pleasant View Road Site 11; 2.25 mi off MD 28	STRE	A	4.65	$104,625	2017
Elmer Derr Road	STRE	A	4.89	$110,025	2012
Park Mills Road and Lily Pons Road	OUT	A	0.11	$2,430	2015
FR Highway Operations-Lander Road, Sites 8 and 9 2013	OUT	A	0.16	$3,600	2013
Jefferson Valley LLC - Woodbourne Manor, MD 383	OUT	A	0.09	$2,025	2016
FR Highway Operations-Bethel Road	OUT	A	0.30	$6,638	2014
Fish Hatchery Road	OUT	A	0.63	$14,175	2013
FR Highway Operations-Horine Road	OUT	A	0.40	$9,000	2015
FR DPW-Old Frederick Road, Bridge No, 20-02	OUT	A	0.51	$11,475	2016
FR DPW-Bridge No F-20-04-Lewistown Road	STRE	A	4.44	$99,900	2014
FR CO Highway Operations/Lewistown Rd Site 1-4	OUT	A	0.50	$11,250	2018
Lenhard Rd 2	OUT	A	0.48	$10,800	2015
Layman Rd at Blacks Mill Rd	OUT	A	0.49	$11,025	2018
FR Highway Operations-North Franklinville Road	STRE	A	4.65	$104,625	2012
Saint Marks Road	OUT	A	0.60	$13,500	2012
Catholic Church Road Site 1	OUT	A	0.13	$2,925	2015
South Mountain Rd, 1	OUT	A	0.72	$16,200	2012
FR Highway Operations-Catholic Church Road	OUT	A	0.20	$4,500	2013
Baltimore Rd and Mains Ln Intersection	OUT	A	0.12	$3,000	2018
Bill Moxley Rd.	OUT	A	0.13	$3,125	2017
approx 1000 ft from 3342 Garfield Rd approx 1000 ft from 3342 Garfield Rd approx 1000 ft from 334*	OUT	A	0.09	$2,188	2017
5630A Ijamsville Rd	OUT	A	0.21	$5,250	2014

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
just prior to 4523 Bill Moxley Rd	OUT	A	0.10	$2,375	2017
Holter Road	OUT	A	0.08	$1,938	2019
Mt. Zion Rd. and Jefferson Blvd Intersection	OUT	A	0.18	$4,563	2017
Lander Road at Sunrise Drive	OUT	A	0.20	$5,000	2013
Camelot Ct.	OUT	A	0.13	$3,250	2017
Moser Rd.	OUT	A	0.07	$1,813	2017
Grid G2 South of RR Tracks	OUT	A	0.08	$2,000	2016
Bartonsville Rd. at Reichs Ford Rd. Intersection	OUT	A	0.11	$2,625	2017
Bill Moxley Rd.	OUT	A	0.09	$2,250	2017
Holter Road	OUT	A	0.14	$3,458	2019
Holter Road	OUT	A	0.05	$1,125	2019
5901 Old National Pike	OUT	A	0.30	$7,500	2016
Ballenger Creek Pike, 375' SE of Point of Rocks Rd	OUT	A	0.18	$4,375	2013
Holter Road	OUT	A	0.10	$2,438	2019
500 Ft S of Urbana Pkwy and Urbana Pike Intersection	OUT	A	0.45	$11,250	2018
site is just prior to 10002 Glade Rd	OUT	A	0.13	$3,250	2017
11127 Dublin Road	OUT	A	0.44	$11,000	2015
Ramsburg Rd, 1.2 mi off of Old Frederick Rd at 8423 Ramsburg Rd, 1.2 mi off of Old Frederick Rd at*	OUT	A	0.34	$8,500	2014
Apples Church Rd.	OUT	A	0.09	$2,313	2017
Bridgeport Road, 1.3 mi off Rt 140	OUT	A	0.26	$6,500	2013
9217 Baltimore Rd	OUT	A	0.06	$1,500	2018
Water Street Road, .22 mi north of Stauffer Road	OUT	A	0.17	$4,188	2007
Bartonsville Rd.	OUT	A	0.11	$2,625	2017
Monocacy River Park behind DUSWM	FPU	A	19.11		2021
Beaver Dam Stream Restor	FPU	A	1.52	$45,600	2016
Horine Road at Jenerations Family Farm	STRE	A	4.35	$97,875	2017
11434 Bridegport Road	OUT	A	0.47	$10,575	2011
Franklinville Rd	STRE	A	4.23	$95,175	2016
Saint Marks Road 1	STRE	A	4.50	$101,250	2019
Saint Marks Road 5	OUT	A	0.24	$5,400	2019
Sumantown Rd 1	OUT	A	0.71	$15,975	2019

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Sumantown Rd 2	OUT	A	0.57	$12,825	2019
4025 Fishers Hollow Road	OUT	A	0.09	$2,025	2019
FR Highway Operations-Old Middletown Road, Site 1 2013	OUT	A	0.15	$3,375	2011
FR Highway Operations-Old Middletown Road, Site 2 2013	OUT	A	0.24	$5,288	2011
Quebec School Road	STRE	A	5.91	$132,975	2017
.2 mi right of poffenberger	STRE	A	17.75	$399,263	2017
5355 Carroll Boyer Road	STRE	A	6.69	$150,525	2019
5450 Carroll Boyer Road	STRE	A	3.99	$89,775	2017
Creamery Road	STRE	A	4.67	$104,963	2017
1.1 miles s of RT 26	OUT	A	0.89	$20,025	2012
6048 Old Bohn Road	OUT	A	0.16	$3,600	2015
Mapleville Road, 1.5 miles south of MD 26 (Liberty Road), or 0.5 miles north of Dollyhyde Rd.	OUT	A	0.17	$3,893	2018
Jesse Smith Road, 1.3 miles from Old National Pike (MD 144) and Jesse Smith RoadJesse Smith Road, 1.	OUT	A	0.20	$4,500	2018
just prior to 15002 Grimes road	OUT	A	0.94	$21,150	2017
intersect of Claybaugh Rd and Simpsons Mill Rd	OUT	A	0.71	$15,975	2014
Layman Rd 300ft east of Hesson Bridge Rd/Hessong Bidge intersection	OUT	A	0.26	$5,850	2018
Roddy Road Park	STRE	A	5.25	$118,125	2011
close to 7456 Eylers Valley	STRE	A	4.95	$111,375	2016
7209 Eylers Valley Flint Road	OUT	A	0.31	$6,975	2011
across from blacks funeral home	OUT	A	0.11	$2,475	2019
6916 Blacks Mill Road; across from bridge Catoctin Furnace Rd	OUT	A	0.97	$21,780	2017
Pete Wiles Road Bridge, 1.3 mi N of MD 17, Right Hand Tributary	OUT	A	0.38	$8,438	2011
4001 Bill Moxley Road	OUT	A	0.09	$2,070	2017
Covell Rd bridge	OUT	A	0.65	$14,670	2019
Bethel Road	STRE	A	4.32	$97,200	2014
Pete Wiles Road Bridge, 1.3 mi N of MD 17, Left Bank Tributary	OUT	A	0.89	$19,913	2017
1000 ft from the intersection at Pleasant Walk Rd & Easterday	OUT	A	0.19	$4,275	2019
8709 Apples Church Road	OUT	A	0.83	$0	2011
Bennie Duncan Road, .52 mi east of Hoffman Seachrist Road	OUT	A	0.54	$12,150	2014

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
intersect of Claybaugh Rd and Simpsons Mill Rd	OUT	A	0.47	$10,643	2014
North Franklinville Road Site 2	STRE	A	4.65	$104,625	2017
Thurston Rd over Bennett creek bridge no 07-02	OUT	A	0.26	$5,850	2017
4025 Fishers Hollow Road	OUT	A	0.19	$4,275	2019
FR Co Hwy / Baltimore Rd Site 1 outlet	OUT	A	0.15	$3,375	2018
1000 ft from the intersection at Pleasant Walk Rd & Easterday	OUT	A	0.15	$3,431	2019
Covell Rd bridge	OUT	A	0.33	$7,425	2019
6916 Blacks Mill Road; across from bridge Catoctin Furnace Rd	OUT	A	0.33	$7,403	2017
Thurston Rd over Bennett creek bridge no 07-02	OUT	A	0.28	$6,255	2017
11433 Daysville Road	OUT	A	0.48	$10,800	2015
Daysville Road, 1.0 mi east of Water Street Road	OUT	A	0.13	$2,813	2016
Daysville Road, 1.0 mi east of Water Street Road	OUT	A	0.12	$2,588	2016
Harp Road Culvert inlet	OUT	A	0.21	$4,725	2017
Harp Rd.	OUT	A	0.22	$4,950	2017
Indian Springs Road	OUT	A	0.15	$3,375	2017
Indian Springs Roadd	OUT	A	0.10	$2,250	2017
Spring Ridge Parkway	STRE	A	3.84	$86,400	2013
Ball Road over Peter Pan Run	OUT	A	0.54	$12,150	2016
.1 mile from the intersection of sumantown road and Carroll Boyer Road	OUT	A	0.41	$9,113	2019
Gas House Pike at Linganore Creek	OUT	A	0.85	$19,125	2017
Gas House Pike at Linganore Creek	OUT	A	0.85	$19,125	2017
Dollyhyde Road at intersect of Timmons Road	OUT	A	0.12	$2,588	2018
Hines Road	OUT	A	0.10	$2,160	2017
Frederick Hwy ops dorcus road site 2 outlet	OUT	A	0.09	$2,025	2019
FR Hwy Ops-Fox Road Site 1	OUT	A	0.22	$4,950	2018
Frederick Hwy Ops-Middle Point Road	OUT	A	0.24	$5,378	2018
Linthicum Road	OUT	A	0.21	$4,613	2019
Legore Bridge Road	OUT	A	0.16	$0	2008

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Buffalo Road, .20 mi from Shirley Bohn Rd	OUT	A	0.13	$2,948	2013
Utica Road 1	OUT	A	0.24	$5,400	2013
Frederick Hwy Ops-Layman Road	OUT	A	0.11	$2,475	2013
Hoovers Mill Road, .13 mi west of Frushour Road	STRE	A	4.20	$94,500	2013
Beaver Dam Road, .63 mi west of Lackey Road, (believe it is NE of Lackey Road actually)	OUT	A	0.12	$2,700	2012
Beaver Dam Road, .63 mi west of Lackey Road, (believe it is NE of Lackey Road actually)	OUT	A	0.32	$7,088	2012
Bunker Hill Road, 325 ft west of Wachter Road	OUT	A	0.20	$4,590	2012
Harbaugh Valley Road .10 miles west of Sunshine Trail	OUT	A	0.30	$6,750	2012
Harbaugh Valley Road. 10 miles east of Harbaugh rd	OUT	A	0.05	$1,125	2012
Prices Distillery Road and Haines intersection, 3A	OUT	A	0.22	$4,950	2012
Prices Distillery Road and Haines intersection, 3B	OUT	A	0.21	$4,725	2012
Frederick Hwy Ops Appolds Road	OUT	A	0.22	$4,950	2019
South Mountain Rd, 2	OUT	A	0.65	$14,625	2017
Prices Distillery Rad, Site 1 inlet	OUT	A	0.31	$6,975	2012
3527 Roy Shafer Road	OUT	A	0.46	$10,406	2015
end of road by the boat launch	OUT	A	0.76	$17,145	2019
Mapleville Road, 1.5 miles south of MD 26 (Liberty Road), or 0.5 miles north of Dollyhyde Rd.	OUT	A	0.29	$6,458	2018
Saint Marks Road 5	OUT	A	0.16	$3,600	2019
11434 Bridegport Road	OUT	A	0.34	$7,650	2011
Utica Road 1	OUT	A	0.24	$5,400	2013
Elmer Derr - Site 3	OUT	A	0.18	$4,050	2013
Saint Marks Road	OUT	A	0.22	$4,950	2012
FR Highway Operations-Horine Road	OUT	A	0.04	$900	2015
Pleasant View Road Site 2; .4 miles off of MD 28	OUT	A	0.08	$1,800	2017
Prices Distillery Road, Site 3	OUT	A	0.23	$5,175	2012
Park Mills Road and Lily Pons Road	OUT	A	0.17	$3,713	2015
Ramsburg Road	OUT	A	0.19	$4,275	2014

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Willow Tree Drive South, .14 mi so of US-40 A	OUT	A	0.23	$5,175	2012
Bartonsville Rd.	OUT	A	0.10	$2,375	2017
Holter Road	OUT	A	0.11	$2,688	2019
South Renn Rd, 250' and 800' north of Cap Stine Rd	OUT	A	0.18	$4,500	2015
.1 miles from intersection with Bethel Road	OUT	A	0.47	$11,750	2019
0.5 mi from Gregg Rd	OUT	A	0.08	$2,000	2017
Bridgeport Road, .23 mi so of Rt 140	OUT	A	0.13	$3,125	2012
.8 miles from Good Intent rd and Keymar Rd Intersection (Site 1)	OUT	A	0.22	$5,375	2018
Baker Road, 800ft from intersection with Smith Lane	OUT	A	0.16	$4,000	2016
just off 12504 Renner road	OUT	A	0.15	$3,625	2019
11221 Cash Smith Rd	OUT	A	0.29	$7,200	2014
Old Middletown Road at intersect of Roy Shafer Rd	OUT	A	1.01	$25,250	2017
just prior to 4719 Reels Mill Rd	OUT	A	0.22	$5,425	2017
Pinecliff Park 8350 Pinecliff Park Road	OUT	A	0.08	$1,900	2013
1530 Thurston Road Natural Bed Rock	OUT	A	0.24	$5,875	2015
11750 Simpson Mill Road	OUT	A	0.27	$6,775	2019
Intersection of Etzler Mill Road and Renner Road	OUT	A	0.59	$14,825	2019
Intersection of Etzler Mill Road and Renner Road	OUT	A	0.13	$3,275	2019
Manor Drive, .30 mi no of Pennshop Road	OUT	A	0.50	$12,525	2014
13103 Pennshop Road	OUT	A	0.15	$3,725	2019
site just prior to 4315 Molesworth Terrace	OUT	A	0.12	$3,000	2017
Spruce Run Road #3, 0.2 miles off MD Rt 17 (Woflsville Road)	OUT	A	0.16	$4,000	2015
12605 Jesse Smith Road	OUT	A	0.47	$11,800	2017
.1 miles east of Rocky Ridge and Old Frederick Rd intersection	OUT	A	0.17	$4,250	2019
.2 miles south from the water tower	OUT	A	0.07	$1,750	2019
3405 Sumantown Road	OUT	A	0.23	$5,700	2013
3405 Sumantown Road	OUT	A	0.17	$4,150	2017

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Loy Wolfe Road, 2.34 mi no of Pleasant Walk Rd	OUT	A	0.08	$1,925	2010
Loy Wolfe Road, 2.52 mi no of Pleasant Walk Rd	OUT	A	0.11	$2,750	2010
Loy Wolfe Road, 1.7 mi no of Pleasant Walk Rd	OUT	A	0.21	$5,300	2018
Loy Wolfe Road, 1.6 mi no of Pleasant Walk Road	OUT	A	0.09	$2,150	2018
13355 site 1	OUT	A	0.09	$2,250	2018
8550 Mapleville Road 8550 Mapleville Road	OUT	A	0.14	$3,400	2013
8502 Mapleville Road	OUT	A	0.13	$3,125	2017
Myers Road, 150' south of MD 77	OUT	A	0.22	$5,500	2012
Keysville Road at the intersection of Simmons Road	OUT	A	0.16	$4,000	2012
3601 Kemptown Church Road Site	OUT	A	0.71	$17,800	2012
Stottlemyer Road, 500' so of Garfield Road	OUT	A	0.18	$4,500	2012
7307 Friends Creek Road	OUT	A	0.17	$4,125	2014
Bartonsville Rd.	OUT	A	0.11	$2,625	2017
adjacent to 8611 Pete Wiles Rd	OUT	A	0.10	$2,583	2019
1 mile South of park central rd	OUT	A	0.25	$6,250	2019
1.5 miles from Foxville Deer Field road 300 ft from site 2	OUT	A	0.18	$4,500	2019
Foxville Church Road, 300' east of Quirauk School Rd	OUT	A	0.13	$3,225	2012
Apple Church Rd, .30 mi from Mud College Rd	OUT	A	0.26	$6,500	2019
Catoctin Hollow Road, 1.5 mi from Md Rt 77	OUT	A	0.08	$2,000	2015
South of 4304 Fishers Hollow Rd	OUT	A	0.16	$4,075	2019
North of 4304 Fishers Hollow Rd	OUT	A	0.20	$4,900	2019
Fr Co Hwy/Fishers Hollow Rd - Sites 1-16. Site 10; North of 4330 Fishers Hollow Road	OUT	A	0.36	$8,875	2018
4402-A Fishers Hollow Road	OUT	A	0.19	$4,800	2018
South of 4402 B Fishers Hollow Road	OUT	A	0.28	$6,925	2018
4405 Fishers Hollow Road	OUT	A	0.10	$2,500	2018
North of 4458 Fishers Hollow Road	OUT	A	0.17	$4,125	2018
South of 4623 Fishers Hollow Road	OUT	A	0.17	$4,250	2018
South of 4702 Fishers Hollow Road	OUT	A	0.17	$4,250	2018

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Fishers Hollow Road	OUT	A	0.14	$3,425	2018
4750 Fishers Hollow Road	OUT	A	0.26	$6,500	2018
11704 Keymar Road	OUT	A	0.08	$2,075	2015
Loy Wolfe Road, 2.4 mi no of Pleasant Walk Rd	OUT	A	0.10	$2,500	2012
Meeting House Rd, .20 mi east of Harp Hill Rd	OUT	A	0.08	$2,063	2013
intersection of Cavell rd and Thurston next to the bridge	OUT	A	0.17	$4,200	2012
site just prior to 4994 tall oaks Dr	OUT	A	0.13	$3,125	2017
150' from intersection of Friends Lane and Friends Creek Road	OUT	A	0.23	$5,750	2018
Frederick Hwy Ops Appolds Road	OUT	A	0.22	$5,500	2019
11455 Renner Road	OUT	A	0.09	$2,175	2019
Frederick Hwy Ops-Muth Road	OUT	A	0.12	$3,000	2019
11036 Keymar Road	OUT	A	0.13	$3,250	2019
14519 Old Frederick Road	OUT	A	0.16	$4,000	2019
10741 Renner Road	OUT	A	0.09	$2,300	2019
Frederick Hwy Ops Albaugh Road Site 1	OUT	A	0.16	$3,900	2020
7915 McKaig Road	OUT	A	0.14	$3,600	2019
10092 Dudley Drive	OUT	A	0.29	$7,175	2019
3851 Prices Distillery Road	OUT	A	0.26	$6,600	2015
Muth road	OUT	A	0.24	$5,925	2019
2.34 mi north of Pleasant Walk Rd	OUT	A	0.10	$2,575	2012
5601 Holter Road	OUT	A	0.21	$5,175	2016
intersection of Rocky Ridge and Old Frederick Road	OUT	A	2.00	$50,000	2019
1.6 South of foxvilldeer field road	OUT	A	0.33	$8,300	2019
Simmons Rd; .10 mi from Four Points Bridge Rd	OUT	A	0.15	$3,750	2019
Holter road north of new CVS	OUT	A	0.16	$3,875	2019
Old Middletown Road	OUT	A	0.66	$16,500	2019
250' from intersection with Bethel Road	OUT	A	0.48	$12,000	2019
12909 Moxton Dr	OUT	A	0.08	$2,000	2019
Keysville Road .4 miles east of Simmons Road	OUT	A	0.55	$13,825	2012
Good Intent Rd, 500' east of Keymar Rd	OUT	A	0.07	$1,675	2014
Reforestation of FEMA co	FPU	A	0.06	$1,800	2016

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Reforestation of FEMA co	FPU	A	0.02	$600	2016
Reforestation of FEMA co	FPU	A	0.08	$2,400	2016
Reforestation of FEMA co	FPU	A	0.03	$900	2016
Reforestation of FEMA co	FPU	A	0.02	$600	2016
Extension Service Forest	FPU	A	1.28	$38,400	2008
Extension Service Forest	FPU	A	0.29	$8,700	2008
CRL - (Site 7, ID-8411)	FPU	A	0.07		2021
CRL - (Site 7, ID-8411)	FPU	A	1.75		2021
CRL - (Site 9, ID-8445)	FPU	A	0.76		2021
CRL - (Site 18, ID-8522) 6	FPU	A	10.42		2021
CRL - (Site 17, ID-8521) 1	FPU	A	5.41		2021
CRL - (Site 17, ID-8521) 2	FPU	A	3.47		2021
CRL - (Site 19, ID-8523)	FPU	A	3.56		2021
CRL - (Site 8, ID-8431)	FPU	A	0.08	$21,464	2021
Catoctin Creek Nature Center	FPU	A	0.45	$7,272	2021
Catoctin Creek Nature Center	FPU	A	0.01		2021
CRL - (Site 18, ID-8522) 7	FPU	A	1.96		2021
CRL - (Site 17, ID-8521) 3	FPU	A	14.35		2021
Septic Denitrification	SEPD	A	2.6	$0	2008
Septic Denitrification	SEPD	A	4.94	$0	2009
Septic Denitrification	SEPD	A	0.78	$0	2010
Septic Connection	SEPC	A	0.39	$0	2011
Septic Denitrification	SEPD	A	2.6	$0	2011
Septic Denitrification	SEPD	A	4.16	$0	2012
Septic Denitrification	SEPD	A	10.92	$0	2013
Septic Connection	SEPC	A	0.39	$0	2014
Septic Denitrification	SEPD	A	7.54	$0	2014
Septic Connection	SEPC	A	0.78	$0	2015
Septic Denitrification	SEPD	A	9.1	$0	2015
Septic Denitrification	SEPD	A	5.20	$2,539,200	2016
Septic Pump-Out	SEPP	A	9.00	$0	2016
Septic Connection	SEPC	A	0.39	$0	2017
Septic Denitrification	SEPD	A	6.76	$414,000	2017
Septic Pump-Out	SEPP	A	24.18	$0	2017
Septic Connection	SEPC	A	0.39	$0	2018
Septic Denitrification	SEPD	A	2.08	$257,000	2018
Septic Pump-Out	SEPP	A	40.98	$25,000	2018
Septic Connection	SEPC	A	1.56	$0	2019
Septic Denitrification	SEPD	A	5.20	$0	2019

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	NPDES PROGRAM COST	YEAR
Septic Pump-Out	SEPP	A	56.00	$40,200	2019
Septic Connection	SEPC	A	0.39	$0	2020
Septic Denitrification	SEPD	A	4.44	$0	2020
Septic Pump-Out	SEPP	A	67.77	$49,841	2020
Septic Connection	SEPC	A	0.23	$0	2021
Septic Denitrification	SEPD	A	2.88	$0	2021
Septic Pump-Out	SEPP	A	51.33	$49,950	2021
REDE	OTH	A	8.59	$0	2019
Street Sweeping	VSS	A	21.84	$42,153	2016
Street Sweeping	VSS	A	18.83	$34,956	2017
Street Sweeping	VSS	A	11.20	$23,591	2018
Street Sweeping	VSS	A	20.55	$41,096	2019
Street Sweeping	VSS	A	10.50	$21,000	2020
Street Sweeping	VSS	A	17.15	$236,226	2021
TRADING	OTH	A	365.74		2021
		Total	**1,981.03**	**$32,132,613**	

APPENDIX 2: PROGRAMMED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

The table below includes actions that are planned and funded which will meet impervious area treatment and pollutant reduction requirements. These are projects with completion dates beyond June 30, 2021.

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	COST	YEAR
Briercrest Apartments - Retrofit	PWED	S	5.12	$1,059,622	FY22
Cambridge Farms, SWM Pond No. 1 - Retrofit	PWED	S	8.6	$971,115	FY22
Cloverhill New Stormwater #1	FBIO	S	18.5	$243,260	FY22
Cloverhill New Stormwater #2	FBIO	S	9.25	$217,948	FY22
Copperfield SWM Pond - Retrofit	PWED	S	6.81	$766,486	FY22
Glade Manor - Pond #1 - Retrofit	MSGW	S	18.76	$1,460,860	FY22
Green Hill Manor - SWM Pond #3 - Retrofit	MSGW	S	22.66	$1,046,014	FY22
Green Hill Manor, Pond #1 - Retrofit	MSGW	S	16.54	$1,262,880	FY22
Holy Family Catholic Community Worship Center - Retrofit	PWED	S	7.99	$775,786	FY22
Jefferson Junction Shopping Center - ED Pond - Retrofit	PWED	S	4.93	$387,810	FY22
Potomac Station Regional Retention Pond - Point of Rocks Retrofit	PWET	S	20.48	$1,247,809	FY23
Cambridge Farms, SWM Pond No. 2 - Retrofit	PWED	S	56.97	$1,428,205	FY24
Samhill Estates Regional SWM Facility - Retrofit	PWED	S	34.4	$1,208,273	FY25
Waterside Detention Basin - Retrofit	PWED	S	14.38	$885,125	FY25
Public Safety Training Facility - Retrofit	PWED	S	24.53	$1,701,399	FY26
Cloverhill III, Section 7, ED Basin - Retrofit	PWED	S	17.51	$907,411	FY27
LIPI-2018-STRE-0009	STRE	A	34.76	$2,058,285	FY22
McKaig Road Regenerative Stormwater Conveyance	STRE	A	6.8	$377,857	FY22
Beaver Dam Road WMRCD/FSA Stream Restoration	STRE	A	16.7	$0	FY23
Cambridge Farms, SWM Pond No. 2 - NPDES 752 - Protocol 5	STRE	A	1.67	$142,820	FY23
Point of Rocks MS4 Stream Restoration - Phase II	STRE	A	21.94	$2,882,210	FY23
Holy Family Catholic Community Worship Center - Protocol 5	STRE	A	1.97	$77,579	FY24
Stream Restoration Upstream of NPDES 752 A	STRE	A	10.27	$882,844	FY24
Sam Hills Estates Stream Restoration	STRE	A	19.6	$1,211,957	FY25
Cloverhill Stream Restoration	STRE	A	31.5	$2,221,639	FY27
Pine Cliff Phase 2 Stream Restoration	STRE	A	13.1	$643,748	FY27
Stream Restoration Upstream of BMP463	STRE	A	15.9	$846,664	FY27
Catoctin Creek Nature Center	FPU	A	0.50	$7,272.00	FY22
CRL - (Site 1, ID-8255)	FPU	A	0.87	$32,172.00	FY22
CRL - (Site 15, ID-8515)	FPU	A	1.71	$416,293.00	FY22

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	COST	YEAR
CRL - (Site 15, ID-8515)	FPU	A	10.46	$416,293.00	FY22
CRL - (Site 15, ID-8515)-2	FPU	A	1.19	$416,293.00	FY22
CRL - (Site 17, ID-8521) 1	RFP	A	2.04	$61,892.00	FY22
CRL - (Site 17, ID-8521) 2	RFP	A	2.47	$61,892.00	FY22
CRL - (Site 17, ID-8521) 3	RFP	A	6.62	$61,892.00	FY22
CRL - (Site 17, ID-8521) 4	FPU	A	1.38	$61,892.00	FY22
CRL - (Site 17, ID-8521) 5	RFP	A	0.22	$61,892.00	FY22
CRL - (Site 18, ID-8522) 6	RFP	A	6.36	$263,315.00	FY22
CRL - (Site 18, ID-8522) 7	RFP	A	0.51	$263,315.00	FY22
CRL - (Site 19, ID-8523)	RFP	A	2.22	$91,743.00	FY22
CRL - (Site 7, ID-8411)	RFP	A	0.35	$12,221.00	FY22
CRL - (Site 7, ID-8411)	RFP	A	2.41	$12,221.00	FY22
CRL - (Site 8, ID-8431)	RFP	A	0.86	$40,308.00	FY22
CRL - (Site 9, ID-8445)	RFP	A	5.34	$230,668.00	FY22
Fountain Rock Nature Center and Park 1	RFP	A	0.08	$2,911.00	FY22
Fountain Rock Nature Center and Park 2	FPU	A	0.11	$2,911.00	FY22
Fountain Rock Nature Center and Park 3	RFP	A	0.18	$1,663.00	FY22
Fountain Rock Nature Center and Park 4	FPU	A	0.13	$1,940.00	FY22
Md. Ag. Extension Services	FPU	A	0.51	$3,382.00	FY22
Monocacy River Park behind DUSWM	RFP	A	6.60	$99,436.00	FY22
Robin Meadows	RFP	A	3.64	$47,571.00	FY22
CRL-Bry #2	FPU	A	0.24	$9,547.54	FY23
CRL-Bry #4	FPU	A	0.51	$20,468.88	FY23
Dickinson_Dean1	FPU	A	0.31	$1,840.53	FY23
Dickinson_Dean2	FPU	A	0.40	$2,387.30	FY23
Dickinson_Dean3	FPU	A	1.26	$7,609.35	FY23
Dickinson_Dean4	FPU	A	1.95	$11,760.43	FY23
Dickinson_Dean5	FPU	A	0.61	$3,690.03	FY23
Gannon_Jackand Rosalyn2	UTC	A	0.12	$749.16	FY23
Gannon_JackandRosalyn1	RFP	A	1.60	$9,657.52	FY23
Gannon_JackandRosalyn3	UTC	A	0.16	$992.98	FY23
Bledsoe_John1	FPU	A	0.61	$24,277.51	FY24
Bledsoe_John2	FPU	A	0.18	$7,157.02	FY24
Burke_Pamela1	FPU	A	0.38	$15,278.18	FY24
Burke_Pamela1	FPU	A	0.58	$23,285.32	FY24
CRL-Bry #3	FPU	A	0.81	$32,333.31	FY24
FC-Ballenger Creek	FPU	A	7.74	$46,680.35	FY24
FC-Othello Park 2	FPU	A	1.44	$56,373.08	FY24
FC-Othello Park 3	FPU	A	0.73	$78,915.88	FY24

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	COST	YEAR
FC-Othello Park 4a	FPU	A	0.14	$10,943.69	FY24
FC-Othello Park 4b	FPU	A	0.32	$10,943.69	FY24
FC-Othello Park 5	FPU	A	0.29	$5,293.27	FY24
FC-Othello Park1a	FPU	A	1.57	$27,378.23	FY24
FC-Othello Park1b	FPU	A	0.18	$37,201.46	FY24
FC-Roundtree1	FPU	A	0.60	$3,599.76	FY24
FC-Roundtree2	RFP	A	0.07	$422.44	FY24
FC-Utica Park1	FPU	A	0.68	$4,102.21	FY24
FC-Utica Park2	FPU	A	0.19	$1,173.55	FY24
FC-Utica Park3	FPU	A	0.21	$1,253.10	FY24
FC-Utica Park4	FPU	A	0.08	$503.63	FY24
FC-Utica Park5	FPU	A	0.67	$4,017.46	FY24
FC-Utica Park6	UTC	A	0.31	$1,839.33	FY24
Haines_Gary	RFP	A	2.89	$115,746.90	FY24
OWEN P. FARIS AND LEAH MAC	FPU	A	0.69	$10,279.59	FY24
OWEN P. FARIS AND LEAH MAC	RFP	A	1.24	$24,312.86	FY24
Steele_Robert1	FPU	A	1.42	$56,952.60	FY24
Steele_Robert2	FPU	A	2.12	$84,925.81	FY24
Steele_Robert3	RFP	A	1.17	$46,630.51	FY24
No Description	FPU	A	2.89	-	FY24
		Total	**555.76**	**$30,387,518**	

APPENDIX 3: IDENTIFIED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

The table below includes actions that are not yet funded but which have been identified through watershed plans or other studies, and which can help meet impervious area restoration and pollutant load reduction requirements.

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP CREDIT ACRES	COST	YEAR
Stanford Industrial Park, Sec. 3, Pond "A" - Retrofit	PWED	S	6.50	$713,720	FY22
Stanford Industrial, Sec. 3, Pond "B" - Retrofit	PWED	S	9.30	$732,379	FY22
Hannover Regional Facility - Retrofit	PWED	S	20.00	$1,528,451	FY24
The Greens Subdivision - New Stormwater	PWED	S	10.39	$532,198	FY24
New Market West, SWM Pond #1 - Retrofit	PWED	S	19.96	$928,310	FY25
New Market West, SWM Pond No. 2 - Retrofit	PWED	S	20.02	$1,013,265	FY25
Spring Ridge - SWM Pond #9 - Retrofit	PWED	S	13.05	$756,972	FY25
Springdale Detention Pond - Retrofit	PWET	S	7.99	$442,583	FY25
Windsor Knolls Middle School - Retrofit	PWED	S	13.60	$657,000	FY25
Robin's Meadow BMP A - New Stormwater	PWED	S	17.68	$973,759	FY26
Spring Ridge - WQ Basin "E" - Retrofit	PWED	S	18.05	$1,257,903	FY26
The Legends - Retrofit	PWED	S	10.42	$655,978	FY26
Spring Ridge - SWM Pond #10 - Retrofit	PWED	S	17.42	$1,025,760	FY27
Spring Ridge - SWM Pond #8 - Retrofit	PWED	S	25.51	$1,287,290	FY27
Spring Ridge, Quality Pond #4A - Retrofit	PWED	S	19.78	$724,976	FY27
Spring Ridge, Sec. E1E - Pond B3 - Retrofit	PWED	S	8.46	$420,000	FY27
Builders Supply & Lumber (Evergreen Woodworks) - Retrofit	PWET	S	11.60	$609,228	FY28
Rose Hill Manor Maintenance BMP - CARR-2019-MSWG-1101	MSWG	S	0.40	$207,226	FY28
The Vistas at Springdale HOA - Retrofit	PWED	S	9.10	$488,605	FY28
Ballenger Creek Trail New BMP - BALL-2019-SPSC-1103	STRE	S	13.80	$325,352	FY25
CATO-2018-STRE-0001 -	STRE	S	87.38	$3,546,675	FY25
Rose Hill Manor Stream Restoration - CARR-2019-STRE-0025	STRE	S	23.98	$954,395	FY25
LINL-2019-STRE-00005	STRE	S	48.00	$1,860,000	FY27
LINL-2019-STRE-00007	STRE	S	31.00	$1,176,701	FY27
LINL-2019-STRE-00008	STRE	S	30.00	$1,126,503	FY27
		Total	**493.39**	**$23,945,230**	

APPENDIX 4: POTENTIAL PROJECTS AND COSTS

The tables below present **Potential** projects needed to meet all local TMDL reduction targets based on the load reduction results of the TIPP model and cost data from previously completed and currently programmed and identified planned County restoration projects. This plan will be continuously re-evaluated to ensure that the modeling is as accurate as possible and that the most cost-effective strategies are being implemented.

Number of Projects per TMDL Watershed						
BMP Type	Catoctin Creek	Double Pipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy	Total No. of Projects
Bioretention			30			30
Sand Filters	5		25		3	33
Pond Retrofit	4		40		11	55
Submerged Gravel Wetlands	1		20		1	22
Stream Restoration	29	5	147		27	208
Forest Planting	20	5	115		21	161
Riparian Buffer	25	11	125		30	191

Cost per TMDL Watershed						
BMP Type	Catoctin Creek	Double Pipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy	Total Cost by BMP Type
Bioretention			$5,783,539			$5,783,539
Sand Filters	$1,220,027		$6,100,133		$732,016	$8,052,176
Pond Retrofit	$2,836,345		$28,363,446		$7,799,948	$38,999,738
Submerged Gravel Wetlands	$1,256,584		$25,131,687		$1,256,584	$27,644,856
Stream Restoration	$25,592,389	$4,412,481	$129,726,938		$23,827,397	$183,559,205
Forest Planting	$1,186,442	$296,611	$6,822,042		$6,822,042	$9,550,859
Riparian Buffer	$1,912,452	$841,479	$9,562,261		$2,294,943	$14,611,134
Total	**$34,004,239**	**$5,550,570**	**$211,490,046**		**$37,156,651**	**$288,201,506**

APPENDIX 5: MANAGEMENT PRACTICES

STORMWATER BMPS

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 Frederick 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 practices include the following:

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.

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. Part of the County's local TMDL implementation includes Carroll County's Enhanced Surface Sand Filter practices.

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.

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. Part of the County's local TMDL implementation includes submerged gravel wetland projects.

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.

Forest Planting - Urban forest planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The planting area must be 0.5 contiguous acres or greater and have a survival rate of 100 trees planted per area. At least 50% of the trees should have a 2 inch diameter or greater, or a 1 inch caliper at the time of planting.

Urban Tree Canopy - Urban tree canopy planting is the conversion of pervious turf to tree canopy over turf. The understory remains managed (regularly mowed and/or fertilized). One tree planted is the equivalent of 0.01 acre, or 100 trees is equivalent to one acre of implementation. Survival rate is assumed to be 100% and trees are not required to be planted in a contiguous area.

Riparian Forest Buffers - Riparian forest buffers are planted adjacent to a stream, with a recommended buffer of 100 feet and a 35 foot minimum width required.

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.

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.

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.

Dry Detention Ponds - Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow. Hydrodynamic structures are included 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.

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

ALTERNATIVE BMPS

IMPERVIOUS SURFACE DISCONNECTIONS

Frederick 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.

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.

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

STREET SWEEPING

Street sweeping is a source control operational program that the County has managed to reduce pollutant loads. The County uses vacuum sweepers and tracks the mass of material collected.

SEPTIC SYSTEMS

Loads for septic systems in the WTM are based on a loading rate for system type with attenuation through a number of physical processes as well as a standard rate of decay. The number of septic systems was calculated based on the inverse of properties in the County served by sewer in a GIS exercise. Systems are assumed to be conventional, and can be improved upon in a number of ways:

- Septic repairs fix a failing septic system.
- Septic system education is designed to prevent failures through proper management of systems, including regular septic pumping. Effectiveness is based on awareness and willingness to change. A septic system education program will be created in the current permit cycle in the Programmed scenario to meet these goals. A 40% willingness to change is assumed based on Swann (1999) and an awareness factor of 40% is used for a media campaign that includes television.
- Septic connection retirement to sewer requires the ability to connect a system to a sewer line and are not as common but do occur periodically.

SANITARY SEWER OVERFLOW (SSO) REPAIR AND ABATEMENT

SSO abatement is an ongoing program to eliminate deficiencies in the sanitary sewer system that lead to overflows of sewage into streams, primarily during wet weather. The following activities were reported for the County's Chesapeake Bay Two Year Milestones. They are currently underway and are anticipated to be carried out more intensely in the future.

- Sewage pump station upgrades
- Televised inspection of sewer lines
- Sewer line cleaning
- Sewer line and manhole replacements
- Inflow and infiltration projects
- Root control projects

- Smoke testing

ELIMINATION OF ILLICIT CONNECTIONS

Frederick County has a program to control household illicit connections to the storm sewer system, some of which may be cross-connections between sanitary and storm sewers, leading to contaminated flow from stormwater outfalls. The County's IDDE Program identifies potential illicit discharges in three ways: (1) through dry weather screenings completed during as-built inspections and/or triennial maintenance inspections, (2) through citizen and/or agency reporting, and (3) during biological stream sampling within 75 meter segments of the stream. More information about these programs is available in the County's NPDES MS4 Annual Reports.

DOMESTIC PET SOURCE ELIMINATION

For public lands owned by the County, MDE (MDE Bacteria 2014) advocates using agencies such as the park service and public works to improve and/or maintain services such as trash collection and pet waste disposal. The County is working with these entities and reviewing trash collection to identify any potential improvements. These entities are part of the discussion of how to properly implement the pet waste management program. Specifically, the program should include:

- Installation of pet waste stations in areas identified as high dog-walking spots, such as parks and sidewalks
- Assuring the proper management of pet waste stations (such as the regular emptying of waste and replenishment of biodegradable bags)
- A protocol for trash collection and waste disposal, ideally with an identified leader/coordinator who has input from all parties
- Increasing the amount of signage of leash laws and the presence of rangers in parks to support leash law abidance. Possible signs include (VA DEQ, 2011):
    - Picking up your pet's waste helps keep our water clean
    - Pet waste contains bacteria that damages waterways
    - Removal of pet waste required by an ordinance.
    - Neighbors enjoy NOT having to avoid doggie poop while out walking
    - Location of pet waste stations
    - Period reminders

Pet waste management for private land is based on MDE's guidance that "education programs should inform homeowners about pet waste management on their properties and its effects on local waterways. The plan should indicate which agencies are involved and their specific roles." (MDE Bacteria 2014). The pet waste management program will address homeowner education on proper pet waste management and the damage to stream health caused by pet waste. Frederick County initiated various pet waste surveys to obtain feedback from its residents on the habitats that are found throughout the County. Frederick County is moving forward with the next steps of its pet waste program as well as evaluating viable options such as:

- Working with MDE on its Scoop the Poop program
    - MDE (via personal communication with the County's Office of Sustainability and Environmental Resources) is very interested in working to lower pet waste in the state with the Scoop the Poop program. MDE is interested in our proposed sampling effort and may be able to help with outreach

efforts and campaigning. This includes development of graphics, magnets with county-specific mascots, and bone-shaped doggy bag holders which can be attached to a leash.

- Creating a Google Map that shows the locations of pet waste stations in communities (VA DEQ, 2011)
- Identifying agencies/offices, community associations, non-profits, and interested members of the community for assistance in this educational program.

EXPANDED PET WASTE EDUCATION

Swann (1999) conducted a study on pet waste education and determined that to reach the highest percentage of the population possible, education should be based on a variety of media. To encourage pet owners to clean up after their pets, PSAs in newspaper, radio, and television would complement awareness messages being spread on the County's website and its social media accounts. Brochures could also augment the educational effort. In addition to the aware message campaign, the County has the following options:

- Installing pet waste stations in residential areas. Pet waste stations should be located in areas that most likely have a high traffic of pet walkers; this specifically includes high density residential areas as identified with GIS land use maps;
- Appointing a Lead Coordinator who will be responsible for pet waste station and biodegradable bag orders, assembly and installation of stations, station maintenance, and outreach (VA DEQ, 2011)

Addressing pet waste is crucial in order for total bacteria counts to lower in the County's waterways. Therefore it is best for the County to use all of the above measures in a concentrated effort that includes the County, park workers, police, schools, any interested non-governmental associations, and volunteers. By using all outreach methods available, we can assume maximum awareness percentage (45%) and maximum behavior change (56%), resulting in 25% program efficiency (VADEQ 2013).

SILT FENCES

When a vegetated buffer is not possible, silt fences can be installed. Locations for silt fences are identified by pin-pointing sources of erosion in watersheds and intersecting those locations with impermeable areas. Although not as efficient as riparian buffers, silt fences lower the rate of *E. coli* entering water bodies and prevent high peaks in *E. coli* counts after storm events (EPA Office of Water, 2012). While Erosion and Sediment Control may not appear to be related to *E. coli* loads in waters, the reasoning behind this is scientifically supported. Erosion and sediment control do factor into water bacteria counts, since erosion into water sources can bring with it bacteria that otherwise would not have contaminated the source (Pachepsky, Y. A. and Shelton, D. R., 2011).

WILDLIFE SOURCE ELIMINATION

According to MDE in the E. coli TMDL for Double Pipe Creek, "Neither Maryland nor EPA is proposing the wildlife controls to allow for the attainment of water quality standards, although managing the overpopulation of wildlife remains an option for state and local stakeholders" (MDE DP 2009); however the SW-WLAs include wildlife sources and are impossible to meet without wildlife management. In its guidance for bacteria TMDLs (MDE Bacteria 2014), MDE states that:

> *The plan should address vector control (i.e., limiting animal populations that transmit disease pathogens) associated with garbage (rats), animal control issues like raccoons,*

> *resident geese populations, and where appropriate the management of deer populations. For instance, poor trash handling (i.e., not putting trash bags in cans, etc.) often attracts wildlife (e.g., rats, raccoons, and deer) and encourages these animals to stay permanently. This results in unintended population explosions in the urban/developed sector.*

Deer are severely overpopulated due to a loss of natural predators, and cause multiple environmental problems to include the loss of plant understory and fecal matter contamination. Though the TMDL focuses primarily on human sources, deer feces was confirmed to be the source of an *E. coli* outbreak in strawberries in Oregon in 2011. *E. coli* in deer feces can persist in the environment. A study by Andrey Guber et al (2014) showed an increase of bacteria growth of 1.5-3 orders of magnitude within the first 4-8 days of deer droppings, and a rate of die-off which still showed active populations 32 days later. Other studies involving leaf splash of fecal material have shown survival up to 177 days. Guber et al. found that deer pellets have an erodibility similar to cow manure disks, which are easily eroded by rain. Substantial studies exist showing the transport of bacteria from cow manure, so the results may be extrapolable. Deer produce an average of 15 pounds manure per 1000 pounds of animal mass per day according to *Population Density Estimates and Fecal Production Rates* by Lucas Gregory. MDE cited 5.00E+08 counts per deer per day in its TMDL for Shellfish in the Lower Patuxent (MDE PAX 2004) using USEPA (2000). That amounts to 182.5 billion Colony Forming Units (CFUs) per year. The load to the stream would be affected by transport processes on the surface.

In Frederick County, the Doe Harvest Challenge, run by Farmers and Hunters Feeding the Hungry (FHFH), helps to control deer populations. This is an annual competition. While the program is aimed at feeding the hungry, decreasing crop damage, and keeping deer off of roads, this also lowers wildlife sources of fecal bacteria. Participation is free and unlimited, and hunters receive a Doe Harvest Challenge card for each donated doe. In 2012, this resulted in 3,205 donated deer which resulted in 600,000+ meals in food banks, soup kitchens, and churches in the State of Maryland (Frederick County News Release, 2013).

Throughout the year, two Frederick County butchers, Clint's Cuts and Shuff's Meat Market, participate in FHFH, which is a nonprofit that provides venison to the hungry (MarylandBucks.com). Legally harvested deer can be donated for free at any FHFH donation centers, although meat must be clean, field-dressed deer weighing more than 70 lbs (The Gazette 2009). Future plans could attempt to quantify the MPN in deer feces in order to estimate the benefit of this program on *E. coli* removal.

BMPS FOR FUTURE CONSIDERATION

One element of Adaptive Management is to track emerging practices in pollutant treatment technology. The Chesapeake Bay Program has a formal procedure for this through the Water Quality Goal Implementation Team (WQGIT), which will convene an Expert Panel to review possible new treatment. Frederick County is also tracking potential new programs and practices. A short summary of BMPs which may be considered for future restoration plan updates is discussed below. These BMPs address one or more of the pollutants for which TMDLs have been approved

Potential BMP	Priority	Nitrogen	Phosphorus	Sediment	Bacteria
Algal Flow-way Technologies	High	x	x	x	
Stream Stabilization Research	High				x
Septic System Authority	Medium	x			x
Hobby Livestock Fencing	Medium		x	x	x

Potential BMP	Priority	Nitrogen	Phosphorus	Sediment	Bacteria
Expanded Cover Crops	Medium	x	x	x	x
Transient Human Populations	Low				x
Canada Goose Abatement	Medium				x
Protecting Natural Predators of *E. Coli*	Low				x

ALGAL FLOW-WAY TECHNOLOGIES

The WQGIT approved the use of Algal Flow-way Technologies (AFT) for nutrient and sediment reductions for both tidal and non-tidal waters. AFTs are gently inclined systems where water to be treated is pumped on to a raceway or screen and allowed to flow down gradient to an outlet. Algae colonize the raceway and take up nutrients from the source water. Periodically, the algae are harvested and removed for either landfilling or reuse for biofuels, compost, soil amendments, or animal feed and the nutrients are removed from the waterbody.

Nutrient credit is determined through sampling and monitoring the mass and concentrations in the harvested algae. MDE (2014) provided guidance for converting pollutant reductions to impervious acre restoration credit. In future restoration plans, Frederick County could investigate sites where installation would be feasible.

STREAM STABILIZATION RESEARCH

E. coli is found in stormwater, and is associated with erosion from land uses because "particulate matter (PM) in runoff serves as a substrate and generates a shielding mechanism for these organisms" (Dickenson 2012). Perhaps more important than the load coming from the land surface, during storm events the near-bank floodplain, streambank, and stream bottom are significant sources of *E. coli* attached to sediment. The WTM as modeled in this plan does not provide a bacteria reduction credit from stream restoration or near-bank sediment management; however, if loads from these sources can be defined through research, the model can be modified to quantify loads and reductions from reduced stream erosion. A growing body of research shows the importance of stream stabilization as an important tool for *E. coli* reduction in streams impacted by stormwater. For example:

- Byappanahalli et al. (2012) notes that "enterococci may be present in high densities in the absence of obvious fecal sources and that environmental reservoirs of these FIB [fecal indicator bacteria] are important sources and sinks, with the potential to impact water quality". Byappanahalli et al. (2003) found that "median *E. coli* counts were highest in stream sediments, followed by bank sediments, sediments along spring margins, stream water, and isolated pools. This study found "significant correlations between *E. coli* numbers in stream water and stream sediment, submerged sediment and margin, and margin and 1 m from shore" in a small coastal stream in Michigan. The study concluded that *E. coli* in riparian sediment can be both a source and sink of chronically high levels of the bacteria seen in the water column.
- Davies et. al. (2015) found that *E. coli* can be persistent when attached to wet sediment, even to TSS in the water column. They conducted an experiment to look at bacteria survival over time and determined that "throughout the duration of the experiment (68 days), the same proportion of *E. coli* organisms remained culturable, suggesting that sediment provides a favorable, non starvation environment for the bacteria."
- *E. coli* is preferentially transported in the water column by specific suspended sediment particle sizes; therefore, modeling tools that address TSS may be able to be modified to address *E.coli* fate and transport. (Qian 2016)

BMPs which serve to prevent the loss of sediment from various sources including near bank floodplains, stream banks, and stream bottoms will further protect sediment-bound *E.coli* from entering the water column. In personal communication with Dr. Byappanahalli by email, he suggested that populations are not homogenous in the landscape, which makes prediction of reduction from bank controls extremely challenging.

SEPTIC SYSTEM AUTHORITY

Preventing residential systems from failing is a key prevention strategy. There are several approaches to this, with different levels of cost and effectiveness. Current and future programs consist of outreach and education, and upgrade of failing systems through the Bay Restoration Fund. Establishing an authority similar to a wastewater authority could provide additional financial resources to upgrade or restore failed systems or connect them to the WWTP. This would remove the financial burden from the system owner and increase the likelihood of achieving 100% functional systems.

HOBBY LIVESTOCK FENCING

Reductions of bacteria can be calculated on a per-animal removal basis for livestock. Livestock are not included in the SW-WLAs for any TMDLs; however, it is known that residential properties in the watershed often have hobby livestock, to include chickens, horses, and even cattle. An estimate of the number of hobby livestock is not possible, as they are not tracked in the agricultural census; however, elimination of these livestock or reduction of their exposure to runoff has a calculable reduction in the WTM. Dairy cattle, for example, are estimated in the WTM to have a 100% exposure to runoff with a bacteria load of 2,000 bn MPN/yr. There is currently no mechanism to address hobby livestock, but the challenges posed by these animals due to overgrazing/bank trampling and stormwater exposure to fecal material should be considered.

EXPANDED COVER CROPS

There is literature supporting the use of crops and vegetative strips to lower the total counts of fecal coliform in nearby waterways. R.A. Young et al. (1979) quantified the effectiveness of vegetative (crop) buffer strips in controlling pollution from feedlot runoff on a 4% slope. Overall runoff was reduced by 67% by crop buffer strips, and an overall reduction in coliform organisms also occurred. Crop buffer strips lowered the total solids transported by 79%, which would also reduce the number of solids that fecal coliform can bind to and use to reach water bodies. Larsen et al (1994) quantified the reduction in fecal coliform transport from manure to the edge of plots at 83% with the addition of 2 foot-long grass sod filter strips. Bacterial transport was not significantly changed by the rain intensities tested.

The County could institute a program of installing and maintaining narrow filter strips in areas where practices that require more space are not feasible. This could be especially impactful in rural areas with hobby farms, since farming conditions were used in Larsen et al. (1994) The County could develop an educational program aimed at rural areas and areas known to have hobby farms, or an incentive program for private residences to develop and maintain narrow filter strips may be pursued. This intriguing potential future scenario would include identifying total number of acres of crops and sod strips being used for this purpose, and an 83% reduction rate for *E. coli* could be used.

TRANSIENT HUMAN POPULATIONS

MDE recommends jurisdictions to address areas that have frequent homeless population visits and public areas without sanitary facilities. MDE (MDE Bacteria 2014) prescribes working with non-governmental organizations, the health department, police, and schools to develop surveys that can be part of an educational outreach program;

however, the WTM does not take into account educational outreach on health concerns of bacteria in regards to public areas and the homeless.

A comprehensive human source control educational program could include many interested parties working in concert to increase public knowledge of human waste problems in the County. Surveys on areas that are known to be frequented by the homeless could be given out to professionals who have this information, including the police department, health department, and schools. After identifying areas of high traffic, the installation of public restrooms, portable toilets, and/or outreach material on human waste issues could be implemented in identified areas of concern. This would be in conjunction with a County-wide public educational program which should be multimedia based. The County may use television, radio and newspaper public service announcements (PSAs), pamphlets in local stores that volunteer to participate, and County web-pages and social media accounts to ensure the maximum possible percentage of public members are reached. The ability to execute such a program at the current time is low.

CANADA GOOSE ABATEMENT

MDE's bacteria TMDL guidance (MDE Bacterial 2014) states that:

> *poorly vegetated or poorly maintained stormwater management ponds often attract resident geese populations. These factors lead to an increase in bacterial pollution entering nearby waterways. Even though the direct control of these sources does not necessarily fall under the purview of the MS4, bacteria from these sources is transported through the MS4 stormwater collection system to receiving waterbodies.*

Since non-migratory Canada goose (*Branta Canadensis*) populations often return to nesting areas or relocate nearby unless moved at least 200 miles away (French and Parkhurst 2009), techniques that remove significant numbers of geese or prevent them from entering a specific area that is crucial to water conservation should be focused on. The County could start with a list of techniques and identify which ones work best. From French and Parkhurst (2009), unless otherwise noted, these include:

- Husbandry controls
    - Planting species that are less palatable to geese, such as periwinkle, myrtle, pachysandra, English ivy, hosta (plantain lily), and ground junipers
    - Prohibit supplemental feeding of geese, as this promotes continuous congregations of geese in the feeding area
- Non-Lethal Methods
    - Visually frightening devices that resemble scarecrows, owl effigies, or rubber snakes
    - Poles covered with mylar reflective tape, which captures sunlight glare and scares off geese
- Lethal Methods
    - Recreational hunting
    - Addling eggs
    - Oiling or puncturing eggs
- Capture
    - During summer molt, when geese are flightless, geese may be rounded up and captured
        - This is a promising practice not only because the geese are flightless but since most complaints about geese occur in spring and summer (Cooper 1998)

- Temporary barriers such as fences made of wood, wire, rope, or bird-scare tape can be used to enclose and entrap flightless geese
- Other programs have had success in capturing geese for processing and human consumption (Cooper 1998)

Multiple methods may prove to be useful components of a full goose removal/control program. Quantifying the effects of a goose removal program could be based on each adult goose producing up to 1.5 lbs (680.4g) of fecal matter per day (French and Parkhurst, 2009). According to Alderisio and DeLuca (1999), Canada Goose feces contains average concentration of fecal coliform bacteria per gram of 1.53×10^4; furthermore, "fecal sample weights collected from 171 geese ranged from 0.44 to 25.4 g, with a mean of 8.35 g per goose fecal sample." The number of CFU per goose per year is estimated to be: $680.4g/25.4g * 1.53 \times 10^4 *365$, or 149,544,244.

In addition, public education in the form of signs and brochures at parks and areas of recreation would help strengthen community understanding of wildlife waste and the problems it creates for County waterways. The public should be aware of the program's goals (the improvement of water quality and therefore water ecosystems via reduction of wildlife waste sources). The public should also know this Plan does not call for the removal of the entire Canada goose population. Canada goose removal is of lower priority because the coliform source is less concerning than human sources, and because the level of effort required for bacteria removal is not the most efficient.

PROTECTING NATURAL PREDATORS OF E. COLI

The persistence of *E. coli* bacteria in wetted sediments may be attributable in part to an upset in natural predation of these bacteria due to the introduction of agricultural chemicals. Staley et al (2014) inhibited natural predation of *E. coli* using several agricultural chemicals to "isolate the effects of predation or competition on survival of allochthonous bacteria. The result of the experiment was that "each treatment increased the survival of Fecal Indicator Bacteria (FIB) and pathogens. Chlorothalonil's effect was similar to that of cycloheximide, significantly reducing protozoan densities and elevating densities of FIB and pathogens relative to the control. Atrazine treatment did not affect protozoan densities, but, through an effect on competition, resulted in significantly greater densities of En. faecalis and *E. coli* O157:H7. Hence, by reducing predaceous protozoa and bacterial competitors that facilitate purifying water bodies of FIBs and human pathogens, chlorothalonil and atrazine indirectly diminished an ecosystem service of fresh water." In watersheds with combined stormwater and agriculture, decreasing the use of certain agricultural chemicals could lead to reduced bacteria.

Natural Predators of E.coli
"Grazing by bacterivorous protozoa, bacteriophage infection followed by virus-mediated lysis, and predation by some bacteria are among the biotic effects that control the abundance of prokaryotic organisms in the environment. … Bacteriophage infection affects a much wider range of bacteria, and viral infection was suggested to be a mechanism responsible for the elimination of up to 50% of autochthonous bacteria from aquatic habitats …Some estimates suggest that protozoan grazing is responsible for up to 90% of the overall mortality of both autochthonous and allochthonous microorganisms from freshwater and marine environments (Byappanahalli et. al.

CHESAPEAKE BAY (2010)

Scenario	BMP	Description	Length	Impervious	Pervious	Sum of Lbs TN Reduction (EOT)	Sum of Lbs TP Reduction (EOT)
Progress	FBIO	Bioretention	-	1.70	4.70	5,679	1,189
	FSND	Sand Filter	-	8.72	4.52		
	MMBR	Micro-Bioretention	-	0.67	0.25		
	MRWH	Rainwater Harvesting	-	0.05	-		
	PWED	Extended Detention Structure, Wet	-	203.10	330.74		
	PWET	Retention Pond (Wet Pond)	-	49.79	230.51		
	STRE	Stream Restoration	16,664	-	-		
	FPU	Forest Planting	-	-	49.57		
	RFP	Riparian Forest Planting	-	-	222.51		
	UTC	Urban Tree Canopy Planting	-	-	1.70		
Programmed	FBIO	Bioretention	-	55.50	27.75	4,705	837
	MSGW	Submerged Gravel Wetlands	-	181.09	40.56		
	PWED	Extended Detention Structure, Wet	-	817.80	156.40		
	PWET	Retention Pond (Wet Pond)	-	237.59	20.48		
	STRE	Stream Restoration	10,857	-	-		
	FPU	Forest Planting	-	-	121.87		
	RFP	Riparian Forest Planting	-	-	158.12		
	UTC	Urban Tree Canopy	-	-	2.64		
Identified	MSWG	Grass Swale	-	1.27	0.30	983	584
	PWED	Extended Detention Structure, Wet	-	878.24	242.96		
	PWET	Retention Pond (Wet Pond)	-	76.03	19.59		
	STRE	Stream Restoration	11,708	-	-		
Potential	FBIO	Bioretention	-	99.4	184.7	43,321	11,484
	FSND	Enhanced Surface Sand Filter	-	50.90	94.60		
	MSGW	Submerged Gravel Wetlands	-	464.80	863.10		
	PWET	Wet Pond Retrofit	-	733.70	1,362.70		
	STRE	Stream Restoration	224,224	-	-		
	FPU	Forest Planting	-	-	1,423.00		
	RFP	Riparian Forest Planting	-	-	515.20		

APPENDIX 7: LOWER MONOCACY SEDIMENT SCENARIOS

Lower Monocacy River* - Sediment (2000)						
Scenario	**BMP**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TSS Reduction**
Progress	FBIO	Bioretention	-	1.70	4.70	2,319,621.64
	FSND	Sand Filter	-	8.72	4.52	
	MMBR	Micro-Bioretention	-	2.97	1.45	
	MRWH	Rainwater Harvesting	-	0.05	-	
	PWED	Extended Detention Structure, Wet	-	194.07	254.58	
	PWET	Retention Pond (Wet Pond)	-	13.51	52.47	
	STRE	Stream Restoration	5,229	-	-	
	FPU	Tree Planting	-	-	31.38	
	RFP	Riparian Forest Planting	-	-	72.20	
	UTC	Urban Tree Canopy Planting	-	-	0.20	
Programmed	PWED	Extended Detention Structure, Wet	-	73.31	403.67	795,976.37
	MSGW	Submerged Gravel Wetlands	-	25.65	106.04	
	STRE	Stream Restoration	1,565	-	-	
	FPU	Forest Planting	-	-	64.16	
	RFP	Riparian Forest Planting	-	-	34.44	
Identified	MSWG	Grass Swale	-	0.30	0.97	592,515.52
	PWED	Extended Detention Structure, Wet	-	51.28	68.64	
	STRE	Stream Restoration	1,889	-	-	
Potential	FBIO	Bioretention	-	99.40	184.70	48,920,988.09
	FSND	Enhanced Surface Sand Filter	-	38.60	71.70	
	MSGW	Submerged Gravel Wetlands	-	422.50	784.70	
	PWET	Wet Pond Retrofit	-	733.70	1,362.70	
	STRE	Stream Restoration	158,466	-	-	
	FPU	Forest Planting	-	-	368.00	
	RFP	Riparian Forest Planting	-	-	931.30	

APPENDIX 8: LOWER MONOCACY PHOSPHORUS SCENARIOS

Lower Monocacy - Phosphorus (2009)						
Scenario	**BMP**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TP Reduction**
Progress	FBIO	Bioretention	-	1.70	4.70	1,320.94
	FSND	Sand Filter	-	8.72	4.52	
	MMBR	Micro-Bioretention	-	0.67	0.25	
	MRWH	Rainwater Harvesting	-	0.05	-	
	PWED	Extended Detention Structure, Wet	-	194.07	254.58	
	PWET	Retention Pond (Wet Pond)	-	13.51	52.47	
	STRE	Stream Restoration	5,433	-	-	
	FPU	Tree Planting	-	-	38.54	
	RFP	Riparian Forest Planting	-	-	182.30	
Programmed	PWED	Extended Detention Structure, Wet	-	73.31	403.67	500.58
	MSGW	Submerged Gravel Wetlands	-	25.65	106.04	
	STRE	Stream Restoration	2,365	-	-	
	FPU	Forest Planting	-	-	82.25	
	RFP	Riparian Forest Planting	-	-	92.45	
	UTC	Urban Tree Canopy Planting	-	-	0.76	
Identified	MSWG	Grass Swale	-	0.30	0.97	809.10
	PWED	Extended Detention Structure, Wet	-	207.64	498.55	
	STRE	Stream Restoration	7,339	-	-	
Potential	FBIO	Bioretention	-	99.40	184.70	15,471.31
	FSND	Enhanced Surface Sand Filter	-	38.60	71.70	
	MSGW	Submerged Gravel Wetlands	-	422.50	784.70	
	PWET	Wet Pond Retrofit	-	733.70	1,362.70	
	STRE	Stream Restoration	158,466	-	-	
	FPU	Forest Planting	-	-	368.00	
	RFP	Riparian Forest Planting	-	-	931.30	

APPENDIX 9: UPPER MONOCACY SEDIMENT SCENARIOS

Upper Monocacy River - Sediment (2000)						
Scenario	**Bmp**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TSS Reduction**
Progress	STRE	Stream restoration	4,003.5	-	-	1,037,444.00
	FPU	Tree planting	-	-	9.53	
	RFP	Riparian Forest Planting	-	-	2.92	
	UTC	Urban Tree Canopy Planting	-	-	0.80	
Programmed	FBIO	Bioretention	-	27.75	27.75	682,660.72
	PWED	Extended detention structure, wet	-	17.51	46.88	
	STRE	Stream restoration	1,575	-	-	
	FPU	Forest Planting	-	-	9.53	
	RFP	Riparian Forest Planting	-	-	2.92	
	UTC	Urban Tree Canopy	-	-	0.80	
Identified		No BMPs				-
Potential	FSND	Enhanced Surface Sand Filter	-	4.60	8.60	8,866,854.12
	MSGW	Submerged Gravel Wetlands	-	21.10	39.20	
	PWET	Wet Pond Retrofit	-	201.80	374.70	
	STRE	Stream Restoration	29,106	-	-	
	FPU	Forest Planting	-	-	67.20	
	RFP	Riparian Forest Planting	-	-	223.50	

APPENDIX 10: UPPER MONOCACY PHOSPHORUS SCENARIOS

Upper Monocacy River - Phosphorus (2009)						
Scenario	**BMP**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TP Reduction**
Progress	STRE	Stream restoration	4,003.50	-	-	332.35
	FPU	Forest Planting	-	-	7.74	
	RFP	Riparian Forest Planting	-	-	23.96	
Programmed	FBIO	Bioretention	-	27.75	27.75	242.21
	PWED	Extended Detention Structure, Wet	-	17.51	46.88	
	STRE	Stream Restoration	1,575	-	-	
	FPU	Forest Planting	-	-	9.53	
	RFP	Riparian Forest Planting	-	-	2.92	
	UTC	Urban Tree Canopy Planting	-	-	0.80	
Identified		No BMPs				-
Potential	FSND	Enhanced Surface Sand Filter	-	4.60	8.60	2,901.74
	MSGW	Submerged Gravel Wetlands	-	21.10	39.20	
	PWET	Wet Pond Retrofit	-	201.80	374.70	
	STRE	Stream Restoration	29,106	-	-	
	FPU	Forest Planting	-	-	67.20	
	RFP	Riparian Forest Planting	-	-	223.50	

APPENDIX 11 CATOCTIN CREEK SEDIMENT SCENARIOS

Catoctin Creek – Sediment (2000)						
Scenario	**BMP**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TSS Reduction**
Progress	PWED	Extended Detention Structure, Wet	-	9.03	76.16	368,687.53
	PWET	Retention Pond (Wet Pond)	-	19.33	99.59	
	STRE	Stream Restoration	1,439.50	-	-	
	FPU	Forest Planting	-	-	6.46	
	RFP	Riparian Forest Planting	-	-	13.57	
	UTC	Urban Tree Planting	-	-	0.63	
Programmed	PWED	Extended Detention Structure, Wet	-	65.58	210.85	486,455.11
	STRE	Stream Restoration	1,523	-	-	
	FPU	Forest Planting	-	-	5.17	
	RFP	Riparian Forest Planting	-	-	14.25	
Identified	PWED	Extended Detention Structure, Wet	-	19.52	110.93	1,176,939.32
	PWET	Retention Pond (Wet Pond)	-	7.99	51.83	
	STRE	Stream Restoration	4,369	-	-	
Potential	FSND	Enhanced Surface Sand Filter	-	7.70	14.30	9,199,284.14
	MSGW	Submerged Gravel Wetlands	-	21.10	39.20	
	PWET	Wet Pond Retrofit	-	73.40	136.30	
	STRE	Stream Restoration	31,262	-	-	
	FPU	Forest Planting	-	-	64.00	
	RFP	Riparian Forest Planting	-	-	186.30	

Catoctin Creek - Phosphorus (2009)						
Scenario	**BMP**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TP Reduction**
Progress	PWED	Extended Detention Structure, Wet	-	9.03	76.16	163.89
	PWET	Retention Pond (Wet Pond)	-	19.33	99.59	
	STRE	Stream Restoration	1,439.50	-	-	
	FPU	Forest Planting	-	-	4.37	
	RFP	Riparian Forest Planting	-	-	13.57	
Programmed	PWED	Extended Detention Structure, Wet	-	65.58	210.85	255.06
	STRE	Stream Restoration	1,523	-	-	
	FPU	Forest Planting	-	-	5.17	
	RFP	Riparian Forest Planting	-	-	14.25	
Identified	PWED	Extended Detention Structure, Wet	-	19.52	110.93	351.44
	PWET	Retention Pond (Wet Pond)	-	7.99	51.83	
	STRE	Stream Restoration	4,369	-	-	
Potential	FSND	Enhanced Surface Sand Filter	-	7.70	14.30	2,778.23
	MSGW	Submerged Gravel Wetlands	-	21.10	39.20	
	PWET	Wet Pond Retrofit	-	73.4 0	136.30	
	STRE	Stream Restoration	31,262	-	-	
	FPU	Forest Planting	-	-	64.00	
	RFP	Riparian Forest Planting	-	-	186.30	

APPENDIX 13: DOUBLE PIPE CREEK SEDIMENT SCENARIOS

Double Pipe Creek - Sediment (2000)						
Scenario	**BMP**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TSS Reduction**
Progress	STRE	Stream Restoration	1,450	-	-	366,616.83
	RFP	Riparian Forest Planting	-	-	4.03	
Programmed	STRE	Stream Restoration	3,515	-	-	898,719.07
	FPU	Forest Planting	-	-	9.33	
	RFP	Riparian Forest Planting	-	-	10.32	
Identified		No BMPs				-
Potential	STRE	Stream Restoration	5,390	-	-	1,494,893.32
	FPU	Forest Planting	-	-	16.00	
	RFP	Riparian Forest Planting	-	-	82.00	

APPENDIX 14: DOUBLE PIPE CREEK PHOSPHORUS SCENARIOS

Double Pipe Creek - Phosphorus (2009)						
Scenario	**BMP**	**Description**	**Length**	**Impervious**	**Pervious**	**Sum of lbs TP Reduction**
Progress	STRE	Stream Restoration	1,450	-	-	105.15
	RFP	Riparian Forest Planting	-	-	4.03	
Programmed	STRE	Stream Restoration	3,515	-	-	266.06
	FPU	Forest Planting	-	-	9.33	
	RFP	Riparian Forest Planting	-	-	10.32	
Identified		No BMPs				-
Potential	STRE	Stream Restoration	5,390	-	-	517.38
	FPU	Forest Planting	-	-	16.00	
	RFP	Riparian Forest Planting	-	-	82.00	

APPENDIX 15: WTM MODEL ASSUMPTIONS

The WTM requires inputs specific to the watershed. It also contains assumptions which can be modified. Slight modifications were made to the WTM where more specific information was available, and where changes were supported in the literature.

- Primary Sources:
  - Land use and Impervious cover data were based on GIS overlays of the TMDL boundary, the County's MS4 jurisdiction, impervious cover derived from planimetric mapping, and urban land use delineated in MDP's land use/land cover files. To best match the baseline year of 2004, both land use and impervious cover layers as of 2005 were used.
  - The WTM uses a variation of the Simple Method (Schueler, 1987) to calculate loads from urban areas and export coefficients to calculate rural loads. The Simple Method requires an Event Mean Concentration (EMC) to calculate loads. Loads were calculated using EMCs reported in the National Stormwater Quality Database (NSQD) (Pitt et al., 2004). EMCs used in the model are shown below, which also cross-references land use categories from MDP.

MDP Land Use	MDP LU Codes	EMC (MPN/100 mL)
Residential	11,12,13,191,192	8,345
Open Urban	18	7,200
Commercial / Institutional	14,16	4,300
Roadway	80	1,700

  - Annual rainfall: From the Frederick Airport
  - Watershed area: watershed minus municipal areas from GIS
  - Stream miles: stream miles clipped to the watershed boundary in GIS
  - Hydrologic Soil group and depth to groundwater: In GIS from NRCS clipped to watershed boundary minus municipalities
- Secondary Sources
  - Dwelling units:
    - These were calculated in GIS using an overlay of TMDL watersheds, County parcels, residential land use from MDP, and the County MS4 boundary.
    - % Unsewered dwelling units: These were calculated by estimating the number of sewered residential parcels in GIS and subtracting them from the total number of parcels.
  - Septic Systems:
    - % of septic systems <100' to waterway: Calculated by buffering a stream layer by 100 ft and overlaying the result with residential parcel data.
    - Soils: Clay/mixed dominant soils from NRCS
    - System type: assumed to be 100% conventional as this type dominates in Frederick County.
    - Typical separation from groundwater: 5 feet
    - Current septic system management: medium
  - Sanitary Sewer Overflows (SSOs):
    - Default data from WTM was used for number of overflows per mile and quantity of sewage per overflow. Miles of sanitary sewer provided by County agencies.

- Illicit Connections: Businesses from planning layer
- Urban channel
  - Method 1 standard assumption of channel erosion

- Existing Management Practices: Serves as baseline and does not change between model runs.
  - Pet waste education: no
  - BMPs: assume zero for existing scenario
  - Riparian Buffers: calculated from forest layer using 35 foot buffer calculation using total area of forest within the buffer
  - Maintenance: .4, no ordinance
- Future Management Practices: Changes for each model run. WTM1 represents **Completed**, WTM2 is **Programmed**, WTM3 is **Identified** and WTM4 is **Potential**.
  - Pet waste education:
    - **Completed:** No
    - **Programmed**, **Identified**, and **Potential:** yes for all scenarios. From Swann (1999), use multiple outreach methods including television, assume maximum awareness percentage (45%) and maximum behavior change (56%), resulting in 25% program efficiency.
  - Riparian buffers: Acres converted to miles at 35 foot buffer.
  - Stormwater retrofits: Load reductions for wet ponds, wetlands, and filters were not changed from the number given in the WTM. Hunt et al. (2008) found the bacteria removal efficiency of bioretention practices to be 70%. The manner in which the County implements bioswales fits with the Watershed Treatment Model's definition of a bioretention practice; therefore bioswale was given a 70% reduction as well. Scenarios for the WTM for structural stormwater management retrofits come from the same geodatabase export as the nutrient/sediment models for each watershed.
  - Illicit Connection Removal: 100% of the system is surveyed with varying percentages of repairs made. 100% was used for **Potential** treatment.
  - Sanitary Sewer Overflow (SSO) Repair/Abatement: The County has an SSO abatement program and has shown a downward trend of SSOs over time. SSO repair was assumed to be 100% for **Potential** treatment.
  - Septic System Education: A 40% willingness to change is assumed based on Swann (1999) and an awareness factor of 40% is used for a media campaign that includes television. The purpose of the education is to increase the level of routine maintenance and septic pumping to reduce failures.
  - Septic System Repair: Repairs are based on 100% inspection and a repair rate consistent with the number performed by the Health Department for each watershed over a five year period. Septic repairs fix a failing septic system. Repairs were applied to 100% of the systems within the watershed.
  - Septic System Retirement: The County has completed seven of these in the past ten years. This information was reported by the Planning Department.

APPENDIX 16: DOUBLE PIPE CREEK *E.COLI* SCENARIOS

STRUCTURAL BMPS

3 = PROGRESS				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Riparian Buffer		0.00	4.03	4.03
Planting Trees on Pervious Urban	FPU	0.00	4.03	4.03

4 = PROGRAMMED				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Riparian Buffer		0.00	10.32	10.32
Planting Trees on Pervious Urban	FPU	0.00	19.65	19.65

5 = IDENTIFIED				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**

6 = POTENTIAL				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Riparian Buffer		0.00	82.00	82.00
Planting Trees on Pervious Urban	FPU	0.00	16.00	16.00

OPERATIONAL BMPS

1 – COMPLETE		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	115	systems
Septic System Repair	4	systems
Septic System Upgrade	6	systems
Septic System Retirement		

2 – PROGRAMMED		
BMP Type	**Number**	**Unit**
Pet Waste Education	32	households
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

3 – IDENTIFIED		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal	50%	remediated
SSO Repairs		
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

4 – POTENTIAL		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal	50%	remediated
SSO Repairs		
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

APPENDIX 17: LOWER MONOCACY RIVER *E. COLI* SCENARIOS

STRUCTURAL BMPS

1 = BASELINE				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Infiltration Berm	MIBR	0.74	1.16	1.90
Dry Well	MIDW	0.69	0.19	0.88
Grass Swale	MSWG	51.38	558.37	609.75
Bioretention	FBIO	14.60	22.66	37.26
Surface Sand Filter	FSND	4.33	9.17	13.51
Dry Swale	ODSW	0.32	0.01	0.33
Extended Detention Structure, Wet	PWED	495.09	1,553.93	2,049.02
Shallow Marsh	WSHW	16.04	100.05	116.09
Infiltration Basin	IBAS	20.40	14.34	34.74
Infiltration Trench	ITRN	100.45	75.27	175.73
Dry Pond	XDPD	221.02	762.54	983.56
Dry Extended Detention Pond	XDED	800.72	1,399.38	2,200.10

2 = PERMIT				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Micro-Bioretention	MMBR	2.30	1.20	3.50
Bioretention	FBIO	1.70	4.70	6.40
Riparian Buffer		0.00	39.33	39.33
Planting Trees on Pervious Urban	FPU	0.00	66.97	66.97

3 = PROGRESS				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Rainwater Harvesting	MRWH	0.05	0.00	0.05
Micro-Bioretention	MMBR	2.97	1.45	4.42
Bioretention	FBIO	1.70	4.70	6.40
Surface Sand Filter	FSND	8.72	4.52	13.24
Extended Detention Structure, Wet	PWED	194.07	254.58	448.65
Retention Pond (Wet Pond)	PWET	13.51	52.47	65.98
Riparian Buffer		0.00	187.93	187.93
Planting Trees on Pervious Urban	FPU	0.00	243.42	243.42

4 = PROGRAMMED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Submerged Gravel Wetland	MSGW	25.65	106.04	131.69
Extended Detention Structure, Wet	PWED	73.31	403.67	476.98
Riparian Buffer		0.00	102.91	102.91
Planting Trees on Pervious Urban	FPU	0.00	185.92	185.92

5 = IDENTIFIED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Grass Swale	MSWG	0.30	0.97	1.27
Extended Detention Structure, Wet	PWED	207.64	498.55	706.19

6 - POTENTIAL				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Submerged Gravel Wetland	MSGW	525.00	975.00	1,500.00
Enhanced Filters	MENF	490.00	910.00	1,400.00
Bioretention	FBIO	66.30	123.10	189.40
Retention Pond (Wet Pond)	PWET	550.30	1,022.00	1,572.30
Riparian Buffer		0.00	856.80	856.80
Planting Trees on Pervious Urban	FPU	0.00	368.00	368.00

OPERATIONAL BMPS

1 – COMPLETE		
BMP Type	Number	Unit
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	5,207	systems
Septic System Repair	7,648	systems
Septic System Upgrade	98	systems
Septic System Retirement	12	systems

2 – PROGRAMMED		
BMP Type	Number	Unit
Pet Waste Education	2,648	households
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

3 – IDENTIFIED		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal	50%	remediated
SSO Repairs	35%	remediated
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

4 – POTENTIAL		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal	50%	remediated
SSO Repairs	40%	remediated
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

APPENDIX 18: UPPER MONOCACY RIVER *E.COLI* SCENARIOS

STRUCTURAL BMPS

1 = BASELINE				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Bioretention	FBIO	10.05	2.79	12.84
Dry Swale	ODSW	0.35	0.06	0.41
Extended Detention Structure, Wet	PWED	102.57	75.16	177.73
Shallow Marsh	WSHW	31.90	56.61	88.51
Infiltration Trench	ITRN	55.41	87.09	142.51
Dry Pond	XDPD	72.04	201.70	273.74
Dry Extended Detention Pond	XDED	113.59	274.29	387.88

2 = PERMIT				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Riparian Buffer		0.00	0.51	0.51
Planting Trees on Pervious Urban	FPU	0.00	1.01	1.01

3 = PROGRESS				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Riparian Buffer		0.00	24.47	24.47
Planting Trees on Pervious Urban	FPU	0.00	32.20	32.20

4 = PROGRAMMED				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Bioretention	FBIO	27.75	27.75	55.50
Extended Detention Structure, Wet	PWED	17.51	46.88	64.39
Riparian Buffer		0.00	17.07	17.07
Planting Trees on Pervious Urban	FPU	0.00	27.41	27.41

6 - POTENTIAL				
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**
Submerged Gravel Wetland	MSGW	73.40	136.20	209.60
Enhanced Filters	MENF	110.10	204.40	314.50
Retention Pond (Wet Pond)	PWET	165.10	306.60	471.70
Riparian Buffer		0.00	111.80	111.80
Planting Trees on Pervious Urban	FPU	0.00	32.00	32.00

OPERATIONAL BMPS

1 – COMPLETE		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	1,721	systems
Septic System Repair	1,956	systems
Septic System Upgrade	97	systems
Septic System Retirement	1	systems

2 – PROGRAMMED		
BMP Type	**Number**	**Unit**
Pet Waste Education	600	households
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

3 – IDENTIFIED		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal	50%	remediated
SSO Repairs	50%	remediated
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

4 – POTENTIAL		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Illicit Connection Removal	50%	remediated
SSO Repairs	50%	remediated
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		