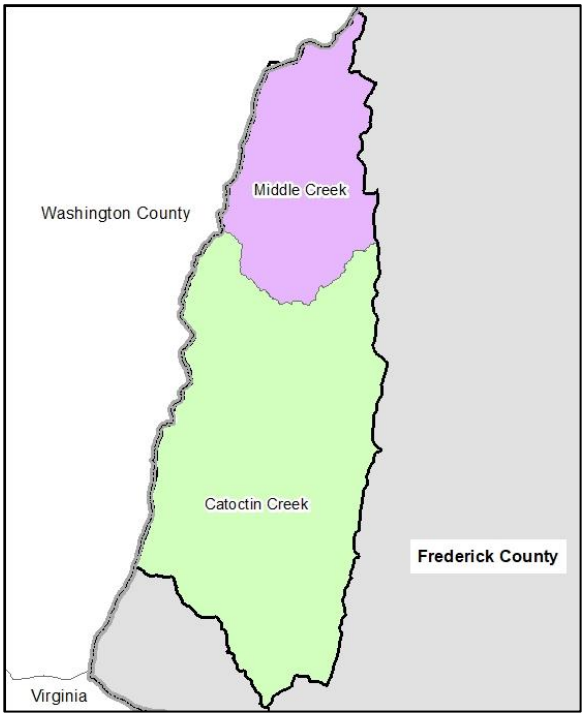
Dewberry



Catoctin Creek Watershed Assessment

Frederick County, MD

May 2019

SUBMITTED BY:

Dewberry
10461 Mill Run Circle
Suite 300
Owings Mills, MD 21117

SUBMITTED TO:

Frederick County Office of Sustainability and Environmental Resources
30 North Market St.
Frederick, MD 21701

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EXECUTIVE SUMMARY

Frederick County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase I Permit, Chesapeake Bay Total Maximum Daily Load (TMDL), and local watershed TMDLs, require the County to identify and prioritize structural and nonstructural water quality improvement projects within its watersheds. Specifically, the County's NPDES MS4 Phase I Permit requires the County to develop detailed watershed assessments for each of its Maryland hierarchical 8-digit watersheds located within the County's jurisdictional boundary. The watershed assessments are required to identify and ranks projects geared towards meeting applicable pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater Waste Load Allocations (SW-WLAs). The goal of this Catoctin Creek Watershed Assessment is to provide a framework the County can follow to improve water quality conditions using strategic restoration efforts for meeting NPDES MS4 Phase I, local TMDL, and Chesapeake Bay TMDL requirements in the most cost-effective manner. In addition, the watershed assessment follows the Environmental Protection Agency's (EPA) Clean Water Act Section 319 guidance for development of a watershed plan and addresses Elements "a-i", helping to make the County eligible for potential grant funding for restoration efforts.

The Catoctin Creek Watershed is located in western Frederick County and is approximately 77,000 acres in size. It consists of two NPDES watersheds – Catoctin Creek and Middle Creek – and is almost 50% agricultural with the remaining land roughly split between urban and forested land uses. According to values published in the *Frederick County Stormwater Restoration Plan* (December 2018), the County will need to reduce Total Phosphorus (TP) loads by 955 lbs. and Total Suspended Sediment (TSS) loads by 1,411,681 lbs. in order to meet the SW-WLAs published in the local TMDLs for Catoctin Creek. The towns of Middletown, Myersville, Burkittsville, and Jefferson are four incorporated municipalities within the watershed. Middletown and Myersville are covered by a NPDES MS4 Phase II permit; therefore, areas within these town boundaries were not evaluated as part of this assessment.

Frederick County's three-step evaluation process for conducting watershed assessments was used to complete this effort. The evaluation includes a GIS desktop analysis to review available data and identify potential opportunity locations; field/visual assessments to evaluate potential opportunities and assess existing conditions; and a post-field analysis to establish proposed restoration techniques, estimate treatment and costs, and rank potential opportunities. The opportunities evaluated as part of the Catoctin Creek Watershed Assessment include pond retrofit sites, new stormwater best management practice (SWM BMP) locations, and stream restoration locations. A total of thirty-nine (39) pond retrofits, thirty (30) new SWM BMPs, and forty-three (43) stream restoration sites were identified during the GIS desktop analysis. Of these, twenty-two (22) pond retrofit, twelve (12) new SWM BMP, and twenty (20) stream restoration sites were assessed in the field. Following the post-field analysis, twelve (12) pond retrofit, one (1) new SWM BMP, and five (5) stream restoration sites were taken to feasibility concepts. Proposed practice types selected for pond retrofits included Enhanced Surface Sand Filters, Pocket Sand Filters, Wet Ponds, Extended Detention Wet Ponds, and a Pocket Pond. The proposed practice type for the new SWM BMP is a Regenerative Step Pool Conveyance. The stream restoration projects propose a combination of Natural Channel Design and Legacy Sediment Removal design approaches that aim to provide stream function and ecological improvements.

Once feasibility concepts were developed for each of the proposed locations, pollutant load reductions, impervious acre treatment, and costs were estimated using guidance from the Maryland Department of Environment (MDE), Frederick County, and the Urban Stormwater Workgroup. Nutrient and impervious acre credit, cost, construction, and community and watershed impact metrics were then used to prioritize and rank the projects. The proposed projects taken to feasibility concept provide an estimated total impervious treatment credit of 196.54 acres. Pollutant reduction estimates (Edge of Stream) for the feasibility concept projects sum to 2,108 lbs./year of Total Nitrogen, 986 lbs./year of TP, and 607,731 lbs./year of TSS. The TP and TSS reductions anticipated from full implementation of the feasibility concept projects represent 103% and 43% of the required reductions for the local TMDLs respectively. The estimated cost of implementing these restoration projects is $10,806,581.

Catoctin Creek Watershed Assessment Report

Frederick County, MD

1. INTRODUCTION

1.1. Purpose of Watershed Assessment

Regulatory drivers such as Frederick County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase I Permit, the Chesapeake Bay Total Maximum Daily Load (TMDL), and local watershed TMDLs, require the County to improve water quality conditions within its watersheds. Specifically, the County's NPDES MS4 Phase I Permit requires the County to develop detailed watershed assessments for the entire County and restore twenty percent (20%) of the impervious area that is not already restored to the maximum extent practicable (MEP).

Detailed below are the specific permit requirements and associated assessment approaches used for the Catoctin Creek Watershed Assessment (8-digit Watershed ID 02140305).

1. PERMIT REQUIREMENT: Determine current water quality conditions.
   ASSESSMENT APPROACH: The Catoctin Creek Watershed Assessment used an ArcMap GIS desktop analysis to evaluate existing data, including the results of the Frederick County Stream Survey (FCSS), to identify potential areas of impairments and opportunities to improve water quality. Property owners and stakeholders were then contacted to further understand what impairments they see as well as request permission to access their property to visually assess the area.
2. PERMIT REQUIREMENT: Include the results of a visual watershed inspection.
   ASSESSMENT APPROACH: Visual assessments were then conducted during which general sketches and photos were taken to assist in developing approaches to improve water quality.
3. PERMIT REQUIREMENT: Identify and rank water quality problems.
   ASSESSMENT APPROACH: Following the visual watershed inspection, existing conditions and opportunities were ranked using an established prioritization matrix.
4. PERMIT REQUIREMENT: Prioritize all structural and nonstructural water quality improvement projects.
   ASSESSMENT APPROACH: Opportunities receiving the highest ranking were prioritized for development of feasibility concepts for restoration. Estimated costs, impervious acre treatment, and pollutant load reductions were calculated and used to develop a final prioritization of the opportunities.
5. PERMIT REQUIREMENT: Specify pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater wasteload allocations (SW-WLAs).
   ASSESSMENT APPROACH: The County identified pollutant load reduction benchmarks and deadlines in their *Frederick County Stormwater Restoration Plan* (December 2018). Information specific to the Catoctin Creek Watershed is included in the assessment.

1.2. Watershed Assessment Objectives

The goal of the Catoctin Creek Watershed Assessment is to provide a framework for meeting NPDES MS4 Phase I, Chesapeake Bay TMDL and local TMDL requirements. The watershed assessment analyzes existing conditions, identifies priority areas for restoration, prioritizes restoration projects to address target pollutants, develops cost estimates for implementation, proposes a schedule for implementation, discusses education and outreach opportunities, and establishes a process for monitoring and measuring project success. As illustrated in Figure 1, the County has developed a three-step evaluation process for conducting watershed assessments to meet these objectives.

The assessment also follows Environmental Protection Agency's (EPA) Clean Water Act Section 319 grant funding program requirements. EPA has identified nine (9) watershed elements to be included in watershed plans, referred to as Elements "a-i" and briefly described below:

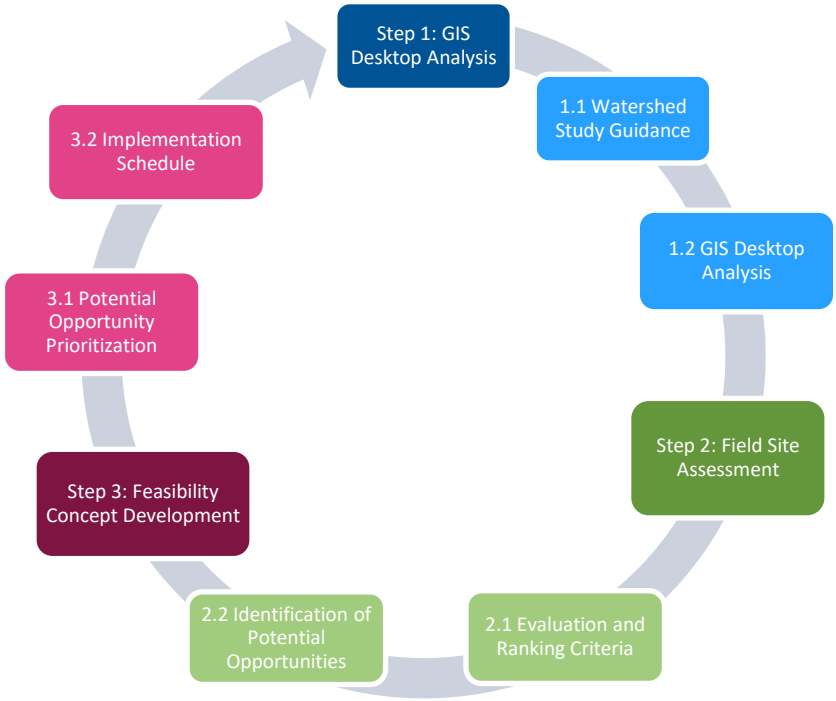

Figure 1: Overview of Watershed Assessment Process

- **Element a – Identify Causes & Sources of Impairments:** Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed.
- **Element b – Expected Load Reductions from Management Measures:** Attribute and quantify pollutant loads for each source of impairment. Calculate the estimated load reductions expected from the proposed management measures.
- **Element c – Identify Proposed Management Measures:** A description of the proposed management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be needed to implement this plan.
- **Element d – Technical and Financial Assistance Needs:** Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.
- **Element e – Information, Education, and Public Participation:** An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the proposed management measures that will be implemented.
- **Element f - Schedule:** Schedule for implementing the proposed management measures identified in the plan.
- **Element g – Milestones:** A description of interim milestones for determining whether nonpoint source management measures or other control actions are being implemented.
- **Element h – Load Reduction Evaluation Criteria:** Provide a summary of the set of criteria to be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards. Show that criteria meet quantitative and qualitative measures and identify interim water quality indicator milestones.
- **Element i – Monitoring Component:** Provide a summary of a monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established in Element h.

1.3. Catoctin Creek Watershed Overview

Maryland has delineated the state's waterways into 138 watersheds which generally represent drainage divides between 3rd order rivers or streams. There are five state delineated 8-digit watersheds within Frederick County. Due to their relative size, the County has further divided the 8-digit watersheds into smaller NPDES watersheds which are further subdivided into sub-watersheds and catchments (Figure 2). The Catoctin Creek 8-digit Watershed (02140305) is located in western Frederick County and is the focus of this watershed assessment (Figure 3).

The Catoctin Creek 8-digit Watershed is 77,062 acres in size and is almost completely contained within Frederick County, with approximately 150 acres located in Washington County. The 8-digit watershed is comprised of two (2) NPDES watersheds – Catoctin Creek and Middle Creek (Figure 4), 22 sub-watersheds (Figure 5), and 212 catchments.

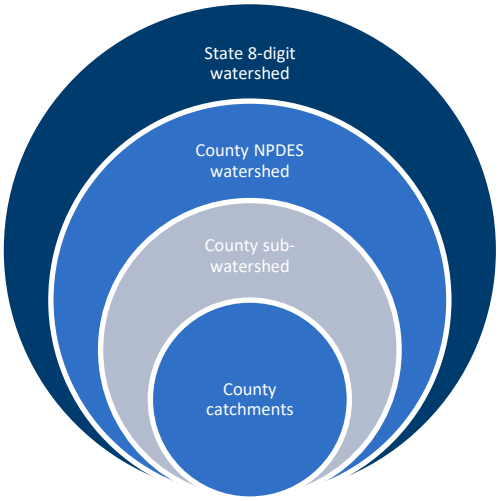

Figure 2: Nesting of State delineated watersheds and County delineated watersheds

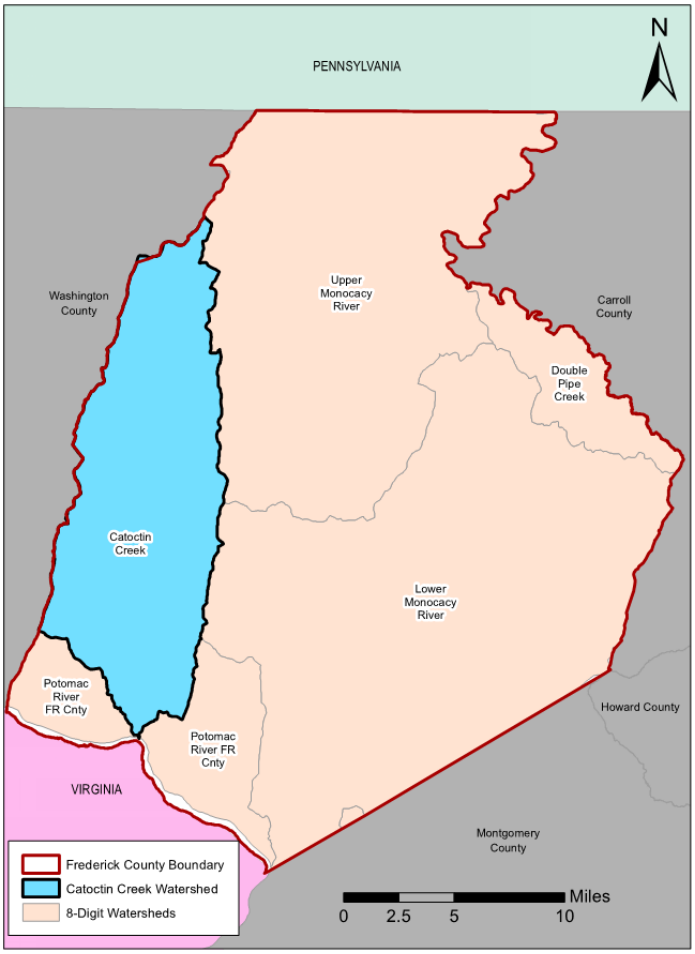

Figure 3: Vicinity Map

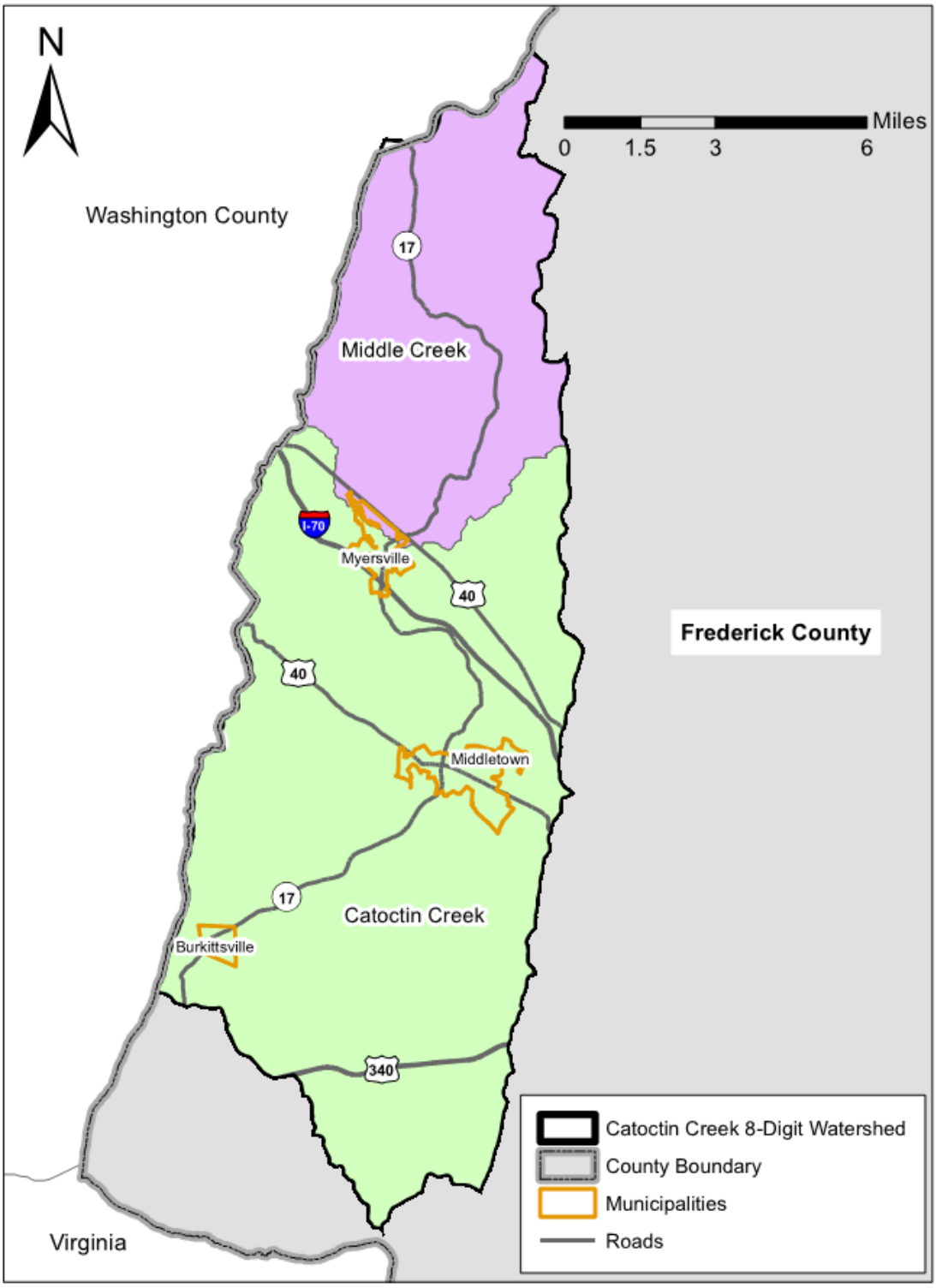

Figure 4: NPDES Watersheds within Catoctin Creek Watershed

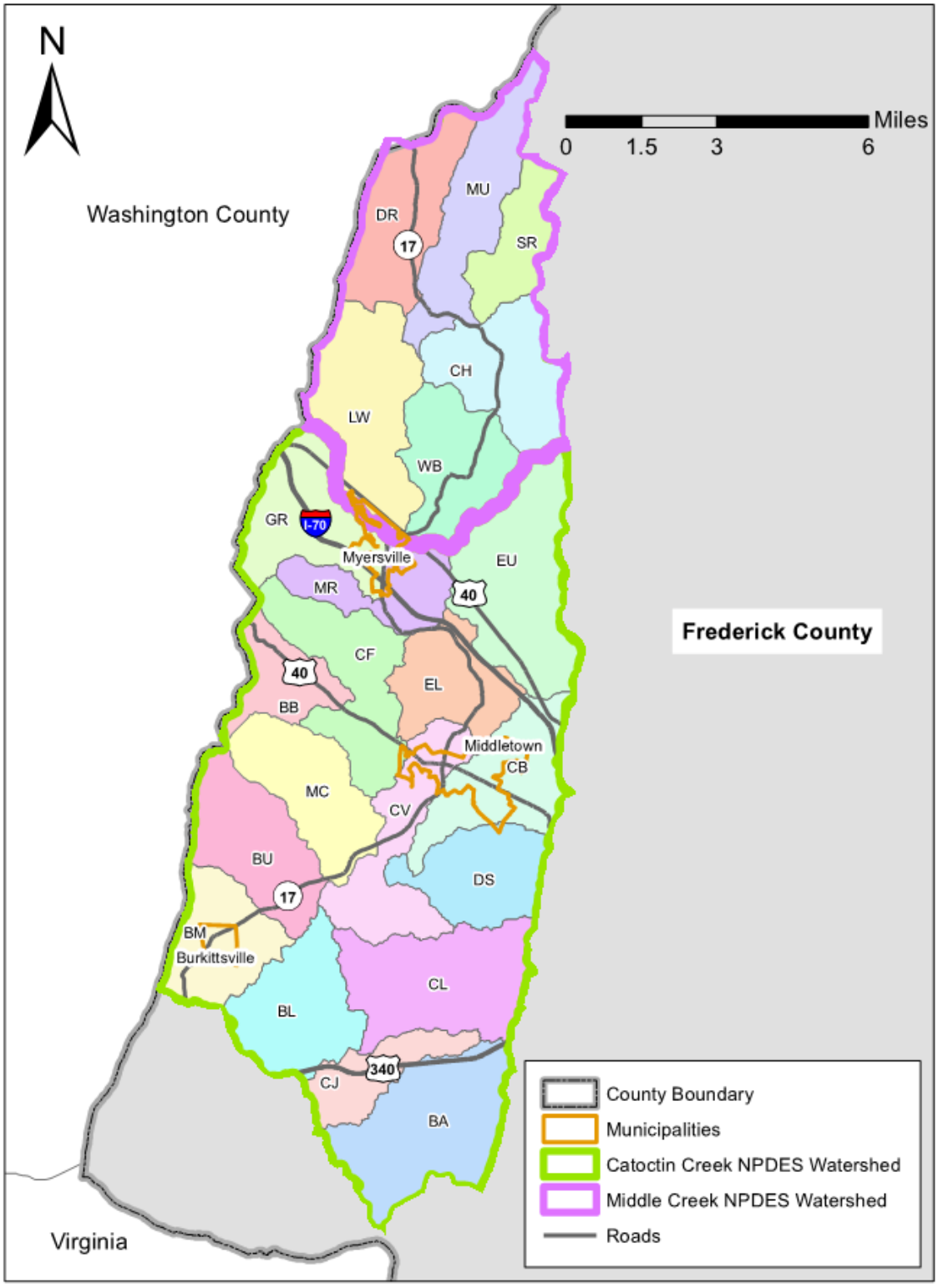

Figure 5: Sub-Watersheds within Catoctin Creek Watershed

NOTE: A table of the sub-watersheds can be found in Appendix A

2. EXISTING WATERSHED CONDITIONS AND POLLUTANT LOADS

2.1. Existing Watershed Conditions

Surface water quality and watershed condition are driven by the predominant land use/land cover, the extent of development, the number and types of existing stormwater controls, and the amount of protected natural resources within the watershed boundary. Dewberry used available GIS data from Frederick County's Interagency Information Technologies (IIT) Division, the Maryland Department of Natural Resources (DNR), the Maryland Department of Environment (MDE), and the Maryland Department of Planning (MDP) to evaluate the existing conditions within the Catoctin Creek Watershed. Reviewed data included mapped streams, roads, and stormwater infrastructure; designated uses; land use/land cover; protected lands; and mapped green infrastructure hubs and corridors. Frederick County IIT data used to evaluate existing conditions was provided on October 11, 2017.

2.1.1. Use Classes and Designated Uses for Surface Waters

The Code of Maryland Regulations (COMAR) Section 26.08.02.08 assigns use classes to Maryland's surface waters (rivers/ streams, impoundments, and tidal waters). The use class is a set of designated uses that apply to a waterbody which individually may or may not be supported now, but should be attainable. Waterbodies which do not meet the assigned designated use are considered impaired and identified for potential development of a TMDL (as discussed in Section 2.2). A summary of the use classifications and designated uses for surface waterbodies in Maryland is provided in Appendix A. The predominant use classes within the Catoctin Creek Watershed include I-P (Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply), III-P (Nontidal Cold Water and Public Water Supply), and VI-P (Recreational Trout Waters and Public Water Supply) (Figure 6).

2.1.2. Land Use

MDP has developed a land use/land cover map to show development trends on the landscape in Maryland. In order to provide a concise summary of existing conditions within the Catoctin Creek Watershed, Dewberry reclassified the MDP land use/land covers into seven (7) categories: urban, agricultural, forest, water, wetlands, barren land, and transportation. Only five (5) categories are represented within the Catoctin Creek Watershed as areas categorized by MDP as wetlands and barren land do not exist within the watershed.

The predominant land uses/land covers within the Catoctin Creek Watershed (Figure 7) are agricultural (47%), forest (28%), and urban (24%). The urbanized areas are mainly within the incorporated municipalities of Middletown, Myersville, and Burkittsville, as well as the incorporated municipality of Jefferson. Middletown is located in the east portion of the watershed and is approximately 1,256 acres in size. Myersville is located near the center of the watershed and is approximately 658 acres in size. Burkittsville is located in the southwest portion of the watershed and is approximately 289 acres in size. Middletown and Myersville are NPDES MS4 Phase II Municipalities with their own restoration requirements; therefore, areas within their municipal boundaries were not evaluated for restoration opportunities. The breakdown of land use/land cover in the Frederick County portion of the Catoctin Creek Watershed is presented in Table 1 and Chart 1.

Table 1: Watershed Land Use/Cover

Land Use Category	Catoctin Creek	
	Acres	Percent
Urban	18,708	24.32%
Agricultural	36,365	47.28%
Forest	21,503	27.96%
Water	31	0.04%
Transportation	306	0.40%
TOTAL	**76,913**	**100%**

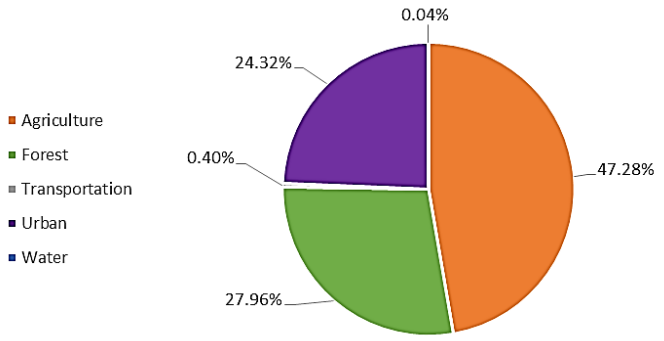

Chart 1: Catoctin Creek Watershed Land Use

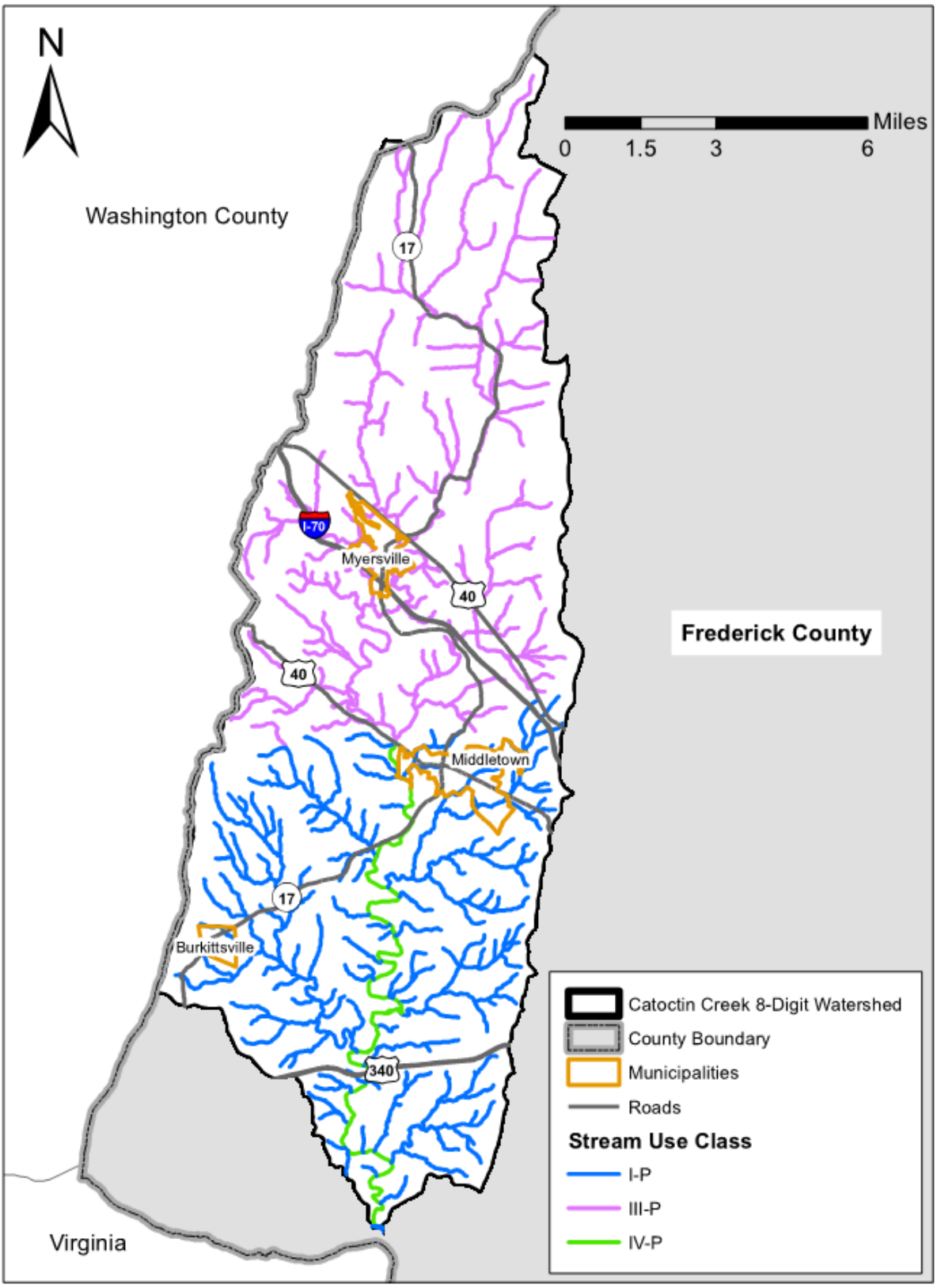

Figure 6: Stream Use Classes within Catoctin Creek Watershed

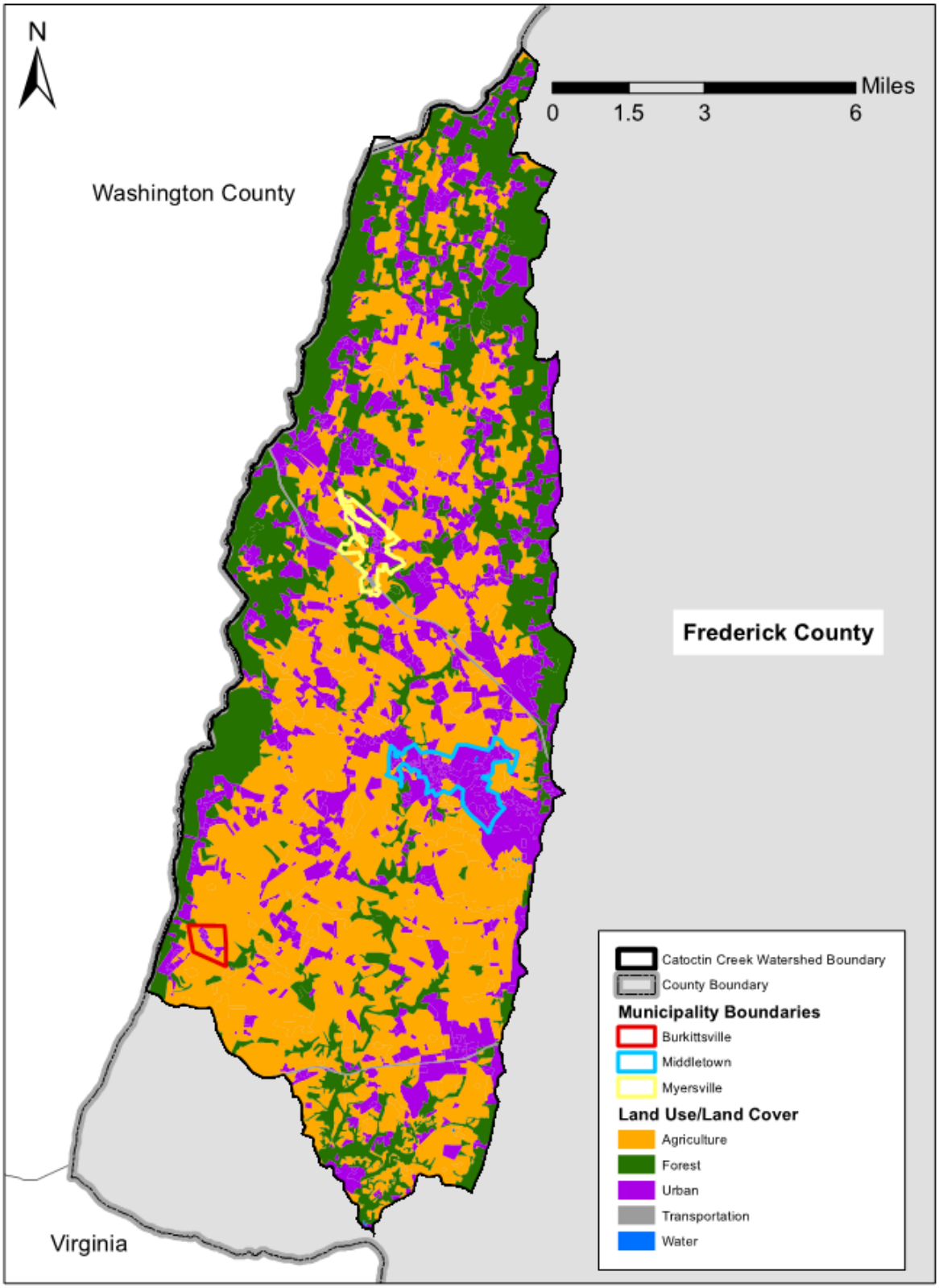

Figure 7: Catoctin Creek Watershed Land Use/Land Cover

2.1.3. Protected Lands

The potential for changes in stream health is partially mitigated by the density of protected lands within a watershed since these are areas that are at a lower risk of future development. Approximately 17% (13,355 acres) of land are protected within the Catoctin Creek Watershed per Maryland DNR GIS data (Figure 8). Maryland Environmental Trust properties account for the largest number of protected land parcels within the watershed (191 parcels), while agricultural easements account for the largest amount of protected land area (4,742 acres).

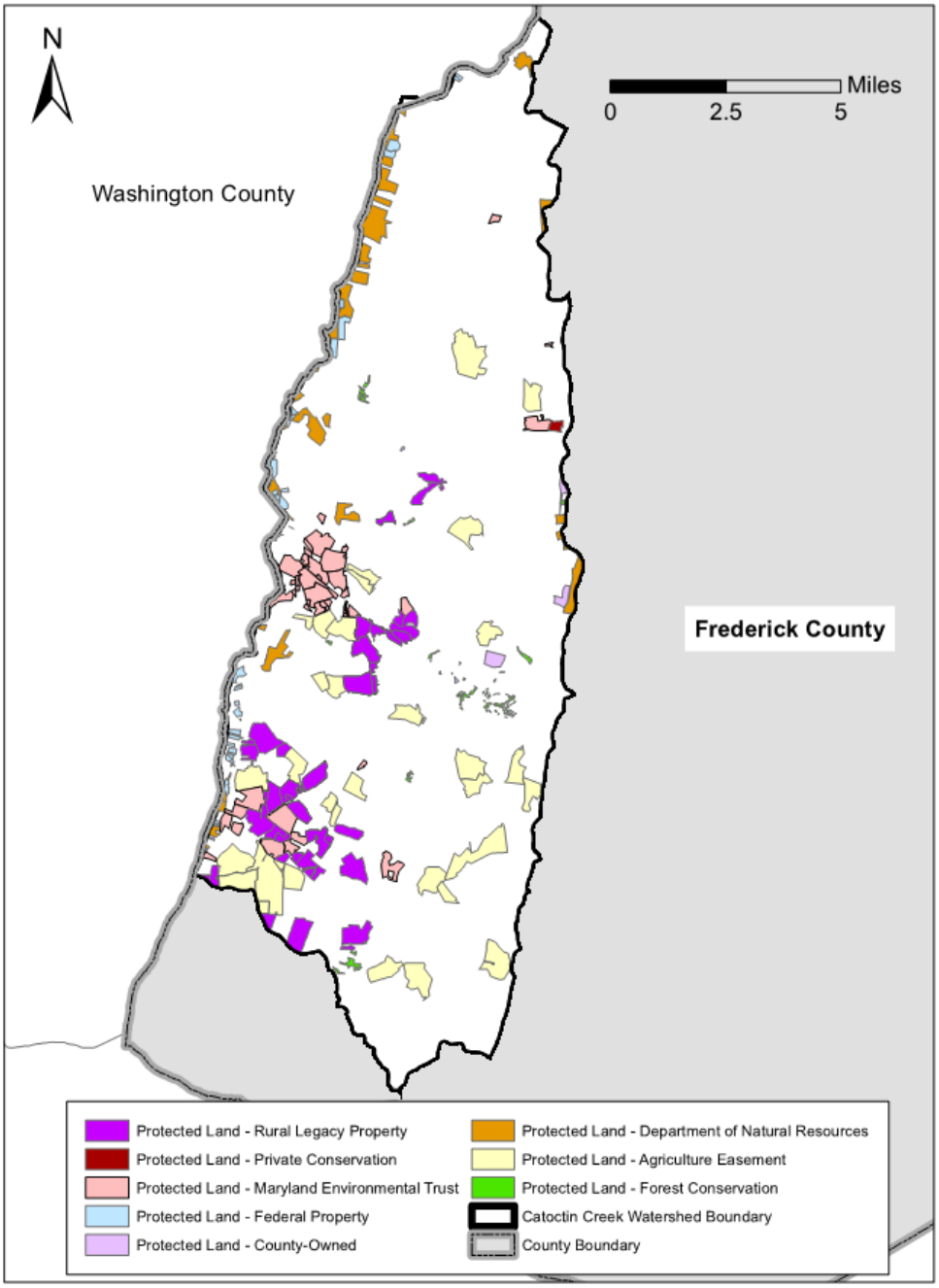

Figure 8: Catoctin Creek Watershed Protected Lands

2.1.4. Green Infrastructure

Green Infrastructure is undeveloped lands, such as forests and wetlands that provide beneficial ecosystem services. These areas are most often recognized for the vital habitat they provide to wildlife, but in a watershed context they are also important for filtering rainwater, storing and cycling nutrients, reducing soil erosion, and maintaining hydrologic function. Approximately 33% (25,128 acres) of land within the Catoctin Creek Watershed has been identified as green infrastructure hubs and corridors (Figure 9).

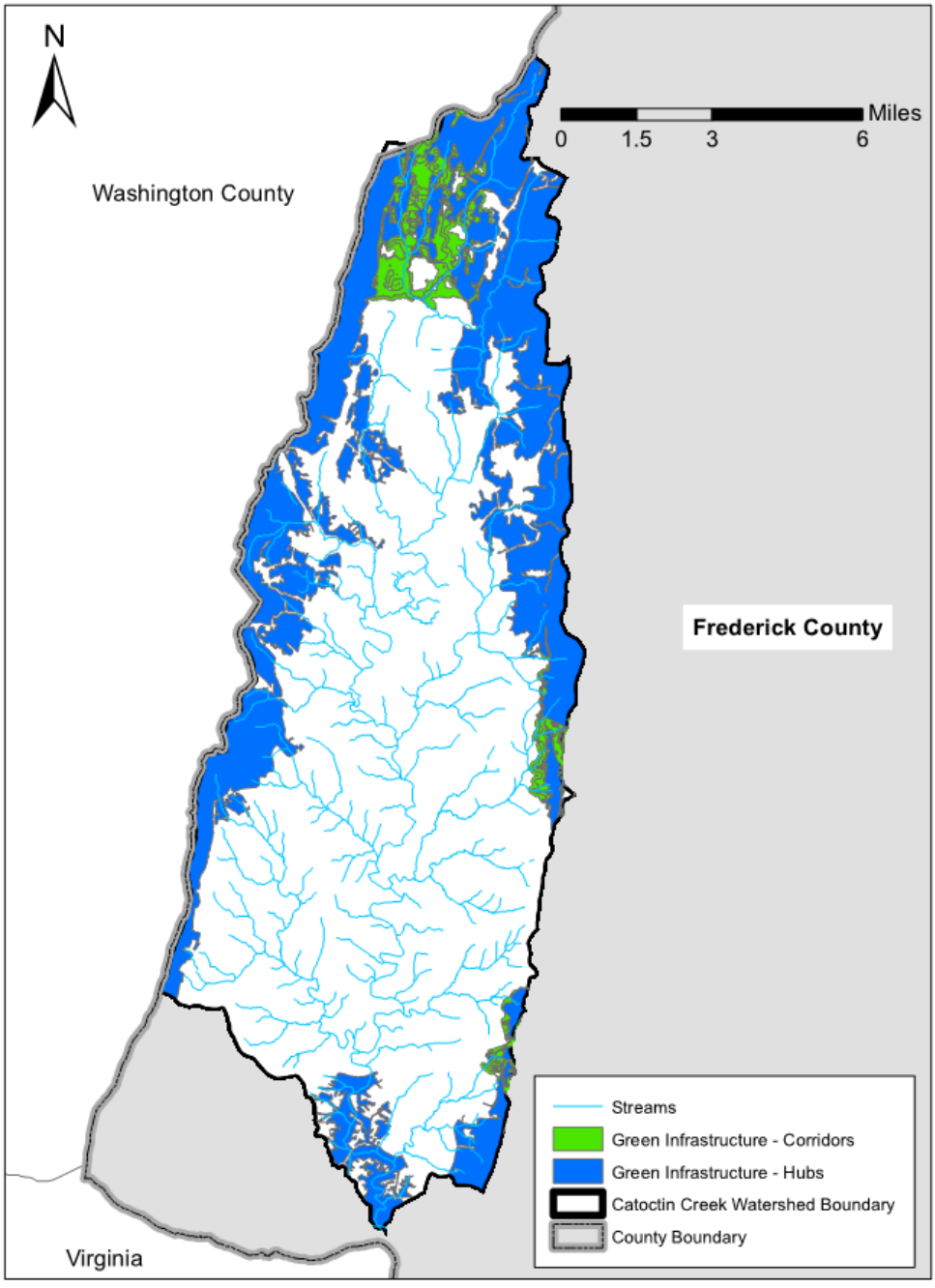

Figure 9: Catoctin Creek Watershed Green Infrastructure

2.1.5. Existing SWM BMPs

The Frederick County NPDES database (version received on 10/11/2017) contains a total of 150 stormwater best management practices (SWM BMPs) within the Catoctin Creek Watershed (Figure 10), 91 of which are shown as having pre-2002 design approval dates. Approximately 1,850 acres of the watershed fall within the 150 existing SWM BMP drainage areas. Land developed before 2002 is considered untreated because stormwater design standards that were in place at the time did not require water quality volume treatment for one inch of runoff. Section 3.2.1 discusses the GIS analysis steps taken to identify the pre-2002 BMPs that were targeted for retrofit during this study.

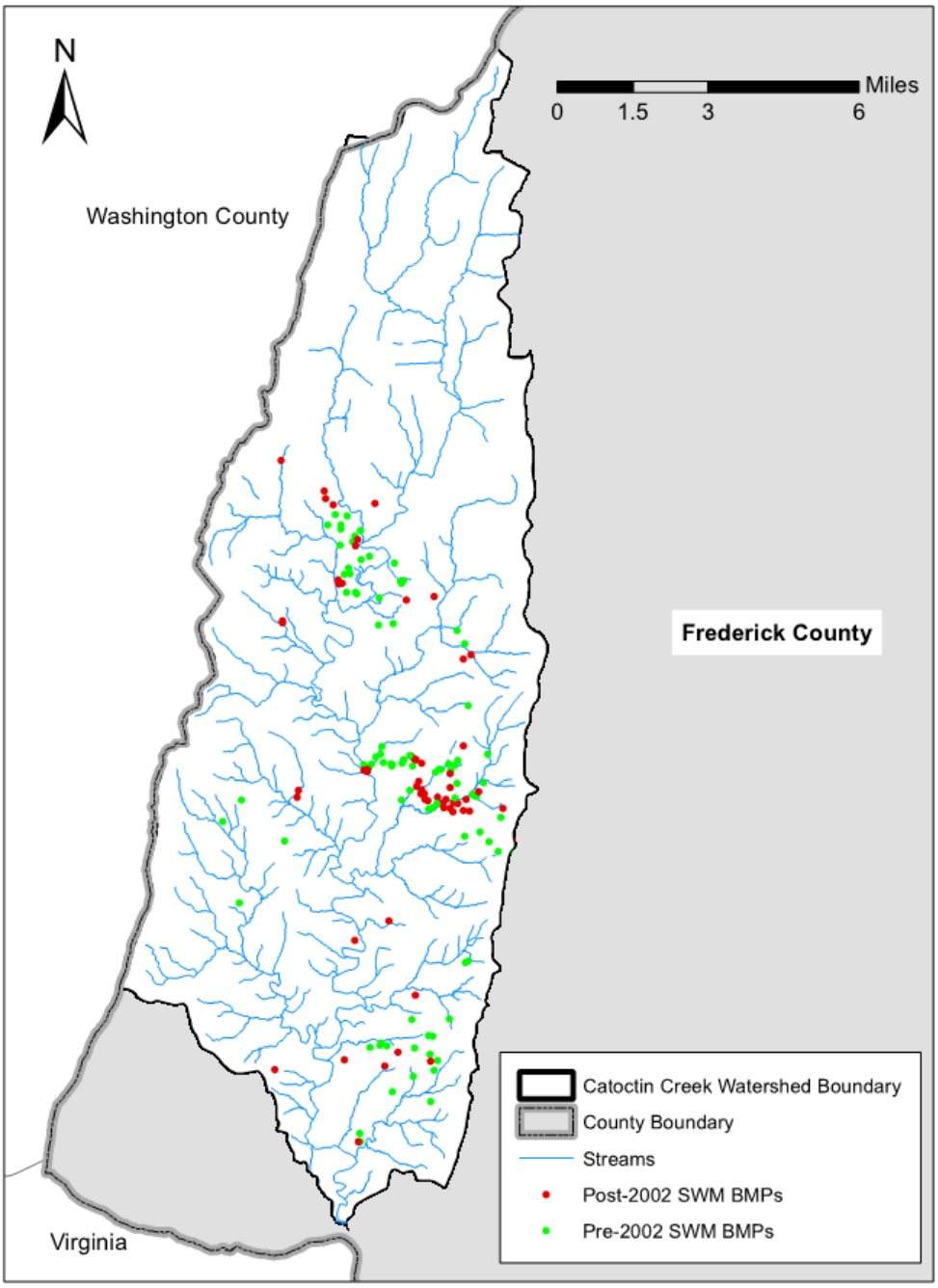

Figure 10: Catoctin Creek Watershed Existing SWM BMPs

2.1.6. Biological Monitoring Data

The Frederick County Stream Survey (FCSS) is a program that assesses the health of County streams through the collection and analysis of biological, water quality, and physical habitat data. The survey uses a stratified random statistical site selection design at the countywide scale, and follows methods similar to the Maryland DNR's Maryland Biological Stream Survey (MBSS). Round 1 of FCSS sampling occurred from 2008 to 2011, Round 2 was from 2013 to 2016, and the County is currently conducting Round 3.

The Frederick County Stream Survey 2013-2016 Four-year Report (Versar 2017) summarizes biological conditions by State 8-digit watersheds, including the Catoctin Creek Watershed. The report also summarizes data by County NPDES watershed, including Catoctin Creek and Middle Creek. Data collected during Round 2 of the FCSS program resulted in a Physical Habitat Index (PHI) rating of Degraded and a Benthic Index of Biological Integrity (BIBI) rating of Fair. Figure 11 shows the Round 2 PHI ratings of each site and Figure 12 shows the Round 2 BIBI ratings for each site. Both figures also show the average rating by NPDES watershed.

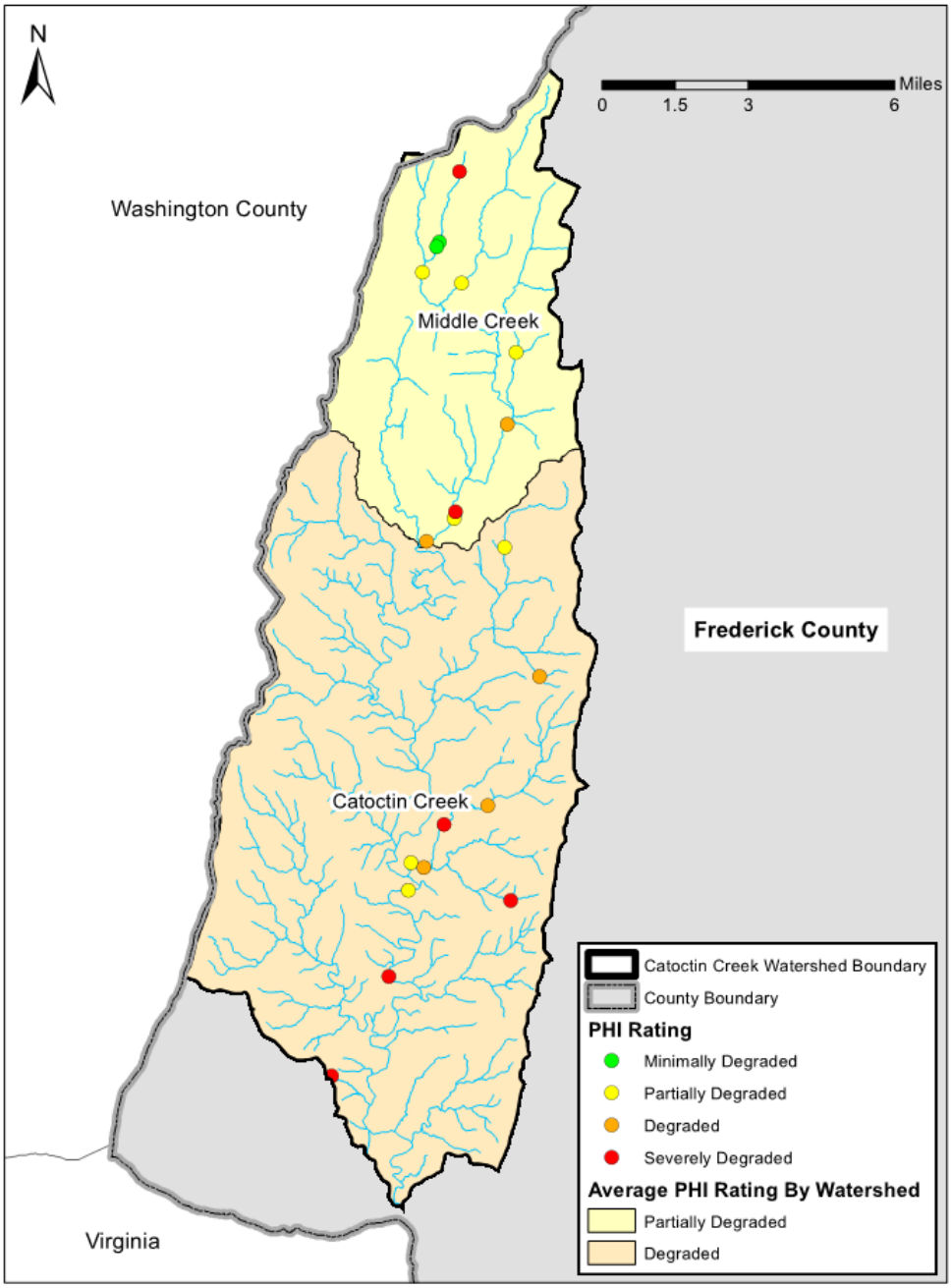

Figure 11: Catoctin Creek Watershed FCSS Round 2 PHI Data

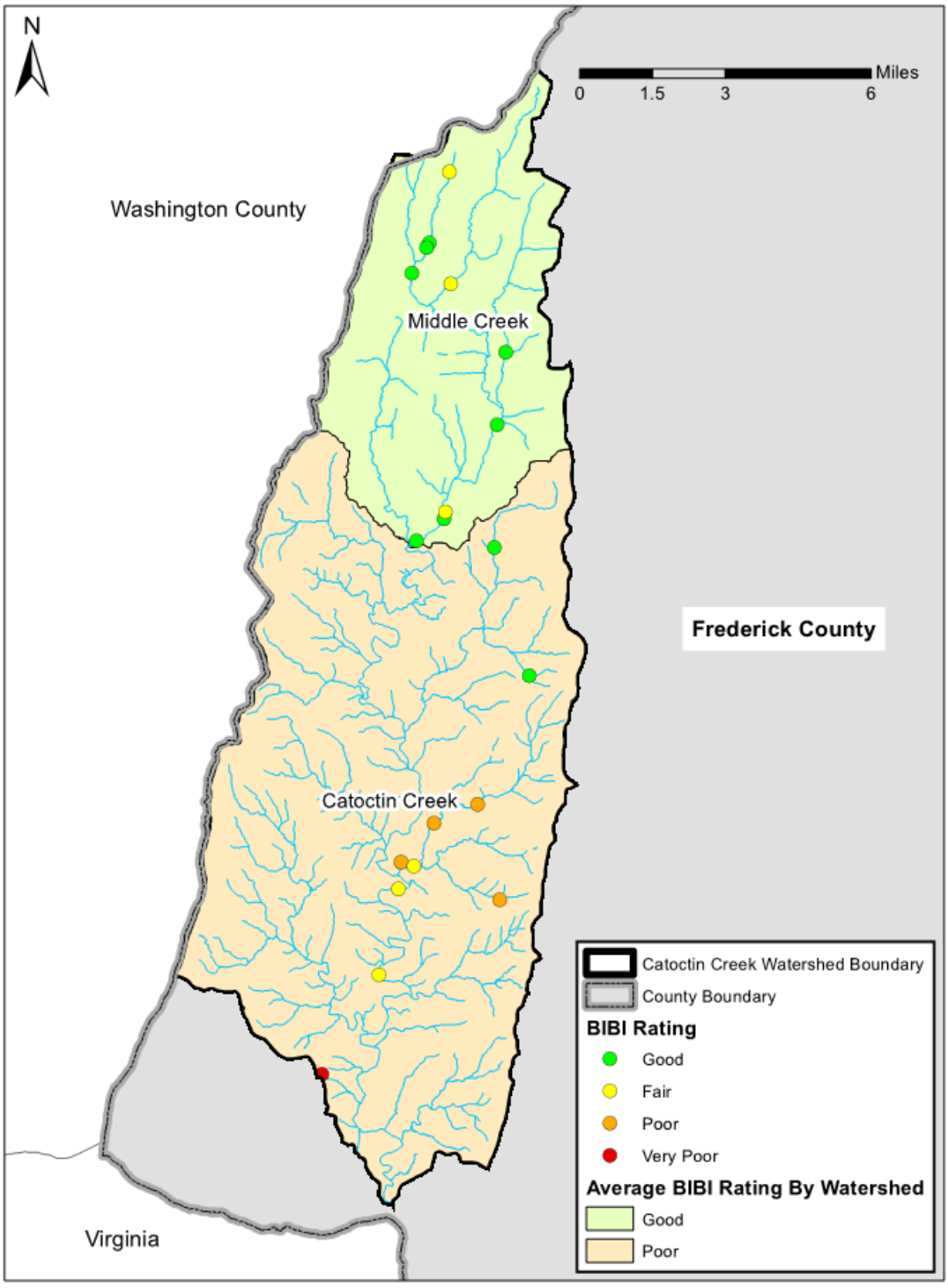

Figure 12: Catoctin Creek Watershed FCSS Round 2 BIBI Data

2.2. Existing Pollutant Loads and Total Maximum Daily Loads (TMDLs)

A TMDL is established for a waterbody when monitoring data determines the waterbody is no longer meeting state water quality standards and designated uses. The TMDL represents the maximum amount of a pollutant a waterbody can receive and allocates the load reductions necessary to the source(s) of the identified pollutant. Allocations attributed to point sources are called wasteload allocations and those attributed to non-point sources are called load allocations. There are three TMDLs applicable to the Catoctin Creek watershed – the Chesapeake Bay TMDL and two local TMDLs for phosphorus and sediment. All three have a stormwater wasteload allocation (SW-WLA) from urban sources which the County must address.

In December 2018, the County completed the *Frederick County Stormwater Restoration Plan* (hereafter referred to as the Restoration Plan) to comply with Part IV.E.2.b of the County's NPDES MS4 permit, (Frederick County, December 2018). Specifically, the Restoration Plan addresses meeting the SW-WLAs for TMDLs applicable to Frederick County waterways, including those within the Catoctin Creek Watershed. The County's approach includes categorizing completed and planned restoration projects into five (5) Restoration Tiers. As described in the Restoration Plan, the Restoration Tiers include:

- Baseline: Reflects the pollutant loading, impervious surface, and projects in the ground at the time the TMDL goal(s) was established.
- Completed: Projects which apply to restoration credit and have been completed between the baseline date and June 30, 2018 (the end of the reporting period for the Restoration Plan).
- Programmed: Projects which are under contract or are funded with proposed completion dates after July 1, 2018.
- Identified: Projects which have been identified in a County planning document and have engineering estimates of treated pervious and impervious acres.
- Potential: Projects selected using the best available information on BMP costs, available land, and a level of implementation required to meet the TMDL requirements.

Highlighted below is information from the Restoration Plan specific to the MS4 source sector of the two local TMDLs for the Catoctin Creek Watershed. For more information on how Frederick County is addressing its Chesapeake Bay TMDL allocations, please refer to the Restoration Plan. Section 2.2.6 provides information on existing pollutant loads within the entire watershed based on the Chesapeake Assessment Scenario Tool (CAST).

2.2.1. Sediment TMDL

2.2.1.1. Target Reductions

The sediment TMDL for the Catoctin Creek Watershed was submitted to EPA in September 2007 and subsequently approved in July 2009. As shown in Table 2 (Table 13 of the Restoration Plan), the TMDL requires a 49.1% reduction from baseline year conditions.

Table 2 – Calibrated Sediment Local TMDL SW-WLA and Target Load Reduction

Watershed Name	Watershed Number	Baseline Year	Pollutant	MDE Published Reduction Percent[1]	Baseline Impervious Area[2]	Baseline Pervious Area[2]	Calibrated Baseline Load[3]	Calibrated Reduction[4]
Catoctin Creek	2140305	2000	Sediment	49.1%	880	7,666	2,875,114	**1,411,681**

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

1) 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.
3) Baseline loads modeled using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.
4) Calibrated reductions calculated by applying the MDE published percent reduction to the calibrated baseline loads.

2.2.1.2. Projects and Associated Reductions

The County modeled pollutant load reductions using projects in the established Restoration Tiers to estimate load reductions achieved and approximate when the SW-WLA reduction would be attained. It is anticipated that sediment TMDL reduction requirements will be achieved by projects included in the "Potential" Restoration Tier as illustrated in Table 3 (Table 23 of the Restoration Plan).

Table 3 – Reductions by scenario for Catoctin Creek Sediment TMDL

Scenario	Scenario Reduction (lbs./yr.)	Cumulative Reduction (lbs./yr.)	Load (lbs./yr.)	% of Required Reduction
Baseline	0.0	0	2,875,114	0.0%
Complete	9,013.9	9014	2,866,100	0.6%
Programmed	102,565.7	111,580	2,763,534	7.9%
Identified	340,515.8	452,095	2,423,019	32.0%
Potential	959,814.5	1,411,910	1,463,204	**100.0%**
Calibrated Reduction	**1,411,681**			

2.2.2. Phosphorus TMDL

2.2.2.1. Target Reductions

The phosphorus TMDL for the Catoctin Creek Watershed was submitted to EPA in September 2012 and subsequently approved in September 2013. As shown in Table 4 (Table 13 of the Restoration Plan), the TMDL requires an 11% reduction from baseline year conditions.

Table 4 – Calibrated Phosphorus Local TMDL SW-WLA and Target Load Reduction

Watershed Name	Watershed Number	Baseline Year	Pollutant	MDE Published Reduction Percent[1]	Baseline Impervious Area[2]	Baseline Pervious Area[2]	Calibrated Baseline Load[3]	Calibrated Reduction[4]
Catoctin Creek	2140305	2009	Phosphorus	11.0%	1,032	8,357	8,681	**955**

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

1) 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.
3) Baseline loads modeled using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.
4) Calibrated reductions calculated by applying the MDE published percent reduction to the calibrated baseline loads.

2.2.2.2. Projects and Associated Reductions

The County modeled pollutant reductions using the established Restoration Tiers to estimate load reductions achieved and approximate when the SW-WLA reduction would be attained. It is anticipated that phosphorus TMDL reduction requirements will be achieved by projects in the "Potential" Restoration Tier as illustrated in Table 5 (Table 25 of the Restoration Plan).

Table 5 – Reductions by scenario for Catoctin Creek Phosphorus TMDL

Scenario	Scenario Reduction (lbs./yr.)	Cumulative Reduction (lbs./yr.)	Load (lbs./yr.)	% of Required Reduction
Baseline	6.7	6.7	8,681.2	0.7%
Complete	20.2	26.9	8,654	2.8%
Programmed	136.9	163.7	8,517	17.1%
Identified	484.2	647.9	8,033	67.8%
Potential	1,394.8	2,036.0	6,645	**213.2%**
Calibrated Reduction	**394.7**			

2.2.3. Anticipated Funding

The Restoration Plan presents the required funding levels for meeting each of the local TMDLs and prioritizes completion of TMDLs with lower requirements first while also maintaining some level of implementation for TMDLs requiring more intensive efforts. The Restoration Plan assumes an average funding level of $4.5M per year and that funding from FY2019 to FY2022 is earmarked for projects in the "Programmed" and "Identified" Restoration Tiers. Funding for "Potential" projects is expected to begin in FY2023. As such, Table 6 (Table 50 from the Restoration Plan) illustrates the projected funding levels required to address the two local TMDLs for the Catoctin Creek Watershed.

Table 6 – Potential tier funding timeline through FY2040 (in $000)

	Fiscal Year	Catoctin Creek
Total Potential Cost		**$20,091**
Forecast Completion		**2033**
	FY2023	$2,009
	FY2024	$2,009
	FY2025	$2,009
	FY2026	$2,009
	FY2027	$2,009
	FY2028	$2,009
	FY2029	$2,009
	FY2030	$2,009
	FY2031	$2,009
	FY2032	$2,009

2.2.5. Proposed Projects and Anticipated Completion Dates

A breakdown of the projects included in the "Potential" Restoration Tier for the Catoctin Creek Watershed are provided in Table 7 (Appendix 4 from the Restoration Plan). As stated in the Restoration Plan, "…these 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. The most cost-effective BMPs implemented by the county (Stream Restoration, Bioswale, and Riparian Forest Buffers) were selected. They will be completed after December 30, 2019 and after Identified projects." As indicated in Table 8 (Table 51 from the Restoration Plan), it is anticipated that the sediment and phosphorus TMDLs will be addressed in 2033 and 2028 respectively. More detail on the Catoctin Creek sediment and phosphorus restoration project scenarios which were developed by the County can be found in Appendix 4, 11, and 12 of the Restoration Plan.

Table 7 – Number of Projects Included "Proposed" Restoration Tier for the Catoctin Creek Watershed

BMP Type	Catoctin Creek
Bioretention	0
Bioswale	0
Filters	0
Grass Channel	0
Infiltration	0
Wet Pond Retrofit	8
Wetland	0
Streams (LF)	15,750
Tree Planting	0
Riparian Buffer	5

Table 8 – Summary of TMDL completion

	Catoctin Creek	
Pollutant	Sediment	Phosphorus
Years to Complete	10	5
Completion Year	**2033**	**2028**

2.2.6. Existing Loads

Existing pollutant loads for the entire Catoctin Creek Watershed were determined based on pollutant loading rates developed for the Chesapeake Bay TMDL. To estimate existing pollutant loads, Dewberry used CAST – a web-based nitrogen, phosphorus, and sediment load estimator which reports pollutant loads on the land-river segment scale. There are three (3) land-river segments in the Catoctin Creek Watershed.

A Chesapeake Bay scenario was developed by the CAST Administrator on March 20, 2019 to represent 2018 progress in meeting the Chesapeake Bay TMDL. The scenario includes all restoration practices and SWM BMPs credited by the Chesapeake Bay Program (CBP). This data was submitted by the states to CBP and copied into the CAST scenario. Dewberry downloaded the load estimates for the 2018 Progress Scenario for land uses and streams within the three land-river segments and summarized the loading estimates by source for the entire watershed in Table 9. CAST reports loads as both Edge of Stream (EOS) and Edge of Tide (EOT). EOS loads are those that are delivered to local streams, while EOT loads are those that

are delivered to the tidal portion of the Chesapeake Bay. Values for both are provided in Table 9 as EOS loads are important for tracking progress on local TMDLs while EOT loads are important for tracking progress on the Chesapeake Bay TMDLs. For the purposes of this assessment, it has been assumed that the estimates shown in Table 9 represent the most current and up to date pollutant loads for the watershed.

NOTE: The values presented in Table 9 represent pollutant loads from the entire Catoctin Creek Watershed and will vary from those presented in the County's Restoration Plan as those loads represent baseline levels (i.e. land use loads with baseline BMPs) from 2010 conditions in the Frederick County MS4 source sector associated with the local TMDLs.

Table 9 – Existing Pollutant Loads from Land Use and Stream Sources in the Catoctin Creek Watershed

Load Source	Unit	Unit Amount	Edge of Stream (EOS) Pollutant Loads			Edge of Tide (EOT) Pollutant Loads		
			TN	TP	TSS	TN	TP	TSS
			(lbs./yr.)			(lbs./yr.)		
Impervious Roads	Acres	1,062.46	15,286.76	1,012.56	2,286,767.12	10,898.16	645.99	1,262,114.54
Impervious Non-Roads	Acres	1,717.37	19,083.94	1,285.37	3,600,673.38	13,596.95	818.88	1,982,936.50
Tree Canopy Over Impervious	Acres	652.04	8,510.45	535.15	1,585,582.25	5,906.30	334.74	864,168.16
Tree Canopy Over Turf Grass	Acres	1,284.75	7,069.31	1,038.31	903,569.78	5,070.02	663.57	498,651.11
Turf Grass	Acres	8,154.73	59,020.08	8,620.32	5,753,855.14	42,185.76	5,499.64	3,168,011.75
Mixed Open	Acres	2,339.31	4,194.83	916.84	3,210,378.20	2,913.07	574.10	1,758,938.74
Forest	Acres	30,619.63	41,095.97	1,899.23	1,839,975.82	28,079.88	1,167.05	993,185.18
Non-Tidal Floodplain Wetland	Acres	64.71	79.52	3.79	3,224.20	56.34	2.42	1,778.33
Non-Tidal Other Wetland	Acres	505.66	615.69	30.05	23,959.31	444.63	19.22	13,113.73
Open Water	Acres	694.50	5,779.59	427.51	-	4,692.26	363.92	-
Cropland	Acres	24,969.94	419,663.94	13,998.03	24,869,080.76	306,478.16	9,020.04	13,742,049.04
Pasture	Acres	4,865.54	42,790.58	6,106.93	61,051.30	30,580.20	3,912.32	33,838.97
Stream Bed and Bank	Miles	154.30	48,515.22	11,188.06	42,264,293.31	34,394.13	7,092.76	23,198,161.91
Total			**671,705.88**	**47,062.15**	**86,402,410.57**	**485,295.86**	**30,114.65**	**47,516,947.96**

3. METHODOLOGY

3.1. Utilization of Watershed Guidance Document

Frederick County created a guidance document (Frederick County 2017) to ensure consistent procedures were followed amongst the different watershed assessments. The document provides procedures for identifying three (3) different types of restoration practices: 1) Stormwater pond retrofits, 2) New stormwater opportunities, and 3) Stream restoration. In some instances, there were procedures provided in the guidance that were not applicable to the unique conditions of the Catoctin Creek Watershed; therefore, a description of the specific methodology used for the Catoctin Creek Watershed is described in this section. Furthermore, as the watershed assessment was underway, Dewberry and the County used additional MDE approved resources to enhance identification and development of cost-effective feasibility concepts for potential opportunities.

3.2. Desktop Site Assessment

A Watershed Assessment Template Geodatabase was provided by Frederick County on 10/11/2017. This database was used to capture restoration opportunities identified during the GIS desktop assessment. The database includes the following feature classes:

(1) **SWSTRUCTURE:** A point feature class for new stormwater or retrofit opportunities identified within the watershed.
(2) **SWSTRUCTURE_DRAINAGE:** A polygon feature class for drainage areas associated with SWSTRUCTURE points.
(3) **STREAM:** A line feature class for stream restoration opportunities identified within the watershed.
(4) **LANDUSECHANGE:** A polygon feature class for tree planting or impervious removal opportunities identified within the watershed.
(5) **OTHER:** A polygon feature class for other opportunities, identified issues, or maintenance needs observed within the watershed.

3.2.1. Pond Retrofit Sites

Based on MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acre Treated – Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (August 2014 and hereafter referred to as MDE's Accounting Guidance), all impervious areas defined as SWM Era 1 and 2 are considered untreated as they only address water quantity control rather than water quality control. These locations offer a cost-effective approach for restoration as the site already exists, the potential for utility conflict is low, and minor modifications to the facility could achieve all or a portion of the required water quality volume (WQv) criteria. Middletown and Myersville are covered under their own NPDES MS4 Phase II permit; therefore, any stormwater facilities within these town boundaries were not evaluated as part of this assessment. The County's NPDES Database (version dated 10/11/2017) was used to compile a list of all SWM BMPs within the Catoctin Creek Watershed. The following GIS analysis steps were used to identify existing SWM BMPs that have the best retrofit potential:

MDE's Accounting Guidance (August 2014) establishes a methodology for categorizing a jurisdiction's impervious area as treated or untreated by defining four (4) distinct regulatory eras where SWM requirements correlate with a certain level of BMP performance. These eras include:

(1) **SWM Era 1:** land developed prior to 1985
(2) **SWM Era 2:** land developed between 1985 – 2002
(3) **SWM Era 3:** land developed between 2002 – 2010
(4) **SWM Era 4:** land developed after 2010

- Selected all SWM BMPs that fall within the Catoctin Creek Watershed.
- Removed SWM BMPs that fall within Middletown or Myersville.
- Removed any remaining records that fall were classified as SWM Era 3 or 4 facilities.
- Removed any SWM BMPs that have a maintenance owner of a Frederick County entity/agency, the Town of Middletown, or the Town of Myersville. **NOTE:** Analysis of County-owned pre-2002 SWM BMPs was conducted under separate tasks and is not applicable to this watershed assessment. Middletown and Myersville are Phase II jurisdictions with their own restoration requirements.
- Removed any remaining SWM BMPs that are not categorized as being a pond (per the Watershed Guidance).

- Removed any SWM BMPs categorized as extended detention wet ponds. A separate effort focusing on the analysis of WQv provided by extended detention wet ponds will be completed in the future.
- All remaining SWM BMPs were added to the Watershed Assessment GDB point feature class named SWSTRUCTURE.

As-built and design plans were reviewed for SWM BMPs remaining. Several additional SWM BMPs were removed from consideration when plan and GIS data review suggested they may already provide a full inch of treatment in existing conditions, and could be analyzed as part of a future WQv analysis effort. Other existing SWM BMPs with the potential to treat only a small amount of impervious (generally less than 1 acre) were categorized as backup field assessment options. Notification letters were mailed to all property owners responsible for maintenance of existing SWM BMPs selected for field assessments. A summary of the results of the GIS Desktop Analysis is provided in Section 4.1.

3.2.2. New SWM BMP sites

The purpose of this component was to evaluate untreated impervious areas to identify potential locations where new SWM BMPs could be installed to provide additional treatment. Land that was developed before 1985 typically does not drain to a SWM BMP since the regulations did not require stormwater management at the time. Available green space adjacent to untreated impervious surfaces or areas downstream of non-SWM BMP outfall pipes/channels are ideal locations for the placement of new SWM BMPs.

A GIS Desktop Analysis was completed to identify areas of untreated impervious within the watershed. SWM BMP drainage areas digitized within the County's NPDES Database were used to remove all treated or undertreated (pre-2002 BMPs) impervious surfaces from consideration. GIS data including stormwater structures and conveyances, contours, parcel boundaries, streams, restoration opportunities identified during previous assessments, and flow accumulation lines were used to identify potential new SWM BMP locations and were added to the SWSTRUCTURE feature class. Preliminary drainage areas were developed in GIS in order to estimate impervious area treatment. In addition to the analysis of GIS data, feedback from County staff was a critical component of the site selection process as institutional knowledge of future development plans can assist in identifying or omitting sites. Permission letters were mailed to all property owners prior to field assessments and responses were tracked in a spreadsheet. New SWM BMP sites were only assessed if the appropriate permissions were obtained. A summary of the results of the GIS Desktop Analysis is provided in Section 4.1.

3.2.3. Stream Restoration Sites

The purpose of the stream restoration site desktop assessment was to identify degraded stream channels where a restoration project would likely result in the reduction of pollutants delivered to Catoctin Creek and the Chesapeake Bay, and also result in measurable stream function parameter lift (see Section 3.4.2 for discussion on stream function parameters). Round 1 and Round 2 Frederick County Stream Survey (FCSS) GIS data was used as the primary factor to identify degraded stream channels. Streams sampled during FCSS Round 1 or Round 2 were selected for possible field visits if one or more of the following criteria were met:

- Benthic Index of Biotic Integrity (BIBI) score of Poor or Very Poor
- Physical Habitat Index (PHI) score of Degraded or Severely Degraded
- Bank erosion score of Moderate or Severe

Additional stream sites were selected for consideration if aerial photography or Google Street View showed the presence of degraded conditions. The County's Land Preservation Administrator identified several more degraded stream reaches, and also provided feedback on all potential stream restoration opportunities located on agricultural properties.

Grade control features, such as road crossings or tributary confluences, were used to set the initial stream restoration site boundaries. Stream restoration site boundaries set during the desktop assessment were used to identify property owners with land that would need to be accessed during the field assessments. Permission letters were mailed to all property owners prior to the field assessments, and responses were tracked in a spreadsheet. Stream reaches were only assessed if the appropriate permissions were obtained. A summary of the results of the GIS Desktop Analysis is provided in Section 4.2.

3.3. Field Site Assessment

Field inspections were conducted during April – July 2018. Dewberry conducted detailed site visits to evaluate a number of parameters that effect the feasibility of the restoration opportunities identified during the desktop assessment.

3.3.1. Pond Retrofit Sites

Dewberry staff conducted detailed SWM investigations to evaluate retrofit opportunities for existing SWM BMPs. In most cases, Frederick County staff provided Dewberry with SWM as-built plans prior to field visits. Dewberry used the as-built plans and Retrofit Reconnaissance Investigation (RRI) forms and procedures to document existing conditions and evaluate retrofit feasibility of the existing SWM BMPs. Copies of completed RRI forms can be found in Appendix C. A summary of the results of the Field Site Assessments is provided in Section 4.1.

Items evaluated during field investigations included:

- Surrounding land uses
- Condition of the existing facility
- Condition of associated structures and conveyances in the immediate vicinity of the facility
- Proposed retrofit elements (e.g. adding forebays, riser replacement)
- Proposed retrofit BMP types
- Site constraints (e.g. utility conflicts, access, and permitting factors)

3.3.2. New SWM BMP sites

Dewberry staff conducted detailed SWM investigations to evaluate opportunities to treat untreated impervious surfaces. Dewberry used GIS maps with aerial imagery and the County's NPDES database stormwater features to document existing conditions and evaluate the feasibility of implementing new BMPs on site. Dewberry used RRI forms and procedures to document existing conditions and evaluate opportunities to install new practices. Copies of completed RRI forms can be found in Appendix C. A summary of the results of the Field Site Assessment is provided in Section 4.1. Items evaluated during field investigations included:

- Surrounding land uses
- Presence and condition of any stormwater structures and conveyances on site
- Verification of preliminary drainage areas created during the desktop assessment
- Proposed BMP types
- Site constraints (e.g. utility conflicts, ownership, access, and permitting factors)

3.3.3. Stream Restoration Sites

Dewberry staff conducted stream assessments to evaluate stream restoration opportunities. We rated parameters presented in the *Function-Based Rapid Stream Assessment Methodology* (Starr et al. 2015) to document existing conditions and assess the functional uplift potential of stream sites. Modified Function-Based Rapid Stream Assessment field forms were completed for each site and can be found in Appendix C. GIS maps with aerial imagery and property boundaries were used to modify proposed restoration site boundaries and note the locations of any important features (e.g. erosion, head cuts, and utilities). A summary of the results of the Field Site Assessment is provided in Section 4.2. Items evaluated during field investigations included:

- Surrounding land uses
- Sources of concentrated flow
- Floodplain connectivity
- Riparian vegetation
- Lateral channel stability
- Shelter for fish and macroinvertebrates
- Sediment supply/bed stability

- Percent shading
- Presence of in-stream organic matter
- Proposed restoration approach
- Potential for other restoration opportunities adjacent to site (e.g. tree planting and outfall stabilization)
- Site constraints (e.g. utility conflicts, ownership, access, and permitting factors).

3.4. Post-Field Analysis and Ranking Criteria

3.4.1. Pond Retrofits and New SWM BMPs

Project Selection and Concept Designs

Chapter 4 of *The 2000 Maryland Stormwater Design Manual Volume I & II* (hereafter referred to as *MDE 2000 Manual*), identifies five (5) groups of structural water quality SWM BMPs: (1) ponds (P-1 through P-5), (2) wetlands (W-1 through W-4), (3) infiltration (I-1 and I-2), (4) filtering systems (F-1 through F-6), and (5) open channels (O-1 and O-2). Chapter 5 identifies treatment methodologies using nine (9) groups of micro-scale practices: (1) rainwater harvesting (M-1), (2) submerged gravel wetlands (M-2), (3) landscape infiltration (M-3), (4) infiltration berms (M-4), (5) dry wells (M-5), (6) micro-bioretention (M-6), (7) rain gardens (M-7), (8) swales (M-8), and (9) enhanced filters (M-9). In many cases, the micro-scale practices resemble the larger structural practices but aim to provide stormwater treatment at the source rather than using "end-of-pipe" treatment typically used for larger drainage areas. Each of the groups have several design variations which have different SWM BMP performance criteria. The BMP groups and design variations by MDE code for each of the groups is provided in Appendix A.

In instances where the:

- Existing facility was a dry pond, the retrofit focused on providing treatment via enhanced surface sand filters inside of the existing SWM BMP footprint and stormwater easement when possible. Enhanced surface sand filters were designed using *Carroll County's Supplement to the Maryland Stormwater Design Manual Volumes I & II*. Sediment forebays or stilling basins were added at the facility's primary inflow points and maintenance access roads were added to provide access to the facility's structures.
- Existing facility was a pond (either dry or wet) and an enhanced surface sand filter was not feasible due to site constraints, the retrofit focused on providing treatment via a combination of pocket ponds, wet ponds, and wet extended detention ponds inside of the existing SWM BMP footprint and stormwater easement when possible. Sediment forebays were added at the facility's primary inflow points and maintenance access roads were added to provide access to the facility's structures.
- Existing facility was a pond (either dry or wet) and the drainage area to the SWM BMP was less than ten (10) acres, the retrofit focused on providing treatment via filtering systems inside of the existing SWM BMP footprint and stormwater easement when possible. Sediment forebays were added at the facility's primary inflow points and maintenance access roads were added to provide access to the facility's structures.
- The site contains no existing facility, the concept design evaluated the feasibility of installing a new pond, regenerative stormwater conveyance, sand filter, and/or bioretention. If other opportunities existed, they were noted in the summary fact sheet but a feasibility concept was not developed.

After the most appropriate retrofit/restoration project option was identified, a feasibility retrofit concept was developed for each project location. The general feasibility retrofit concept development process included the following considerations:

- Hydrology
    - Collection and evaluation of design information for the existing SWM BMP in order to establish the hydrologic design criteria for the retrofit. If drainage areas were not available, they were generated for the existing SWM BMP. In some instances, drainage areas were revised to match drainage patterns observed during field assessments. All apparent untreated areas in the proximity of the SWM BMP were evaluated for opportunities to divert it to the facility for additional impervious acre and nutrient reduction credit. Where as-built information was not available, mapping data from the County as well as field assessments and measurements were used.

- It was assumed that additional development had not occurred within the drainage area to the existing BMP since its design and the RCN and T_c values provided in the County's NPDES Database were used for the stormwater retrofit calculations.
- An impervious cover layer generated in Spring 2014 was provided by the County on 10/11/17. Updates to the impervious cover within the drainage areas of the BMPs was not included in the scope of work for the task.
- For purposes of calculating the breakdown of soil type within a BMP drainage area, the Maryland SSURGO Soils GIS layer was used. The Hydrologic Soil Group (HSG) designation used to calculate the percent coverage within BMP drainage areas was taken from the HYDROLGRP field in the SSURGO GIS layer.

- BMP Sizing:
  - The WQ_v and recharge volume required to treat the entire untreated impervious area drainage to the SWM BMP was calculated using the Unified Sizing Criteria of the *MDE 2000 Manual*.
  - Per Figure 2.1 of the MDE 2000 Manual, Frederick County is located in the Western Rainfall Zone and the rainfall depth (P) that should be used for calculating the WQv is 0.9". However, a rainfall depth of 1" was used to calculate the WQv in order to maximize the impervious area and nutrient reduction treatment per MDE's Accounting Guidance (August 2014).
  - Design computations assumed the SWM BMP was sized to provide adequate quantity control in existing conditions. Quantity control required versus quantity control provided should be evaluated and verified during final design.
- Feasibility Concept Plans:
  - The feasibility concept plans address a range of considerations based on the as-built information, available mapping, and field assessments including: type of management, compliance with current stormwater design criteria, management volumes, impervious area managed, modification of the storm drain system, pre-treatment, outfall or channel stabilization measures, preliminary grading (max. 2:1 in cut, 3:1 in fill), maintenance and construction access, Frederick County and/or MDE permit needs, constructability, landscaping, natural resource impacts and related permitting, utilities, right-of-way, other site constraints, and geotechnical investigation requirements.

Calculating Pollutant Loads and Loading Rates

There are three (3) land-river segments located within the Frederick County portion of the Catoctin Creek Watershed:

- MD-H24021PM1_3510_4000
- MD-N24021PM1_3510_4000
- MD-N24021PM1_4000_4290

To obtain pollutant loads for each land-river segment, a "no action" scenario was run using CAST in which no SWM BMPs are reported as being installed within the watershed. The pollutant loads for all land uses reported in the watershed were extracted for the three (3) land-river segments. Pollutant loading rates for each land-river segment were calculated by dividing the pollutant load by the total number of acres within each land use category. Both Edge of Stream (EOS) and Edge of Tide (EOT) loading rates were calculated to allow the County to track progress towards meeting SW-WLAs for local TMDLs and the Chesapeake Bay TMDLs as required by the County's NPDES permit.

NOTE: The pollutant loads obtained through the process described above are representative of loads from the entire Catoctin Creek Watershed assuming no BMP implementation and will vary from those presented in the County's Restoration Plan as those loads represent baseline levels (i.e. land use loads with baseline BMPs) from 2010 conditions in the Frederick County MS4 source sector associated with the local TMDLs. This process is followed to more accurately represent loads when no BMPs are present within the drainage areas to proposed SWM BMPs.

Land use raster data for the Chesapeake Bay Phase 6 model was downloaded from the USGS Land Use Viewer website in August 2018 (https://chesapeake.usgs.gov/phase6/map). This raster data contains the same land use categories present in the

land use load summary extracted from CAST. The impervious surface categories (Impervious Roads and Impervious Non-Roads) were erased from the dataset and replaced with the County's impervious shapefile. Impervious polygons with a "Feature_Ty" of "ROAD" were categorized as Impervious Roads, and all other impervious polygons were categorized as Impervious Non-Roads. This process left several "NoData" cells in the new raster where impervious data was erased, but not replaced. The "NoData" cells accounted for 65 acres of the dataset, which is approximately 0.08% of the watershed. These cells were assumed to be Turf Grass for two reasons: 1) It is the most common land use type in urbanized areas containing SWM BMPs within the Catoctin Creek Watershed and 2) It has moderate pollutant loading rates that are generally higher than natural areas (forests and wetlands), but lower than impervious and agricultural areas. This final land use raster was used to determine the land use types present within each proposed SWM BMP project drainage area.

Total pollutant loads within each SWM BMP drainage area were calculated by multiplying each land use's loading rate by the number of acres present for that land use, and then summing the land use pollutant loads.

$$= \sum(LR)(A)$$

Where: LR = Land Use Loading Rate (lbs./year)
A = Land Use Area (acres)

Calculating Pollutant Load Reductions

The "Credit for Pollutant Removal Efficiencies and WLAs" Section on page 13 of the MDE 2014 Guidance establishes the protocol for estimating the pollutant removal efficiencies of proposed retrofit/restoration projects. Using this protocol, each proposed retrofit/restoration project was classified as either a Runoff Reduction (RR) Practice or a Stormwater Treatment (ST) Practice. The Runoff Depth Treated (inches) was calculated using the runoff storage volume (acre-feet) of the proposed restoration project and the impervious area (acres).

$$= \frac{(RS)(12)}{IA}$$

Where: RS = Runoff Storage Volume (acre-feet)
IA = Impervious Area (acres)

NOTE: For the purposes of determining the pollutant removal efficiency and the estimated pollutant load reduction of the proposed SWM BMP project, it was assumed that the proposed management measure would provide water quality volume (WQv) treatment for one inch of runoff, except where noted. The pollutant removal efficiency and pollutant load reductions should be re-calculated when the project is taken to final design. The preliminary computations for the proposed pond retrofits and new SMW BMPs for which feasibility retrofit concepts were developed are provided in Appendix D.

The Runoff Depth Treated was used in combination with the SWM BMP removal rate adjustor curves provided in Appendix A of the MDE 2014 Guidance to determine the pollutant removal efficiency of the proposed SWM BMP project. The estimated pollutant reduction for each project was calculated by multiplying the pollutant load for the project drainage area by the pollutant removal efficiency obtained from the SWM BMP removal rate adjustor curves.

Impervious Acre Treatment Estimates

Section III – *BMP Implementation and Restoration Credits: Credit for Impervious Acres Treated* of the 2014 MDE Guidance establishes procedures for calculating impervious acre credits for individual and redevelopment projects and procedures for determining if a project is eligible to receive extra credit for additional impervious acres treated.

The retrofit/restoration projects proposed under this Task are all considered individual projects, therefore the procedures under Section III.1 were used to calculate the impervious acre treatment. Sections III.1 and III.2 state that projects will be credited using the following criteria:

- "An acre for acre impervious credit will be given when a BMP is designed to provide treatment for the full WQ_v (One inch of rainfall); or

- A proportional acreage of credit will be given when less than the WQ_v is provided: (percent of the WQ_v achieved) x (drainage area impervious acres)." **NOTE:** This was not used for this study because all feasibility concepts show treatment for the full WQv.
- A proportional acreage of credit will be given when more than the WQ_v is provided. The credit will increase by 0.1 acres for every 0.4 inches treated above one inch. **NOTE:** This was not used for this study as described below.

NOTE: When completing the stormwater computations for the feasibility retrofit concepts, it was assumed that the maximum WQv treatment that could be provided by the proposed project was one inch, even if the feasibility concept design indicated there was adequate space to provide more treatment. This volume was then used as the Runoff Storage Volume (RS) in the equation above to calculate the Runoff Depth Treated. In some instances, the calculated Runoff Depth Treated was greater than one inch. In order to provide the County with a conservative estimate of impervious acre treatment, credit for only one inch of treatment was claimed. The actual impervious acre treatment credit to be claimed for a project should be calculated when the project is taken to final design.

Project Cost Evaluation

Planning level construction cost estimates for potential SWM BMP types were provided by Frederick County in the *BMP Estimated Construction Costs* worksheet located in the Prioritization Spreadsheet, and are shown in Table 10.

Table 10 – Proposed BMP Estimated Construction Costs

BMP Type	Estimated Construction Cost	Unit
Stormwater Pond Retrofit	$22,000	Per Impervious Acre
Bioretention Construction	$75,000	Per Impervious Acre
New Stormwater Pond	$45,000	Per Impervious Acre
Enhanced Surface Sand Filters	$45,000	Per Impervious Acre
Regenerative Stormwater Conveyance	$450	Per Linear Foot

The following six (6) assumptions were used to develop total cost estimates for new SWM BMP and retrofit projects:

1. A 10% contingency was added to the estimated construction costs to acquire a total construction cost estimate
2. Design and engineering costs were estimated to be 32% of the construction costs;
3. Inspection costs were estimated to be 10% of the construction costs;
4. Project Management costs were estimated to be 5% of the construction, design and engineering costs;
5. Site Improvement costs were estimated to be 8% of the construction costs; and
6. The total cost estimate was calculated by summing the costs computed for assumptions 1-5.

A summary of the estimated project costs for each proposed SWM BMP retrofit can be found in Section 5.3. The "Total Cost" for each project has been provided in the concept fact sheet and in the site summary tables for each project (Appendix D).

Prioritization of Projects

In order to prioritize the projects, Dewberry coordinated with the County to identify a number of BMP Prioritization Metrics (Table 11). The metrics were categorized into four (4) categories:

- Nutrient and Impervious Acre Credit
- Cost
- Construction
- Community and Watershed Impacts

Each prioritization metric was assigned a weight and three-point numerical ratings were established. Table 11 provides a summary of the prioritization metrics, weights, and ratings. A Total Combined Score was generated, using the process described below, for each of the proposed projects. Projects receiving a higher score were considered to be better candidates than those receiving lower scores.

The projects were assigned a numerical rating for each prioritization metric. The value for each prioritization metric was calculated by multiplying the metric's weight by the assigned numerical rating for the project. The prioritization metric values were added together to obtain a subtotal score for each of the four (4) prioritization categories. The subtotals for each category were added to generate a Total Combined Score for each project. If there was a tie between projects, the project that provided the greatest WQv treatment based on the preliminary computations was given a higher rank.

Table 11: Pond Retrofit and New SWM BMP Prioritization Matrix

Ranking Components	Weight	Rating			Remarks
		1	2	3	
Nutrient and Impervious Acre Credit:					
Estimated TN Removed (lbs./yr.)	2	<244	244 - 488	>488	Ranges based on other watershed study ratings
Estimated TP Removed (lbs./yr.)	2	<29	29 - 57	>57	
Estimated TSS Removed (lbs./yr.)	2	<14,000	14,000 - 29,000	>29,000	
Impervious Acre Credit (ac)	4	<5	5 - 15	>15	
Stormwater Era	10	1985-2002 BMP providing treatment of 1 inch or greater	1985-2002 BMP providing treatment of 0.5 inch	pre-1985	This is based on the design approval date from the County's NPDES database. If no date was available, the SWM BMP should be assigned a rating of 1.
Subtotal	***60***				
Cost:					
Overall Planning Level Costs	6	> $800K	$200K - $800K	< $200K	Ranges are based on acceptable costs to move projects forward as well as guidance provided by the Chesapeake & Atlantic Coastal Bays Trust Fund
Cost/Pound of Nitrogen Removed	2	> $2,000	$149 - $2,000	$149	
Cost/Pound of Phosphorus Removed	2	> $5,000	$800 - 5,000	$800	
Cost/Pound of Sediment Removed	2	> $10	$1.55 - $10	$1.55	
Cost/Impervious Acre Treated	8	>80,000	$54,000 - $80,000	<$54,000	
Subtotal	***60***				
Construction:					
Utility Conflicts	2	Extensive Conflicts	Minor Conflicts	No Conflicts	**Extensive conflicts** impact 2 or more utilities and require significant design and construction efforts to move multiple utilities (i.e. sewer); **Minor conflicts** impact two or less utilities and do not require significant design and construction (i.e. cable)
ROW Requirements/Property Ownership	5	Easement required	Temporary construction access easement only	No additional ROW requirements	**Easement Required** = the proposed retrofit will occur on private property and the County will be required to obtain an easement from the current property owner in order to implement the project; **Temporary Construction Access Only** = the proposed retrofit is located on County-owned property but in order to access the site for construction, a temporary easement will need to be acquired
Constructability/Access	3	Difficult	Moderate	Easy	Criteria evaluated to rank constructability/access includes; property ownership, site constraints, potential utility conflicts, site topography, and proposed grading.
Maintenance Burden	4	High Maintenance Requirements	Moderate Maintenance Requirements	Low Maintenance Requirements	Based on Table 4.5 from MD 2000 Manual
Proximity to Karst	2	Within karst area	Within 1/4 mile distance of karst	Outside karst area	Karst geology regions are characterized by formations underlain by carbonate rock and typified by the presence of limestone caverns and sinkholes. Specific design considerations are required for BMPs proposed within karst areas.

Table 11: Pond Retrofit and New SWM BMP Prioritization Matrix

Ranking Components	Weight	Rating			Remarks
		1	2	3	
Local/State/Federal Permitting Requirements	4	High	Moderate	Low	**High** = extensive permitting requirements including full wetland/stream permitting, forest resource ordinance, NOI for construction requiring public comment, etc. **Moderate** = significant permitting requirements including minor stream/wetland impacts, FRO, NOI for construction under the public comment threshold. **Low** = minor permitting requirements, likely just local permitting for grading and stormwater management review
Subtotal	***60***				
Community and Watershed Impacts:					
Proximity to Stream Restoration	10	No known stream restoration projects within or downstream of BMP	Proposed or existing stream restoration located upstream of BMP	Proposed or existing stream restoration located downstream of BMP	Frederick County NPDES BMP data (STREAM_RESTORATION and STREAM_SITE_SELECTION feature classes) and projects proposed during this watershed study should be used to determine the presence/absence of nearby stream restoration projects.
Public Acceptance	2	Low	Moderate	High	
Public Safety	4	Proposed SWM BMP condition presents a potential public safety concern - Fencing is proposed	-	No public safety concern	Sites either pose a potential public safety concern or they do not pose a potential public safety concern. There are no sites with a 2 rating for this public safety category.
Partnership Opportunities	2	No partnership opportunities	Opportunities to partner with 1-3 outside stakeholders	Opportunities to partner with >3 outside stakeholders	
Public Visibility/Outreach Opportunity	2	Low visibility	Moderate visibility	High visibility	**Low visibility** sites have minimal opportunities for education/outreach. **Moderate visibility** sites have some opportunities for education/outreach. **High visibility** sites have significant opportunities for education/outreach.
Subtotal	60				
	240				

Low score = bad candidate = low priority

High score = good candidate = high priority

Take the Rating Score multiplied by the weight

3.4.2. Stream Restoration Sites

Project Selection and Concept Designs

A number of factors were evaluated during concept development for the proposed stream restoration projects. The ultimate goal in selecting and designing any successful stream restoration project is providing the highest functional lift attainable as described in *A Function-Based Framework for Stream Assessment and Restoration Projects* (Harman et al. 2012). All levels of the stream functions pyramid (Figure 13) were considered during concept development, as well as some other key factors that can influence the success of the proposed projects. In general, concepts were developed using the following key considerations and assumptions:

1. Hydrology:

Hydrology is the base of the Stream Functions Pyramid and therefore influences all other stream functions. Stream hydrology is largely controlled by precipitation, size of a stream's drainage area, type of land use/land cover within a drainage area, and geologic conditions. Hydrology is generally considered an independent variable since the factors controlling stream hydrology are either extremely difficult, or impossible to alter. All stream restoration opportunities selected for concept development are first or second order streams in rural settings where land use is dominated by forest, agriculture, and pasture. No streams within the Catoctin Creek Watershed are influenced by karst, and all streams selected for concept development are in similar geologic settings.

2. Hydraulics:

Stream hydraulics involve the transport of water in the channel, on the floodplain, and through sediments. Floodplain connectivity is arguably the most important factor influencing stream channel hydraulics, and is also the easiest to evaluate during rapid visual stream assessments. Floodplain connectivity observations made during field visits were used during concept development to make floodplain reconnection recommendations when riparian conflicts did not exist adjacent to incised stream channels.

Legacy sediments often contribute to the severity of floodplain disconnection observed along stream channels. Legacy sediments are defined as sediments deposited in stream valleys following anthropogenic disturbances such as land-clearing and agricultural practices. These sediments were often trapped in the valleys by milldams or other obstructions that have since been removed. The presence of legacy sediments and recommendations for their removal were documented in the concepts.

3. Geomorphology:

Stream geomorphology involves the interaction of flowing water with the stream bed, banks, suspended sediments, and organic matter. These interactions lead to the transport and storage of sediments and organic matter within a stream channel. Lateral stability, riparian zone conditions, bedform diversity, and bar frequency and type are all geomorphology factors evaluated in the field to aid in concept development. Locations of recommended lateral stability and riparian cover improvements are shown on the concept maps. Overall stream restoration project type (i.e. Natural Channel Design vs. Legacy Sediment Removal) recommendations are briefly discussed in the concept documents and are based on the hydraulic and geomorphic factors that have been discussed in this section. Details regarding specific stabilization methods and materials were not evaluated during this assessment, but will be decided during final design.

4. Physicochemical Health:

The physicochemical functions of a stream include the interaction of physical and chemical processes that influence water quality. An evaluation of water quality parameters is not something that's typically included in rapid visual assessments since some amount of lab work is normally involved. The presence of organic matter and degree of decomposition was noted during field assessments, but these visual parameters did not influence decisions made during concept development. It is assumed that all restoration projects will have a positive impact on stream physicochemical health, but the degree of functional lift is largely controlled by conditions present within the project drainage areas.

5. Biology:

Biology functions are at the top of the stream functions pyramid and are supported by the other four functions. As discussed in Section 2.1.5, the FCSS program assesses the health of Frederick County streams through the collection and

analysis of biology, habitat, and water quality data. FCSS BIBI data is discussed in the stream restoration concept documents for sites where FCSS monitoring has been conducted. A prediction on the possibility of achieving biological uplift is included in the discussion of the proposed restoration. For the purposes of this planning level watershed assessment, it was assumed that stream sites with the following conditions have the best opportunity for biological uplift:

- Poor existing BIBI scores within the reach
- Opportunities for floodplain reconnection are present
- Opportunities for riparian enhancement are present when riparian cover does not already exist
- Opportunities to create diverse and stable bedforms through instream stabilization exist
- Diverse biological communities were observed upstream of the restoration reach
- The drainage area contains large portions of forested land and/or high quality wetlands

6. Ownership:

All of the stream restoration opportunities selected for concept development are located on private property. All stream restoration concept property owners gave permission for their property to be accessed during the field assessments for this watershed assessment only. During concept development it was assumed that these same property owners will be agreeable to having a project completed on their property in the future, but property owner coordination and easement acquisition will need to be revisited during project selection and design.

7. Access:

Multiple options for accessing the stream were considered for each site. Proposed access paths shown on concepts utilize existing roads and driveways whenever possible. Potential paths are also shown along the stream channel for movement of vehicles and heavy machinery. All access options will need to be discussed with property owners and reevaluated during final design.

8. Livestock:

Livestock were present adjacent to and within several of the stream restoration concept sites. It was assumed that livestock will remain on site following the proposed restoration projects. Installation of livestock fencing is recommended for all sites where fencing does not currently exist. Proposed post-restoration livestock crossing locations are shown in areas where existing crossings were observed in the field. All restoration activities involving the exclusion and movement of livestock will be discussed with property owners during the final design process.

9. Site Constraints:

Anticipated site constraints observed in the field and in GIS were documented in the concept document. Constraints included the presence of above ground and underground utilities, environmental features (wetlands, etc.), stream closure periods, relocation of fencing, and coordination with property owners regarding the presence of cattle during construction.

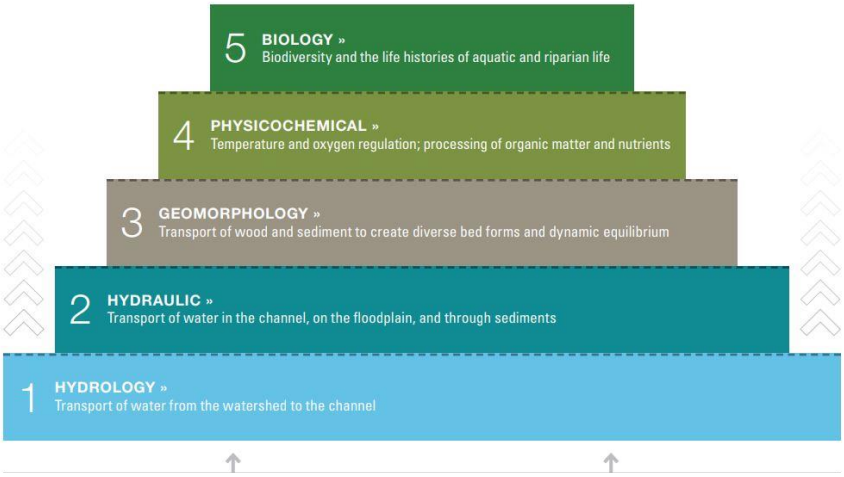

Figure 13: Stream Functions Pyramid (Harman et al. 2012)

Calculating Pollutant Load Reductions

Stream restoration pollutant reduction estimates were based on the *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects* (Schueler and Stack 2014). The expert panel report recommends using the following default pollutant removal rates for planning level purposes:

- Total Nitrogen (TN) – 0.075 lbs./ft/yr.
- Total Phosphorus (TP) – 0.068 lbs./ft/yr.
- Total Suspended Solids (TSS) – 44.88 lbs./ft/yr.

The default rates were applied to stream restoration opportunities identified in the Catoctin Creek Watershed by multiplying each of the removal rates by the proposed length of the projects to get project specific TN, TP, and TSS reductions.

Impervious Acre Treatment Estimates

Section IV – *Alternative BMP Credits* of the 2014 MDE Guidance addresses the possibility of using alternative BMPs for meeting NPDES MS4 permit restoration requirements. Alternative BMPs are defined as a restoration practice not contained in Chapters 3 or 5 of the Maryland Stormwater Design Manual, and include stream restoration. MDE developed an impervious acre equivalent factor for alternative BMPs because the type of treatment provided is often very different than SWM facilities. MDE provided an impervious acre equivalent of 0.01 acres per linear foot for stream restoration projects, which was applied to all proposed stream restoration opportunities identified during this assessment.

Project Cost Evaluation

Frederick County originally provided a planning level construction cost estimate of $450 per linear foot restored for stream restoration projects. This value was used to prioritize those sites to be taken to the feasibility concept phase. However, following further evaluation during feasibility concept development, it was determined that the sites had very limited constraints so the cost was reduced to $350 per linear foot restored.

The following six assumptions were used to develop total cost estimates for stream restoration projects:

1. A 10% contingency was added to the estimated construction costs to acquire a total construction cost estimate;
2. Design and engineering costs were estimated to be 32% of the construction costs;
3. Inspection costs were estimated to be 10% of the construction costs;
4. Project Management costs were estimated to be 5% of the construction, design and engineering costs;
5. Site Improvement costs were estimated to be 8% of the construction costs; and
6. The total cost estimate was calculated by summing the costs computed for assumptions 1-5.

A summary of the estimated project costs for each proposed stream restoration project can be found in Section 5.3. The "Total Cost" has been provided in the concept fact sheet for each project (Appendix D).

Prioritization of Projects

In order to prioritize the projects, Dewberry coordinated with the County to identify a number of BMP Prioritization Metrics (Table 12). The metrics were categorized into four categories:

- Nutrient and Impervious Acre Credit
- Cost
- Construction
- Community and Watershed Impacts

Each prioritization metric was assigned a weight and three-point numerical ratings were established. Table 12 provides a summary of the prioritization metrics, weights, and ratings. A Total Combined Score was generated, using the process described below, for each of the proposed projects. Projects receiving a higher score were considered to be better candidates than those receiving lower scores.

The projects were assigned a numerical rating for each prioritization metric. The value for each prioritization metric was calculated by multiplying the metric's weight by the assigned numerical rating for the project. The prioritization metric values were added together to obtain a subtotal score for each of the four prioritization categories. The subtotals for each category were added to generate a Total Combined Score for each project.

Table 12: Stream Restoration Prioritization Matrix

Ranking Components	Weight	Rating			Remarks
		1	2	3	
Nutrient and Impervious Acre Credit:					
Estimated TN Removed (lbs./yr.)	2	<150	150 - 225	>225	Use default rate of 0.075 lb/ft/yr. unless consultant strongly believes that a higher removal rate can be achieved through the use of an expert panel protocol, in which case best professional judgement should be used.
Estimated TP Removed (lbs./yr.)	2	<136	136 - 204	>204	Use default rate of 0.068 lb/ft/yr. unless consultant strongly believes that a higher removal rate can be achieved through the use of an expert panel protocol, in which case best professional judgement should be used.
Estimated TSS Removed (lbs./yr.)	2	<89,760	89,760 - 134,640	>134,640	Use default rate of 44.88 lb/ft/yr. unless consultant strongly believes that a higher removal rate can be achieved through the use of an expert panel protocol, in which case best professional judgement should be used.
Linear Feet	4	<1,500	1,500-3,000	>3,000	
Impervious Acre Credit (ac)	10	<15	15-30	>30	Based on the impervious acre equivalent of 0.01 acres per LF for non-RSC projects, or drainage area for RSC projects.
Subtotal	***60***				
Cost:					
Overall Planning Level Costs	3	>$800K	$600K - $800K	<600K	Based on acceptable costs for these types of projects
Cost/Pound of Nitrogen Removed	1	> $2,000	$149 - $2,000	$149	Use construction cost of $350 per LF and professional judgement if site requires additional costs
Cost/Pound of Phosphorus Removed	1	> $5,000	$800 - 5,000	$800	Use construction cost of $350 per LF and professional judgement if site requires additional costs
Cost/Pound of Sediment Removed	1	> $10	$1.55 - $10	$1.55	Use construction cost of $350 per LF and professional judgement if site requires additional costs
Cost/Impervious Acre Treated	4	>$80,000	$60,000 - $80,000	<$60,000	Use construction cost of $350 per LF and professional judgement if site requires additional costs
Subtotal	***30***				
Construction:					
Conflicts	4	Extensive Conflicts	Minor Conflicts	No Conflicts	**Extensive conflicts** impact 2 or more utility crossings and require significant design and construction efforts to move multiple utilities (i.e. sewer) or significant impacts to healthy riparian/upland habitats; **Minor conflicts** impact two or less utility crossings and do not require significant design and construction (i.e. cable) and minimal impacts to healthy riparian/upland habitats
Easement Requirements	2	Easement required for >8 properties	Easement required for ≤ 8 properties	No additional easement requirements or Temporary construction access easement only	**Easement Required** = the proposed project will occur on private property and the County will be required to obtain an easement from the current property owner in order to implement the project; **Temporary Construction Access Only** = the proposed project is located on County-owned property but in order to access the site for construction, a temporary easement will need to be acquired

Table 12: Stream Restoration Prioritization Matrix

Ranking Components	Weight	Rating			Remarks
		1	2	3	
Constructability/Access	2	Difficult	Moderate	Easy	Criteria evaluated to rank constructability/access includes: site topography, wet/dry areas, wetland impacts, distance from road, and vegetation clearing.
Existing Forest Retention Ordinance (FRO) Present	2	Yes, >25% of the LOD	Yes, ≤25% of the LOD	No FRO present	Use the Frederick County Forest_Resource GIS layer
Subtotal	***30***				
Community and Watershed Impacts:					
Benthic IBI Score	4	Good/Fair	Poor	Very Poor	Use FCSS BIBI data
Land use/Impervious Cover Within Watershed	2	Damaged	Impacted	Sensitive	Use FCSS Land use and Impervious data. **Damaged** = Urban, actively urbanizing, or primarily agricultural. Typically less than 20% forest or >15% impervious. **Impacted** = Suburban development or active agriculture occurring. Typically 20-70% forested or 7-15% impervious. **Sensitive** = Rural communities or slow growth. Primarily forested and <7% impervious
Floodplain Connectivity	4	Connected	Incised with limited floodplain area	Incised with large floodplain area	Floodplain Connectivity should be based on field observations of incision, approximate bankfull height ratio (low top of bank height/bankfull height), and the adjacent floodplain or floodprone area. **Connected** = The stream channel is not incised and stormflows appear to have frequent access to the floodplain. **Incised with limited floodplain area** = Stormflows access the floodplain on rare occasions and floodplain area available for reconnection may be limited. **Incised with large floodplain area** = Only the largest stormflows are able to access the floodplain; bank height is nearly twice bankfull depth throughout the reach. A large floodplain is available for reconnection.
Lateral Stability of Stream Channel	5	Stable	Moderately Stable	Unstable	The lateral stability of the reach should be based on field observations of active erosion and BEHI factors that are noted during the assessment. **Stable** = Stream banks are stable and have properties that should allow for continued resistance to erosion (i.e. low BEHI parameter ratings). **Moderately Stable** = Stream banks are moderately resistant to erosion, but signs of active erosion are present. **Unstable** = Stream banks are actively eroding and banks will likely continue to erode. Field indicators are typically raw banks, numerous fallen bank trees, and high BEHI parameters.
Proximity to Stormwater Management	2	No known stormwater management upstream	Underperforming/pre-2002 era stormwater management upstream	Post 2002 era stormwater management upstream or proposed retrofit	Frederick County NPDES BMP data (existing and proposed BMPs) and projects proposed during this watershed study should be used to determine the level of stormwater management upstream of the stream site.
Functional Lift Potential	3	Geomorphic Level	Physiochemical Level	Biological Level	This should take into account both existing and proposed conditions.
Subtotal	***60***				
	180				

Low score = bad candidate = low priority

High score = good candidate = high priority

Take the Rating Score multiplied by the weight

4. POTENTIAL OPPORTUNITIES IDENTIFIED

As discussed in Section 1.2 and illustrated in Figure 1, Dewberry followed the County's three-step evaluation process for conducting the Catoctin Creek Watershed Assessment. Sites identified during a step but not promoted to the next step (for example: sites identified during Step 1: GIS Desktop Analysis but not promoted to Step 2: Field Site Assessment) typically either had fatal flaws identified upon further evaluation or other site constraints that made the potential opportunity less cost effective at this time. Table 13 provides a summary of the results of each evaluation step. The value listed in the "Site Status" column of Tables 14 - 16, represents the final status of a site at the completion of the watershed assessment. For example, a site listed as "Desktop" was not taken to the field assessment step whereas a site listed as "Concept" was taken to the field assessment and ultimately the concept development steps.

Table 13 – Summary of Assessment Results

Potential Opportunity Type	Step 1: GIS Desktop Analysis	Step 2: Field Site Assessments	Step 3: Feasibility Concept Development
Pond Sites	39	22	12
New BMP Sites	30	12	1
Stream Restoration Sites	43	20	5
TOTAL	**112**	**54**	**18**

4.1. Pond Retrofits and New SWM BMPs

The assessment identified a total of thirty-nine (39) retrofit opportunities through the desktop analysis in the Catoctin Creek Watershed. Field assessments were conducted for twenty-two (22) retrofit sites, and concept documents were developed for twelve (12) sites (Appendix D). Table 14 provides details on each retrofit opportunity identified throughout the course of the watershed assessment, and Figures 14 – 17 show the site locations. All retrofit opportunities are located within the Catoctin Creek NPDES watershed because all existing SWM Era 1 or SWM Era 2 BMPs located within the Middle Creek NPDES watershed are within the Town of Myersville.

The assessment identified a total of thirty (30) new SWM BMP opportunities in the Catoctin Creek Watershed. Three (3) new SWM BMP opportunities are located with the Middle Creek NPDES watershed, but all new SWM BMP opportunities selected for field assessments and concept development are located within the Catoctin Creek NPDES watershed. Proposed SWM BMP types included bioretentions, micro-bioretentions, sand filters, rain gardens, submerged gravel wetlands, bio-swales, and step pool storm conveyances (sometimes referred to as regenerative stormwater conveyances). Field assessments were conducted for a total of twelve (12) new SWM BMP sites, and concept documents were developed for one (1) site (Appendix D). Table 15 provides details on each new SWM BMP opportunity identified throughout the course of the watershed assessment, and Figures 18 – 22 show the site locations.

Table 14 – Retrofit Opportunities

BMP No.	Structure Name	MDE Structure Type**	Design Approval Date	Era Designation	Site Status
29	Cambridge Farms, SWM Pond No. 1	EDSD	4/22/1990	SWM Era 2	Concept
115	Briercrest Apartments	EDSD	11/14/1990	SWM Era 2	Concept
188*	The Hills @ Maryland National - Extended Detention	EDSD	6/10/2002	SWM Era 2	Concept
413	Springdale Detention Pond	DP	7/22/1981	SWM Era 1	Concept
419	Holy Family Catholic Community Worship Center	EDSW	8/17/1995	SWM Era 2	Concept
420	Sheppard Pratt, SWM Pond #1	EDSD	9/23/1996	SWM Era 2	Concept

Table 14 – Retrofit Opportunities

BMP No.	Structure Name	MDE Structure Type**	Design Approval Date	Era Designation	Site Status
421	Sheppard Pratt, SWM Pond #2	EDSD	9/20/1996	SWM Era 2	Concept
628	The Legends	BR, EDSD	4/16/1999	SWM Era 2	Concept
672	Jefferson Court, Section 2 - WQ Pond	EDSD	4/11/1996	SWM Era 2	Concept
695	Jefferson Junction Shopping Center - ED Pond	EDSD	8/7/2000	SWM Era 2	Concept
752	Cambridge Farms, SWM Pond No. 2	EDSD	6/25/1993	SWM Era 2	Concept
1163	The Vistas at Springdale HOA	EDSW	4/25/2001	SWM Era 2	Concept
25	Jefferson Junction	DP	2/29/1988	SWM Era 2	Field
31	Maryland National Golf Club - Bioretention Area	BR	3/31/2000	SWM Era 2	Field
33	Maryland National Golf - E.D. Pond	EDSD	3/31/2000	SWM Era 2	Field
116	Warren Electric, Inc.	IB	12/7/1989	SWM Era 2	Field
117	Myersville Family Medical Center, Detention Basin	EDSD	1/11/1989	SWM Era 2	Field
208	The Vistas at Springdale, SWM Pond #2	SM	4/23/2001	SWM Era 2	Field
268	Valley View Estates, Section 3 - Shallow Marsh	EDSW	5/7/2001	SWM Era 2	Field
386	Wiles Estates Check Dams	SW	3/13/1990	SWM Era 2	Field
496	The Crossings at Middletown	EDSD	3/31/1997	SWM Era 2	Field
616	Middletown Valley Seventh Day Adventist Church	EDSD	6/23/1997	SWM Era 2	Field
19	Pecan Hill II	EDSW	3/14/1990	SWM Era 2	Desktop
61	Jefferson Oaks	SM	9/14/1989	SWM Era 2	Desktop
81***	Fountaindale South - Lot 602 (Joe Brown's Pond)	EDSW	5/10/1990	SWM Era 2	Desktop
352	Medd Property ED Basin	EDSD	6/7/1995	SWM Era 2	Desktop
388	Highfields, Section 2	IB	9/13/1990	SWM Era 2	Desktop
492	P.H. Drayer, Inc.	EDSD	1/7/1992	SWM Era 2	Desktop
567	High's at Middletown, Basin #1 (Upper Basin)	SM	12/11/1997	SWM Era 2	Desktop
568***	High's at Middletown, Basin #2 (Lower Basin)	SM	12/11/1997	SWM Era 2	Desktop
612	Adams Advanced Nutrition	BR	5/15/2000	SWM Era 2	Desktop
623	Musket Ridge Golf Course - Pond #1	WP	7/30/1999	SWM Era 2	Desktop
624***	Musket Ridge Golf Course - Pond #2	WP	11/5/1999	SWM Era 2	Desktop
879***	Musket Ridge Golf - Biofilter #1	BR	4/20/2000	SWM Era 2	Desktop
880***	Musket Ridge Golf Course - Biofilter #2	BR	4/20/2000	SWM Era 2	Desktop
881***	Musket Ridge Golf Course - Biofilter #3	BR	4/20/2000	SWM Era 2	Desktop
882***	Musket Ridge Golf Course - Biofilter #4	BR	4/20/2000	SWM Era 2	Desktop
989	Valley Baptist Church - Biofilter 'A'	BR	5/6/1998	SWM Era 2	Desktop
990	Valley Baptist Church - Biofilter 'B'	BR	5/6/1998	SWM Era 2	Desktop

*Has SWM Era 3 design approval date, but plan review/field observations confirmed no WQv treatment provided; facility was classified as SWM Era 2.
**A table of MDE Structure Types is available in Appendix A
***Site designated for future WQv analysis study

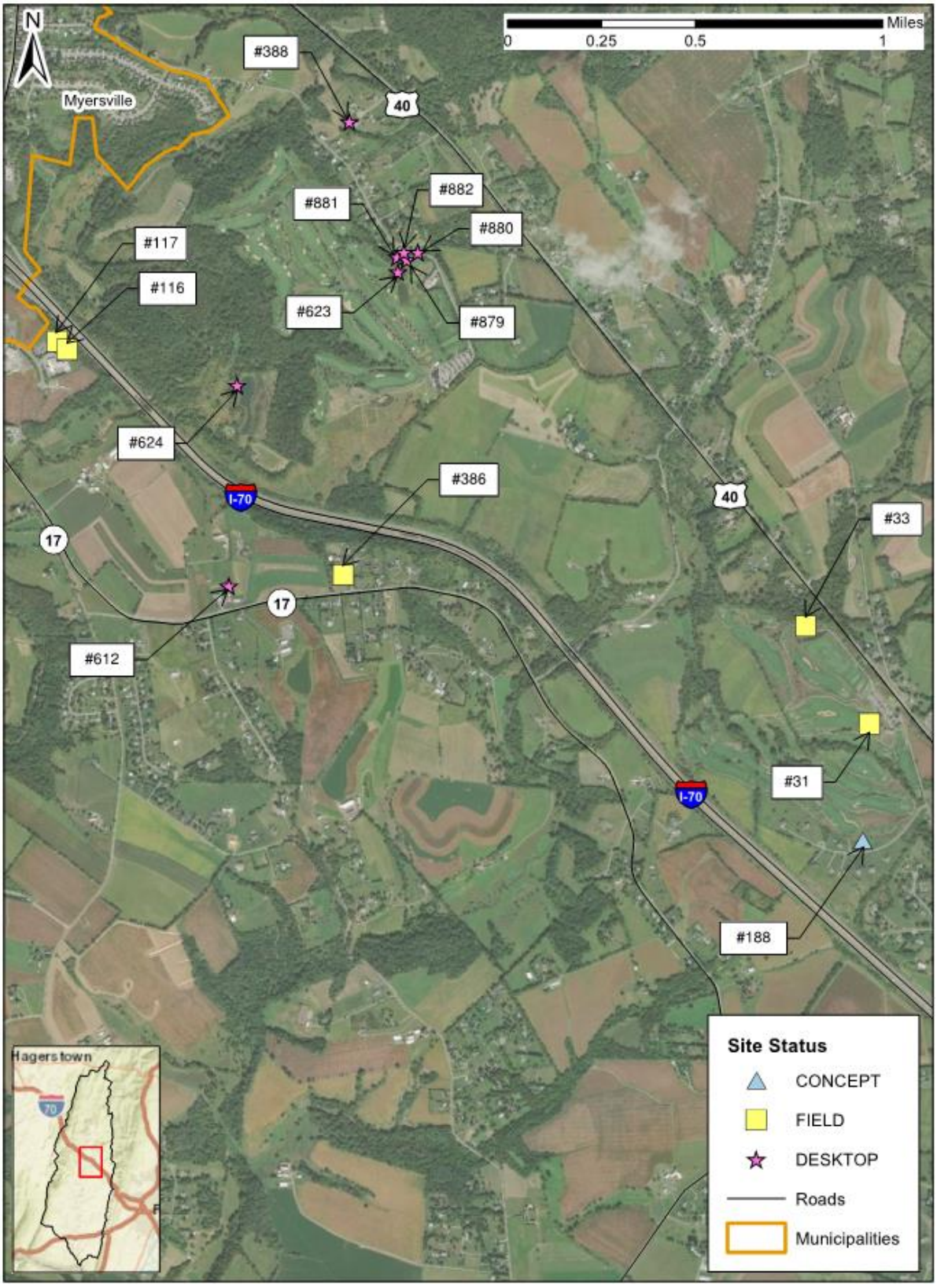

Figure 14: Catoctin Creek Watershed Retrofit Opportunities – Map 1

Figure 15: Catoctin Creek Watershed Retrofit Opportunities – Map 2

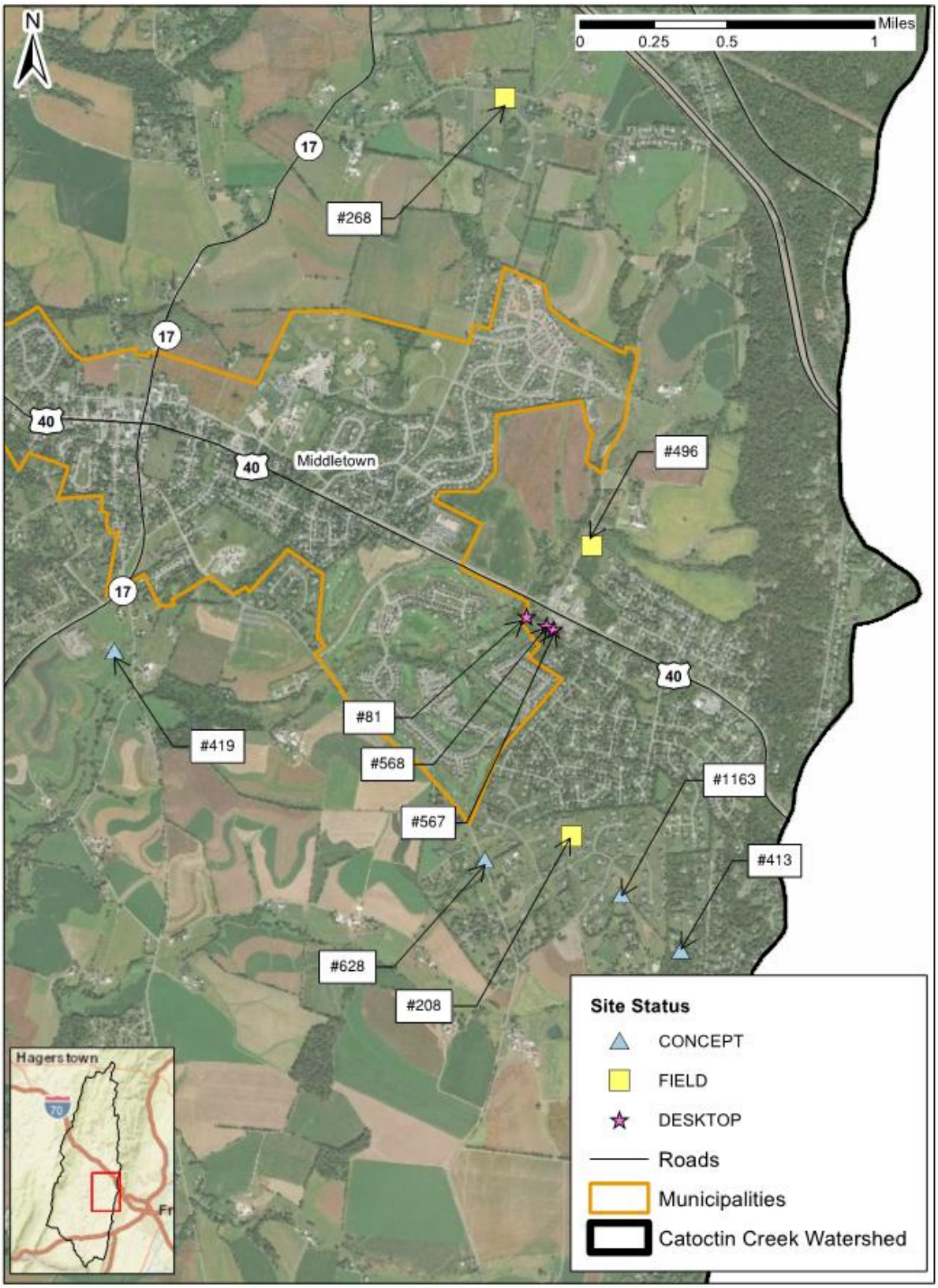

Figure 16: Catoctin Creek Watershed Retrofit Opportunities – Map 3

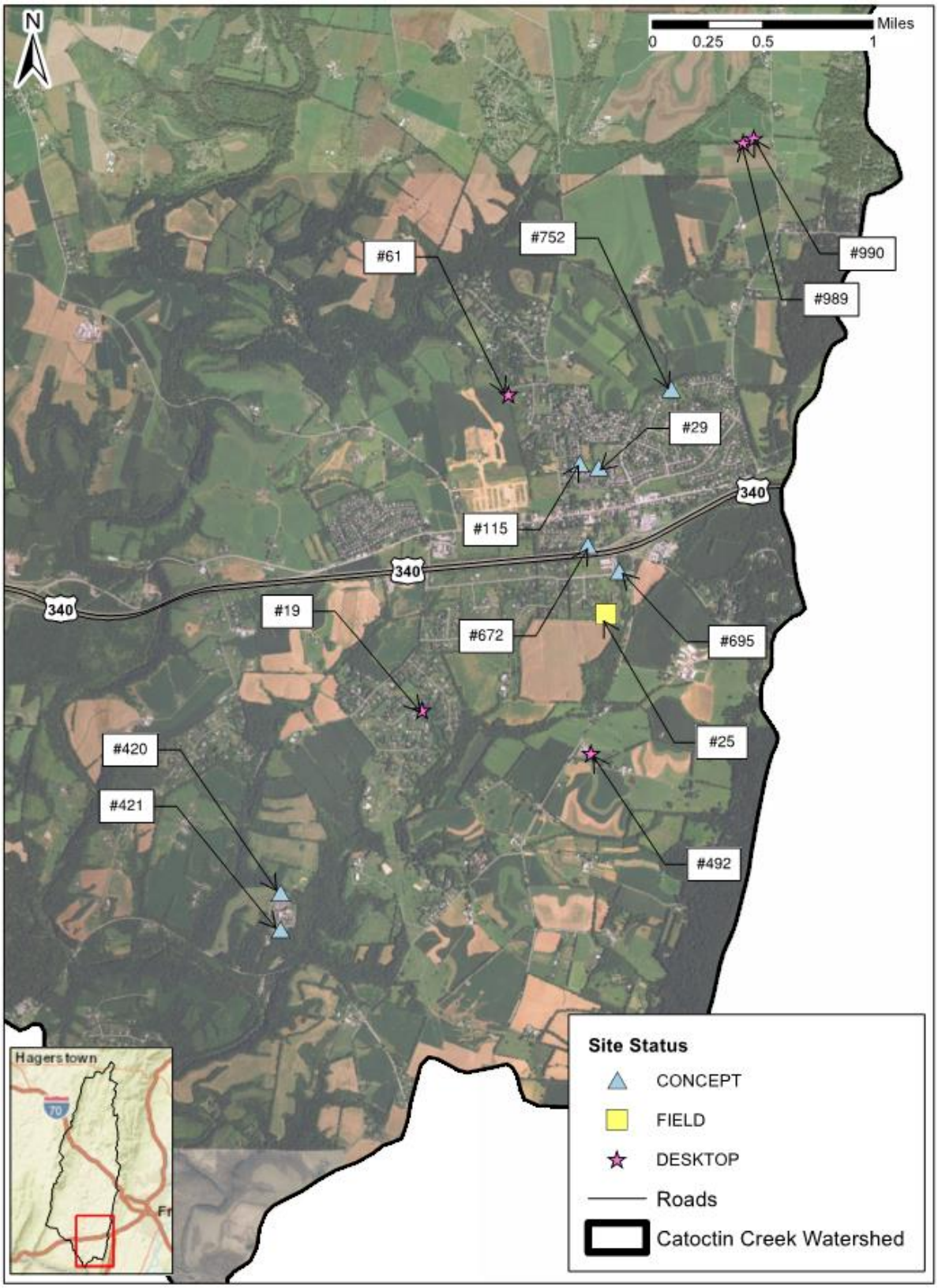

Figure 17: Catoctin Creek Watershed Retrofit Opportunities – Map 4

Table 15 – New SWM BMP Opportunities

Site ID	Proposed BMP Type	Property Owner	Site Status
CATO-2018-SPSC-0005	Step Pool Storm Conveyance	Miller and Miller Properties LLC	Concept
CATO-2018-FBIO-0002	Bioretention	Springbrook Townhomes	Field
CATO-2018-FBIO-0008	Bioretention	Middletown United Methodist Church	Field
CATO-2018-FBIO-0010	Bioretention	Holy Family Catholic Church	Field
CATO-2018-FSND-0001*	Sand Filter	JCA IV Myersville LLC	Field
CATO-2018-FSND-0003	Sand Filter	Alban Partnership	Field
CATO-2018-FSND-0004*	Sand Filter	Barbara A Colunga	Field
CATO-2018-MRNG-0001	Rain Gardens	JCA IV Myersville LLC	Field
CATO-2018-MRNG-0002	Rain Gardens	Holy Family Catholic Church	Field
CATO-2018-MSGW-0002	Submerged Gravel Wetlands	Frederick County	Field
CATO-2018-SPSC-0002	Step Pool Storm Conveyance	No owner listed/Open Space	Field
CATO-2018-SPSC-0006	Step Pool Storm Conveyance	Gerardo & Carole Sepe	Field
CATO-2018-FBIO-0001	Bioretention	Springbrook Townhomes	Desktop
CATO-2018-FBIO-0003	Bioretention	Springbrook Townhomes	Desktop
CATO-2018-FBIO-0004	Bioretention	Locust Valley Bible Church	Desktop
CATO-2018-FBIO-0005	Bioretention	Locust Valley Bible Church	Desktop
CATO-2018-FBIO-0006	Bioretention	Fordham Holdings LLC	Desktop
CATO-2018-FBIO-0007	Bioretention	Harmony Church of the Brethren	Desktop
CATO-2018-FSND-0002	Sand Filter	T&T Enterprises	Desktop
CATO-2018-MMBR-0001	Micro-Bioretention	Fordham Holdings LLC	Desktop
CATO-2018-MMBR-0002	Micro-Bioretention	Trust of Jefferson United Methodist Church	Desktop
CATO-2018-MMBR-0003	Micro-Bioretention	Trust of Jefferson United Methodist Church	Desktop
CATO-2018-MSWB-0001	Bio-Swale	SHA ROW	Desktop
CATO-2018-MSWB-0002	Bio-Swale	Burkitsville Ruritan Club	Desktop
CATO-2018-SPSC-0001	Step Pool Storm Conveyance	J Ingram & Sons Inc	Desktop
CATO-2018-SPSC-0003	Step Pool Storm Conveyance	Terry and Gloria Tasker	Desktop
CATO--2018-SPSC-0004	Step Pool Storm Conveyance	Douglas Adams	Desktop
MIDD-2018-FBIO-0001	Bioretention	St. Mark's Evan Luthern Church	Desktop
MIDD-2018-FBIO-0002	Bioretention	Harne Mehrl G & Carol A	Desktop
MIDD-2018-FBIO-0003	Bioretention	Salem United Methodist Church of Wolfsville	Desktop

*CATO-2018-FSND-0001 and CAT-2018-FSND-0004 are proposed sand filters that were assigned to concept development after field assessments. The placement of a sand filter at CATO-2018-FSND-0001 would require the relocation of an existing riser structure and the replacement of an existing embankment, resulting in a high project cost for very little impervious treatment. The placement of a sand filter at CATO-2018-FSND-0004 would require much more space than what is available on site, and further analysis showed that full treatment of the proposed BMP's drainage area can be provided by the proposed RSC project located in the downstream channel (CATO-2018-SPSC-0005).

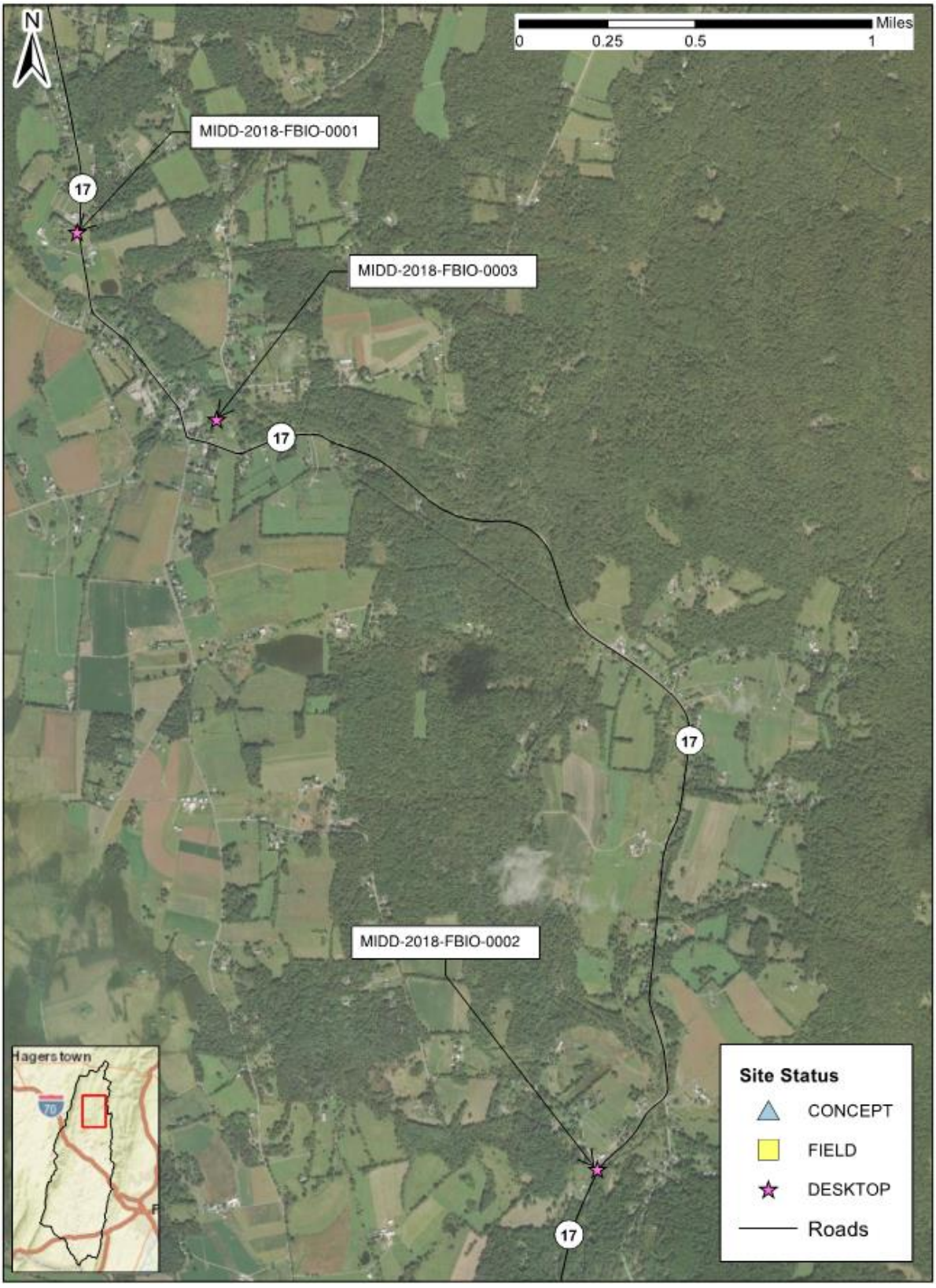

Figure 18: Catoctin Creek Watershed New BMP Opportunities – Map 1

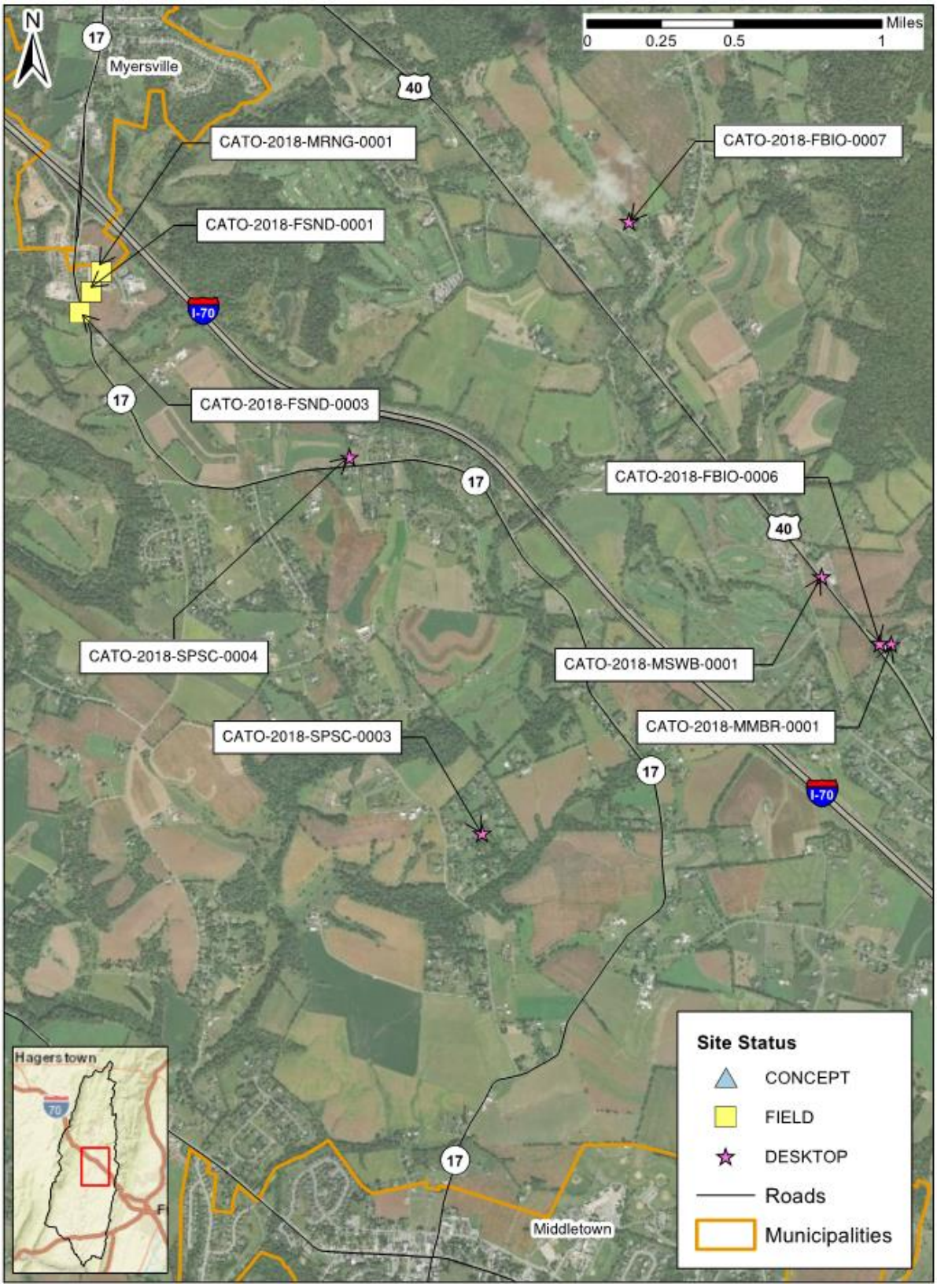

Figure 19: Catoctin Creek Watershed New BMP Opportunities – Map 2

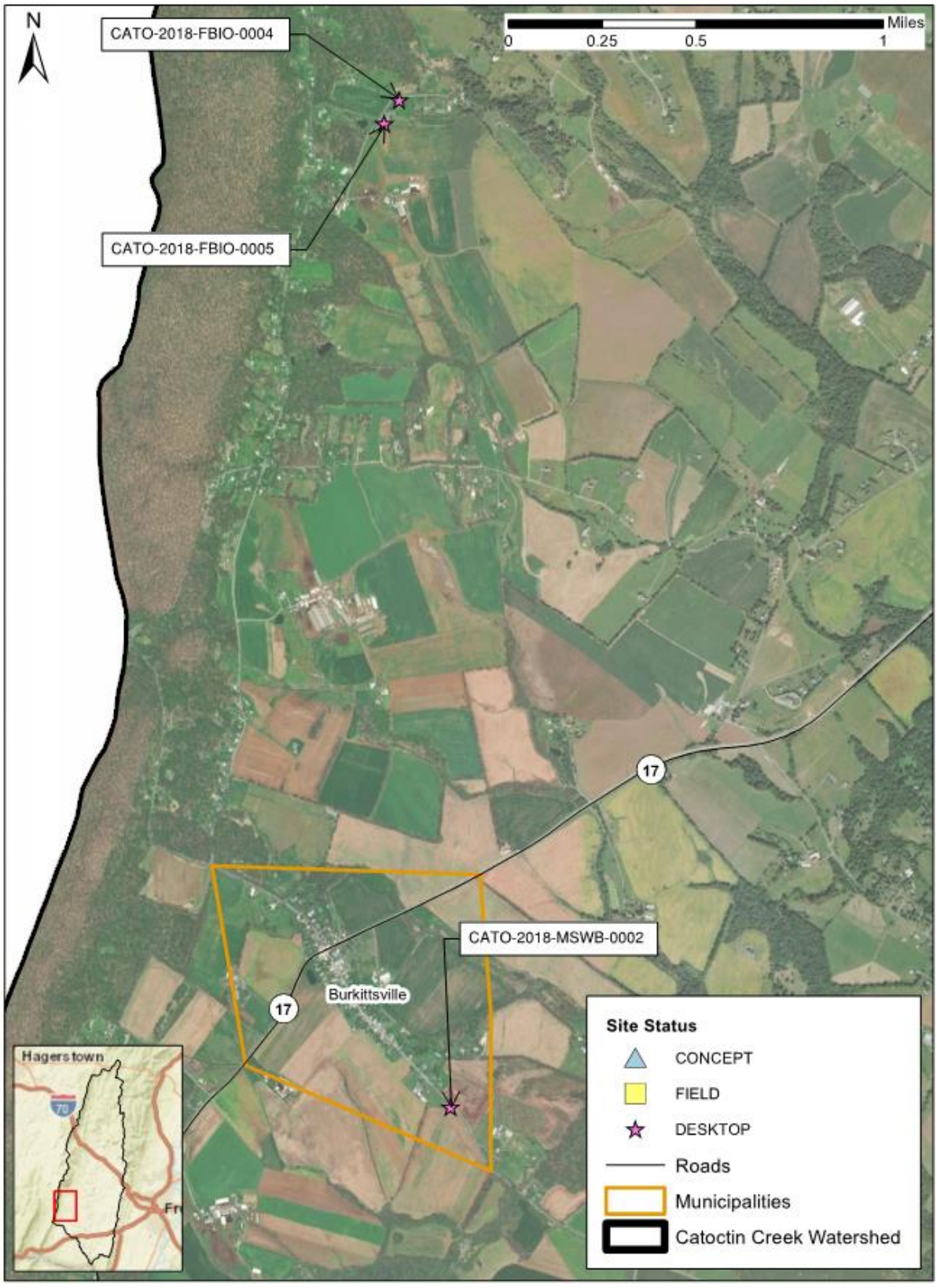

Figure 20: Catoctin Creek Watershed New BMP Opportunities – Map 3

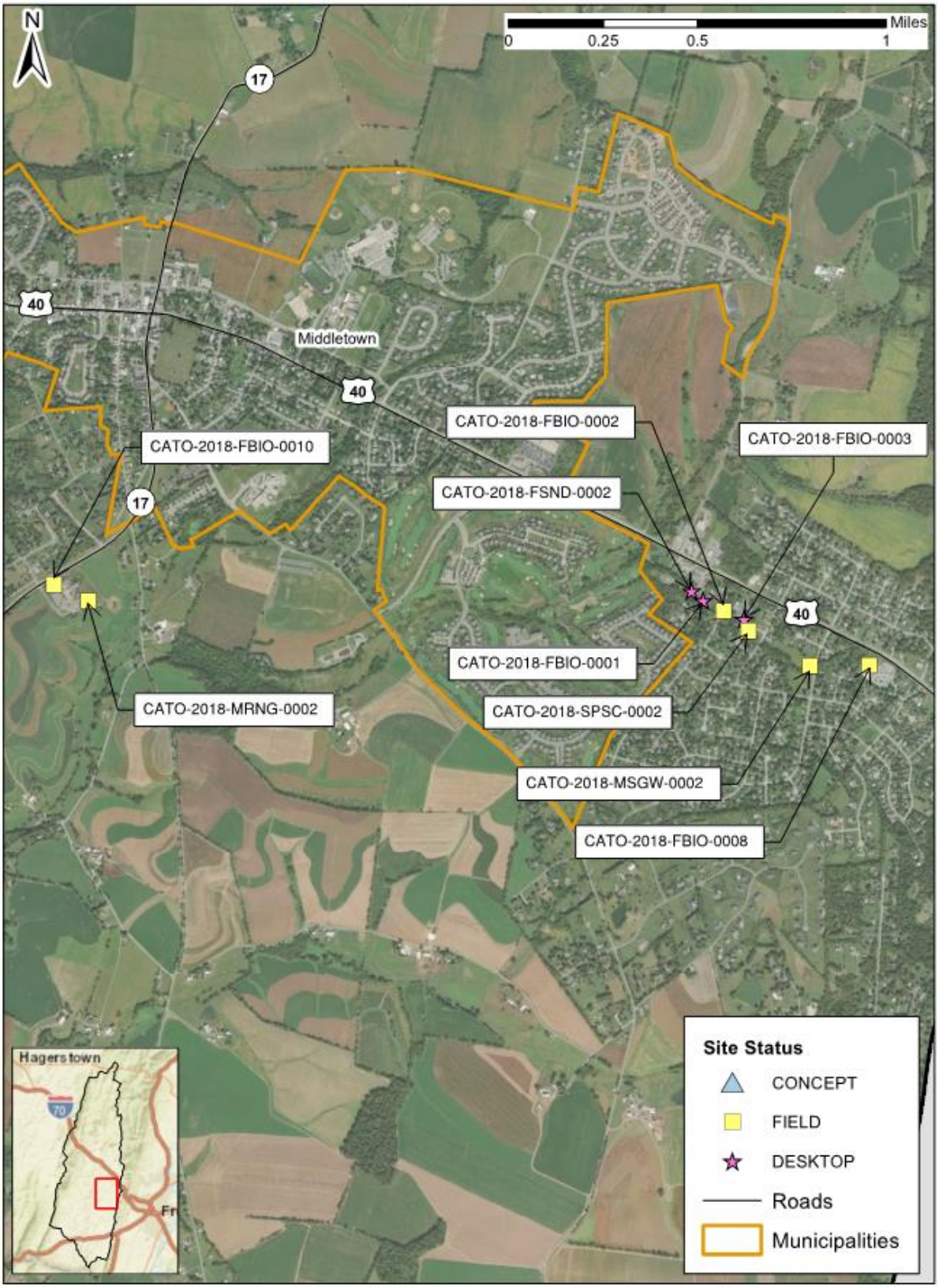

Figure 21: Catoctin Creek Watershed New BMP Opportunities – Map 4

Figure 22: Catoctin Creek Watershed New BMP Opportunities – Map 5

4.2. Stream Restoration

The assessment identified a total of forty-three (43) stream restoration opportunities in the Catoctin Creek Watershed. Twelve (12) stream restoration opportunities are located with the Middle Creek NPDES watershed, and the remainder are located within the Catoctin Creek NPDES watershed. Field assessments were conducted for a total of twenty (20) stream restoration sites totaling approximately 50,000 linear feet in length. Concept documents were developed for five (5) sites totaling approximately 11,000 linear feet in length (Appendix D). Table 16 provides details on each stream restoration opportunity identified and Figures 23 – 25 show the site locations.

Table 16 – Stream Restoration Opportunities

Site ID	Length (linear feet)	Site Status	Site ID	Length (linear feet)	Site Status
CATO-2018-STRE-0001	4581	Concept	**CATO-2018-STRE-0005**	3256	Desktop
CATO-2018-STRE-0008	2010	Concept	**CATO-2018-STRE-0006**	3781	Desktop
CATO-2018-STRE-0016[a]	1750	Concept	**CATO-2018-STRE-0007**	4103	Desktop
CATO-2018-STRE-0018	1789	Concept	**CATO-2018-STRE-0009**	1777	Desktop
CATO-2018-STRE-0020[a]	735	Concept	**CATO-2018-STRE-0010**	3831	Desktop
CATO-2018-STRE-0030[b]	165	Concept	**CATO-2018-STRE-0011**	1646	Desktop
CATO-2018-STRE-0031[b]	154	Concept	**CATO-2018-STRE-0012**	2163	Desktop
CATO-2018-STRE-0002	3419	Field	**CATO-2018-STRE-0013**	1115	Desktop
CATO-2018-STRE-0021	2478	Field	**CATO-2018-STRE-0014**	3327	Desktop
CATO-2018-STRE-0022	2513	Field	**CATO-2018-STRE-0015**	1769	Desktop
CATO-2018-STRE-0026	2426	Field	**CATO-2018-STRE-0017**	833	Desktop
CATO-2018-STRE-0029	2367	Field	**CATO-2018-STRE-0019**	514	Desktop
MIDD-2018-STRE-0001	1863	Field	**CATO-2018-STRE-0023**	1401	Desktop
MIDD-2018-STRE-0002	5442	Field	**CATO-2018-STRE-0024**	2378	Desktop
MIDD-2018-STRE-0005	4138	Field	**CATO-2018-STRE-0025**	496	Desktop
MIDD-2018-STRE-0006	2170	Field	**CATO-2018-STRE-0027**	6476	Desktop
MIDD-2018-STRE-0007	2537	Field	**CATO-2018-STRE-0028**	710	Desktop
MIDD-2018-STRE-0009	4026	Field	**MIDD-2018-STRE-0003**	1390	Desktop
MIDD-2018-STRE-0010	416	Field	**MIDD-2018-STRE-0004**	2014	Desktop
MIDD-2018-STRE-0011	1745	Field	**MIDD-2018-STRE-0008**	1995	Desktop
CATO-2018-STRE-0003	4135	Desktop	**MIDD-2018-STRE-0012**	2230	Desktop
CATO-2018-STRE-0004	3366	Desktop			

[a]The field investigations for CATO-2018-STRE-0016 and CATO-2018-STRE-0020 included an assessment of approximately 5,360 linear feet of stream, and 2,050 linear feet of stream, respectively. Concepts were only developed for the downstream most portion of each site.
[b]CATO-2018-STRE-0030 and CATO-2018-STRE-0031 are channel stabilization projects associated with the retrofit of BMP 413. The locations of the two stabilization projects are shown on the BMP 413 concept plan, but separate stream restoration concepts were not developed for these sites.

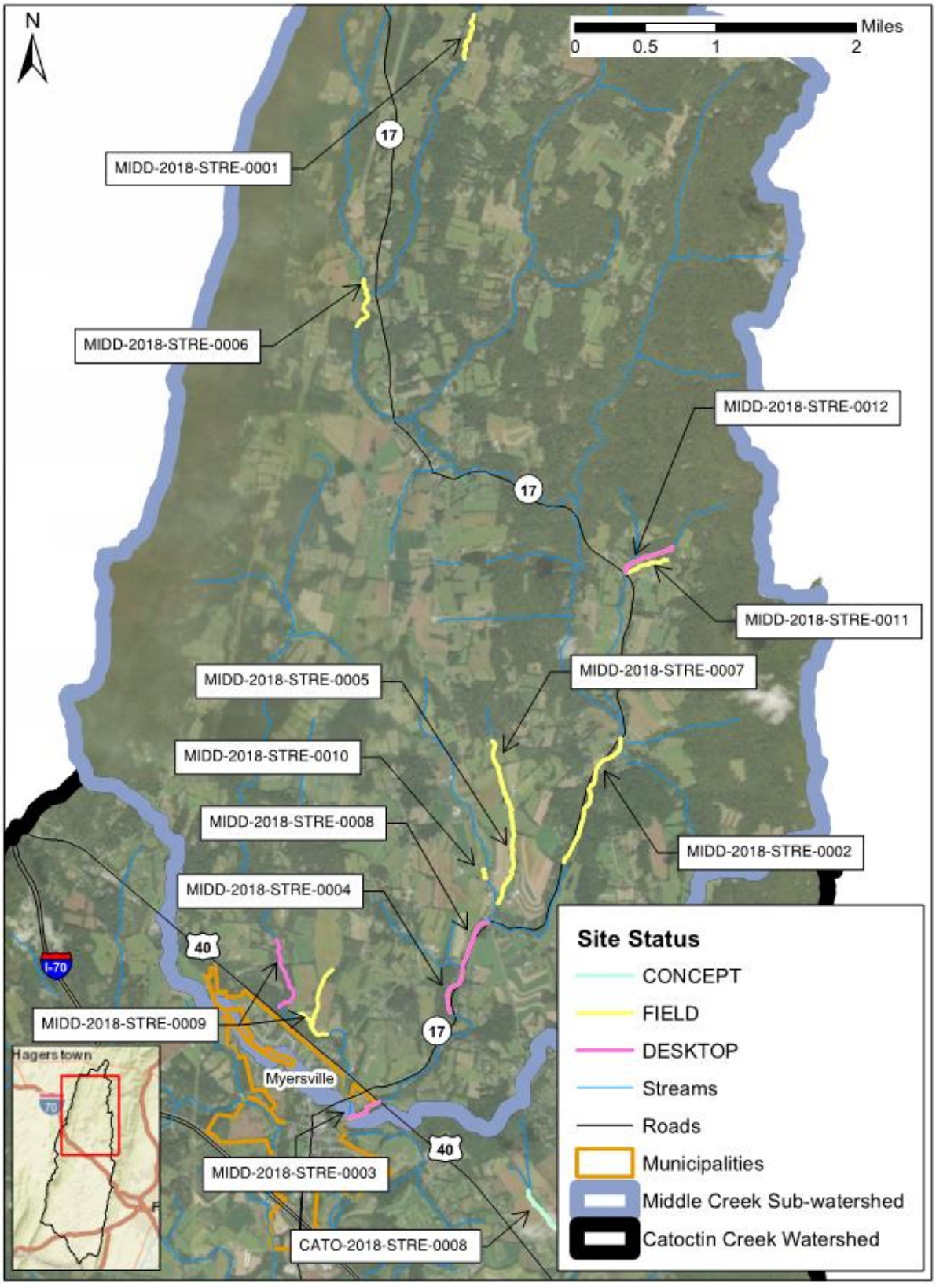

Figure 23: Catoctin Creek Watershed Stream Restoration Opportunities – Map 1

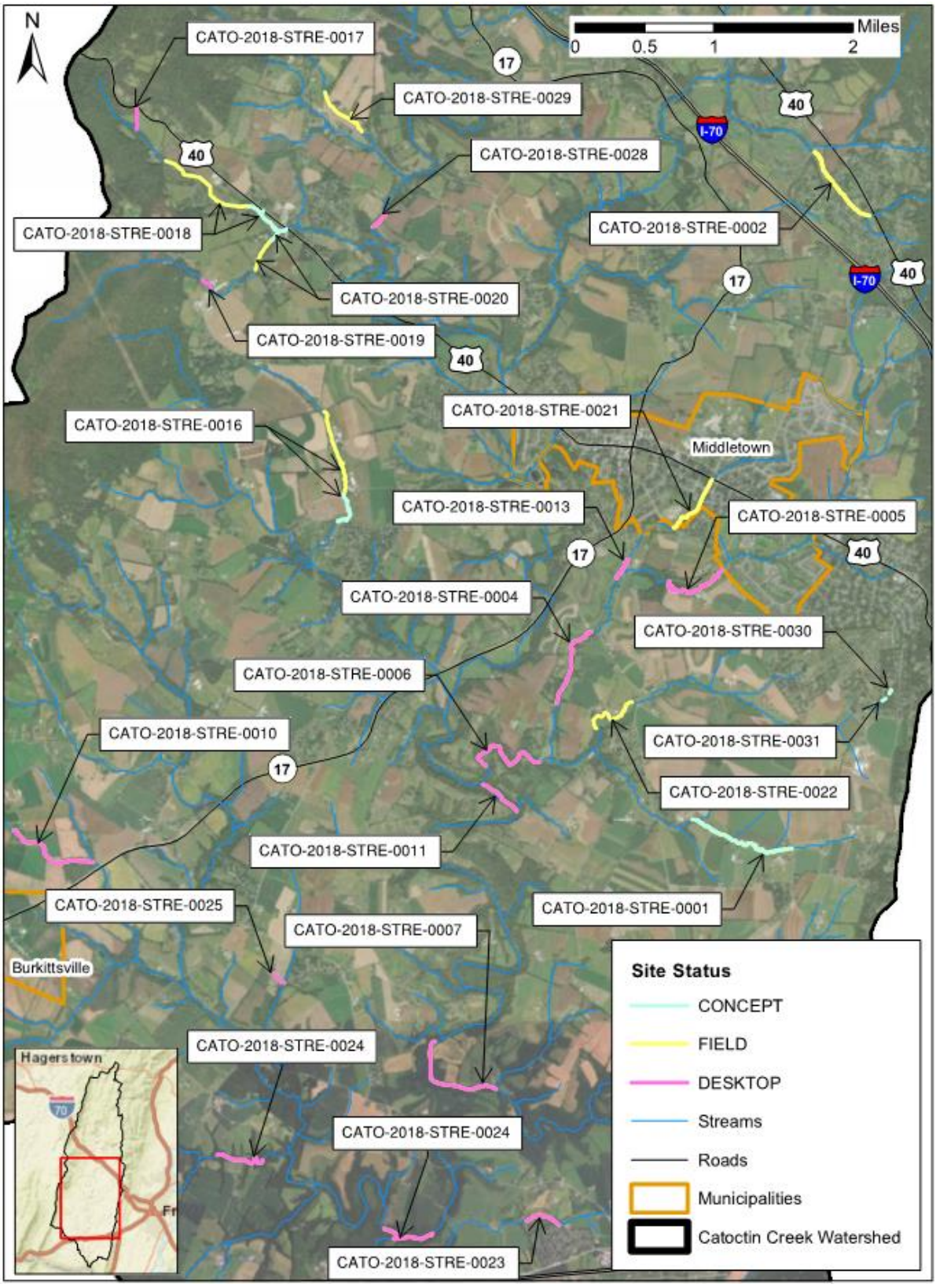

Figure 24: Catoctin Creek Watershed Stream Restoration Opportunities – Map 2

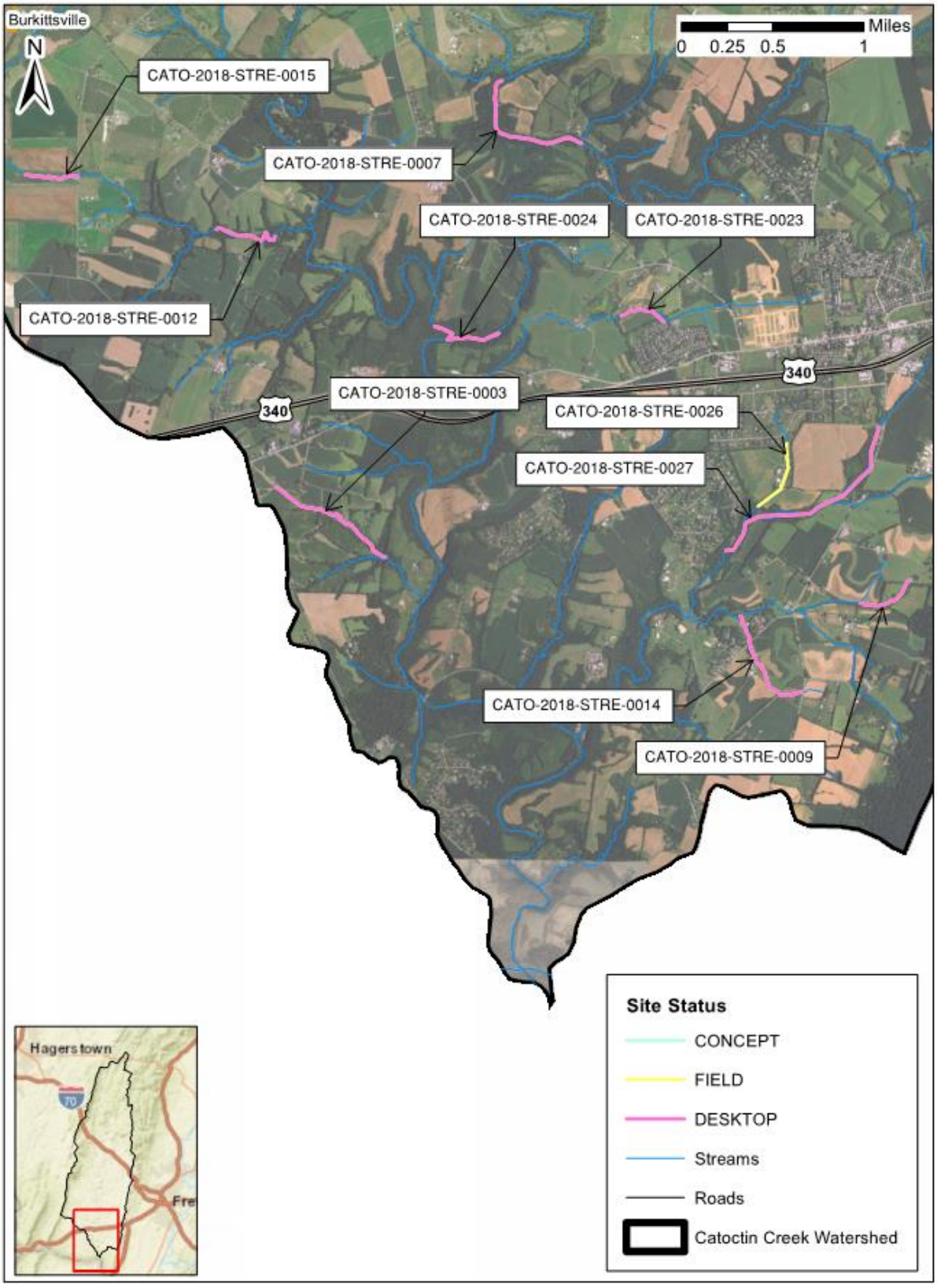

Figure 25: Catoctin Creek Watershed Stream Restoration Opportunities – Map 3

5. PRIORITY PROJECTS

5.1. Recommended Priority Projects

5.1.1. Pond Retrofits and New SWM BMPs

As described in Section 3 – Methodology, Dewberry evaluated existing stormwater management best management practices (SWM BMPs) and new stormwater opportunities within the Catoctin Creek Watershed. Dewberry selected appropriate projects based on existing conditions identified during the field assessments. Using Chapter 4 of the MDE 2000 Manual and the *Carroll County Supplement to the Maryland Stormwater Design Manual Volumes I & II*, the following project types were selected: wet ponds, extended detention wet ponds, pocket sand filters, pocket pond, regenerative step pool conveyance, and surface sand filters. All project options attempt to address 1 inch of runoff from the entire untreated impervious area within the drainage area to provide the full WQ_v treatment per the MD 2000 Manual. Table 17 below provides a list of the proposed retrofit/restoration projects for each SWM BMP and new stormwater opportunity. If N/A is listed under "Existing Practice Type" then the facility is a new BMP. All other projects which did not move to concept level are listed in Appendix B.

Table 17: Proposed Retrofit and New BMP Projects

BMP No./Site ID	Existing Practice Type	Proposed Practice Type
BMP #413	Dry Pond	Wet Pond (P-2)
BMP #419	Extended Detention Wet Pond	Extended Detention Wet Pond (P-3)
BMP #1163	Extended Detention Wet Pond	Extended Detention Wet Pond (P-3)
BMP #420	Extended Detention Dry Pond	Pocket Sand Filter (F-5)
BMP #421	Extended Detention Dry Pond	Pocket Sand Filter (F-5)
BMP #752	Extended Detention Dry Pond	Wet Pond (P-2)
CATO-2018-SPSC-0005	N/A	Regenerative Step Pool Conveyance
BMP #695	Extended Detention Dry Pond	Pocket Pond (P-5)
BMP #29	Extended Detention Dry Pond	Enhanced Surface Sand Filter
BMP #115	Extended Detention Dry Pond	Enhanced Surface Sand Filter
BMP #672	Extended Detention Dry Pond	Enhanced Surface Sand Filter
BMP #628	Bioretention/Extended Detention Dry Pond	Enhanced Surface Sand Filter
BMP #188	Extended Detention Dry Pond	Enhanced Surface Sand Filter

5.1.2. Stream Restoration

As described in Section 3 – Methodology, Dewberry evaluated stream restoration opportunities within the Catoctin Creek Watershed. Dewberry selected appropriate projects based on existing stream function parameters evaluated in the field, and the potential for a project to result in functional lift. Table 18 below provides a list of projects for which stream restoration concepts were developed. The functional lift potential shown for each project is based on a combination of field observations, monitoring data, and GIS data. The proposed restoration approaches are based on field observations and site constraints. All projects which did not move to concept level are listed in Appendix B.

Table 18: Proposed Stream Restoration Projects

Site ID	Functional Lift Potential	Proposed Restoration Approach
CATO-2018-STRE-0001	Geomorphic Level	Natural Channel Design and Legacy Sediment Removal
CATO-2018-STRE-0008	Physicochemical Level	Natural Channel Design (focus on head cut stabilization)
CATO-2018-STRE-0016	Biological Level	Natural Channel Design or Legacy Sediment Removal
CATO-2018-STRE-0018	Biological Level	Natural Channel Design or Legacy Sediment Removal
CATO-2018-STRE-0020	Geomorphic Level	Natural Channel Design

5.1.3. Project Prioritization Scores

As described in Section 3 – Methodology, Dewberry identified prioritization metrics in coordination with the County. Once the feasibility concepts were complete for each proposed project, a prioritization score was assigned using the identified metrics. Table 19 summarizes the results for each SWM BMP retrofit, new stormwater, and stream restoration opportunity selected for concept development. The proposed projects are ordered by Total Combined Score from highest to lowest. The higher the score, the higher the priority. **NOTE:** Stream restoration projects were prioritized separately from pond retrofits and new SWM BMPs.

Table 19: Project Prioritization Scores

BMP Site/Site ID	Proposed Practice Type	Nutrient & Impervious Acre Credit (Max = 60)	Cost (Max = 60)	Construction (Max = 60)	Community & Watershed Impacts (Max = 60)	Total Combined Score (Max = 240)	WQv Treatment Provided (ac. ft.)	Prioritization Ranking
Pond Retrofits and New BMP Projects								
BMP #413	Wet Pond (P-2)	46	42	37	52	177	1.09	1
BMP #419	Extended Detention Wet Pond (P-3)	30	48	55	36	169	0.33	2
BMP #1163	Extended Detention Wet Pond (P-3)	40	44	47	36	167	1.98	3
BMP #420	Pocket Sand Filter (F-5)	30	48	51	38	167	0.21	4
BMP #421	Pocket Sand Filter (F-5)	30	48	48	38	164	0.19	5
BMP #752	Wet Pond (P-2)	50	38	41	34	163	3.68	6
CATO-2018-SPSC-0005	Regenerative Step Pool Conveyance	40	48	39	34	161	0.42	7
BMP #695	Pocket Pond (P-5)	30	48	47	36	161	0.20	8
BMP #29	Surface Sand Filter	36	34	45	36	151	3.29	9
BMP #115	Surface Sand Filter	34	34	45	38	151	2.58	10
BMP #672	Surface Sand Filter	30	34	51	36	151	1.82	11
BMP #628	Surface Sand Filter	38	34	40	38	150	2.66	12
BMP #188	Surface Sand Filter	30	40	43	32	145	0.57	13
Stream Restoration Projects								
CATO-2018-STRE-0001	Stream Restoration	60	14	22	42	138	N/A	1
CATO-2018-STRE-0018	Stream Restoration	34	14	26	54	128	N/A	2
CATO-2018-STRE-0016	Stream Restoration	34	14	24	52	124	N/A	3
CATO-2018-STRE-0008	Stream Restoration	40	14	20	39	113	N/A	4
CATO-2018-STRE-0020	Stream Restoration	20	20	22	48	110	N/A	5

5.2. Pollutant Load Reductions

As described in Section 3 – Methodology, Dewberry estimated the anticipated impervious acre treatment and pollutant reductions associated with the proposed SWM BMP retrofits, new stormwater, and stream restoration opportunities. Tables 20 and 21 below summarize the results for each project. Projects are ordered by prioritization ranking. **NOTE:** In Table 20, the practice proposed that does not have a design approval date or an existing practice type in the table below is a new SWM BMP to treat currently untreated impervious area. All other sites not listed below are found in Appendix B.

Table 20: Estimated Impervious Area Treatment and Pollutant Reductions for Proposed Retrofit/New Stormwater Opportunity Projects

Rank	BMP Site	Design Approval Date	Existing Practice Type	Proposed Practice Type	Estimated Treatment for Proposed Conditions							
					Drainage Area	Impervious Area Treated	Pollutant Reductions (EOS)			Pollutant Reductions (EOT)		
							TN	TP	TSS	TN	TP	TSS
					(ac)	(ac)	(lbs./yr.)			(lbs./yr.)		
1	BMP #413	7/22/1981	Dry Pond	Wet Pond (P-2)	59.82	7.99	123.61	25.51	22,320.63	95.79	16.73	12,140.01
2	BMP #419	8/17/1995	Extended Detention Wet Pond	Extended Detention Wet Pond (P-3)	9.65	3.35	28.77	5.28	5,236.99	21.62	3.48	2,848.92
3	BMP #1163	4/25/2001	Extended Detention Wet Pond	Extended Detention Wet Pond (P-3)	80.10	9.1	200.00	44.02	32,470.52	153.48	28.87	17,659.93
4	BMP #420	9/23/1996	Extended Detention Dry Pond	Pocket Sand Filter (F-5)	4.72	2.25	15.37	2.64	3,317.77	11.80	1.73	1,804.44
5	BMP #421	9/20/1996	Extended Detention Dry Pond	Pocket Sand Filter (F-5)	3.58	1.57	11.57	2.06	2,425.91	8.87	1.35	1,319.38
6	BMP #752	6/25/1993	Extended Detention Dry Pond	Wet Pond (P-2)	182.63	24.16	505.66	88.63	77,636.18	388.28	58.22	42,260.25
7	CATO-2018-SPSC-0005	N/A	N/A	Regenerative Step Pool Conveyance	13.94	4.79	70.80	9.58	8,925.17	54.15	6.29	4,854.25
8	BMP #695	8/7/2000	Extended Detention Dry Pond	Pocket Pond (P-5)	2.15	1.46	7.62	1.12	1,821.28	5.85	0.74	990.54
9	BMP #29	4/22/1990	Extended Detention Dry Pond	Enhanced Surface Sand Filter	29.14	7.53	86.08	17.00	15,945.59	66.07	11.15	8,672.32
10	BMP #115	11/14/1990	Extended Detention Dry Pond	Enhanced Surface Sand Filter	37.60	10.00	24.81	4.99	4,668.21	19.04	3.27	2,538.90
11	BMP #672	4/11/1996	Extended Detention Dry Pond	Enhanced Surface Sand Filter	10.12	3.15	30.67	5.81	5,924.40	23.52	3.81	3,222.11
12	BMP #628	4/16/1999	Bioretention/Extended Detention Dry Pond	Enhanced Surface Sand Filter	54.46	10.40	153.25	32.02	27,190.32	117.55	21.00	14,788.04
13	BMP #188	6/10/2002	Extended Detention Dry Pond	Enhanced Surface Sand Filter	10.29	1.83	32.38	6.22	9,977.54	21.49	3.89	5,602.20
				Totals:	469.05	87.58	1,290.60	244.89	217,860.52	987.53	160.53	118,701.30

Table 21: Estimated Impervious Area Treatment and Nutrient Reductions for Proposed Stream Restoration Projects

Rank	Site ID	Estimated Treatment for Proposed Conditions				
		Linear Feet	Impervious Acre Credit	Pollutant Reductions		
				TN	TP	TSS
		(ft)	(ac)	(lbs./yr.)		
1	CATO-2018-STRE-0001	4,581	45.81	344	312	205,595
2	CATO-2018-STRE-0018	1,789	17.89	134	122	80,290
3	CATO-2018-STRE-0016	1,781	17.81	134	121	79,943
4	CATO-2018-STRE-0008	2,010	20.10	151	137	90,214
5	CATO-2018-STRE-0020	735	7.35	55	50	32,987
	Totals:	10,896	108.96	817	741	489,030

5.3. Cost Estimates

5.3.1. Pond Retrofits and New BMPs

As described in Section 3 – Methodology, Dewberry developed planning level cost estimates for the proposed SWM BMP retrofit and new stormwater opportunity using the *BMP Estimated Construction Costs* worksheet in the Prioritization Spreadsheet provided by Frederick County. Table 22 below provides the estimated design costs, construction costs, contingency costs, operation and maintenance (O&M) costs, total life cycle costs, and costs per impervious acre for each project. The projects are ordered by prioritization ranking. All other sites not listed below are found in Appendix B.

Table 22: Estimated Planning Level Costs for Proposed Retrofit/New Stormwater Opportunity Projects

Rank	BMP Site	Total Treated Impervious within Drainage Area (Ac.)	Design Approval Date	Existing Practice	Proposed Practice	Construction Cost[1]	Contingency[2]	Total Construction Cost[3]	D&E[4]	Inspection[5]	Project Management[6]	Site Improvement[7]	Total Cost[8]	Cost/Impervious Acre[9]
1	BMP #413	7.99	7/22/1981	Dry Pond	Wet Pond (P-2)	$175,780.00	$17,578.00	$193,358.00	$56,249.60	$17,578.00	$11,601.48	$14,062.40	$292,849.48	$36,652.00
2	BMP #419	3.35	8/17/1995	Extended Detention Wet Pond	Extended Detention Wet Pond (P-3)	$73,700.00	$7,370.00	$81,070.00	$23,584.00	$7,370.00	$4,864.20	$5,896.00	$122,784.20	$36,652.00
3	BMP #1163	9.1	4/25/2001	Extended Detention Wet Pond	Extended Detention Wet Pond (P-3)	$200,200.00	$20,020.00	$220,220.00	$64,064.00	$20,020.00	$13,213.20	$16,016.00	$333,533.20	$36,652.00
4	BMP #420	2.25	9/23/1996	Extended Detention Dry Pond	Pocket Sand Filter (F-5)	$49,500.00	$4,950.00	$54,450.00	$15,840.00	$4,950.00	$3,267.00	$3,960.00	$82,467.00	$36,652.00
5	BMP #421	1.57	9/20/1996	Extended Detention Dry Pond	Pocket Sand Filter (F-5)	$34,540.00	$3,454.00	$37,994.00	$11,052.80	$3,454.00	$2,279.64	$2,763.20	$57,543.64	$36,652.00
6	BMP #752	24.16	6/25/1993	Extended Detention Dry Pond	Wet Pond (P-2)	$531,520.00	$53,152.00	$584,672.00	$170,086.40	$53,152.00	$35,080.32	$42,521.60	$885,512.32	$36,652.00
7	CATO-2018-SPSC-0005*	4.79	N/A	N/A	Regenerative Step Pool Conveyance	$94,500.00	$9,450.00	$103,950.00	$30,240.00	$9,450.00	$6,237.00	$7,560.00	$157,437.00	$32,867.85
8	BMP #695	1.46	8/7/2000	Extended Detention Dry Pond	Pocket Pond (P-5)	$32,120.00	$3,212.00	$35,332.00	$10,278.40	$3,212.00	$2,119.92	$2,569.60	$53,511.92	$36,652.00
9	BMP #29	7.53	4/22/1990	Extended Detention Dry Pond	Surface Sand Filter	$338,850.00	$33,885.00	$372,735.00	$108,432.00	$33,885.00	$22,364.10	$27,108.00	$564,524.10	$74,970.00
10	BMP #115	10.00	11/14/1990	Extended Detention Dry Pond	Surface Sand Filter	$450,000.00	$45,000.00	$495,000.00	$144,000.00	$45,000.00	$29,700.00	$36,000.00	$749,700.00	$74,970.00
11	BMP #672	3.15	4/11/1996	Extended Detention Dry Pond	Surface Sand Filter	$141,750.00	$14,175.00	$155,925.00	$45,360.00	$14,175.00	$9,355.50	$11,340.00	$236,155.50	$74,970.00
12	BMP #628	10.40	4/16/1999	Bioretention/Extended Detention Dry Pond	Surface Sand Filter	$468,000.00	$46,800.00	$514,800.00	$149,760.00	$46,800.00	$30,888.00	$37,440.00	$779,688.00	$74,970.00
13	BMP #188	1.83	6/10/2002	Extended Detention Dry Pond	Surface Sand Filter	$82,350.00	$8,235.00	$90,585.00	$26,352.00	$8,235.00	$5,435.10	$6,588.00	$137,195.10	$74,970.00
					Totals:	$2,672,810.00	$267,281.00	$2,940,091.00	$855,299.20	$267,281.00	$176,405.46	$213,824.80	$4,452,901.46	

*[1]Construction Cost = BMP Estimated Construction Cost * Impervious Acres*
[2]Contingency = 10% of Construction Cost
[3]Total Construction Costs = Construction Cost + Contingency
[4]D&E = 32% of Construction Cost
[5]Inspection = 10% of Construction Cost
[6]Project Management = 5% of (D&E + Construction Cost)
[7]Site Improvement = 8% of Construction Cost
[8]Total Cost = Total Construction Cost + D&E + Inspection + Project Management + Site Improvement
[9]Cost per Impervious Acre = Total Cost / Impervious Acres
**New BMP Opportunity*

5.3.2. Stream Restoration

As described in Section 3 – Methodology, Dewberry developed planning level cost estimates for the proposed stream restoration opportunities using a construction cost of $350 per linear foot. Table 23 below provides the estimated design costs, construction costs, contingency costs, operation and maintenance (O&M) costs, total life cycle costs, and costs per impervious acre for each project. The projects are ordered by prioritization ranking. All other sites not listed below are found in Appendix B.

Table 23: Estimated Planning Level Costs for Proposed Stream Restoration Projects

Rank	Site ID	Impervious Acre Credit (Ac.)	Construction Cost[1]	Contingency[2]	Total Construction Cost[3]	D&E[4]	Inspection[5]	Project Management[6]	Site Improvement[7]	Total Cost[8]	Cost/Impervious Acre[9]
1	CATO-2018-STRE-0001	45.81	$1,603,350.00	$160,335.00	$1,763,685.00	$513,072.00	$160,335.00	$105,821.10	$128,268.00	$2,671,181.10	$58,310.00
2	CATO-2018-STRE-0018	17.89	$626,150.00	$62,615.00	$688,765.00	$200,368.00	$62,615.00	$41,325.90	$50,092.00	$1,043,165.90	$58,310.00
3	CATO-2018-STRE-0016	17.81	$623,439.95	$62,344.00	$685,783.95	$199,500.78	$62,344.00	$41,147.04	$49,875.20	$1,038,650.96	$58,310.00
4	CATO-2018-STRE-0008	20.10	$703,542.98	$70,354.30	$773,897.28	$225,133.75	$70,354.30	$46,433.84	$56,283.44	$1,172,102.60	$58,310.00
5	CATO-2018-STRE-0020	7.35	$257,250.00	$25,725.00	$282,975.00	$82,320.00	$25,725.00	$16,978.50	$20,580.00	$428,578.50	$58,310.00
	Totals:		$3,813,732.93	$381,373.30	$4,195,106.23	$1,220,394.53	$381,373.30	$251,706.38	$305,098.64	$6,353,679.06	$58,310.00

[1]*Construction Cost = BMP Estimated Construction Cost * Impervious Acres*
[2]*Contingency = 10% of Construction Cost*
[3]*Total Construction Costs = Construction Cost + Contingency*
[4]*D&E = 32% of Construction Cost*
[5]*Inspection = 10% of Construction Cost*
[6]*Project Management = 5% of (D&E + Construction Cost)*
[7]*Site Improvement = 8% of Construction Cost*
[8]*Total Cost = Total Construction Cost + D&E + Inspection + Project Management + Site Improvement*
[9]*Cost per Impervious Acre = Total Cost / Impervious Acre Credit*

6. PUBLIC EDUCATION AND OUTREACH

Frederick County aims to implement permit-suggested outreach topics, and meet its own goals and objectives from *The Strategic Plan to Improve Water Quality through Public Outreach in Frederick County, Maryland*, published in November 2003, by conducting outreach and education events and activities with County residents. Outreach activities are used to educate citizens, to direct the course of watershed assessments, and to identify landowners/stakeholders for potential restoration activities. This watershed assessment identifies potential restoration opportunities identified through such outreach activities, as well as County research, that could improve water quality and provide community education on the reasoning behind these projects; and how the public can implement additional activities in their own home. The Office of Sustainability and Environmental Resources (OSER) understands the importance of engaging with the public early and often and presents this Watershed Assessment to the public for feedback so any clarifications necessary to finalize it.

The draft of the Catoctin Creek Watershed Assessment will be shared with the general public, soliciting comments and input, and any relevant ideas and program improvements will be incorporated into the final draft. Solicitation of public input will be accomplished through:

- A notice in the local newspapers and on the County's website outlining how the public may obtain information on the development of the watershed assessment;
- Providing copies of the watershed assessment to interested parties upon request; and
- Providing a minimum of thirty (30) day comment period before finalizing the watershed assessment.

In addition, to this public document, OSER continually enhances its outreach materials as well as its efforts to provide its citizens with needed educational touchpoints. Some of the County's key public outreach and education initiatives are as follows:

- Outreach related to the Monocacy & Catoctin Watershed Alliance (MCWA) and Green Leader Brigade;
- Outreach related to the Green Homes Challenge (GHC);
- Outreach related to Residential Septic Pump-outs;
- Outreach related to Pet Waste;
- Outreach related to Stormwater Management;
- Outreach related to Watershed Assessments and;
- Other County Outreach Initiatives.

6.1. Outreach Related to the Monocacy & Catoctin Watershed Alliance

The Upper and Lower Monocacy Watershed Restoration Action Strategy (WRAS) Steering Committees developed the Monocacy & Catoctin Watershed Alliance (MCWA or the Alliance) in order to continue outreach begun during the Upper and Lower Monocacy WRAS efforts and to begin implementation of the Upper and Lower Monocacy WRAS plans.

MCWA is a mutual, collaborative, non-advocacy effort among individuals and organizations desiring to work together to improve the health of the Monocacy and Catoctin Watersheds. The County continues to coordinate MCWA and meet on a bi-monthly basis enabling attendees to discuss educational outreach opportunities, as well as develop restoration and protection projects to support water quality and habitat initiatives, and review and discuss recently developed watershed assessments and restoration plans. Partners involved in MCWA include but are not limited to:

- Local Organizations
  - Audubon Society of Central Maryland
  - Catoctin and Frederick Soil Conservation Districts
  - Catoctin Forest Alliance
  - Frederick County Forest Conservancy District Board
  - Catoctin Land Trust
  - Frederick County Conservation Club
  - Frederick County Master Gardeners

  - Local Citizens
  - Bar-T Mountainside Challenge & Retreat Center
- Regional Organizations
  - Potomac Conservancy
  - Potomac Watershed Partnership
  - Interstate Commission on the Potomac River Basin (ICPRB)
  - Center for Watershed Protection (CWP)
  - Potomac Valley Fly Fishers, Inc.
  - Chesapeake Conservation Corps
  - Trout Unlimited
- Funding Agencies
  - Chesapeake Bay Trust
  - Alice Ferguson Foundation
  - Maryland Dept. of the Environment/U.S. EPA Clean Water Act Section 319 (h) Program
  - Maryland Urban & Community Forestry Committee (MUCFC)
  - National Fish and Wildlife Foundation (NFWF)
  - Chesapeake & Atlantic Coastal Bays Trust Fund
- Educational Institutions
  - Hood College
  - Mount Saint Mary's University
  - University of Maryland Extension Office
  - Frederick County Public Schools (FCPS)
- Government Organizations
  - Frederick County Council
  - Frederick County Executive
  - Frederick County Division of Planning and Permitting
  - Office of Sustainability and Environmental Resources
  - Comprehensive Planning
  - Development Review
  - Permits and Inspections
  - Division of Public Works
  - Division of Utilities and Solid Waste Management
  - Health Department, Environmental Health Section
  - Division of Parks and Recreation
  - Sustainability Commission
  - Municipalities in Frederick County
  - Maryland Department of Natural Resources
    - Forest Service
    - Fisheries
    - Watersheds Program
    - Wildlife & Heritage Service
  - Maryland Department of the Environment
  - Cunningham Falls State Park
  - National Park Service
    - Catoctin Mountain Park
    - Monocacy National Battlefield Park

        - Rivers, Trails and Conservation Assistance
    - U.S. Environmental Protection Agency
        - Environmental Information and Analysis
    - U.S. Fish and Wildlife Service

The Alliance website (watershed-alliance.frederickcountymd.gov) is updated with a list of upcoming of events, past articles, links to quarterly meeting presentations, resources, and publications. Information on MCWA is also available in the OSER quarterly e-newsletter, expanding the Alliance's reach to more than 2,200 County households and/or Alliance partners.

7. MONITORING

The County utilizes all of its Watershed Assessments and Feasibility Studies to continually grow the potential opportunities which then feed into the County's overall Restoration Plan, last published December 2018. All identified opportunities have associated water quality benefits including reducing nutrients and sediments that enter into the County's waterways. When projects completed, their associated benefits are recalculated based on final project design. These benefits include the success in capturing impervious surface area runoff as well as nitrogen, phosphorous, sediment, and E. coli reductions at the local and Chesapeake Bay TMDL level. The County relies heavily on Guidance provided by MDE, The Bay Program, and expert panels to assist in quantifying the reduction benefits for each completed restoration project. In addition to guidance documents, the County utilizes targeted restoration monitoring as well as a County-wide Stream Survey to continually learn more about the overall health of the County's streams.

7.1. Load Reduction Evaluation Criteria

The County uses both a quantitative and qualitative approach to tracking and measuring progress.

Quantitative measures track project implementation progress and estimated pollutant and impervious area reductions associated with implementation. Calibrated load reductions are the targets used for TMDL compliance at the Bay and local levels. These target reductions are calculated based on TMDL percent reductions and baseline loads; and modeled using land use loading rates. Reductions for stormwater treatment have been modeled using a custom geodatabase script that uses the most accurate up-to-date information on BMPs with physical locations. 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 have been determined using current data from County agencies working with these programs. Load reductions for each type of BMP are based on the MDE 2014 Accounting Guidance (MDE 2014).

Qualitative measures evaluate overall program success. The County tracks and reports progress annually with the submission of the County's Annual Report for their NPDES Phase I MS4 permit. The County will use the recommendations presented in the Catoctin Creek Watershed Assessment to establish goals as previously described and evaluate the progress towards meeting those goals in the Annual Report submission

7.2. Monitoring

Frederick County has a number of initiatives in place to monitor and assess the results of watershed protection and restoration efforts. As documented in its *National Pollutant Discharge Elimination System (NPDES) 2014 Annual Report*, the County has designed a monitoring program to include two (2) separate monitoring efforts: (1) targeted restoration monitoring and (2) County-wide, probability-based stream monitoring, with sites randomly selected and stratified by watershed called the Frederick County Stream Survey (FCSS).

7.2.1. Targeted Restoration Monitoring

The County's targeted stream restoration program assesses the physical, chemical and biological conditions of streams within Frederick County during designated sampling periods. Stream sampling locations vary by year and are based on supporting on-going restoration efforts. In 2018, the County completed targeted restoration monitoring in the Bennett Creek, Fishing Creek, and Potomac Direct (Point of Rocks) NPDES watersheds.

7.2.2. Frederick County Stream Survey (FCSS)

As described in Section 2.1.6, the FCSS is a probability-based survey (with random site selection) which uses rapid benthic macroinvertebrate and physical habitat assessments methods to assess County stream conditions. The program was developed using the similar protocols to the Maryland Biological Stream Survey (MBSS) but on a finer scale.

The County's survey includes 200 sites randomly selected across the County's 20 NPDES watersheds. The survey is carried out over a four (4) year period with 50 sites sampled each year. Establishing the timeframe in such a manner minimizes

the influence of wet and dry years on the survey results and the combined four-year results provide a snapshot of stream conditions. Round 1 of the FCSS ran from 2008 – 2011 and Round 2 ran from 2013 - 2016. Round 3 commenced in 2018 and will end in 2022 and is being conducted using methods outlined in the FCSS Sampling and Analysis Plan (Frederick County May 2018). Sites are visited a single time during the Spring Index Period (March through April). Data collection includes benthic macroinvertebrate sampling; in-situ water quality; stream discharge; aqueous grab samples; and spring and summer MBSS habitat, index period, and vernal pool data. Grab water samples are analyzed for Turbidity, Total Nitrogen, Total Phosphorus, Ammonia-N, TKN (calculated), Nitrate-Nitrogen, Dissolved Organic Carbon, Total Copper, Total Lead, Total Zinc, Chloride, and Total Hardness.

7.2.3. State Monitoring Efforts

State monitoring efforts include the Maryland Biological Stream Survey (MBSS). The MBSS is a probability-based or random design stream monitoring program implemented by the Maryland DNR. It provides an unbiased estimate of stream condition with known precision at various spatial scales ranging from large 6-digit river basins and medium-sized 8-digit watershed to the entire state. The first statewide round was completed in 1997 and the fourth round of MBSS sampling ended in 2018. There are over 5,300 sampling sites statewide. Data from the three previous rounds can be used as baseline conditions. Results from future rounds can be used to evaluate changes within the County.

8. REFERENCES

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