Non-Tidal South River Watershed Sediment TMDL

Stormwater Wasteload Allocation Attainment Report

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Prepared For

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List of Acronyms

BIBI	Benthic Index of Biotic Integrity
BMP	Best Management Practices
BSID	Biological Stressor Identification
BWPR	Bureau of Watershed Protection and Restoration
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
CC	Chesapeake Conservancy
CIP	Capital Improvement Projects
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DPW	Department of Public Works
EOS	Edge of Stream
EOT	Edge of Tide
EPA	United States Environmental Protection Agency
ESD	Environmental Sensitive Design
FIBI	Fish Indices of Biotic Integrity
FY	Fiscal Year
GIS	Geographic Information System
GRTS	Generalized Random Tesselation Stratified
IR	Integrated Report
LA	Load Allocation
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
MEP	Maximum Extent Practicable
MPHI	Maryland Physical Habitat Index
MS4	Municipal Separate Storm Sewer System
NGOs	Non-Governmental Organizations
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
NTU	Nephelometer Turbidity Units
PCB	Polychlorinated Biphenyls
PS	Point source
PSU	Primary Sampling Unit
RBP	Rapid Bioassessment Protocol
SAV	Submerged Aquatic Vegetation
MDOT SHA	Maryland Department of Transportation Maryland State Highway Administration
SIP	Stormwater Infrastructure Program
SOP	Standard Operating Procedures
SPSC	Step Pool Storm Conveyance

STB	Stream Bed and Bank
SWM	Stormwater Management
SW-WLA	Stormwater Wasteload Allocation
TIPP	TMDL Implementation Progress and Planning spreadsheet
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
WLA	Wasteload Allocation
WM	Watershed Model
WMT	Watershed Management Tool
WPRF	Watershed Protection and Restoration Fee
WPRP	Watershed Protection and Restoration Program
WQIP	Water Quality Improvement Projects
WQS	Water Quality Standards

1 Introduction

1.1 Background

The Anne Arundel County Department of Public Works (DPW) Bureau of Watershed Protection and Restoration (BWPR) is required to develop restoration or attainment plans to address local water quality impairments for which a Total Maximum Daily Load (TMDL) has been established by the Maryland Department of the Environment (MDE) and approved by the U.S. Environmental Protection Agency (EPA). A TMDL establishes a maximum load of a specific single pollutant or stressor that a waterbody can assimilate and still meet water quality standards for its designated use class.

Under the Federal Clean Water Act (CWA), the State of Maryland is required to assess and report on the quality of waters throughout the state. Where Maryland's water quality standards are not fully met, Section 303(d) requires the state to list these water bodies as impaired waters. States are then required to develop a TMDL for pollutants of concern for the listed impaired waters. The South River watershed has several impaired waters listings in Maryland's Integrated Report of Surface Water Quality [303(d) list and 305(b) Report] including nutrients, sediment, bacteria, polychlorinated biphenyls (PCBs), and chlorides. There are currently four final approved TMDLs within the South River watershed; the Chesapeake Bay TMDL for nutrients approved in 2010, a total suspended solids (TSS; sediment) approved in 2017, a PCB TMDL approved in 2015 and a bacteria (fecal coliform) TMDL approved in 2005. This attainment report addresses the sediment TMDL.

The TMDL loading targets, or allocations, are divided among the pollution source categories, which in this case includes non-point sources (termed load allocation or LA) and point sources (termed waste load allocation or WLA). The WLA consists of loads attributable to regulated process water or wastewater treatment, and regulated stormwater, which is the stormwater wasteload allocation (SW-WLA). For the purposes of the TMDL and consistent with implementation of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Discharge Permit (MS4), stormwater runoff from MS4 areas is considered a point source contribution.

The South River watershed lies entirely within Anne Arundel County, therefore the TMDL Stormwater WLA is allocated to Anne Arundel County and the Maryland Department of Transportation State Highway Administration (MDOT SHA). Anne Arundel County's current MS4 permit (20-DP-3316, MD0068306) issued by MDE in November of 2021, requires the development of restoration plans for each SW-WLA approved by EPA prior to the effective date of the permit (permit section F.2), and requires an annual TMDL assessment report to document implementation progress, pollutant load reductions, and program costs. According to the *General Guidance for Local TMDL Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plans (WIPs)* (MDE, 2022b) attainment of TMDL requirements can be defined via two primary means, resulting in the development of an attainment plan:

1. Documented achievement of WLAs via implemented practices and modeling exercises
2. Documented achievement of water quality criteria consistent with MDE published assessment methodologies.

Anne Arundel County BWPR submitted a TMDL Document of Attainment for the 2017 sediment TMDL to MDE in September 2018 (Anne Arundel County, 2018). Following review and comment from MDE and further modeling analysis, it was found that the South River TMDL had not yet been attained at that time. Development of a South River restoration plan was on hold in anticipation of the release of MDE's TMDL Implementation Progress and Planning (TIPP) spreadsheet tool (MDE, 2021c), for modeling local TMDL nutrient and sediment loads and reductions. The TIPP tool was used to model load reductions through FY2022 for this attainment plan, and resulted in changes to the baseline, permit, and progress loads and load reductions.

This document responds to MDE's 4.29.2019 comments on the *South River Sediment TMDL Documentation of Attainment* submitted to MDE September 2018 and presents modeling results that document the attainment of Anne Arundel County's sediment SW-WLA for the South River watershed and satisfies Section F.2 of the County's NPDES MS4 permit. The County recognizes that achievement of water quality criteria and delisting of waterbodies meeting the water quality criteria is the ultimate goal. As a result, this document provides a discussion of monitoring approaches to demonstrate that habitat and sediment related stressors are addressed and will continue to be addressed in the South River watershed.

1.2 Watershed Description

The South River is one of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the central portion of the County (Figure 1). The Severn River watershed is located to the north, the Patuxent River watershed is located to the west, and the Rhode River watershed is located to the south. The South River drains directly into the Chesapeake Bay.

The watershed comprises approximately 36,514 acres and lies entirely within the County. The watershed includes several named streams including Bacon Ridge Branch, Bell Branch, Broad Creek, Church Creek, Duvall Creek, Marriots Branch, North River, and the mainstem of the South River. Communities within the South River watershed include Riva, Edgewater, Selby-on-the-Bay, and Hillsmere Shores.

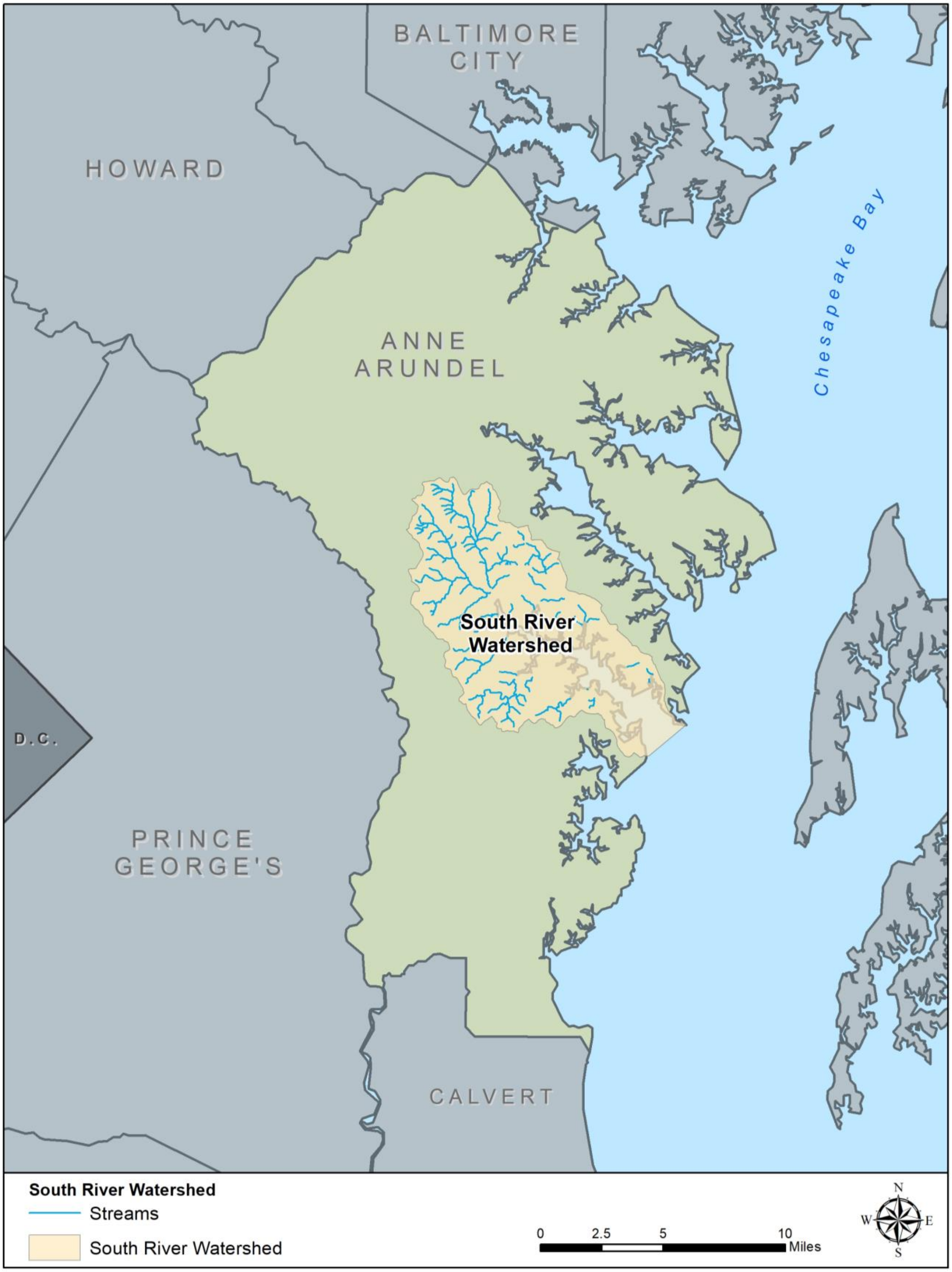

Figure 1: Watershed Location Map

1.3 TMDL Allocated Loads Summary

This section describes the derivation of the TMDL reduction target for sediment. This document only addresses loads allocated to Anne Arundel County NPDES regulated stormwater point source sediment. Additional SW-WLAs for the South River watershed assigned to the Maryland State Highway Administration and other NDPES regulated stormwater are not the responsibility of Anne Arundel County and are not addressed in this document.

The TIPP spreadsheet tool (MDE, 2021c) was used to model baseline and progress loads. The TIPP tool was developed by MDE's Water and Science Administration to simplify the load estimating and planning process for development and tracking of local TMDL plans. The spreadsheet tool estimates load reductions at various points in the watershed planning process, allowing users to assess current progress and future BMP implementation. The spreadsheet uses Chesapeake Bay Program Watershed Model Phase 6 (CBP WM P6) Chesapeake Assessment Scenario Tool (CAST) 2017d No Action (No BMP) scenario loading rates with disaggregated Stream Bed and Bank (STB) loads at the county 8-digit watershed scale. Details of the modeling and load calculations are included in Section 4.

Based on MDE guidance, potential increases in the stormwater sediment load since the TMDL 2009 baseline year that are attributed to growth in the stormwater sector (i.e. growth in developed land uses) are not accounted for in the development of this attainment report. When accounting for pollutant loading, local TMDLs are considered met when the load reductions associated with restoration progress coupled with the planned restoration load reductions exceed the load reduction required. Methods to address additional sediment loads since the baseline year and potential future loads that may result from anticipated growth within the County are discussed in Section 2.3.

The required percent reduction assigned to the Anne Arundel County Phase I MS4 source (28.0%) in the local TMDL was applied to the new baseline load to calculate required sediment reduction. The required sediment reduction was then subtracted from the new baseline load to calculate the TIPP-compatible target SW-WLA. Sediment target load, FY2022 Progress and Attainment reduction, and Planned Implementation reduction for the South River Anne Arundel County Phase I MS4 source are shown in Table 1.

- **Baseline Scenario Load:** Sediment baseline load (i.e., land use load with treatment from baseline development and restoration BMPs included) from 2009 conditions in the South River watershed was calculated by modeling BMP implementation up to baseline year 2009 in the TIPP spreadsheet tool. Baseline loads were used to calculate the target load or stormwater wasteload allocated (SW-WLA) nutrient and sediment loads.
- **Required Percent Reduction:** Reduction percentages assigned to Anne Arundel County NPDES regulated stormwater point source as noted in the TMDL document.
- **Local TMDL SW-WLA:** Because the County's local TMDLs were developed by MDE under older versions of the Chesapeake Bay Program Watershed Model or using a different modeling tool, the sediment SW-WLA was translated by the County into TIPP-compatible target loads using the TIPP model while maintaining the original percent reductions required in the TMDL (28%). Allocated loads are calculated from the baseline loads using the TIPP, using the following calculation: Target Load = Baseline Load – (Baseline Load x Target % Reduction).
- **FY2022 Progress Load:** Progress load achieved from restoration BMP implementation after the baseline year through Fiscal Year (FY) 2022 (i.e., June 30, 2022) were calculated using the TIPP.
- **Planned Scenario Load:** Load that will result from implementation of additional planned BMPs in the watershed.

Table 1: FY2022 Progress Reductions Achieved Resulting in Attainment

Baseline Load and TMDL SW-WLA	**TSS-EOS lbs/yr**
2009 Baseline Scenario Load	18,936,404
Required Percent Reduction	28.0%
Required Reduction	5,302,193
Local TMDL SW-WLA	13,634,211
FY2022 Progress and Attainment Results	**TSS-EOS lbs/yr**
Progress Scenario Load	12,855,977
Progress Reduction Achieved	6,080,427
Percent Reduction Achieved	32.1%
Planned Implementation Results	**TSS-EOS lbs/yr**
Planned Scenario Load	6,492,872
Planned Reduction Achieved	12,443,532
Percent Reduction Achieved	65.7%

2 Causes and Sources of Impairment

This section describes the designated uses, water quality, and biological conditions of the watershed, as well as land use and impervious surface data that may explain the water quality impairments currently affecting the watershed.

2.1 Impairments

2.1.1 Pollutant Impacts

Elevated levels of sediment currently impair the South River watershed as evident through the 303(d) listings and local TMDL requirements. Sediment, both from upland and in-stream sources, can impact in-stream habitat by covering and filling gravelly and rocky substrate, which is a preferred substrate habitat for some aquatic organisms (fish and benthic communities) and necessary for some fish species for spawning. Finer clays, silts and sands associated with sediment as a pollutant are more mobile and transient and provide less stable and livable space for more sensitive benthic macroinvertebrate species by filling the interstitial spaces between larger substrate particles in the channel bottom. Increases in sediment loads in channels that cannot adequately transport the load can lead to deposition and aggrading streams. These factors often negatively impact channel flow, causing additional erosion and increases in flooding, particularly if road crossing capacity is limited by sediment accumulation. Suspended sediment in the water column may limit light penetration and prohibit healthy propagation of algae and submerged aquatic vegetation (SAV). Suspended sediments can cause gill abrasion in fish and can limit clarity which impacts aquatic species that rely on sight for feeding.

2.1.2 Water Quality

2.1.2.1 Use Designations

According to Water Quality Standards (WQS) established by MDE in the Code of Maryland Regulations (COMAR), the Surface Water Use Designation for the non-tidal South River watershed is Use I – Water Contact Recreation, Protection of Nontidal Warmwater Aquatic Life. The sediment TMDL of non-tidal tributary streams address the narrative water quality criteria specific to designated uses for the support of aquatic health (COMAR 26.08.02.03). Use designations for the South River Watershed are presented in Table 2 (COMAR 26.08.02.02).

Table 2: Use Designations of the South River Watershed

Designated Uses	Use I
Growth and propagation of fish (not trout), other aquatic life and wildlife	X
Water contact sports	X
Leisure activities involving direct contact with surface water	X
Fishing	X
Agricultural water supply	X
Industrial water supply	X
Propagation and harvesting of shellfish	-
Seasonal migratory fish spawning and nursery use	-
Seasonal shallow-water submerged aquatic vegetation use	-
Open-water fish and shellfish use	-
Seasonal deep-water fish and shellfish use	-
Seasonal deep-channel refuge use	-
Growth and propagation of trout	-
Capable of supporting adult trout for a put and take fishery	-
Public water supply	-

Source: https://mde.maryland.gov/programs/water/tmdl/waterqualitystandards/pages/wqs_designated_uses.aspx

2.1.2.2 Tier II High Quality Waters

Tier II waters are those that have an existing water quality that is significantly better than the WQS minimum requirements (MDE, 2021d). Maryland's antidegradation policy has been promulgated to provide implementation of more restrictive planning efforts in areas where Tier II waters have been designated to maintain the condition of high-quality waters. This implementation has the greatest immediate effect on local government planning due to higher standards for discharge into Tier II waters. Currently, Tier II streams are identified according to fish and benthic indices of biological integrity (FIBI and BIBI). Streams listed as Tier II waters will always remain Tier II waters.

Based on analysis of MDE Tier II spatial data (as of August 2022), Maryland has designated 263 Tier II streams segments. There are no Tier II stream segments within the South River watershed.

2.1.2.3 TMDLs and 303(d) Impairments

TMDLs are established for waterbodies on Maryland's 303(d) integrated list of impaired waterbodies to set pollutant limits to achieve attainment of the designated use. For each combination of waterbody and pollutant, the State must estimate the maximum allowable pollutant load, or TMDL, that the waterbody can receive and still meet water quality standards. TMDLs are required by the CWA. Category 4a of the 303(d) list describes impaired waters with a TMDL or other reduction measure in place. Category 5 lists impaired waters in need of a TMDL. The combined 2020-2022 Integrated Report included a new subcategory to Category 5 called Category 5s and includes waterbody impairments caused by chloride from road salt. MDE is addressing chloride impairments (5s) using 'straight-to-implementation' approaches to expedite chloride reduction practices; therefore, a local TMDL implementation plan is not needed for chloride listings.

The South River watershed was originally listed on Maryland's 2002 Integrated Report (IR) as impaired for impacts to biological communities. The biological assessment was based on the combined results of Maryland's Biological Stream Survey (MBSS) Round 1 (1995-1997) and Round 2 (2000-2004) data. The results of the Biological Stressor Identification (BSID) analysis for the South River watershed are presented in a report entitled *Watershed Report for Biological Impairment of the Non-Tidal South River Watershed in Anne Arundel County, Maryland Biological Stressor Identification Analysis Results and Interpretation.* The report states that the degradation of biological communities in the South River watershed is strongly associated with anthropogenic impacts, poor epifaunal substrate, marginal to poor and poor instream habitat structure, no riparian buffer, high chlorides, and low pH. The BSID analysis determined that the biological impairment in the South River watershed is due in part to stressors within the sediment and instream habitat parameter groupings. Since sediment was identified as a stressor to the biological community in the South River watershed, the watershed was listed in Category 4a of the 2020-2022 IR as impaired by sediment and with an approved TMDL. In addition to sediment, the South River watershed was identified in Maryland's 2020-2022 IR as having multiple other impairments. The 2020-2022 IR classifies impairments by reporting categories which determine whether the development of a TMDL is required. A description of IR reporting categories is presented in Table 3.

Table 3. Maryland's 2020-2022 Integrated Report Reporting Categories (MDE, 2022a)

Integrated Report Category	Description
1	Water bodies that meet all WQS and no use is threatened
2	Water bodies meeting some WQS but with insufficient data and information to determine if other WQSs are being met
3	Insufficient data and information are available to determine if water quality standards are being attained
4a	Water body is impaired and TMDL is already approved to established
4b	Water body is impaired but other pollution control requirements are expected to attain WQS
4c	Water body impairment is not caused by a pollutant
5	Water body is impaired, does not attain the WQS, and a TMDL is required.
5s	Water body impairment is caused by chloride from road salt.

South River watershed impairments identified in the 2020-2022 IR are listed by category in

Table 4. This TMDL, the subject of this Attainment Report, is noted under Category 4a.

Table 4. South River Watershed 2020-2022 Impairments

Assessment Unit	Designated Use	Water Type	Impairment	Notes
Category 2				
Broad Creek	Aquatic Life & Wildlife	Non-tidal	Zinc	
Annapolis Landing	Water Contact Sports	Public Beach	Enterococcus	
South River Mesohaline	Fishing	Chesapeake Bay Segment	Mercury in Fish	
Broad Creek	Aquatic Life & Wildlife	Non-tidal	Low pH	
Broad Creek	Aquatic Life & Wildlife	Non-tidal	Copper	
Broad creek	Aquatic Life & Wildlife	Non-tidal	Lead	
South River Mesohaline	Shellfishing	Tidal Shellfish Area	Fecal Coliform	
Category 4a				
Assessment Unit	**Designated Use**	**Water Type**	**Impairment**	**Notes**
South River Mesohaline	Fish & Shellfish	Chesapeake Bay Segment	Nitrogen	Ches. Bay TMDL approved 2012
South River Mesohaline	Seasonal SAV	Chesapeake Bay Segment	TSS	Ches. Bay TMDL approved 2012
South River Mesohaline	Fish & Shellfish	Chesapeake Bay Segment	Phosphorus	Ches. Bay TMDL approved 2012
South River Mesohaline	Shellfish Harvesting	Tidal Shellfish Area	Fecal Coliform	Bacteria TMDL approved 2006
Ramsey Lake	Shellfish Harvesting	Tidal Shellfish Area	Fecal Coliform	Bacteria TMDL approved 2006
Duvall Creek	Shellfish Harvesting	Tidal Shellfish Area	Fecal Coliform	Bacteria TMDL approved 2006
Selby Bay	Shellfish Harvesting	Tidal Shellfish Area	Fecal Coliform	Bacteria TMDL approved 2006
South River Mesohaline	Fish	Chesapeake Bay Segment	PCB in fish tissue	PCB TMDL approved 2016
Non-tidal South River	Aquatic Life & Wildlife	1st thru 4th Order Streams	TSS	Sediment TMDL approved 2017
Category 4c				
Assessment Unit	**Designated Use**	**Water Type**	**Impairment**	**Notes**
South River	Aquatic Life & Wildlife	1st thru 4th Order Streams	Lack of Riparian Buffer	
Category 5				
Assessment Unit	**Designated Use**	**Water Type**	**Impairment**	**Notes**
South River Mesohaline	Aquatic Life & Wildlife	Chesapeake Bay Segment	Cause Unknown	
Category 5s				
Assessment Unit	**Designated Use**	**Water Type**	**Impairment**	**Notes**
South River	Aquatic Life &Wildlife	1st thru 4th Oder Streams	Chlorides	

2.2 Sources

The sediment loads in the South River watershed originate from anthropogenic, urban, and impervious sources (MDE, 2017). An additional likely source is in-stream processes related to channel erosion. An analysis of the land use/land cover and impervious surfaces of the watershed was conducted and is summarized in the following sections.

2.2.1 Land Use/Land Cover

The type and density of various land uses can have a dramatic effect on water quality and stream habitat. Forested areas slow stormwater flow and allow water to gradually seep into soils and drain into streams. Vegetation and soils bind nutrients and pollutants found within stormwater—improving water quality as it infiltrates the ground. Developed areas, with a high percentage of impervious surfaces (buildings, paved roads, parking lots, etc.), generally increase the volume of stormwater—increasing the amount of pollutants entering streams. Increased stormflow affects stream habitat negatively by increasing bank erosion and decreasing instream and riparian habitat. Agricultural land, if managed incorrectly, can also impair streams with increases in nutrients, sediment, and bacteria.

A summary of 2020 land use conditions in the MS4 area of the watershed and the entire watershed is presented in Table 5. Land use in the MS4 portion of the watershed is similar to the land use of the entire South River watershed, with land use distribution consisting primarily of forest, residential, agriculture, and commercial.

Table 5. 2020 Land Use in the South River Watershed

Land Use Category	South River MS4 Area		South River Watershed	
	Acres	% of Total	Acres	% of Total
Airport	25	0.1%	25	0.1%
Commercial	1,327	4.1%	1,602	4.4%
Forested Wetland	2,514	7.7%	2,708	7.4%
Industrial	138	0.4%	185	0.5%
Open Space	1,164	3.6%	1,501	4.1%
Open Wetland	323	1.0%	377	1.0%
Pasture/Hay	1,121	3.4%	1,240	3.4%
Residential 1/2-acre	1,427	4.4%	1,455	4.0%
Residential 1/4-acre	2,748	8.4%	3,092	8.5%
Residential 1/8-acre	674	2.1%	907	2.5%
Residential 1-acre	3,089	9.5%	3,156	8.7%
Residential 2-acre	5,783	17.8%	5,857	16.1%
Row Crops	986	3.0%	1,012	2.8%
Transportation	580	1.8%	1,124	3.1%
Utility	428	1.3%	432	1.2%
Water	205	0.6%	275	0.8%
Woods-Coniferous	107	0.3%	156	0.4%
Woods-Deciduous	143	0.4%	145	0.4%
Woods-Mixed	9,793	30.1%	11,153	30.6%
Total	**32,574**	**100.0%**	**36,401**	**100.0%**

2.2.2 Impervious Surfaces

Impervious surfaces concentrate stormwater runoff, accelerate flow rates and direct stormwater to receiving streams, where it can cause stream erosion and habitat degradation. Runoff from impervious surfaces transports pollutants, which can cause the runoff to have higher pollution concentrations than runoff generated from pervious areas. In general, undeveloped watersheds with small amounts of impervious cover are more likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover. Impervious cover is a primary factor when determining pollutant characteristics and loadings in stormwater runoff.

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

A summary of 2022 impervious surface types in the MS4 area of the watershed and the entire watershed is presented in Table 6. There are 4,114 acres of impervious cover in the MS4 portion of the watershed and 4,973 acres in the entire watershed. The majority of these impervious surfaces are buildings, roads, driveways, and parking areas.

Table 6. 2022 Impervious Surfaces in the South River Watershed

Impervious Surface	South River MS4 Area		South River Watershed	
	Acres	% of Total	Acres	% of Total
Athletic Court	36	0.9%	38	0.8%
Building	1,198	29.1%	1,322	26.6%
Deck	84	2.0%	88	1.8%
Driveway	832	20.2%	869	17.5%
Other	30	0.7%	39	0.8%
Parking Area	566	13.8%	708	14.2%
Path	33	0.8%	36	0.7%
Patio	139	3.4%	149	3.0%
Pier	4	0.1%	5	0.1%
Road	966	23.5%	1,456	29.3%
Runway/Taxiway	5	0.1%	5	0.1%
Sidewalk	187	4.6%	223	4.5%
Swimming Pool	35	0.8%	36	0.7%
Total	**4,114**	**100.0%**	**4,973**	**100.0%**

2.3 Anticipated Growth

Future urban sector growth and the anticipated increase in urban loads that may result are expected to be controlled by two elements: stormwater management to the maximum extent practicable (MEP) that is required with new development and anticipated "Accounting for Growth" policies. This attainment plan shows that the reduction required from the initial baseline year load, calibrated to the current Bay model, has been met. Based on coordination with MDE, TMDL restoration planning should focus on the untreated and undertreated areas associated with the urban footprint at the time of the TMDL baseline. Future load and loads potentially added to the urban sector since the baseline year to present, are not accounted for here as they are addressed under other programs described below.

2.3.1 Plans for Future Growth

Plan2040 (Anne Arundel, 2021), the General Development Plan for Anne Arundel County, was adopted in May 2021 and includes policy framework to protect the natural environment and shape development of the built environment. With an expected population increase of 0.4 to 1% per year from 2020 to 2040, the plan outlines how the County will balance future growth while creating resilient, environmentally sound, and sustainable communities. The County has six goals related to the natural environment:

- Preserve, enhance, and restore sensitive areas, including habitats of rare, threatened, and endangered species, streams, floodplains, tidal and non-tidal wetlands, bogs, shorelines, steep slopes, and all applicable buffers.
- Retain existing forest cover, increase forest replanting efforts, and increase urban tree canopy.
- Expand, enhance and continue to protect the County's greenways, open space, rural areas, including the Priority Preservation Area.
- Improve and protect water quality by reducing impacts from stormwater runoff, wastewater discharge, and septic systems.
- Ensure the safe and adequate supply of groundwater resources and wastewater treatment services for current and future generations.
- Create resilient, environmentally sound and sustainable communities.

The County created a Development Policy Areas Map which identifies areas in the County where development and redevelopment are encouraged, as well as areas where preservation of rural or suburban character and natural features are prioritized. Several goals related to the built environment will decrease stormwater runoff and improve water quality:

- Align development regulations and review practices with Plan2040, that recognizes the importance of the County's environmental features; limitations on infrastructure; and the desire to focus development, redevelopment and revitalization in the Targeted Development, Redevelopment and Revitalization Policy Areas; enhance quality of life; and protect and enhance neighborhoods.
- Preserve the agricultural and rural character of the County's Rural and Agricultural Policy Area.
- Support quality of life and economic vitality in County Peninsula Policy Areas, while preserving environmentally sensitive areas.
- Focus and encourage carefully planned and high-quality development, redevelopment, and revitalization in the Targeted Development, Redevelopment and Revitalization Policy Areas while meeting environmental requirements.
- Promote vibrant, high-quality development in Town Centers that provides opportunities to live, work, learn, and play without daily use of a car.
- Revitalize and stabilize existing communities in order to preserve physical character, capitalize on investments and infrastructure, strengthen and beautify neighborhoods, and create economically, socially, and environmentally sustainable communities.

- Provide a well-maintained multimodal transportation network that is safe, efficient, environmentally sensitive, and provides practical and reliable transportation choices and connections for all users.
- Increase the County's resilience to future changes in climate and reduce emissions of greenhouse gases.

The plan has an emphasis on protection of the natural environment, as well as plans to redevelop in targeted areas, which will result in redevelopment of areas developed prior to new stormwater requirements, resulting in overall reduced stormwater runoff. Redevelopment in areas of high impervious surface cover will slow the increase of impervious surface coverage across the County. Compact growth will also reduce development pressure on rural and natural areas (Anne Arundel, 2021). The County's careful planning for future growth and development will reduce the potential detrimental impact that future development in the South River could have on the ability for non-tidal streams in the watershed to meet the State's thresholds for assessing sediment impacts.

2.3.2 Offsetting Nutrient and Sediment Loads from Future Growth

Despite intentional and compact growth and development in the County, pollutant loading from urban stormwater sources is expected to increase. It is anticipated that new development will make use of environmentally sensitive design (ESD) stormwater treatment according to MDE's Stormwater Regulations.

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

In addition to the 2007 Stormwater Management Act, the following state programs effectively mitigate most of the pollutant loading impacts from new development: 1991 Forest Conservation Act, 1997 Priority Funding Areas Act, 2009 Smart, Green & Growing Planning Legislation, 2010 Sustainable Communities Act, 2011 Best Available Technology Regulation, and the 2012 Sustainable Growth & Agricultural Preservation. It states in Part VI Special Programmatic Conditions of Anne Arundel County's current NPDES MS4 permit that "any additional loads will be offset through Maryland's Aligning for Growth policies and procedures as articulated through Chesapeake Bay milestone achievement" (MDE, 2021).

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

3 Best Management Practices

Best management practices (BMPs) include both structural practices and programmatic practices that provided management and, in some cases, restoration of water quality and natural resources. The BMPs in this plan are either already implemented or are planned for implementation to achieve and maintain the South River sediment local TMDL reductions. This section describes the types of BMPs being implemented in the watershed. Load reductions that result from these measures are discussed in Section 4.

3.1 BMP Definitions and Treatment

This section briefly describes each practice. Associated BMP names used in the TIPP are included in *italics*. However, for this attainment report modeling, the stormwater BMPs were entered by PE (rainfall depth treated) and BMP type at the Runoff Reduction/Stormwater Treatment level. More specific information about modeling is provided in Section 4.1.

3.1.1 BMPs for Sediment Load Reduction

Many stormwater BMPs address both water quantity and quality, however, some BMPs are more effective at reducing sediment than others. The stormwater practices listed below keep the focus on "green technology" to reduce the impacts of stormwater runoff from impervious surfaces.

The implemented and planned BMP practices are approved by MDE and described in the 2021 MS4 Accounting Guidance (MDE, 2021b) and have been included as BMPs in the TIPP tool. Exceptions to this are dry ponds which include dry detention ponds and dry extended detention ponds. These practices are no longer considered for future implementation; however, there are many existing facilities that are still actively treating runoff throughout the County, so they are described here as well. The practices include:

Stormwater BMPs – Runoff Reduction

- **Bioretention** — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. Rain gardens may be engineered to perform as a bioretention. *BMP Short Name(s) used in the TIPP = BioRetNoUdAB / BioRetUdAB / BioRetUdCD*
- **Bioswales** — An open channel conveyance that functions similarly to bioretention. Unlike other open channel designs, there is additional treatment through filter media and infiltration into the soil. *BMP Short Name(s) used in the TIPP = Bioswale*
- **Dry Detention Ponds** – Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow. These devices are designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff. *BMP Short Name(s) used in the TIPP = Dryponds*
- **Dry Extended Detention Ponds** – Depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. They are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, allowing additional wet

sedimentation to improve treatment effectiveness. *BMP Short Name(s) used in the TIPP = ExtDryPonds*

- **Green Roof –** Green roofs are alternative surfaces that replace conventional construction materials and include a protective cover of planting media and vegetation, reducing impervious cover and more closely mimicking natural hydrology. "Extensive" green roof is a lightweight system where the media layer is between two and six inches thick and is limited to low-growing herbaceous plants. "Intensive" green roofs have thicker soil layers and can support trees and shrubs. *Modeled in the TIPP as Runoff Reduction (RR).*
- **Impervious Disconnection** – Disconnecting existing impervious area runoff from stormwater drainage systems such as directing rooftops and/or on-lot impervious surfaces to pervious areas with amended soils. *BMP Short Name(s) used in the TIPP = ImperviousDisconnection*
- **Permeable Pavement -** Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. *BMP Short Name(s) used in the TIPP = PermPavNoSVNoUdAB / PermPavNoSVUdAB / PermPavNoSVUdCD / PermPavSVNoUdAB / PermPavSVUdAB / PermPavSVUdCD*
- **Rainwater Harvesting –** Rainwater harvesting practices intercept and store rainfall for future use. The capture and re-use of rainwater promotes conservation, as well as reduces runoff volumes and the discharge of pollutants downstream. Rainwater harvesting includes rain barrels and larger storage tanks or cisterns. *Modeled in the TIPP as Runoff Reduction (RR).*

Stormwater BMPs – Stormwater Treatment

- **Infiltration** — A depression or trench to form a shallow basin where sediment is trapped and stormwater infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil; they are not constructed on poor soils, such as C and D soil types. Yearly inspections to determine if the basin or trench is still infiltrating runoff are planned. Dry wells, infiltration basins, infiltration trenches, and landscaped infiltration are all examples of this practice type. *BMP Short Name(s) used in the TIPP = Infiltration / InfiltWithSV*
- **Urban Filtering** - Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit. *BMP Short Name(s) used in the TIPP = Filter / UrbFilterRR / UrbFilterST*
- **Vegetated Open Channels** - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. *BMP Short Name(s) used in the TIPP = VegOpChanNoUdAB / VegOpChanNoUdCD*
- **Wet ponds or wetlands** — A water impoundment structure that intercepts stormwater runoff then releases it at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached pollutants. Until 2002 in Maryland, these practices were generally designed to meet water quantity, not water quality objectives. There is little or no vegetation within the pooled

area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal, but phosphorus and sediment are reduced. *BMP Short Name(s) used in the TIPP = WetPondWetland*

- **Stormwater Conversions –** Stormwater conversions, or retrofits, may include converting dry ponds, dry extended detention ponds, or wet extended detention ponds into wet pond structures, wetlands, or infiltration basins. Load reductions are calculated in the TIPP for both the prior BMP type, as a negative reduction, and the retrofit BMP type to calculate the net reductions from the facility (i.e., additional treatment). This is the suggested approach by MDE to prevent double counting reductions from retrofits.

Land Use Conversion BMPs

- **Impervious Surface Reduction** - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Disconnection of rooftop and non-rooftop runoff, rainwater harvesting (e.g., rain barrels), and sheetflow to conservation areas are examples of impervious surface reduction. *Land Use Conversion(s) in TIPP = Converting from Aggregate Impervious to Turf / Converting from Aggregate Impervious to Forest / Converting from Aggregate Impervious to Tree Canopy over Turf*
- **Forest Planting –** Urban forest planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The planting area must be 0.5 contiguous acres or greater and have a survival rate of 100 trees planted per area. At least 50% of the trees should have a 2-inch diameter or greater, or a 1-inch caliper at the time of planting. *Land Use Conversion in TIPP = Converting from Turf to Forest*
- **Riparian Forest Planting –** Riparian forest buffers are planted adjacent to a stream, with a recommended buffer of 100 feet and a 35-foot minimum width required. *Land Use Conversion in TIPP = Converting from Turf to Forest with Buffer*
- **Urban Tree Canopy Planting** - Urban tree canopy planting is the conversion of pervious turf to tree canopy over turf. The understory remains managed (regularly mowed and/or fertilized). One tree planted is the equivalent of 0.01 acre, or 100 trees is equivalent to one acre of implementation. Survival rate is assumed to be 100% and trees are not required to be planted in a contiguous area. *Land Use Conversion in TIPP = Converting from Turf to Tree Canopy over Turf*
- **Street Trees** – Street trees are any tree planting that occurs over an impervious surface (e.g., trees planted in sidewalk boxes on a roadside curb). Similar to Urban Tree Canopy plantings, one tree planted is the equivalent of 0.01 acres, or 100 trees is equivalent to one acre of implementation. Survival rate is assumed to be 100% and trees are not required to be planted in a contiguous area. *Land Use Conversion in TIPP = Converting from Aggregate Impervious to Tree Canopy over Aggregate Impervious*
- **Conservation Landscaping –** Conservation landscaping refers to areas of managed turf that are converted into perennial meadows using species that are native to the Chesapeake Bay region. *Land Use Conversion in TIPP = Converting from Turf to Mixed Open*

Alternative BMPs

- **Stream Restoration –** Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, helping to improve habitat and water quality conditions in degraded streams. Load reductions calculated in the TIPP using the default rate will be replaced with individual site-specific values once protocol information is available. Details on the protocols can be found in the *Consensus Recommendations* *for Improving the Application of the Prevented Sediment Protocol for Urban Stream Restoration Projects Built for Pollutant Removal Credit* (Wood, 2020) and *Consensus Recommendations to Improve Protocols 2 and 3 for Defining Stream Restoration Pollutant Removal Credits* (Wood and Schueler, 2020).

- **Outfall Stabilization –** Per the report *Recommendations for Crediting Outfall and Gully Stabilization Projects in the Chesapeake Bay Watershed* (Hanson et. al, 2019), outfall stabilization projects are an engineering approach to design a stable channel to dissipate energy that extends from the upland source to the stream channel. Load reductions from outfall stabilization projects are creditable only if Protocol 5 is applied.
- **Street Sweeping** — Street sweeping is an annual practice that must be tracked and reported each year to receive load reduction credit. Per the MDE 2021 MS4 Accounting Guidance (MDE, 2021b), MS4 jurisdictions may generate varying load reduction credit based on a range of sweeping schedules and type of sweeper used.
- **Storm Drain Cleaning –** Storm drain cleaning is an annual practice that must be tracked and reported each year to receive load reduction credit. Per the MDE 2021 MS4 Accounting Guidance (MDE, 2021b), load reduction credit is available when the mass of nutrient-rich catch basin sediments is measured and physically removed from the storm drain system. Load reductions vary based on the material removed: organic or inorganic. At this time, the County is not weighing organic and inorganic material separately; so, an assumption of the percentage of organic and inorganic material is being used. This assumption may change based on future surveys.

3.2 BMP Database and Implementation Status

The County relies on a geographic information system (GIS) geodatabase to spatially locate projects and manage tables of data related to projects. Features are tracked spatially with records of the necessary treatment values, statuses, built dates, BMP information, and planning information needed for reporting and modeling. The BMP geodatabase is used to generate the input data that are used to measure progress towards TMDL reduction targets and to populate the MS4 annual report geodatabase components related to BMPs. Regular review and upkeep of the data is imperative to this process. The growth and development of this spatial database is a critical component of the reporting and tracking capability of the County.

BMPs associated with new development and redevelopment are entered into the County's BMP geodatabase when a grading permit is closed by the Anne Arundel Department of Inspections & Permits. Staff within the Bureau of Engineering, who collect and maintain GIS data for County's stormwater infrastructure, use the as-built drawings submitted at the closure of the grading permit and follow standard operating procedures to locate all stormwater BMPs, assign each BMP a unique ID, and enter all available data from the drawings required for MS4 reporting and infrastructure management into the BMP geodatabase. The BMP geodatabase has integrated quality control measures, such as data fields with pre-defined domains, range limits, and mandatory completion rules. Staff within BWPR then review these BMP data and employ quality assurance practices to monitor for data entry errors, correct interpretation of as-built drawing information, and to ensure the record completeness. In addition, if required or desired data are not available on the as-built drawings, BWPR staff review stormwater management design reports or other documents submitted under the grading permit to supplement the data collected by the Bureau of Engineering.

BMPs implemented for restoration purposes, in particular those planned as part of the County's Capital Improvement Program (CIP) or by the County's non-governmental organization (NGO) partners, are entered into the County's BMP geodatabase at the schematic design phase by BWPR staff using the same quality control and quality assurance practices noted above. Data are recorded and tracked for each design phase of the project and data for completed projects submitted to MDE are collected from as-built drawings. BWPR staff review the calculations associated with equivalent impervious acres and expected pollutant load reductions at each phase of a project to ensure that all project credits align with current MDE crediting guidance.

BMP status is based on progress in planning, design, and construction of structural, ESD, and alternative BMPs, and are identified as **Complete, Under Construction, In Design,** or **Planned** for each BMP. Unit treatment (e.g., impervious and turf acres, acres converted, linear feet) for each type of BMP is grouped based on project phase status and built date and entered into the TIPP. This allows the County to assess pollutant reduction progress in near real time and plan BMPs needed to meet the remaining reduction goal. The TIPP Progress scenario includes **Complete** BMPs, while TIPP Planned scenario includes **Under Construction, In Design and Planned** BMPs. Modeling in the TIPP is described in Section 4.1. Definitions of the project phases are provided below.

- **Complete:** Sites that have completed construction and include a built or install date
- **Under Construction:** Sites that have completed the design phase and are currently under construction; these sites do not have a built date
- **In Design:** Sites that are currently in design and have not started construction; these sites do not have a built date
- **Planned:** Sites included in the County's CIP tracking but with no open task order at this time

4 2022 Progress and Attainment Summary

The following section summarizes modeling methods, the County's implementation efforts resulting in attainment, and the load reductions achieved.

4.1 Modeling Methods

This section provides a summary of the County's methodology for calculating sediment loads and load reductions including the 2009 baseline, the required reductions from the 2009 baseline condition, and progress and attainment through the end of fiscal year 2022. Sediment loads and WLAs are presented as tons/year in the sediment TMDL but are discussed as pounds/year in this document.

4.1.1 Overview

In 2021, MDE released their TMDL TIPP tool (MDE, 2021c). As noted in Guidance for Developing Local Nutrient and Sediment TMDL (Total Maximum Daily Load) SW WLA Watershed Implementation Plans (WIPs), "MDE requires jurisdictions to use this tool for consistency among load reduction calculation methodologies and ease of reporting progress" (MDE, 2022c). The TIPP spreadsheet tool was developed by MDE's Water and Science Administration to simplify the load estimating and planning process. The spreadsheet tool estimates load reductions at various points in the watershed planning process, allowing users to assess current progress and future BMP implementation. Land use specific loading rates are multiplied by an amount, which may be acres or systems depending on the load source, to calculate loads coming off the land. The land use loading rates used in this spreadsheet are Chesapeake Bay Phase 6 CAST-2017d Watershed Model No Action (No BMP) scenario loading rates aggregated at the 8-digit watershed scale by county and include STB loads determined by a variation of the method used to determine STB load in the MDE 2021 MS4 Accounting Guidance document (MDE 2021b). These loads account for inconsistencies in load distribution between the Phase 5 and 6 model.

The TIPP spreadsheet tool estimates load reductions for TN, TP, and TSS at two different scales: Edge-of-Stream (EOS) and Edge-of-Tide (EOT). EOS loads in this spreadsheet are calculated using the methods and BMP efficiencies recommended by the expert panels approved by the Chesapeake Bay Program. The EOS scale is used for local TMDL modeling and the County's implementation plans. The EOT scale incorporates in-stream uptake, processing, and transport that affects nutrient and sediment loads from the upstream source to the receiving water body. EOT loads in this spreadsheet are calculated using Chesapeake Bay Phase 6 Watershed Model No Action scenario delivery factors at the Maryland 8-digit watershed scale. The EOT scale is used in Bay TMDL modeling. Bay TMDL modeling is not included in this attainment report.

Modeling methodologies may change in the future because of updated versions of the Bay Model, which could change loading rates, or because of crediting changes directed by MDE or Expert Panels, which would affect load reduction calculations or BMP percent efficiencies. The TIPP spreadsheet tool was originally developed by MDE and if information needs to be updated MDE will release an updated version of the tool. Revised components of the updated version will then need to be incorporated into the County's TIPP workbooks. The County will need to stay up to date on decisions impacting local TMDL pollutant modeling. Implementation plans may be revised, as necessary, if modeling changes occur in the future.

4.1.2 Model Translation

Anne Arundel County's modeling approach does not seek to determine the current level of loading compared to the originally published SW-WLA. Instead, reduction requirements have been developed based on MDE's guidance (MDE, 2014a) regarding the process for determining whether WLA requirements have been met:

> *… it is recommended that local jurisdictions demonstrate their progress towards achieving SW-WLAs by comparing reduction percentages rather than absolute loads.* – Page 6, Technical Recommendations 1.g.

It is understood that the absolute loads listed in the TMDL and load reductions developed by the County will vary because the model used to develop the TMDL is different from what is currently available and may not be available to the County or other permittees. The SW-WLAs are translated into a compatible target load using the TIPP spreadsheet tool. Demonstrating progress by percent reduced will allow the County to meet the TMDL based on the best and most accurate data available on land use, sources, loading rates, and removal efficiencies.

To translate SW-WLAs that were developed under older versions of the CBP watershed model or using different models, the published baseline loads were re-calculated in the TIPP spreadsheet by modeling baseline BMPs within the TMDL watershed on top of baseline land use.

TIPP Baseline Land Use Data Inputs

Land use within the County's jurisdiction is a critical factor in models used to assess TMDL compliance. Land cover data from the National Land Cover Database (NLCD) was used to quantify land cover acreage for the baseline year. Because NLCD land cover classifications are inconsistent with the Phase 6 Chesapeake Bay Watershed Model land cover classes, the backcasting method developed by Baltimore County (MDE, 2021e) was applied to NLCD data used within the TMDL progress modeling.

Backcasting was achieved by comparing MDE-modified 2013/2014 Chesapeake Conservancy (CC) land cover data to 2013 NLCD land cover data. Before backcasting, several steps were taken to pre-process the NLCD and CC data. Firstly, MDE's classification of 'Mixed Open/Agriculture' was disaggregated into 'Mixed Open' and 'Agriculture'. This was achieved by reclassifying 'Mixed Open/Agriculture' to 'Agriculture' where the land cover classification intersected with a parcel with an agricultural assessment. All other occurrences of 'Mixed Open/Agriculture' that did not intersect with a parcel with an agricultural assessment were reclassified as 'Mixed Open'.

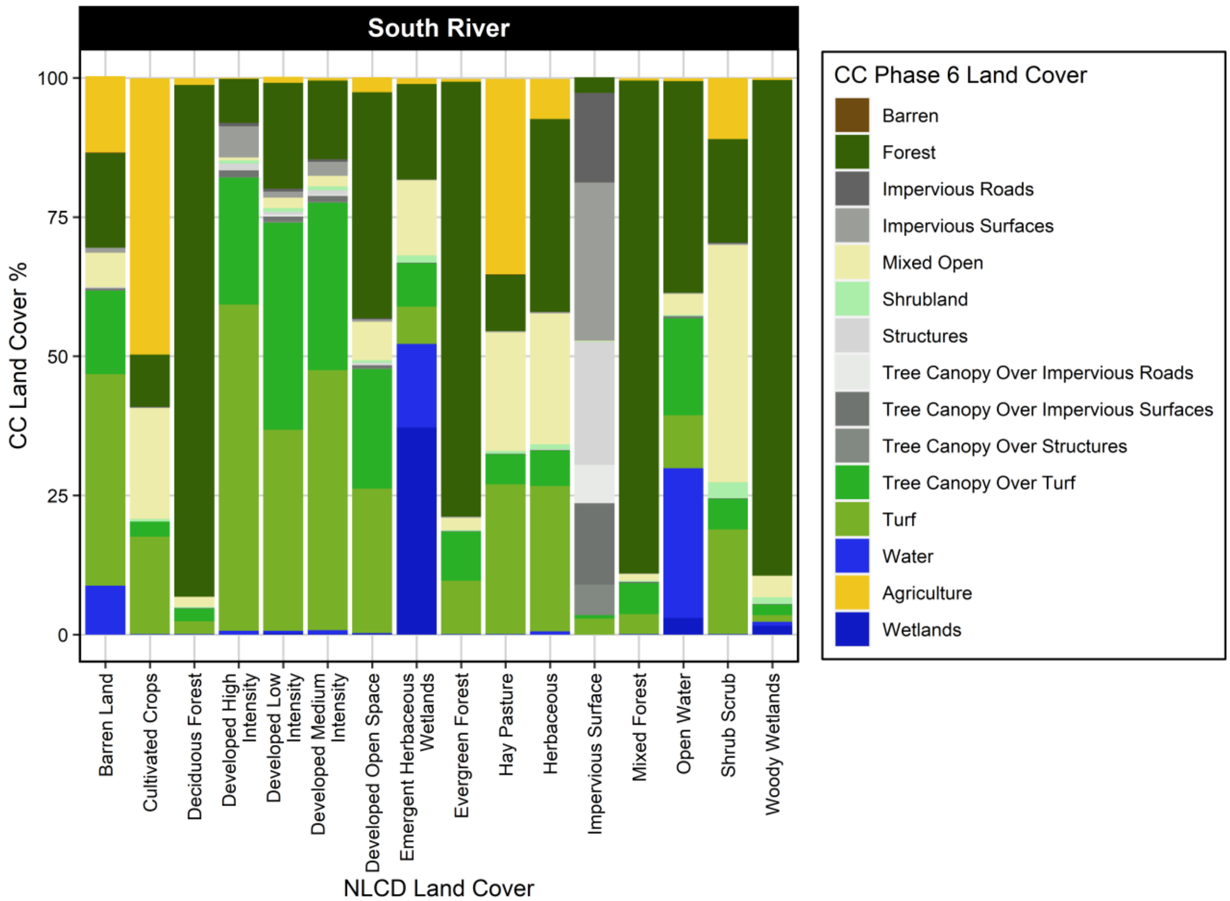

Figure 2. Unique NLCD-CC translations for the South River TMDL watershed

As NLCD land cover data does not have an 'Impervious' land cover category, but rather is classified as different intensities of 'Developed', all NLDC land cover data were reclassified as 'Impervious' if it intersected with the County's impervious land cover dataset. The 2007 County impervious data were used for backcasting, as it was the earliest impervious dataset closest to the 2009 baseline year. Finally, NLCD data were clipped to the extent of the County MS4-regulated area, removing State, Federal, and any other land that does not fall under the County's jurisdiction.

Backcasting was conducted for the South River TMDL watershed separately, rather than county-wide. Using both the 2013/2014 NLCD and CC land cover data, for each NLCD land cover category, the percentage of different CC land cover classes within each NLCD land cover class were summarized. The NLCD land cover acreages were then multiplied by the percentages of CC land covers presented in Figure 2, transforming the NLCD land cover to CC land cover classes compatible with the TIPP spreadsheet tool.

The resulting baseline land use acres are shown in Table 7 below and were used as data input into the TIPP.

Table 7: TIPP Model Baseline Land Use Data Inputs

Land Use Type	South River TSS (2009)
Aggregate Impervious	2,348.52
Turf	7,515.03
Total	**9,863.55**

Reduction Target Derivation

The required percent reduction is published in the local TMDL document and will vary based on the impairment. These percentages form the basis of the County's reporting on progress towards compliance. The required local TMDL reductions are calculated using the formula below. The required percent reduction assigned to the Anne Arundel County MS4 source is applied to the translated baseline load to calculate the required pollutant load reduction. The required pollutant reduction was then subtracted from the baseline load to calculate the target SW-WLA. Baseline, progress, and implementation loads translated using the TIPP spreadsheet tool allow for direct comparison of progress and planned load reductions against the TMDL targets.

$$Reqd\ Reduction_{AA\ Co} = Baseline\ Load_{AA\ Co} * Reqd\ Reduction\ \%$$

Where:

Reqd Reduction $_{AA\ Co}$ = Reduction amount required for Anne Arundel County
Baseline Load $_{AA\ Co}$ = Anne Arundel County translated Baseline Load
Reqd Reduction % = Published percent reduction assigned to Anne Arundel County NPDES regulated stormwater point source in the TMDL document

The SW-WLAs in the nutrient and sediment TMDLs were developed by MDE using the Chesapeake Bay Program Watershed Model Phase 5.3.2 (CBP P5.3.2) and were translated by the County into TIPP-compatible target loads. Sediment loads required for the South River Anne Arundel County Phase I MS4 source are shown in Table 8.

Table 8: Sediment Loads Required for the Local TMDL in the South River watershed

	South River
Impairment (Unit)	Sediment (lbs/yr)
Baseline Load and TMDL SW-WLA	
Baseline Year	2009
Impairment Baseline Loads	18,936,404
Target % Reduction	28.0%
Total Reduction Required	5,302,193
Target Load (SW-WLA)	13,634,211

4.2 Implementation Results

Project implementation occurring from baseline year 2009 through the end of FY2022 is detailed by BMP type in Table 9. According to the modeling, these FY2022 progress restoration BMPs have achieved sediment load reduction in excess of the target load reduction, resulting in attainment of the TMDL SW-WLA goal. Despite successful attainment, the County has additional planned BMPs, which are also presented in Table 9. These additional BMPs will result in even greater overachievement of SW-WLA goal reductions, as described in Section 4.3. Information on completed projects and programs is tracked within the County's BMP geodatabase and submitted to MDE as part of the County MS4 annual report geodatabase.

Table 9: Current BMP Implementation through FY2022 for the South River

BMP	Unit	CY2009 – FY2022 Progress	Planned	Total Restoration[3]
Structural Permanent Practices				
Bioretention	acre	28.73		28.73
Bioswale	acre	0.71		0.71
Grass Swale	acre	0.71		0.71
Impervious Surface Reduction (to Tree Canopy over Turf)	acre	0.26		0.26
Infiltration Trench	acre	19.54		19.54
Micro-Bioretention	acre	0.65		0.65
Multiple Pond Systems		5.94		5.94
Outfall Stabilization	linear ft		785	785
Permeable Pavement	acre	0.27		0.27
Rain Gardens	acre	1.11		1.11
SPSC (bank protection)	linear ft	363		363
SPSC (water quality treatment)	acre	133.53	23.56	157.09
Submerged Gravel Wetlands	acre	0.95		0.95
Surface Sand Filter	acre	4.98		4.98
Wet Ponds or Wetlands	acre	220.10		220.10
Urban Stream Restoration	linear ft	27,582	19,060	46,642
Annual Practices				
Inlet Cleaning[1]	lbs/yr	50,602.4		50,602.4
Street Sweeping[2]	miles/yr	20.28	0	20.28

Source: BWPR BMP geodatabase and MDE MS4 FY22 annual report geodatabase

[1] Progress value is the average pounds of material removed annually from FY2017 through FY2018.

[2] Progress value is the average road miles swept annually from FY2016 through FY2018.

[3] Total Restoration includes CY2009-FY2022 and Planned projects, no baseline BMPs included.

4.3 Load Reduction Results

The implementation summarized in Table 9 above resulted in the load reductions presented here in Table 10. Figure 3 presents the baseline and target loads compared with the progress and planned loads. Figure

4 presents the cumulative load reductions achieved by BMP type from the baseline year through current progress.

Table 10: FY2022 Progress Reductions Achieved Resulting in Attainment

Baseline Load and TMDL SW-WLA	TSS-EOS lbs/yr
2009 Baseline Scenario Load	18,936,404
Required Percent Reduction	28.0%
Required Reduction	5,302,193
Local TMDL SW-WLA	13,634,211
FY2022 Progress and Attainment Results	**TSS-EOS lbs/yr**
Progress Scenario Load	12,855,977
Progress Reduction Achieved	6,080,427
Percent Reduction Achieved	32.1%
Planned Implementation Results	**TSS-EOS lbs/yr**
Planned Scenario Load	6,492,872
Planned Reduction Achieved	12,443,532
Percent Reduction Achieved	65.7%

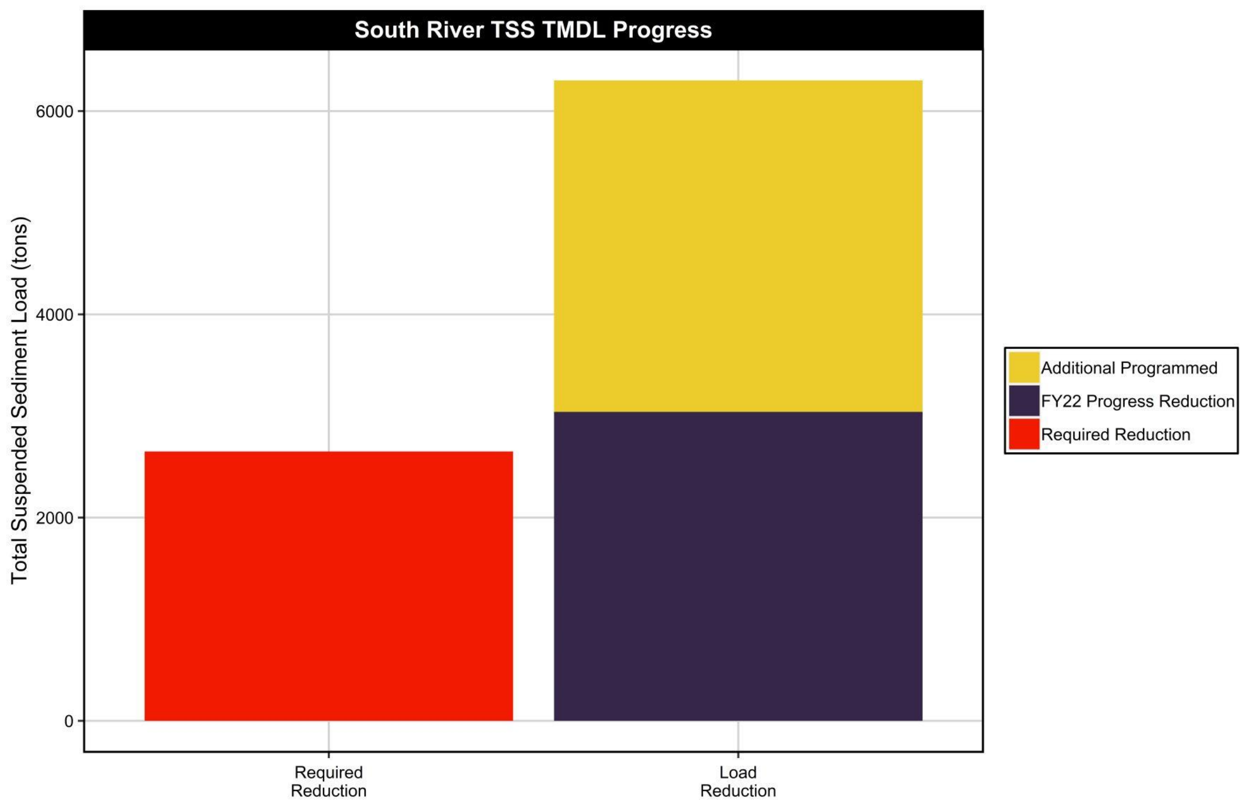

Figure 3. TSS Baseline and Required Reduction compared with Progress and Planned Loads

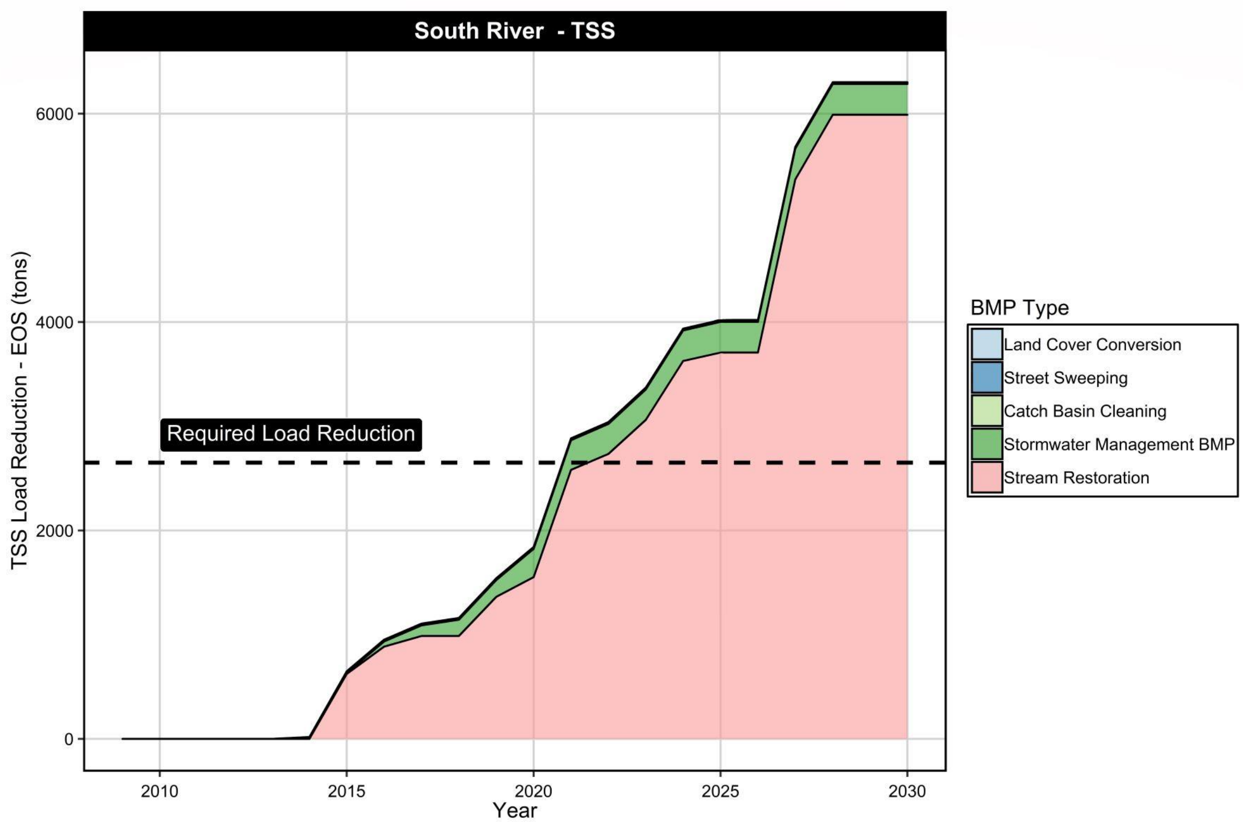

Figure 4. Cumulative progress TSS load reduction in the South River watershed since the 2009 baseline year by BMP type.

5 BMP Inspection and Maintenance

With BMPs installed throughout the watershed and successful attainment of sediment WLA goals, it is important that the BMPs remain functional and maintained. Anne Arundel County has established policies and procedures in place for stormwater management facility inspection, maintenance, and enforcement.

5.1 Background

Both the State and County stormwater management (SWM) Codes require maintenance inspections be performed on all SWM practices during the first year of operation and every three years thereafter. The first year of operation inspections are performed by the Environmental Control Inspectors before Certificates of Completion are issued for the grading permits under which the practices were constructed. The three-year maintenance inspections include assessment of debris and trash accumulation, plant composition and health, vegetative cover, dewatering, erosion, sediment and/or leaves and debris accumulation, blockages, structure components, maintenance access, and overall function of facility.

The responsibility for triennial maintenance inspections of BMPs is divided between two groups of inspectors within the County. All BMPs owned or maintained by DPW are inspected by BWPR's Stormwater Infrastructure Program (SIP) inspectors. In addition to performing triennial maintenance inspections and identifying all maintenance and repairs required, these inspectors utilize established contracts to promptly address any issues noted during the inspection. For certain significant repairs or upgrades, where the necessary work exceeds existing contracts, CIP projects may be planned to address compliance issues for those BMPs. SIP inspectors then perform follow-up inspections to verify that all work was completed properly and that the BMP functions as designed and is in compliance with all State and County SWM Codes.

BMPs not owned or maintained by DPW are inspected by the Department of Inspection and Permits Environmental Control Inspectors on a triennial basis. The inspection and enforcement processes utilized by these inspectors are detailed below.

5.2 Phase 1 Inspection and Enforcement

Phase 1 reflects the first time a SWM practice receives a three-year maintenance inspection and maintenance is required. Using the proper Maintenance Inspection Checklists, the Inspector performs the required three-year maintenance inspection, indicating on the Checklist boxes if maintenance is required, not required or the item is non-applicable. The information on the completed Checklist will serve to comply with the inspection requirements of COMAR 26.17.02.11 and is used to complete a Phase 1 Correction Notice issued in the field or mailed to the property owner. The Phase 1 Correction Notices are prepared using the I&P standard computerized inspection report software. They include a detailed description of the maintenance required and the compliance date by which the required maintenance is to be completed. If necessary, Phase 1 Correction Notices can be completed by hand using the standard Environmental Programs Inspection Report Form. Phase 1 Correction Notices contain the proper contact information. The BMP geodatabase is updated to document when a three-year Maintenance Inspection is performed. For monthly reporting purposes, all re-inspections are recorded as inspections and not as facilities inspected or as new correction notices issued. Depending on the degree of maintenance required, a Compliance Schedule may be appropriate. All proposed Compliance Schedules must be authorized by the I&P Environmental Control Inspection Supervisor.

5.3 Phase 2 Inspection and Enforcement

Phase 2 reflects situations where Phase 1 Enforcement was not successful in obtaining compliance. Phase 2 Enforcement consists of a formal Phase 2 Violation Notice in the form of a certified letter to the property owner or responsible party. The Phase 2 Violation Notice is prepared by the Environmental Control Inspector using the appropriate form letter, reviewed by the Environmental Control Inspection Supervisor/Environmental Code Administrator as appropriate, and signed by the Environmental Control Inspection Supervisor. The Phase 2 Notice establishes final compliance dates for the completion of the required maintenance. The final compliance dates may reflect agreed upon Compliance Schedules as authorized by the Environmental Control Inspection Supervisor.

5.4 Phase 3 Inspection and Enforcement

Phase 3 reflects situations where Phase 2 Enforcement was not successful in obtaining compliance. Phase 3 enforcement consists of a legal referral to the Office of Law for the enforcement of the Private Inspection and Maintenance Agreement recorded against the deed for the property in question. The referral is prepared by the Environmental Code Administrator using the records associated with the violation.

6 Financial Summary

6.1 Implementation Cost

A major source of funding for the implementation of restoration projects is the County's Watershed Protection and Restoration Fee (WPRF). Funding for the programmed restoration projects is through both the CIP and through the County's BWPR Grant Program. In addition to funding provided through the WPRF Anne Arundel County actively pursues grant funding from Federal, State and NGOs to leverage funding for its restoration projects.

The total cost of completed and planned projects described in this plan for the South River watershed is approximately $43,533,454. Table 11 provides a summary of the cost of BMP implementation by BMP type as well as funding needs for planned BMPs by BMP type. Planned projects are sites that are either under construction, in design, or included in the County's CIP database. Project costs for all County CIP projects are inclusive of all project elements and include design, obtaining land ROW, and construction. Project costs for non-CIP projects are based on the best available information the County is able to obtain from NGO partners or other entities funding restoration projects.

Table 11: Restoration Cost for FY22 Current Progress and Planned Implementation

Project type	FY22 Progress	Planned	Total Cost
SWM BMP	$5,948,462	$884,206	$6,832,668
Stream Restoration	$16,140,485	$20,447,419	$36,587,904
Street Sweeping	$24,931	$0	$24,931
Catch Basin Cleaning	$87,951	$0	$87,951
Impervious Removal	$0	$0	$0
Total	**$22,201,829**	**$21,331,625**	**$43,533,454**

7 Monitoring

Official monitoring for Integrated Report assessments and impairment status is the responsibility of the State; however, the County's BWPR has several on-going monitoring programs that target measures of water quality. In addition, MDE has stressed specifically for sediment impairments the connection between in-stream biological health and meeting the intent of the sediment TMDL goals.

To determine the specific parameters to be monitored for tracking progress, one must understand the approach used for the initial listing. In 2002, the State began listing biological impairments on the Integrated Report, at the 8-digit scale, based on a percentage of stream miles degraded and whether they differ significantly from a reference condition watershed (<10% stream miles degraded). The biological listing is based on Benthic and Fish Indices of Biotic Integrity (BIBI/FIBI) results from wadeable streams from assessments conducted by the Maryland Department of Natural Resources (MDNR) Maryland Biological Stream Survey (MBSS). The South River was listed for biological community impairment in 2002. The South River watershed was listed for sediments in the 2014 Integrated Report as a total suspended solids Category 5 (in need of a TMDL) listing.

MDE then utilized its Biological Stressor Identification (BSID) process to identify the probable or most likely causes of poor biological conditions. The BSID identified that biological communities in the South River watershed are likely degraded due to 'altered flow/sediment and instream habitat related stressors', 'anthropogenic alterations of riparian buffer zones', and inorganic pollutants (i.e., chlorides).

Based on the results of the BSID (MDE, 2014b), MDE replaced the biological impairment listing with a listing for total suspended solids (TSS). The 2020-2022 integrated report (MDE, 2022a) lists 'Habitat

Evaluation' as the indicator, and urban runoff/storm sewers as the source. It is noted that the *Decision Methodology for Solids for the April 2002 Water Quality Inventory (updated in February of 2012)*[1], makes a specific distinction between two different, although related 'sediment' impairment types in free-flowing streams:

1. **TSS**: The first type is an impact to water clarity with impairment due to TSS using turbidity measured in Nephelometer Turbidity Units (NTUs). Although numeric criteria have not been established in Maryland for TSS, MDE uses a threshold for turbidity, a measurement of water clarity, of a maximum of 150 Nephelometer Turbidity Units (NTU's) and maximum monthly average of 50 NTU as stated in Maryland COMAR regulations (26.08.02.03-3). Turbidity also may not exceed levels detrimental to aquatic life in Use I designated waters.
2. **Sedimentation / siltation**: The second type is an impact related to erosional and depositional impacts in wadeable streams. The measures used are biocriteria and the criteria for Use I streams (the protection of aquatic life and growth and propagation of fish (other than trout) and other aquatic life).

With these two sediment impairments in mind the South River, which is listed as impaired for TSS, would seem to be a water clarity issue; however, the methodology used for listing (biological and habitat measures related sediment deposition) seems to point to an in-stream sediment deposition problem. In all likelihood both types of impairment, water clarity and sedimentation, are factors and both should be incorporated into monitoring programs to track changes in the watershed condition over time.

Anne Arundel County's BWPR has several on-going monitoring programs that target measures of water clarity and sedimentation. These programs are described here.

7.1 Countywide Biological Monitoring

7.1.1 Background and Goals

Biological monitoring and assessment provide a direct measure of the ecological health of a stream. Stream organisms are continuous monitors of both short- and long-term water quality and other environmental factors and act as direct indicators of the quality of a stream. Advantages of using benthic macroinvertebrates include their generally restricted mobility and often multi-year life cycles, allowing them to integrate the effects of both chemical and physical perturbations over time. When hydrologic regimes of streams are altered, the physical nature of the habitat changes due to accelerated erosion and deposition of channel soils and other materials. This changes the capacity of a stream to support a healthy biota. Changes in the quality of the water resource are reflected as changes in the structural and functional attributes of the macroinvertebrate assemblage. Biological monitoring and assessment results can be used to detect impairment of the biological community and to assess the severity of impacts from both point source (PS) and nonpoint source (NPS) pollution. When coupled with information on chemical and physical stressors, these types of exposure-and effect data can be used to improve water quality assessments. Over the past several decades, biological monitoring and assessment of aquatic communities along with characterization of their chemical and physical habitats have increased with application of these data to watershed management policies and practices.

[1] http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Documents/Assessment_Methodologies/AM_Solids_2012.pdf

Historically, many municipalities have been hampered in their ability to recommend and implement pollution control and remediation efforts because the chemical, physical, and biological condition of most of their water resources have not been adequately characterized. To expand its monitoring program, Anne Arundel County developed a stream monitoring program consisting of chemical, physical, and biological assessment techniques to document and track changes in the condition of stream resources County-wide. Problems resulting from chemical contamination and physical habitat alteration are reflected by changes in the aquatic biota. Therefore, inclusion of a biological monitoring component provides Anne Arundel County with the relevant indicators for assessing the condition of, and managing, its water resources.

In 2004, a Countywide Biological Monitoring and Assessment Program for Anne Arundel County, Maryland was developed to assess the biological condition of the County's streams at multiple scales (i.e., site-specific, primary sampling unit (PSU), and countywide). Under the Countywide Biological Monitoring and Assessment program, biology (i.e., benthic macroinvertebrates) and stream habitat, as well as geomorphological and water quality parameters, are assessed at approximately 240 sites throughout the entire County over a 5-year period using a probabilistic, rotating-basin design.

Round 1 of the County's Biological Monitoring and Assessment Program occurred between 2004 and 2008, and Round 2 took place between 2009 and 2013. Round 3 monitoring was initiated in 2017, with fish sampling and additional water quality parameters added (Southerland et al., 2016), and was completed in 2021. Field data collection in the South River watershed took place during 2017 and 2019. Annual reports and Round summary reports are available for review at:

http://www.aacounty.org/departments/public-works/wprp/ecological-assessment-and-evaluation/biological-monitoring/biological-monitoring-reports/index.html

The primary goals of the program are to assess the current status of biological stream resources, establish a baseline for comparison with current and future assessments, and to relate them to specific programmatic activities. The County currently uses a combination of chemical sampling, geomorphic assessment, storm water sampling, and biological sampling to assist in its environmental management decision-making process. This combination of monitoring greatly assists the County in assessing progress toward achieving Stormwater Wasteload allocations set forth in Sediment TMDLs. The biological monitoring program's stated goals are applicable at three scales; Countywide, Watershed-wide, and Stream-specific, and include the following components.

- Status: describe the overall stream condition
- Trends: how has the overall stream condition changed over time
- Problem identification/prioritization: identify the impaired and most degraded streams
- Stressor-response relationships: identify anthropogenic stressors and their biological response
- Evaluation of environmental management activities: monitor the success of implemented programs and restoration/retrofit projects

7.1.2 Methods

Both field sampling and data analysis methods were developed for the program to be directly comparable to Department of Natural Resources' Maryland Biological Stream Survey (MBSS), and complementary to those in place in Prince George's, Montgomery, and Howard Counties in Maryland (Hill and Stribling, 2004). Primary data collected include site location (latitude and longitude), pH, dissolved oxygen, water temperature and conductivity, benthic macroinvertebrate index of biotic integrity (BIBI), and physical habitat index (PHI) following MBSS methodologies (Kazyak, 2001; DNR, 2007; Stranko et. al, 2019) and

EPA's Rapid Bioassessment Protocol (EPA RBP; Barbour et al., 1999). Biological data were analyzed using the revised (2005) version of the MBSS Coastal Plain BIBI (Southerland et al., 2005).

A more detailed description of the sampling and analysis methods can be found in the annual Biological Monitoring and Assessment Program Annual Reports (Anne Arundel County, 2004-2021). Specific information regarding the sampling and analysis methods, including the standard operating procedures (SOPs), can be found in the Documentation of Method Performance Characteristics for the Anne Arundel County Biological Monitoring Program (Hill et al., 2010) and the Quality Assurance Project Plan for Anne Arundel County Biological Monitoring and Assessment Program (Hill et al., 2011, AA County, 2017).

The South River watershed is made up of two PSUs: Upper North River, and Lower North River. Ten sampling sites were sampled in each of these PSUs in Round 1 and Round 2, while eight sites were sampled in each during Round 3. Following these procedures, the County is collecting several parameters related to water clarity and sediment deposition at each site.

- Water Quality Measures and Observations
    - Turbidity (measured), observations of general water clarity and color
    - Grab samples analyzed for nutrients, metals, DOC, TOC, and chloride
- Biological Measures
    - Benthic macroinvertebrates (BIBI)
    - Fish (FIBI)
- Habitat Measures
    - General: bar formation and substrate, presence/absence of substrate type
    - PHI: epibenthic substrate, instream habitat
    - RBP: epifaunal substrate / available cover, pool substrate characterization, sediment deposition, channel alteration
- Geomorphic Measures
    - Particle size analysis using modified Wolman pebble counts at 10 transects proportioned by channel bed features

7.1.3 Results

The South River watershed is made up of two PSUs: Upper North River (PSU 11), and Lower North River (PSU 11). Results summarized at the PSU scale with average BIBI and habitat ratings (PHI and RBP) presented in Table 12.

Table 12: Countywide Biological Monitoring Results

PSU Name	Round	PSU Code	Year Sampled	Drainage Area (acres)	BIBI Rating	PHI Rating	RBP Rating
Upper North River	1	11	2005	12,797	F	PD	PS
Upper North River	2	11	2011	12,797	P	PD	S
Upper North River	3	11	2017	12,797	P	PD	PS
Lower North River	1	12	2005	23,681	P	D	PS
Lower North River	2	12	2009	23,681	P	PD	S
Lower North River	3	12	2019	23,681	P	PD	PS

BIBI Ratings: G = Good, F = Fair, P = Poor, VP = Very Poor

PHI Ratings: MD = Minimally Degraded, PD = Partially Degraded, D = Degraded, SD = Severely Degraded

RBP Ratings: C = Comparable, S = Supporting, PS = Partially Supporting, NS = Non-Supporting

7.1.3.1 Biological

During Round 1, biological sampling was completed in 2005 for both the Upper North River and Lower North River sampling units. Benthic macroinvertebrate metric and index scores for sites assessed during the Round 1 sampling effort are presented in Table 13. BIBI narrative condition ratings throughout the South River watershed presented in Figure 5. Overall, 55% of the sites in the watershed were rated as “Fair,” 35% rated “Poor,” 5% rated “Good,” and 5% rated “Very Poor.” Upper North River received the second highest average BIBI score of all PSUs during Round 1, with a mean BIBI score of 3.34 ± 0.46 and a corresponding biological condition rating of “Fair.” The Lower North River PSU received a “Poor” biological condition rating, with a mean BIBI score of 2.63 ± 0.54.

Table 13: BIBI Data for Round 1 (2005)

Site ID	Year	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scraper Taxa	Percent Climbers	BIBI	Rating
11-13A	2005	19	6	2.0	1	33.7	1	13.9	3.86	Fair
11-15A	2005	18	3	3.0	1	63.0	0	13.0	3.29	Fair
11-17A	2005	24	4	0.0	0	35.4	1	18.8	3.29	Fair
11-07	2005	23	4	0.0	0	33.0	0	12.6	3.00	Fair
11-05	2005	31	7	1.0	1	48.5	1	8.2	4.14	Good
11-06	2005	17	3	0.0	0	72.6	1	2.8	2.71	Poor
11-04	2005	16	4	0.0	0	61.5	1	8.6	3.00	Fair
11-02	2005	28	6	3.1	1	60.8	0	22.7	3.86	Fair
11-14A	2005	21	1	3.0	1	23.2	4	8.1	3.29	Fair
11-11A	2005	24	6	0.0	0	48.0	0	7.8	3.00	Fair
12-04	2005	22	3	1.0	1	22.9	0	33	3.29	Fair
12-07	2005	18	2	0.0	0	20.8	1	14.1	2.71	Poor
12-06	2005	19	3	0.0	0	8.9	0	10	2.14	Poor
12-05	2005	20	2	0.0	0	53.4	0	6.7	2.43	Poor
12-03	2005	14	3	0.0	0	25.3	2	4.2	2.71	Poor
12-01	2005	27	4	0.0	0	15.5	1	15.5	3.00	Fair
12-08	2005	23	5	0.0	0	48.0	2	7.1	3.57	Fair
12-09	2005	14	3	0.0	0	1.9	1	6.8	2.14	Poor
12-02	2005	17	3	0.0	0	48.5	0	3.9	2.43	Poor
12-10	2005	11	2	0.0	0	1.1	2	0.0	1.86	Very Poor

During Round 2, biological sampling was completed in 2009 (Lower North River) and 2011 (Upper North River). Results of the Round 2 sampling effort are presented in Table 14. Overall, 50% of the sites in the watershed were rated as "Poor," 30% rated "Fair," 5% rated "Good," and 15% rated "Very Poor." Both Upper North and Lower North PSUs received "Poor" biological condition ratings, with mean BIBI scores of 2.74 ± 0.88 and 2.60 ±0.59, respectively.

Table 14. BIBI Data for Round 2 (2009-2011)

Site ID	Year	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scraper Taxa	Percent Climbers	BIBI	Rating
R2-11-01	2011	32	6	0.9	1	17.9	0	32	3.57	Fair
R2-11-03	2011	17	0	0.0	0	4.6	0	17	1.86	Very Poor
R2-11-05	2011	23	4	0.0	0	12.7	0	23	2.43	Poor
R2-11-06	2011	29	7	2.8	2	10.2	4	29	4.43	Good
R2-11-09	2011	29	5	0.9	1	9.0	1	29	3.57	Fair
R2-11-11A	2011	18	2	0.0	0	5.3	2	18	2.71	Poor
R2-11-13A	2011	14	2	0.0	0	1.8	2	14	2.43	Poor
R2-11-16A	2011	25	0	0.0	0	3.3	3	25	2.71	Poor
R2-11-17A	2011	14	0	0.0	0	5.4	0	14	1.57	Very Poor
R2-11-20A	2011	21	0	0.0	0	1.9	1	21	2.14	Poor
R2-12-01	2009	27	2	0.0	0	11.9	1	27	3.00	Fair
R2-12-02	2009	25	1	0.0	0	4.7	0	25	2.14	Poor
R2-12-03	2009	29	4	0.0	0	34.0	0	29	2.71	Poor
R2-12-04	2009	23	6	0.0	0	27.8	0	23	3.00	Fair
R2-12-06	2009	18	0	0.0	0	9.5	0	18	1.29	Very Poor
R2-12-07	2009	34	4	0.0	0	7.3	0	34	2.14	Poor
R2-12-08	2009	29	6	0.0	0	7.6	0	29	2.71	Poor
R2-12-11A	2009	15	2	0.0	0	52.8	0	15	2.71	Poor
R2-12-12A	2009	28	6	0.0	0	48.0	0	28	3.29	Fair
R2-12-13A	2009	22	3	0.0	0	39.6	0	22	3.00	Fair

In Round 3, the study design was modified and a total of 8 sites were sampled in each PSU. Sampling was performed in the Upper North in 2017 and Lower North in 2019, and site-specific results are presented in Table 15. Fifty percent of the sites were rated as "Poor," 31% were rated as "Fair" and the remaining 19% rated as "Very Poor." There were no sites rated "Good" for biological condition in Round 3. The Upper North mean BIBI score was 2.68 ± 0.74, resulting in a narrative rating of "Poor." The Lower North River PSU also received a "Poor" biological condition rating, with a mean BIBI score of 2.39 ± 0.74.

Table 15. BIBI Data for Round 3 (2017-2019)

Site ID	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scraper Taxa	Percent Climbers	BIBI	Rating
11-L1M-03-17	29	7	1	15.8	0.9	1	17.5	3.86	Fair
11-L1M-04-17	20	4	1	7.5	3.3	0	5.8	2.43	Poor
11-L2M-01-17	20	4	1	10.3	0.9	0	49.5	3.00	Fair
11-L2M-02-17	25	5	0	5.3	0.0	4	43.0	3.29	Fair
11-R3M-02-17	18	2	0	3.3	0.0	0	44.2	2.14	Poor
11-R3M-03-17	32	4	0	6.4	0.0	6	17.4	3.00	Fair
11-R3M-07-17	21	2	0	10.0	0.0	1	0.8	2.14	Poor
11-R3M-08-17	12	0	0	2.5	0.0	0	64.4	1.57	Very Poor
12-L1M-02-19	20	1	0	6.2	0.0	0	15.4	1.86	Very Poor
12-L1M-03-19	12	2	1	0.8	0.8	0	18.6	2.43	Poor
12-L2M-01-19	12	0	0	1.7	0.0	0	0.8	1.00	Very Poor
12-L2M-02-19	22	3	0	27.9	0.0	0	9.6	2.71	Poor
12-R3M-01-19	23	4	1	1.9	0.9	2	13.2	3.57	Fair
12-R3M-03-19	19	3	0	5.5	0.0	1	18.3	2.43	Poor
12-R3M-05-19	26	1	1	5.5	1.1	0	19.8	2.71	Poor
12-R3M-07-19	15	2	0	2.7	0.0	1	17.9	2.43	Poor

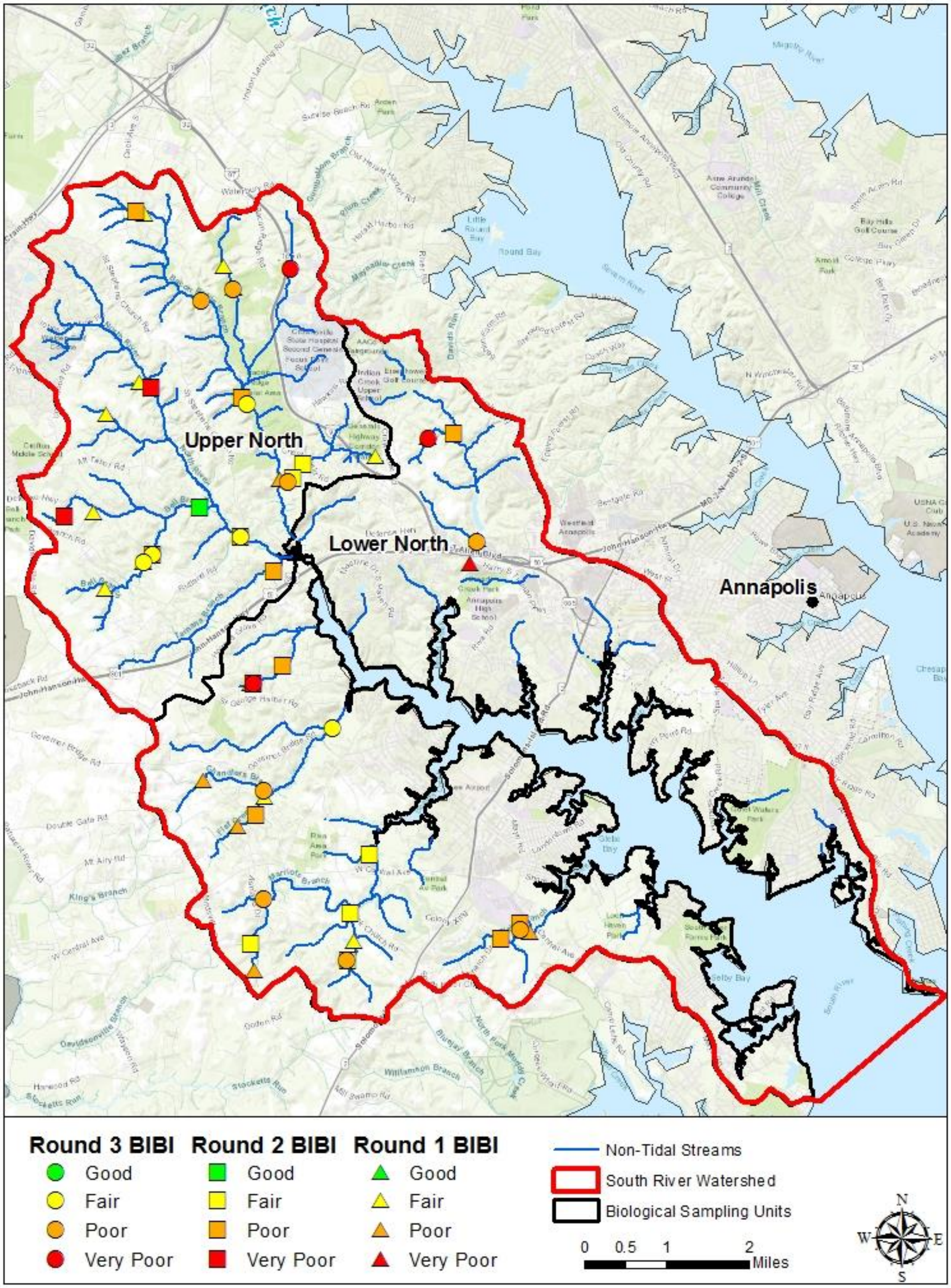

Figure 5: Biological Sampling Results (2005 - 2019).

7.1.3.2 Physical Habitat

During Round 1, all sampling was completed during the spring index period of 2005. Results of the Round 1 habitat assessments are presented in Table 16. Maryland Physical Habitat Index (MPHI) narrative condition ratings across the South River watershed are presented in Figure 6. The MPHI rated 50% of sites "Partially Degraded," 45% as "Degraded," and 5% "Severely Degraded." There were no sites rated "Minimally Degraded" in Round 1. The Upper North River PSU received a narrative habitat condition rating of "Partially Degraded" with a mean MPHI score of 66.75 ± 10.0. The Lower North River PSU received a mean MPHI score of 64.98 ± 8.49, and a corresponding narrative rating of "Degraded."

Table 16: Physical Habitat Index Data from Round 1 (2005).

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	#Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
11-13A	2005	100.00	91.34	34.39	52.32	80.13	98.32	76.08	Partially Degraded
11-15A	2005	100.00	73.32	48.39	50.51	60.60	68.92	66.96	Partially Degraded
11-17A	2005	15.79	31.57	46.76	59.05	93.27	94.87	56.89	Degraded
11-07	2005	100.00	58.94	32.56	56.61	100.00	95.75	73.98	Partially Degraded
11-05	2005	71.68	78.67	28.40	37.36	75.63	61.24	58.83	Degraded
11-06	2005	69.36	40.96	24.65	44.54	50.15	50.00	46.61	Severely Degraded
11-04	2005	100.00	91.34	44.88	52.15	80.60	98.75	77.95	Partially Degraded
11-02	2005	65.72	91.34	44.84	74.28	71.66	98.32	74.36	Partially Degraded
11-14A	2005	31.22	78.67	38.56	71.93	80.23	93.10	65.62	Degraded
11-11A	2005	48.32	84.56	40.75	80.93	87.00	79.58	70.19	Partially Degraded
12-04	2005	57.72	91.34	25.99	31.61	54.93	57.01	53.10	Degraded
12-07	2005	31.22	58.94	43.65	50.22	90.30	93.10	61.24	Degraded
12-06	2005	54.78	58.94	59.27	62.06	79.51	80.63	65.86	Degraded
12-05	2005	77.16	84.56	53.49	66.04	80.07	72.46	72.30	Partially Degraded
12-03	2005	48.32	68.32	64.27	42.54	69.75	57.01	58.37	Degraded
12-01	2005	100.00	91.34	57.53	61.29	87.09	87.56	80.80	Partially Degraded
12-08	2005	77.16	84.56	38.92	61.41	74.95	74.16	68.53	Partially Degraded
12-09	2005	3.31	45.47	68.91	66.82	68.22	83.67	56.07	Degraded
12-02	2005	59.13	68.32	30.58	46.33	85.34	81.65	61.89	Degraded
12-10	2005	44.71	68.32	91.93	83.12	44.17	97.47	71.62	Partially Degraded

Round 2 habitat assessments were completed during spring 2009 (Lower North) and spring 2011 (Upper North). Results of the Round 2 assessments are presented in Table 17. The MPHI rated 50% of sites "Partially Degraded," 35% as "Degraded," 10% as "Minimally Degraded," and 5% as "Severely Degraded." Upper North River received a mean MPHI score of 70.0 ± 10.0 and a corresponding narrative rating of "Partially Degraded." Lower North River also received a "Partially Degraded" narrative rating, with a mean MPHI score of 66.3 ± 10.8.

Table 17. Physical Habitat Index Data from Round 2 (2009-2011).

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	#Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
R2-11-01	2011	64.62	99.94	94.97	97.04	74.36	80.63	85.26	Minimally Degraded
R2-11-03	2011	86.16	99.94	69.77	67.82	67.47	86.61	79.63	Partially Degraded
R2-11-05	2011	75.39	99.94	74.57	75.72	57.36	44.72	71.28	Partially Degraded
R2-11-06	2011	32.31	99.94	52.51	40.70	37.47	94.87	59.63	Degraded
R2-11-09	2011	86.16	99.94	48.02	40.80	64.65	44.72	64.05	Degraded
R2-11-11A	2011	80.78	54.42	90.33	84.20	75.16	77.46	77.06	Partially Degraded
R2-11-13A	2011	100.00	26.57	95.10	90.08	78.05	89.45	79.88	Partially Degraded
R2-11-16A	2011	32.31	91.34	52.05	41.59	59.83	74.16	58.55	Degraded
R2-11-17A	2011	100.00	21.22	71.63	71.10	46.33	94.87	67.52	Partially Degraded
R2-11-20A	2011	10.77	58.94	63.81	69.92	47.54	92.20	57.20	Degraded
R2-12-01	2009	64.62	36.34	16.62	39.08	47.51	83.67	47.97	Severely Degraded
R2-12-02	2009	37.70	100.00	44.62	61.24	80.67	74.16	66.40	Partially Degraded
R2-12-03	2009	21.54	100.00	42.32	96.47	85.56	77.46	70.56	Partially Degraded
R2-12-04	2009	48.47	100.00	56.02	86.66	100.00	63.25	75.73	Partially Degraded
R2-12-06	2009	16.16	100.00	36.12	69.71	99.15	89.45	68.43	Partially Degraded
R2-12-07	2009	70.01	36.34	100.00	100.00	100.00	94.87	83.54	Minimally Degraded
R2-12-08	2009	21.54	99.94	48.48	72.85	87.38	54.77	64.16	Degraded
R2-12-11A	2009	21.54	84.56	48.12	39.00	77.88	59.16	55.04	Degraded
R2-12-12A	2009	26.93	100.00	28.62	54.35	61.22	67.08	56.37	Degraded
R2-12-13A	2009	70.01	99.94	46.68	70.02	90.17	70.71	74.59	Partially Degraded

During Round 3, all habitat assessments were completed during the summer index period sampling visits. Results of the Round 3 habitat assessments are presented in Table 18. During Round 3, the MPHI rated 44% of sites “Partially Degraded,” 31% as “Degraded,” 13% as “Minimally Degraded,” and 13% were unrated. It should be noted that the two unrated stream sites were dry at the time of assessments; therefore, no physical habitat data was collected. The Lower North PSU received a “Partially Degraded” narrative rating, with a mean MPHI score of 69.19 ± 7.05. Upper North received a mean MPHI score of 70.04 ± 7.77 and a corresponding narrative rating of “Partially Degraded.”

Table 18. Physical Habitat Index Data from Round 3 (2017-2019).

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	#Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
11-L1M-03-17	2017	67.81	84.56	57.35	48.31	78.43	45.28	63.62	Degraded
11-L1M-04-17*	2017	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No PHI Rating
11-L2M-01-17	2017	55.23	99.94	68.76	59.08	86.94	65.58	72.59	Partially Degraded
11-L2M-02-17	2017	12.14	68.32	87.05	81.02	74.16	93.63	69.39	Partially Degraded
11-R3M-02-17	2017	80.86	68.32	71.23	62.96	76.44	84.86	74.11	Partially Degraded
11-R3M-03-17	2017	100	58.94	94.95	84.3	57.09	91.65	81.16	Minimally Degraded
11-R3M-07-17*	2017	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No PHI Rating
11-R3M-08-17	2017	31.22	88.49	54.57	39.99	67.15	74.84	59.38	Degraded
12-L1M-02-19	2019	69.95	99.94	51.96	45.02	84.55	92.74	74.02	Partially Degraded
12-L1M-03-19	2019	7.26	78.67	68.74	61	76.8	78.1	61.76	Degraded
12-L2M-01-19	2019	38.17	91.34	43.51	50	81.19	98.83	67.17	Partially Degraded
12-L2M-02-19	2019	68.17	99.94	35.2	42.5	93.38	61.65	66.81	Partially Degraded
12-R3M-01-19	2019	70.53	63.55	100	94	73.73	92.2	82.33	Minimally Degraded
12-R3M-03-19	2019	43.76	84.56	47.42	54.54	91.46	58.31	63.34	Degraded
12-R3M-05-19	2019	61.19	84.56	38.89	44.71	77.85	69.28	62.75	Degraded
12-R3M-07-19	2019	48.66	99.94	54.28	47.07	100	95.4	74.22	Partially Degraded

*Denotes sites that were dry during assessments

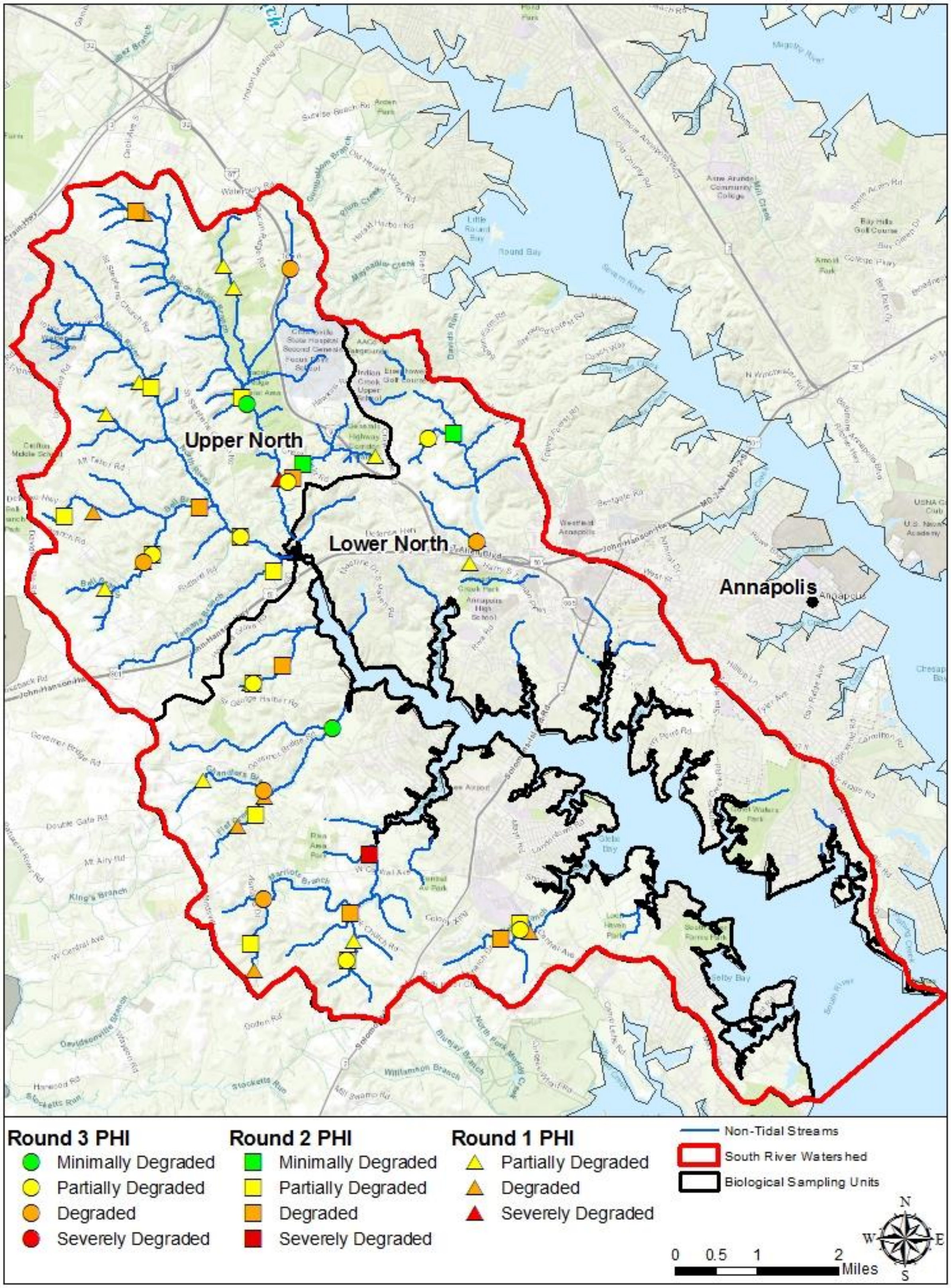

Figure 6: Physical Habitat Assessment Results (2005 - 2019).

7.1.4 Data Management

Data for the Countywide Biological monitoring program is currently stored in a number of databases, analyzed and reported annually. The County is working toward developing a more comprehensive geodatabase data management solution. The complete collection of annual reports are available to the public at aarivers.org.

7.1.5 Conclusions

At the completion of Round 2, analyses were performed to compare statistical differences between mean index values (i.e., BIBI, PHI) from Round 1 and Round 2 to determine if any changes in PSU scores were statistically significant. The report authors used the method recommended by Schenker and Gentleman (2001), which is the same method used by the MBSS to evaluate changes in condition over time and is considered a more robust test than the commonly used method, which examines the overlap between the associated confidence intervals around two means (Hill et. al, 2014). Despite a slight decrease in mean BIBI scores in the Upper North River from 3.34 in Round 1 to 2.74 in Round 2, the increase was not statistically significant using a 95% confidence interval. Similarly, there was no statistically significant change observed in the Lower North River between Rounds 1 and 2, given mean BIBI scores of 2.63 and 2.60, respectively. These results suggest there has not been a measurable change in the average BIBI condition across the entire South River watershed from 2005 through 2011.

In 2019, this analysis was performed again to compare statistical differences between mean BIBI values from Round 3 and prior rounds. In the Upper North River PSU, a slight decrease in mean BIBI scores occurred from Round 2 (2.74) to Round 3 (2.68); however, the decrease was not statistically significant using a 95% confidence interval. Conversely, a statistically significant decrease in BIBI scores was observed from Round 1 (3.34) compared to Round 3 (2.68). No statistically significant differences in BIBI scores were observed in the Lower North River PSU between rounds. These results suggest there has not been a measurable change in the average BIBI condition across the broader South River watershed from 2005 to 2019.

7.1.6 Future Monitoring

While no measurable change in biological conditions across the South River watershed in previous Rounds of biological monitoring (2005 to 2019) has been observed, there has been significant restoration efforts occurring recently in the watershed, with additional planned restoration for the future. Additional monitoring will be needed to measure the possible effects of restoration efforts on water quality and biological conditions of the watershed.

The County will begin Round 4 of their Countywide Biological Monitoring and Assessment Program in 2023. The program will be compliant with the 'Watershed Assessment Monitoring' requirement in the County's MS4 permit. Site selection will utilize Generalized Random Tessellation Stratified (GRTS) on Maryland DNR's MBSS version of the National Hydrography Dataset (NHD) 1:24,000 stream layer. In Round 4, eight sites will be sampled per PSU, per the Round 3 design power analysis. For each PSU all eight sites will be sampled in the same year.

The focus of the ongoing watershed biological assessment is to obtain additional data to determine watershed conditions for purposes of supporting further listing/de-listing decisions. MDE published the *Delisting Methodology for Biological Assessments in Maryland's Integrated Report* (MDE, 2021f) which outlines the monitoring and biocriteria requirements for a waterbody to be de-listed from the 303(d) list. In general, to consider a waterbody for delisting, that waterbody must have at least two sampling events with IBI scores of 3.0 or greater for both fish and benthos. The Countywide Program will provide data points that can be used to support listing/delisting decisions.

7.2 Targeted Biological Monitoring

In addition to the Countywide Program, the County conducts targeted biological monitoring. This monitoring utilizes the same methods and procedures as used in the Countywide Program, but the sites are not randomly selected. There are two general approaches to site selection in the targeted work. Some sites are on restored reaches that the County tracks to see how the stream benthic community changes over time in response to the restoration. The other group of sites, varying in number from year to year, is established on reaches planned for future restoration work. The intent is to create a baseline of biological conditions to justify project implementation by providing permitting agencies evidence that biological and habitat impairments exist within a reach of interest. The County also samples one site that is a minimally disturbed stream reach to use as a reference reach. As discussed in Section 7.1, the County is working toward storing data in a geodatabase.

A more detailed description of the Targeted Biomonitoring Program, including the latest published summary report can be found here:
https://www.aacounty.org/departments/public-works/wprp/targeted%20biomonitoring/index.html
and here:
https://www.aacounty.org/departments/public-works/wprp/ecological-assessment-and-evaluation/2016%20Targeted%20Site%20Summary%20Report_Final.pdf

A total of six targeted biological sites were sampled in 2022 in the South River watershed (Figure 7). Four sites (BR-01, BR-02, BR-03, and BR-04) are on Bacon Ridge Branch and are associated with a completed stream restoration project in Bacon Ridge Park. The other two sites (HH-01 and HH-02) are on Shepard's Cove Tributary are also monitoring post-restoration conditions. The monitoring will collect one year of pre-restoration data and one year of post-restoration data.

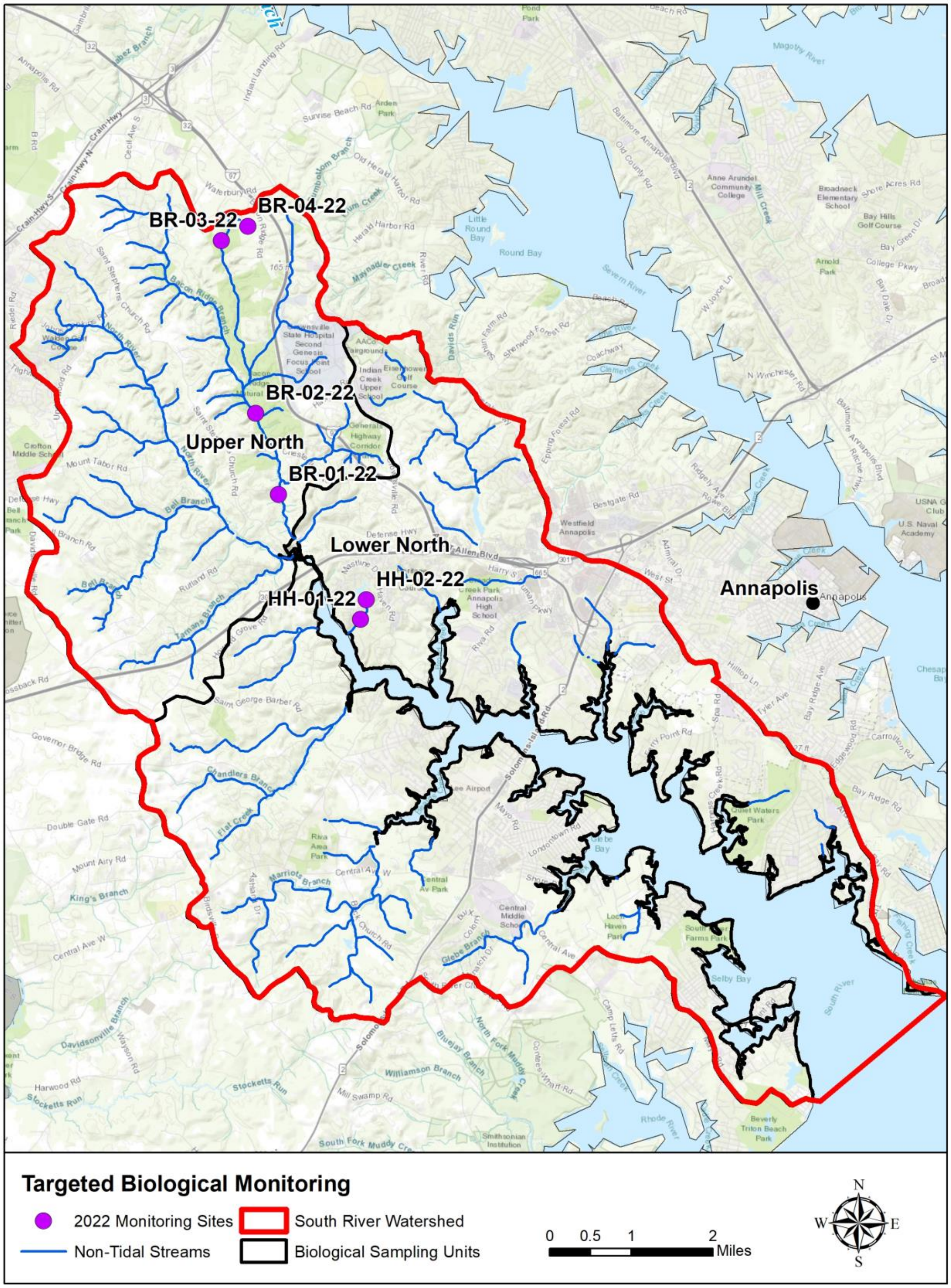

Figure 7: 2022 Targeted Biological Monitoring Sites in the South River Watershed

7.3 Watershed Assessments

In 2001, Anne Arundel County initiated a series of systematic and comprehensive watershed assessments and management plans for restoration and protection across the County. The plans were developed within the regulatory context that includes NPDES MS4 requirements, local TMDLs and Watershed Implementation Plans for the Chesapeake Bay TMDL, Maryland Stormwater Regulations and the Water Resources Element of the County's General Development Plan.

Biological monitoring is a component of the characterization and prioritization process within the management plans. The biological monitoring data is primarily utilized in the County's Watershed Management Tool (WMT), which was developed and is maintained by the BWPR. Within this program, sampling sites were selected using a targeted approach with the goal of having at least one, and sometimes two sites located within each subwatershed planning unit in order to examine the relationships between land use and ecological conditions downstream. Monitoring components include benthic macroinvertebrate community sampling, in situ water chemistry measurements, and instream and riparian physical habitat condition assessments. Waters quality grab sampling and detailed geomorphic assessment have been included for some watershed studies, but not as routine monitoring components.

The goals of the Watershed Assessment Program include:

- Characterize subwatersheds
- Prioritize subwatersheds for preservation and restoration; and
- Inform stressor-response relationships for planning and modeling.

The County continues to reevaluate its monitoring programs as the state of the science progresses, as the understanding of water quality and ecological interactions are improved, and as regulatory programs are added or modified.

8 Tracking Implementation of Management Measures

Anne Arundel County manages a comprehensive system for adding and tracking projects and accounting for new programs. New BMPs constructed through new development and redevelopment projects are entered into the County's BMP database and NPDES MS4 geodatabase as they come on-line. BWPR is responsible for implementing and tracking Water Quality Improvement Projects (WQIP; i.e., restoration and retrofit projects and programs). Additional internal County groups including Bureau of Highway Road Operation Division, which is responsible for maintenance efforts (i.e., street sweeping and inlet cleaning), report back to BWPR. The County is also capturing and tracking projects implemented by the AAWSA through the BWPR-Chesapeake Bay Trust Restoration Grant Program.

8.1 Annual NPDES MS4 Reporting

As a requirement of the NPDES permit described in Part V.A, on or before December 31 of each year, the County must submit a progress report demonstrating implementation of the NPDES stormwater program based on the fiscal year. If the County's MS4 Annual Report does not demonstrate compliance with their permit and show progress toward meeting SW-WLAs, the County must implement BMP and program modifications within 12 months. The MS4 Annual Report includes the following (items in bold font directly relate to elements of the load reduction evaluation criteria):

a. The status of implementing the components of the stormwater management program that are established as permit conditions including:
    i. Permit Administration,
    ii. Legal Authority,
    iii. Source Identification,
    iv. Stormwater Management,
    v. Erosion and Sediment Control,
    vi. Illicit Discharge Detection and Elimination,
    vii. Property Management and Maintenance,
    viii. Public Education,
    ix. Stormwater Restoration,
    x. Countywide Stormwater TMDL Implementation Plan,
    xi. Assessment of Controls, and
    xii. Program Funding.

b. **A narrative summary describing the results and analyses of data, including monitoring data that is accumulated throughout the reporting year.**

c. Expenditures for the reporting period and the proposed budget for the upcoming year.

d. A summary describing the number and nature of enforcement actions, inspections and public education programs.

e. **The identification of water quality improvements and documentation of attainment and/or progress toward attainment of benchmarks and applicable WLAs developed under EPA approved TMDLs; and,**

f. **The identification of any proposed changes to the County's program when WLAs are not being met.**

All annual reporting is required to be made using MDE's MS4 Geodatabase format. Elements of the database, following MDE's current schema (Version 1.2 Draft Updates, November 2021), include feature classes and associated tables that store and report the County's restoration projects to MDE. MDE and the CBP use the data for larger scale Chesapeake Bay modeling and TMDL compliance tracking. The relevant database features include:

- AltBMPLine - stream restoration, shoreline restoration, outfalls
- AltBMPPoint – septic system practices (pump-out, upgrades, connections)
- AltBMPPoly – tree planting, street sweeping, inlet cleaning, impervious removal
- RestBMP – stormwater BMPs (SPSC, bioretention, wet ponds etc.)

8.2 TMDL Annual Progress Assessment Reporting

Anne Arundel County produces a Countywide TMDL Stormwater Implementation Plan to assess and report progress for each County TMDL that has a completed and final implementation plan in place. The reports include implementation and load reduction summaries for the projects and programs completed in the current reporting year, and also for the full restoration period from the baseline through the current reporting year. Comparisons are made to the planned implementation targets to determine if the County is on track. Costs of program implementation are reported. For sediment TMDLs, a section is dedicated to reporting County water quality and biomonitoring results from the Countywide Biomonitoring Program and from any relevant targeted restoration monitoring sites. The Countywide TMDL Stormwater Implementation Plan is submitted to MDE with the County's MS4 Annual Report.

8.3 Financial Assurance Plan Reporting

The County's FAP outlines the County's financial ability to meet its local and Chesapeake Bay TMDL obligations and is another mechanism of reporting to MDE. The FAP demonstrates the County's ability to fund projects that will reduce pollutants of concern and make measurable progress towards improving water quality. Anne Arundel County's first FAP was submitted to MDE in July of 2016, and submitted an updated version was adopted by the County Council on October 3, 2022 (Resolution #37-22) and will be submitted as an appendix to the County's FY2022 Annual NPDES MS4 Report. A copy of the 2022 Financial Assurance Plan can be found at: https://www.aacounty.org/departments/public-works/wprp/financial-assurance-plan/index.html.

9 TMDL Collaboration

Anne Arundel County and MDOT SHA have historically maintained a good working relationship on water quality issues. In October 2021, the County and MDOT SHA met to discuss the progress made toward achieving their assigned SW-WLAs. Based on modeling at that time, MDOT SHA had met in excess its required sediment reduction for the South River and was willing to discuss allocating some of their overage to assist Anne Arundel in meeting its SW-WLA. Subsequent to that meeting, MDE finalized the TIPP modeling tool and as documented in this plan, the County has achieved its SW-WLA for the South River.

Attainment of a SW-WLA is not the ultimate goal for achieving TMDL targets. TMDLs must be maintained once achieved. The County will continue its collaboration with MDOT SHA into the future to ensure that the sediment TMDL for the South River Watershed is maintained. This will be achieved through collaboration on future restoration project planning and implementation, not only with MDOT SHA but with The Arundel Rivers Federation, an NGO that designs, constructs, inspects and maintains restoration projects throughout the watershed.

10 Conclusion

This South River TMDL Attainment report documents the progress achieved through the end of FY2022, resulting in attainment of the sediment TMDL SW-WLA goal for the watershed. The report outlines the project and program implementation completed through FY2022, planned implementation, and the associated modeled pollutant load and load reductions achieved that result in attainment of the TMDL SW-WLA goal.

Anne Arundel County has spent $22,201,829 in capital and operational costs in the South River Watershed since the baseline year of the TMDL (2009) and plans to spend an additional $21,331,625 on restoration efforts. With those funds, the County is completing restoration projects and implementing programmatic practices including inlet cleaning and street sweeping. Modeled load reductions through the end of FY2022 are 32.1% reduction from baseline loads on a total goal of 28.0% reduction, resulting in attainment of the SW-WLA goals. The additional planned projects will result in a percent reduction of 65.7%, far exceeding the TMDL goals. The County recognizes that inspection and maintenance of these installed BMPs will be a critical part of maintaining attainment and has a robust Inspection and Enforcement program to achieve that.

Biological stream monitoring data thus far with three rounds completed indicates a watershed that is in fair to poor biological health. While decreases in mean BIBI scores between Round 1 and Round 3 were statistically significant in the Upper North PSU, no significant differences in BIBI scores occurred in the Lower North PSU. This suggests there has not been a measurable change in the average BIBI condition across the broader South River watershed from 2005 to 2019. However, significant restoration efforts have occurred recently in the watershed, with additional planned restoration for the future. Additional monitoring will be needed to measure the possible effects of restoration efforts on water quality and biological conditions of the watershed. The County plans to begin Round 4 sampling in 2023.

This attainment plan documents achievement of the SW-WLA via implemented practices and modeling exercises, however the County recognizes that achievement of water quality criteria and delisting of waterbodies meeting the water quality criteria is the ultimate goal. Following MDE's guidance for delisting, the County will continue to monitor biological resources in the South River watershed to identify streams that have the potential for delisting. In the near term, the County will continue to inspect and maintain stormwater BMPs and restoration BMPS to ensure optimum functioning while continuing to identify opportunities for additional sediment reduction and habitat improvement. Opportunities will be identified in collaboration with MDOT SHA and the Arundel Rivers Federation, an NGO working on restoration in the watershed.

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