

Patapsco Lower North Branch Watershed

2020 Sediment TMDL Annual Assessment Report

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Prepared For

Anne Arundel County
Bureau of Watershed Protection and Restoration
Department of Public Works
2662 Riva Road, MS 7301
Annapolis, Maryland 21401



Prepared By

KCI Technologies, Inc.
936 Ridgebrook Road
Sparks, MD 21152



Table of Contents

1	Introduction	1
1.1	Background	1
1.2	Watershed Description	1
1.3	TMDL Allocation and Planned Loads Summary	3
1.4	Planned Reductions	4
1.5	Modeling Methods.....	5
1.5.1	Overview	5
1.5.2	Stream Bed and Bank Disaggregation.....	6
1.5.3	Practice Level	6
2	2020 Progress Summary.....	11
2.1	Implementation Results.....	11
2.2	Load Reduction Results.....	14
3	Comparison of 2020 Progress and Planned Implementation	14
3.1	Implementation	14
3.2	Load Reductions.....	16
4	Monitoring.....	18
4.1	Countywide Biological Monitoring.....	19
4.1.1	Background and Goals	19
4.1.2	Methods.....	20
4.1.3	Results.....	21
4.1.1	Conclusions	29
4.2	Targeted Restoration Monitoring Program	29
5	Conclusion	32
6	References.....	33

List of Tables

Table 1:	Sediment Loads Required for the Patapsco LNB Local TMDL	4
Table 2:	Patapsco LNB Local TMDL Allocated and Planned Loads.....	4
Table 3:	Typical Sediment Reduction from Stormwater BMPs and Restoration Practices	8
Table 4:	Baseline BMP Implementation.....	11
Table 5:	Current BMP Implementation through FY2020	13
Table 6:	FY2020 Progress Reductions Achieved	14
Table 7:	Restoration BMP Implementation - Current FY2020 and Planned FY2024 Implementation Levels	15
Table 8:	Implementation Milestones Comparison	16
Table 9:	Planning and Target Sediment Load Comparison (lbs/year).....	17
Table 10:	Countywide Biological Monitoring Results	21
Table 11:	BIBI Data for Round 1 (2004-2008)	22
Table 12:	BIBI Data for Round 2 (2009-2013)	23
Table 13:	BIBI Data for Round 3 (2018-2020)	24
Table 14:	Physical Habitat Index Data from Round 1 (2004-2008).....	26
Table 15:	Physical Habitat Index Data from Round 2 (2009-2013).....	27
Table 16:	Physical Habitat Index Data from Round 3 (2018-2020).....	28

List of Figures

Figure 1: Watershed Location Map.....	2
Figure 2: Street Sweeping Routes in the Patapsco LNB Watershed, Anne Arundel County, Maryland	10
Figure 3: Biological Sampling Results from 2004 – 2020.	25
Figure 4: Physical Habitat Assessment Results from 2004 – 2020.	31

List of Acronyms

BayFAST	Chesapeake Bay Facility Assessment Scenario Tool
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
COMAR	Code of Maryland Regulations
DPW	Department of Public Works
EOS	Edge of Stream
EOT	Edge of Tide
EPA	United States Environmental Protection Agency
FIBI	Fish Indices of Biotic Integrity
FY	Fiscal Year
IWPP	Integrated Water Planning Program
LA	Load Allocation
LNB	Lower North Branch
MAST	Maryland Assessment Scenario Tool
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
MPHI	Maryland Physical Habitat Index
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometer Turbidity Units
PSU	Primary Sampling Unit
RBP	Rapid Bioassessment Protocol
SPSC	Step Pool Storm Conveyance
STB	Stream Bed and Bank
SW-WLA	Stormwater Waste Load Allocation
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
WLA	Wasteload Allocation
WM	Watershed Model
WQIP	Water Quality Improvement Projects

1 Introduction

1.1 Background

The Anne Arundel County Department of Public Works (DPW) Bureau of Watershed Protection and Restoration (BWPR) has developed and is currently implementing restoration 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) (MDE, 2011). 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.

There are currently two final approved TMDLs within the Patapsco River Lower North Branch (Patapsco LNB); a bacteria TMDL approved in 2009; and a total suspended solids (TSS; sediment) TMDL approved in 2011. These TMDLs apply to several jurisdictions including Baltimore City and Baltimore, Carroll, Howard, and Anne Arundel Counties, as well as Maryland Department of Transportation State Highway Administration. Anne Arundel County BWPR developed a TMDL restoration plan for the sediment TMDL, drafted in 2015 and finalized in November of 2016 (Anne Arundel County, 2016) after review from MDE and the general public. The plan specifically addresses the Patapsco LNB sediment TMDL under the responsibility of Anne Arundel County. The bacteria TMDL is addressed by Anne Arundel County in a separate plan.

Responsibility for Patapsco LNB sediment reduction is divided among the contributing jurisdictions, listed above. The TMDL loading targets, or allocations, are divided among the pollution source categories, which 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.

Anne Arundel County's current MS4 permit (11-DP-3316, MD0068306) issued by MDE in February of 2014 requires the development of restoration plans for each SW-WLA approved by EPA prior to the effective date of the permit (permit section IV.E.2.b), and requires an annual TMDL assessment report to document implementation progress, pollutant load reductions, and program costs (permit section IV.E.4). The *Patapsco River Lower North Branch Sediment TMDL Restoration Plan* (the plan) (Anne Arundel County, 2016) satisfied the permit planning requirement and this *2020 Patapsco River Lower North Branch Sediment TMDL Annual Assessment Report* satisfies the progress documentation requirement for fiscal year (FY) 2020.

1.2 Watershed Description

The Patapsco LNB is one of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the northwestern portion of the County (Figure 1 **Figure 1**). The watershed shares political boundaries with Howard County along Deep Run and Baltimore County along the mainstem of the Patapsco River. The downstream extent of the watershed borders Baltimore City. The Patapsco LNB watershed is a part of the Chesapeake Bay watershed with the Patapsco River mainstem discharging to the tidal portions of the Patapsco River in Baltimore City before entering the Chesapeake Bay.

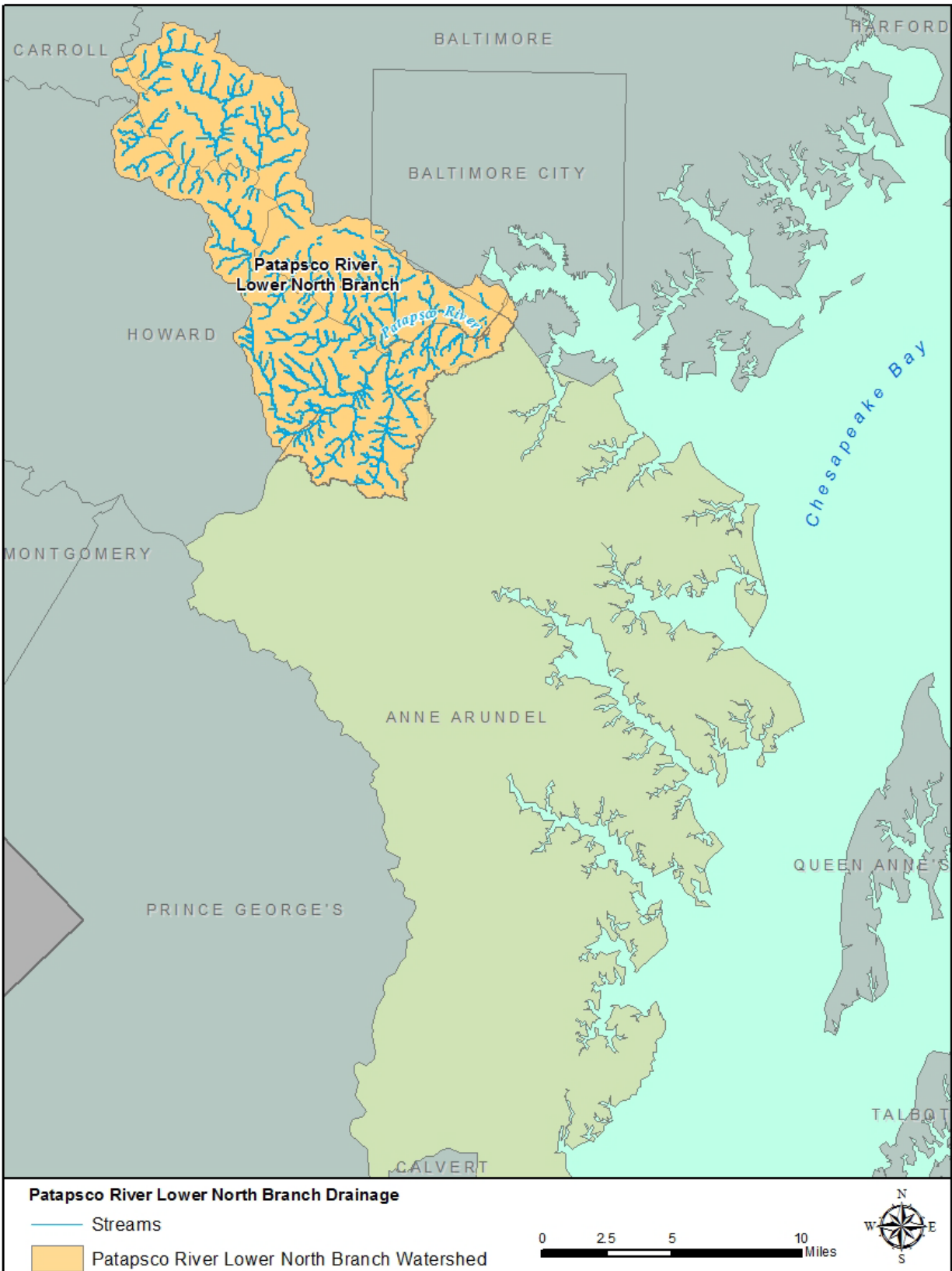


Figure 1: Watershed Location Map

Anne Arundel County's portion of the Patapsco LNB watershed is approximately 15,270 acres (23.9 square miles) in area and contains approximately 96 miles of streams. The watershed includes several named streams including Stoney Run, Piney Run, Deep Run, Holly Creek, and the mainstem of the Patapsco River. Communities within the Patapsco LNB include Linthicum Heights, Hanover, and Severn.

1.3 TMDL Allocation and Planned Loads Summary

This section describes the derivation of the TMDL reduction targets. The SW-WLA in the sediment TMDL was developed by MDE using the Chesapeake Bay Program Watershed Model Phase 5 (CBP WM P5). Baseline, progress, and planned loads were modeled in development of the Patapsco LNB Plan in 2015-2016, using BayFAST (Chesapeake Bay Facility Assessment Scenario Tool) CBP WM P5.3.2. BayFAST was also used for progress modeling in the annual assessment report for fiscal year (FY) 2017. BayFAST function ended in early 2018 and was not available for progress modeling for the FY2018 annual assessment; therefore, FY2018 progress was modeled using MAST (Maryland Assessment Scenario Tool), which was compatible with BayFAST and built on Bay Model version P5.3.2. However, MAST availability ended in early 2019.

MDE is currently working on a new local TMDL modeling tool that will be available in the future to report progress toward nutrient and sediment load reductions. If completed and available, this new spreadsheet model will be used for FY2021 modeling, likely resulting in changes to the baseline, permit, and progress loads and load reductions in this report.

Since development of the final plan in late 2016, Phase 6 of the Bay Model has been developed and is currently being deployed in the Chesapeake Assessment Scenario Tool (CAST). Given that BayFAST and MAST were no longer available to report progress toward local TMDLs in FY2019, and MDE was currently developing a new system compatible with Phase 6 of the Bay Model, MDE Integrated Water Planning Program (IWPP) recommended not creating a temporary system for reporting load reduction progress for FY2019 annual assessments. Therefore, local TMDL progress modeling was suspended for one year until MDE, in conjunction with the MS4 counties, developed a methodology to address sediment disaggregation issues observed in the stream bed and bank (STB) load source in CAST (Chesapeake Assessment Scenario Tool) CBP WM P6. FY2020 progress marks the first year Anne Arundel County has used CAST for modeling Patapsco LNB loads. The STB TSS disaggregation methodology is used in FY2020 modeling and is described in section 1.5.2. below.

CAST, created by the Chesapeake Bay Program, is a web-based pollutant estimation tool that calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Phase 6 Model (CBP WM P6). Section 1.5 contains details on the modeling specifics. Because the TMDL was developed under an older version of the model, the SW-WLA needed to be translated into a CAST-compatible target load. In order to do this, the 2005 baseline sediment load was re-calculated in CAST by modeling baseline BMPs in Patapsco LNB on top of baseline impervious and pervious Anne Arundel County Phase I MS4 acres.

The required percent reduction assigned to the Anne Arundel County Phase I MS4 source (22.2%) in the local TMDL was then 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 CAST-compatible target SW-WLA. Sediment loads required for the Patapsco LNB Anne Arundel County Phase I MS4 source are shown in Table 1. The loads modeled under P5.3.2 were reported in the plan and FY2017

– FY2018 annual assessment reports and are included in Table 1 for reference. The loads modeled under P6 are used in this year’s annual assessment.

Table 1: Sediment Loads Required for the Patapsco LNB Local TMDL

Model	2005 Baseline Load (lbs/yr)	Required Reduction %	Required Reductions (lbs/yr)	TMDL Load Allocation (SW-WLA) (lbs/yr)
P5.3.2	1,422,388	22.2%	315,770	1,106,618
P6	11,527,942	22.2%	2,559,203	8,968,739

1.4 Planned Reductions

Table 2, provides a concise summary of the loads and reductions at important timeline intervals including the 2005 baseline, 2020 progress, and 2025 final planning intervals. These terms and dates are used throughout the plan and explained in more detail in the following sections. They are presented here to assist the reader in understanding the definition of each, how they were derived, and to provide an overall summary demonstrating the percent reduction required and percent reduction achieved through full implementation of this plan. Sediment loads and wasteload allocations are presented as tons/year in the *Total Maximum Daily Load of Sediment in the Patapsco River Lower North Branch Watershed, Baltimore City and Baltimore, Howard, Carroll and Anne Arundel Counties, Maryland* but will be discussed as lbs/year in this report.

- **2005 Baseline Load:** Baseline level (i.e., land use loads with baseline best management practices [BMPs]) from 2005 conditions in the Patapsco LNB watershed. Baseline load was used to calculate the stormwater allocated sediment loads, or SW-WLA.
- **2020 Progress Load and Reduction:** Progress load and load reduction achieved from stormwater BMP implementation through 2020.
- **2025 Allocated Load:** Allocated load is calculated from the 2005 baseline level, calibrated to CBP P6 as noted above, using the following calculation: 2025 Allocated Load = 2005 Baseline Load – (2005 Baseline Load x 0.222).
- **2025 Planned Load and Planned Reduction:** Load and reduction that will result from implementation of planned BMPs.

Table 2: Patapsco LNB Local TMDL Allocated and Planned Loads

	Sediment (tons/year)	Sediment (lbs/year)
2005 Baseline Load	5,764	11,527,942
2020 Progress Load	5,545	11,090,717
2020 Progress Reduction	219	437,225
2025 TMDL Allocated Load	4,484	8,968,739
2025 Planned Load*	5,040	10,079,080
2025 Planned Reduction	724	1,448,861
Required Percent Reduction	22.2%	22.2%
Planned Percent Reduction	12.6%	12.6%

*It is assumed that stormwater runoff from new development will be treated to the maximum extent practicable to achieve 90% sediment removal and Accounting for Growth policies will address the remaining 10%.

1.5 Modeling Methods

1.5.1 Overview

The baseline, progress, and planned pollutant loads for the Patapsco LNB watershed were determined using CAST, which is a web-based pollutant load estimation tool that calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model Phase 6 (CBP WM P6). Local TMDL baseline loads were calibrated in CAST by modeling BMPs installed prior to the TMDL baseline year using a 2005 CAST Progress Scenario on top of baseline land use background loads. This ensures that the same set of baseline BMPs are used throughout future progress and planned scenarios. The required sediment load reduction was calculated by multiplying the local TMDL target reduction percent with the CAST baseline load. This reduction target was then subtracted from the baseline load modeled in CAST to determine the target sediment load (i.e., local SW-WLA).

Modeling conducted in previous years had used BayFAST and MAST, which were both web-based pollutant load estimation tools. The BayFAST model was shut down in early 2018 and MAST became unavailable in early 2019. CAST replaces both BayFAST and MAST and is also a web-based tool that allows users to select a geographic area and apply BMPs to the area to estimate nitrogen, phosphorus, and sediment loads and load reductions.

BayFAST, MAST, and CAST both estimate load reductions for point and nonpoint sources including agriculture, urban, forest, and septic loading. Load reductions are not tied to any single BMP, but rather to a suite of BMPs working in concert to treat the loads. The Chesapeake Bay Program Partnership Watershed Model calculates reductions from all BMPs as a group, much like a treatment train. Reductions are processed in order, with land use change BMPs first, load reduction BMPs next, and BMPs with individual effectiveness values last. The overall the load reduction can vary depending on which BMPs are implemented.

CAST provides analysis and load output at two different scales: Edge-of-Stream (EOS) and Edge-of-Tide (EOT). Edge-of-tide loads incorporate in-stream processes, such as nutrient uptake by algae or other aquatic life and generally result in lower delivered loads from the upstream source to the receiving water body, which in this case is the Chesapeake Bay. The EOT scale is used in Bay TMDL modeling. This TMDL is for impairments in the freshwater tributary streams; therefore, the County's plan focuses on reducing loads delivered from upland and instream tributary sources. As a result, EOS estimates are more appropriate and are used for the modeling analysis.

Pollutant load reductions achieved by stream restoration and annual practices (e.g., street sweeping and inlet cleaning) were calculated outside of CAST following MDE's 2020 accounting guidance (MDE, 2020) and Bay Program methods. Stream restoration projects were credited using project specific load reductions calculated using the Bay Program's Protocol method, when available. Planned stream restoration load reductions were modeled using 248 lbs TSS per linear foot. Sediment reduction credit for vacuum-assisted street sweeping were calculated based on a sweeping frequency of 1 pass every two weeks and the annual number of miles swept averaged over the span of the 5-year permit term. Sediment reductions for inlet cleaning were calculated based on the annual aggregate load collected (assumed sediment was 40% organic and 60% inorganic material) and averaged over the span of the 5-year permit term.

1.5.2 Stream Bed and Bank Disaggregation

The Phase 6 Chesapeake Bay Program Model provides a separate load source for stream bed and bank loads, while the P5.3.2 model included these stream loads implicitly in the upland load sources. The stream bed and bank load includes stream loads from streams located in agriculture, natural, MS4, and non-regulated developed land areas, and therefore was disaggregated for a single source sector to determine the stream load attributed to the County's stormwater sector that should be included under the SW-WLA for this TMDL.

The stream bed and bank load was disaggregated using calculations provided by the Chesapeake Bay Program using the same principals used by CAST to calculate the total stream bed and bank load. The calculation for TSS disaggregation is as follows:

$$\text{TSS STB load} = ((\text{Scenario EOS without STB TSS} / \text{CAL EOS without STB TSS}) * \text{STB base TSS}) + (4/3 * \text{Scenario Impervious TSS})$$

Where:

EOS = edge-of-stream

STB = stream bed and bank load source

TSS = total sediment

CAL = calibration average

This equation is used to calculate the stream bed and bank load for a given scenario outside of CAST. Load reductions associated with stream restoration practices are applied directly to the stream bed and bank loads in CAST. As a result, stream restoration practices are modeled in a spreadsheet outside of CAST and the calculated load reductions are subtracted from the disaggregated stream bed and bank load to determine the total disaggregated stream bed and bank load for a given scenario (i.e. baseline, progress, planned).

1.5.3 Practice Level

This section briefly describes each practice and includes a summary of the typical sediment reductions achieved with each type.

1.5.3.1 Modeled in CAST

- **Bioretention** — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. Rain gardens may be engineered to perform as a bioretention.
- **Bioswales** — An open channel conveyance that functions similarly to bioretention. Unlike other open channel designs, there is additional treatment through filter media and infiltration into the soil.
- **Dry Detention Ponds** – Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow. CAST modeling includes hydrodynamic structures in this category. These devices are designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles,

micropools, and absorbent pads to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.

- **Dry Extended Detention Ponds** - Depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. They are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, allowing additional wet sedimentation to improve treatment effectiveness.
- **Impervious Surface Reduction** - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Disconnection of rooftop and non-rooftop runoff, rainwater harvesting (e.g., rain barrels), and sheetflow to conservation areas are examples of impervious surface reduction.
- **Infiltration** — A depression or trench to form a shallow basin where sediment is trapped and stormwater infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil; they are not constructed on poor soils, such as C and D soil types. Yearly inspections to determine if the basin or trench is still infiltrating runoff are planned. Dry wells, infiltration basins, infiltration trenches, and landscaped infiltration are all examples of this practice type.
- **Outfall Enhancement with Step Pool Storm Conveyance (SPSC)** – The SPSC is designed to stabilize outfalls and provide water quality treatment through pool, subsurface flow, and vegetative uptake. All County SPSCs are completed at the end of outfalls, prior to discharging to a perennial stream. The retrofits promote infiltration and reduce stormwater velocities. This strategy is modeled in CAST as filtering practices. Some SPSC sites qualified for Protocol 5 load reductions. Protocol 5 load reductions were added to modeling results outside of CAST when applicable.
- **Stormwater Retrofits** – Stormwater retrofits may include converting dry ponds, dry extended detention ponds, or wet extended detention ponds into wet pond structures, wetlands, infiltration basins, or decommissioning the pond entirely to install SPSC (step pool storm conveyance). Stormwater retrofits were modeled in CAST by calculating the net treatment (retrofit BMP vs. original BMP) for retrofit BMPs of the same CAST BMP type category (e.g., wet pond) within the same land river segment. If a net calculation was not required (i.e., original CAST BMP type category was different than the retrofit CAST BMP type category), the original BMP treatment was removed from the baseline BMPs carried over into progress and planned scenarios and replaced with treatment from the more effective retrofit BMP. This procedure prevents over counting stormwater BMP treatment.
- **Urban Filtering** - Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.
- **Urban Tree Plantings** - Urban tree planting is planting trees on urban pervious areas at a density that would produce a forest-like condition over time. The intent of the planting is to convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting
- **Vegetated Open Channels** - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.

- **Wet ponds or wetlands** — A water impoundment structure that intercepts stormwater runoff then releases it at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached pollutants. Until 2002 in Maryland, these practices were generally designed to meet water quantity, not water quality objectives. There is little or no vegetation within the pooled area, nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal, but phosphorus and sediment are reduced.

The effectiveness for each of these practices are found in Table 3.

Table 3: Typical Sediment Reduction from Stormwater BMPs and Restoration Practices

BMP	Sediment Reduction
Bioretention A/B soils	80%
Bioretention C/D soils	55%
Bioswales	80%
Dry Detention Ponds	10%
Dry Extended Detention Ponds	60%
Impervious Surface Reduction ¹	-
Infiltration	95%
Outfall Enhancement with SPSC ²	80%
Stream Restoration ³	248 lbs/linear ft
Urban Filtering	80%
Urban Tree Plantings ¹	-
Vegetated Open Channels	70%
Wet Ponds or Wetlands	60%
Inlet Cleaning - Organic	400 lbs/ton removed
Inlet Cleaning - Inorganic	1,400 lbs/ton removed
Street Sweeping – 1 pass/2 weeks	11%

Sources: MDE, 2020 and CAST documentation

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

² Outfall enhancement with SPSC modeled as filtering practices in CAST

³ Stream restoration listed with revised interim rate, now termed the ‘planning rate’; some stream restoration projects used Bay Program Protocols to calculate load reductions.

1.5.3.2 Modeled using MDE Guidance

Inlet cleaning, street sweeping, and urban stream restoration load reductions are modeled outside of CAST using MDE’s 2020 accounting guidance and Bay Program methods. The methods are compatible with Phase 6 of the Bay Model.

- **Inlet Cleaning** - Storm drain cleanout practice ranks among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with NPDES stormwater permits. Reduction credit is based on the mass of material collected, at the rate of 400 lbs TSS per ton of organic material and 1,400 lbs TSS per ton of inorganic material (MDE, 2020). Data for the mass removed was reported by the County’s Bureau of Highways. The total mass of material collected by the inlet cleaning program each year is distributed proportionately across all of the inlets cleaned and then summed at the watershed

scale. The County's inlet cleaning program is now at maturity and while amounts of material collected each year may vary, the current level of effort will be maintained in the foreseeable future.

- **Street sweeping** — Starting Fiscal Year 2015, Anne Arundel County enhanced their street sweeping program (Anne Arundel County DPW, 2015; Figure 2). This enhanced program targets impaired watersheds and curbed streets that contribute trash/litter, sediment, nutrients, and other pollutants. Load reductions for this assessment are calculated using the length/area of street swept and 11% reduction efficiency for TSS for street swept every two weeks using vacuum sweepers (MDE, 2020). Data for the curb miles swept and frequency (1 pass/2 weeks) was reported by the County's Bureau of Highways. The County's street sweeping program is now at maturity and while amounts of material collected each year may vary, the current level of effort will be maintained in the foreseeable future.
- **Urban 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. These projects were modeled outside of CAST using load reductions at the rate of 248 lbs TSS per linear foot (MDE, 2020) for older projects that pre-dated full adoption of the Bay Program's protocol methods, and for future projects where a planning rate is appropriate for use before the full design is complete and protocol calculations are developed. Project specific load reductions calculated using the Bay Program's Protocol method were used when available.

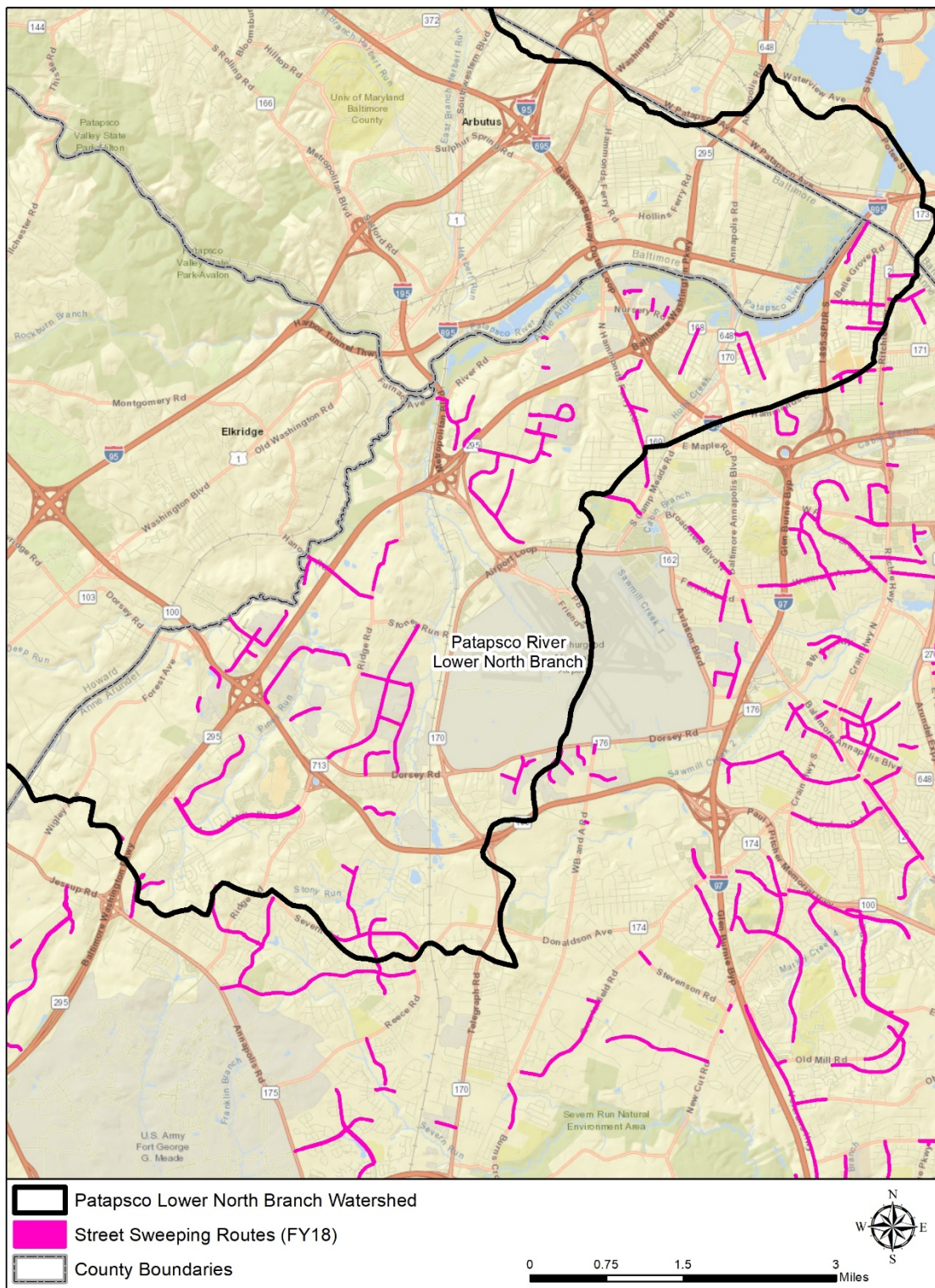


Figure 2: Street Sweeping Routes in the Patapsco LNB Watershed, Anne Arundel County, Maryland

2 2020 Progress Summary

The following section summarizes the County's implementation efforts, the resulting load reductions achieved, and the costs of program implementation.

2.1 Implementation Results

Project implementation information extracted from CAST for the 2005 Progress Scenario used to develop baseline loads is presented in Table 4. Implementation up through the end of FY2020 is detailed in Table 5. Information on completed projects and programs is gleaned primarily from the County's MS4 geodatabase. All 2020 implementation is included in the database. In 2018 the County completed a comprehensive record review of stormwater BMPs. The County's MS4 Geodatabase has been updated to incorporate the results of the review.

Dry Pond Conversions

Two dry pond conversions were completed in the watershed in FY2020. One project converted the dry pond to an infiltration basin (Groveland Road Pond Retrofit) and the other converted to a shallow marsh (Fairbanks Drive Retrofit)

Inlet Cleaning

A total of 12 inlet cleaning records using storm drain vacuuming were recorded in FY2020. A total of 2.53 tons of material was collected during that period.

Street Sweeping

Building upon on the County's enhanced street sweeping program, 27.7 curb miles were swept in the watershed during FY2020. The total mass of material collected by the street sweeping program during the same time was 61.5 tons. Total mass reported for FY2020 is the average of annual mass removed for FY2016 through FY2020. It is noted that while average mass of material collected is presented here and in the following tables to demonstrate implementation levels, load reduction calculations are based on curb miles swept and frequency.

The total cost of County implemented practices and programs implemented in FY2020 is \$793,510.

Table 4: Baseline BMP Implementation

BMP	Unit	2005 Baseline
Structural Permanent Practices		
Runoff Reduction Performance Standard	acre	121.66
Stormwater Treatment Performance Standard	acre	680.63
Bioretention	acre	2.29
Bioswale	acre	4.51
Dry Ponds	acre	465.26
Extended Detention Dry Ponds	acre	769.46
Impervious Surface Reduction	acre	13.00
Infiltration Practices	acre	511.41

BMP	Unit	2005 Baseline
Filtering Practices	acre	8.78
Permeable Pavement	acre	1.62
Wet Ponds or Wetlands	acre	768.08
Annual Practices		
Inlet Cleaning	inlets/yr	0.0
Street Sweeping	lbs /yr	0.0

Table 5: Current BMP Implementation through FY2020

BMP	Unit	CY2006 - FY2019 Restoration ²	FY2020 Restoration ²	FY2020 Progress ³	FY2020 Restoration Cost ⁴
Structural Permanent Practices					
Bioretention	acre	0.03	0	0.03	
Bioswale	acre	0.55	0	0.55	
Dry Ponds	acre	0	0	0	
Extended Detention Dry Ponds	acre	0	0	0	
Impervious Surface Reduction	acre	0	0	0	
Infiltration	acre	21.45	0	21.45	
Permeable Pavement	acre	5.78	0	5.78	
Stormwater Retrofits ¹	acre	0	26.29	26.29	\$733,797
Vegetated Open Channels	acre	0	0	0	
Wet Ponds or Wetlands	acre	407.82	0	407.82	
Urban Stream Restoration	linear ft	250	0	250	
Outfall Enhancement with SPSC	acre	0	0	0	
Annual Practices					
Inlet Cleaning ⁵	inlets/yr	NA	12	12	\$5,922
Street Sweeping ⁶	lbs /yr	NA	123,035	123,035	\$53,791
Total FY2020 Cost					\$793,510

Source: BWPR urban BMP, WQIP and MDE MS4 FY2020 geodatabase

¹ Includes projects that convert dry ponds into wet ponds. Stormwater retrofits are modeled by decreasing acreage for dry ponds and increasing acreage for wet ponds.

² Restoration completed in each specific period, i.e. CY2006-FY2019 and FY2020.

³ Total cumulative restoration accounting for the full CY2006-FY2020 period.

⁴ Cost of projects and programs for the FY2020 period only. Only costs using County funds are included.

⁵ Number of inlets refers to the number of inlet cleaning records from the County's MS4 geodatabase.

⁶ Value listed here is the lbs of material removed, not specifically the fine TSS sediment; FY2020 is the average of annual reported values for FY2016 through FY2020.

2.2 Load Reduction Results

The implementation summarized in Table 5 above resulted in the load reductions presented here in Table 6. Through FY2020, the County has achieved a 3.8% reduction in TSS with a goal of 22.2% reduction.

Table 6: FY2020 Progress Reductions Achieved

Baseline Load and TMDL SW-WLA	TSS-EOS lbs/yr
2005 Baseline Scenario Load	11,527,942
Required Percent Reduction	22.2%
Required Reduction	2,559,203
Local TMDL SW-WLA	8,968,739
2020 Results	TSS-EOS lbs/yr
Progress Scenario Load	11,090,717
Progress Reduction Achieved	437,225
Percent Reduction Achieved	3.8%

3 Comparison of 2020 Progress and Planned Implementation

This section describes the current progress of both implementation and load reductions in comparison to the planned totals and the progress that was expected by FY2020.

3.1 Implementation

Table 7 compares implementation of completed restoration BMPs through FY2020 (FY2020 Progress) with the total planned levels of implementation that were derived in the initial plan (Anne Arundel County, 2016) as well as with the planned restoration BMPs through FY2024 based on the County's MS4 geodatabase. Progress has been made towards several of the strategies (e.g. stormwater retrofits, wet ponds/wetlands) and street sweeping is continuing at a level very close to the initially prescribed rate.

Implementation of two wet pond/wetland retrofits were completed by the end of FY2020. Implementation of stream restoration, SPSC projects, infiltration projects, and stormwater retrofits are on-going.

Estimates of inlet cleaning in the development of the plan were based on the total number of inlets cleaned Countywide with estimates based on the numbers of inlets in each watershed and assumptions of the average sediment yield from each inlet cleaned. The plan then called for a level of treatment consistent with the progress rate of 213 inlets per year. The actual number cleaned in the current reporting period is 12. While the number of inlets addressed this year fell short of the original goal, the inlet cleaning program is still yielding very good results and remains an important part of the County's program.

Table 7: Restoration BMP Implementation - Current FY2020 and Planned FY2024 Implementation Levels

BMP	Units	FY2020 Progress	Total Planned Restoration ¹	Total Planned – FY2024 ²	Percent Complete ³
Bioretention	acre	0.03	15.2	0	0.2%
Bioswale	acre	0.6	0	0	NA
Dry Ponds	acre	0	314.2	0	0%
Extended Detention Dry Ponds	acre	0	548.6	0	0%
Filtering Practices	acre	0	8.8	0	0%
Impervious Surface Reduction	acre	0	13.0	0	0%
Infiltration	acre	21.5	624.0	11.1	3.4%
Permeable Pavement	acre	5.8	0	0	NA
Stormwater Retrofits	acre	26.3	76.7	404.3	34.3%
Wet Ponds or Wetlands	acre	407.8	1,464.9	0	27.8%
Urban Stream Restoration	linear feet	250	15,150	560	1.7%
Urban Tree Plantings	acre	0	0.2	0	0%
Outfall Enhancement with SPSC	acre	0	171.0	8.3	0%
Annual Practices					
Inlet Cleaning	inlets/yr	12	213	213	5.6%
Street Sweeping	curb-miles	27.7	29.6	29.6	93.6%

¹ Planned restoration totals used in 2016 restoration plan and BayFAST modeling.

² Planned restoration totals through FY2024 from County's current MS4 geodatabase and used in CAST modeling.

³ Compares implementation progress through FY2020 to planned restoration totals through FY2024.

To track progress, the 2025 implementation milestone first reported in the 2016 plan was compared against the 2020 progress reported here in this assessment. Table 8 presents the strategies that are planned for the 2021-2025 milestone period.

Table 8: Implementation Milestones Comparison

BMP	Unit	2020 Progress	2021-2025 Planned Reduction
Bioretention	acre	0.03	0
Bioswale	acre	0.6	0
Infiltration	acre	21.5	11.1
Permeable Pavement	acre	5.8	0
Stormwater Retrofits	acre	26.3	404.3
Wet Ponds or Wetlands	acre	407.8	0
Urban Stream Restoration	linear feet	250	560
Outfall Enhancement with SPSC	acre	0	8.3
Annual Practices			
Inlet Cleaning	inlets/yr	12	213
Street Sweeping	curb-miles	27.7	29.6

3.2 Load Reductions

This section compares the required and planned sediment load reductions against the progress made through FY2020. Values given in Table 9 include the load reductions for each period (generally the milestone years) and the resulting load. Actual reductions are shown for 2020 and planned results are provided for the 2025 period. The planned reductions in this case refer to projects that are in the County's database and are moving forward with implementation, and does not refer to the total planned projects and reductions that were presented in the initial TMDL restoration plan. All values shown (reductions, loads, percent reduction) are the cumulative values, not the year over year changes.

Overall, the results indicate that on a TMDL allocated goal of 22.2%, the County has achieved a 3.8% reduction, which translates to 17% progress towards the reduction goal. The 2016 plan (Anne Arundel County, 2016) anticipated 18.1% reduction by 2017. The reduction progress of 3.8% in FY2020 is behind that 2017 goal. FY2020 modeling resulted in less progress in 2020 when compared to the previous analysis performed at the end of FY2018. This is a result of several factors, including changes in modeling methods (specifically, stream bed and bank disaggregation methods in 2019 and 2020), changes to the BMP data in the geodatabase, and reduction in inlet cleaning and street sweeping implementation over time.

The County's initial estimate and plan were based on a 2025 end date for meeting the sediment TMDL. Meeting the end date will require additional planned projects. The County currently has 11 restoration projects that are in planning and design phases that are scheduled to be complete by FY2024. These projects include stream restoration, SPSCs, wet pond, sand filters, shallow marsh, and infiltration trench.

Estimates of sediment reduction from planned projects show an additional reduction of 1,488,861 lbs over the next four years which represents an additional 8.8% reduction, added to the 3.8% achieved

through FY2020 will result in a total reduction progress of 12.6%. The number of projects in the County's near term plans is insufficient to meet the allocated load. Additional projects and load reduction strategies will need to be identified to make up the difference. The County is evaluating the potential for achieving additional load reductions in this watershed through the implementation of land conversion BMPs including: forest planting, conservation landscaping, impervious surface reduction, tree canopy plantings and forest conservation.

It is noted that the reductions in sediment by FY2025 outlined in this restoration plan is based on the assumption that all of the planned restoration and programmatic strategies will be completed.

MDE is currently working on a new local TMDL modeling tool that will be available in the future to report progress toward load reductions. It is anticipated that this new spreadsheet model will be used for FY2021 modeling, so additional changes are anticipated to the baseline, permit, and progress loads and load reductions in the FY2021 report.

Table 9: Planning and Target Sediment Load Comparison (lbs/year)

Milestone Year	Actual Load Reduction	Actual Load	Actual % Reduction from Baseline	Planned Load Reduction	Planned Load	Planned % Reduction From Baseline
2005 Baseline	-	11,527,942	-	-	-	-
2020 Progress	437,225	11,090,717	3.8%	-	-	-
2025 Allocated	-	-	-	2,559,203	8,968,739	22.2%
2025 Planned	-	-	-	1,448,861	10,079,080	12.6%

4 Monitoring

Official monitoring for Integrated Report assessments and impairment status is the responsibility of the State; however, the County has many on-going monitoring programs that can support the State's efforts. 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. The Patapsco LNB was originally listed for sediments in 1996 as a suspended sediment listing. This was refined in 2008 to a listing for total suspended solids. 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 Patapsco LNB was listed for biological community impairment in 2002.

MDE then utilized its Biological Stressor Identification (BSID) process to identify the probable or most likely causes of poor biological conditions. For sediment specifically, the BSID identified 'altered hydrology and increased urban runoff have resulted in degradation to streambed morphology, streambed scouring, and subsequent elevated suspended transport through the watershed.' Overall, the results indicated inorganic pollutants (i.e. chlorides, acute ammonia, sulfate), and flow/sediment related stressors as the primary stressors causing impacts to biological communities.

Based on the results of the BSID (MDE, 2012c), MDE replaced the biological impairment listing with a listing for total suspended solids (TSS). The 2012 and 2014 integrated reports (MDE, 2012a and MDE, 2014a) 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 (MDE, 2012b) (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 Patapsco LNB, which is listed as impaired for TSS, would seem to be a water clarity issue; however, the methodology used for listing (biological and habitat

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

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 Bureau of Watershed Protection and Restoration (BWPR) has several on-going monitoring programs that target measures of water clarity and sedimentation. These programs are described here.

4.1 Countywide Biological Monitoring

4.1.1 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 provide 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.

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 is providing 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 followed between 2009 and 2013. During 2017, Round 3 monitoring was initiated and fish sampling and additional water quality parameters were added. Field collection in Patapsco LNB took place between 2018 and 2020. 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 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 has stated goals 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

4.1.2 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) and EPA's Rapid Bioassessment Protocol (EPA RBP). 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 (Crunkleton, et al., 2013; Crunkleton, et al., 2012; Crunkleton, et al., 2011; Crunkleton, et al., 2010; Victoria, et al., 2011). 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).

The Patapsco LNB watershed is made up of three PSUs, Piney Run, Stony Run and Lower Patapsco. Ten sampling sites were sampled in each of these PSUs during Rounds 1 & 2 of sampling, while Round 3 shifted to 16 sites split equally between large and small stream strata. Methodologies follow those used by MBSS for the biological sampling (benthic macroinvertebrates only) and habitat evaluations have included both MBSS's Physical Habitat Index (PHI) and the EPA's Rapid Bioassessment Protocol (RBP) metrics. In-situ water quality measures are also collected at each site along with a geomorphic evaluation utilizing cross-sections, particle substrate analysis using pebble counts, and measures of channel slope.

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

4.1.3 Results

The Patapsco LNB watershed is made up of three PSUs: Piney Run, Stony Run and Lower Patapsco. Results summarized at the PSU scale with mean BIBI and habitat ratings (PHI and RBP) are presented in Table 10.

Table 10: Countywide Biological Monitoring Results

PSU Name	Round	PSU Code	Year Sampled	Drainage Area (acres)	BIBI Rating	PHI Rating	RBP Rating
Piney Run	1	1	2007	4,868	P	D	PS
Piney Run	2	1	2012	4,868	P	D	PS
Piney Run	3	1	2018	4,868	P	D	PS
Stony Run	1	2	2007	6,203	P	D	PS
Stony Run	2	2	2010	6,203	P	PD	S
Stony Run	3	2	2020	6,203	F	D	PS
Lower Patapsco	1	3	2004	4,040	P	PD	PS
Lower Patapsco	2	3	2012	4,040	P	PD	NS
Lower Patapsco	3	3	2018	4,040	P	D	NS

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

4.1.3.1 Biological

During Round 1, biological sampling was completed in 2004 (Lower Patapsco) and 2007 (Piney Run and Stony Run). Results of the Round 1 sampling are presented in Table 11. BIBI narrative condition ratings for all three rounds of sampling are presented in Figure 3. Overall, 40% of the sites in the watershed were rated as “Fair,” 40% rated “Poor,” and 20% were rated “Very Poor.” There were no sites rated as “Good.” Lower Patapsco received the highest average BIBI score of the three PSUs during Round 1, with a mean BIBI score of 2.69 ± 0.61 and a corresponding biological condition rating of “Poor,” while Piney Run received a nearly identical mean BIBI score of 2.69 ± 0.80 and a “Poor” rating. Stony Run received the lowest mean BIBI score if 2.37 ± 0.70 and a corresponding biological condition rating of “Poor.”

During Round 2, biological sampling was completed in 2010 (Stony Run) and 2012 (Piney Run, Lower Patapsco). Results of the Round 2 sampling effort are presented in Table 12. Overall, 43% of the sites in the watershed were rated as “Poor,” 30% rated “Fair,” and 23% rated “Very Poor”, and 3% rated “Good.”

All three PSUs in the watershed received a corresponding biological condition rating of “Poor.” Piney Run and Stony Run received nearly identical mean BIBI scores of 2.69 ± 0.90 and 2.69 ± 0.98 , respectively. The Lower Patapsco PSUs received the lowest mean BIBI score of 2.43 ± 0.74 .

Table 11: BIBI Data for Round 1 (2004-2008)

Site ID	Year	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scrapper Taxa	Percent Climbers	BIBI	Rating
01-01	2007	14	1	0.0	0	0.0	0	3	1.57	Very Poor
01-02	2007	33	5	2.9	1	27.5	1	9	3.86	Fair
01-04	2007	27	6	1.0	1	3.8	0	5	3.00	Fair
01-05	2007	24	6	0.0	0	43.6	1	5	3.29	Fair
01-07	2007	27	2	0.9	1	1.8	0	5	2.71	Poor
01-08	2007	23	0	0.0	0	0.9	0	13	2.14	Poor
01-09	2007	31	4	1.0	1	1.9	1	10	3.29	Fair
01-10	2007	30	5	0.0	0	3.0	1	2	2.71	Poor
01-12A	2007	30	3	1.0	1	7.7	1	3	3.00	Fair
01-13A	2007	11	1	0.0	0	0.0	0	2	1.29	Very Poor
02-01	2007	31	1	0.0	0	26.9	0	2	2.14	Poor
02-03	2007	25	4	0.0	0	19.6	0	0	2.14	Poor
02-04	2007	18	3	0.0	0	76.2	2	1	3.00	Fair
02-05	2007	31	3	0.9	1	13.9	0	7	3.00	Fair
02-06	2007	12	0	0.0	0	0.0	1	0	1.29	Very Poor
02-07	2007	20	1	0.0	0	1.9	0	6	1.57	Very Poor
02-11A	2007	25	3	0.9	1	33.3	0	12	3.57	Fair
02-18A	2007	26	6	0.0	0	6.7	1	5	2.71	Poor
02-19A	2007	19	2	0.0	0	5.7	1	1	2.14	Poor
02-20A	2007	25	3	0.0	0	2.8	0	4	2.14	Poor
03-01	2004	13	1	0.0	0	2.0	2	4	1.86	Very Poor
03-02	2004	21	3	0.0	0	22.6	0	9	2.43	Poor
03-04	2004	23	0	0.0	0	0.9	4	13	2.71	Poor
03-05	2004	30	7	0.0	0	20.2	4	15	3.57	Fair
03-07	2004	26	4	0.0	0	19.5	1	11	3.00	Fair
03-09	2004	15	4	1.0	1	4.0	1	2	2.71	Poor
03-12A	2004	14	3	2.2	1	2.2	2	8	3.00	Fair
03-13A	2004	22	2	1.0	1	4.1	1	14	3.29	Fair
03-16A	2004	12	0	0.0	0	1.6	1	7	1.57	Very Poor
03-17A	2004	19	1	2.0	1	2.0	1	12	2.71	Poor

Table 12: BIBI Data for Round 2 (2009-2013)

Site ID	Year	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scrapper Taxa	Percent Climbers	BIBI	Rating
01-01	2012	8	0	0.0	0	0.0	1	6.0	1.57	Very Poor
01-02	2012	20	1	0.0	0	3.6	4	18.9	2.43	Poor
01-03	2012	20	1	0.0	0	2.0	4	10.8	2.43	Poor
01-04	2012	19	1	0.0	0	24.8	1	1.8	2.14	Poor
01-05	2012	11	1	0.0	0	5.5	1	18.3	1.86	Very Poor
01-06	2012	19	1	0.0	0	9.2	5	14.7	2.43	Poor
01-07	2012	25	7	0.0	0	9.3	4	10.2	3.29	Fair
01-08	2012	25	3	1.9	1	10.2	6	21.3	3.86	Fair
01-09	2012	18	0	0.0	0	3.6	2	15.5	2.43	Poor
01-10	2012	29	6	4.4	2	10.6	4	14.2	4.43	Good
02-01	2010	30	2	0.0	0	5.5	6	16.4	3.00	Fair
02-02	2010	16	1	0.0	0	0.0	4	14.9	2.43	Poor
02-06	2010	31	8	0.0	0	45.8	9	3.7	3.57	Fair
02-08	2010	28	7	0.0	0	15.6	3	8.3	3.57	Fair
02-09	2010	28	5	0.0	0	3.5	6	8.8	3.29	Fair
02-10	2010	23	3	0.0	0	2.6	7	4.4	2.71	Poor
02-15A	2010	24	0	0.0	0	0.0	2	10.8	2.71	Poor
02-16A	2010	31	6	0.0	0	19.2	5	9.6	3.57	Fair
02-18A	2010	12	1	0.0	0	0.0	0	0.0	1.00	Very Poor
02-20A	2010	11	0	0.0	0	0.0	0	0.0	1.00	Very Poor
03-02	2012	21	3	0.0	0	1.9	2	1.9	2.43	Poor
03-03	2012	22	4	0.9	1	15.4	3	9.4	3.57	Fair
03-04	2012	8	0	0.0	0	1.0	2	2.9	1.86	Very Poor
03-05	2012	8	0	0.0	0	0.9	1	6.9	1.57	Very Poor
03-06	2012	14	4	0.0	0	8.6	1	1.9	2.14	Poor
03-07	2012	17	4	0.0	0	4.6	1	2.8	2.14	Poor
03-08	2012	18	5	1.9	2	15.4	3	4.8	3.86	Fair
03-10	2012	18	2	0.0	0	9.9	1	22.5	2.43	Poor
03-11A	2012	22	4	2.0	2	8.9	4	5.9	3.57	Fair
03-15A	2012	11	3	0.0	0	12.1	1	1.0	2.14	Poor

During Round 3, biological sampling was completed in 2018 for both Piney Run and Lower Patapsco, and in 2020 for Stony Run. Results of the Round 3 sampling effort are presented in Table 13. Overall, 46% of the sites in the watershed were rated as “Fair,” 38% rated “Poor,” and 17% rated “Very Poor.” There were no sites rated as “Good.” Stony Run received the highest mean BIBI score of 3.07 ± 0.47 and was the only subwatershed to receive a biological condition rating of “Fair.” Lower Patapsco received a mean BIBI score of 2.14 ± 0.98 and a corresponding biological condition rating of “Poor,” while Piney Run received a mean BIBI score of 2.61 ± 0.43 and a “Poor” rating.

Table 13: BIBI Data for Round 3 (2018-2020).

Site ID	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scrapper Taxa	Percent Climbers	BIBI	Rating
01-L1M-01-18	15	3	0.0	0	0.9	5	0.0	2.14	Poor
01-L1M-02-18	22	2	0.0	0	2.7	3	22.5	3.00	Fair
01-L2M-01-18	19	2	0.0	0	7.8	1	21.6	2.43	Poor
01-L2M-02-18	26	4	0.0	0	6.9	3	19.8	3.00	Fair
01-R3M-01-18	22	3	0.0	0	0.9	3	37.6	3.00	Fair
01-R3M-02-18	21	2	0.0	0	4.6	6	29.6	2.71	Poor
01-R3M-03-18	23	4	0.0	0	7.0	7	2.6	2.71	Poor
01-R3M-04-18	13	2	0.0	0	0.0	0	47.7	1.86	Very Poor
02-L1M-01-20	17	3	0.0	0	36.1	5	0.9	3.00	Fair
02-L1M-03-20	25	5	15.7	1	2.6	3	4.3	3.86	Fair
02-L2M-01-20	22	3	0.0	0	21.2	4	1.9	3.00	Fair
02-L2M-04-20	14	0	0.0	0	1.0	2	7.8	2.14	Poor
02-R3M-02-20	19	4	26.4	1	1.8	2	3.6	3.29	Fair
02-R3M-03-20	25	2	0.0	0	2.9	2	7.8	2.71	Poor
02-R3M-04-20	22	3	1.7	1	11.0	4	0.8	3.29	Fair
02-R3M-05-20	19	3	2.7	1	11.7	3	0.9	3.29	Fair
03-L1M-02-18	21	1	0.0	0	0.0	0	4.3	1.57	Very Poor
03-L1M-03-18	22	3	0.0	0	2.8	1	6.6	2.43	Poor
03-L2M-01-18	28	4	0.0	0	4.7	3	34.0	3.00	Fair
03-L2M-03-18	29	7	1.0	1	4.9	4	25.2	3.86	Fair
03-R3M-01-18	12	0	0.0	0	0.9	2	10.5	2.14	Poor
03-R3M-03-18	28	3	0.0	0	0.0	0	6.7	2.14	Poor
03-R3M-04-18	1	0	0.0	0	0.0	0	0.0	1.00	Very Poor
03-R3M-05-18	11	0	0.0	0	0.0	1	13.6	1.00	Very Poor

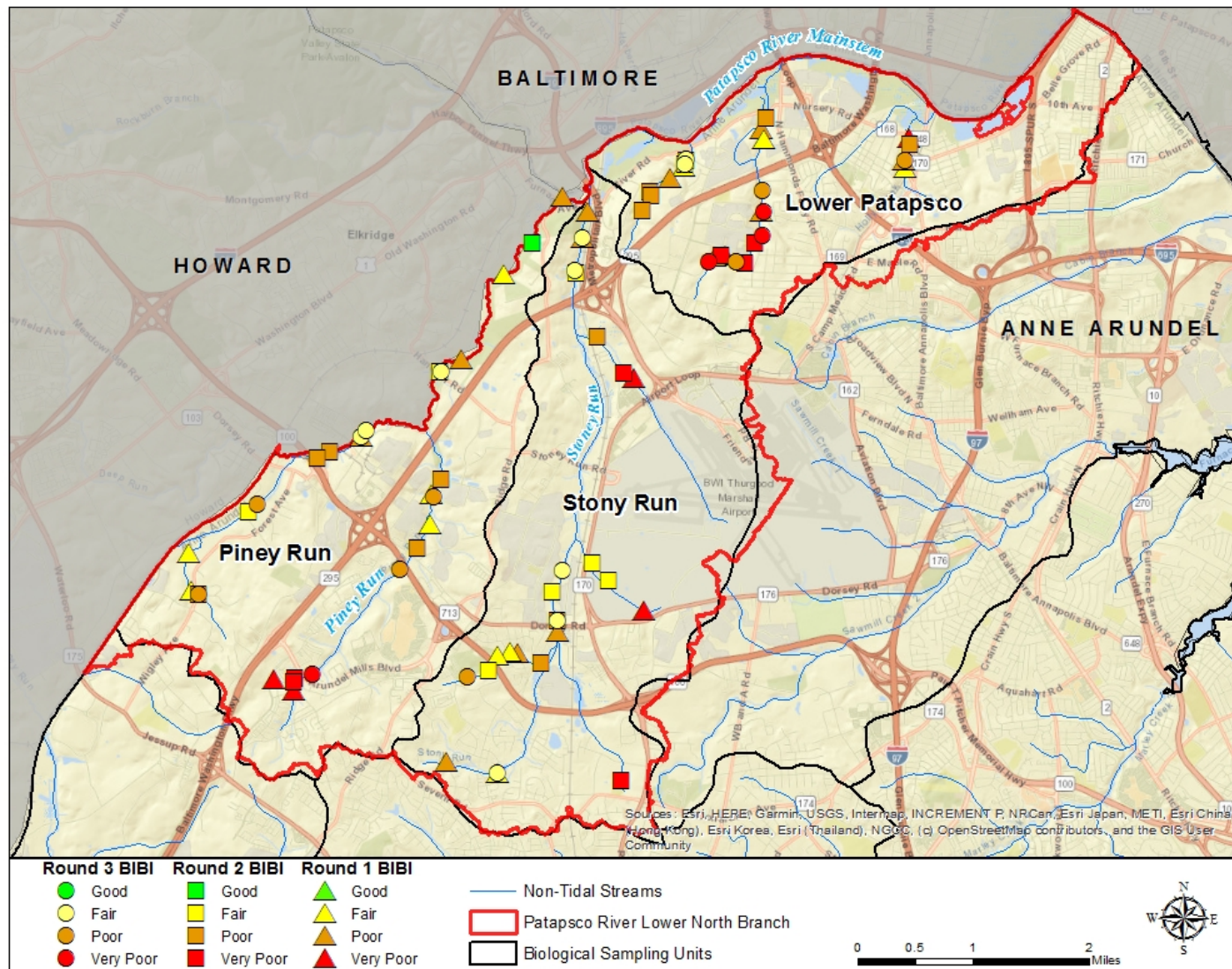


Figure 3: Biological Sampling Results from 2004 – 2020.

4.1.3.2 Physical Habitat

Physical habitat assessments during Round 1 were performed concurrently with the biological assessments. Results of the Round 1 habitat assessments are presented in Table 14. MPHI narrative condition ratings for all three rounds are presented in Figure 4. The MPHI rated 50% of sites “Degraded,” 30% as “Partially Degraded,” 17% “Severely Degraded” and 3% “Minimally Degraded.” Lower Patapsco received the highest average MPHI score of the three PSUs during Round 1, with a score of 67.14 ± 11.79 and a corresponding narrative rating of “Partially Degraded.” Both Piney Run and Stony Run received narrative ratings of “Degraded,” with average MPHI scores of 58.76 ± 14.01 and 58.66 ± 7.92 , respectively.

Table 14: Physical Habitat Index Data from Round 1 (2004-2008)

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
01-01	2007	48.47	91.34	83.31	83.91	66.63	54.77	71.41	Partially Degraded
01-02	2007	43.08	63.55	55.64	65.84	58.92	54.77	56.97	Degraded
01-04	2007	43.08	99.94	87.61	90.65	74.09	59.16	75.75	Partially Degraded
01-05	2007	21.54	58.94	84.06	85.08	70.89	70.71	65.20	Degraded
01-07	2007	37.70	84.56	64.11	59.29	42.14	59.16	57.83	Degraded
01-08	2007	16.16	99.94	35.28	44.96	26.50	67.08	48.32	Severely Degraded
01-09	2007	43.08	40.96	12.21	39.67	26.79	54.77	36.25	Severely Degraded
01-10	2007	26.93	15.33	53.26	45.82	24.50	63.25	38.18	Severely Degraded
01-12A	2007	43.08	73.32	76.11	80.10	49.93	63.25	64.30	Degraded
01-13A	2007	43.08	100.00	59.77	98.11	82.12	54.77	72.97	Partially Degraded
02-01	2007	37.70	54.42	55.91	64.29	69.48	63.25	57.51	Degraded
02-03	2007	21.54	40.96	58.67	99.96	87.35	70.71	63.20	Degraded
02-04	2007	48.47	54.42	88.68	88.76	77.69	83.67	73.61	Partially Degraded
02-05	2007	16.16	58.94	44.81	59.56	64.47	83.67	54.60	Degraded
02-06	2007	43.08	68.32	47.29	48.79	64.61	63.25	55.89	Degraded
02-07	2007	37.70	58.94	75.23	71.21	64.42	54.77	60.38	Degraded
02-11A	2007	43.08	99.94	58.16	73.38	73.40	54.77	67.12	Partially Degraded
02-18A	2007	43.08	45.47	51.79	69.28	32.04	77.46	53.19	Degraded
02-19A	2007	5.39	8.55	70.71	75.21	47.69	63.25	45.13	Severely Degraded
02-20A	2007	37.70	84.56	57.53	58.08	34.88	63.25	56.00	Degraded
03-01	2004	59.24	78.67	84.49	82.18	61.54	83.67	74.97	Partially Degraded
03-02	2004	16.16	84.56	40.96	68.20	70.84	89.45	61.69	Degraded
03-04	2004	37.70	78.67	84.77	77.06	56.10	92.20	71.08	Partially Degraded
03-05	2004	91.55	78.67	100.00	67.46	66.85	74.16	79.78	Partially Degraded
03-07	2004	96.93	84.56	100.00	69.68	69.31	70.71	81.87	Minimally Degraded
03-09	2004	26.93	68.32	85.18	77.71	62.73	67.08	64.66	Degraded

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
03-12A	2004	10.77	58.94	50.85	39.70	57.73	94.87	52.14	Degraded
03-13A	2004	43.08	73.32	81.59	60.97	53.54	44.72	59.54	Degraded
03-16A	2004	21.54	45.47	57.99	50.92	67.19	44.72	47.97	Severely Degraded
03-17A	2004	59.24	91.34	100.00	99.70	71.16	44.72	77.69	Partially Degraded

Results of the Round 2 habitat assessments are presented in Table 15. The MPHI rated 37% of sites as “Partially Degraded,” 30% as “Degraded,” 17% as “Severely Degraded,” and 17% as “Minimally Degraded.” Both Stony Run and Lower Patapsco PSUs received “Partially Degraded” narrative ratings, with mean MPHI scores of 68.7 ± 15.1 and 66.3 ± 14.9 , respectively. Piney Run received the lowest MPHI score of 64.5 ± 13.1 and a corresponding narrative rating of “Degraded.”

Table 15: Physical Habitat Index Data from Round 2 (2009-2013)

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
01-01	2012	59.24	91.34	83.75	84.59	91.05	63.25	78.87	Partially Degraded
01-02	2012	37.7	49.95	82.42	71.77	79.17	83.67	67.45	Partially Degraded
01-03	2012	26.93	45.47	87.4	74.05	49.37	83.67	61.15	Degraded
01-04	2012	5.39	73.32	41.73	41.66	72.18	92.2	54.41	Degraded
01-05	2012	32.31	63.55	73.29	66.19	65.22	80.63	63.53	Degraded
01-06	2012	64.62	63.55	88.18	80.81	80.29	86.61	77.34	Partially Degraded
01-07	2012	32.31	99.94	100	90.06	100	92.2	85.75	Minimally Degraded
01-08	2012	5.39	21.22	59.04	45.78	51.08	94.87	46.23	Severely Degraded
01-09	2012	5.39	84.56	70.78	66.19	64.35	80.63	61.98	Degraded
01-10	2012	53.85	31.57	58.57	50.58	29.54	67.08	48.53	Severely Degraded
02-01	2010	48.47	78.67	80.75	74.69	73.30	83.67	73.26	Partially Degraded
02-02	2010	16.16	58.94	54.72	45.78	70.37	94.87	56.80	Degraded
02-06	2010	80.78	91.34	97.13	83.77	75.14	70.71	83.14	Minimally Degraded
02-08	2010	32.31	99.94	83.59	82.37	68.33	67.08	72.27	Partially Degraded
02-09	2010	43.08	73.32	81.54	79.51	84.78	80.63	73.81	Partially Degraded
02-10	2010	16.16	54.42	76.15	69.07	55.92	59.16	55.15	Degraded
02-15A	2010	75.39	99.94	90.91	85.11	73.21	94.87	86.57	Minimally Degraded
02-16A	2010	53.85	99.94	96.73	83.16	71.50	100.00	84.20	Minimally Degraded
02-18A	2010	32.31	78.67	47.90	53.32	69.85	89.45	61.92	Degraded

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
02-20A	2010	32.31	0.00	52.82	55.86	51.06	44.72	39.46	Severely Degraded
03-02	2012	53.85	84.56	85.1	77.58	71.47	80.63	75.53	Partially Degraded
03-03	2012	64.62	78.67	90.29	91.29	95.28	92.2	85.39	Minimally Degraded
03-04	2012	26.93	31.57	34.29	33.54	63.42	63.25	42.17	Severely Degraded
03-05	2012	26.93	91.34	34.36	24.53	100	63.25	56.73	Degraded
03-06	2012	5.39	73.32	88.62	75.6	78.82	77.46	66.54	Partially Degraded
03-07	2012	32.31	99.94	86.45	86.86	91.05	83.67	80.05	Partially Degraded
03-08	2012	70.01	58.94	84.55	80.31	89.49	92.2	79.25	Partially Degraded
03-10	2012	32.31	63.55	57.73	54.46	67.26	63.25	56.43	Degraded
03-11A	2012	75.39	100	59.58	62.54	80.04	63.25	73.47	Partially Degraded
03-15A	2012	37.7	58.94	29.34	25.77	60.74	70.71	47.2	Severely Degraded

Physical habitat assessments during Round 3 were performed concurrently with the summer biological assessments. Results of the Round 3 habitat assessments are presented in Table 16. Of the PSUs sampled in Round 3, the MPHI rated 54% of sites “Degraded,” 25% as “Partially Degraded,” 21% “Severely Degraded.” Stony Run received the highest average MPHI score of 65.07 ± 7.05 and a corresponding narrative rating of “Degraded.” Lower Patapsco and Piney Run also received a narrative rating of “Degraded,” with average MPHI scores of 55.78 ± 8.12 and 59.59 ± 9.46 , respectively.

Table 16: Physical Habitat Index Data from Round 3 (2018-2020).

Station	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
01-L1M-01-18	47.44	58.94	58.09	68.08	60.73	79.16	62.07	Degraded
01-L1M-02-18	37.50	54.42	41.13	37.50	95.84	56.57	53.83	Degraded
01-L2M-01-18	15.79	63.55	35.91	41.64	69.20	80.63	51.12	Degraded
01-L2M-02-18	23.05	63.55	41.77	62.66	48.39	79.69	53.18	Degraded
01-R3M-01-18	42.78	68.32	29.43	26.27	63.15	29.44	43.23	Severely Degraded
01-R3M-02-18	47.44	68.32	60.87	72.45	68.53	63.25	63.48	Degraded
01-R3M-03-18	32.59	54.42	78.02	66.47	56.22	96.96	64.11	Degraded
01-R3M-04-18	39.70	63.55	55.58	65.75	61.77	62.18	58.09	Degraded
02-L1M-01-20	40.55	36.34	65.65	61.35	83.98	82.06	61.65	Degraded
02-L1M-03-20	35.62	84.56	75.00	69.24	100.00	88.60	75.50	Partially Degraded
02-L2M-01-20	29.79	63.55	81.92	69.02	61.77	44.72	58.46	Degraded

Station	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
02-L2M-04-20	35.14	78.67	48.66	62.04	99.53	79.37	67.24	Partially Degraded
02-R3M-02-20	36.34	73.32	51.82	58.23	40.97	73.83	55.75	Degraded
02-R3M-03-20	45.64	91.34	67.59	62.43	100.00	86.61	75.60	Partially Degraded
02-R3M-04-20	33.89	40.96	72.61	69.06	67.51	74.39	59.74	Degraded
02-R3M-05-20	40.76	58.94	69.88	51.70	100.00	78.53	66.63	Partially Degraded
03-L1M-02-18	36.34	45.47	57.15	51.58	61.56	62.05	52.36	Degraded
03-L1M-03-18	15.79	49.95	85.70	84.08	60.68	0.00	49.37	Severely Degraded
03-L2M-01-18	35.14	78.67	83.61	89.92	73.07	89.07	74.91	Partially Degraded
03-L2M-03-18	44.71	40.96	77.87	73.38	76.14	95.05	68.02	Partially Degraded
03-R3M-01-18	32.59	21.22	28.13	38.55	62.82	96.61	46.65	Severely Degraded
03-R3M-03-18	33.89	68.32	65.50	51.99	73.62	51.48	57.47	Degraded
03-R3M-04-18	3.31	68.32	29.92	35.80	68.88	95.22	50.24	Severely Degraded
03-R3M-05-18	49.17	73.32	28.43	40.99	59.17	34.64	47.62	Severely Degraded

4.1.1 Conclusions

At the completion of Round 2, analyses were performed to compare statistical differences between mean index values (i.e., BIBI, PHI) from two time periods (e.g., 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). None of the individual PSUs saw a significant change in mean BIBI scores between Round 1 and Round 2. These results suggest there has not been a measurable increase in the average BIBI condition across the broader Patapsco Lower North Branch Watershed between Round 1 and Round 2. Initial results from Round 3 showed no significant increases compared to Rounds 1 and 2 for both Lower Patapsco and Piney Run PSUs. Statistical analysis has not yet been completed for Stony Run.

4.2 Targeted Restoration Monitoring Program

In addition to the Countywide Program, the County implements a targeted biological monitoring program. This program utilizes the same techniques and procedures as use in the Countywide Program, but the sites are not randomly selected. There are two general approaches to site selection in the targeted work. First, the County samples a collection of long term sites every year, the number of which has varied over the years. Currently, there are 34 sites in the program, 18 of which are past or proposed stream restoration sites that the County tracks to see how the stream insect community has changed, or will change, over time while one site is a minimally disturbed stream reach that is used as a reference reach. Most of the sites in this group have only been monitored post-restoration. Another 15 sites are allocated to the Sawmill Creek Project (SCP) with the purpose of tracking changes in the aquatic biological integrity, as well as several abiotic factors, in Sawmill Creek and its tributaries over a period of five years (2017-

2021). The goal of this project is to ascertain which factor, or combination of factors, are contributing to the watershed's unexpected biological integrity.

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

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.

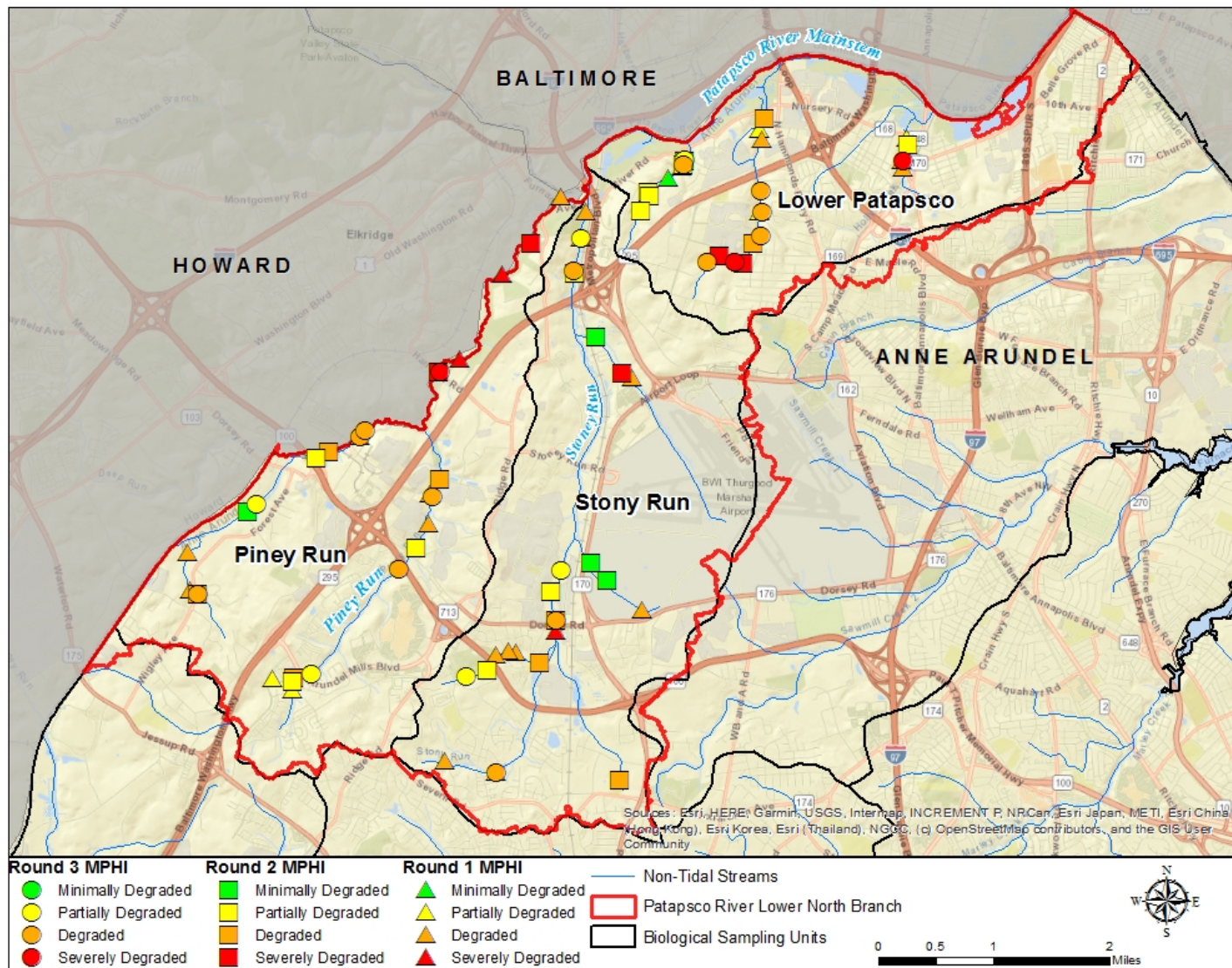


Figure 4: Physical Habitat Assessment Results from 2004 – 2020.

5 Conclusion

This Patapsco LNB TMDL Annual Assessment report documents the progress achieved through the end of FY2020. The assessment includes a report on project and program implementation completed in the current report year and cumulatively through FY2020. The report summarizes the modeled and calculated pollutant load reductions and loads achieved through the implemented programs. Further, the report compares the implementation levels and load reductions against the overall goals, specifically the SW-WLA, and the planned milestone targets as outline in the 2016 plan (Anne Arundel County, 2016).

Anne Arundel County spent \$793,510 in FY2020 in operational and capital costs in the Patapsco LNB Watershed implementing programmatic practices including inlet cleaning, street sweeping, and restoration projects. Load reductions are at 3.8% on a total goal of 22.2%. Based on the current rate of progress and the projects that the County has in design phases to be completed in 2021-2025, the County will need additional planned projects to meet the load reduction ahead of the 2025 date set in the County's plan.

MDE is currently working on a new local TMDL modeling tool that will be available in the future to report progress toward load reductions. It is anticipated that this new spreadsheet model will be used for FY2021 modeling, so additional changes are anticipated to the baseline, permit, and progress loads and load reductions in the FY2021 report.

Biological stream monitoring data thus far with three rounds completed, indicates a watershed that is in poor to fair biological health. Initial results from Round 3 sampling showed no statistically significant trends in biological condition.

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