Upper Patuxent River Watershed

2020 Sediment TMDL Annual Assessment Report

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Prepared For

Anne Arundel County
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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
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
PCB	Polychlorinated Biphenyls
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 three final TMDLs in the Upper Patuxent for which Anne Arundel County has some responsibility; total suspended solids (TSS; sediment) and bacteria TMDLs were all approved in 2011; and a Polychlorinated Biphenyls (PCB) TMDL was approved in 2017. These TMDLs apply to several jurisdictions including Howard, Prince George's, 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 and comment from MDE and the general public. The plan specifically addresses the Upper Patuxent sediment TMDL under the responsibility of Anne Arundel County. The bacteria and PCB TMDLs are addressed by Anne Arundel County in separate plans.

Responsibility for Upper Patuxent sediment reduction is divided among the contributing jurisdictions, listed above. The TMDL loading targets, or allocations, are also divided among the pollution source categories, which in this case includes non-point sources (termed load allocation or LA) and point sources (termed waste load allocation or WLA). The WLA consists of loads attributable to regulated process water or wastewater treatment, and 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 *Upper Patuxent River Sediment TMDL Restoration Plan* (the plan) (Anne Arundel County, 2016) satisfied the permit planning requirement and this *2020 Upper Patuxent River Sediment TMDL Annual Assessment Report* satisfies the progress documentation requirement for fiscal year (FY) 2020.

1.2 Watershed Description

The Upper Patuxent is one of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the western portion of the County (Figure 1). The watershed shares political boundaries with Prince George's County along the Patuxent River and a smaller portion of the watershed is shared with Howard County. The Upper Patuxent watershed is a part of the Chesapeake Bay watershed with the Patuxent River mainstem discharging directing into the Chesapeake Bay. Anne Arundel County's portion of the Upper Patuxent watershed is approximately 22,420 acres (35.0 square miles) in area and contains approximately 90 total perennial miles of stream reaches. The watershed includes several named streams including

Figure 1: Watershed Location Map

Stocketts Run, Davidsonville Branch, Ropers Branch, and the mainstem of the Upper Patuxent River. The watershed includes portions of the Patuxent Wildlife Refuge (Figure 1).

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 Upper Patuxent 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 mode 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 that would be 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. FY2020 progress marks the first year Anne Arundel County has used CAST for modeling Upper Patuxent loads. The STB TSS disaggregation methodology is used in FY2020 modeling and is described in section 1.5.2.

CAST, created by the Chesapeake Bay Program, is a web-based pollutant estimation tool that calculates pollutant load and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model Phase 6 (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 the Upper Patuxent using a 2005 CAST Progress Scenario on top of baseline year (2005) land use background loads.

The required percent reduction assigned to the Anne Arundel County Phase I MS4 source (11.4%) 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 are shown in Table 1. The loads modeled under P5.3.2 were used 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 plan.

Table 1: Sediment Loads Required for the Upper Patuxent River Local TMDL

Model	2005 Baseline Load (lbs/yr)	Required Reduction %	Required Reductions (lbs/yr)	TMDL Load Allocation (SW-WLA) (lbs/yr)
P5.3.2	485,565	11.4%	55,354	430,211
P6	10,925,666	11.4%	1,245,526	9,680,140

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 Upper Patuxent River Watershed, Anne Arundel, Howard and Prince George's 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 Upper Patuxent 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 was calculated from the 2005 baseline levels, calibrated to CBP P6 as noted above, using the following calculation: 2025 Allocated Load = 2005 Baseline Load – (2005 Baseline Load x 0.205).
- **2025 Planned Load and Planned Reduction**: Load and reduction that will result from implementation of planned BMPs.

Table 2: Upper Patuxent Local TMDL Allocated and Planned Loads

	Sediment (tons/year)	Sediment (lbs/year)
2005 Baseline Load	5,462	10,925,666
2020 Progress Load	5,255	10,510,375
2020 Progress Reduction	208	415,291
2025 TMDL Allocated Load	4,840	9,680,140
2025 Planned Load*	4,792	9,583,462
2025 Planned Reduction	671	1,342,204
Required Percent Reduction	11.4%	11.4%
Planned Percent Reduction	12.3%	12.3%

*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 Upper Patuxent 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 (2005) 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 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 we-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 toll 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 all 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 into 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 needs to be 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:

TSS STB load = ((Scenario EOS without STB TSS / CAL EOS without STB TSS) * STB base TSS) + (4/3 * 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 eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting
- **Vegetated Open Channels** - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed. 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.

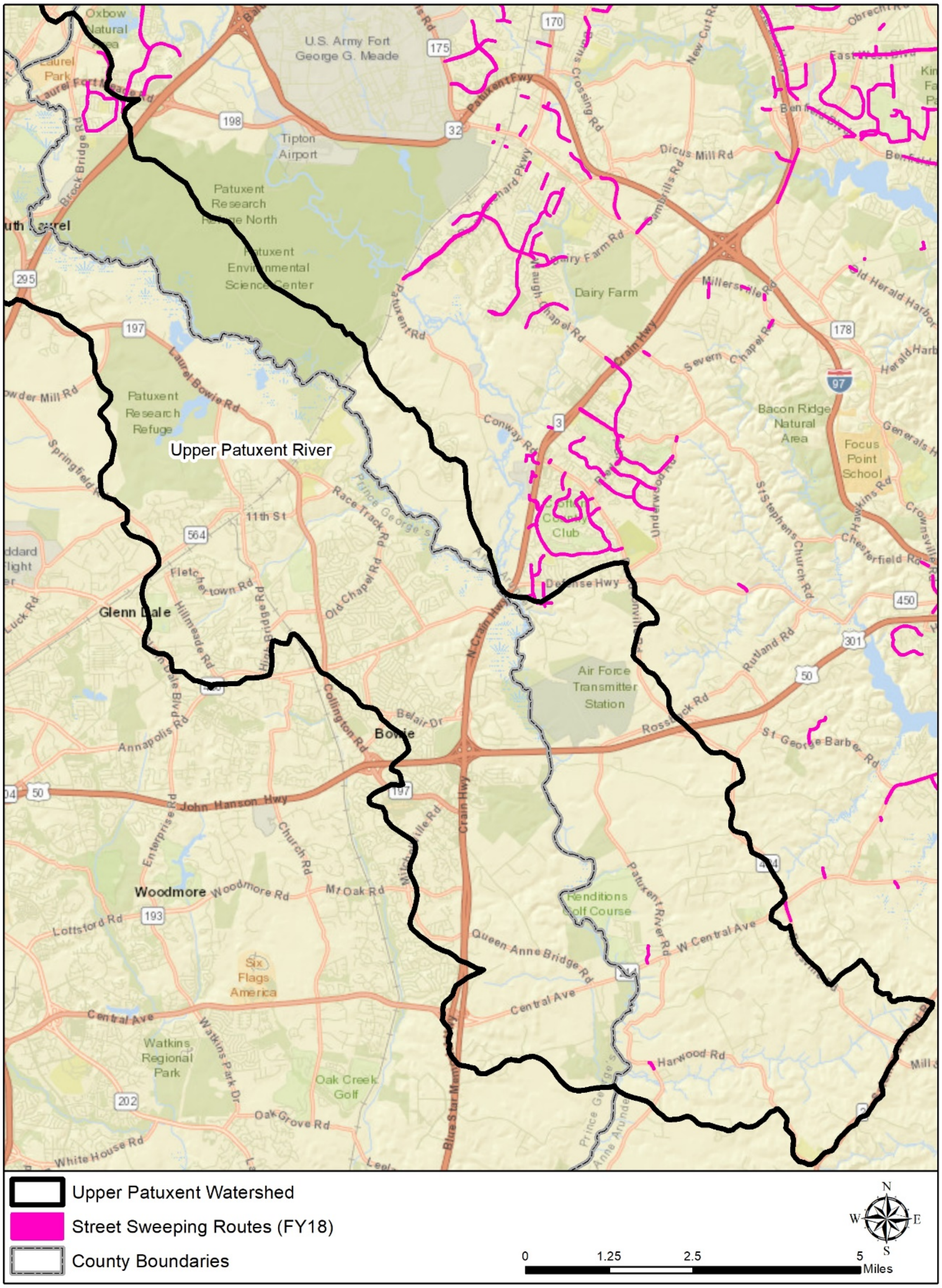

Figure 2: Street Sweeping Routes in the Upper Patuxent Watershed, Anne Arundel County, Maryland

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.

Stream Restoration
One stream restoration project was completed in the watershed in FY2020 (Mount Airy Court – Kings Branch Stream Restoration).

Street Sweeping
Building upon on the County's enhanced street sweeping program, 3.7 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 8.5 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 the practices and programs implemented in FY2020 is $885,780.

Table 4: Baseline BMP Implementation

BMP	Unit	2005 Baseline
Structural Permanent Practices		
Runoff Reduction Performance Standard	acre	16.91
Stormwater Treatment Performance Standard	acre	335.27
Bioswale	acre	1.28
Dry Ponds	acre	53.00
Extended Detention Dry Ponds	acre	13.64
Infiltration Practices	acre	153.75
Urban Tree Planting	acre	0.01
Wet Ponds or Wetlands	acre	138.52
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	0	0.1	
Bioswale	acre	0	0	0	
Dry Ponds	acre	0	0	0	
Extended Detention Dry Ponds	acre	0	0	0	
Impervious Surface Reduction	acre	0.1	0	0.1	
Infiltration	acre	0	0	0	
Urban Filtering	acre	0	0	0	
Urban Tree Planting	Acre	1.0	0	1.0	
Stormwater Retrofits[1]	acre	0	0	0	
Vegetated Open Channels	acre	0	0	0	
Wet Ponds or Wetlands	acre	22.3	0	22.3	
Urban Stream Restoration	linear ft	0	236.0	236.0	$878,526
Outfall Enhancement with SPSC	acre	0	0	0	
Annual Practices					
Inlet Cleaning[5]	inlets/yr	NA	0	0	
Street Sweeping[6]	lbs /yr	NA	17,087	17,087	$7,254
				FY2020 Total Cost	$885,780

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 11.4% reduction.

Table 6: FY2020 Progress Reductions Achieved

Baseline Load and TMDL SW-WLA	TSS-EOS lbs/yr
2005 Baseline Scenario Load	10,925,666
Required Percent Reduction	11.4%
Required Reduction	1,245,526
Local TMDL SW-WLA	9,680,140
2020 Results	**TSS-EOS lbs/yr**
Progress Scenario Load	10,510,375
Progress Reduction Achieved	415,291
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 with 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 was made for several strategies (e.g. bioretention, wet ponds, urban stream restoration) and street sweeping is continuing at a level very close to the initially prescribed rate.

Implementation of one stream restoration project was completed during this reporting period. Implementation of SPSC and stream restoration projects are on-going. Currently Anne Arundel County is in the design phase for the Maryland City Outfall and Stream Restoration project. The project includes three SPSCs with a combined 69 acre drainage area and restoration of several stream reaches totaling over 2,500 feet.

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 38 inlets per year. No inlets were cleaned during the current reporting period. While the number of inlets addressed this year fell short of the original goal, the inlet cleaning program is still yielding very good results Countywide 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[2]	Total Planned – FY2024[3]	Percent Complete[4]
Bioretention	acre	0	0.1	0	0%
Bioswale	acre	0	4.0	0	0%
Dry Ponds	acre	0	52.6	0	0%
Extended Detention Dry Ponds	acre	0	13.6	0	0%
Impervious Surface Reduction	acre	0.1	0.1	0	100%
Infiltration	acre	0	255.0	0	0%
Urban Filtering	acre	0	10.0	0	0%
Stormwater Retrofits[1]	acre	22.3	37.2	0	60%
Vegetated Open Channels	acre	0	0	0	NA
Wet Ponds or Wetlands	acre	0	204.4	0	0%
Urban Stream Restoration	linear feet	236.0	5,000.0	2,518.0	5%
Urban Tree Planting	acre	0.2	0	0	NA
Outfall Enhancement with SPSC	acre	0	201.7	69.4	0%
Annual Practices					
Inlet Cleaning	inlets/yr	0	38	38	0%
Street Sweeping	curb-miles	3.7	4.9	4.9	76%

[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] Planned restoration totals used in 2016 restoration plan and BayFAST modeling.
[3] Planned restoration totals through FY2024 from County's current MS4 geodatabase and used in CAST modeling.
[4] 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	FY2020 Progress	2021-2025 Planned Reduction
Urban Stream Restoration	linear feet	236.0	2,518.0
Impervious Surface Reduction	acre	0.1	0
Outfall Enhancement with SPSC	acre	0	69.4
Wet Ponds or Wetlands Retrofits	acre	22.3	0
Annual Practices			
Inlet Cleaning	no. of inlets/yr	0	38
Street Sweeping	curb miles	3.7	4.9

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 11.4%, the County has achieved a 3.8% reduction, which translates to 33% progress towards the reduction goal. The 2016 plan (Anne Arundel County, 2016) anticipated 10.6% reduction by 2017. The reduction progress of 3.8% in FY2020 is behind that 2017 goal. However, implantation of planned projects currently in design will allow the County to surpass the 11.4% reduction goal by 0.9% by 2024.

The County's initial estimate and plan were based on a 2025 end date for meeting the TMDL. Although the progress as of FY2020 is slightly behind schedule, the overall program is on track to meet the end date ahead of schedule with completion of a small number of restoration projects and continued street sweeping and inlet cleaning as prescribed.

The Maryland City Outfall and Stream Restoration project, based on early calculations at the 30% design phase, is estimated to reduce over 400 tons of sediment. Once the project is finalized, the load reductions will be updated and compared to the target goals. The project is expected to make substantial progress towards the final goal.

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	-	10,925,666	-	-	-	-
2020 Progress	415,291	10,510,375	3.8%	-	-	-
2025 Allocated	-	-	-	1,245,526	9,680,140	11.4%
2025 Planned	-	-	-	1,342,204	9,583,462	12.3%

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 Upper Patuxent was originally listed for sediments in 1996 as a total suspended solids/sediment 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 Upper Patuxent was listed for biological community impairment in 2006.

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, 2010), 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 (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 critiera 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 Upper Patuxent, which is listed as impaired for TSS, would seem to be water clarity issue; however the methodology used for listing (biological and habitat

[1] http://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 took place between 2009 and 2013. During 2017, Round 3 monitoring was initiated and fish sampling and additional water quality parameters were added. Field data collection in Upper Patuxent took place during between 2018 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

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 Upper Patuxent watershed is made up of three PSUs: Upper Patuxent, Middle Patuxent, and Stocketts Run. Ten sampling sites were sampled in each of these PSUs in Round 1 and Round 2, while eight sites were sampled in 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

4.1.3 Results

The Upper Patuxent watershed is made up of three PSUs: Upper Patuxent, Middle Patuxent, and Stocketts Run. 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
Upper Patuxent	1	16	2007	6,957	P	PD	PS
Upper Patuxent	2	16	2011	6,957	P	MD	S
Upper Patuxent	3	16	2019	6,957	P	PD	S
Middle Patuxent	1	18	2004	6,332	P	PD	S
Middle Patuxent	2	18	2010	6,332	F	PD	PS
Middle Patuxent	3	18	2019	6,332	P	PD	PS
Stocketts Run	1	19	2005	8,714	F	PD	PS
Stocketts Run	2	19	2013	8,714	P	PD	PS
Stocketts Run	3	19	2018	8,714	F	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

4.1.3.1 Biological

During Round 1, biological sampling was completed in 2004 (Middle Patuxent), 2005 (Stocketts Run) and 2007 (Upper Patuxent). Results of the Round 1 sampling effort are presented in Table 11. BIBI narrative condition ratings are presented in Figure 3 for the Upper Patuxent PSU and Figure 4 for the Middle Patuxent and Stocketts Run PSUs. Overall, 43% of the sites in the watershed were rated as “Poor,” 33% rated “Fair,” 13% rated “Good,” and 10% rated “Very Poor.” Stocketts Run received the highest average BIBI score of all PSUs during Round 1, with a mean BIBI score of 3.51 ± 0.87 and a corresponding biological condition rating of “Fair.” Both Middle Patuxent and Upper Patuxent PSUs received “Poor” biological condition ratings, with mean BIBI scores of 2.94 ±0.71 and 2.37 ±0.38, respectively.

During Round 2, biological sampling was completed in 2010 (Middle Patuxent), 2011 (Upper Patuxent), and 2013 (Stocketts Run). Results of the Round 2 sampling effort are presented in Table 12. Overall, 43% of the sites in the watershed were rated as “Poor,” 37% rated “Fair,” 3% rated “Good,” and 17% rated “Very Poor.” Middle Patuxent received the highest average BIBI score of all PSUs during Round 2, with a mean BIBI score of 3.32 ± 0.58 and a corresponding biological condition rating of “Fair.” Both Stocketts

Run and Upper Patuxent PSUs received “Poor” biological condition ratings, with mean BIBI scores of 2.60 ±0.91 and 2.34 ±0.50, respectively.

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 Scraper Taxa	Percent Climbers	BIBI	Rating
16-01	2007	18	3	0.0	0	35.3	0	8.4	2.71	Poor
16-02	2007	21	0	0.0	0	50.6	0	3.5	2.14	Poor
16-03	2007	17	2	0.0	0	3.8	0	1.0	1.86	Very Poor
16-05	2007	19	4	0.0	0	40.2	0	13.1	2.71	Poor
16-10	2007	27	0	0.0	0	14.9	0	1.8	2.14	Poor
16-11A	2007	23	2	0.0	0	49.6	0	10.6	3.00	Fair
16-12A	2007	22	0	0.0	0	0.0	0	5.4	1.86	Very Poor
16-13A	2007	16	0	0.0	0	43.6	1	6.8	2.43	Poor
16-14A	2007	20	4	0.0	0	62.5	0	1.9	2.43	Poor
16-16A	2007	31	4	0.0	0	27.8	0	6.5	2.43	Poor
18-02	2004	23	6	0.0	0	25.0	1	13.4	3.29	Fair
18-03	2004	25	1	0.0	0	2.2	1	8.9	2.43	Poor
18-04	2004	26	4	1.0	1	2.9	2	13.7	3.57	Fair
18-05	2004	9	3	0.0	0	4.7	0	2.8	1.57	Very Poor
18-06	2004	20	2	0.0	0	5.4	1	20.4	2.43	Poor
18-07	2004	26	3	0.0	0	5.0	2	8.3	3.00	Fair
18-09	2004	23	3	0.0	0	2.3	1	10.2	2.71	Poor
18-11A	2004	23	6	1.0	1	8.0	0	18.0	3.29	Fair
18-12A	2004	18	5	0.0	0	4.1	2	19.6	3.00	Fair
18-20A	2004	23	5	1.1	1	50.5	1	10.5	4.14	Good
19-01	2005	24	9	16.5	2	54.6	2	4.1	4.71	Good
19-02	2005	21	4	0.0	0	23.5	2	7.8	2.71	Poor
19-03	2005	17	6	0.0	0	29.7	2	10.9	3.57	Fair
19-04	2005	21	4	0.0	0	24.5	1	24.5	2.71	Poor
19-05	2005	15	2	0.0	0	10.1	1	5.1	2.43	Poor
19-06	2005	23	3	0.0	0	32.0	1	6.2	3.00	Fair
19-07	2005	18	4	0.0	0	13.1	2	38.1	3.00	Fair
19-08	2005	26	5	0.0	0	32.7	2	13.9	3.86	Fair
19-09	2005	27	9	12.6	2	53.7	1	12.6	4.71	Good
19-10	2005	26	9	20.4	3	28.6	0	8.2	4.43	Good

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 Scraper Taxa	Percent Climbers	BIBI	Rating
16-01	2011	19	1	0.0	0	34.7	0	6.9	2.14	Poor
16-03	2011	17	3	0.0	0	72.5	1	0.9	2.71	Poor
16-04	2011	20	2	0.0	0	12.2	0	4.3	2.14	Poor
16-05	2011	11	0	0.0	0	2.9	0	16.2	1.57	Very Poor
16-06	2011	19	4	0.0	0	50.5	0	1.8	2.43	Poor
16-08	2011	26	6	0.0	0	61.3	0	0.9	3.00	Fair
16-09	2011	10	1	0.0	0	31.3	0	1.0	1.86	Very Poor
16-11A	2011	10	4	0.0	0	90.8	0	0.0	1.86	Very Poor
16-12A	2011	12	5	0.0	0	69.4	1	1.8	2.71	Poor
16-15A	2011	19	3	0.0	0	67.3	3	2.9	3.00	Fair
18-02	2010	32	3	0.0	0	6.1	1	11.4	2.71	Poor
18-03	2010	32	10	1.9	1	36.9	1	5.8	3.86	Fair
18-04	2010	26	5	0.0	0	18.1	1	3.4	3.00	Fair
18-05	2010	21	4	0.0	0	52.7	2	10.0	3.29	Fair
18-06	2010	18	6	0.8	1	11.0	1	5.1	3.29	Fair
18-07	2010	34	6	0.0	0	16.8	3	2.8	3.29	Fair
18-08	2010	28	4	0.0	0	22.3	0	16.5	2.71	Poor
18-09	2010	34	10	1.7	2	39.8	3	5.9	4.43	Good
18-10	2010	21	6	0.0	0	49.2	0	7.5	2.71	Poor
18-11A	2010	27	5	0.8	1	20.8	2	5.0	3.86	Fair
19-02	2013	21	3	0.0	0	9.6	4	7.8	2.43	Poor
19-03	2013	13	2	0.0	0	8.6	2	1.0	2.14	Poor
19-04	2013	17	4	0.0	0	11.6	3	1.1	2.71	Poor
19-05	2013	11	1	0.0	0	1.8	1	0.0	1.29	Very Poor
19-06	2013	20	6	9.4	2	26.0	4	3.1	3.86	Fair
19-07	2013	11	5	1.0	1	8.3	1	0.0	2.43	Poor
19-08	2013	15	6	12.5	4	14.4	1	1.0	3.86	Fair
19-10	2013	15	0	0.0	0	5.9	0	2.0	1.57	Very Poor
19-11A	2013	22	4	2.0	2	8.9	4	5.9	3.57	Fair
19-16A	2013	11	3	0.0	0	12.1	1	1.0	2.14	Poor

During Round 3, biological sampling was completed in 2018 (Stocketts Run) and 2019 (Middle Patuxent and Upper Patuxent). Results of the Round 3 sampling effort are presented in Table 13. Overall, 38% of the sites in the watershed were rated as "Poor," 29% rated "Very Poor," 21% rated "Fair," and 13% rated "Good." Stocketts Run received the highest average BIBI score of all PSUs during Round 3, with a mean BIBI score of 3.11 ± 1.18 and a corresponding biological condition rating of "Fair." Both Middle Patuxent and Upper Patuxent PSUs received "Poor" biological condition ratings, with mean BIBI scores of 2.68 ±0.84 and 2.07 ±0.52, respectively.

Table 13: BIBI Data for Round 3 (2018-2019)

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
16-L1M-01-19	12	3	0.0	0	0.9	1	3.5	1.86	Very Poor
16-L1M-02-19	13	3	0.0	0	67.0	0	1.9	2.14	Poor
16-L2M-01-19	8	0	0.0	0	92.0	0	2.7	1.86	Very Poor
16-L2M-02-19	11	1	0.0	0	71.4	0	0.0	1.57	Very Poor
16-R3M-02-19	20	7	0.0	0	70.4	1	2.8	3.00	Fair
16-R3M-09-19	8	2	0.0	0	84.4	0	0.0	1.86	Very Poor
16-R3M-14-19	16	4	0.0	0	59.3	1	5.6	2.71	Poor
16-R3M-15-19	8	1	0.0	0	67.6	0	0.0	1.57	Very Poor
18-L1M-02-19	20	2	2.5	1	4.2	1	17.6	3.00	Fair
18-L1M-03-19	12	1	0.0	0	0.0	1	4.7	1.57	Very Poor
18-L2M-01-19	18	2	0.0	0	2.1	1	7.4	2.14	Poor
18-L2M-02-19	29	3	6.5	1	14.0	1	10.3	3.57	Fair
18-R3M-01-19	16	5	0.0	0	4.7	0	1.9	2.14	Poor
18-R3M-02-19	18	3	0.0	0	22.8	0	8.8	2.43	Poor
18-R3M-03-19	25	5	1.9	1	17.9	2	16.0	4.14	Good
18-R3M-04-19	30	1	0.0	0	14.7	1	4.6	2.43	Poor
19-L2M-01-18	22	6	10.1	2	19.3	5	29.4	4.43	Good
19-R3M-01-18	15	1	0.0	0	0.0	1	10.9	2.14	Poor
19-R3M-03-18	17	0	0.0	0	1.8	0	5.5	1.57	Very Poor
19-R3M-06-18	17	2	0.0	0	4.5	1	10.9	2.43	Poor
19-L2M-07-18	17	1	0.0	0	1.8	1	9.0	2.14	Poor
19-R3M-07-18	23	3	8.3	1	10.1	1	15.6	3.57	Fair
19-L1M-03-18	25	8	13.3	2	22.5	4	34.2	4.71	Good
19-L1M-01-18	20	6	8.7	2	12.6	1	20.4	3.86	Fair

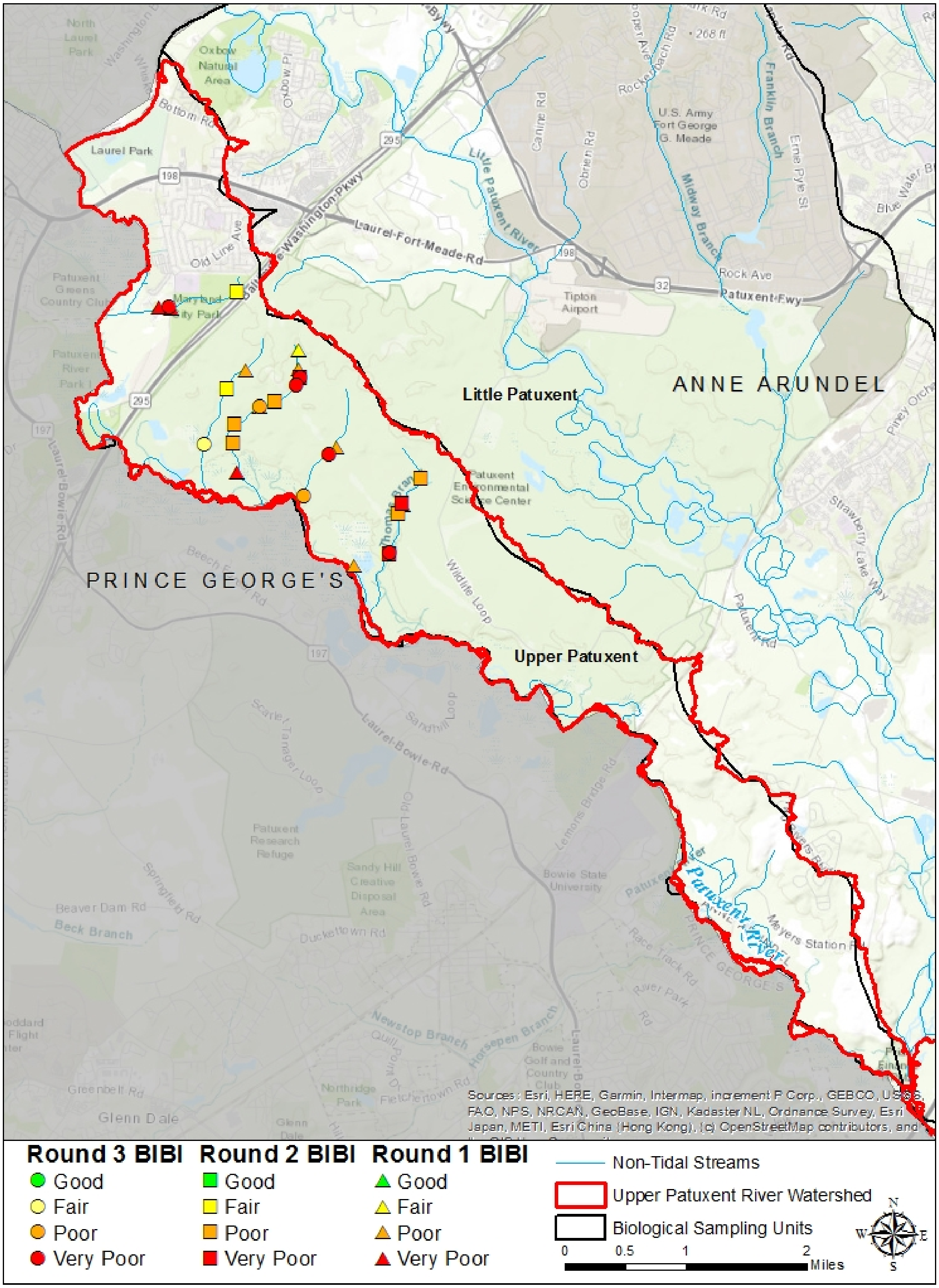

Figure 3: Biological Sampling Results in the Upper Patuxent PSU (2004 - 2019).

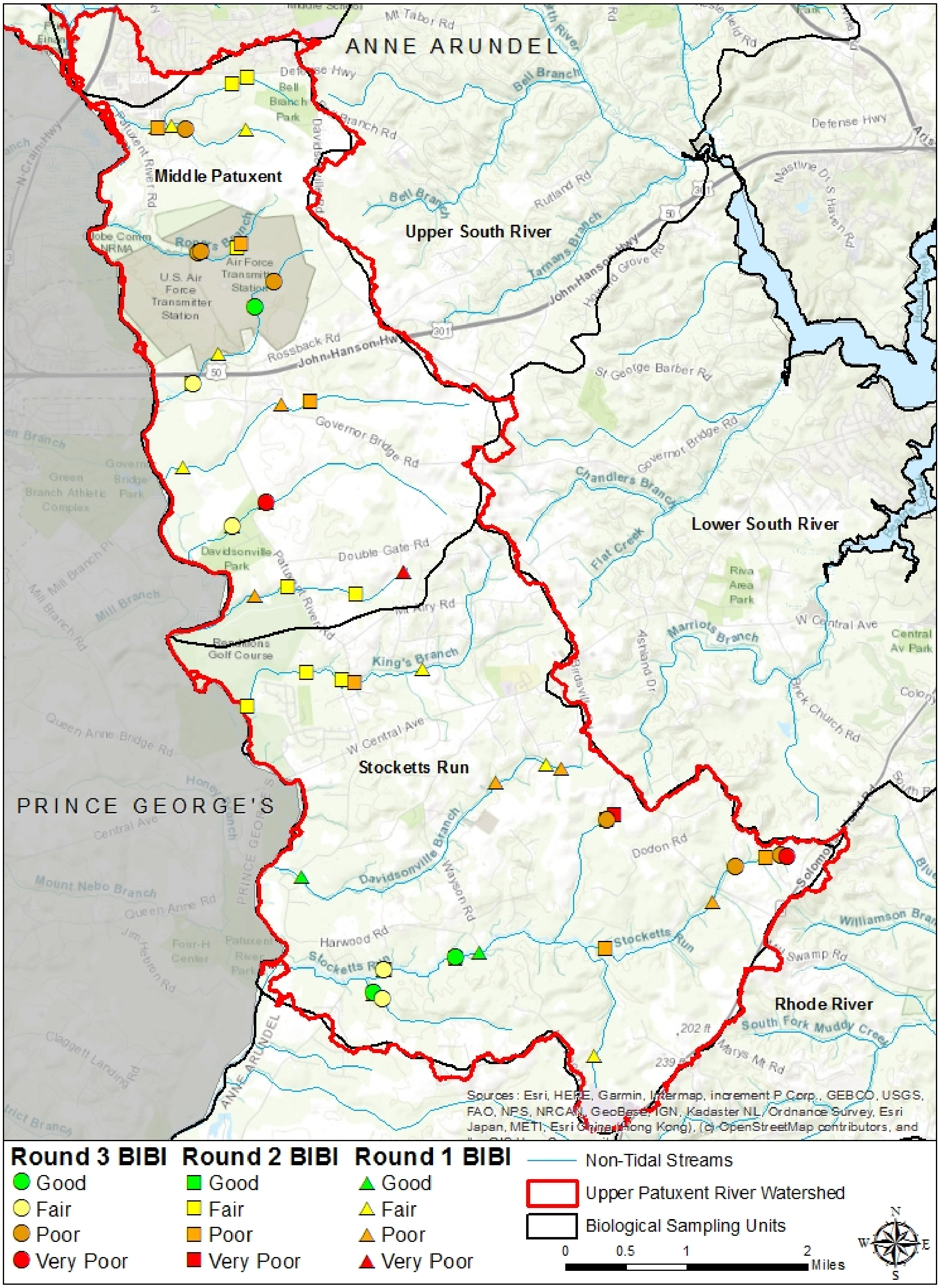

Figure 4: Biological Sampling Results in the Middle Patuxent and Stocketts Run PSU (2004 - 2019).

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 are presented in Figure 5 for the Upper Patuxent PSU and Figure 6 for the Middle Patuxent and Stocketts Run PSUs. The MPHI rated 50% of sites "Partially Degraded," 30% as "Minimally Degraded," 17% "Degraded" and 3% "Severely Degraded." All three PSUs received a narrative habitat condition rating of "Partially Degraded" during Round 1. The Middle Patuxent PSU received the highest mean MPHI score of 79.15 ± 6.68, followed by Upper Patuxent (75.88 ± 12.97) and Stocketts Run (68.99 ± 10.12).

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
16-01	2007	75.39	100.00	56.19	86.94	84.77	70.71	79.00	Partially Degraded
16-02	2007	75.39	100.00	66.59	85.02	76.74	63.25	77.83	Partially Degraded
16-03	2007	0.00	49.95	53.86	61.08	62.97	77.46	50.89	Severely Degraded
16-05	2007	26.93	78.67	90.58	100.00	78.04	77.46	75.28	Partially Degraded
16-10	2007	80.78	100.00	44.29	69.85	99.08	70.71	77.45	Partially Degraded
16-11A	2007	80.78	100.00	84.10	100.00	100.00	74.16	89.84	Minimally Degraded
16-12A	2007	10.77	84.56	47.90	60.84	71.58	54.77	55.07	Degraded
16-13A	2007	86.16	100.00	34.72	97.23	83.66	89.45	81.87	Minimally Degraded
16-14A	2007	80.78	100.00	91.12	100.00	83.16	74.16	88.20	Minimally Degraded
16-16A	2007	80.78	100.00	69.71	100.00	95.21	54.77	83.41	Minimally Degraded
18-02	2004	75.39	99.94	86.00	73.46	55.29	67.08	76.19	Partially Degraded
18-03	2004	53.85	99.94	89.33	91.76	59.86	83.67	79.73	Partially Degraded
18-04	2004	86.16	100.00	85.23	79.77	52.73	100.00	83.98	Minimally Degraded
18-05	2004	26.93	91.34	57.56	81.57	79.50	100.00	72.82	Partially Degraded
18-06	2004	96.93	100.00	100.00	100.00	55.50	100.00	92.07	Minimally Degraded
18-07	2004	43.08	78.67	50.00	86.34	78.20	80.63	69.49	Partially Degraded
18-09	2004	37.70	78.67	100.00	100.00	67.65	74.16	76.36	Partially Degraded
18-11A	2004	53.85	100.00	100.00	100.00	65.03	89.45	84.72	Minimally Degraded
18-12A	2004	64.62	78.67	100.00	100.00	63.45	83.67	81.74	Minimally Degraded
18-20A	2004	75.39	99.94	75.75	60.93	50.53	83.67	74.37	Partially Degraded
19-01	2005	42.39	78.67	84.81	79.10	72.70	77.46	72.52	Partially Degraded
19-02	2005	80.05	63.55	84.74	77.02	73.80	82.67	76.97	Partially Degraded
19-03	2005	45.82	49.95	40.87	45.86	100.00	78.00	60.08	Degraded
19-04	2005	59.13	78.67	31.74	31.51	96.23	79.06	62.72	Degraded
19-05	2005	73.92	68.32	47.01	46.37	94.91	80.63	68.53	Partially Degraded

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
19-06	2005	81.26	78.67	58.49	31.48	63.87	70.71	64.08	Degraded
19-07	2005	71.68	84.56	100.00	100.00	99.77	95.31	91.89	Minimally Degraded
19-08	2005	59.13	68.32	76.15	72.66	60.10	84.66	70.17	Partially Degraded
19-09	2005	37.50	78.67	66.70	68.90	61.42	89.45	67.10	Partially Degraded
19-10	2005	28.28	58.94	44.12	75.49	50.74	77.46	55.84	Degraded

Results of the Round 2 habitat assessments are presented in Table 15. The MPHI rated 57% of sites "Partially Degraded," 30% as "Minimally Degraded," and 13% as "Degraded." There were no sites rated "Severely Degraded" in Round 2. Upper Patuxent received the highest average MPHI score of all PSUs during Round 2, with a mean MPHI score of 85.3 ± 6.3 and a corresponding narrative rating of "Minimally Degraded." Both Middle Patuxent and Stocketts Run PSUs received "Partially Degraded" narrative ratings, with mean MPHI scores of 75.0 ± 10.4 and 68.0 ± 5.6, respectively.

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
16-01	2011	100.0	91.34	91.04	98.02	75.88	100.0	92.7	Minimally Degraded
16-03	2011	100.0	99.94	94.31	88.47	65.55	86.61	89.1	Minimally Degraded
16-04	2011	80.78	99.94	59.60	68.12	91.91	63.25	77.2	Partially Degraded
16-05	2011	100.0	73.32	81.46	86.54	84.12	100.0	87.5	Minimally Degraded
16-06	2011	96.93	99.94	82.44	82.53	68.07	86.61	86.0	Minimally Degraded
16-08	2011	75.39	99.94	100.0	94.61	66.20	70.71	84.4	Minimally Degraded
16-09	2011	100.0	99.94	97.10	92.86	82.23	100.0	95.3	Minimally Degraded
16-11A	2011	80.78	91.34	88.26	86.14	72.28	83.67	83.7	Minimally Degraded
16-12A	2011	32.31	99.94	85.36	81.58	82.03	77.46	76.4	Partially Degraded
16-15A	2011	37.70	99.94	88.24	93.26	89.47	70.71	79.8	Partially Degraded
18-02	2010	80.78	91.34	77.32	80.04	79.89	74.16	80.5	Partially Degraded
18-03	2010	43.08	91.34	69.95	72.04	83.08	59.16	69.7	Partially Degraded
18-04	2010	86.16	99.94	67.05	63.55	71.62	77.46	77.6	Partially Degraded
18-05	2010	80.78	68.32	68.22	70.93	70.68	83.67	73.7	Partially Degraded
18-06	2010	59.24	91.34	37.43	36.87	54.60	31.62	51.8	Degraded
18-07	2010	53.85	91.34	88.98	83.69	78.22	77.46	78.9	Partially Degraded
18-08	2010	86.16	99.94	61.33	58.14	77.69	74.16	76.2	Partially Degraded

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
18-09	2010	86.16	99.94	100.0	94.70	92.93	63.25	89.5	Minimally Degraded
18-10	2010	53.85	91.34	64.64	56.18	51.42	89.45	67.8	Partially Degraded
18-11A	2010	59.24	99.94	96.20	85.89	89.53	74.16	84.1	Minimally Degraded
19-02	2013	64.62	84.56	48.66	48.97	83.00	31.62	60.2	Degraded
19-03	2013	86.16	84.56	72.68	67.20	54.07	54.77	69.9	Partially Degraded
19-04	2013	70.01	84.56	79.68	69.07	73.88	77.46	75.7	Partially Degraded
19-05	2013	64.62	84.56	64.21	66.25	95.75	31.62	67.8	Partially Degraded
19-06	2013	64.62	91.34	78.73	73.13	54.49	70.71	72.1	Partially Degraded
19-07	2013	59.24	68.32	78.86	69.75	77.16	63.25	69.4	Partially Degraded
19-08	2013	26.93	49.95	77.88	66.24	64.84	77.46	60.5	Degraded
19-10	2013	70.01	49.95	67.76	62.69	100.0	70.71	70.1	Partially Degraded
19-11A	2013	26.93	63.55	79.21	68.33	55.32	70.71	60.6	Degraded
19-16A	2013	75.39	78.67	78.27	68.83	79.09	59.16	73.2	Partially Degraded

Results of the Round 3 habitat assessments are presented in Table 16. During Round 3, the MPHI rated 63% of sites “Partially Degraded,” 17% as “Minimally Degraded,” and 21% as “Degraded.” There were no sites rated “Severely Degraded” in Round 3. Upper Patuxent received the highest average MPHI score of all PSUs during Round 3, with a mean MPHI score of 75.55 ± 6.69 and a corresponding narrative rating of “Partially Degraded.” Both Middle Patuxent and Stocketts Run PSUs received “Partially Degraded” narrative ratings, with mean MPHI scores of 68.13 ± 7.49 and 71.77 ± 6.26, respectively.

Table 16: Physical Habitat Index Data from Round 3 (2018-2019).

Station	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
16-L1M-01-19	25.64	78.67	48.37	72.67	84.23	71.07	63.44	Degraded
16-L1M-02-19	54.32	84.56	43.01	56.73	90.92	73.49	67.17	Partially Degraded
16-L2M-01-19	65.35	58.94	76.23	93.00	100.0	90.00	80.58	Partially Degraded
16-L2M-02-19	64.97	99.94	53.65	58.78	100.0	80.31	76.27	Partially Degraded
16-R3M-02-19	69.83	91.34	59.17	88.03	100.0	82.57	81.82	Minimally Degraded
16-R3M-09-19	45.82	68.32	90.31	100.0	100.0	81.55	81.00	Minimally Degraded
16-R3M-14-19	100.0	99.94	47.55	43.65	85.77	91.47	78.06	Partially Degraded
16-R3M-15-19	60.78	99.94	53.03	57.80	100.0	82.46	75.67	Partially Degraded
18-L1M-02-19	50.02	91.34	71.65	69.16	94.91	93.46	78.42	Partially Degraded

Station	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
18-L1M-03-19	40.76	73.32	66.40	81.14	78.14	80.63	70.07	Partially Degraded
18-L2M-01-19	59.13	99.94	54.18	61.57	100.0	43.40	69.70	Partially Degraded
18-L2M-02-19	36.34	78.67	53.12	56.34	100.0	57.16	63.60	Degraded
18-R3M-01-19	50.84	99.94	54.04	50.26	100.0	0.00	59.18	Degraded
18-R3M-02-19	35.14	99.94	52.98	48.60	64.40	41.63	57.11	Degraded
18-R3M-03-19	41.78	73.32	82.94	83.31	100.0	67.95	74.88	Partially Degraded
18-R3M-04-19	65.72	84.56	55.99	64.42	100.0	63.12	72.30	Partially Degraded
19-L1M-01-18	51.66	68.32	100.0	85.42	61.28	73.03	73.28	Partially Degraded
19-L1M-03-18	78.93	91.34	92.81	75.02	100.0	91.65	88.29	Minimally Degraded
19-L2M-01-18	35.86	73.32	100.0	91.93	71.22	85.44	76.30	Partially Degraded
19-L2M-07-18	78.21	78.67	69.35	65.19	100.0	91.84	80.54	Partially Degraded
19-R3M-01-18	56.27	45.47	61.00	68.71	100.0	62.05	65.58	Degraded
19-R3M-03-18	54.93	91.34	67.30	78.61	100.0	80.42	78.77	Partially Degraded
19-R3M-06-18	50.84	84.56	83.96	55.22	83.77	49.33	67.95	Partially Degraded
19-R3M-07-18	94.87	84.56	75.66	86.57	81.18	87.47	85.05	Minimally Degraded

4.1.4 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). Only one PSU, Stocketts Run, saw a statistically significant change in mean BIBI scores between Round 1 (3.51) and Round 2 (2.60), resulting in a downgrade in biological condition from "Fair" to "Poor." As noted in the Round 2 Report (Hill et al. 2014), there were no significant differences in either RBP or MPHI habitat scores in Stocketts Run, suggesting that the observed changes were not the result of degraded physical habitat conditions. However, statistically significant differences were observed in conductivity values for Stocketts Run between sampling rounds. Stocketts Run saw mean conductivity values jump from 171.40 µS/cm in Round 1 (2005) to 242.73 µS/cm in Round 2 (2013). This suggests increases in conductivity support the notion that changing water quality conditions are most likely responsible for the observed shift in biological conditions observed in this PSU. Since there we no statistically significant differences in the percentage of impervious surface or drainage area to each sampling location, the changes in water quality conditions are not likely attributed to changes in land use between rounds. It is plausible that differences in salt usage for roadway de-icing between sampling years may be responsible for the observed differences in stream conductivity, and subsequently decreased BIBI scores. However, results of Round 3 sampling in Stocketts Run showed an improvement in the mean BIBI score that resulted in an increase back up to a 'Fair' biological condition, although it was not considered a statistically significant increase. No statistically significant changes were observed in Round 3 in Middle Patuxent or Upper Patuxent PSUs.

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.

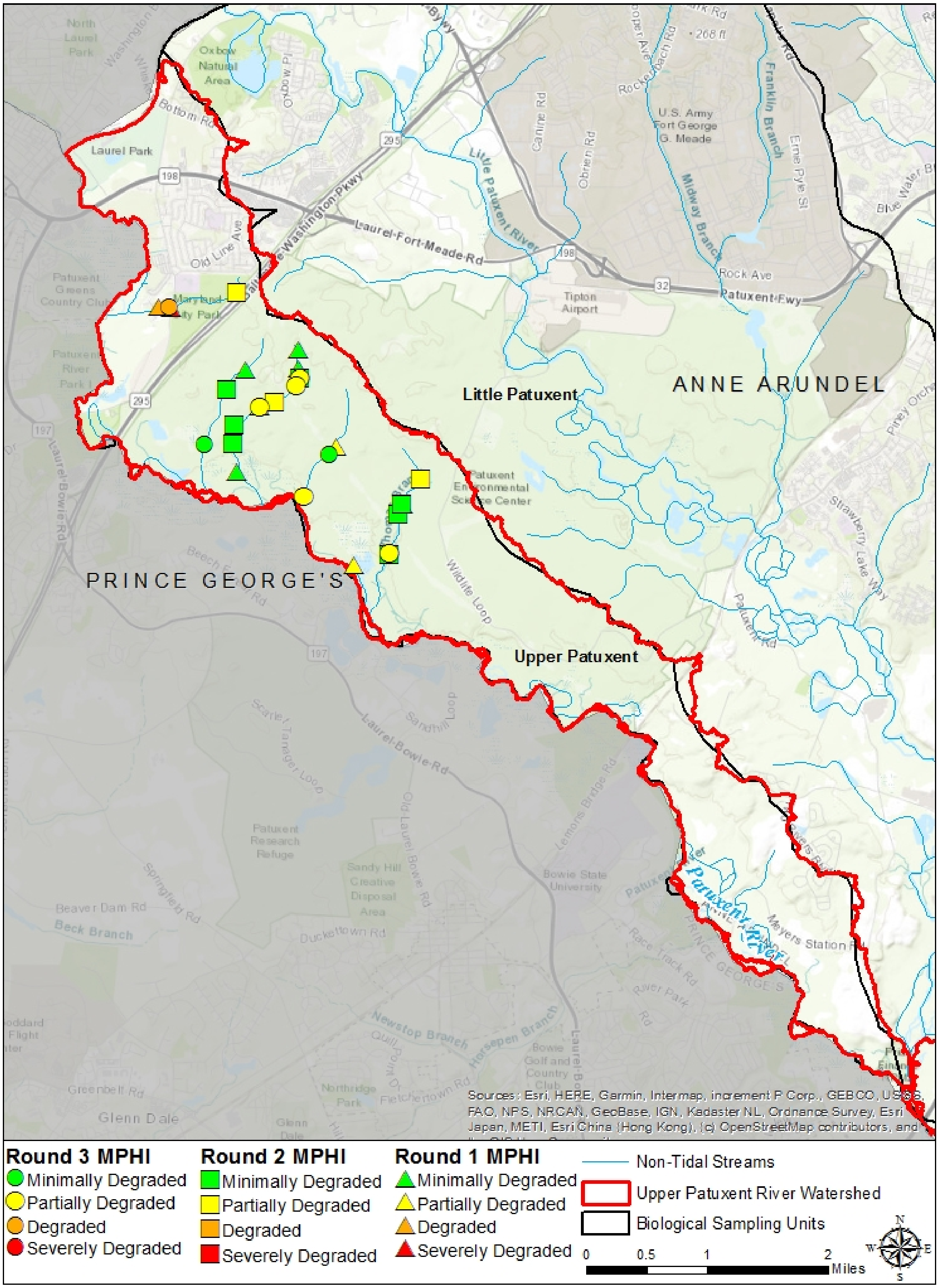

Figure 5: Physical Habitat Assessment Results in the Upper Patuxent PSU (2004 - 2019).

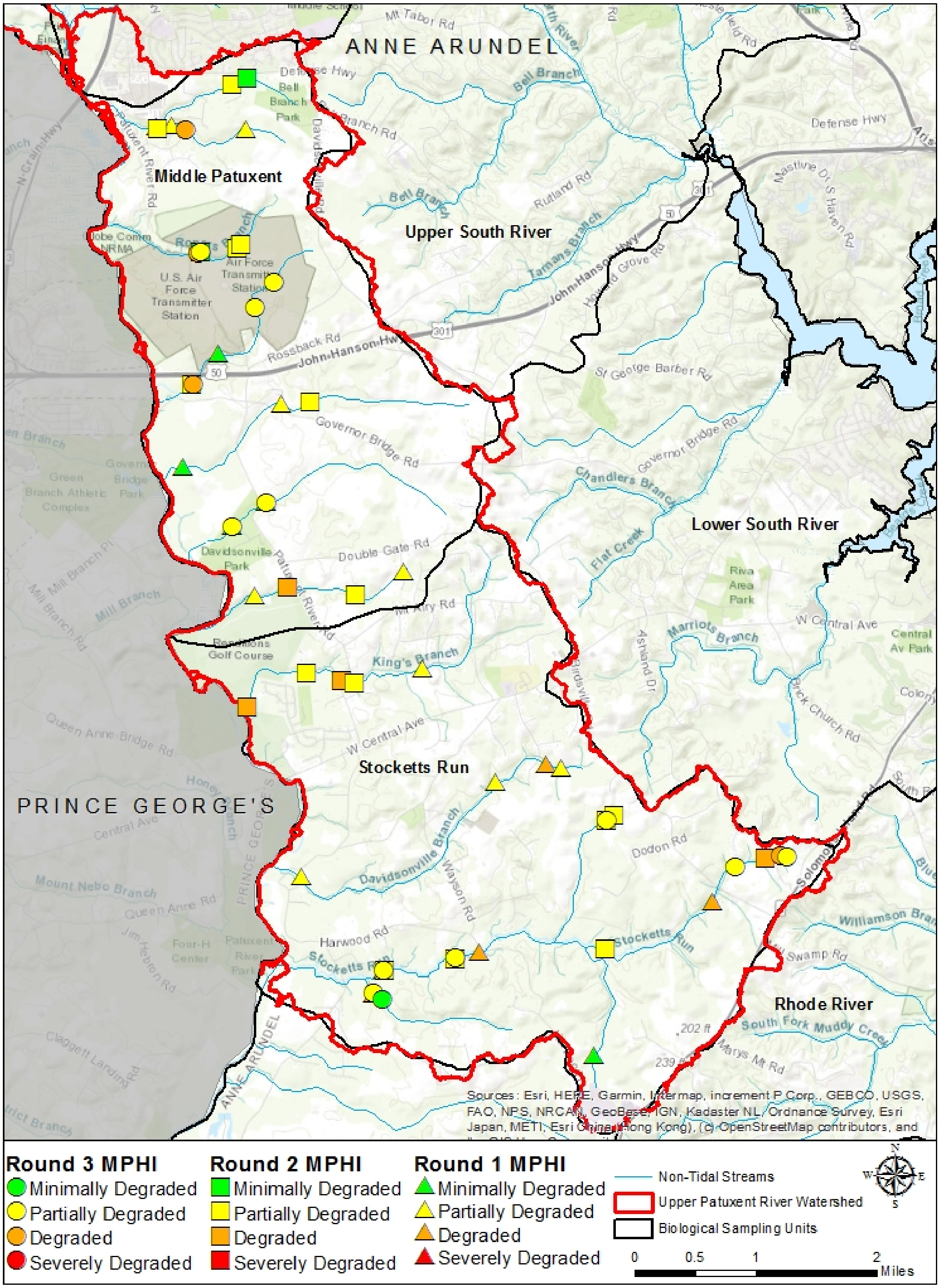

Figure 6: Physical Habitat Assessment Results in the Middle Patuxent and Stocketts Run PSUs (2004 - 2019).

5 Conclusion

This Upper Patuxent River 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 $885,780 dollars in FY2020 in capital and operational costs in the Upper Patuxent watershed to address the TMDL. With those funds, the County is implementing programmatic practices including inlet cleaning and street sweeping. Load reductions are at 3.8% on a total goal of 11.4% and the County is on track to meet the load reduction with planned projects before the 2025 date set in the County's plan. After three rounds of sampling, biological stream monitoring data indicates a watershed that remains in fair to poor biological health. No overall biological condition trends were observed in any of the three PSUs between Round 1 and Round 3. Changes in mean BIBI scores over time were not statistically significant, with the exception of Stocketts Run which saw a significant decrease from Round 1 to Round 2 before increasing back to "Fair" condition in Round 3.

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.

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