2019 Annual Baltimore Harbor Nutrient TMDL Assessment

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Prepared For

Anne Arundel County
Watershed Protection and Restoration Program
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List of Acronyms

BayFAST	Chesapeake Bay Facility Assessment Scenario Tool
BMP	Best Management Practices
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
DEL	Delivered
DPW	Department of Public Works
EOR	Edge of River
EOS	Edge of Stream
MAST	Maryland Assessment Scenario Tool
MDE	Maryland Department of the Environment
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyls
SPSC	Step Pool Storm Conveyance
SW to the MEP	Stormwater to the Maximum Extent Practicable
SW-WLA	Stormwater Wasteload Allocation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
EPA	United States Environmental Protection Agency
WLA	Wasteload Allocation
WPRP	Watershed Protection and Restoration and Program

1 Introduction

1.1 Background

The Anne Arundel County Department of Public Works (DPW) Watershed Protection and Restoration Program (WPRP) 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, 2006). 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 five final approved TMDLs within the Patapsco River Mesohaline Stream Segment, hereafter referred to as the Baltimore Harbor Watershed, for which Anne Arundel County has some responsibility; a total suspended solids (TSS; sediment) TMDL for the Patapsco River Lower North Branch approved in 2001, an *Escherichia coli* TMDL for the Patapsco River Lower North Branch approved in 2009, a nitrogen TMDL approved in 2007, a phosphorus TMDL approved in 2007, and a Polychlorinated Biphenyls (PCB) TMDL approved in 2012. These TMDLs apply to several jurisdictions including Baltimore City, Baltimore, Carroll, Howard, and Anne Arundel Counties. Anne Arundel County WPRP developed a TMDL restoration plan dealing with both total nitrogen (TN) and phosphorus (TP) (referred to in this document collectively as the nutrient 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 Baltimore Harbor Watershed nutrient TMDL under the responsibility of Anne Arundel County. The sedimentation/siltation, *E. coli* and PCB TMDLs are being addressed by Anne Arundel County in separate plans.

Responsibility for Baltimore Harbor Watershed nutrient 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 wasteload 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 in its final form by the MDE in February of 2014 required 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 progress with implementation, pollutant load reductions, and program costs (permit section (IV.E.4). The *Baltimore Harbor Watershed Nutrient TMDL Restoration Plan* (the plan) (Anne Arundel County, 2016) satisfied the permit planning requirement and this *2019 Baltimore Harbor Nutrient TMDL Annual Assessment Report* satisfies the progress documentation requirement.

1.2 Watershed Description

The Baltimore Harbor Watershed consists of two of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the northern portion of the County (Figure 1). The watershed shares political boundaries with Baltimore City, Baltimore, Carroll, and Howard Counties. The Baltimore Harbor Watershed is a part of the Chesapeake Bay watershed with the Baltimore Harbor joining the Chesapeake Bay at North Point near Fort Howard and Rock Point near Fort Smallwood.

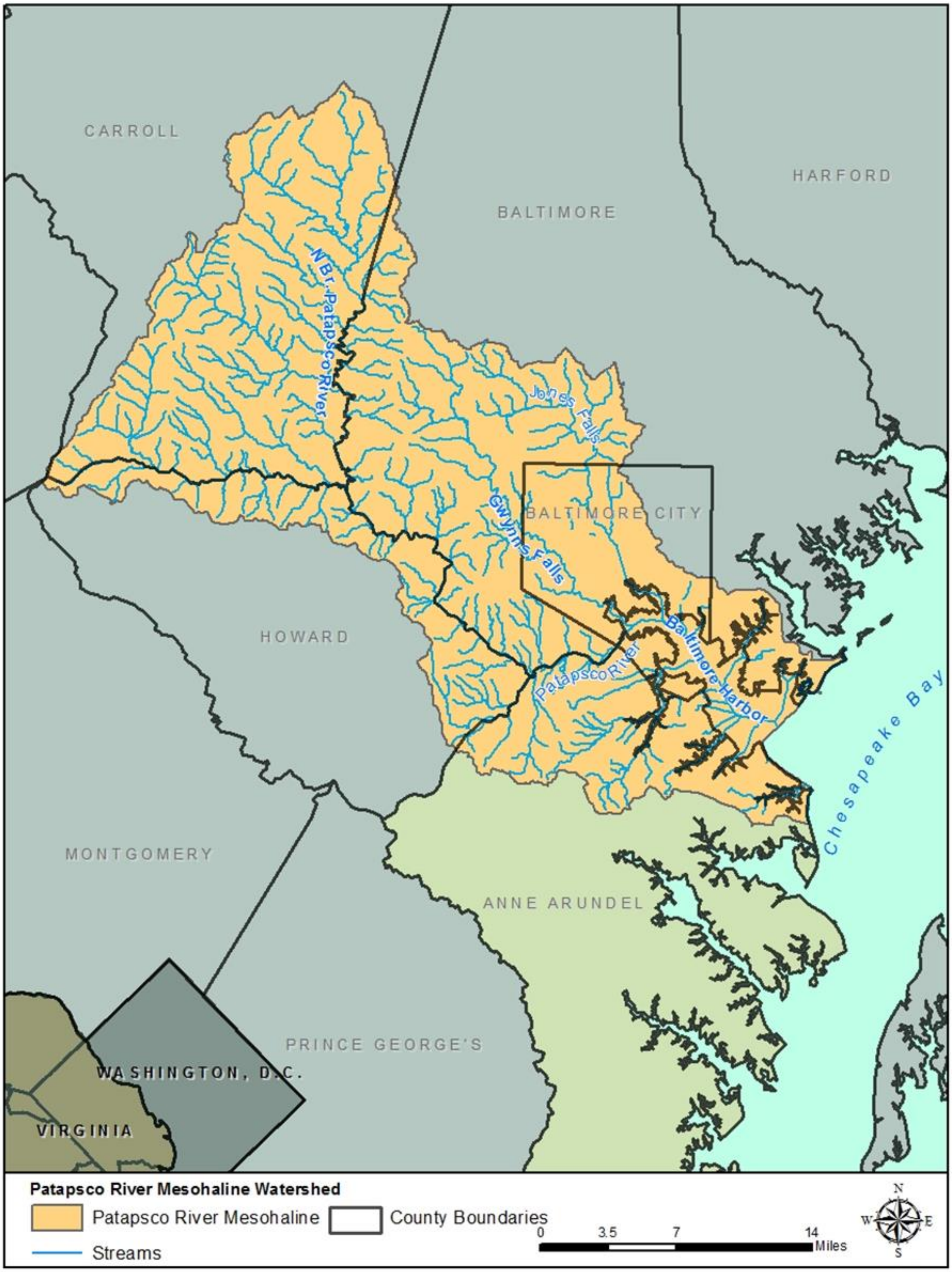

Figure 1: Watershed Location Map

The Baltimore Harbor watershed in Anne Arundel County is approximately 45,134 acres (70.5 square miles) in area and contains approximately 202 total miles of stream reaches. The watershed includes several named streams including Back Creek, Cabin Branch, Cox Creek, Curtis Creek, Deep Run, Furnace Creek, Holly Creek, Marley Creek, Nabbs Creek, Patapsco River Lower North Branch Mainstem, Piney Run, Rock Creek, Sawmill Creek, Stoney Run, Swan Creek, and the mainstem of the tidal Patapsco River.

Communities within the Baltimore Harbor watershed include Hanover, Linthicum Heights and Severn.

1.3 TMDL Allocation and Planned Loads Summary

This section describes the derivation of the TMDL reduction targets. SW-WLAs in the nutrient TMDL were developed using the Chesapeake Bay Program Phase 5 (CBP P5) watershed model. Baseline, progress, and planned loads were modeled in the past (2015 through 2018) using BayFAST (Chesapeake Bay Facility Assessment Scenario Tool) and MAST (Maryland Assessment Scenario Tool). BayFAST function was ended in early 2018 and not available for modeling FY2017 through FY2019 progress; therefore, FY2017 and FY2018 progress was modeled using MAST, which was compatible with BayFAST and built on Bay model version P5.3.2. MAST availability ended in early 2019 consequently this FY2019 progress reflects the County's first use of Chesapeake Assessment Scenario Tool (CAST) Chesapeake Bay Program Watershed Model Phase 6 (CBP WM P6) model.

CAST, created by the Chesapeake Bay Program, is a web-based pollutant load estimating tool that calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Phase 6 Model. See section 1.5 below for more 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 1995 baseline nutrient load was re-calculated in CAST by modeling baseline BMPs in Baltimore Harbor Watershed on top of baseline land use conditions.

The required reduction percent assigned to the Anne Arundel County Phase I MS4 source (15.0%) in the local TMDL regulation was then applied to the new baseline load to calculate required nutrient reduction. The required nutrient reduction was then subtracted from the baseline load to calculate the target SW-WLA. Nutrient loads required for the Baltimore Harbor Watershed Anne Arundel County Phase I MS4 source are shown in Table 1, which compares P5.3.2 results with P6 results.

Table 1: Nutrient Loads Required for the Baltimore Harbor Watershed Local TMDL

Model	1995 Baseline Load (lbs/yr)		Required Reduction %		Required Reductions (lbs/yr)		TMDL Load Allocation (SW-WLA) (lbs/yr)	
	TN	TP	TN	TP	TN	TP	TN	TP
P5.3.2	161,514	13,941	15.0%	15.0%	24,227	2,091	137,287	11,850
P6	228,361	11,888	15.0%	15.0%	34,254	1,783	194,107	10,105

1.4 Planned Reductions

Table 2 provides a concise summary of the loads and reductions at important timeline intervals including the 1995 baseline, 2019 progress, and 2030 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 definitions 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. Nutrient loads and wasteload allocations are presented as lbs/year. All loads presented below were calculated in CAST.

- **1995 Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from 1995 conditions in the Baltimore Harbor Watershed. Baseline loads were used to calculate the stormwater allocated nutrient loads, or SW-WLA.
- **2019 Progress Loads and Reductions**: Progress loads and load reductions achieved from stormwater best management practice (BMP) implementation through FY2019. The 2019 Progress Loads are calculated from the 1995 Baseline Loads by the following calculations: 2019 Progress Load = 1995 Baseline – 2019 Progress Reduction.
- **2030 Allocated Load**: Allocated loads are calculated from the 1995 baseline levels, calibrated to CBP Phase 6 as noted above, using the following calculation: 2030 Allocated Load = 1995 Baseline – (1995 Baseline x 0.15).
- **2030 Planned Loads and Planned Reductions**: Loads and reductions that will result from implementation of this plan. The 2030 Planned Loads are calculated from the 1995 Baseline Loads by the following calculation: 2030 Planned Load = 1995 – 2030 Planned Reduction.

Table 2: Baltimore Harbor Watershed Local TMDL Allocated and Planned Loads

	Nitrogen (lbs/year)	Phosphorus (lbs/year)
1995 Baseline Loads	228,361	11,889
FY2019 Progress Loads	218,937	11,140
FY2019 Progress Reductions	9,424	749
FY2030 Planned Loads*	191,161	7,745
FY2030 Planned Reductions	37,200	4,144
TMDL Allocated Loads	194,107	10,105
Required Percent Reduction	15.00%	15.00%
Planned Percent Reduction Achieved	16.29%	34.85%

*It is assumed that all new development will be treated with SW to the MEP implementation to achieve 50% nitrogen removal and 60% phosphorus removal and Accounting for Growth policies will address the remaining 50% and 40%, respectively.

1.5 Modeling Methods

1.5.1 Overview

The baseline, progress, and planned pollutant loads for the Baltimore Harbor watershed were determined using CAST, which calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership P6 Watershed Model. Modeling conducted in previous years had used BayFAST and MAST, which were both web-based pollutant load estimating tools.

The BayFAST model was shut down in early 2018 and MAST became unavailable in early 2019. CAST was released to replace 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. Local TMDL baseline loads were calibrated in CAST by modeling BMPs installed prior to the TMDL baseline year using a 1995 CAST Progress Scenario on top of baseline year (1995) land use background loads. This ensures that the same set of baseline BMPs are used throughout future progress and planned scenarios. BMPs are entered at the land-river segment scale in CAST. The target nutrient load (i.e., local TMDL SW-WLA) was calculated by multiplying the local TMDL target reduction percent with the CAST baseline load to first calculate a calibrated reduction target. This reduction target was then subtracted from the baseline load modeled in CAST to determine the TMDL load allocation.

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 at the end. The overall the load reduction can vary depending on which BMPs are implemented.

CAST provides load outputs at two different scales: Edge-of-Stream (EOS) and Delivered (DEL). Delivered loads incorporate in-stream nutrient processing, 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. The DEL scale is used in Bay TMDL modeling. The EOS scale is used in some local TMDLs and models the land-to-water effect of transport processes to small streams. A stream-to-river delivery factor (edge of river; EOR) is available for each land-river segment of the Bay watershed and can be applied to the EOS loads to account for the fate and transport of nutrients and sediment through denitrification, bank erosion, floodplain deposition, and reservoir deposition (Chesapeake Bay Program, 2017). Rather than focusing on the loads to the small tributary streams of the watershed, this TMDL plan focuses on reducing the nutrient load to the Baltimore Harbor, so the EOR scale is more appropriate and was used for all the modeling analysis.

1.5.1 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 loads from agriculture, natural, MS4, and non-regulated developed land areas, and therefore needs to be disaggregated for a single source sector, like MS4s.

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 calculations for TN and TP are as follows:

TN STB load = (Scenario EOS without STB TN / CAL EOS without STB TN) * STB base TN
TP STB load = (Scenario EOS without STB TP / CAL EOS without STB TP) * STB base TP

Where:
EOS = edge-of-stream
STB = stream bed and bank load source
TN = total nitrogen
TP = total phosphorus
CAL = calibration average

These equations are 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).

1.5.2 Practice Level

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

1.5.2.1 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. 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.
- **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 their NPDES stormwater permits. Nutrient reduction credit is based on the mass of material collected, at the rate of 4.44 lbs TN and 0.48 lbs TP per ton of organic material

and 3.78 lbs TN and 0.84 lbs TP per ton of inorganic material (MDE, 2019). Data for the mass removed was reported from 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

- **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 bioswales.
- **Permeable Pavement -** Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.
- **Street sweeping** — Starting Fiscal Year 2015, Anne Arundel County enhanced their street sweeping program which now includes sweeping curb-miles and parking lots within the Baltimore Harbor Watershed (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 efficiencies of 2% reduction for TN and 5% for TP for street swept every two weeks (MDE, 2019). Data for the curb miles swept and frequency (1 pass/2 weeks) was reported from 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 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 rate 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, includes bioswales. 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 measured effectiveness for each of these practices are found in Table 3.

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

BMP	Nitrogen Reduction	Phosphorus Reduction
Bioretention A/B soils, no underdrain	80%	85%
Bioretention C/D soils, underdrain	25%	45%
Bioswales	70%	75%
Dry Detention Ponds	5%	10%
Dry Extended Detention Ponds	20%	20%
Impervious Surface Reduction[1]	-	-
Infiltration w/ sand, A/B soils, no underdrain	85%	85%
Outfall Enhancement with SPSC[2]	70%	75%
Permeable Pavement, w/o sand, veg, C/D soils, underdrain	10%	20%
Rain Gardens	70%	75%
Stream Restoration[3]	0.075 lbs/linear ft	0.068 lbs/linear ft
Filtering Practices	40%	60%
Urban Tree Plantings[1]	-	-
Vegetated Open Channels, A/B soils, no underdrain	45%	45%
Wet Ponds or Wetlands	20%	45%
Inlet Cleaning – Organic	4.44 lbs/ton removed	0.48 lbs/ton removed
Inlet Cleaning – Inorganic	3.78 lbs/ton removed	0.84 lbs/ ton removed
Street Sweeping – 1 pass/2 weeks	2%	5%

Sources: CAST documentation

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

[2] Outfall enhancement with SPSC modeled as bioswales in CAST

[3] Stream restoration listed with revised interim rate; some stream restoration projects used Bay Program Protocols to calculate load reductions.

1.5.2.2 Modeled using MDE Guidance

Urban stream restoration and shoreline stabilization load reductions are modeled outside of CAST using MDE's 2019 accounting guidance and Bay Program methods. The methods are compatible with Phase 6 of the Bay Model.

- **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, help improve habitat and water quality conditions in degraded streams. These projects were modeled outside of CAST using load reductions at the rate of 0.075 lbs TN per linear foot and 0.068 lbs TP per linear foot (MDE, 2019), and project specific load reductions calculated using the Bay Program's Protocol method were used when available.
- **Shoreline Stabilization** – Anne Arundel County has implemented three shoreline stabilization projects in the Baltimore Harbor Watershed. These projects were modeled outside of CAST using load reductions at the rate of 0.086 lbs TN per linear foot and 0.061 lbs TP per linear foot (MDE, 2019).

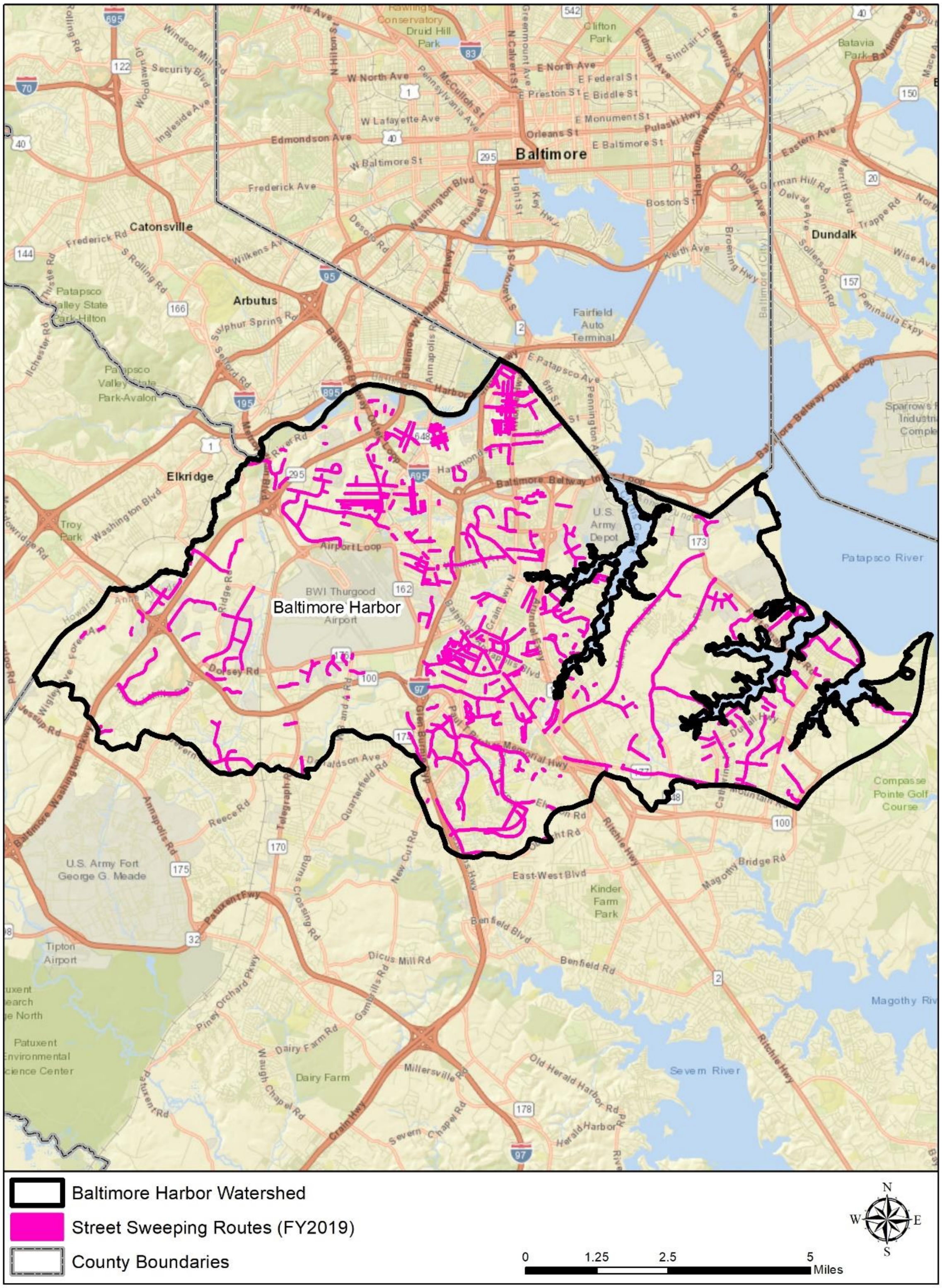

Figure 2: Street Sweeping Routes in Baltimore Harbor Watershed, Anne Arundel County, Maryland

2 2019 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 1995 Progress Scenario used to develop the Baseline loads is presented in Table 4. Implementation up through the end of fiscal year 2019 is detailed in Table 5. Information on completed projects and programs is gleaned entirely from the County's MS4 geodatabase. All FY2019 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 FY2019 (Oakview Village Northern). This project restored 1,056 linear feet of stream.

Wet Ponds
Four wet pond retrofit projects were completed in the watershed in FY2019.

Outfall Stabilization
Two outfall stabilization projects were completed in FY2019, totaling 505ft (8289 Elvaton Rd and Mulberry Rd).

Inlet Cleaning
A total of 330 inlets cleaning records using storm drain vacuuming were recorded in FY2019.

Street Sweeping
Building upon the County's enhanced street sweeping program, 157.5 curb miles were swept in the watershed during FY2019. The total mass of material collected by the street sweeping program during that period was 198.57 tons.

The total cost of the practices and programs implemented in FY2019 is $ 4,727,566.

Table 4: Baseline BMP implementation

BMP	Unit	1995 Baseline
Structural Permanent Practices		
Runoff Reduction Performance Standard	acre	0.7
Stormwater Treatment Performance Standard	acre	809.9
Dry Ponds	acre	157.3
Extended Detention Dry Ponds	acre	25.9
Infiltration	acre	107.6
Permeable Pavement	acre	0.93
Wet Ponds or Wetlands	acre	14.2
Annual Practices		
Inlet Cleaning	inlets/yr	0.0
Street Sweeping	lbs /yr	0.0

Table 5: Current BMP Implementation through FY2019

BMP	Unit	1996 - 2015 Restoration[1]	2016 Restoration[1]	2017 Restoration[1]	2018 Restoration[1]	2019 Restoration[1]	2019 Progress[2]	2019 Restoration Cost[3]
Structural Permanent Practices								
Runoff Reduction Performance Standard	acre	0	0	0	0	0	0	
Stormwater Treatment Performance Standard	acre	0	0	0	0	0	0	
Bioretention	acre	0	0	0	0	0	0	
Bioswale	acre	0	0	0.6	0	0	0.6	
Dry Ponds	acre	0	0	0	0	0	0	
Extended Detention Dry Ponds	acre	0	0	0	0	0	0	
Impervious Surface Reduction	acre	0.1	0	0	0	0	0.1	
Infiltration	acre	0	0	68.0	53.4	0	121.4	
Outfall Enhancement with SPSC	acre	0	31.7	18.4	41.9	0	92.0	
Outfall Stabilization	linear ft	0	30	160	35	505	730	$ 626,693
Permeable Pavement	acre	0	0	5.8	0	0	5.8	
Rain Gardens	acre	0	0	1.0	0	0	1.0	
Shoreline Stabilization	linear ft	0	608.2	0	46	0	654.2	
Urban Stream Restoration	linear ft	500	0	0	440	1,056	1,996	$ 1,403,148
Wet Ponds or Wetlands	acre	43.7	44.7	77.5	64.7	287.3	517.9	$ 2,164,620
Annual Practices								
Inlet Cleaning[4]	inlets/yr	729	0	118	452	330	330	$ 366,305
Street Sweeping[4]	lbs /yr	NA	NA	505,073	328,113	397,142	397,142	$ 166,800
							Total FY2019 Cost	$ 4,727,566

Source: MDE MS4 FY2019 geodatabase

[1] Restoration completed in each specific period, i.e. 1996-2015, 2016, 2017, 2018, and 2019.

[2] Total cumulative restoration accounting for the full 1995-2019 period.

[3] Cost of projects and programs for the FY2019 period only. Only costs using County funds are included.

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

[5] Value listed here is the lbs of material removed.

2.2 Load Reduction Results

The implementation summarized in Table 5 above resulted in the load reductions presented here in Table 6.

Of the 9,424 lbs of nitrogen progress reduction achieved through FY2019, 39 lbs (0.4% of the total reduction) are being removed by shoreline stabilization, and 703 lbs (7.5%) is accounted for by urban stream restoration. Of the 749 lbs of phosphorus progress reduction achieved through FY2019, 56 lbs (7.5% of the total reduction) are being removed by shoreline stablization, and 304 lbs (40.6%) is accounted for by urban stream restoration. The remainder is being reduced by the suite of restoration projects.

Table 6: 2019 Progress Reductions Achieved

Baseline Load and TMDL SW-WLA	TN-EOS lbs/yr	TP-EOS lbs/yr
1995 Baseline Scenario Load	228,361	11,888
Required Percent Reduction	15.0%	15.0%
Required Reduction	34,254	1,783
Local TMDL SW-WLA	194,107	10,105
2019 Results	**TN-EOS lbs/yr**	**TP-EOS lbs/yr**
Progress Scenario Load	218,937	11,140
Progress Reduction Achieved	9,424	749
Percent Reduction Achieved	4.1%	6.3%

3 2019 Progress Comparison

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 2019.

3.1 Implementation

Table 7 compares implementation of existing restoration BMPs up through fiscal year 2019 (2019 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 FY2023 from the County's MS4 geodatabase. Several of the strategies are more than half way to full implementation (wet ponds or wetlands, impervious surface reduction) and street sweeping is continuing at a rate greater than the initially prescribed rate.

Implementation of BMP retrofits to wet ponds/wetlands and infiltration is on-going. Implementation of SPSC outfall enhancement, and stream restoration projects are also on-going. Several BMP types were not initially planned for in the 2016 plan but were implemented in the watershed. Those project types include bioswales, outfall stabilization, permeable pavement, rain gardens, and shoreline stabilization.

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 729 inlets per year. The actual number of inlet cleaning records in the current reporting period is 330, however the mass of sediment extracted from those inlets exceeded the initial average inlet estimates therefore a significant drop in loads reduced by that practice did not occur.

Table 7: Restoration BMP Implementation - Current 2019 and Planned 2030 Implementation Levels

BMP	Units	Total Planned Restoration[1]	Total Planned – FY2023[2]	2019 Progress	Percent Complete[3]
Bioretention	acre	29.1	13.5	0	0%
Bioswale	acre	0	0	0.6	n/a
Dry Ponds	acre	37.1	0	0	n/a
Extended Detention Dry Ponds	acre	44.7	0	0	n/a
Impervious Surface Reduction	acre	0.1	0.1	0.1	100%
Infiltration	acre	86.2	349.9	121.4	34.7%
Outfall Enhancement with SPSC	acre	3,043.3	354.0	92.0	26.0%
Outfall Stabilization	linear feet	0	0	730	n/a
Permeable Pavement	acre	0	0	5.8	n/a
Rain Gardens	acre	0	0	1.0	n/a
Shoreline Stabilization	linear feet	0	4,334	654.2	15.1%
Urban Stream Restoration	linear feet	79,171.0	33,261	1,996	6.0%
Wet Ponds or Wetlands	acre	913.7	948.7	517.9	54.6%
Annual Practices					
Inlet Cleaning	inlets/yr	729	330	330	45.3%
Street Sweeping	curb-miles	96.1	157.5	157.5	164%

[1] Planned restoration totals used in 2016 restoration plan and BayFAST modeling.
[2] Planned restoration totals through FY2023 from County's current MS4 geodatabase and used in CAST modeling.
[3] Compares implementation progress through FY2019 to planned restoration totals through FY2023.

To track progress, the 2030 implementation milestone first reported in the 2016 plan was compared against the 2019 progress reported here in this assessment. Table 8 presents the strategies that are planned for the 2020-2030 milestone period.

Multiple BMP conversion projects (to wet ponds or wetlands) were completed in the FY 2019 period along with two outfall stabilization projects, and one stream restoration project. Both outfall stabilization projects were not initially planned for. Street sweeping continues at a rate greater than the prescribed rate and with better supporting information on measured quantities of curb miles swept is now yielding very good results. Inlet cleaning appears to be lower than planned, but measured mass removed from inlets shows a much larger removal of material than was initially planned for in the restoration plan. These programs are at maturity and will be maintained at this level of effort in the foreseeable future.

Table 8: Implementation Milestones Comparison

BMP	Unit	2019 Progress	2020 - 2030 Planned Restoration
Bioretention	acre	0	13.5
Bioswale	acre	0.6	0
Dry Ponds	acre	0	0

BMP	Unit	2019 Progress	2020 - 2030 Planned Restoration
Extended Detention Dry Ponds	acre	0	0
Impervious Surface Reduction	acre	0.1	0
Infiltration	acre	121.4	228.5
Outfall Enhancement with SPSC	acre	92.0	262.0
Outfall Stabilization	linear feet	730	0
Permeable Pavement	acre	5.8	0
Rain Gardens	acre	1.0	0
Shoreline Stabilization	linear feet	654.2	3,679.8
Urban Stream Restoration	linear feet	1,996	31,265
Wet Ponds or Wetlands	acre	517.9	430.8
Annual Practices			
Inlet Cleaning	no. of inlets/yr	330	330
Street Sweeping (roads)[1]	curb-miles	157.5	157.5

3.2 Load Reductions

This section compares the required and planned nutrient load reductions against the progress made through fiscal year 2019. Values given in Table 9 include the load reductions for each period (generally the milestone years) and the resulting load. Both the planned results and the actual results are shown for the 2019, 2023, and 2030 periods. 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 15.0%, the County has achieved a 4.1% reduction for nitrogen and 6.3% for phosphorus, which translates to 27.5% progress towards the reduction goal for nitrogen and 42.0% for phosphorus. The 2016 plan (Anne Arundel County, 2016) anticipated 3.0% reduction for nitrogen and 7.9% reduction for phosphorus by FY2017, and 8.2% reduction for nitrogen and 40.1% reduction for phosphorus by FY2020. Comparing progress for nitrogen reduction through FY2019 to these two milestones, the County is ahead of the FY2017 milestone reduction and is behind the planned 2020 milestone. Considering phosphorus, FY2019 progress is slightly behind the FY2017 milestone, and behind the FY2020 milestone.

The County's initial estimate and plan were based on a 2030 end date for meeting the nutrient TMDL. Although the progress compared to the FY2017 milestone is slightly behind schedule, the program is on track to meet both the phosphorus and nitrogen end dates ahead of schedule with completion of currently planned restoration projects and continued street sweeping and inlet cleaning as prescribed. The County currently has 55 restoration projects that are in planning and design phases that are scheduled to be complete by FY2023. These projects include stream restoration, shoreline stabilization, SPSCs, bioretention, wet ponds and wetlands, and infiltration basins and trenches.

Estimates of phosphorus reduction from planned projects show an additional reduction of 2,715 lbs over the next four years (FY2020-FY2023) which represents an additional 22.8% reduction, added to the 6.3% achieved through FY2019 will result in a total reduction progress of 29.1%. Implementation of these planned projects should result in the County meeting the TP reduction during FY2022-FY2023.

Estimates of nitrogen reduction from planned projects show an additional reduction of 22,221 lbs over the next four years which represents an additional 9.8% reduction, added to the 4.1% achieved through FY2019 will result in a total reduction progress of 13.9%. Projecting the annual rate of planned implementation for nitrogen reduction for FY2020-FY2023 out into the future, the County will meet the nitrogen reduction prior to 2030.

It is noted that the 16.3% reduction in nitrogen and 46.5% reduction in phosphorus by FY2030 outlined in this restoration plan is based on the assumption that all of the planned restoration and programmatic strategies would be completed, which is not often the case due to feasibility, site constraints etc.

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

Milestone Year	Planned Load Reduction		Planned Load		Planned % Reduction From Baseline		Actual Load Reduction		Actual Load		Actual % Reduction from Baseline	
	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
1995 Baseline	-	-	-	-	-	-	-	-	228,361	11,890	-	-
2019 Progress	-	-	-	-	-	-	9,424	749	218,937	11,140	4.1%	6.3%
2023 Planned	31,644	3,465	196,716	8,424	13.9%	29.1%	-	-	-	-	-	-
2030 Allocated	34,254	1,783	194,107	10,105	15.0%	15.0%	-	-	-	-	-	-
2030 Planned	37,200	4,144	191,161	7,745	16.3%	34.9%	-	-	-	-	-	-

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.

Anne Arundel County's Watershed Protection and Restoration Program (WPRP) has several on-going monitoring programs that target measures of watershed condition and relative nutrient levels. These programs are described here.

4.1 Countywide Biological Monitoring

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. 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 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

The Baltimore Harbor watershed is made up of five PSUs; Piney Run, Stony Run, Lower Patapsco, Sawmill Creek, and Marley Creek. Ten sampling sites were sampled in each of these PSUs during each round of sampling. 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 measurements are also performed at each site along with a geomorphic evaluation utilizing cross-sections, particle substrate analysis using pebble counts, and measures of channel slope.

In addition to collecting the parameters described above, the County added water quality sampling at each site to the Round 3 monitoring initiative. These parameters, which include the analysis of nutrient levels, are listed below:

- Total Nitrogen (TN)
- Ammonia (NH3)
- Ammonium (NH4)
- Nitrate (NO3)
- Nitrite (NO2)
- Total Phosphorus (TP)
- Phosphate (PO4)
- Dissolved organic carbon (DOC)
- Total organic carbon (TOC)
- Copper
- Lead
- Zinc
- Chloride

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 for Baltimore Harbor Watershed

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	2009	4,868	P	PD	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
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
Sawmill Creek	1	4	2008	11,044	VP	D	PS
Sawmill Creek	2	4	2010	11,044	P	D	PS
Sawmill Creek	3	4	2019	11,044	P	PD	S
Marley Creek	1	5	2006	19,425	P	D	PS
Marley Creek	2	5	2009	19,425	VP	D	PS
Marley Creek	3	5	2018	19,425	P	D	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

4.2 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 13 sites in the program, 12 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. The latest 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.

5 Conclusion

This Baltimore Harbor Watershed TMDL Annual Assessment report documents the progress achieved through the end of fiscal year 2019. The assessment includes a report on project and program implementation completed in the current report year and cumulatively through FY2019. 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 outlined in the 2016 plan (Anne Arundel County, 2016).

Anne Arundel County spent $4.7 million dollars in FY2019 in capital and operational costs on practices to address the Baltimore Harbor Nutirent TMDL. With those funds, the County is completing restoration projects and implementing programmatic practices including inlet cleaning and street sweeping. Load reductions are at 4.1% for nitrogen and 6.3% for phosphorus on a total goal of 15.0% reduction for each. The County currently has approximately 50 restoration projects that are in planning and design phases that are scheduled to be complete by FY2023. These projects include stream restoration, shoreline stabilization, SPSCs, bioretention, wet ponds and wetlands, and infiltration basins and trenches. With completion of these projects and through continuation of currently existing operations programs, the County plans to meet the load reductions with additional project implementation before the 2030 date set in the County's plan.

Biological stream monitoring data thus far with two rounds completed, and a third underway, indicates a watershed that remains in poor biological health. Sawmill Creek (PSU 4) monitoring was completed in 2019 and results were included in the current report. One remaining Baltimore Harbor watershed, Stony Run (PSU 2), is scheduled to be monitored again in the County's rotating framework in 2020, which once completed will provide a check on overall biological condition trends.

6 References

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