Baltimore Harbor Watershed

2020 Nutrient TMDL Annual Assessment Report

February | 2021

Prepared For

Anne Arundel County
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List of Acronyms

BayFAST	Chesapeake Bay Facility Assessment Scenario Tool
BIBI	Benthic Indices of Biotic Integrity
BMP	Best Management Practices
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
DPW	Department of Public Works
EOR	Edge of River
EOS	Edge of Stream
EOT	Edge of Tide
EPA	United States Environmental Protection Agency
FY	Fiscal Year
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
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyls
PHI	Physical Habitat Index
PSU	Primary Sampling Unity
RBP	Rapid Bioassessment Protocol
SPSC	Step Pool Storm Conveyance
STB	Stream Bed and Bank
SW-WLA	Stormwater Wasteload Allocation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
WLA	Wasteload Allocation
WM	Watershed Model
BWPR	Bureau of Watershed Protection and Restoration

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, 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 2011; 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, as well as Maryland Department of Transportation State Highway Administration. Anne Arundel County BWPR developed a TMDL restoration plan dealing with both total nitrogen (TN) and phosphorus (TP) (referred to 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 by the 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 *Baltimore Harbor Watershed Nutrient TMDL Restoration Plan* (the plan) (Anne Arundel County, 2016) satisfied the permit planning requirement and this *2020 Baltimore Harbor Nutrient TMDL Annual Assessment Report* satisfies the progress documentation requirement for fiscal year (FY) 2020.

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.

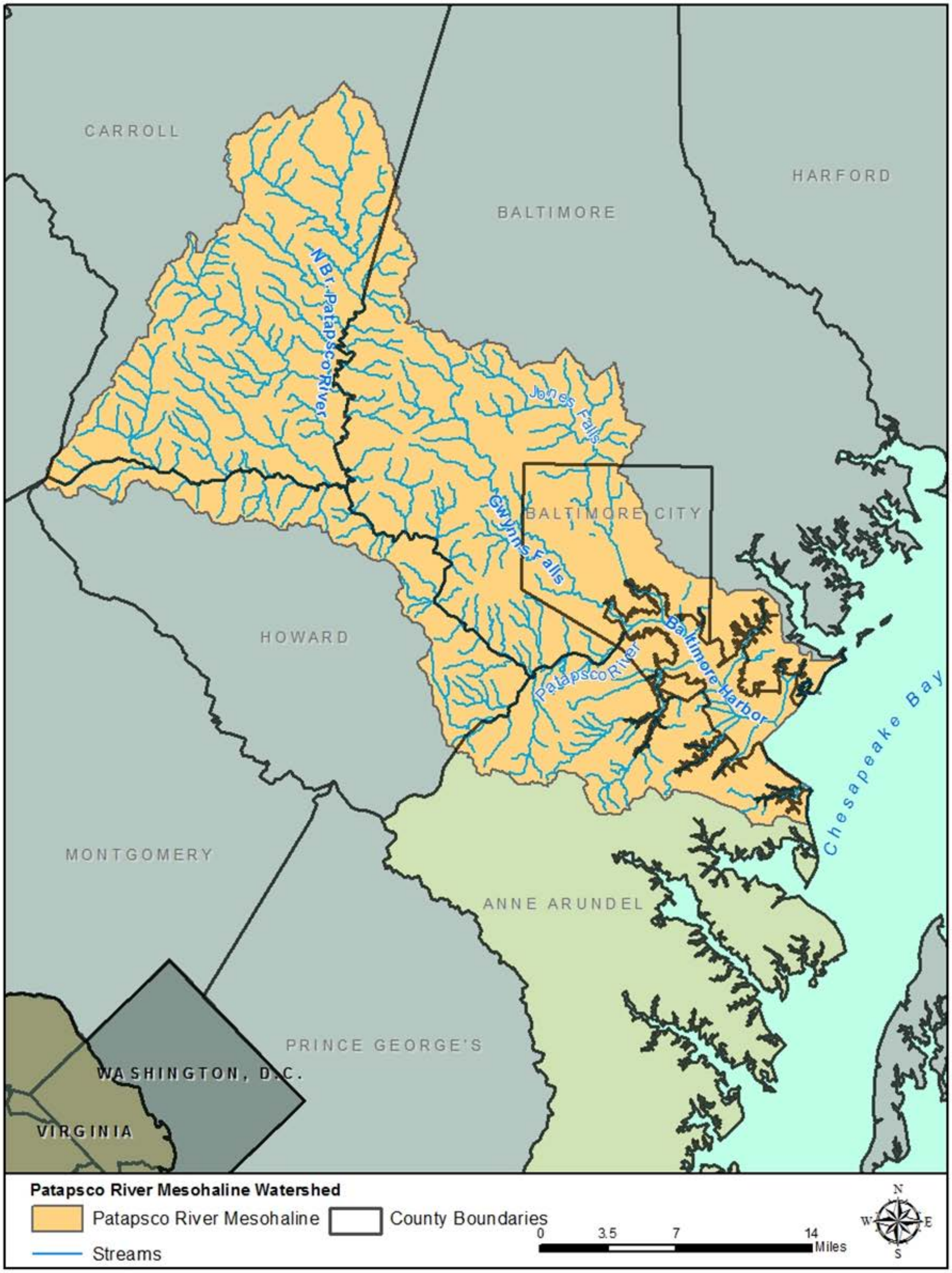

Figure 1: Watershed Location Map

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 Watershed Model Phase 5 (CBP WM P5). 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 FY2018 through FY2020 progress; therefore, FY2018 progress was modeled using MAST, which was compatible with BayFAST and built on Bay Model version P5.3.2. However, MAST availability ended in early 2019. FY2019 progress was modeled using CAST (Chesapeake Assessment Scenario Tool) Chesapeake Bay Program Watershed Model Phase 6 (CBP WM P6). FY2020 progress marks the second year Anne Arundel County has used CAST for modeling.

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 FY21 modeling, likely resulting in changes to the baseline, permit, and progress loads and load reductions in this report.

CAST, created by the Chesapeake Bay Program, is a web-based pollutant load estimation tool that calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Phase 6 Model. 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 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 percent reduction assigned to the Anne Arundel County Phase I MS4 source (15.0%) in the local TMDL was then applied to the CAST modeled 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. These loads have been revised from what was presented in the FY19 annual assessment due to an update to CAST in July 2020 (CAST-17d to CAST-19) and revisions to the stream bed and bank load disaggregation calculations.

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

1995 Baseline Load (lbs/yr)		Required Reduction %		Required Reduction (lbs/yr)		TMDL Load Allocation (SW-WLA) (lbs/yr)	
TN	TP	TN	TP	TN	TP	TN	TP
227,754	11,513	15.0%	15.0%	34,163	1,727	193,591	9,786

1.4 Planned Reductions

Table 2 provides a concise summary of the loads and reductions at important timeline intervals including the 1995 baseline, 2020 progress, and 2030 final planning intervals. These terms and dates are used throughout the Restoration 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 the Restoration Plan. Nutrient loads and wasteload allocations are presented as lbs/year. All loads presented below were calculated in CAST.

- **1995 Baseline Load**: Baseline level (i.e., land use load with baseline best management practices [BMPs]) from 1995 conditions in the Baltimore Harbor Watershed. Baseline load was used to calculate the stormwater allocated nutrient loads, or SW-WLA.
- **2020 Progress Load and Reduction**: Progress load and load reduction achieved from stormwater BMP implementation through 2020.
- **2030 Allocated Load**: Allocated load is calculated from the 1995 baseline level, calibrated to CBP Phase 6 as noted above, using the following calculation: 2030 Allocated Load = 1995 Baseline – (1995 Baseline x 0.15).
- **2030 Planned Load and Planned Reduction**: Load and reduction that will result from implementation of planned BMPs.

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

	Nitrogen (lbs/year)	Phosphorus (lbs/year)
1995 Baseline Load	231,359	14,062
FY2020 Progress Load	221,412	13,150
FY2020 Progress Reduction	9,947	913
FY2030 Planned Load*	209,128	11,208
FY2030 Planned Reduction	22,231	2,854
TMDL Allocated Load	196,655	11,953
Required Percent Reduction	15.00%	15.00%
Planned Percent Reduction Achieved	9.6%	20.3%

*It is assumed that stormwater runoff from new development will be treated to the maximum extent practicable 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. This is the second year that Anne Arundel County has used CAST for modeling annual assessment pollutant loads for the Baltimore Harbor. Modeling conducted in previous years had used BayFAST and MAST, which were both web-based pollutant load estimation tools.

The BayFAST model was discontinued 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 required nutrient load reduction was calculated by multiplying the local TMDL target reduction percent with the CAST baseline load. This reduction target was then subtracted from the baseline load modeled in CAST to determine the target sediment load (i.e., local SW-WLA).

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 outputs at two different scales: Edge-of-Stream (EOS) and Edge-of-Tide (EOT). Edge-of-tide 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, which in this case is the Chesapeake Bay. The EOT 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, 2020). 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. This follows the logic and scale used in the TMDL itself, wherein the impairment is in the downstream receiving water of the mesohaline segment, not in the tributary streams. The average Stream to River TN and TP delivery factor of the three land river segments within the Baltimore Harbor watershed was applied to the final scenario load to translate EOS loads to EOR loads.

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 0.075 lbs TN and 0.068 lbs TP removed per linear foot. Nutrient 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. Nutrient reductions for inlet cleaning are calculated based on the annual aggregate load collected (assumed sediment was 40% organic and 60% inorganic material) and averaged over the span of the 5-year permit term.

1.5.2 Stream Bed and Bank Disaggregation

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

1.5.3 Practice Level

This section briefly describes each practice and includes a summary of the typical nutrient 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. 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 SPSCs sites qualified for Protocol 5 load reductions. Protocol 5 load reductions were added to modeling results outside of CAST when applicable.
- **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.
- **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 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]	40%	60%
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: 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, urban stream restoration and shoreline stabilization 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. 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, 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 (FY) 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 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 0.075 lbs TN per linear foot and 0.068 lbs TP 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.
- **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, 2020).

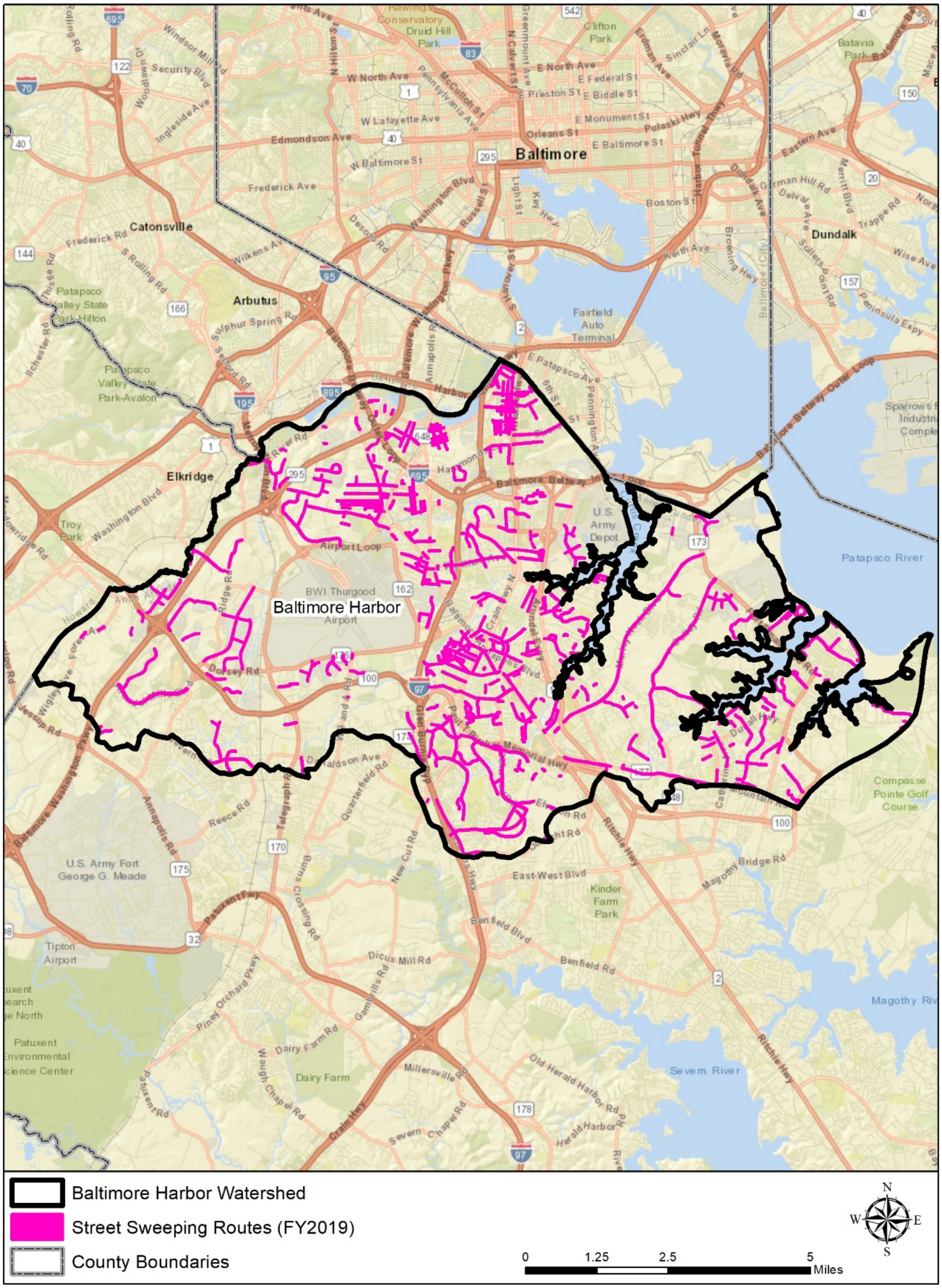

Figure 2: Street Sweeping Routes in the Baltimore Harbor Watershed, Anne Arundel County, Maryland

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 1995 Progress Scenario used to develop the 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 entirely 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 FY2020 (Furnace Creek Phase 2). This project restored 3,642 linear feet of stream.

Wet Ponds/ Dry Pond Conversions
One new wet pond project was completed in the watershed in FY2020. Two dry pond conversions were completed in the watershed in FY2020. One project converted the dry pond to an infiltration basin (Groveland Road Pond Retrofit) and the other converted to a shallow marsh (Fairbanks Drive Retrofit)

Shoreline Restoration
One shoreline restoration project was completed in FY2020 (Fort Smallwood Park Phase 3). This project stabilized 1,640 linear feet of shoreline.

Tree Planting
One tree planting project was completed in FY2020 (Jumpers Hole Road Reforestation), planting a total area of 2.7 acres within a 100 foot buffer of a perennial stream.

Impervious Surface Reduction
One impervious surface reduction project was completed in FY2020 (Jumpers Hole Road Impervious Surface Removal), removing a total area of 0.04 acres.

Inlet Cleaning
A total of 103 inlets cleaning records using storm drain vacuuming were recorded in FY2020. A total of 56.67 tons of material was collected during that period.

Street Sweeping
Building upon the County's enhanced street sweeping program, 78.8 curb miles were swept in the watershed during FY2020. The average mass of material collected by the street sweeping program was 196.2 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 $11,359,103

Table 4: Baseline BMP implementation

BMP	Unit	1995 Baseline
Structural Permanent Practices		
Runoff Reduction Performance Standard	acre	802.8
Stormwater Treatment Performance Standard	acre	1546.8
Bioswale	acre	0.9
Conservation Landscaping	acre	676.4
Dry Ponds	acre	885.1
Extended Detention Dry Ponds	acre	408.3
Floating Treatment Wetlands	acre	157.3
Infiltration	acre	398.2
Permeable Pavement	acre	7.5
Wet Ponds or Wetlands	acre	344.7
Annual Practices		
Inlet Cleaning	inlets/yr	0.0
Street Sweeping	lbs /yr	0.0

Table 5: Current BMP Implementation through FY2020

BMP	Unit	CY1996 - FY2019 Restoration[1]	FY2020 Restoration[1]	FY2020 Progress[2]	FY2020 Restoration Cost[3]
Structural Permanent Practices					
Bioretention	acre	0	0	0	
Bioswale	acre	0.6	0	0.6	
Dry Ponds	acre	0	0	0	
Extended Detention Dry Ponds	acre	0	0	0	
Impervious Surface Reduction	acre	0	0.04	0.04	$14,700
Infiltration	acre	121.4	12.4	133.8	$416,504
Outfall Enhancement with SPSC	acre	91.5	0	91.5	
Permeable Pavement	acre	5.8	0	5.8	
Rain Gardens	acre	0.7	0	0.7	
Shoreline Stabilization	linear ft	1,114.0	1,640.0	2,754.0	$2,879,500
Tree Planting	acre	0	2.7	2.7	$70,000
Urban Stream Restoration	linear ft	1,746.0	3,642.0	5,388.0	$ 5,754,269
Wet Ponds or Wetlands	acre	637.8	60.7	698.5	$ 1,938,830
Annual Practices					
Inlet Cleaning[4]	inlets/yr	NA	103	103	$132,619
Street Sweeping[4]	lbs /yr	NA	392,368	392,368	$152,681
				Total FY2020 Cost	$11,359,103

Source: MDE MS4 FY2020 geodatabase

[1] Restoration completed in each specific period, i.e. CY1996-FY2019 and FY2020.

[2] Total cumulative restoration accounting for the full CY1996-FY2020 period.

[3] Cost of projects and programs for the FY2020 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, 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 4.3% reduction for TN and a 6.5% reduction in TP, both with a goal of 15% reduction.

Table 6: FY2020 Progress Reductions Achieved

Baseline Load and TMDL SW-WLA	TN-EOS lbs/yr	TP-EOS lbs/yr
1995 Baseline Scenario Load	231,359	14,062
Required Percent Reduction	15.0%	15.0%
Required Reduction	34,704	2,109
Local TMDL SW-WLA	196,655	11,953
2020 Results	**TN-EOS lbs/yr**	**TP-EOS lbs/yr**
Progress Scenario Load	221,412	13,150
Progress Reduction Achieved	9,947	913
Percent Reduction Achieved	4.3%	6.5%

3 Comparison of 2020 Progress and Planned Implementation

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

3.1 Implementation

Table 7 compares implementation of completed restoration BMPs through FY2020 (FY2020 Progress) with the total planned levels of implementation that were derived in the initial plan (Anne Arundel County, 2016) as well as with the planned restoration BMPs through FY2024 from the County's MS4 geodatabase. Several of the strategies are half way or more to full implementation (wet ponds or wetlands, infiltration) and street sweeping is continuing at a rate close to 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, permeable pavement, rain gardens, sand filters, tree planting, 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 103. While the number of inlets addressed this year fell short of the original goal, the inlet cleaning program is still yielding very good results and remains an important part of the County's program.

Multiple BMP conversion projects (to wet ponds or wetlands) were completed by the end of FY2020, along with one new restoration wet pond project, and one stream restoration project. Additionally, one shoreline restoration, one tree planting, and one impervious surface reduction project was completed. Street sweeping continues at a rate almost as high as the prescribed planned rate.

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

BMP	Units	FY2020 Progress	Total Planned Restoration[1]	Total Planned – FY2024[2]	Percent Complete[3]
Bioretention	acre	0	29.1	3.8	0%
Bioswale	acre	0.6	0	0	NA
Dry Ponds	acre	0	37.1	0	0%
Extended Detention Dry Ponds	acre	0	44.7	0	0%
Impervious Surface Reduction	acre	0.04	0.1	0	40.0%
Infiltration	acre	133.8	86.2	56.3	155.2%
Outfall Enhancement with SPSC	acre	91.5	3,043.3	243.9	3.0%
Permeable Pavement	acre	5.8	0	0	NA
Rain Gardens	acre	0.7	0	0	NA
Sand Filter	acre	0	0	169.8	NA
Shoreline Stabilization	linear feet	2,754.0	0	2,040.0	NA
Tree Planting	acre	2.7	0	0	NA
Urban Stream Restoration	linear feet	5,388.0	79,171.0	27,623.0	6.8%
Wet Ponds or Wetlands	acre	698.5	913.7	269.3	76.4%
Annual Practices					
Inlet Cleaning	inlets/yr	103	729	729	17.7%
Street Sweeping	curb-miles	78.8	96.1	96.1	82.0%

[1] Planned restoration totals used in 2016 restoration plan and BayFAST modeling.
[2] Planned restoration totals through FY2024 from County's current MS4 geodatabase and used in CAST modeling.
[3] Compares implementation progress through FY2020 to planned restoration totals through FY2024.

To track progress, the 2030 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 2021-2030 milestone period.

Table 8: Implementation Milestones Comparison

BMP	Unit	2020 Progress	2021 - 2030 Planned Restoration
Bioretention	acre	0	3.8
Bioswale	acre	0.6	0
Dry Ponds	acre	0	0
Extended Detention Dry Ponds	acre	0	0
Impervious Surface Reduction	acre	0.04	0
Infiltration	acre	133.8	56.3
Outfall Enhancement with SPSC	acre	91.5	266.1
Permeable Pavement	acre	5.8	0
Rain Gardens	acre	0.7	0
Shoreline Stabilization	linear feet	2,754.0	2,040.0

BMP	Unit	2020 Progress	2021 - 2030 Planned Restoration
Urban Stream Restoration	linear feet	5,388.0	29,437.0
Wet Ponds or Wetlands	acre	698.5	269.3
Annual Practices			
Inlet Cleaning	no. of inlets/yr	103	729
Street Sweeping (roads)[1]	curb-miles	78.8	96.1

3.2 Load Reductions

This section compares the required and planned nutrient 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. The actual results are provided for 2020 and planned reductions for the 2024, and 2030 periods. 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 15.0%, the County has achieved a 4.3% reduction for nitrogen and 6.5% for phosphorus, which translates to 28.7% progress towards the reduction goal for nitrogen and 43.3% 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 FY2020 to these two milestones, the County is ahead of the FY2017 milestone reduction and is behind the planned 2020 milestone. Considering phosphorus, FY2020 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 FY2020 milestone is slightly behind schedule, the program is on track to meet the phosphorus end date with completion of currently planned restoration projects and continued street sweeping and inlet cleaning as prescribed. Meeting the nitrogen end date, however, will require additional planned projects. The County currently has 43 restoration projects that are in planning and design phases that are scheduled to be complete by FY2024. 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 1,888 lbs over the next four years (FY2021-FY2024) which represents an additional 13.4% reduction, added to the 6.5% achieved through FY2020 will result in a total reduction progress of 19.9%. Implementation of these planned projects should result in the County meeting the TP reduction during FY2022-FY2024.

Estimates of nitrogen reduction from planned projects show an additional reduction of 12,041 lbs over the next four years which represents an additional 5.2% reduction, added to the 4.3% achieved through FY2020 will result in a total reduction progress of 9.5%. Projecting the annual rate of planned implementation for nitrogen reduction for FY2020-FY2024 out into the future, through FY2030, it is anticipated that the County will meet the nitrogen reduction goal prior to 2030. There is currently a gap

in the number of projects in the County's near term plans to meet the goal and additional project sites will be added over the next several years to make up the difference.
It is noted that the reductions in nitrogen and phosphorus by FY2030 outlined in this restoration plan is based on the assumption that all of the planned restoration and programmatic strategies will be completed.

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

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

Milestone Year	Actual Load Reduction		Actual Load		Actual % Reduction from Baseline		Planned Load Reduction		Planned Load		Planned % Reduction From Baseline	
	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
1995 Baseline	-	-	231,359	14,062	-	-	-	-	-	-	-	-
2020 Progress	9,947	913	221,412	13,150	4.3%	6.5%	-	-	-	-	-	-
2024 Planned	-	-	-	-	-	-	21,988	2,801	209,371	11,262	9.5%	19.9%
2030 Allocated	-	-	-	-	-	-	34,704	2,109	196,655	11,953	15.0%	15.0%
2030 Planned	-	-	-	-	-	-	22,231	2,854	209,128	11,208	9.6%	20.3%

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.

Anne Arundel County's Bureau of Watershed Protection and Restoration (BWPR) 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 Rounds 1 & 2 of sampling, while Round 3 shifted to 16 sites split equally between large and small stream strata. Methodologies follow those used by the Maryland Department of Natural Resources (MDNR) Maryland Biological Stream Survey (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 Benthic Indices of Biotic Integrity (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
Stony Run	3	2	2020	6,203	F	D	PS
Lower Patapsco	1	3	2004	4,040	P	PD	PS
Lower Patapsco	2	3	2012	4,040	P	PD	NS
Lower Patapsco	3	3	2018	4,040	P	D	NS
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 Biological 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.

5 Conclusion

This Baltimore Harbor Watershed 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 outlined in the 2016 plan (Anne Arundel County, 2016).

Anne Arundel County spent $11.4 million dollars in FY2020 in capital and operational costs on practices to address the Baltimore Harbor TMDL. With those funds, the County is completing restoration projects and implementing programmatic practices including inlet cleaning and street sweeping. Load reductions through FY2020 are at 4.3% for nitrogen and 6.5% for phosphorus on a total goal of 15.0% reduction for each. The County currently has 43 restoration projects that are in planning and design phases that are scheduled to be complete by FY2024. 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 operational programs, the County plans to meet the load reductions with additional project implementation before the 2030 date set in the County's plan.

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

Biological stream monitoring data thus far with three rounds completed, indicates a watershed that remains in generally poor overall biological health. Stony Run (2) was completed in 2020, which concludes Round 3 biological monitoring within this watershed. This was the only PSU to show an increase in average biological conditions above 'Poor' through three rounds of sampling. However, overall biological condition trends indicate conditions that generally remain consistent across all rounds, with only minor changes occurring over time.

6 References

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