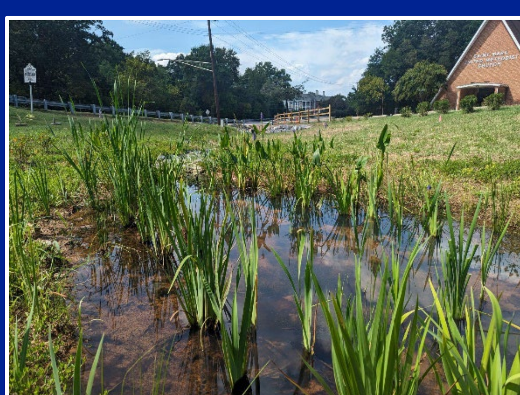


BALTIMORE HARBOR WATERSHED

NUTRIENT TMDL RESTORATION PLAN UPDATE

FEBRUARY 2024

Anne Arundel County
Bureau of Watershed
Protection
& Restoration

BALTIMORE HARBOR WATERSHED

NUTRIENT TMDL RESTORATION PLAN UPDATE

PREPARED FOR:

Anne Arundel County

Department of Public Works

Bureau of Watershed Protection and Restoration

2662 Riva Road

Annapolis, Maryland 21401

PREPARED BY:

Environmental Systems Analysis, Inc. (ESA)

2141 Priest Bridge Drive, Suite 1

Crofton, Maryland 21114

Versar Global Solutions

9200 Rumsey Road, Suite 1

Columbia, Maryland 21045

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

LIST OF ACRONYMS

AAWSA	Anne Arundel Watershed Stewards Academy
BIBI	Benthic Index of Biotic Integrity
BMP	Best Management Practice
BWPR	Bureau of Watershed Protection and Restoration
CC	Chesapeake Conservancy
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DO	Dissolved Oxygen
DPW	Department of Public Works
EPA	(United States) Environmental Protection Agency
FIBI	Fish Index of Biotic Integrity
GIS	Geographic Information System
IBI	Index of Biotic Integrity
IWPP	Integrated Water Planning Program
MBSS	Maryland Biological Stream Survey
MD DNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MS4	Municipal Separate Storm Sewer System
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometer Turbidity Unit
PATMH	Patapsco River Mesohaline
PHI	Physical Habitat Index
PSU	Primary Sampling Unit
RBP	Rapid Bioassessment Protocol
RR	Runoff Reduction
SpC	Specific Conductivity
ST	Stormwater Treatment
SW	Stormwater
SW-WLA	Stormwater Wasteload Allocation
TIPP	TMDL Implementation Progress and Planning

TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey
WIP	Watershed Implementation Plan
WLA	Wasteload Allocation

1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) approved Maryland's recommendation to list the Patapsco River Mesohaline (PATMH) water network as impaired for the nutrients nitrogen and phosphorus in 2007, as published in *Total Maximum Daily Loads (TMDL) of Nitrogen and Phosphorus for the Baltimore Harbor in Anne Arundel, Baltimore, Carroll and Howard Counties, and Baltimore City, Maryland*. Baltimore's harbor is located in the PATMH watershed, also known as the Baltimore Harbor watershed, as it is shown (with all jurisdictions) in Figure 1. The Baltimore Harbor Watershed, as defined by the Maryland Department of Natural Resources (MD DNR; Maryland 8-Digit code: 02130903), includes 74,899 acres and includes portions of Anne Arundel and Baltimore County, and the City of Baltimore, as shown in Figure 1. The full Patapsco River Lower North Branch, as defined by MD DNR (Maryland 8-Digit code: 02130906) includes 75,755 acres and includes portions of Anne Arundel Baltimore, Carroll, and Howard Counties, and the City of Baltimore. The full 8-digit-level Baltimore Harbor Watershed is also listed as impaired for nitrogen and phosphorus according to Section 303(d) of the Federal Clean Water Act (CWA); the full Patapsco River Lower North Branch is not listed for nutrient loadings. For each impaired surface water network, the State of Maryland is required by the EPA to develop a Total Maximum Daily Load (TMDL) for each impairment and submit it to the EPA for approval. Per the EPA, a TMDL is defined as the maximum pollutant load that a water body can assimilate and continue to meet the applicable water quality standard. The TMDLs that Maryland develops are designed to achieve the TMDL requirements for the Chesapeake Bay (EPA, 2010).

To address the impairments, Anne Arundel County is responsible for the portion of the drainage area for PATMH (Baltimore Harbor watershed) located within its jurisdiction, as shown in Figure 2. For the remainder of this report, unless otherwise defined, the term Baltimore Harbor Watershed refers to the portion of the full PATMH drainage basin that is located within Anne Arundel County. The Baltimore Harbor Watershed is further divided into the Baltimore Harbor and Patapsco River Lower North Branch watersheds where the portions of the full 8-digit watersheds of the same names intersect the county boundary.

Anne Arundel County developed a nutrient TMDL restoration plan for Baltimore Harbor Watershed that documented nutrient loads applicable to baseline conditions and current and planned treatment projects as of 2016 (Anne Arundel County, 2016a). This document is an update to the 2016 restoration plan and addresses the nutrient-related components of Maryland's *Phase III Watershed Implementation Plan to Restore Chesapeake Bay by 2025* and local TMDL implementation targets. The results and projections in the TMDL restoration plan update are applicable to the analysis conducted during 2023.

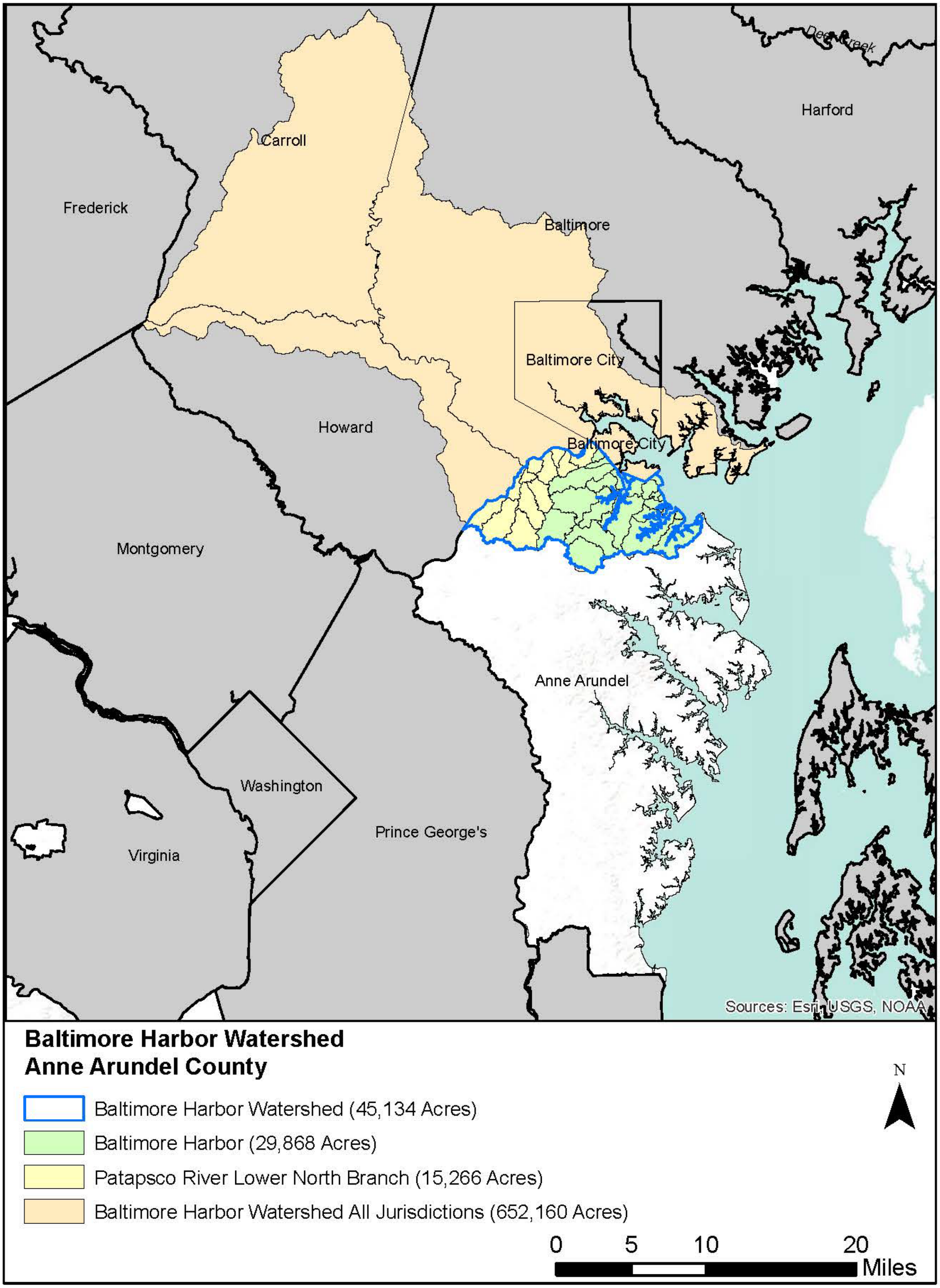


Figure 1: Baltimore Harbor Watershed Overview

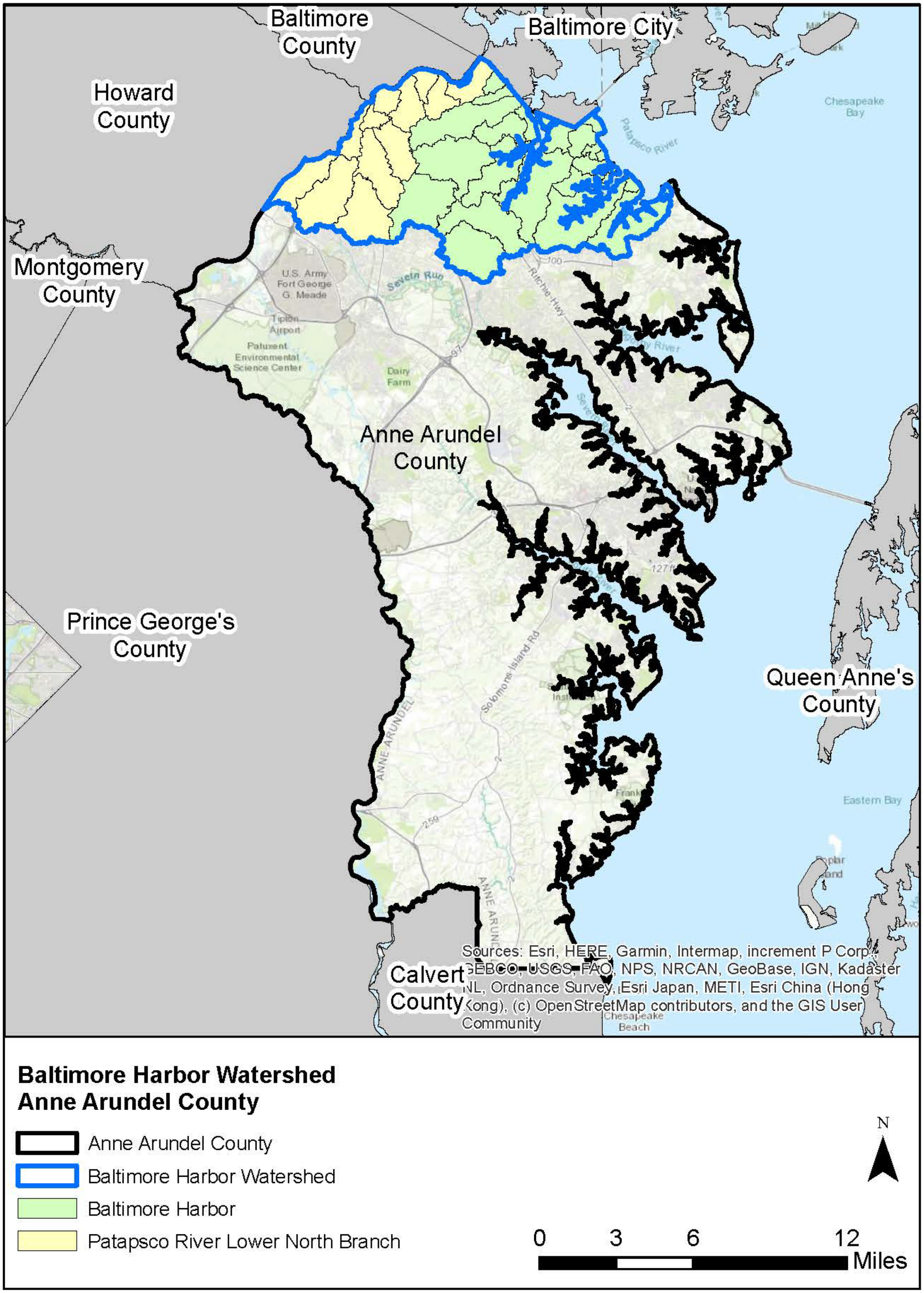


Figure 2: Baltimore Harbor Watershed in Anne Arundel County, MD

1.1 Background

The PATMH drainage basin is on the Maryland Department of Environment (MDE) 303(d) impairment list for nitrogen, phosphorus, polychlorinated biphenyls, bacteria, and total suspended sediment. Maryland listed the watershed for nitrogen and phosphorus in 2007. Anne Arundel County is required under the National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Separate Storm Sewer System (MS4) permit to manage, implement, and enforce stormwater management programs in accordance with the CWA and corresponding stormwater NPDES regulations in 40 CFR Parts 122-124. Anne Arundel County is currently in the fifth generation of its MS4 permit; the first permit was issued in 1993. Anne Arundel County's current MS4 permit requires that Best Management Practices (BMPs) and programs implemented pursuant to the permit be consistent with applicable stormwater Wasteload Allocations (WLAs) developed under TMDLs established or approved by the EPA.

Anne Arundel County's Bureau of Watershed Protection and Restoration (BWPR) developed a nutrient TMDL restoration plan specifically for Baltimore Harbor Watershed relevant to nitrogen and phosphorus that was approved by the Maryland Department of Environment (MDE) in November 2016. The TMDL restoration plan stated that nutrient loads would be reduced by 15 percent relative to baseline (2009), and the target reductions would be met by 2020 for phosphorus and by 2030 for nitrogen. Baseline loads that apply to the watershed are 274,049 pounds per year for nitrogen and 21,624 pounds per year for phosphorus. Therefore, the target maximum loads for the watershed with the fifteen percent reductions applied would be 232,941 pounds per year for nitrogen and 18,380 pounds per year for phosphorus.

The current MS4 permit (20-DP-3316, MD0068306), which was issued on November 5, 2021, requires Anne Arundel County to update previously approved restoration plans for all TMDL Stormwater Wasteload Allocations (SW-WLA) by the end of the permit term (November 4, 2026) and use the most recent MDE guidance documents when developing the plans. The nutrient TMDL restoration plan update was prepared using MDE's *General Guidance for Local TMDL Stormwater Wasteload Allocation Watershed Implementation Plans* (August 2022) and includes descriptions of monitoring programs, actionable management triggers, data sources, and stakeholders. The seven (7) required plan elements and the sections in which the elements are addressed are provided in Table 1.

Table 1: Seven Required Plan Elements and Report Section (MDE, 2022c).

Element	Report Section
1. What is being adaptively managed, e.g., a resource, a pollutant, a program, and/or individual implementation projects? For SW-WLA plans, this will be the pollutant1.	**1.0**
2. Why is adaptive management being used?	**6.0**
2.1. Is there an aspect of the water resource management process that is specialized?	
2.2. Does the jurisdiction expect to have to modify the project or program as a result of an issue?	
3. What are the stepwise goals and objectives that consider both jurisdictional resources and the goals and objectives of the SW-WLA and TMDL? What are the costs associated with proposed management strategies?	**4.0**
3.1. What is the budget?	
3.2. Who has responsibility?	
3.3. Who is legally liable?	
4. Who is the primary audience of the plan and why?	**7.0**
5. What information is available and how is that information used to inform WIP development?	**3.0**
5.1. Is information from permit required watershed assessments being addressed in detail by section in the TMDL implementation plan?	
5.2. Have other documents/studies been published that contribute to understanding the watershed as a multi-faceted system and the natural resources it supports?	
5.3. Do other watershed plans exist in the watershed; either generated by a government, utility, or non-governmental entity? Provide this information and details about other monitoring programs, so data can be shared on a regularly scheduled basis.	
5.4. Has the jurisdiction modeled pollutant sources and expected load reductions from potential, planned actions, where applicable?	
5.5. Is monitoring data being used to inform actions?	
6. How does the watershed function for the public in terms of its beneficial uses (beneficial uses will vary based on the pollutant in question)?	**2.0**
6.1. How are stakeholders considered in the planning document (Required Element - see “Stakeholders” section below for further details)?	
6.2. What are the watershed resource concerns of the jurisdiction’s constituents?	
6.3. Have they been enumerated in the WIP?	
6.4. What conflicts exist or can be foreseen?	
7. What are the proposed planning horizons and how will they be justified?	**5.0**
7.1. Identify indicators and determine if they are currently meeting goals.	
7.1.1. How will goals and progress toward goals be achieved;	
7.1.2. and endure alongside economic development and population growth.	
7.2. Is the proposed planning horizon the point at which improvement is expected?	
7.3. Or is the planning horizon simply based on model accounting?	
7.4. For example: why is the milestone goal expected from the process at this point in time, e.g., why does a jurisdiction expect to see average watershed embeddedness scores decrease by 5% within the next 5 years?	
7.5. Who does what if milestones for horizons are not met on time?	

NOTE:

Primary elements 1-7 are required while sub-elements are recommendations only except where noted.

1.2 Goals and Objectives

The objectives of the updated nutrient TMDL restoration plan and the implementation of restoration practices are to restore the assimilative capacity of the Baltimore Harbor Watershed relative to nutrient loads, meet applicable water quality criteria for nitrogen and phosphorus, and qualify the watershed for removal from the MDE 303(d) list (MDE, August 2022). Anne Arundel County intends to achieve these goals by documenting restoration practices, which when combined will meet the 15-percent reductions needed for nitrogen and phosphorus loads relative to baseline conditions. Anne Arundel County will apply adaptive management strategies to maintain load reductions and select monitoring parameters that are able to indicate if water quality criteria are being met after the restoration projects are implemented. Specific urban stormwater goals identified in Anne Arundel County's Chesapeake Bay TMDL Phase II Watershed Implementation Plan Final Report (Anne Arundel County, 2012a) include the following elements:

- Restored stream stability,
- Restored hydrology with floodplains and streams,
- Restored biological health of streams, and
- Compliance with water quality standards.

2.0 WATERSHED FUNCTION

The Baltimore Harbor Watershed provides recreational opportunities, such as boating, fishing, and crabbing, in its tidal waters and provides habitat and resources for aquatic and terrestrial organisms throughout the watershed. There are residential neighborhoods, restaurants, parks, fishing piers, and private beaches in the watershed. The restoration plan update is designed to ensure that nutrient loads meet the SW-WLAs so that current and future generations are able to enjoy the natural resources of the Baltimore Harbor Watershed and ultimately the Chesapeake Bay. The restoration techniques to address the nutrient TMDLs include stream restoration, street sweeping, storm drain cleaning, land use conversion, SWM BMPs, and outfall, stream and shoreline restorations. Implementing these practices should enhance and improve the watershed functions of Water Contact Recreation and Protection of Nontidal Warmwater Aquatic Life (Use Class I) and Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (Use Class II).

2.1 Water Use Designation, Water Quality Criteria, and Condition Assessment Ratings

According to water quality standards established by MDE and published in the Code of Maryland Regulations (COMAR) 26.08.02.08[1], the surface waters of Anne Arundel County's portion of the Baltimore Harbor Watershed qualify for Use Class I and II waters. Use Class I waters are generally designated to support water contact recreation and the protection of non-tidal warm water aquatic life. Use Class II waters generally support estuarine and marine aquatic life and shellfish harvesting. The detailed designated uses of Use Class I and II waters in the Baltimore Harbor Watershed are shown in Table 2.

Table 2: Maryland's Designated Uses for Surface Waters (MDE, 2019)

Designated Uses	Baltimore Harbor	Patapsco River Lower North Branch
Growth and propagation of fish (not trout), other aquatic life and wildlife	X	X
Water contact sports	X	X
Leisure activities involving direct contact with surface water	X	X
Fishing	X	X
Agricultural water supply	X	X
Industrial water supply	X	X
Propagation and harvesting of shellfish	X	-
Seasonal migratory fish spawning and nursery use	X	-
Seasonal shallow-water submerged aquatic vegetation use	X	-
Open-water fish and shellfish use	X	-
Seasonal deep-water fish and shellfish use	X	-
Seasonal deep-channel refuge use	X	-

Water quality criteria that support the designated uses applicable to Anne Arundel County's portion of the PATMH drainage basin are listed in the tables below. State water quality criteria for Use Class I Waters and Use Class II Waters are listed in Table 3. Specific to dissolved oxygen, the criterion for both Use Classes is a minimum concentration of five milligrams per liter at any time. Narrative ratings applicable to dissolved oxygen concentrations, as established for the MD DNR Biological Stream Survey (MBSS), are listed in Table 4. Narrative ratings applicable to ranges of select water quality parameters, as established by MD DNR, are listed in Table 5.

Table 3: Use Class I and Class II Water Quality Criteria (COMAR Sect 26, Part 2)

Water Quality Parameter	Standard
Dissolved Oxygen	Not less than 5 milligrams per liter
Temperature	May not exceed 90 degrees Fahrenheit
pH	Not less than 6.5 or greater than 8.5
Turbidity	May not exceed 150 Nephelometric Turbidity Units (NTUs) from any discharge or 50 NTU monthly average

Table 4: Dissolved Oxygen (DO) Concentration Ratings (MBSS, 2011)

Rating	DO (mg/L)
Low	<3.0
Moderate	3.0-5.0
High	>5.0

Table 5: Nutrient Pollutant Ratings (MD DNR, 2005)

Parameter	Rating		
	Low	Moderate	High
Nitrogen	<1.5	1.5-7.0	>7.0
Phosphorus	<0.025	0.025-0.070	>0.070
Ortho-phosphate	<0.008	0.008-0.03	>0.03
Nitrate	<1.0	1.0-5.0	>5.0
Nitrite	<0.0025	0.0025-0.01	>0.01
Ammonia	<0.03	0.03-0.07	>0.07

Evaluations of the biological condition of streams are based on the characteristics of the fish and benthic macroinvertebrate communities found in the streams. The Index of Biotic Integrity (IBI) scores are rated on a scale of 1 to 5 scale as shown in Table 6.

Table 6: MBSS Biological Condition Rating

IBI Score	Narrative Rating
4.00-5.00	Good
3.00-3.99	Fair
2.00-2.99	Poor
1.00-1.99	Very Poor

The EPA Rapid Bioassessment Protocol (RBP) is also used to evaluate the condition of streams. Biological surveys, bioassays, chemical monitoring, and habitat parameters are used to develop the results of the RBP for each site. Site conditions are scored to generate an overall rating for the site. Narrative ratings applicable to the scores are shown in Table 7. The ratings indicate the relative ability of the site to support biological communities.

Table 7: EPA Rapid Bioassessment Protocols (RBP) Rating

Score	Narrative Rating
151+	Comparable
126-150	Supporting
101-125	Partially Supporting
0-100	Non-Supporting

The MBSS Physical Habitat Index (PHI) is used to assess the available habitat of a stream and the ability of the stream to support biological communities. Multiple physical habitat parameters with scores are used to generate a total score for the site. Narrative ratings applicable to the total score are shown in Table 8.

Table 8: MBSS Physical Habitat Index (PHI) Rating

Score	Narrative Rating
81-100	Minimally Degraded
66-80.9	Partially Degraded
51-65.9	Degraded
0-50.9	Severely Degraded

2.2 Stakeholders

Baltimore Harbor Watershed stakeholders include government agencies, non-governmental organizations, and private landowners and businesses. Some of the prominent stakeholders in the process include the Anne Arundel County Commercial Owners, Anne Arundel County Chamber of Commerce, Environmental Committee, and Leadership Anne Arundel (Anne Arundel County, 2012a). The list of non-governmental organizations includes: Alliance for the Chesapeake Bay, Chesapeake Bay Trust, Chesapeake Rivers Association, Chesapeake Environmental Protection Association, and Anne Arundel Patapsco River Alliance.

Anne Arundel County Watershed Stewards Academy (AAWSA) is a 501(c)(3) non-profit organization that provides tools for trained watershed stewards to mobilize and work within their communities to implement projects such as rain gardens and conservation landscapes that reduce pollution in local waterways. The AAWSA website (www.aawsa.org) provides information to address nutrient loadings, including the AAWSA Rainscaping Manual and the Conservation Landscape Design Tool, and access to stormwater seminars, and information on permitting and grants. Stewards and local communities are integral in the success of reducing pollutant loads and meeting TMDL goals.

Anne Arundel County has given numerous public presentations throughout the development of the County's Phase II Watershed Implementation Plan (WIP) to disseminate information on the Chesapeake Bay TMDL, the WIP process, and strategies for meeting the County's assigned pollutant load reductions. In addition to providing a level of understanding to the public, the County uses the presentations as an opportunity to receive input and comments on restoration efforts.

The Anne Arundel County BWPR provides continual public outreach tools through web and social media platforms, which are accessible through its website www.aarivers.org. The website offers valuable information on Anne Arundel County watersheds, including an interactive clickable map that displays geographically referenced environmental, utility, and land use data and restoration project locations, descriptions, and drainage areas. This outreach platform is also used to notify the public of the opportunity to review and comment on TMDL restoration plans. The BWPR has also published several web-based tools to assist Anne Arundel County and its partners with restoration design, restoration project scoping, and nutrient and sediment credit calculation for proposed restoration projects. Furthermore, the BWPR produces the annual "A Land of Rivers" report that documents and highlights restoration projects completed by the County and its partners.

The Anne Arundel County Department of Public Works (DPW) regularly holds public meetings on various topics and projects. The meetings engage the community and solicit feedback for restoration practices. The meeting notices are publicly available on DPW's website: https://www.aacounty.org/public-works/public-meeting-calendar.

Anne Arundel County also provides opportunities for property owners to reduce their taxes and stormwater fees. Residential and commercial property owners may be eligible to receive credit towards their county real property taxes for the recent installation of qualified stormwater management practices. Eligible property owners in the county also can reduce their Watershed Protection and Restoration Fee, also known as the stormwater fee, by up to 50 percent for proactive and sustainable uses of stormwater runoff controls. More information and applications for these credit programs are available on the Anne Arundel County BWPR website.

2.3 Watershed Resource Concerns

Residents from two communities in the watershed, Glen Burnie and Brooklyn Park, have identified some common watershed resource concerns. Residents have requested improved stormwater management and reduced pollutant loads from stormwater runoff. Anne Arundel County intends to address these concerns through the completion of stormwater management retrofit projects funded or designed by BWPR.

Another concern is the desire for more green infrastructure in the watershed. Anne Arundel County is addressing this concern by identifying opportunities for additional green infrastructure and securing funding for feasibility studies, land acquisition, and design (Anne Arundel County, 2018a, 2018b). Similarly, residents in the Baybrook community are interested in securing funding for green infrastructure in Garrett Park and improving access and community outreach for educational programming at Masonville Cove Environmental Education Center on the Patapsco River (Anne Arundel County, 2016b). The Greater Baybrook Alliance (www.greaterbaybrookalliance.org/) has been created, in part, to deal specifically with some of these issues

3.0 EXISTING INFORMATION

The BWPR completed the Patapsco River Non-Tidal Watershed Assessment in 2011 and the Patapsco River Tidal and Bodkin Creek Watershed Assessment in August 2012 to document watershed conditions and set priorities for restoration planning. Additionally, Anne Arundel County developed its Chesapeake Bay TMDL Phase II WIP in 2012 in response to requirements set forth in the Chesapeake Bay TMDL for nitrogen, phosphorus, and sediment. The County submits annual TMDL Stormwater Implementation Plan Progress Reports, which incorporate the most recent data and models, with the County's Annual NPDES MS4 Report to MDE. The County uses these documents to inform their decision-making regarding the implementation of restoration projects. The information has been incorporated into this restoration plan update to show the County's use of existing information to meet SW-WLA goals.

3.1 Watershed Assessments

Watershed assessments completed by Anne Arundel County in 2011 and 2012 (Anne Arundel County, 2011, 2012b) identified the portion of the Baltimore Harbor Watershed in Anne Arundel County as being 45,134 acres in size and consisting of 33 subwatersheds: 12 in the county portion of the Patapsco River Lower North Branch 8-digit watershed (29,868 acres) and 21 in the county portion of the Baltimore Harbor 8-digit watershed (15,266 acres). The Baltimore Harbor 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 Brooklyn Park, Glen Burnie, Hanover, Linthicum Heights, and Severn. Figure 3 shows the subwatersheds in the Baltimore Harbor Watershed. Table 9 shows watershed characteristics for the Baltimore Harbor Watershed.

As discussed in the water assessment reports, the majority of nutrient loadings within the Baltimore Harbor Watershed are attributed to instream sources and urban stormwater runoff; much of the watershed was developed before stormwater management controls were required (Anne Arundel County, 2011, 2012b). Figures 4 and 5 show nitrogen and phosphorus loadings, respectively, by subwatershed as documented in the 2011 and 2012 watershed assessment reports, along with the locations of projects that are characterized as current progress, interim, and planned BMPs and restorations. Current progress projects are defined as completed projects, interim projects have attained at least a 30-percent design stage, and planned projects are not yet at the 30-percent design stage. The figures show the greater number of BMP and restoration projects within the subwatersheds with the higher nutrient loadings. Figure 6 shows the priority status of the subwatersheds, as identified in the watershed assessment reports (Anne Arundel County, 2011, 2012b) and illustrates that the greater number of BMP and restoration projects are located within the subwatersheds that were given medium-high and high priorities. Figure 7 shows the restoration status of stream, outfall, and shoreline projects (combined) within the subwatersheds; most of the projects are located within subwatersheds that were given higher priority for restoration, as identified in the watershed assessment reports (Anne Arundel County, 2011, 2012b).

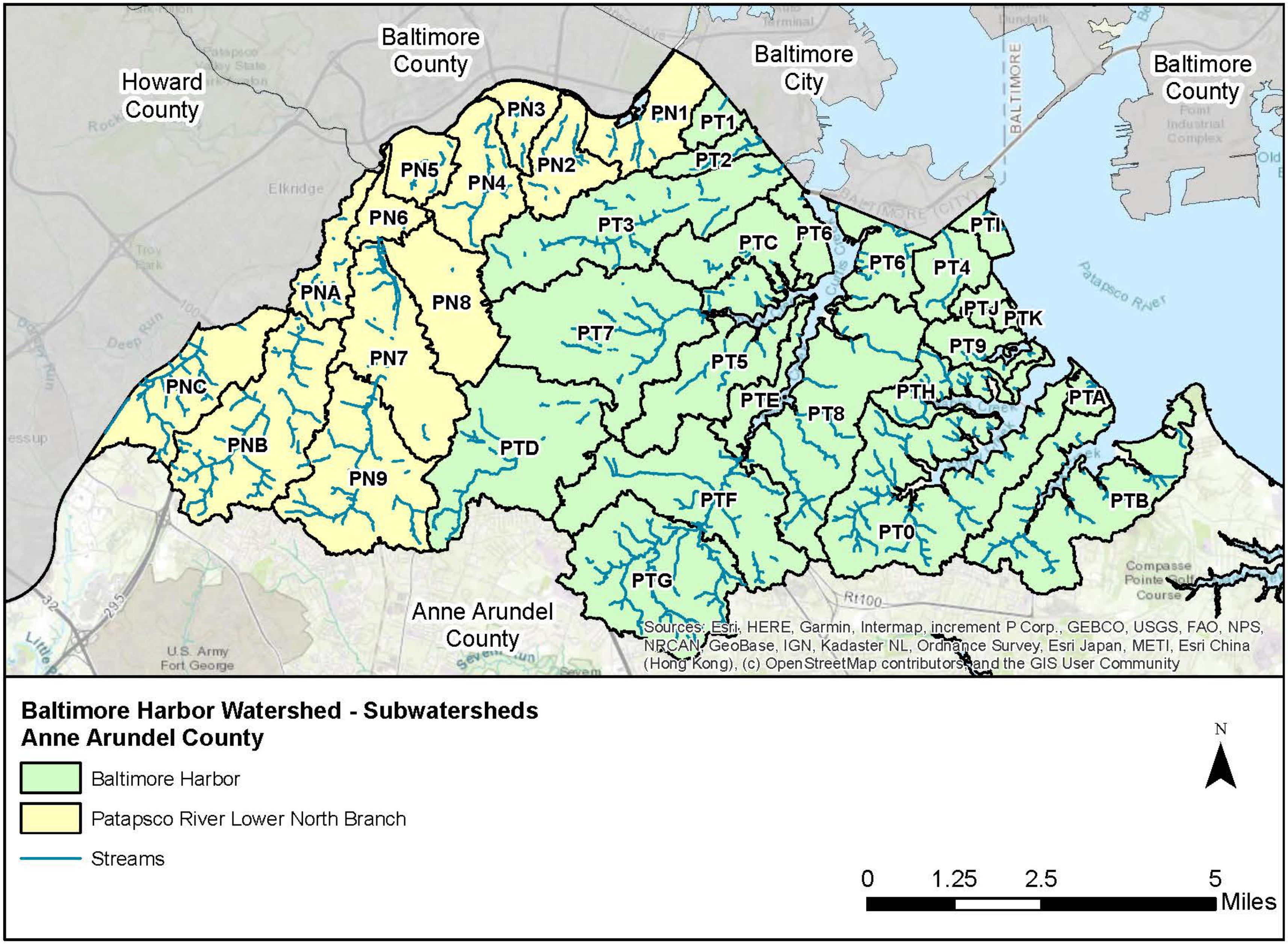


Figure 3: Baltimore Harbor Subwatersheds in Anne Arundel County, MD

Table 9: Baltimore Harbor Subwatershed Characteristics (Anne Arundel County GIS)

Subwater-shed Code	Subwatershed Name	Percent Imper-vious	Impervi-ous Acres	Drainage Area (acres)	Drain-age Area (square miles)	Total Stream Length (miles)
PN1	Patapsco River Mainstem	13	131	1030	1.6	2.4
PN2	Holly Creek	6	52	855	1.3	4.1
PN3	Patapsco River Mainstem	14	74	526	0.8	3.2
PN4	Unnamed Tributary	15	171	1175	1.8	5.1
PN5	Patapsco River Mainstem	9	50	574	0.9	2
PN6	Stoney Run I	15	66	431	0.7	0.6
PN7	Stoney Run II	7	137	1908	3	5.8
PN8	Stoney Run III	7	94	1440	2.3	1.2
PN9	Stoney Run IV	10	242	2401	3.8	12.9
PNA	Deep Run	4	28	710	1.1	3.3
PNB	Piney Run	10	261	2646	4.1	16.4
PNC	Deep Run	7	110	1570	2.5	8.9
PT0	Stony Creek	5	174	3,367	5.3	14.5
PT1	Unnamed Tributary	58	180	312	0.5	0.2
PT2	Cabin Branch II	10	36	370	0.6	2
PT3	Cabin Branch	7	196	2,667	4.2	9.7
PT4	Swan Creek	7	44	652	1	2.7
PT5	Furnace Creek	16	292	1,856	2.9	4.1
PT6	Curtis Creek	10	117	1,179	1.8	0.6
PT7	Sawmill Creek I	11	329	2,914	4.6	8.8
PT8	Marley Creek I	4	104	2,767	4.3	8.2
PT9	Cox Creek	13	68	544	0.9	0.9
PTA	Patapsco River Tidal	7	13	181	0.3	0.6
PTB	Rock Creek	5	133	2,574	4	7.5
PTC	Back Creek	20	205	1,045	1.6	1.3
PTD	Sawmill Creek II	7	180	2,684	4.2	8.6
PTE	Marley Creek II	7	36	492	0.8	0.4
PTF	Marley Creek III	14	341	2,517	3.9	9.8
PTG	Marley Creek IV	9	233	2,517	3.9	16
PTH	Nabbs Creek	5	37	688	1.1	4.1
PTI	Patapsco River Tidal	0	0.8	242	0.4	7
PTJ	Patapsco River Tidal	0	0.06	215	0.3	0
PTK	Patapsco River Tidal	0	0.05	85	0.1	0
Patapsco River Lower North Branch Total			**1,416**	**29,868**	**46.7**	**107.0**
Baltimore Harbor Total			**2,718.91**	**15,266**	**23.9**	**65.9**
Baltimore Harbor Watershed Total			**4,134.91**	**45,134.0**	**70.6**	**172.9**

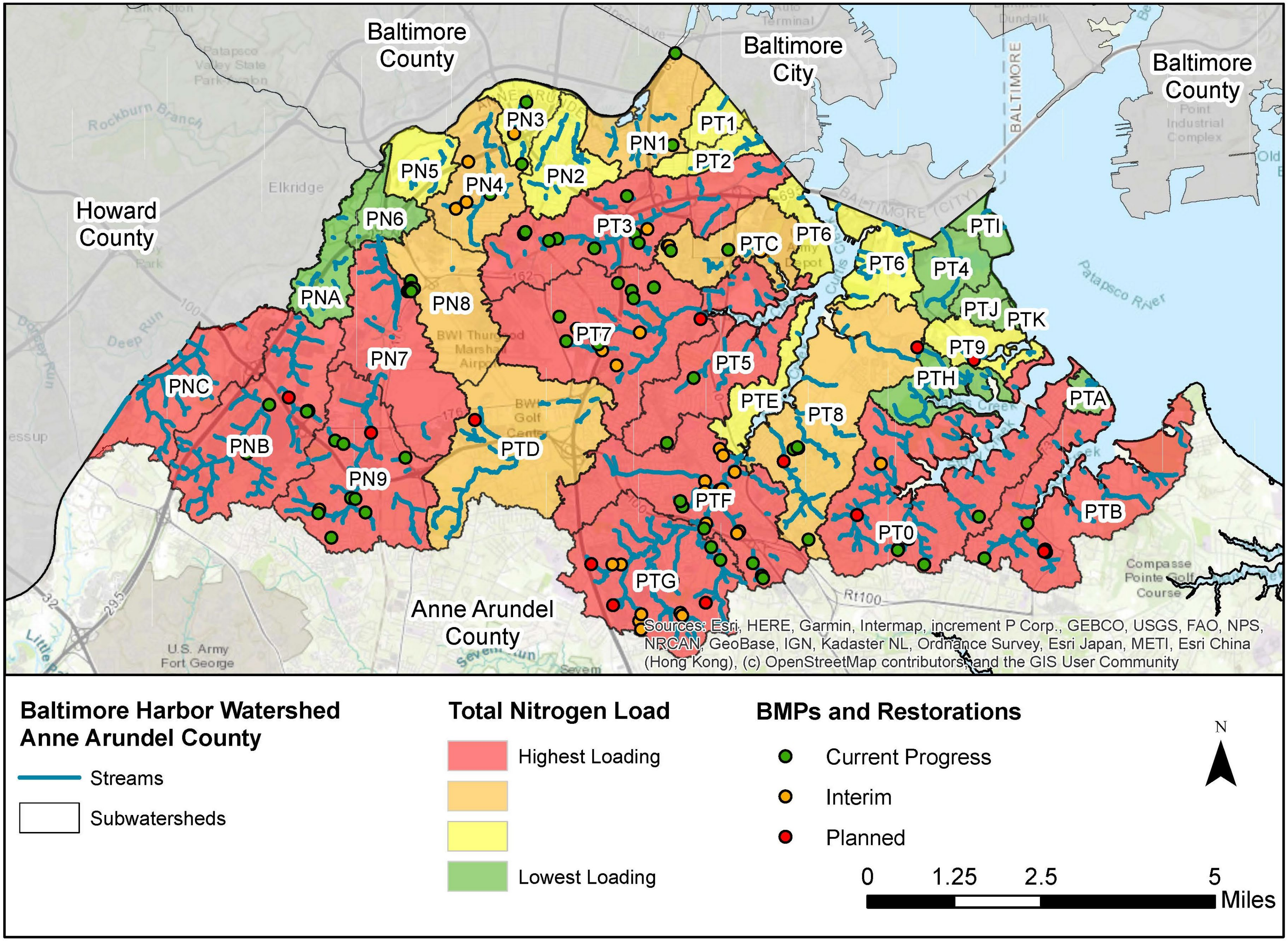


Figure 4: Total Nitrogen Loads with BMP and Restorations

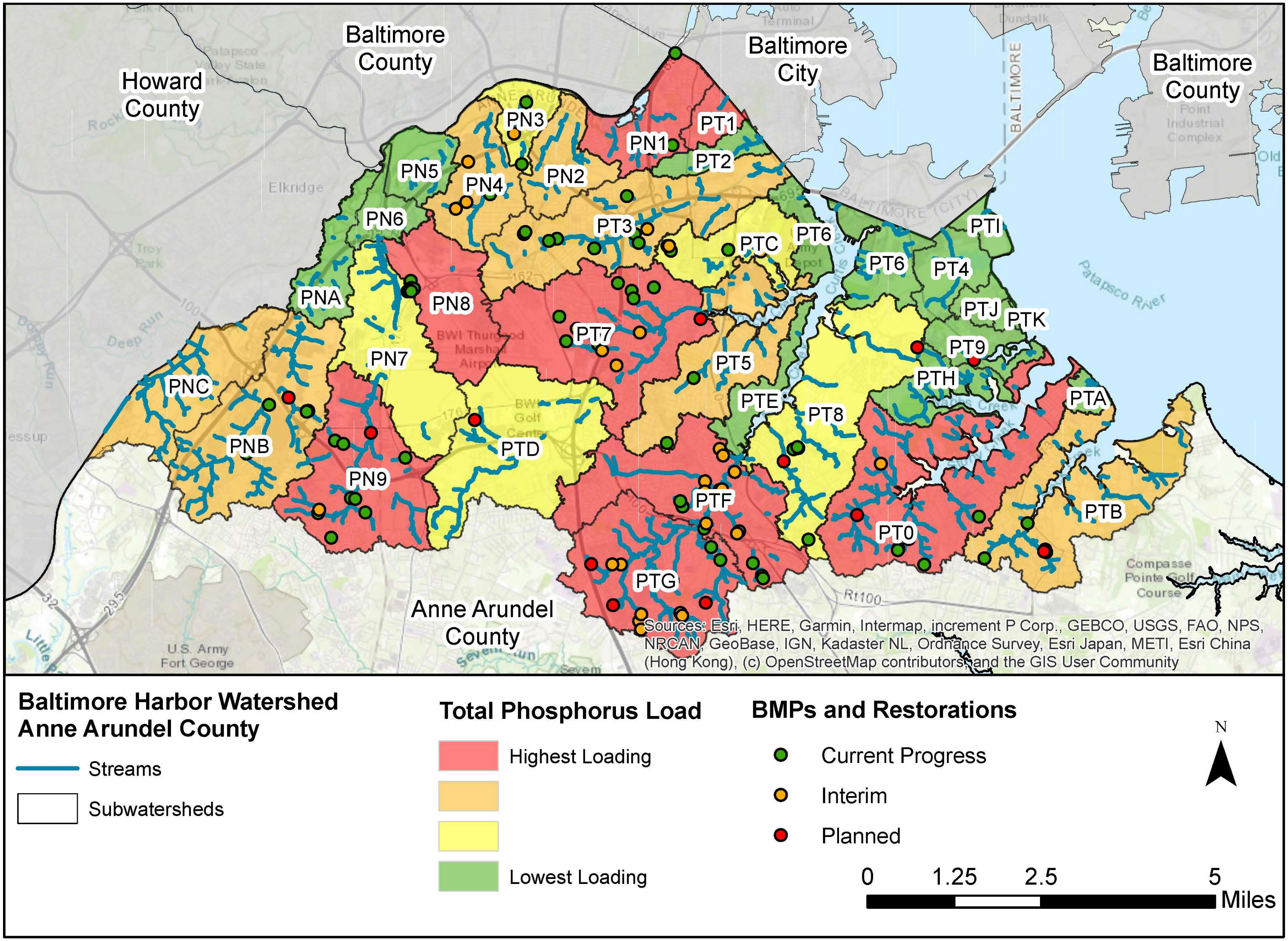


Figure 5: Total Phosphorus Loads with BMPs and Restorations

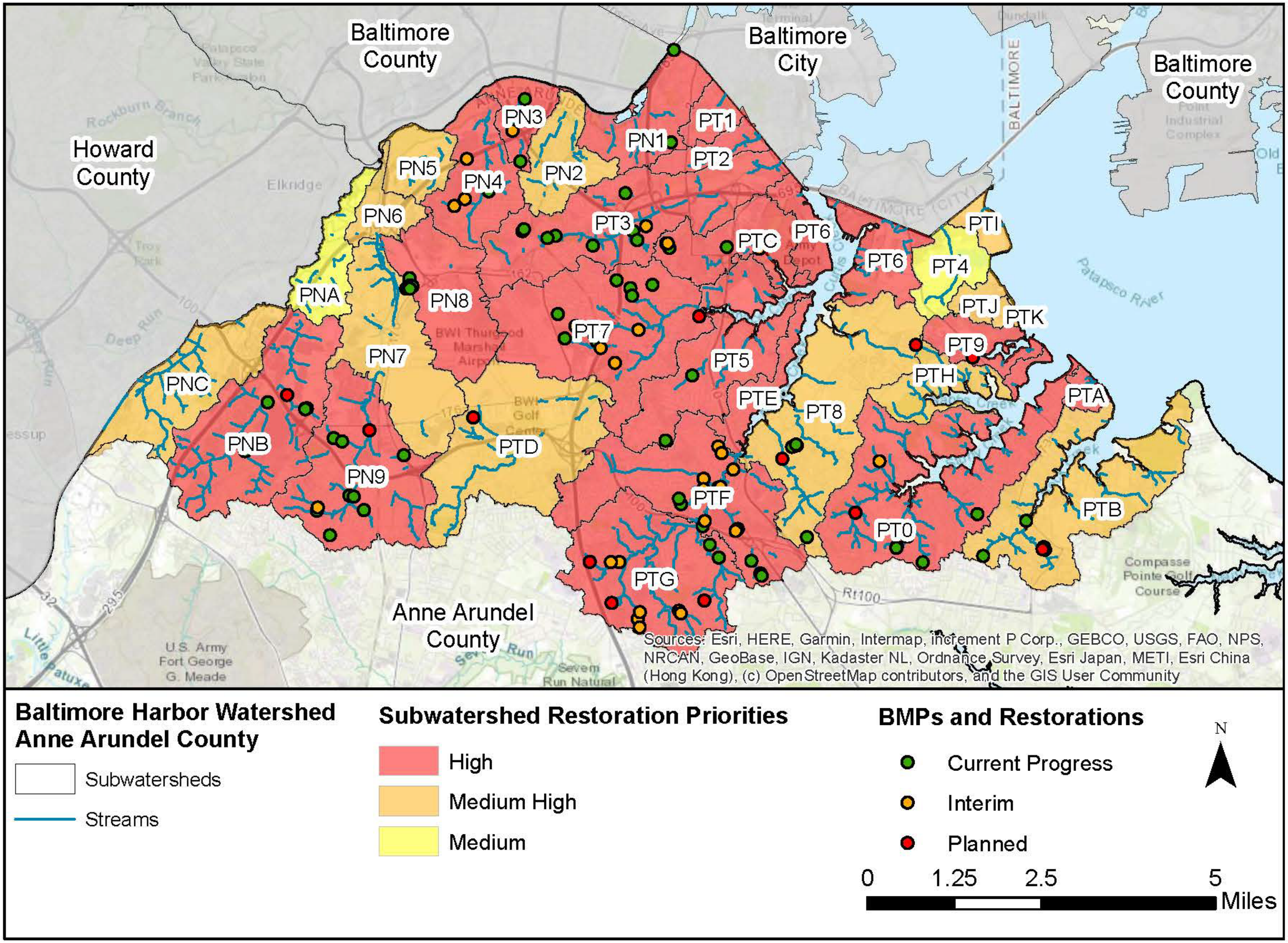


Figure 6: Subwatershed Restoration Priorities with BMPs and Restorations

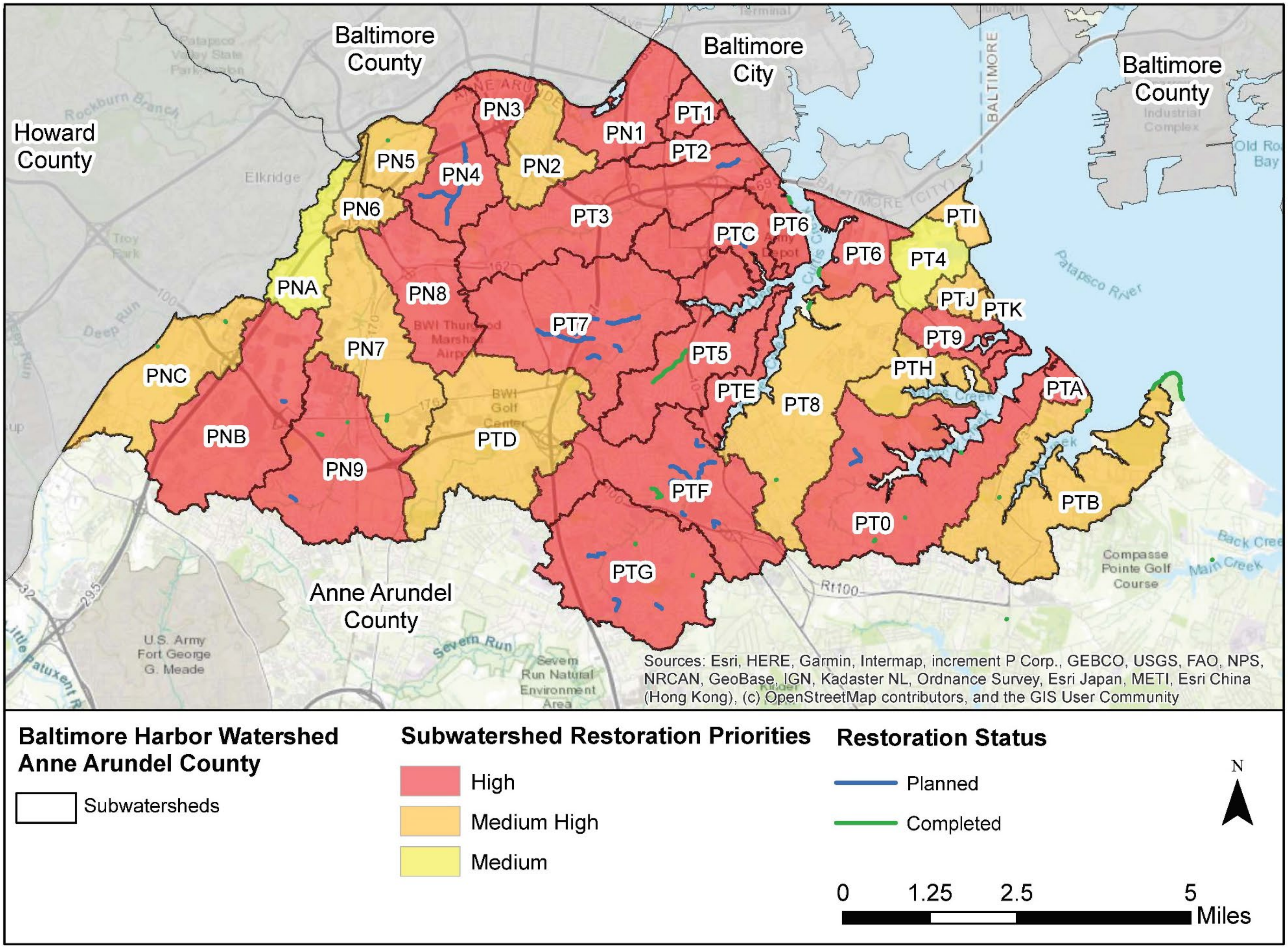


Figure 7: Subwatershed Restoration Priorities with Restoration Status of Stream, Outfall, and Shoreline Projects

3.2 Modeling

Nutrient load reduction progress was determined using the TMDL Implementation Planning and Progress (TIPP) spreadsheet tool, developed by MDE. The TIPP tool estimates pollutant load reductions at various points in the planning process so that current progress and future BMP implementation scenarios can be evaluated. This information is used to ensure that adequate restoration and management practices are planned to meet the load reduction targets.

Land cover data from the National Land Cover Database (NLCD) was used to quantify land cover acreage for the 1995 baseline year because the 2013/2014 Chesapeake Conservancy (CC) land cover data (provided in the TIPP tool) does not reflect the baseline year land use conditions for the Baltimore Harbor Watershed. The amount of land cover that was regulated by the MS4 increased from the 1995 baseline year to 2013/2014, and therefore relying on the 2013/2014 land cover data would inflate baseline year loads in the model. This was resolved by using the backcasting method developed by Baltimore County and approved by MDE. The backcasting method was applied to NLCD data to make it consistent with the Phase 6 Chesapeake Bay Watershed Model land cover classes that are used in the TIPP tool. Backcasting was conducted comparing the 2013/2014 CC land cover data to the 2013 NLCD land cover data.

Before backcasting, several steps were taken to preprocess both the NLCD and CC data. Firstly, MDE's classification of 'Mixed Open/Agriculture' was disaggregated into 'Mixed Open' and 'Agriculture'. This was achieved by reclassifying 'Mixed Open/Agriculture' to 'Agriculture' where the land cover classification intersected with a parcel having an agricultural assessment. All other occurrences of 'Mixed Open/Agriculture' that did not intersect with a parcel having an agricultural assessment were reclassified as 'Mixed Open'. Additionally, the NLCD land cover data does not have an 'Impervious' land cover category but is instead classified as different intensities of 'Developed'. To be consistent with Phase 6 Chesapeake Bay Watershed Model land cover classes, all NLDC land cover data were reclassified as 'Impervious' if it intersected with the County's impervious land cover dataset. The 2007 County impervious data were used for the backcasting, as it was the earliest impervious dataset that provided an accurate representation of impervious surfaces in the County. Finally, NLCD data were clipped to the extent of the County MS4-regulated area, removing state, federal, and any other land that does not fall under the County's jurisdiction.

Backcasting was conducted on the Baltimore Harbor Nutrient TMDL watershed separately, rather than County-wide. Using both the 2013/2014 NLCD and CC land cover data for each NLCD land cover category, the percentages of different CC land cover classes within each NLCD land cover class were summarized. The NLCD land cover acreages were multiplied by the percentages of CC land covers, transforming the NLCD land cover to CC land cover classes, which are compatible with the TIPP tool. Figure 8 serves as the key with which to 'translate' NLCD data prior to 2014 for the Baltimore Harbor Watershed and make data consistent with the Phase 6 Chesapeake Bay Watershed Model land cover classes.

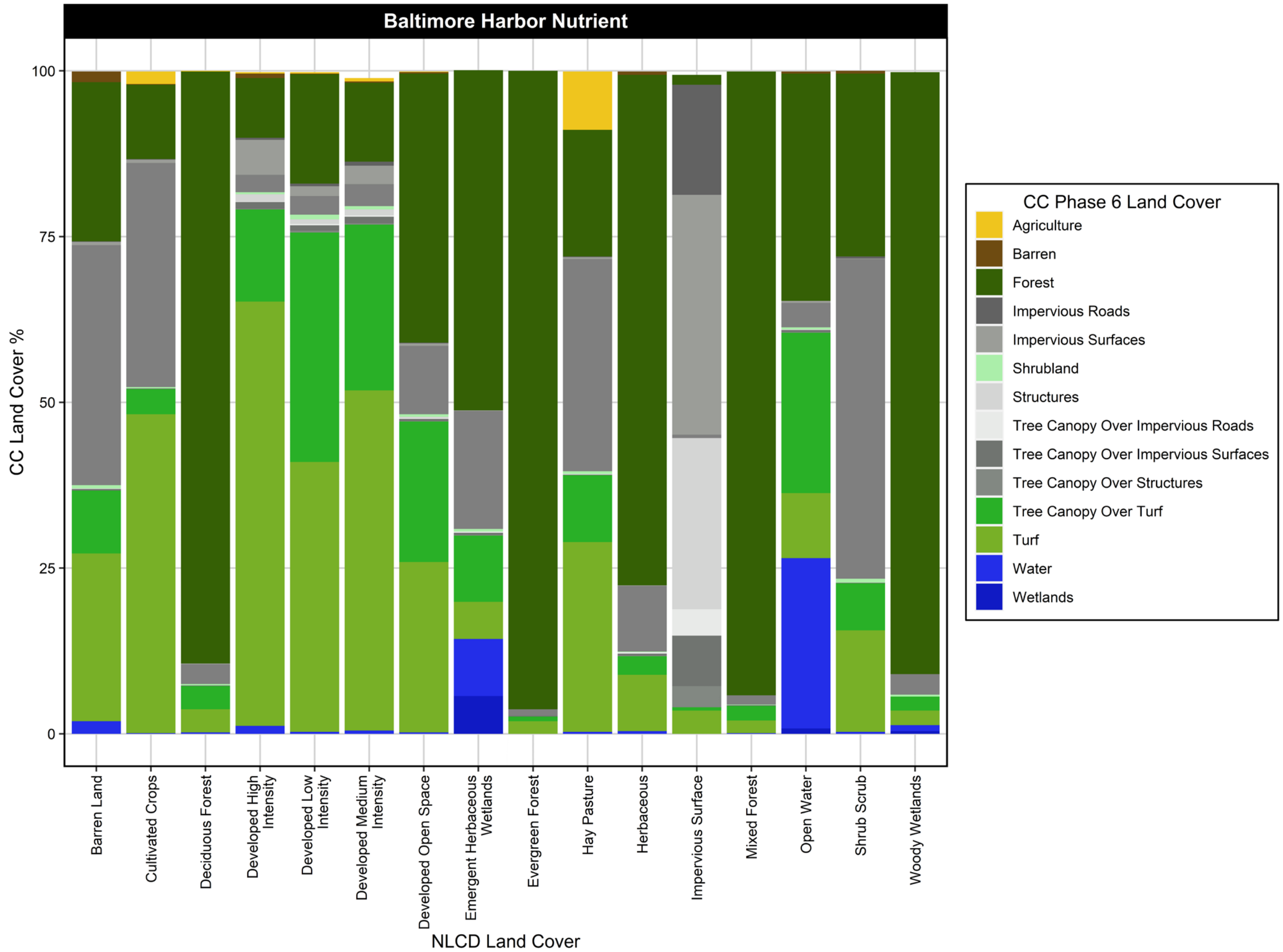


Figure 8: Unique NLCD-CC Translations

Backcasted 'Aggregate Impervious' and 'Turf' acres were entered into the TIPP Tool to determine the baseline load. Land cover classes including 'Tree Canopy over Turf' and 'Tree Canopy over Aggregate Impervious' were added as land cover conversions from 'Turf'. In these cases, 'Tree Canopy over Turf' and 'Tree Canopy over Aggregate Impervious' acres were added to the baseline 'Turf' acres.

3.2.1 Baseline and Current Progress Loads

The types of BMPs that are applicable to the Baltimore Harbor Watershed, and their implementation scenarios, are shown in Table 10. The baseline nitrogen and phosphorus loads and current load reductions in pounds for these BMP practices are shown in Table 11.

Table 10: BMP Project Implementation by Time Period

Type	Baseline Year	FY23 Progress	Milestone and Planned Source Reductions	Total	Units Treated
Stream Restoration	0	6,279.7	58,080.1	64,359.8	Feet
Street Sweeping	0	93.7	0.0	93.7	Lane Miles
Storm Drain Cleaning	0	138,263.8	0.0	138,263.8	Pounds
Land Use Conversion	0	3.1	0	3.1	Acres
Stormwater Management BMPs	1,630.1	894.7	742	3,266.8	Acres

Table 11: Baseline Loads and Current Load Reductions

Load Source		Nitrogen Load (lbs)	Phosphorus Load (lbs)
TIPP Baseline Loads	MS4 Aggregate Impervious	138,817.34	10,469.65
	MS4 Tree Canopy over Aggregate Impervious	25,701.63	1,885.46
	MS4 Tree Canopy over Turf	41,257.19	3,581.11
	MS4 Turf	76,642.96	6,652.58
	Baseline BMPs Load Reduction	(8,370.4)	(964.97)
2009 Baseline		**274,048.73**	**21,623.84**
TIPP Current Progress Load Reductions	Catch Basin Cleaning	(284.13)	(45.63)
	Street Sweeping	(45.27)	(10.39)
	Land Cover Conversion	(13.90)	(1.21)
	Stormwater Management BMP	(5,458.66)	(636.58)
	Stream Restoration	(2,799.36)	(672.11)
FY 2023 Progress Load		**265,447.41**	**20,257.93**

As shown in Table 12, Anne Arundel County has achieved measurable reductions in nutrient loads for the Baltimore Harbor Watershed. As of the 2023 accounting, the nitrogen reduction is 3.14 percent, and the phosphorus reduction is 6.32 percent. The reduction target for both nutrients is 15 percent.

Table 12: Baseline Load and Progress Load Summary

Results and TMDL WLA	Loads and Percent Reduction Nitrogen	Loads and Percent Reduction Phosphorus
2009 Baseline Load (lbs)	274,048.73	21,623.84
2023 Progress Load (lbs)	265,447.41	20,257.93
Percent Reduction	3.14%	6.32%
Target TMDL WLA Reduction	15%	15%

3.2.2 Milestone and Planned Implementation

As shown in the previous section, Anne Arundel County must achieve further load reductions to meet its nutrient reduction TMDL requirements in the Baltimore Harbor Watershed. Figures 9 and 10 illustrate that the target load reductions will be met by 2030 using a combination of current progress reduction (FY23), interim programmed reduction, and planned reduction. Interim programmed (milestone) reduction is defined as load reduction, expressed as either pounds, counts or percent, which are achieved from BMPs that are under a design contract and have reached the 30-percent design phase. Planned reduction is defined as load reduction achieved, expressed as either pounds, counts, or percent, which are achieved from BMPs that are either not under a design contract or have not yet reached the 30-percent design stage.

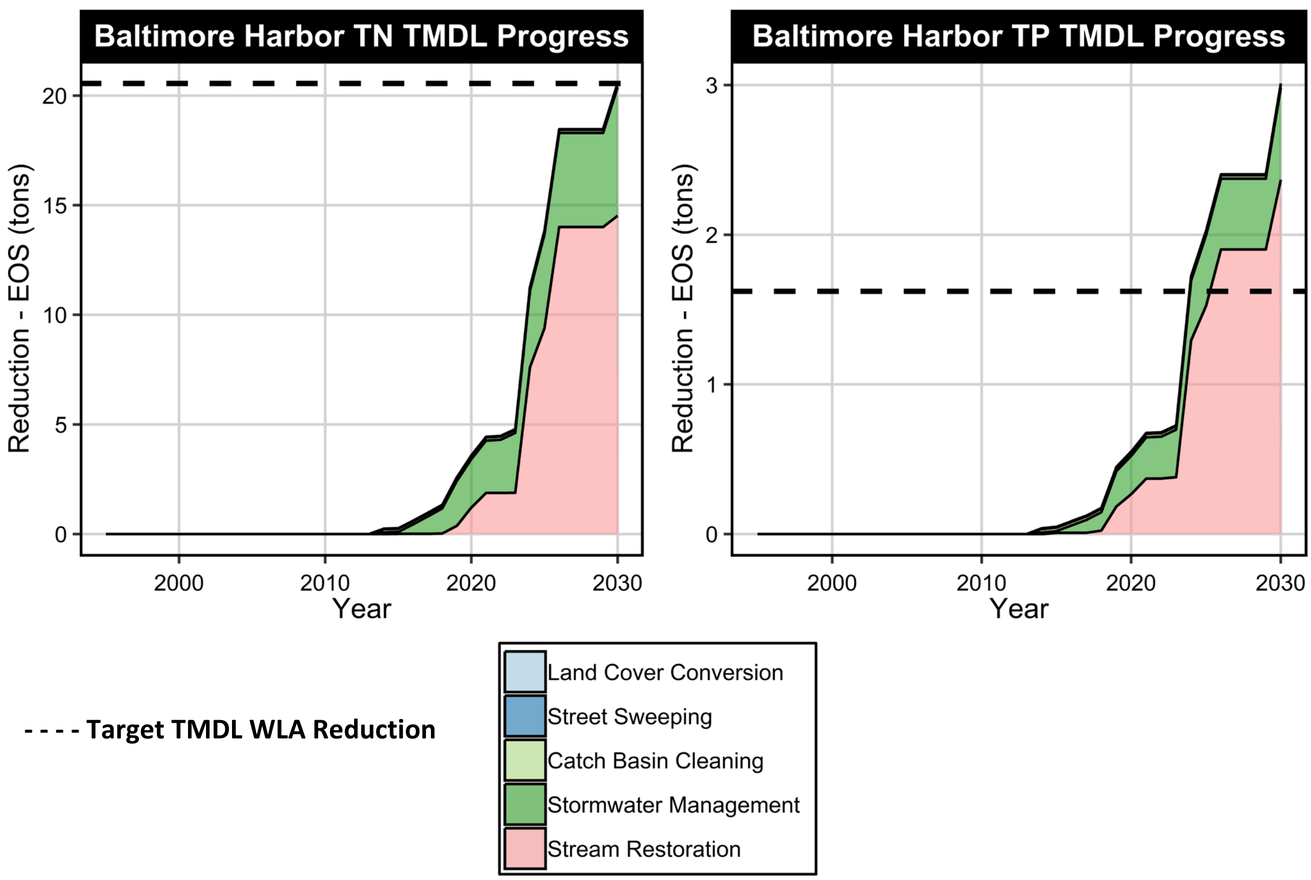


Figure 9: TMDL Progress – BMPs Progress and Reductions

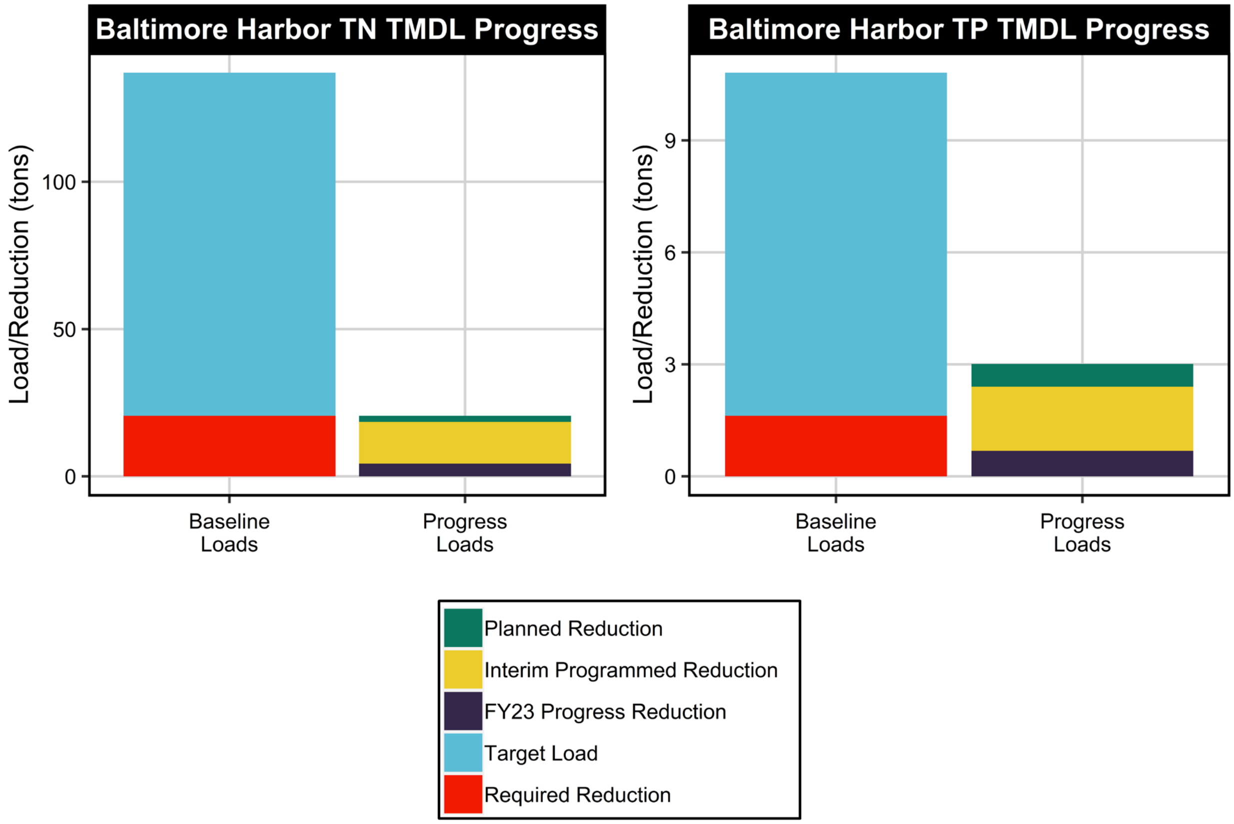


Figure 10: TMDL Progress – Target Loads, Current Progress, and Reductions

Milestone and Planned BMP implementation nutrient loads for the Baltimore Harbor Watershed are shown in Table 13. Milestone and Planned implementation projects include stormwater management BMPs and stream restoration. Figure 11 shows the locations of these projects in the Baltimore Harbor Watershed and whether the projects are Current Progress, Interim (Milestone), or Planned. The TIPP spreadsheets are provided in Appendix A and auxiliary data for each BMP and restoration practice are included in Appendix B.

Table 13: Milestone and Planned BMP Implementation through 2030

Loads and Reductions		Amount	Unit	Nitrogen Load (lbs)	Phosphorus Load (lbs)
Baseline (2009) Load Total				**274,048.73**	**21,623.84**
Current (2023 Progress) Load Total				**265,447.41**	**20,257.93**
Milestone and Planned Source Reductions	Stream Restoration	58,080.10	Feet	26,242.14	4,054.16
	Stormwater Management BMPs	742.03	Acres	6,271.03	593.06
Total Milestone and Planned Source Reductions				**32,513.17**	**4,647.22**
2030 Planned Load: 2023 Progress Load – Total Milestone and Planned Source Reductions				**232,934.24**	**15,601.71**
Total Nutrient Reduction	Percent Reduction Achieved			15.00%	27.85%
	Target TMDL WLA Percent Reduction			15%	15%
	Remaining Percent Reduction Required			0%	-12.85%

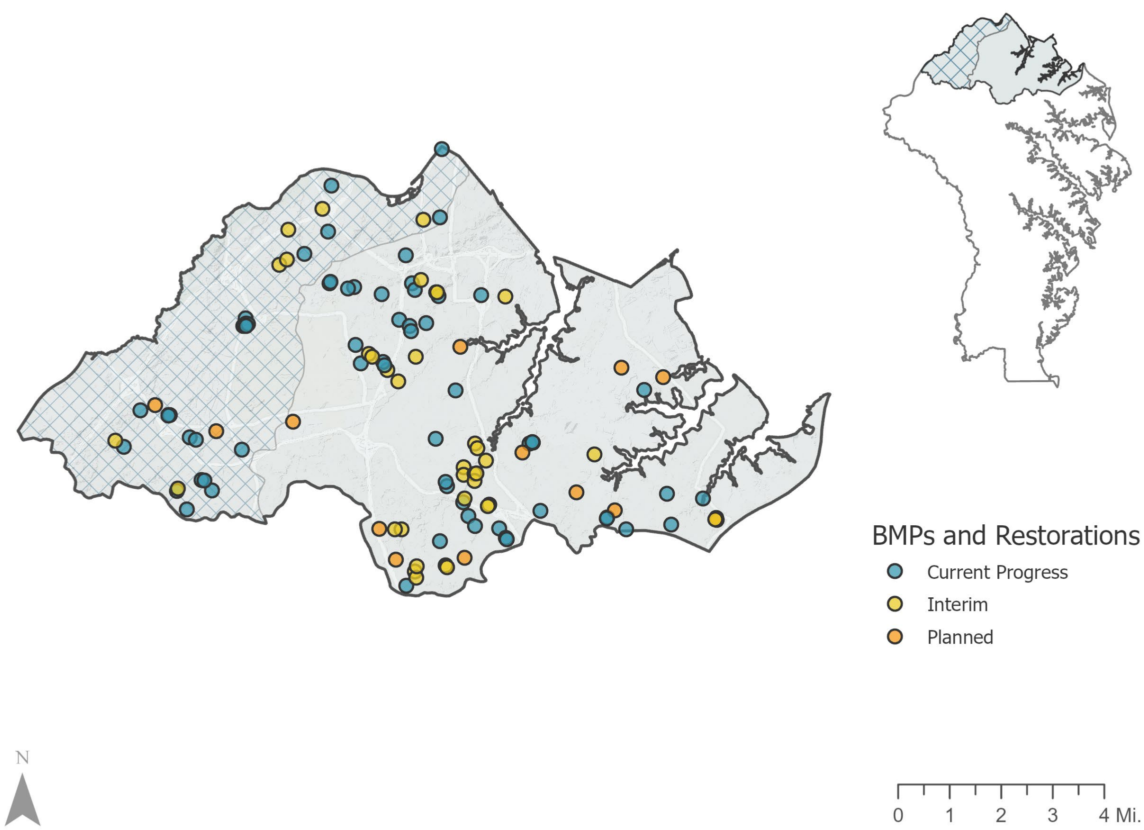


Figure 11: Current Progress, Interim, and Planned Projects

3.3 Monitoring

3.3.1 Biological Monitoring and Habitat Assessments

Anne Arundel County initiated a countywide biological monitoring program in 2004 to document baseline conditions, to establish a method to track changes in biological resources and water quality over time, and to measure and document changes as they related to restoration practices. The program was based on the MD DNR MBSS protocols and included benthic sampling, PHI, and RBP. Additional information regarding Anne Arundel County's biological monitoring program can be found on DPW's program website: https://www.aacounty.org/public-works/bwpr/ecological-assessment-evaluation/biological-monitoring. Summary results of monitoring can be found in Hill and Pieper (2011), Hill et al. (2014), and Hill et al. (2022).

Anne Arundel County divided sampling efforts based on watershed areas identified as Primary Sampling Units (PSUs). The PSUs within Anne Arundel County that drain to the Baltimore Harbor Watershed include Piney Run, Stoney Run, Lower Patapsco River, Sawmill Creek, and Marley Creek as shown in Figure 12. Each PSU contains numerous random sampling stations that are surveyed during each Round, as defined below.

Round 1 of biological monitoring was conducted from 2004 to 2008 to document baseline conditions. Round 2 was conducted from 2009 to 2013, and Round 3 was conducted from 2017 to 2021. The sampling period for Round 1 (2004–2008) correlated with the Baseline Year (2009) used in the TIPP models for all PSUs that overlapped with the Baltimore Harbor Watershed. The sampling period for Round 2 correlated with the Baseline Year (2009) for Piney Run and Marley Creek. Fish sampling and additional sites sampled per annum were added for Round 3.

Results from individual sampling points are aggregated into overall ratings for each PSU for each round. Table 14 summarizes results of biological and habitat monitoring, which show changes over time.

PSU 1 (Piney Run) has not shown any variation from Round 1 to Round 3. The BIBI has remained Poor, PHI has remained Degraded, and the RPB remained Partially Supporting. A FIBI was assessed for the first time in Round 3, which resulted in a Fair rating.

PSU 2 (Stoney Run) showed an improvement in BIBI ratings in Round 3 when it increased from Poor to Fair. A FIBI of Fair was collected in Round 3, which supports the increased BIBI rating. PHI has varied from Partially Degraded to Degraded and RBP has varied from Partially Supporting to Supporting from Round to Round. Additional data is needed to detect a clear trend in improvement for PHI and RBP.

PSU 3 (Lower Patapsco River) has shown little variation in BIBI ratings from Round 1 to Round 3 and has remained Poor throughout. A FIBI score of Poor was also recorded in Round 3. PHI decreased from Partially Degraded in Round 1 and Round 2 to Degraded in Round 3, which is supported by the RBP decreasing from Partially Supporting to Non-Supporting.

The BIBI at PSU 4 (Sawmill Creek) increased from Very Poor in Round 1 to Poor in Rounds 2 and 3, which is supported by a Fair FIBI in Round 3. The PHI increased from Degraded to Partially Degraded in Round 3 and the RBP increased from Partially Supporting to Supporting in Round 3. The County has undertaken additional monitoring in Sawmill Creek in an effort to determine what drives the improved BIBI and RBP scores.

The BIBI at PSU 5 (Marley Creek) has varied from Very Poor to Poor between Rounds and a FIBI of Poor was recorded in Round 3. PHI has remained Degraded, and the RPB remained Partially Supporting throughout the monitoring period.

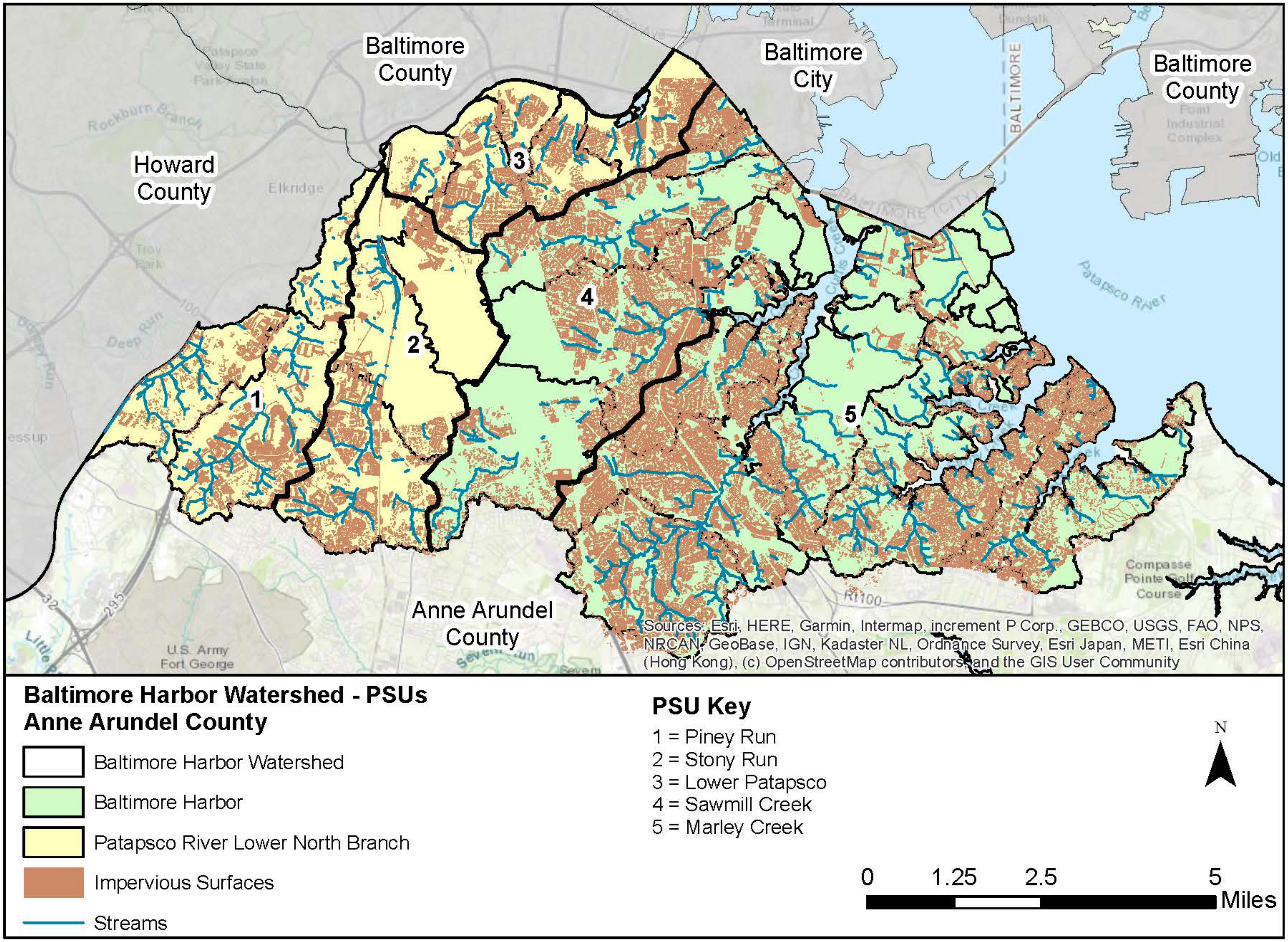


Figure 12: PSUs that intersect the Baltimore County Watershed, sampled by Anne Arundel County during Rounds 1, 2, and 3

Table 14: Biological Condition Narrative Results Summarized by PSU, Rounds 1, 2, and 3

PSU Name	Round	PSU Code	Year Sampled	BIBI	PHI	RBP	FIBI	Notes
Piney Run	1	1	2007	P	D	PS	NC	BIBI: No Change PHI: No Change RBP: No Change
	2		2009	P	D	PS	NC	
	3		2018	P	D	PS	F	
Stoney Run	1	2	2007	P	D	PS	NC	BIBI: P (2007/2010) to F(2020) PHI: D (2007) to PD (2010) to D (2020) RBP: PS (2007) to S (2010) to PS (2020)
	2		2010	P	PD	S	NC	
	3		2020	F	D	PS	F	
Lower Patap-sco River	1	3	2004	P	PD	PS	NC	BIBI : No Change PHI: PD (2004/2012) to D (2018) RBP: PS (2004) to NS (2012/2018)
	2		2012	P	PD	NS	NC	
	3		2018	P	D	NS	P	
Sawmill Creek	1	4	2008	VP	D	PS	NC	BIBI: VP (2008) to P (2010/2019) PHI: D (2008/2010) to PD (2019) RBP: PS (2008/2010) to S (2019)
	2		2010	P	D	PS	NC	
	3		2019	P	PD	S	F	
Marley Creek	1	5	2006	P	D	PS	NC	BIBI: P (2006) to VP (2009) to P (2018) PHI: No Change RBP: No Change
	2		2009	VP	D	PS	NC	
	3		2018	P	D	PS	P	

NOTES:

IBI 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

NC = Not Collected

The overall averaged results for each PSU were within Maryland's Use Class I and II water quality standards for every parameter measured during each Round; only Spring was evaluated for Round 3. For instance, average stream temperatures were below 90 degrees Fahrenheit, average dissolved oxygen levels were above 5.0 milligrams per liter, average pH values were between 6.5 to 8.5, and average turbidity measurements were below the threshold of 150 NTU. Average results are summarized in Table 15. On a few occasions, documented water quality readings did not meet the standards at individual monitoring stations. Measured dissolved oxygen concentrations were below the water quality standard at three stations during Round 1, one station during Round 2, and one station during Round 3. Measurements of pH levels below 6.5 were recorded at four stations during Round 1, three stations during Round 2, and two stations during Round 3. The water quality results from every station are provided in Appendix C. No individual site had water quality measurements that failed to meet the standards during multiple years. All measurements collected at stations in the Stoney Run and Sawmill Creek PSUs met the water quality standards, and no exceedances of turbidity or temperature were recorded at any site during the three Rounds of monitoring. The stations monitored for water quality during Rounds 1, 2, and 3 are shown in Figure 13.

Table 15: In Situ Physicochemical Data Summarized by PSU, Rounds 1, 2, and 3

PSU Name	Round	PSU Code	Year	Average Temp.(C)	Average DO (mg/L)	Average pH	SpC. (uS/cm)	Average Turbidity (NTU)
Piney Run	1	1	2007	6.30	12.6	NC	1056.1	NC
	2		2009	11.93	10.36	7.13	482.9	7.40
	3		Spring 2018	9.00	10.96	7.31	688.4	6.78
			Summer 2018	22.65	6.61	7.24	434.8	26.38
Stoney Run	1	2	2007	7.80	12.1	NC	633.9	NC
	2		2010	11.83	10.77	7.11	434.2	8.67
	3		Spring 2020	11.19	10.25	7.11	322.6	11.20
			Summer 2020	20.50	7.77	7.07	335.4	9.20
Lower Patapsco River	1	3	2004	12.60	6.9	7.70	537.0	8.20
	2		2012	13.79	8.47	6.97	360.4	7.09
	3		Spring 2018	9.09	10.19	7.14	1434.3	12.85
			Summer 2018	21.64	6.39	7.46	359.3	8.83
Sawmill Creek	1	4	2008	8.60	10.8	NC	465.5	NC
	2		2010	10.77	9.46	7.45	558.8	5.92
	3		Spring 2019	11.29	10	6.95	3434.7	5.83
			Summer 2019	19.75	6.22	6.69	335.2	6.97
Marley Creek	1	5	2006	8.00	10.7	6.50	299.4	NC
	2		2009	8.60	10.8	7.10	465.5	NC
	3		Spring 2018	7.18	11.43	6.99	373.0	16.95
			Summer 2018	22.20	7.28	7.33	344.0	34.64

NOTES:
NC = Not Collected

Anne Arundel County began collecting water chemistry data during Round 3, the results of which are summarized in Table 16. A narrative rating of Low, Moderate, or High was applied to the results per Table 5. Speciation of Total Nitrogen and Total Phosphorus were analyzed to determine concentrations of ammonia (NH3-N), Nitrate-Nitrogen (NO3-N), Nitrite-Nitrogen (NO2-N), and Ortho-phosphate (OP).

Round 3 water quality results show that samples collected in the Piney Run PSU contained high concentrations of Total Phosphorus on average, based on the narrative rating scale, and the Stoney Run PSU contained high concentrations of Total Nitrogen on average. Average measured nutrient levels at the remaining PSUs qualified in Low or Moderate classes. Additional data would be needed to evaluate trends over time. The results of the chemical water quality data monitoring are provided in Appendix C.

Table 16: Water Chemistry Data Summarized by PSU, Round 3

PSU Name	PSU Code	Year	Average Total Phosphorus (mg/L)	Average Total Nitrogen (mg/L)	OP (mg/L)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	Notes
Piney Run	1	2018	0.092	1.654	0.055	0.775	0.013	0.624	Low: NO3 Mod: TN High: TP, OP, NH3, NO2
Stoney Run	2	2020	0.037	7.3	0.450	0.095	0.033	1.070	Low: --- Mod: TP, NO3 High: TN, OP, NH3, NO2
Lower Patapsco River	3	2018	0.023	1.597	0.004	0.033	0.011	1.265	Low: OP Mod: TP, TN, NH3 High: NO2, NO3
Sawmill Creek	4	2019	0.029	1.387	0.005	0.068	0.007	1.153	Low: TN, OP, NO2, NO3 Mod: TP, NH3 High: ---
Marley Creek	5	2018	0.024	1.175	0.004	0.031	0.007	0.793	Low: TP, TN, OP, NO3 Mod: NH3, NO2 High: ---

NOTES:
mg/L = milligrams per liter

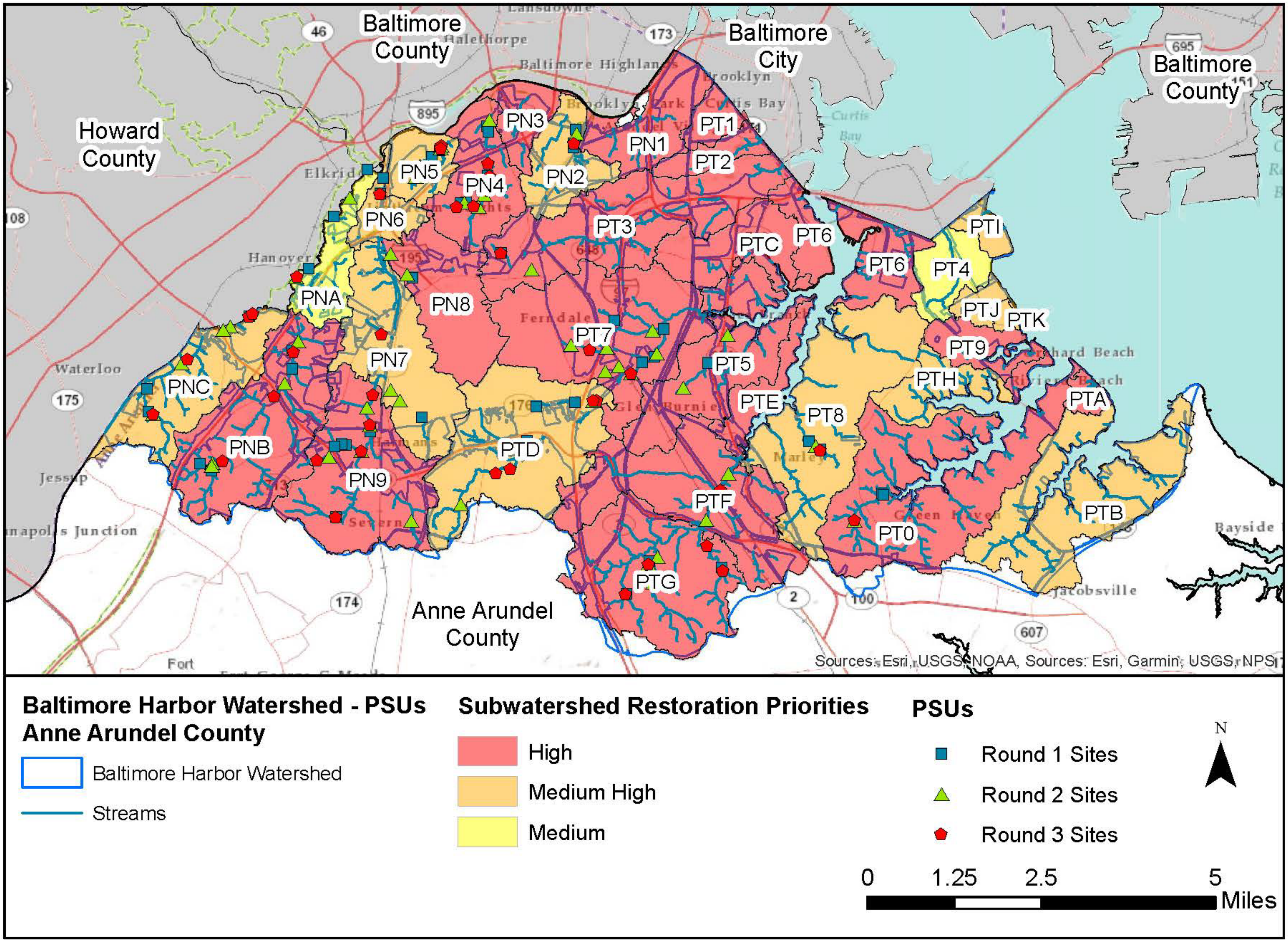


Figure 13: Sampling Site Locations with Subwatershed Restoration Priorities, Rounds 1, 2 and 3

3.3.2 Restoration Monitoring

Long-Term biological monitoring and habitat assessment data will be used to evaluate progress for specific restoration projects. Stream restoration projects in the Baltimore Harbor Watershed include Ferndale Branch, Furnace Branch, Irving Branch, and Muddy Bridge Branch. Data have been collected at these sites from 2016 to 2022 and are reported in Table 17. Stream restoration for all monitoring sites except for Furnace Branch are currently under design.

Construction for the Furnace Branch stream restoration was performed from 2018 to 2020. Three years of baseline data (from station FB-01) collected prior to stream restoration indicated a Benthic IBI of Very Poor and RBP narrative ratings that were Not Supporting or Partially Supporting. The Benthic IBI increased to Poor and the RBP increased to Supporting in the two years following construction; a Fish IBI of Fair was reported in 2022. Analysis results support that the stream restoration resulted in functional uplift for both Benthic IBI and RBP. Additional years of monitoring may detect further improvements as biological communities recover from disturbances caused by stream restoration.

Table 17: Stream Restoration Monitoring Data

Site	Year	Benthic IBI Rating	Fish IBI Rating	RBP Rating	Notes
Ferndale Branch (FD-01)	2017	Fair	---	Supporting	Baseline data Stream restoration planned for 2023
	2018	Poor	Poor	Supporting	
	2019	Poor	---	Partially Supporting	
	2020	Poor	Poor	Supporting	
	2021	Poor	---	Partially Supporting	
	2022	Poor	Poor	Supporting	
Furnace Branch (FB-01)	2016	Very Poor	---	Partially Supporting	Stream restoration 2018 – 2020
	2017	Very Poor	---	Partially Supporting	
	2018	Very Poor	---	Not Supporting	
	2019	---	---	---	
	2020	---	---	---	
	2021	Poor	---	Supporting	
	2022	Poor	Fair	Supporting	
Furnace Branch (FB-02)	2016	Very Poor	---	Not Supporting	Stream restoration 2018 – 2020
	2017	Very Poor	---	Not Supporting	
	2018	Very Poor	---	Not Supporting	
	2019	---	---	---	
	2020	---	---	---	
	2021	Poor	---	Partially Supporting	
	2022	Poor	Fair	Supporting	
Irving Branch (IB-01)	2017	Poor	---	Supporting	Baseline data Stream restoration planned for 2023
	2018	Fair	Poor	Partially Supporting	
	2019	Fair	---	Partially Supporting	
	2020	Fair	Very Poor	Partially Supporting	
	2021	Fair	---	Partially Supporting	
	2022	Poor	Very Poor	Partially Supporting	
Muddy Branch (MB-01)	2017	Very Poor	---	Supporting	Baseline data Stream restoration planned for 2023
	2018	Poor	Fair	Partially Supporting	
	2019	Very Poor	---	Partially Supporting	
	2020	Poor	Fair	Supporting	
	2021	Poor	---	Partially Supporting	
	2022	Poor	Good	Partially Supporting	
Muddy Branch (MB-02)	2017	Poor	---	Supporting	Baseline data Stream restoration planned for 2023
	2018	Very Poor	Very Poor	Not Supporting	
	2019	Very Poor	---	Partially Supporting	
	2020	Very Poor	Poor	Not Supporting	
	2021	Very Poor	---	Partially Supporting	
	2022	Poor	Very Poor	Not Supporting	

4.0 PROPOSED MANAGEMENT STRATEGIES

Model predictions indicate that target load reductions will be met for nitrogen and exceeded for phosphorus by 2030 using a combination of current progress reduction (FY23), interim programmed reduction (milestone projects), and planned projects. Adaptive management will be implemented to maintain these load reductions, and monitoring data will be used to determine if water quality is improving following the implementation of the restoration projects. Milestone and planned projects include stormwater management BMPs and stream restoration. The implementation costs of the milestone stormwater management BMP and stream restoration projects for each subwatershed are shown in Table 18 and Table 19, respectively.

Table 18: Milestone Stormwater Management BMP Project Costs

Watershed Name (8-digit level)	Subwatershed Code	Subwatershed Name	Implementation Cost ($)
Patapsco River Lower North Branch	PN1	Patapsco River Mainstem	1,855,262
Patapsco River Lower North Branch	PN3	Patapsco River Mainstem	1,229,479
Patapsco River Lower North Branch	PN4	Unnamed Tributary	1,640,420
Patapsco River Lower North Branch	PN9	Stoney Run IV	439,966
Patapsco River Lower North Branch	PNB	Piney Run	125,000
Baltimore Harbor	PT3	Cabin Branch	687,785
Baltimore Harbor	PT7	Sawmill Creek I	158,060
Baltimore Harbor	PTB	Rock Creek	1,108,997
Baltimore Harbor	PTC	Back Creek	2,000,000
Baltimore Harbor	PTF	Marley Creek III	553,292
Baltimore Harbor	PTG	Marley Creek IV	1,476,715
Patapsco River Lower North Branch Total			**5,290,127**
Baltimore Harbor Total			**5,984,849**
Baltimore Harbor Watershed Total			**11,274,976**

Table 19: Milestone Stream Restoration Project Costs

Watershed Name (8-digit level)	Subwatershed Code	Subwatershed Name	Implementation Cost ($)
Patapsco River Lower North Branch	PN4	Unnamed Tributary	14,473,400
Baltimore Harbor	PT0	Stony Creek	1,718,370
Baltimore Harbor	PT7	Sawmill Creek I	9,204,351
Baltimore Harbor	PTB	Rock Creek	167,604
Baltimore Harbor	PTC	Back Creek	5,073,224
Baltimore Harbor	PTF	Marley Creek III	13,054,110
Baltimore Harbor	PTG	Marley Creek IV	14,203,425
Patapsco River Lower North Branch Total			**14,473,400**
Baltimore Harbor Total			**43,421,084**
Baltimore Harbor Watershed Total			**57,894,484**

The estimated implementation costs of the planned stormwater management BMP and stream restoration projects for each subwatershed are shown in Table 20 and Table 21, respectively. The planned stormwater management BMP projects are for facility conversions or upgrades. The costs were estimated as $106,000 per acre of impervious area credit. The costs for the planned stream restoration projects were estimated as $1,200 per foot of project stream length.

Table 20: Planned Stormwater Management BMP Project Costs

Watershed Name (8-digit (level)	Subwatershed Code	Subwatershed Name	Estimated Implementation Cost ($)
Baltimore Harbor	PT0	Stony Creek	769,560
Baltimore Harbor	PT7	Sawmill Creek I	5,860,740
Baltimore Harbor	PT8	Marley Creek I	2,062,230
Baltimore Harbor	PT9	Cox Creek	1,510,500
Baltimore Harbor	PTC	Back Creek	7,406,220
Baltimore Harbor	PTD	Sawmill Creek II	2,257,800
Baltimore Harbor	PTG	Marley Creek IV	7,403,040
Baltimore Harbor Total			**27,270,090**
Baltimore Harbor Watershed Total			**27,270,090**

Table 21: Planned Stream Restoration Project Costs

Watershed Name (8-digit level)	Subwatershed Code	Subwatershed Name	Estimated Implementation Cost ($)
Patapsco River Lower North Branch	PN9	Stoney Run IV	1,032,240
Patapsco River Lower North Branch	PNB	Piney Run	2,348,280
Baltimore Harbor	PT0	Stony Creek	4,080,000
Baltimore Harbor	PT8	Marley Creek I	6,480,000
Baltimore Harbor	PTB	Rock Creek	2,520,000
Lower Patapsco River North Branch Total			**3,380,520**
Baltimore Harbor Total			**13,080,000**
Baltimore Harbor Watershed Total			**16,460,520**

The County's approved FY2024 budget for the Watershed Protection and Restoration Fund is $27,408,300. The Watershed Protection and Restoration program supports compliance with the requirements of the County's NPDES MS4 Permit, the Chesapeake Bay TMDL, local watershed TMDLs, and the inspection and maintenance of the County's public stormwater infrastructure (Anne Arundel County, 2023).

5.0 FUTURE PLANNING, MILESTONES, AND BENCHMARKS

The objectives of a TMDL will be met when the assimilative capacity of a waterbody has been restored, water quality criteria have been met, and the waterbody-pollutant impairment combination have been removed from the MDE 303(d) list (MDE, August 2022).

Modeling results indicate that Anne Arundel County has achieved a nitrogen reduction of 3.14 percent and a phosphorus reduction of 6.32 percent in the Baltimore Harbor Watershed as of 2023. The reduction target for both parameters is 15 percent; therefore, the County must achieve further load reductions to meet the TMDL requirements for nutrient reduction. Models used to predict future conditions suggest that Anne Arundel County would be able to achieve the target load reductions by 2030 using a combination of current progress projects (FY23), interim programmed projects, and planned projects. In these scenarios, most practices implemented and planned would involve stormwater management BMP retrofits and stream restoration.

Anne Arundel County will continue to monitor biological condition, conduct habitat assessments, and collect water quality and water chemistry data, and use the results to evaluate changes in environmental responses and water quality measures in catchments where projects have been implemented. These are acceptable monitoring parameters for nutrient TMDLs according to MDE's Guidance. The County will assess progress by comparing data from pre-implementation and post-implementation periods to the established criteria. Specific monitoring parameters that will be evaluated for the updated plan are instream measurements of dissolved oxygen levels, benthic IBI ratings, fish IBI ratings, and nitrogen and phosphorus concentrations. Recent data suggest that dissolved oxygen concentrations averaged at the PSU level are meeting Maryland's

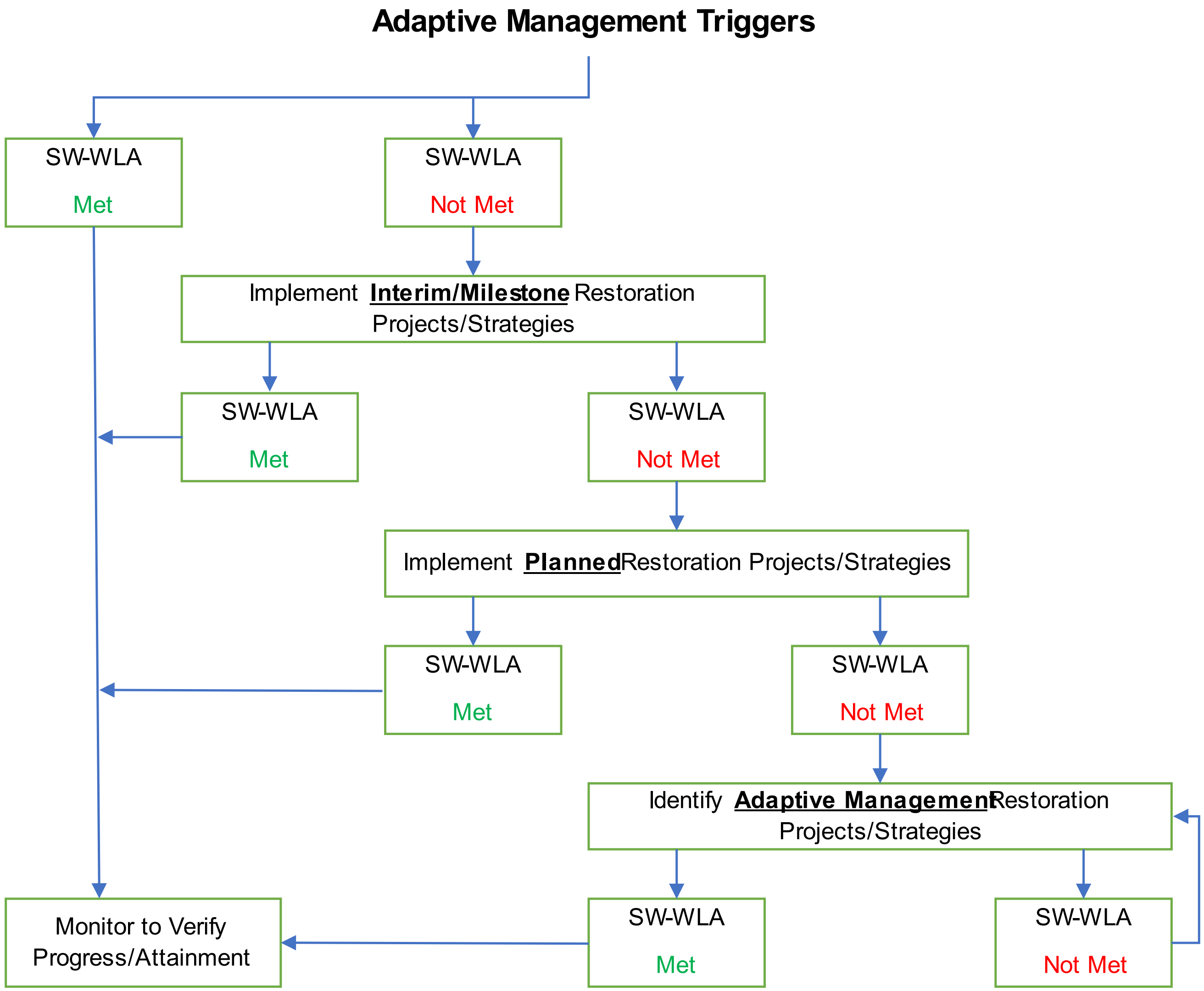
Use Class water quality criterion for dissolved oxygen.

Most of the baseline benthic IBI and fish IBI scores averaged for the PSUs during three Rounds of monitoring (2004–2021) or assessed at current or planned stream restoration sites (2016–2022) rated Very Poor or Poor. Anne Arundel County expects that IBI scores will improve after planned restorations have been successfully implemented and the biological communities have had time to recover from the disturbances associated with the construction. The County uses the results from monitoring at Furnace Branch to provide evidence of the potential for such a recovery. At the site, where stream restoration was completed in 2020, the benthic IBI improved from Very Poor in the baseline condition to Poor two years after the completion of the project. The fish IBI was Fair in 2022, but no baseline data were collected for comparison.

Anne Arundel County began to monitor nitrogen and phosphorus concentrations in Baltimore Harbor Watershed during Round 3 (2018–2020). The results of monitoring in the PSUs indicated that three of the five PSUs had concentrations of nitrogen and phosphorus that were Moderate or Low, based on a narrative rating system used by MD DNR. The other two PSUs monitored had average nitrogen and phosphorus ratings that were equally divided between Moderate and High. Anne Arundel County intends to continue to monitor levels of these nutrients and investigate the potential for correlations between trends in nutrient levels and restoration projects in the same catchment. Refer to Section 2.1 of this report for more information on these criteria and Section 3.3 for the most recent monitoring data.

6.0 ADAPTIVE MANAGEMENT STRATEGIES

Anne Arundel County uses adaptive management strategies to provide flexibility in meeting the TMDL goals. The County will continue to submit updates in the annual Anne Arundel Countywide TMDL Stormwater Implementation Plan Progress reports. These reports include updated TIPP model calculations and descriptions of changes to proposed restoration strategies and justifications for the changes. Any modifications to this plan will be reported in annual reports, and the documentation will show the state of progress toward meeting stormwater WLAs. A log documenting adaptive management strategies, and comments and responses between the County and MDE's IWPP between reporting periods, will be included; the County and IWPP will also hold semi-annual meetings. An example log is provided in Appendix D. Figure 14 shows a flowchart that Anne Arundel County has developed to aid in its adaptive management decision-making process.



`

Figure 14: Anne Arundel County's Adaptive Management Decision Chart

If it is determined through modeling that the target loads are not being met or monitoring results indicate that water quality parameters are not improving, the County will identify and implement additional management strategies. Such management strategies could include, but are not limited to, the following:

- Re-evaluate watershed assessments to identify additional opportunities for restoration or preservation implementation and to refocus programmatic initiatives.
- Provide incentives for restoration project implementation in watersheds where monitored or modeled load reductions are lagging behind schedule.
- Implement projects that address multiple impairments.
- Implement projects for which additional funding can be leveraged.

The County expects that adaptive management strategies will be needed to sustain any gains in nutrient load reductions and to address additional loads associated with future development in the watershed. Adaptive management projects could include additional BMP retrofits; Environmental Site Design; and stream, outfall, and shoreline restorations. The County can implement BMP retrofits and ESD projects throughout the watershed, and many of these practices can be easily adapted to small individual residential properties and public, commercial, or institutional lands. Examples of these practices include rain gardens, landscape infiltration, rainwater harvesting, infiltration berms and trenches, rooftop disconnection, permeable pavers, permeable concrete, and reinforced turf. Table 22 shows BMP retrofits with the highest percentage of predicted nutrient removals; the County will focus on these approaches for adaptively managed projects.

Rain gardens are one of the more multi-faceted practices that are estimated to provide high nutrient removals, can be installed on a variety of public and private lands, and have the potential for an educational component if members of the community could help with plantings and maintenance. Rain gardens are designed to treat specific impervious areas (such as a driveways or rooftops) that have a total drainage area to the facility of no more than 10,000 square feet (MDE, 2009). The estimates for the amount of nutrients removed are based on the impervious acres being treated, surface area, soils, and depth of the rain garden. If the rain garden is established in a public setting, educational signs could be installed to aid the understanding of the importance of nutrient cycling. As an example, Figure 15 shows the priority levels assigned to the subwatersheds of Baltimore Harbor Watershed and public centers, which include schools, churches, parks, assisted living facilities, offices, shopping centers, and park lands, that are feasible options as locations for BMP retrofits and restoration practices.

Figure 16 illustrates approximately 12 miles of stream restoration projects that are in progress, interim programmed, or planned and are located within the medium-to-high stream priority areas. Therefore, there are approximately 58 miles of unrestored stream reaches available for potential stream restoration. To assist with planning and restoration strategies, the BWPR has created a tool that can be used to identify geomorphic changes and potential credit for restored reaches, based on 2017 and 2020 LiDAR data; the County uses the tool as part of the process to identify potential areas for stream restoration, riparian planting, shoreline restoration, upland retrofits, and floating treatment wetlands. Adaptive management strategies allow additional restoration practices to be established in those reaches that have been constructed but need additional maintenance.

Table 22: BMPs and Alternative BMPs with Relatively High Nutrient Removal Efficiencies (MDE, 2022b)

Sector	BMP Short Name (TIPP)	BMP Full Name	Nitrogen Avg. Removal (%)	Phosphorus Avg. Removal (%)	TSS Avg. Efficiency (%)	RR/ST Designation
Developed	BioRetNoUdAB	Bioretention/raingardens - A/B soils, no underdrain	80	85	90	RR
Developed	BioRetUdAB	Bioretention/raingardens - A/B soils, underdrain	70	75	80	RR
Developed	BioRetUdCD	Bioretention/raingardens - C/D soils, underdrain	25	45	55	RR
Developed	Bioswale	Bioswale	70	75	80	RR
Developed	ExtDryPonds	Dry Extended Detention Ponds	20	20	60	RR
Developed	UrbFilterRR	Filter Strip Runoff Reduction	20	54	56	RR
Developed	Filter	Filtering Practices	40	60	80	ST
Developed	InfiltWithSV	Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain	85	85	95	ST/RR*
Developed	Infiltration	Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain	80	85	95	ST/RR*
Developed	PermPavSVNoUdAB	Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain	80	80	85	RR
Developed	PermPavSVUdAB	Permeable Pavement w/ Sand, Veg. - A/B soils, underdrain	50	50	70	RR
Developed	PermPavSVUdCD	Permeable Pavement w/ Sand, Veg. - C/D soils, underdrain	20	20	55	RR
Developed	PermPavNoSVNoUdAB	Permeable Pavement w/o Sand, Veg. - A/B soils, no underdrain	75	80	85	RR
Developed	PermPavNoSVUdAB	Permeable Pavement w/o Sand, Veg. - A/B soils, underdrain	45	50	70	RR
Developed	PermPavNoSVUdCD	Permeable Pavement w/o Sand, Veg. - C/D soils, underdrain	10	20	55	RR
Developed	VegOpChanNoUdAB	Vegetated Open Channels - A/B soils, no underdrain	45	45	70	RR
Developed	VegOpChanNoUdCD	Vegetated Open Channels - C/D soils, no underdrain	10	10	50	RR
Developed	WetPondWetland	Wet Ponds and Wetlands	20	45	60	ST
Developed	ForestBufUrbanEff	Urban Forest Buffer Upland Acres	25	50	50	
Stream	Stream Restoration	Stream Restoration Default Planning Rates	7.5	6.8	248	
Shoreline	Shoreline Management	Shoreline Management	8.6	6.1	164	

NOTES:
RR = Runoff Reduction
ST = Stormwater Treatment
Infiltration practices are ST practices unless designed according to Section IV of the 2021 MS4 Accounting Guidance

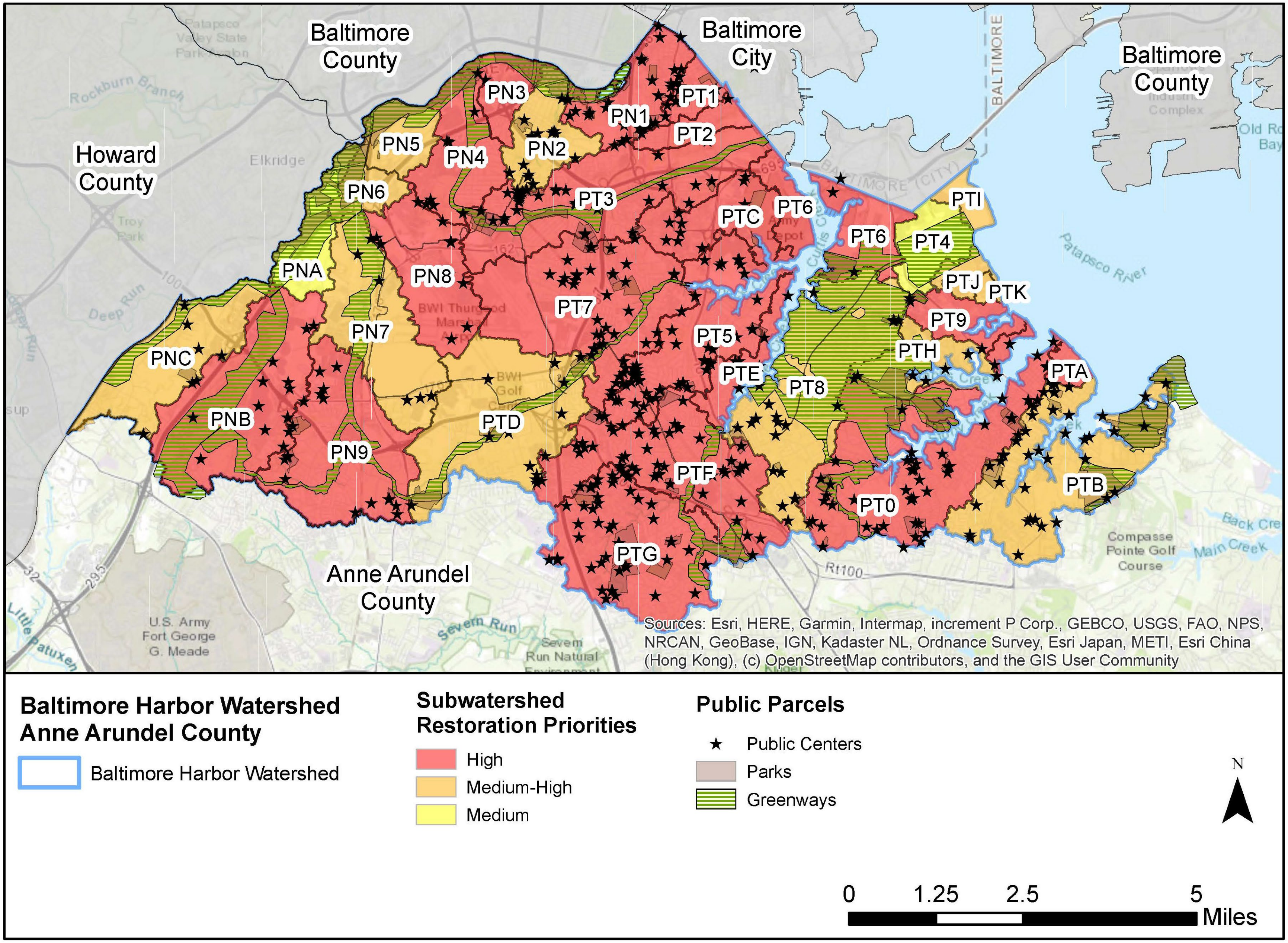


Figure 15: Subwatershed Restoration Priorities with Public Parcels

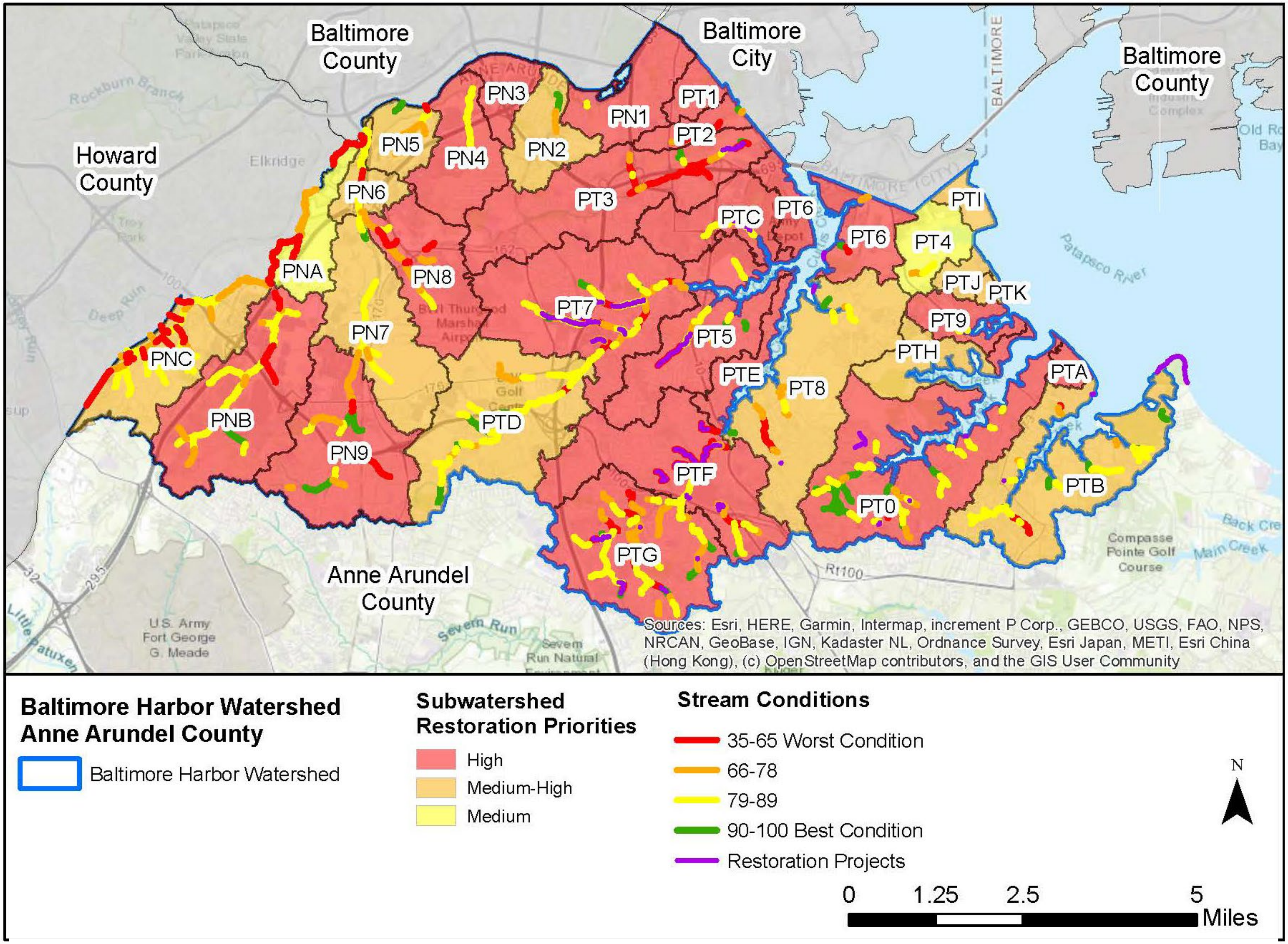


Figure 16: Subwatershed Restoration Priorities with Stream Conditions and Restoration Projects

7.0 AUDIENCE AND COMMENTS - PUBLIC PARTICIPATION, EDUCATION, AND OUTREACH

The primary audiences of the nutrient TMDL restoration plan update are state and federal regulatory agencies, watershed organizations, residents, business owners, landowners, and other local jurisdictions in the Baltimore Harbor Watershed (e.g., City of Baltimore, Baltimore County, Howard County, and Carroll County). Changes to the restoration plan due to adaptive management will be addressed in the annual Countywide Stormwater TMDL Implementation Plan that is submitted as an appendix to the County's annual MS4 report. Descriptions of adaptive management restoration projects will be provided in logs, as shown in Appendix D, that will be included in the annual reports. Anne Arundel County regularly engages stakeholders through opportunities for comments, meetings, and collaboration on restoration projects as discussed in Section 2.2 Stakeholders. The County strives to exceed the 15 percent nutrient load reductions by engaging landowners and those with interests in the Baltimore Harbor Watershed.

8.0 REFERENCES

Anne Arundel County, Office of Budget. 2023. Approved Current Expense Budget and Budget Message, Fiscal Year 2024. Anne Arundel County, Maryland.

Anne Arundel County, 2017-2021. Long-Term Targeted Biological Monitoring Reports for Ferndale Branch (FD-01). Available at https://www.aacounty.org/public-works/bwpr/ecological-assessment-evaluation/long-term-targeted-biomonitoring/ferndale-branch. Accessed December 2023.

Anne Arundel County, 2016-2021. Long-Term Targeted Biological Monitoring Reports for Furnace Branch (FB-01 and FB-02). Available at https://www.aacounty.org/public-works/bwpr/ecological-assessment-evaluation/long-term-targeted-biomonitoring/furnace-branch. Accessed December 2023.

Anne Arundel County, 2011. Patapsco River Non-Tidal Watershed Assessment Comprehensive Summary Report, Final Report. Prepared by Anne Arundel County Department of Public Works, Bureau of Engineering, Watershed Ecosystem and Restoration Services Division, Watershed Assessment and Planning Program. August 2011. Annapolis, MD.

Anne Arundel County, 2012a. Anne Arundel County Government Chesapeake Bay TMDL Phase II Watershed Implementation Plan. July 2012. Annapolis, MD.

Anne Arundel County, 2012b. Patapsco River Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report. Prepared by Anne Arundel County Department of Public Works, Bureau of Engineering, Watershed Ecosystem and Restoration Services Division, Watershed Assessment and Planning Program. August 2012. Annapolis, MD.

Anne Arundel County, 2016a. Baltimore Harbor Watershed Nutrient TMDL Restoration Plan. Prepared by KCI Technologies for Anne Arundel County Department of Public Works, Bureau of Engineering, Watershed Ecosystem and Restoration Services Division, Watershed Assessment and Planning Program. November 2012. Annapolis, MD.

Anne Arundel County, 2016b. Baltimore Regional Neighborhood Initiative – Great Baybrook Vision and Action Plan, July 2016.

Anne Arundel County, 2018a. Brooklyn Park Sustainable Community Action Plan. Application for Designation Renewal, October 2018.

Anne Arundel County, 2018b. Glen Burnie Sustainable Community Action Plan. Application for Designation Renewal, December 2018.

Anne Arundel County, 2021. Baltimore Harbor Watershed 2020 Nutrient TMDL Annual Assessment Report. Prepared by KCI Technologies for Anne Arundel County Department of Public Works, Bureau of Engineering, Watershed Ecosystem and Restoration Services Division, Watershed Assessment and Planning Program. February 2021. Annapolis, MD.

Anne Arundel County, 2021. Plan2040 Volume I: Anne Arundel County General Development Plan. May 2021.

Anne Arundel County, 2022a. Anne Arundel Countywide TMDL Stormwater Implementation Plan FY 22 Annual Progress Report - December 2022. Prepared by Anne Arundel County Department of Public Works, Bureau of Engineering, Watershed Ecosystem and Restoration Services Division, Watershed Assessment and Planning Program. Annapolis, MD. Available at https://www.aacounty.org/public-works/bwpr/npdes-ms4-permit. Accessed December 2023.

Anne Arundel County, 2022b. Anne Arundel Countywide TMDL Stormwater Implementation Plan FY22 NPDES MS4 Annual Report Appendix E: Countywide Stormwater TMDL Implementation Plan. Available at https://www.aacounty.org/public-works/bwpr/npdes-ms4-permit. Accessed December 2023.

Anne Arundel County, 2022c. Anne Arundel County FY22 NPDES MS4 Annual Report Appendix A: Geodatabase: Available at https://www.aacounty.org/public-works/bwpr/npdes-ms4-permit. Accessed December 2023.

Anne Arundel County Department of Health, September 28, 2023, Large Sewage Spill Causes Emergency Closure for Portion of Marley Creek. Available at https://www.aahealth.org/environmental-health/recreational-water-quality/closings-and-advisories/update-121423-sewage-spill. Accessed December 2023.

Anne Arundel County, Annual Reports: "A Land of Rivers" Available at https://www.aacounty.org/public-works/bwpr/annual-reports-land-rivers. Accessed December 2023.

Anne Arundel County, Long-Term Targeted Biomonitoring. Furnace Branch (FB-01 and FB-02). Available at https://www.aacounty.org/public-works/bwpr/ecological-assessment-evaluation/long-term-targeted-biomonitoring/furnace-branch. Accessed December 2023.

Anne Arundel County, Long-Term Targeted Biomonitoring. Ferndale Branch (FD-01). Available at https://www.aacounty.org/public-works/bwpr/ecological-assessment-evaluation/long-term-targeted-biomonitoring/ferndale-branch. Accessed December 2023.

Anne Arundel County, Long-Term Targeted Biomonitoring. Irving Branch (IB-01). Available at https://www.aacounty.org/public-works/bwpr/ecological-assessment-evaluation/long-term-targeted-biomonitoring/irving-branch. Accessed December 2023.

Anne Arundel County, Long-Term Targeted Biomonitoring. Muddy Bridge Branch (MB-01 and MB-02). Available at https://www.aacounty.org/public-works/bwpr/ecological-assessment-evaluation/long-term-targeted-biomonitoring/muddy-bridge . Accessed December 2023.

Anne Arundel County, Open Arundel, Watershed Application and Watershed Restoration Projects. Available at https://maps.aacounty.org/. Accessed December 2023.

Anne Arundel County, Restoration Estimator Tool, Created by Anne Arundel County Department of Public Works, Bureau of Engineering, Watershed Ecosystem and Restoration Services Division, Watershed Assessment and Planning Program. Annapolis, MD. Available at https://www.aacounty.org/public-works/bwpr/watershed-restoration/grant-program/restoration-estimator-tool. Accessed December 2023.

Becker, A.J., Hill, C.R., Gring, J., Spradlin, D., and L. Edmond. 2018. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2018. Anne Arundel County Department of Public Works, Ecological Assessment and Evaluation Program, Annapolis, Maryland.

Becker, A.J., Hill, C.R., Gring, J., Spradlin, D., and J. Saville. 2020. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2019. Anne Arundel County Department of Public Works, Ecological Assessment and Evaluation Program, Annapolis, Maryland.

Becker, A.J., Fenwick, S., Gring, J., Nolan, L., and J. Saville. 2020. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2020. Anne Arundel County Department of Public Works, Ecological Assessment and Evaluation Program, Annapolis, Maryland.

COMAR (Code of Maryland Regulations). Section. 26.08.02.03-3. Water Quality Criteria Specific to Designated Uses. Available at http://mdrules.elaws.us/comar/26.08.02.03-3. Accessed December 2023.

Crunkleton, M.C., C. R. Hill, and M.J. Pieper. 2010. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2010. Anne Arundel County Department of Public Works, Watershed and Ecosystem Services, Annapolis, Maryland. 52 pp., plus Appendices.

Crunkleton, M.C., C. R. Hill, and M.J. Pieper. 2012. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2012. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 50 pp., plus Appendices.

Hill, C. R., and M.J, Pieper. 2011. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: Round One 2004 – 2008. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland.

Hill, C. R., Crunkleton, M.C., and M.J. Pieper. 2014. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: Round Two 2009-2013. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland.

Hill, C.R., Owen, R.A., Becker, A.J., and M.J. Pieper. 2022. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: Round Three 2017-2021. Anne Arundel County Department of Public Works, Ecological Assessment and Evaluation Program, Annapolis, Maryland. 118 pp., plus appendices.

Maryland, 2019. Maryland's Phase III Watershed Implementation Plan to Restore Chesapeake Bay by 2025, Final Document, August 2019.

Maryland Department of the Environment, 2006. Total Maximum Daily Load of Nitrogen and Phosphorus for the Baltimore Harbor Watershed in Anne Arundel, Baltimore, Carroll and Howard Counties and Baltimore City, Maryland (including supplemental technical memoranda and decision letters).

Maryland Department of the Environment, 2009. 2000 Maryland Stormwater Design Manual, Volumes I and II. Revised, 2009. Prepared by the Center for Watershed Protection.

Maryland Department of the Environment, 2019. Maryland's Designated Uses for Surface Waters Baltimore, MD. Available at: https://mde.maryland.gov/programs/water/tmdl/waterqualitystandards/pages/designatedusesmaps.aspx. Accessed December 2023.

Maryland Department of the Environment, 2021. National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System Discharge Permit 11-DP-3316 MD0068306. November 5, 2021. Anne Arundel County, MD.

Maryland Department of the Environment, 2021. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated; Guidance for National Pollutant Discharge Elimination System Stormwater Permits. November 2021. Baltimore, MD.

Maryland Department of the Environment, 2022a. Guidance for Developing Local Nutrient and Sediment TMDL Stormwater Wasteload Allocation Watershed Implementation Plan. March 2022. Baltimore, MD.

Maryland Department of the Environment, 2022b. TMDL Implementation Progress and Planning Tool (TIPP). Updated April 6, 2022. Baltimore, MD. Available at https://mde.maryland.gov/programs/water/tmdl/datacenter/pages/tmdlstormwatertoolkit.aspx. Accessed December 2023.

Maryland Department of the Environment, 2022c. General Guidance for Local Total Maximum Daily Load Stormwater Wasteload Allocation Watershed Implementation Plans. August 2022. Baltimore, MD.

Maryland Department of Natural Resources, 2011. Results from Round 3 of the Maryland Biological Stream Survey (2007-2009), Available at: https://dnr.maryland.gov/streams/Documents/MBSSR3Report.pdf. Accessed December 2023.

Stribling, J.B., B. Jessup, and C.J. Victoria. 2008. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2007. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 34 pp., Appendices.

Stribling, J.B., B. Jessup, and C.J. Victoria. 2008. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2006. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 34 pp., Appendices.

The Baltimore Sun, June 9, 2022. About 50000 Atlantic menhaden and other fish found dead in Marley Creek near Glen Burnie after sewage spill. Available at: https://www.baltimoresun.com/maryland/anne-arundel/bs-md-ar-fish-kill-marley-creek-20220609-4mkwdeeoj5cdfn5d7wcilnhc3i-story.html. Accessed December 2023

United States Geological Survey. Chesapeake Bay Program Phase 6 Land Use Data Set. Available at https://chesapeake.usgs.gov/phase6/map/. Accessed December 2023

U.S. Environmental Protection Agency, 2010. Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus, and Sediment.

Victoria, C.J., and J. Markusic. 2007. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2004. Anne Arundel County Department of Public Works, Watershed and Ecosystems Services Group, Annapolis, Maryland. 31 pp., Appendixes.

Victoria, C.J., J. Markusic, J. Stribling, and B. Jessup. 2010. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2008. Prepared for Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. Prepared by: Tetra Tech, Inc., Center for Ecological Science, Owings Mill, MD.

Victoria, C., J. Markusic, J. Stribling, and B. Jessup. 2011. Aquatic Biological Assessment of Watersheds of Anne Arundel County, Maryland: 2009. Prepared by: Anne Arundel County Department of Public Works, Watershed and Ecosystem Services, Annapolis, MD and Tetra Tech, Inc., Center for Ecological Sciences, Owings Mills, MD.

Appendix A:

TIPP Spreadsheets

Appendix B:

Restoration Projects Auxiliary Data

Appendix C:

Monitoring Data

Appendix D:

Adaptive Management Log