BALTIMORE COUNTY
TMDL IMPLEMENTATION PLAN

Sediment in Baltimore Harbor
(non-tidal streams)

Baltimore County Executive Johnny Olszewski and the County Council

David V. Lykens, Director

Department of Environmental Protection and Sustainability

Submitted to MDE: January 27, 2023
Approved by MDE: (Pending)

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ARA	**Antibiotic Resistance Analysis**
BMP	**Best Management Practice**
BOD	**Biological Oxygen Demand**
BSID	**Biological Stressor Identification**
BST	**Bacteria Source Tracking**
CBP	**Chesapeake Bay Program**
CFR	**Code of Federal Regulations**
Chl *a*	**Chlorophyll *a***
COMAR	**Code of Maryland Regulations**
CWA	**Clean Water Act**
DO	**Dissolved Oxygen**
DPW	**Department of Public Works**
ED	**Extended Detention**
EOF	**Edge of Field**
EOS	**Edge of Stream**
EPA	**U.S. Environmental Protection Agency**
EPS	**Environmental Protection & Sustainability**
FSA	**Farm Service Administration**
HSG	**Hydrologic Soil Groups**
HUC	**Hydrologic Unit Code**
IP	**Implementation Plan**
LA	**Load Allocation**
lbs/yr	**Pounds per Year**
MAST	**Maryland Assessment Scenario Tool**
MD	**Maryland**
MDA	**Maryland Department of Agriculture**
MDE	**Maryland Department of Environment**
MDP	**Maryland Department of Planning**
µg/l	**Micrograms per Liter**
mg/l	**Milligrams per Liter**
MGD	**Million Gallons per Day**

MGS	**Maryland Geological Survey**
MOS	**Margin of Safety**
MPN	**Most Probable Number**
MPR	**Maximum Practicable Reduction**
MS4	**Municipal Separate Storm Sewer System**
NLCD	**National Land Cover Dataset**
NMP	**Nutrient Management Plan**
NOAA	**National Oceanic and Atmospheric Administration**
NPDES	**National Pollutant Discharge Elimination System**
NPS	**Nonpoint Source**
NSA	**Neighborhood Source Assessment**
OIT	**Office of Information Technology**
PAA	**Pervious Area Assessment**
PAI	**Office of Permits Approvals & Inspections**
POM	**Particulate Organic Matter**
PS	**Point Source**
RTG	**Reservoir Technical Group**
SCWQP	**Soil Conservation and Water Quality Plan**
SSA	**Science Services Administration**
SSO	**Sanitary Sewer Overflow**
SWAP	**Small Watershed Action Plan**
SWM	**Stormwater Management**
TMDL	**Total Maximum Daily Load**
TN	**Total Nitrogen**
TP	**Total Phosphorus**
TSI	**Trophic State Index**
TSS	**Total Suspended Solids**
URDL	**Urban Rural Demarcation Line**
USGS	**United States Geological Survey**
USLE	**Urban Soil Loss Equation**
WAG	**Watershed Advisory Group**
WIP	**Watershed Implementation Plan**
WLA	**Waste Load Allocation**

WQBEL	**Water Quality Based Effluent Limitations**
WQIA	**Water Quality Improvement Act**
WQLS	**Water Quality Limited Segment**
WQMP	**Water Quality Management Plan**
WRAS	**Watershed Restoration Action Strategy**
WWTP	**Waste Water Treatment Plant**

This Implementation Plan (IP) has been prepared to address the presence of excess sediment in the Baltimore Harbor watershed that has been found to be negatively affecting the aquatic community. The required amount of reduction in sediment inputs has been determined by a Total Maximum Daily Load (TMDL) developed by the Maryland Department of the Environment (MDE) in the document titled *Total Maximum Daily Load of Sediment in the Baltimore Harbor Watershed, Baltimore City, Baltimore County, and Anne Arundel County, Maryland* (MDE, 2022), and after a public comment period, submitted to the US Environmental Protection Agency (EPA) Region 3 for review and approval. EPA approved the TMDL January 27, 2022.

1.1 What is a TMDL?

A TMDL has two different meanings. It is the document that is produced by MDE when any Maryland water body is listed on the state's 303(d) list of impaired and threatened waters. MDE must then submit the TMDL to EPA for approval. Any time a TMDL document is developed, extensive scientific study is done on the pollutant of concern in the listed water body. This study is done with the goal of finding the maximum load of the pollutant that the water body can receive and still meet Maryland's water quality standards. It is often thought of as a "pollution diet" for the watershed. All of the studying and monitoring that is done in preparing the TMDL document boils down to a single maximum load number that will be the target for pollution reduction in the water body. This number is also called a TMDL. In other words, the goal of the TMDL document is to justify the TMDL number, which can be found within the TMDL document.

The TMDL number is expressed as a sum of all the different sources of the pollutant plus a margin of safety (MOS). The MOS value helps to account for any lack of knowledge or understanding concerning the relationship between loads and water quality and also for any rounding errors in the TMDL calculation (calculation format shown below). Expressing the TMDL in terms of this simple equation makes it easier to see where pollution reduction efforts need to be focused. In other words, which sources can be reduced to reach the final TMDL number, by how much they need to be reduced, and which pollution sources are not practical for reduction. The sources that make up the final TMDL number are categorized as either Load Allocation (LA) or Waste Load Allocation (WLA). LAs are all non-point source loads, meaning that they do not come from a single source or pipe. LAs include agricultural runoff, forest runoff, and upstream loads. WLAs are all point source loads, meaning that they do come from a single traceable source. WLAs are further categorized as process water or stormwater. Process water WLA comes from sources that have permits allowing them to release a specific amount of a pollutant into the water. They include individual industrial facilities, individual municipal facilities, and mineral mining facilities. Stormwater WLA is any stormwater that is regulated by a municipal separate storm sewer systems (MS4) permit, water from industrial facilities permitted to release stormwater, and all runoff from construction sites.

All Baltimore County urban stormwater is regulated under Baltimore County's MS4 permit. That means that stormwater WLA includes all of the water that runs to any storm drain within the watershed area. The MOS is the final part of the equation. The MOS can be implicit, meaning that the final TMDL was calculated in such a way that it accounted for any errors without needing to tack an explicit MOS to the end of the sum of load sources equation. When an explicit MOS is necessary, it is assumed that a 5% reduction of the final TMDL number will be sufficient.

TMDL Sum of Load Sources Equation:

TMDL	=	**LA**	+	**WLA Stormwater**	+	**WLA Process Water**	+	**MOS**

1.1.1 How is the Final TMDL Determined?

The process of determining the TMDL number can be very complex. Pollution data are regularly collected throughout Maryland by many different federal, state, and local government agencies as well as universities and watershed organizations. The agency or organization may send individuals out to the stream to collect and measure information about the watershed as part of a study or regular monitoring program. Data are also collected from the many different monitoring stations that are located throughout Maryland's watersheds. Some of these monitoring stations have been collecting water data for decades. The U.S. Geological Survey and the Maryland Department of Natural Resources monitoring stations are often used as the data source for Maryland TMDLs. To find out who is keeping an eye on your watershed see MDE's Water Quality Monitoring Web Page.

Complex scientific models are often used to help find a practical number for the total reduction. Models often use existing monitoring data and observations about the watershed area in a calculation that determines the TMDL number. The type of model used and the complexity of the model vary by pollutant, water body type, and complexity of flow conditions. The specific model used for this TMDL is explained in Section 3.

In all cases, scientists first find a baseline load for the pollutant. The baseline load is how much of the pollutant is in the water body at the time of the study, before restoration actions specifically developed to reach the TMDL number are implemented. The calculated target number, that is the TMDL, is the final goal. It could be thought of as the finish line in the TMDL process. That is not to say that other restoration efforts will not continue once that target is reached, but that the water body will be able to meet state water quality standards and can be removed from the list of impaired and threatened waters for that particular pollutant.

When calculating the TMDL number, a percent reduction and load reduction are usually calculated as well. The load reduction is the difference between the baseline load and the TMDL target. Think of it as the amount that needs to be removed from the system in order to reach the target. The percent reduction is the percentage of the baseline load that needs to be removed in order to reach the TMDL target.

1.2 Geographic Area

Pollution reduction goals are determined by watershed. A watershed is all the land area where all of the water that runs off that land and all the water running under that land drain into the same place. Everything within a watershed is linked by a common water destination. Watersheds exist at many levels: some very large, and some quite small. Identifying your watershed is similar to identifying your current location on a map. You could say you are in the United States, or that you are in Maryland, or that you are in your kitchen at your specific street address. Similarly, you could say that you are in the Mid-Atlantic Region Watershed, which drains to the Atlantic Ocean, Long Island Sound and Riviere Richelieu, a tributary of the St. Lawrence River. You could also say that you are in the Upper Chesapeake Bay Watershed, which includes the area of drainage to the Chesapeake Bay that is north of the Maryland-Virginia line. Both would describe a watershed that you are located in. However, watersheds can become much more specific.

A system was established by the U.S. Geological Survey for dividing the U.S. into successively smaller hydrologic units. Each hydrologic unit is identified by a hydrologic unit code (HUC), which range from two to twelve digits. The smaller the scale of the watershed, the more digits it has in its code. For example, the Mid-Atlantic Region is a 2-digit watershed and the Upper Chesapeake Bay is a 4-digit watershed. The 6-digit unit, also known as the "basins" unit, is to serve as the common scale for watershed assessments at the national level, but the condition of these basins can be determined based on an aggregation of assessments of even smaller watershed units. Maryland has chosen to go the route of assessing smaller watershed units. As a result, TMDLs are determined at the 8-digit watershed scale. For a further explanation of HUCs or to see maps of watersheds at different HUC levels, go to: USGS Hydrologic Unit Maps. If you would like to know which Maryland 8-digit watershed you are located in, go to MDE's Watershed Locator Map.

It is important to note that 8-digit watersheds can overlap multiple counties and may, therefore, have several regulating authorities.

1.2.1 Baltimore Harbor Geographic Area

Baltimore Harbor is a watershed that covers a total land area of 55,176 acres about 11,453 (20.8%) of which are located within Baltimore County. The Baltimore Harbor direct drainage watershed lies in the Southeast portion of Baltimore County, with considerable portions of the watershed contained within the City of Baltimore and Anne Arundel County. This TMDL Implementation Plan will specifically address the area of the watershed and watershed tributaries that are located in Baltimore County. Details on land uses and the further disposition of the watershed will be addressed during Section 5 of this IP which presents the watershed characterization. Below, Figure 1-1 provides a map of the Baltimore Harbor watershed's location within Baltimore County.

Figure 1-1: Baltimore Harbor Watershed within Baltimore County

1.3 Goal of the TMDL Implementation Actions

TMDL Implementation Plan Objective:

Through a cooperative effort of Baltimore County Department of Environmental Protection and Sustainability, other county agencies, local watershed associations, and the general public, to provide a comprehensive plan of action for achieving TMDL targets and ultimately restoring the health of Baltimore County waters to acceptable water quality standards.

Baltimore County is required to reduce pollution in its waterways; the plans to meet these reductions need to be in place within one year of TMDL issuance by MDE. More on the legal requirements for these implementation plans will be discussed in depth during Section 2 of this document. The goal of this IP is to set the "road map" for the county to reach the goal of reducing pollutant loads in the water to meet water quality standards.

1.4 Document Organization

The Baltimore County TMDL implementation plans provide the following information to explain the necessity of the TMDL Implementation Plan and to develop a management strategy that will be followed in order to meet county TMDL reduction targets. The County will take an adaptive management approach that will include periodic assessments to determine progress and identify changes needed in the management strategy to meet the reduction targets in a timely, cost effective manner.

Section 1: Introduction

This Introduction states the pollutant that is being addressed by the TMDL IP, and the watershed for which the IP was developed. It provides a background on what a TMDL is and how the TMDL is determined. A general description of the geographic area for the specific IP is provided. The Introduction also states the overall goal of the TMDL IP and summarizes the actions that have been identified to bring Baltimore County to that goal. It also includes a brief summary of the contents of the thirteen sections of the TMDL Implementation Plan.

Section 2: Regulatory Policy and Planning

This part of the document describes the administration and legal authority that mandates the development of Baltimore County's TMDL implementation plan and oversees its fulfillment. It will provide a background of how various regulating authorities and policies are related to the requirement to develop a TMDL Implementation Plan. It will also summarize the various planning guidance documents that have been produced to assist in the development of TMDL Implementation Plans and how TMDL Implementation Plans fit in the overall Baltimore County planning context.

Section 3: TMDL Summary

The section summarizes the original TMDL document that was submitted by MDE and approved by the EPA. The summary includes: when the TMDL was developed, what is impaired, why the TMDL was developed, a description of the analysis process that was used to determine the total maximum daily load targets, the baseline year of data collection and analysis, the results from that analysis, and a further break down of the target loads by source sector.

Section 4: Literature Summary

Each TMDL IP will address a specific pollutant. This part of the document provides an overview of the pollutant that is summarized from published literature. The literature summary includes known sources of the pollutant, the impacts associated with the pollutant, the pathways and transformations of the pollutant, and other relevant ecological processes that affect how the pollutant can be controlled and regulated.

Section 5: Watershed Characterization

Characterization of the watershed will include geographical and technical information for the portion of the watershed that is specific to each TMDL IP. Each characterization will describe the watershed acreage, population size, geology and soils, topography, land use, streams, infrastructure related to watershed pollution sources, implemented restoration projects since the baseline year, and changes in pollutant load since the baseline year.

Section 6: Existing Data Summary

This section will include a summary of Baltimore County's existing monitoring data that will be pertinent to the pollutant in question. It may also include some data received from sources other than Baltimore County, such as data from the Maryland Department of the Environment, or other relevant sources.

Section 7: Summary of Existing Restoration Plans

Previous planning efforts will be summarized in this section. Water Quality Management Plans (WQMP) and Small Watershed Action Plans (SWAP) applicable to the IP area are identified. The process and goals for SWAP development are explained.

Section 8: Best Management Practice Efficiencies

This section is an explanation of the best management practices that will be used for removing the particular pollutant and the known efficiency of those best management practices. A table will be found in this section of BMPs and the known reduction efficiency for the pollutants that can be reduced by each BMP. BMP efficiencies will also include a discussion of the uncertainty and research needs for BMPs.

Section 9: Implementation

The implementation section will provide a description of programmatic, management, and restoration actions; and pollutant load reduction calculations to meet the pollutant reduction target for the specific pollutant. For each of the programmatic, management, and restoration actions there will be a list of responsible parties, actions, timeframe of actions, and performance standards.

Section 10: Assessment of Implementation Progress

Assessment of implementation progress will give Baltimore County a formal method of reporting on the development of implementation and of describing the progressive success of implementation actions. The section will include a description of tracking and reporting mechanisms, and a monitoring plan that includes progress monitoring as well as BMP effectiveness monitoring.

Section 11: Continuing Public Outreach Plan

This part of the document will be a continuing public outreach plan. It will encourage public involvement in the implementation process, extending beyond the finalization of this document.

Section 12: References

A list of references used in the creation of this document.

The Legal Authority, Policy, and Planning Framework section will present, in brief, the background on the legal requirements that pertain to the development of Total Maximum Daily Loads (TMDLs), and the preparation of TMDL Implementation Plans. This section will also cover the planning framework for the development of the TMDL Implementation Plans (IP). Furthermore, this section is intended to provide the context for the development of this TMDL Implementation Plan and understanding of the linkage between water quality and the TMDL. Whether at the federal or state level there are a number of processes at work that result in the regulations that must be followed to remain within the law. First, legislation is passed by an elected governing body (e.g. Congress, state legislature), and once passed and signed by the executive branch, they become Acts (laws), such as the Clean Water Act. In order to provide guidelines in maintaining compliance with these laws, it is often necessary that regulations be issued to specify the law's requirements. A regulation is a rule issued by a government agency that provides details on how legislation will be implemented, and may set specific minimum requirements for the public to meet if they are to be considered in compliance with the law. These regulations may come in various forms, such as the Code of Federal Regulations (CFR), or Code of Maryland Regulations (COMAR). The information that follows is generally taken from CFR and COMAR.

Under the Code of Federal Regulations (CFR), Title 40 encompasses the regulations enforced by the U.S. Environmental Protection Agency (EPA). These regulations include not only those related to water quality, but also air quality, noise, and a variety of land based regulations (oil operations, etc.)

2.1 Regulatory and Policy Framework

The ultimate regulatory authority for protecting and restoring water quality rests with the federal government through legislative passage of the Clean Water Act in 1972 and subsequent amendments. Prior to the Clean Water Act (1972), the Federal Water Pollution Control Act (1948) served as the basis for controlling water pollution. The Clean Water Act significantly amended the Federal Water Pollution Control Act and established the basic structure for regulating discharges of pollutants into the waters of the United States. Major amendments were enacted in 1977 and 1987 that further strengthened and expanded the Clean Water Act of 1972. The 1987 amendments incorporated the requirement that stormwater discharges from urban (municipal) areas be required to obtain a permit for discharge and that stormwater discharges from industrial sources also be permitted. There have been a number of minor amendments and reauthorizations over the years that have resulted in the law as it now stands.

There are several significant provisions of the Clean Water Act that pertain to TMDLs. These provisions include the requirement that states adopt Water Quality Standards by designating water body uses and set criteria that protect those uses. The Clean Water Act also requires states to assess their waters and provide a list (known as the 303(d) list) of waters that are impaired. The list specifies the impairing substance and requires that a TMDL be developed to address the impairment.

Through policy (memos dated November 22, 2002 and November 12, 2010) the US EPA has indicated that the pollutant loads attributable to regulated stormwater discharges are to be included in the Waste Load Allocation as a point source discharge and not as part of the non-point load. The initial memo also affirmed that the Water Quality-Based Effluent Limitations

(WQBELs) in Municipal Separate Storm Sewer System (MS4) permits may be expressed in the form of Best Management Practices (BMPs) and not as numeric limits for stormwater discharges. The second memo clarified that when the MS4 permits are expressed in the form of BMPs, the permit should contain objectives and measurable elements (e.g., schedule for BMP installation or level of BMP performance). By providing both an expected level of BMP performance and a schedule of implementation of the various practices, Baltimore County will have addressed this requirement. This plan once approved by Maryland Department of the Environment (MDE) will be enforceable under the terms of the permit.

2.2 Maryland Use Designations and Water Quality Standards

In conformance with the Clean Water Act, the State of Maryland has developed use designations for all of the waters in the state of Maryland, along with water quality standards to maintain the use designations.

Designated uses define an intended human and aquatic life goal for a water body. It takes into account what is considered the attainable use for the water body, for protection of aquatic communities and wildlife, use as a public water supply, and human uses, such as recreation, agriculture, industry, and navigation. Water quality standards include both the Use Designation and Water Quality Criteria (numeric standards). Water Quality Criteria are developed to protect the uses of a water body.

2.2.1 Use Class Designations

Every stream, lake, reservoir, and tidal water body in Maryland has been assigned a Use Designation. The Use Designation is linked to specific water quality standards that will enable the Designated Use of the water body to be met. A listing of the Use Designations follows:

- Use Class I:
    - Water contact recreation, and protection of nontidal warmwater aquatic life.
- Use Class II:
    - Support of estuarine and marine aquatic life and shellfish harvesting (not all subcategories apply to each tidal water segment)
        - Shellfish harvesting subcategory
        - Seasonal migratory fish spawning and nursery subcategory (Chesapeake Bay only)
        - Seasonal shallow-water submerged aquatic vegetation subcategory (Chesapeake Bay only)
        - Open-water fish and shellfish subcategory (Chesapeake Bay only)
        - Seasonal deep-water fish and shellfish subcategory (Chesapeake Bay only)
        - Seasonal deep-channel refuge use (Chesapeake Bay only)
- Use Class III:
    - Nontidal cold water – usually considered natural trout waters
- Use Class IV:
    - Recreational trout waters – waters are stocked with trout

The letter "P" may follow any of the Use Designations, if the surface waters are used for public water supply. There may be a mix of Use Classes within a single 8-digit watershed; for example, Baltimore Harbor has Use I, and Use II designations depending on the subwatershed. While the tidal mainstem of Baltimore Harbor has a Use II designation, this TMDL and IP are specific to the non-tidal streams which would not include the Use II designation.

Table 2-1: Designated Uses and Applicable Use Classes

Designated Uses	Use Classes							
	I	I-P	II	II-P	III	III-P	IV	IV-P
Growth and Propagation of fish (not trout), other aquatic life and wildlife	✓	✓	✓	✓	✓	✓	✓	✓
Water Contact Sports	✓	✓	✓	✓	✓	✓	✓	✓
Leisure activities involving direct contact with surface water	✓	✓	✓	✓	✓	✓	✓	✓
Fishing	✓	✓	✓	✓	✓	✓	✓	✓
Agricultural Water Supply	✓	✓	✓	✓	✓	✓	✓	✓
Industrial Water Supply	✓	✓	✓	✓	✓	✓	✓	✓
Propagation and Harvesting of Shellfish			✓	✓				
Seasonal Migratory Fish Spawning and Nursery Use			✓	✓				
Seasonal Shallow-Water Submerged Aquatic Vegetation Use			✓	✓				
Seasonal Deep-Water Fish and Shellfish Use			✓	✓				
Seasonal Deep-Channel Refuge Use			✓	✓				
Growth and Propagation of Trout					✓	✓		
Capable of Supporting Adult Trout for a Put and Take Fishery							✓	✓
Public Water Supply		✓		✓		✓		✓

2.2.2 Water Quality Criteria

Water quality criteria are developed to protect the uses designated for each water body. Certain standards apply over all uses, while some standards are specific to a particular use. The criteria are based on scientific data that indicate threats to aquatic life or human health. For the protection of aquatic communities the criteria have been developed for fresh water, estuarine water, and salt water. The criteria have been further based on acute levels (have an immediate negative effect) and chronic levels (have longer term effects). The human health criteria are based on drinking water levels, organism consumption levels, or a combination of drinking water and organism consumption levels, or recreational contact bacteria levels.

Dissolved oxygen criteria for all Use Designations is 5 mg/L, except for Use II Designations and special criteria for drinking water reservoir hypolimnion waters (bottom waters of the reservoir).

Bacteria criteria are based on human health concerns, and apply to all Uses, with additional bacteria criteria applicable in shellfish waters. Since none of the local TMDLs are related to the shellfish criteria, they are not discussed here. The human health criteria are based on either the geometric mean of 5 samples or single sample criteria based on the frequency of full body contact, these criteria are displayed in Table 2-2. For the freshwater bacteria TMDLs the indicator bacteria E. coli has been used in the development of the TMDL, therefore it serves as the water quality end point. The human health recreational contact bacteria criteria are displayed in Table 2-2. The table displays both the geometric mean for bacteria and single sample maximum allowable bacteria concentrations based on the frequency of full body contact.

Table 2-2: Bacteria Criteria for Human Health (MPN/100 ml)

Indicator	Steady State Geometric Mean Density	Single Sample Maximum Allowable Density			
		Frequent Full Body Contact Recreation	Moderately Frequent Full Body Contact Recreation	Occasional Full Body Contact Recreation	Infrequent Full Body Contact Recreation
Freshwater (Either Apply)					
Enterococci	33	61	78	107	151
E. coli	126	235	298	410	576
Marine					
Enterococci	35	104	158	275	500

2.3 Planning Guidance

In March of 2008 the EPA released a guidance document on the development of watershed plans titled Handbook for Developing Watershed Plans to Restore and Protect Our Waters. The handbook describes nine minimum elements to be included in watershed plans, commonly called the "a through i" criteria. The criteria include:

a. An identification of the causes and sources or groups of sources that will need to be controlled to achieve the load reductions estimated in the watershed plan.
b. Estimates of pollutant load reductions expected through implementation of proposed Non-point Source (NPS) management measures.
c. A description of the NPS management measures that will need to be implemented.
d. An estimate of the amounts of technical and financial assistance needed to implement the plan.
e. An information/education component that will be used to enhance public understanding and encourage participation.
f. A schedule for implementing the NPS management measures.
g. A description of interim, measurable milestones for the NPS management measures.
h. A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards.
i. A monitoring component to evaluate effectiveness of the implementation efforts over time.

EPA now evaluates watershed plans on the basis of the above criteria in consideration of its grant funding. The State of Maryland is also increasingly using the above criteria for funding consideration. Baltimore County has used these criteria since the publication of the handbook in the development of its Small Watershed Action Plans; and will use the criteria in the development of this TMDL Implementation Plan.

Maryland Department of the Environment (MDE) developed a guidance document in conjunction with local government representatives entitled *Maryland's 2006 TMDL Implementation Guidance for Local Governments*, which provides a framework for the development of TMDL Implementation Plans. MDE has also provided guidance on the development of TMDL Implementation Plans related to specific pollutants. Guidance for specific pollutants includes:

- PCBs
- Bacteria
- Mercury
- Trash

These guidance documents have been taken into consideration in the development of the Baltimore County TMDL Implementation Plans.

2.4 Water Quality Standards Related to This Implementation Plan

The Baltimore Harbor watershed (02-13-09-03) has been designated a combination of Use I, and Use II within Baltimore County. As previously mentioned this TMDL is specific to the non-tidal streams which will be Use I in this instance. These designations include the growth and propagation of fish and other aquatic life and wildlife as a part of the designated use. The water quality criteria applicable to the sediment TMDL include biological community criteria and sediment related criteria.

There are no specific sediment criteria, but there are criteria related to turbidity (COMAR 26.08.02.03-3), which is a function of suspended solids. The criteria specify:

(5)(a) Turbidity may not exceed levels detrimental to aquatic life.

(5)(b) Turbidity in the surface water resulting from any discharge may not exceed 150 units at any time or 50 units as a monthly average. Units shall be measured in Nephelometer Turbidity Units (NTU).

The biological water quality criteria are found in COMAR 26.08.02.03-4 and specify:

A. Quantitative assessments of biological communities in streams (biological criteria) may be used separately or in conjunction with the chemical and physical criteria promulgated in this chapter to assess whether water quality is consistent with the purposes and uses in Regulations .01 and .02 of this chapter.

B. The results of the quantitative assessments of biological communities shall be used for purposes of water quality assessment, including, but not limited to, those assessments required by §§303(d) and 305(b) of the federal Clean Water Act (33 U.S.C. §§1313(d) and 1315(b)).

C. These assessments shall use documented methods that have been subject to technical review, produce consistent and repeatable results, and are objectively interpretable.

D. In using biological criteria to determine whether aquatic life uses are being met, the Department shall allow for the uncertainty and natural variability in environmental monitoring results by using established quantitative and statistical methodologies to establish the appropriate level of uncertainty for these determinations.

E. The Department shall determine whether the application and interpretation of the assessment method are appropriate. In those instances where the Department determines the assessment method is not appropriate, it will provide its justification for that determination.

To determine impairment listings due to aquatic biological community condition, the biological data are analyzed on an 8-digit watershed scale. If the biological scores for benthic macroinvertebrates and fish indicating degraded stream conditions are significantly different than reference condition watersheds (i.e. healthy stream, <10% degraded), then the watershed is determined as not meeting biological water quality criteria. Index scores below 3.0 for the benthic community and fish are considered degraded. Based on the MBSS round one (1995-1997) and two (2000-2004) data presented in the Watershed Report for Biological Impairment of the Baltimore Harbor Watershed in Baltimore City, Baltimore, and Anne Arundel Counties, Maryland Biological Stressor Identification Analysis Results and Interpretation (MDE, 2014) approximately 71% of stream miles are estimated as having fish and/or benthic scores of 'poor' to 'very poor' (less than 3.0). This is supported by 21 of 28 sampling stations having degraded fish and/or benthic IBI scores significantly lower than 3.0.

The water quality end point to be achieved is biological scores greater than 3.0. Baltimore County will assess this end point on a subwatershed basis and use existing data for targeting impaired subwatersheds.

3.0 Introduction

The TMDL summary provides context for the TMDL implementation plan. It is necessary to understand some basic information from the original TMDL document (MDE, 2022) that preceded this particular implementation plan. The TMDL document describes the condition of the watershed at the time that the baseline load of the pollutant was calculated. The baseline load is simply a measurement of the amount of the pollutant that was in the waterbody during a specific time. The baseline load provides a starting pollutant measurement for the county to reduce from, in order to meet the TMDL target. The term TMDL is also used to describe the specific numeric load target, which is explained in detail within the TMDL document. The original TMDL document provides a detailed justification for choosing the TMDL target number. This justification is a description of the entire technical process including monitoring methods and calculations. The following section is a simplification of that section of the TMDL document and a brief explanation of why the TMDL was developed for the specific pollutant in this watershed.

3.1 TMDL Background

- **The Problem:** The TMDL was developed because sedimentation was found to be degrading the health of aquatic organisms in the non-tidal streams of Baltimore Harbor.

The non-tidal streams of Baltimore Harbor were listed as being impaired for impacts to biological communities in 2002 and impacts specifically due to sediments were identified in 2014. Maryland Department of the Environment (MDE) developed the TMDL and submitted it to EPA in December of 2021. It was approved by EPA in January of 2022.

An Index of Biotic Integrity (IBI) was used to determine biological impairment and a Biological Stressor Identification Analysis (BSID) was used to determine that sediment was the primary cause of that biological impairment.

IBI is the preferred tool for measuring the health of the aquatic community in a particular waterbody. An IBI score is a numerical measure of the completeness (Integrity) of the biological community. The Baltimore Harbor TMDL involves two different types of IBI measurement: a Fish IBI (F-IBI) and a Benthic macroinvertebrate IBI (B-IBI). An IBI score is determined by taking a series of samples of the community from different areas of a stream. A number of metrics are evaluated for the samples and are then used to calculate the IBI score. The Biological Assessment of Water Quality for Non-tidal Wadeable Streams is a document that is produced by MDE that explains the accepted methodology for assessing biological impairment in non-tidal streams (MDE, 2014a). It describes how both F-IBI and B-IBI are used in Maryland to evaluate biological data for Clean Water Act requirements.

Notice that IBIs are affected by a wide range of stressors. Even if the TMDL target for sediment is reached and water quality standards for sediment are restored, it is possible that other factors could keep the IBI from reaching a healthy score. There is currently no standard test that can exclusively measure sediment's effect on the health of aquatic life. There is also no sediment concentration standard in Maryland.

Although it is not possible to exclusively measure the effect of sediment on the health of aquatic life, the BSID analysis is designed to systematically and objectively determine the predominate cause of the reduced biological conditions. The IBI identified that a biological impairment exists, but the BSID verified that sediment was the primary impairing substance. For more information on the BSID analysis, see the Baltimore Harbor Biological Stressor Identification Report on the MDE website (MDE, 2014b).

The Main Report of the TMDL, Fact Sheet, BSID, Comment Response Document, and other supporting materials may be found on the MDE webpage titled TMDLs and Water Quality Plans for the Baltimore Harbor Watershed.

3.2 Determination of Impairment

The sediment load in the Baltimore Harbor watershed was studied over an extensive time period. The data used to determine this particular TMDL was gathered from round 1, round 2, and round 3 data of the Maryland Biological Stream Survey (MBSS) (see: Maryland Biological Stream Survey). Notably, none of the MBSS data used to develop this TMDL was gathered from within Baltimore County. MBSS is a set of water quality monitoring programs of the Maryland Department of Natural Resources (DNR) which includes the collecting and analyzing of samples of fish and benthic macroinvertebrates. Benthic macroinvertebrates are organisms without backbones that are visible without a microscope. They live on, under or around rocks and debris on the bottom of lakes, rivers, and streams. The sampled populations act much like “the canary in a coal mine”, but for watersheds. Some species are more tolerant to pollutants than others. The absence of less pollutant tolerant fish or macroinvertebrate species usually indicates that a pollutant has been present long enough and in high enough concentrations to kill off those organisms in that area. This is often seen as an early indication that the pollutant could cause harm to other species. The death of organisms from sedimentation can occur from accumulation over time, such as in the case of habitat modification, or can be an immediate death, such as in the case of smothering. The data provided the information necessary to calculate a final IBI score for both fish and macroinvertebrates for the stream.

It was determined that 2009 will be used as the baseline year of the data collection for this TMDL implementation plan. This 2009 baseline is called out in Section 4.3 of the MDE TMDL document (based on the CBP 5.3.2 2009 progress scenario).

3.3 TMDL Development

A critical step in the TMDL process is establishing the method by which the TMDL targets will be determined. This particular TMDL was developed using a reference watershed approach. Reference watersheds are determined based on Maryland’s biocriteria methodology, which utilizes both B-IBI and F-IBI. Reference watersheds are determined based on calculated IBI scores at MBSS stations. Reference watersheds are those with IBI scores indicating good biological health for the watershed overall. Watershed impairment is evaluated by the percentage of MBSS stations within the watershed that are below an IBI minimum allowable limit in comparison to reference conditions. Based on MBSS data, MDE BSID estimates that approximately 71% of the stream miles in the watershed have B-IBI and/or F-IBI significantly lower than 3.0 on a scale of 1-5.

Sediment loads for Baltimore Harbor were compared to seven reference watersheds with similar physical and hydrological characteristics in the Western Coastal Plain Physiographic Region. Sediment loads were then normalized with background conditions that would be present in a watershed surrounded by all forest cover. This theoretical condition is then used to develop the "forest normalized sediment load… [which] represents how many times greater the current watershed sediment load is compared to the all forested sediment load." MDE reports that "the median and 75th percentile of reference watershed forest normalized sediment loads were found to be 3.9 and 4.5 respectively." The median value of 3.9 was used as the sediment loading threshold (MDE, 2014b). In short, this threshold is established based on an analysis of sediment loads observed in watersheds that are meeting their water quality standards. After the analysis, the amount of sediment loading a watershed may receive without causing considerable detriment to aquatic biota is used to determine the goal for sediment loads in similar watersheds that are not meeting water quality standards.

3.4 TMDL Results

Using the sediment loading threshold analysis in conjunction with current (baseline) sediment loading conditions, a goal for sediment reductions in the watershed may be developed. The baseline load (estimated by the TMDL as 6,982 tons/year) was determined using the 2009 Progress Scenario of the Chesapeake Bay Program model version 5.3.2. The sediment loading threshold determined that the TMDL for sediment in Baltimore Harbor would be 3,247 tons/year, representing a requirement to reduce sediment loading by 53%. Table 3-1 below displays land uses within Baltimore Harbor and the modeled sediment load from each land use in the watershed.

Table 3-1: Baltimore Harbor 2009 Baseline Sediment Loads by Land Use*

General Land Use	Detailed Land Use	Tons of Sediment	Percent of Load (%)
Forest	Forest	115	1.6
	Harvested Forest	8	0.1
AFOs	Animal Feeding Operations	0.2	0.0
Pasture	Pasture	2	0.0
Crop	Crop	51	0.7
Nursery	Nursery	1	0.0
Regulated Urban	Construction	350	5.0
	Developed	6,443	92.3
	Extractive	11	0.2
Point Sources	Industrial Point Sources	1	0.0
	Municipal Point Sources	0	0.0
Total		**6,982**	**100.0**

*adapted from (MDE, 2022) Table 5; totals may not add to 100% due to rounding

Using the current baseline loading from the model, determined to be 6,982 tons/year, and the target load determined from the sediment loading threshold as 3,247 tons/year, the Baltimore Harbor watershed is required to reduce its sediment loading by 3,735 tons/year or 53 percent. Table 3-2 below summarizes the required reductions of sediment for the whole Baltimore Harbor watershed.

Table 3-2: Summary of TMDL Required Sediment Reduction for Baltimore Harbor (all sources)

Baseline Load (tons/year)	Required Load Reduction (tons/year)	TMDL (tons/year)	Total Reduction Percentage (%)
6,982	3,735	3,247	53

Using the landuse data, and knowledge of baseline loading by source sector, it is able to be determined that the baseline load is split up in the following way (tons/year):

Total Baseline Load	=	Nonpoint Sources	+	NPDES Stormwater	+	Wastewater
6,982	=	**177**	+	**6,804**	+	**1**

Adapted from (MDE, 2022) Table 4

3.5 TMDL Reduction Targets by Source Sector

TMDLs must be presented as a sum of waste load allocations (WLA) for point sources and load allocations (LA) for nonpoint source loads and a margin of safety (MOS).

- LA: Nonpoint sources were not targeted for reduction in this TMDL
- WLA: The WLA consists of two permitted sources: process water WLA and stormwater WLA.
    - Process water permits with specific accounting for TSS include municipal facilities, and mineral mining facilities. There was no reduction applied to these sources because they are not a significant portion of the total load.
    - Stormwater WLA can include regulated stormwater flowing from Municipal Separate Storm Sewer Systems (MS4s – the county's storm drain system), industrial facilities permitted to discharge stormwater, and construction sites.
- MOS: The margin of safety is implicit (baked into the calculations) because the forest normalized sediment load and chosen sediment loading threshold was considered to be an environmentally conservative estimate.

Recalling the TMDL equation presented in Section 1 of this TMDL Implementation Plan:

TMDL	=	LA	+	WLA Stormwater	+	WLA Process Water	+	MOS
3,247	=	**177**	+	**3,069**	+	**1**	+	**Implicit**

Adapted from (MDE, 2022) Table 9

To reach the endpoint goals of this TMDL, different sources of sediment pollution will need to be reduced. Baltimore County's requirement for reducing sediment loading is specific to the reductions required to meet the WLA Stormwater load presented in the equation above. Table 3-3 below summarizes reductions required for each category of source sector.

Table 3-3: Summary of Sediment Load Reductions Required by TMDL

	Baseline Load (2009 tons/year)	TMDL (tons/year)	Reduction Required (tons/year)	Percent Reduction (%)
LA/non-point source	177	177	0	0
WLA/point source Stormwater	6,804	3,069	3,735	55
WLA/point source Process Water	1	1	0	0
Margin of Safety	Implicit			
Totals	6,982	3,247	3,735	53

Table 3-4 below breaks out the WLA/point source Stormwater category into more specific categories. This information is taken from the Point Source Technical Memorandum, a supplement to the main TMDL document from MDE (MDE, 2021).

Table 3-4 Detailed Sediment Load Reductions Required for WLA Stormwater Sources in Baltimore Harbor

WLA/point source Stormwater	Baseline Load (2009 tons/year)	TMDL (tons/year)	Reduction Required (tons/year)	Percent Reduction (%)
Anne Arundel County MS4	1,660	697	963	58
Baltimore City MS4	2,109	886	1,223	58
Baltimore County MS4	1,334	560	774	58
State Highways Administration MS4	284	124	160	56
State and Federal Phase II MS4	467	202	265	57
"Other NPDES Regulated Stormwater"	950	600	350	37
Totals	6,804	3,069	3,735	55

The load reductions associated with Baltimore County's MS4 (storm drain system) represent the County's responsibility for implementation.

This review pertains to direct and indirect effects of sediment on fresh water rivers and streams, specifically those effects that are relevant to the Baltimore Harbor non-tidal streams. This is not intended to be an exhaustive review of primary literature, but rather a summary of the sources, pathways, and biological effects of sediment in non-tidal watersheds from literature available to Baltimore County Department of Environmental Protection and Sustainability.

Sediment is solid soil or rock material (e.g. pebbles, sand, dirt, and mud) that is transported by wind, water or ice, or is secreted or carried by organisms, or precipitated from a solution, i.e., chemical sedimentary rocks (U.S. Geological Survey and U.S Department of the Interior 2003). The effects of sediment on a water ecosystem are multi-dimensional (Berry, Rubinstien and Melzian 2003). Stream channels are inherently dynamic systems that change in their width, slope, shape, depth, meander pattern and bed material over time (Berry, Rubinstien and Melzian 2003) (Davis 2009) . Fluctuations in the sediment load occur naturally and are a vital part of the aquatic system. Sediment stress results when significant changes to the normal sediment load occur, compromising the ecological integrity of the water ecosystem (Berry, Rubinstien and Melzian 2003).

Sediment has different impacts on the system depending on the particle size. Classifications include bottom deposition sediment and suspended sediment. Course sediment is typically transported along the bottom of the river or stream, while silt and clay sediments become suspended in the water column. Turbidity is a measure of the water's cloudiness as a result of suspended sediment. Suspended sediment can include material that is large enough to eventually settle as bottom deposition. It can also include particles that fluctuate, through natural processes, between suspensions and deposition. Suspended sediment particles that are small enough to settle very slowly, or not at all, are those that contribute to the problem of turbid water (Berry, Rubinstien and Melzian 2003). Deposited sediment can create unique problems for aquatic life as well. The rate of flow of the river or stream determines what size particles become suspended or deposited (Davis 2009). Faster moving water has the power to move larger particles. Because the rate of water flow changes with water volume, the maximum size of particles in suspension is also subject to change. See USGS Summary Report on Sediment Processes: Chapter 3 - Watershed Sediment Transport; and Chapter 4 - Watershed Sediment Deposition and Storage. By the processes of re-suspension and deposition sediment can be re-introduced into the water column or deposited to the river or stream bed (Colorado Department of Public Health and the Environment, 2005).

Sediments enter the waterbody through a wide variety of transport mechanisms, including surface water (e.g. stormwater runoff), bank sloughing, and atmospheric deposition. See the USGS Summary Report on Sediment Processes: Chapter 2 - Watershed Sediment Sources. Upland and bank erosion contribute to nonpoint sources of the sediment load. Anthropologic activities enhance the erosion process (Booth and Henshaw 2000). Those activities include construction, mining, farming, urban development, and dredging (Berry, Rubinstien and Melzian 2003).

Erosion rates differ by land use. Estimates of average annual erosion rates help to determine the amount of sediment delivered to the waterbody, but not all eroded sediment enters the river. The average annual erosion rate from the land is known as the edge-of-field (EOF) erosion, but the edge-of-stream (EOS) is what actually enters the river reaches. The EOS is calculated using the

EOF, but also takes into account the deposition of sediment on hillsides, and sediment transport through smaller streams and rivers (Maryland Department of the Environment 2011).

Stream bank erosion is aggravated by high water flows during storm events. Impervious surfaces, such as parking lots, roads, and rooftops are often directly connected to the stream channel via the storm sewer system. This causes water to flow more rapidly into the stream during a storm event without the natural filtration that occurs when rain water runs through vegetation and soil. The outcome is higher water flows in the stream channel during storms and higher sediment content in the streams and rivers. The stress of these high flows through the stream and river channels wears away at the banks, causing higher than normal bank erosion (Booth and Henshaw 2000) (Maryland Department of the Environment 2011).

A study produced by U.S. Geological Survey on sediment processes in the Chesapeake Bay watershed found that river basins with the highest percentage of agricultural land use have the highest annual sediment yields (U.S. Geological Survey and U.S Department of the Interior 2003). Basins with the highest percentage of forest cover were found to have the lowest annual sediment yields. The study also found that urbanization can more than double the background sediment yield (U.S. Geological Survey and U.S Department of the Interior 2003). This urban sediment is highest during construction phases and then declines after the initial development is complete. In some instances, when construction alters stream hydrology, the sedimentation rate remains high because the erosion of stream banks continues long after development (U.S. Geological Survey and U.S Department of the Interior 2003). For more information on urbanization and sedimentation, see: U.S. EPA Urbanization and Streams: Studies of Hydrologic Impacts.

Sediment can affect humans by reducing water clarity, which is not aesthetically pleasing. It can also reduce cleanliness of water for swimming or recreational activities, as well as drinking.

An overabundance of sediment in the water column, resulting in cloudy water, inhibits light penetration. This can be a problem for predators, as both big and small fish hunt primarily by sight (Berry, Rubinstien and Melzian 2003) (Lester 2013). When fish and other aquatic animals cannot see their prey, their ability to capture food is limited. Murky water is a problem for both large and small fish, but smaller fish that feed on zooplankton can have an advantage, to a degree, of not being seen as easily by predators while scavenging for food. However, too much cloudiness, negates this advantage and both large and small fish will find it difficult to get enough food for their survival (Lester 2013).

Excessive sediments can also destroy valuable aquatic habitats for fish, aquatic invertebrates, and algae (Berry, Rubinstien and Melzian 2003) (Lisle, 1989). Fish habitats are affected when fine sediment settles into spawning gravels, reducing oxygen levels in the spaces between gravel particles. Spawning gravels are stream bed materials that females excavate to form nests for egg laying. During excavation, females minimize fine sediment particles to enhance gravel permeability and oxygenate the eggs. Decreased oxygenation due to sedimentation can lead to a reduction in survival and growth rates (Colorado Department of Public Health and the Environment 2005; Lisle 1989). Sedimentation can also negatively affect fish through loss of food sources and loss of habitat variety that normally result from natural variations in steam morphology (Colorado Department of Public Health and the Environment, 2005).

Aquatic invertebrates can suffer habitat loss due to sedimentation in addition to being smothered by fine sediments that settle into rocks and gravel. Chapman and McLeod, 1987, as cited in Colorado Department of Public Health and the Environment, 2005, found a relationship between bed material size and macroinvertebrate habitat availability, and also found that excessive sediment decreases the diversity and density of macroinvertebrates. If sediments are carried downstream into brackish and salt waters, it can degrade the health of oyster beds, which are critical for water filtration and cleaning in the Chesapeake Bay (U.S. Geological Survey and U.S Department of the Interior, 2003); (Cerco & Noel, 2005).

Another way that sediments can damage the health of aquatic communities is by transporting pollutants into the watershed. Nutrients, metals, and other toxic substances can form complexes with minerals found in fine sediment, consequently, water runoff not only carries excessive sediments, but often includes pollutants as it washes into waterways. Excess of certain nutrients and minerals can be toxic to many aquatic organisms (Nelson and Booth 2002). For example, excess phosphorus in the water increases the growth of surface level algae. The algae can block out sunlight and prevent it from getting to the submerged aquatic vegetation (SAV), which is an essential part of the aquatic food chain. Excessive algae growth and its life-cycle also uses up oxygen in the water and can create hypoxic conditions, meaning that the dissolved oxygen level is too low to support many aquatic organisms. See USGS Summary Report on Sediment Processes: Executive Summary.

This section will describe the watershed characteristics of the Baltimore Harbor watershed. Section 5.1 has general characterization information and Section 5.2 discusses land use, sediment loads and reductions and the total reduction the Baltimore County MS4 is required to meet the TMDL. Characterizing the watershed can aid planning and restoration targeting efforts and improve understanding of sediment sources.

The TMDL document produced by Maryland Department of the Environment (MDE) used 2009 as the baseline year for data in determining the sediment load reduction required (MDE, 2021). Figure 5-1. shows the Baltimore Harbor watershed, while Figure 5-2 shows non-tidal areas of Baltimore Harbor which are regulated by Baltimore County's NPDES MS4 Permit (highlighted in blue), to which this TMDL is specific.

Figure 5-1: Baltimore Harbor Watershed within Baltimore County

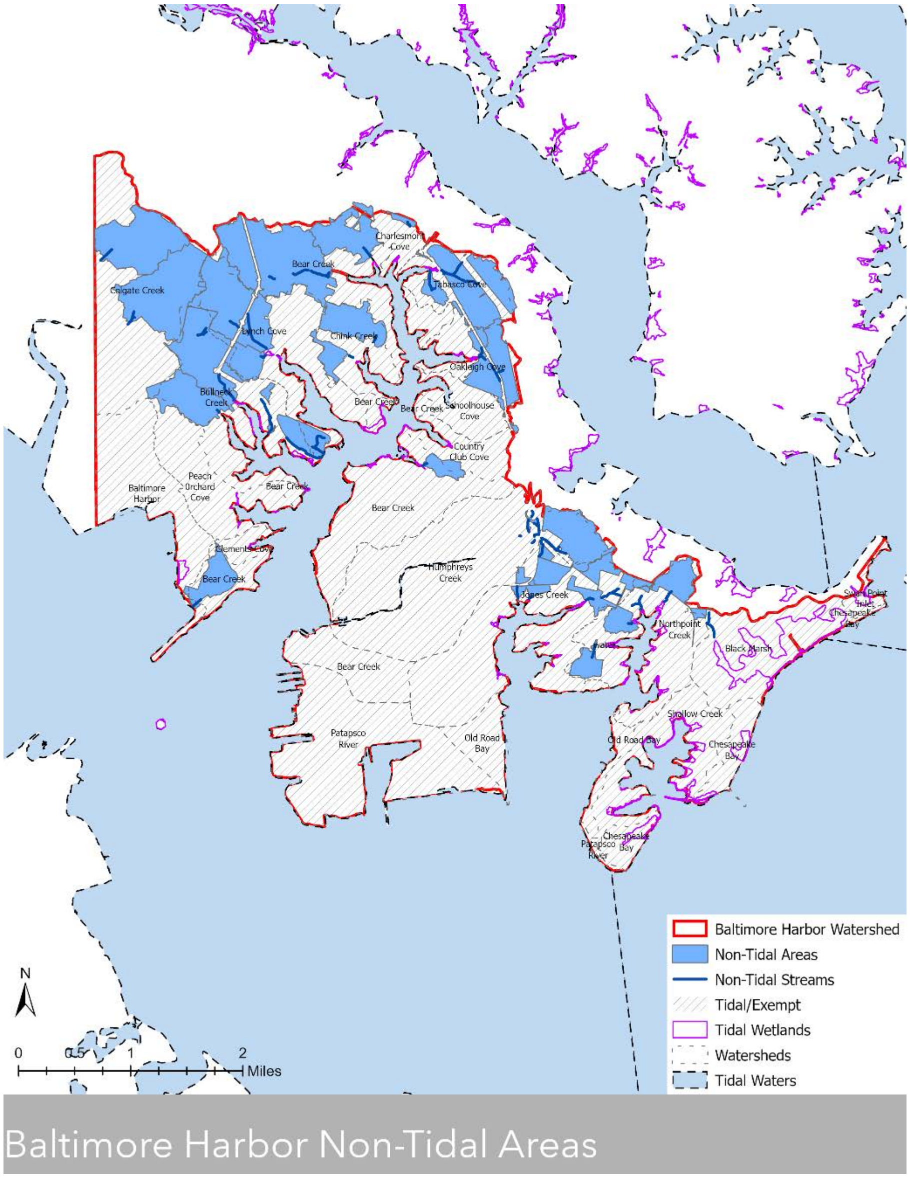

Figure 5-2: Non-Tidal Areas in Baltimore Harbor Watershed Regulated Under Baltimore County's NPDES MS4 Permit

5.1 General Information

5.1.1 Acreage

The Baltimore Harbor watershed contains approximately 11,453 acres within Baltimore County of varying land uses and pollution potential. A significant portion of the Baltimore Harbor watershed is contained within Anne Arundel County and the City of Baltimore, outside the scope of this implementation plan. Of the 11,453 acres in Baltimore County, much of that area drains directly to tidal waters and/or is administered under a stormwater discharge permit separate from the County's responsibility, leaving 1,765 baseline urban acres of land which Baltimore County will be responsible for addressing under this non-tidal sediment TMDL.

5.1.2 Streams

Streams were analyzed using Geographic Information Systems. 2005 Hydrology data was queried on "SINGLE LINE STREAM" and "DOUBLE LINE STREAMS/RIVERS". Double line streams data was divided by 2 and added to the single line stream data to calculate total stream miles. Table 5-1 shows length of streams in the non-tidal portions of Baltimore Harbor within Baltimore County's jurisdiction (see Figure 5-2).

Table 5-1: Streams Data for the Baltimore Harbor Watershed

Linear Feet of Stream	Miles of Stream
33,546	6

5.2 Land use, Sediment Loads, and Reductions

As mentioned above, 2009 is the baseline year for the non-tidal sediment TMDL for the Baltimore Harbor watershed. This section updates the sediment loads and BMP reductions to the point in time for which we have the most recent land use data compatible with the Phase 6 Chesapeake Bay Watershed Model, which is approximately fiscal year 2013. Changes in sediment loads between the 2009 baseline and 2013 are calculated and accounted for.

A land use dataset was required that was compatible with the Phase 6 Chesapeake Bay Watershed Model (CBWMv6) and MDE's TMDL Implementation Progress and Planning (TIPP) tool, that was appropriate for analyzing change over time from 2009 to the present, and that can be summarized for small, specific geographic areas such as the non-tidal areas in Figure 5-2. The CBWMv6 and TIPP tool depend on high resolution (1 meter pixel) land use mapping derived from recent remote sensing technologies such as LiDAR, which is necessary to accurately map urban land covers such as tree canopy and turf. Such high spatial resolution also enables summary for small, specific geographic areas. However, at the time of report preparation, the Chesapeake Bay Program and MDE had released this novel high resolution land use map (CCLU) for a single point in time (2013). Therefore, a "backcasting" mechanism to create comparable land use data for the 2009 baseline year was needed.

The County implemented the MDE approved backcasting method (https://mde.maryland.gov/programs/water/tmdl/datacenter/pages/tmdlstormwaterimplementation.aspx). This method requires a land use data series designed for change over time analysis, covering the time period from 2009 to 2013. The National Land Cover Dataset (NLCD) (Jin, 2013) met these requirements. The County fused NLCD data with concurrent impervious surface data from Baltimore County planimetric GIS data, to ensure that changes in impervious surfaces would be captured as accurately as possible. The County then overlaid the fused 2013 NLCD impervious data with the 2013 CCLU, creating tables that translate the fused NLCD land use categories into the CCLU/CBWMv6/TIPP land use categories. The County then used the translations to convert 2008, 2011, and 2013 fused NLCD land cover acreages into CCLU/CBWMv6/TIPP tool land use categories. The County interpolated between 2008 and 2011 to arrive at 2009 land use acreages.

Pollution loading rates for land use categories were extracted from MDE's TIPP tool and applied to the land use acreages to calculate the land use pollution load. Restoration BMP pollution removal rates and efficiencies were extracted from MDE's TIPP tool, MDE guidance, and CBP guidance documents, and applied to the BMPs present in the non-tidal area.

Table 5-2 shows the non-tidal Baltimore Harbor total suspended sediment (TSS) loads for the baseline and 2013 broken out by all land uses, limited to lands regulated under Baltimore County's NPDES MS4 permit.

Table 5-2: Change In Baltimore Harbor Non-Tidal Sediment Urban Loads Based on Land Use (Baltimore County MS4)

Land Use	TSS Loading Rate (lbs/ac/yr)	Acres Baseline (2009)	TSS Load Baseline (lbs/yr)	Acres (2013)	TSS Load 2013 (lbs/yr)	Δ in acres (acres)	ΔTSS Load 2013 (lbs/yr)
Aggregate Impervious	4,036.0	541.5	2,185,608	548.6	2,214,044.0	7.1	28,436
Impervious Non-Road	2,743.3	295.1	809,514	292.8	803,126.9	-2.3	-6,387
Impervious Road	5,115.3	222.8	1,139,440	220.9	1,130,003.9	-1.9	-9,436
Canopy Over Aggregate Impervious	3,753.4	9.2	34,408	9.1	34,234.7	-0.1	-173
Canopy Over Impervious Non-Road	2,551.2	14.1	35,856	14.0	35,620.3	-0.1	-236
Canopy Over Impervious Road	4,757.2	8.7	41,509	8.7	41,168.1	0	-341
Canopy Over Turf	841.2	114.6	96,371	115.0	96,771.7	0.4	401
Turf	893.0	559.1	499,253	562.7	502,460.8	3.6	3,208
Total		**1,765**	**4,841,960**	**1,771.8**	**4,857,430**	**6.7**	**15,471.4**

Note that Table 5-2 above demonstrates that there were slight increases in aggregate impervious, canopy over turf and turf coupled with a decrease in the reaming land uses. This resulted in an overall increase in the sediment load.

Some restoration has already taken place, both before and after the TMDL baseline year. Pre and post baseline restoration is shown in Table 5-3 and Table 5-4 respectively.

Table 5-3: Baltimore Harbor Non-Tidal Sediment Restoration Reductions Through Baseline (FY2009)

Restoration Type	TSS Reductions (lbs/yr)
Stormwater Management*	**206,555**
Ba Co Restoration Projects	0
Watershed Group Plantings	0
Ba Co Tree Planting	0
Total Restoration	**0**
Total (lbs/yr)	**206,555**

*Stormwater Management includes restoration projects for SWM conversion, SWM retrofit, and impervious removal

Table 5-4: Baltimore Harbor Non-Tidal Sediment Restoration Reductions FY10 Through FY13

Restoration Type	TSS Reductions (lbs/yr)
Stormwater Management*	**25,014**
Ba Co Restoration Projects	0
Watershed Group Plantings	23
Ba Co Tree Planting	76
Total Restoration	**99**
Total (lbs/yr)	**25,113**

*Stormwater Management includes restoration projects for SWM conversion, SWM retrofit, and impervious removal

Baltimore County is responsible for addressing sediment from its MS4. The point source stormwater load is the urban pervious and urban impervious loads, 'Total Urban' from Table 5-5. Also shown in Table 5-5 are the restoration reductions through the baseline year and up through FY13 from Table 5-3 and Table 5-4. The total sediment load after these reductions are applied is shown in Table 5-5.

Table 5-5: Change in Baltimore Harbor Non-Tidal Sediment Urban Loads Based on Land Use

Land Use	TSS Loading Rate (lbs/ac/yr)	Acres Baseline (2009)	TSS Load Baseline (lbs/yr)	Acres (2011)	TSS Load FY13 (lbs/yr)	ΔTSS Load FY13 (lbs/yr)
Total Urban		1,765	4,841,960	1,772	4,857,430	15,471
Development Stormwater Management			-206,555		-231,569	
Restoration Reductions			0		-99	
Total Load (lbs/yr)			**4,635,404**		**4,625,762**	**-9,642**

Section 8 of this Implementation Plan has more specific details on the restoration BMPs and how their reductions shown in Table 5-3 through Table 5-5 are calculated.

Table 3 of the Point Source Technical Memorandum (MDE, 2021) shows that of the 6,804 tons of baseline TSS load contributed by all point source regulated stormwater, Baltimore County MS4 is responsible for 1,334 ton/yr (2,668,000 lbs/yr). Table 5-5 indicates a baseline Baltimore County MS4 regulated stormwater load of 4,635,404 lbs of sediment per year after accounting for BMPs and restoration.

In order to determine the Baltimore County MS4 TMDL target load, the change in the Baltimore County MS4 load from the baseline year (2009) to the end of fiscal year 2013 was calculated and is shown in Table 5-5 (a reduction of 9,642 lbs/yr).

The percent reduction required to meet the TMDL for Baltimore County MS4 is 58% from the baseline load (MDE, 2021). However, since the baseline year, the total sediment load from the Baltimore County MS4 has decreased due to changes in land use and BMPs installed. This decrease in load (-9,642 lbs/yr) was deducted from the reduction required from the baseline load (2,688,535 lbs/yr) to obtain the total sediment reduction required from the end of fiscal year

2013 (2,678,892 lbs/yr). Table 5-6 shows this load decrease along with other data from the calculations used to determine the total reduction required to meet the TMDL.

Table 5-6: Sediment Reduction Required to Meet TMDL (Baltimore County Urban Land)

Baseline TSS Load (lbs/yr)	End of FY13 TSS Load (lbs/yr)	% Reduction Required From Baseline	TSS Reduction Required From Baseline (lbs/yr)	Δ in TSS Load From Baseline Thru FY13 (lbs/yr)	Total TSS Reduction Required as of end of FY13 (lbs/yr)
4,635,404	4,625,762	58%	2,688,535	-9,642	2,678,892

Table 5-7 brings the reduction requirement up to the end of FY22 by incorporating reductions from FY14 through FY22.

Table 5-7: Current Reduction Required to Meet TMDL

Total TSS Reduction Required as of end of FY13 (lbs/yr)	TSS Reductions FY14-FY22 (lbs/yr)	Current TSS Reduction Required as of end of FY22 (lbs/yr)
2,678,892	56,501	2,622,391

In order to meet the requirements of the TMDL, BMPs must be installed to reduce 2,622,391 lbs of sediment per year from the end of Fiscal Year 2022. Section 9 of this TMDL Implementation Plan details how Baltimore County can meet this MS4 allocation of the Baltimore Harbor Non-Tidal Sediment TMDL.

Two ambient water quality monitoring programs provide sediment data for the non-tidal portion of Baltimore Harbor including monitoring done by Baltimore County and the Maryland Department of Natural Resources (DNR). DNR core/trend data is presented in Section 6.1 and Baltimore County trend data is presented in Section 6.2. Section 6.3 examines the current condition of sediment in non-tidal Baltimore Harbor using both sets of data. Baltimore County had a baseflow program but that data is not applicable to the TMDL. The baseflow program sampled dry weather flows only and this is representative of only a small part of the total suspended sediment load. Sites can be seen in Figure 6-1.

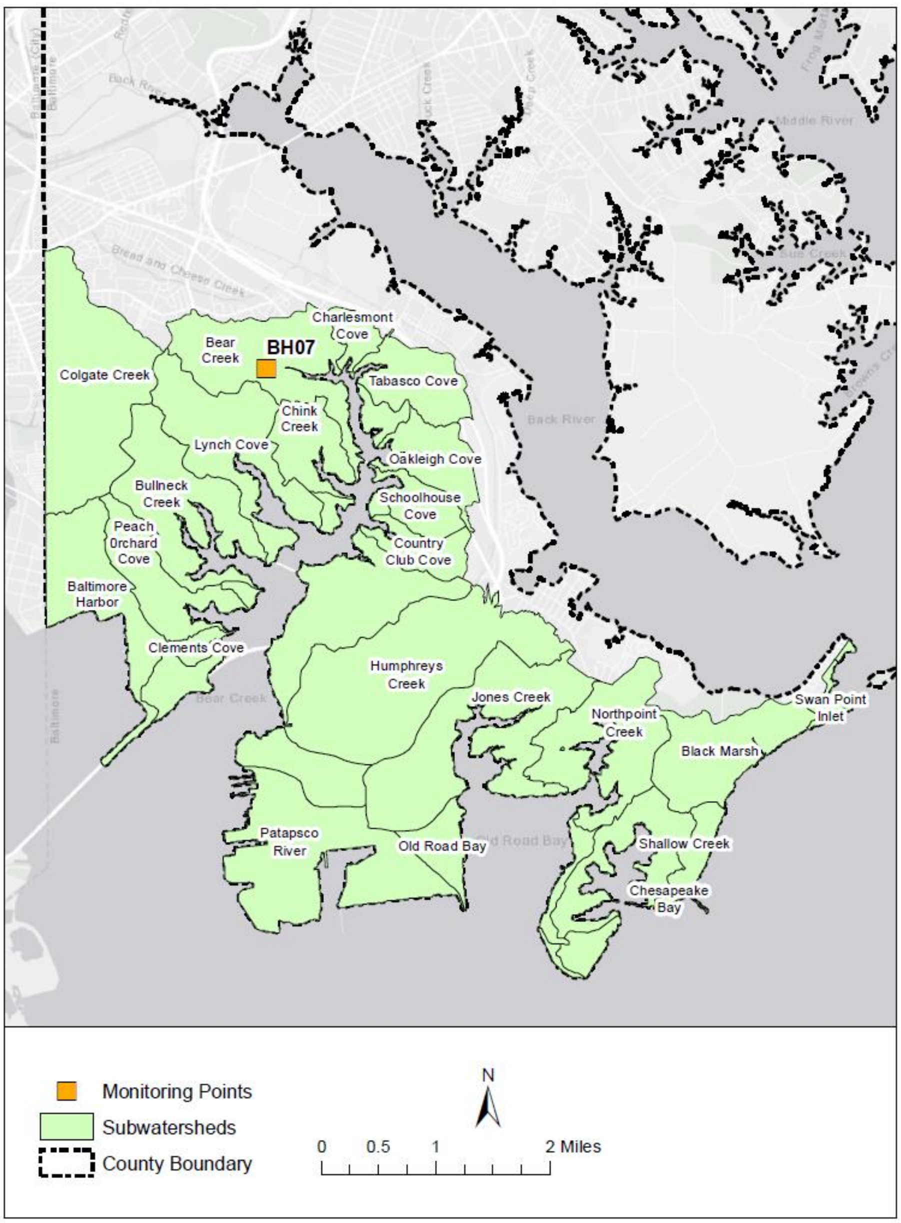

Figure 6-1: Chemical Trend Monitoring Points in Baltimore Harbor Watershed

6.1 Core/Trend Program

DNR conducts an ambient fixed station water quality monitoring program (Core/Trend) to assess statewide water quality status and trends. The 54 sampling locations are distributed throughout the state, with particular attention to the Potomac River, and none are within Baltimore County's portion of the Baltimore Harbor direct drainage. The Pollutant load calculation is as follows:

$$P_L = (P_C x 0.000008345) x (CFS x 448.8 x 1440) \qquad (6.1)$$

Where:

P_L = Pollutant Load,

P_C = Pollutant Concentration,

0.000008345 = Conversion factor to convert mg/L to pounds per gallon,

CFS = Cubic feet per second,

448.8 = Conversion factor to convert cubic feet per second to gallons per minute

1440 = number of minutes in one day

The result of the above equation is in lbs/day of pollutant, which can then be divided by the number of acres in the drainage area to derive the lbs/acre/day load. The flow is the average for the year of cfs at time of sampling.

6.2 Baltimore County Data

In January 2011, Baltimore County's baseflow monitoring program was replaced with a water quality trend monitoring program. The trend monitoring program observes ambient chemical conditions and determines trends in chemical concentrations and pollutant loads over time at forty-one sites. This data is used to determine areas to target for restoration, assess the impact of implemented restoration activities, and determine the amount of progress made towards meeting TMDLs and other restoration goals. The sites are broken into four sampling days which remain the same each month regardless of weather. One of these trend sites is located within Baltimore Harbor:

1. BH07 (311.04 acres) which is located off of Trappe Rd & W. Woodwell Rd in Dundalk;

6.2.1 Summary of Data Results

Water quality parameters measured as part of the County's trend monitoring program include Total Suspended Sediment (TSS). Trend chemical monitoring results collected for these sites are summarized in Table 6-1.

Table 6-1: Average Baltimore County Trend Sampling Results for Baltimore Harbor

Site	Date	Average Daily Flow (cfs)	Annual TSS (lbs)	TSS (lbs/acre/day)
BH07	2016	0.2799	6,830	0.0603
BH07	2017	0.2024	4,593	0.0405
BH07	2018	0.4158	4,940	0.0436
BH07	2019	0.2803	5,772	0.0510
BH07	2020	0.2852	6,458	0.0570
BH07	2021	0.2493	4,523	0.0397
Average		**0.2855**	**5,520**	**0.0487**

Figure 6-2 graphically shows TSS lbs/acre/day at the trend monitoring program sites over the years.

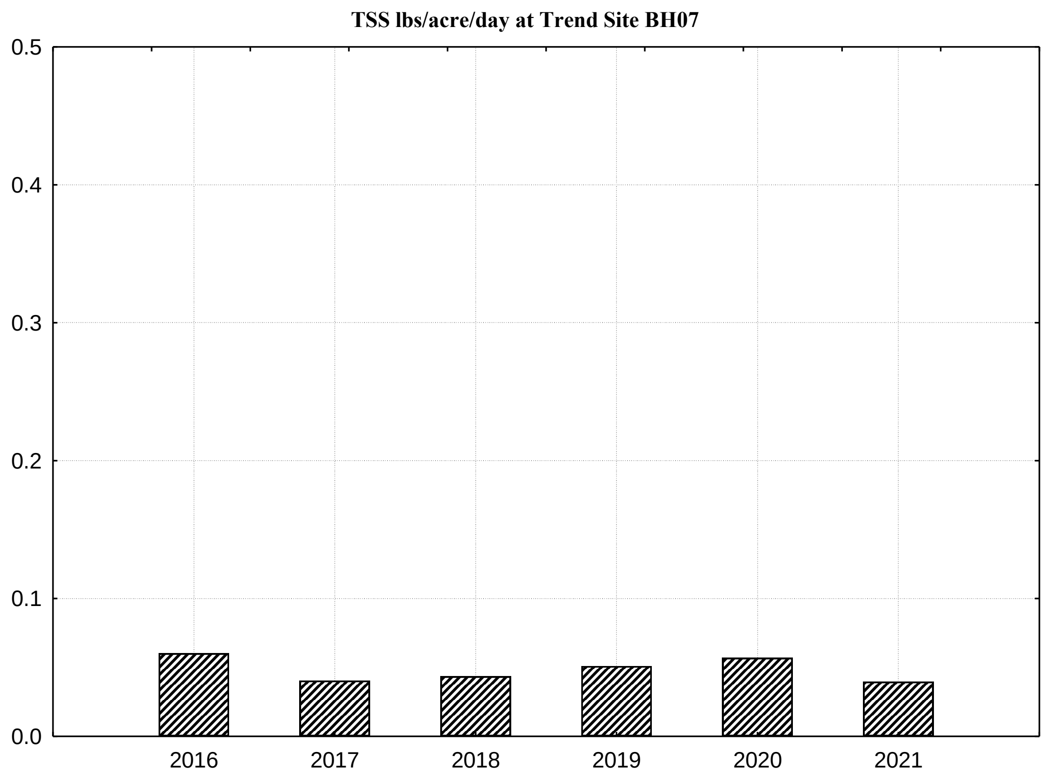

Figure 6-2: TSS lbs/acre/day at Baltimore County Trend Monitoring Site BH07 within Baltimore Harbor Watershed

6.3 Comparison of Data to TMDL Water Quality Standard: Benthic Index of Biological Integrity (BIBI)

Baltimore County conducts biological monitoring of benthic macroinvertebrates on an annual basis using the Maryland Biological Stream Survey (MBSS) protocols (Kazyak 2001, Stranko 2010). The MBSS is a random design stream sampling program that was initiated by the

Maryland DNR in 1993. It is intended to provide unbiased, statewide estimates of the biological resources in streams and rivers.

Benthic macroinvertebrates are organisms without a backbone that live on the bottom of streams and can be seen with the naked eye. They are an important part of stream ecosystems as they are a source of food for other aquatic life, including fish. The presence, numbers, and types of benthic macroinvertebrates also convey information about a water body's quality. Results of the MBSS protocol include a benthic Index of Biological Integrity (BIBI) score based on the benthic community at a sampling site. Qualitative ratings of stream Biological Integrity are based on IBI scores and range from good (4.0 – 5.0), denoting minimally impacted conditions, to very poor (1.0 – 1.9), indicating severe degradation.

6.3.1 Biological Data from Baltimore County

Sites for the Baltimore County biological sampling program are randomly selected, traditionally focusing on the Patapsco/Back River Basin in odd years and the Gunpowder/Deer Creek Basin in even years. New MS4 Permit guidance will result in a shift in this schedule so that all 8-digit watersheds are eligible for random point sampling in every year. No biological monitoring has been conducted in the non-tidal portions of Baltimore Harbor. See Section 10 of this plan for future plans.

6.3.2 Maryland Department of Natural Resources Data

The Maryland Biological Stream Survey (MBSS) was started by the Maryland Department of Natural Resources in 1993 as a small pilot study and expanded statewide by 1994. The MBSS was Maryland's first probability-based or random design stream sampling program intended to provide unbiased estimates of stream conditions with known precision at various spatial scales ranging from large 6-digit river basins and medium-sized 8-digit watersheds to the entire state. In addition to having no data collected by the County in this planning area, Maryland DNR also have not sampled any sites in Baltimore County's portion of the non-tidal drainage of Baltimore Harbor.

The Baltimore Harbor is the common receiving water body which drains Baltimore County land in the Patapsco River, Gwynns Falls, and Jones Falls watersheds, as well as surrounding direct drainages to the Harbor itself. This TMDL for sediment in non-tidal streams is specific only to those streams in the surrounding direct drainage (the other major tributaries have their own separate TMDLs for sediment). Baltimore County's portion of the direct drainage to Baltimore Harbor (Primarily Bear Creek and Old Road Bay) has been previously assessed in a detailed watershed assessment study – the Baltimore Harbor Small Watershed Action Plan (SWAP). In addition to the SWAP, the area has been assessed for the development of multiple other TMDL Implementation Plans to address chlordane, nutrients, and polychlorinated biphenyls.

The SWAP documents present strategies and provide guidance for restoration of their respective portions of the drainage, and identify priority projects for implementation. SWAPs delineate multiple subwatersheds within the main subject of assessment to allow for more focused review of each area, which permits customized plans for restoration in each zone. Neighborhoods, institutional facilities, and potential pollution hot-spots are then identified within the subwatersheds and individually assessed by multiple field crews to develop strategies for pollution reduction in each area. SWAPs identify opportunities to reduce pollution inputs, and set goals and actions for restoring the local waterways to acceptable standards. Appendix A of each SWAP contains a listing of the proposed actions for reducing pollutant inputs in the area of question that would contribute to meeting the SWAP goals for that area.

The SWAP completed for the Baltimore Harbor direct drainage is accessible on the County's webpage for Baltimore Harbor;
https://www.baltimorecountymd.gov/departments/environment/watersheds/bhmain.html.

The TMDL Implementation Plans are accessible on the County's webpage for Total Maximum Daily Load Implementation Plans by Watershed;
https://www.baltimorecountymd.gov/departments/environment/monitoring/tmdlplans.html.

While many other assessments of this watershed area have included both tidal and non-tidal areas, the impairment addressed by this implementation plan is for sediment in Baltimore Harbor's non-tidal portions of waterways within the Harbor drainage.

This section provides an overview of pollutant reduction measures and their predicted effectiveness as approved by the Chesapeake Bay Program (CBP). This overview is meant to serve as a guide to aid in selecting the most efficient possible BMPs that may be implemented to meet the pollutant reduction goals required by the TMDL. This review utilizes conservative estimates of BMP efficiency for planning purposes, as exact types of BMPs (e.g. structural BMPs) will not be chosen until appropriate on-site analysis is complete. It is possible that only some of the listed actions in this section will be selected for inclusion in Section 9 of this Implementation Plan.

8.1 BMP Descriptions

Listed and briefly described below are the approved BMPs for reducing sediment that are applicable to Baltimore Harbor. Most definitions were obtained from CAST Source Data spreadsheet available here: https://cast-reports.chesapeakebay.net/public/SourceData.xlsx. Many of these practices are representative of one of many types of Stormwater Management (SWM) retrofits or conversions. A retrofit is a SWM feature that is installed in an area that has already been developed, but has minimal or no SWM treatment practices currently in place. A conversion uses an existing, older practice that may only provide water *quantity* treatment, and alters it so that water *quality* may be improved as well.

8.1.1 Dry Detention Ponds

Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms.

8.1.2 Hydrodynamic Structures

Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.

8.1.3 Dry Extended Detention Ponds

Dry Extended Detention (ED) basins are depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. As such, they are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness.

8.1.4 Wet Ponds and Wetlands

A water impoundment structure that intercepts stormwater runoff then releases it to an open water system 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 nutrients/toxics. Until recently, these practices were designed specifically to meet water quantity, not water quality objectives. There is little or no vegetation living within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal.

8.1.5 Infiltration Practices

A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration practices, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be build in good soil, they are not constructed on poor soils, such as C and D soil types. Engineers are required to test the soil before approved to build is issued. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if the basin or trench is still infiltrating runoff.

8.1.6 Filtering Practices

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 inspection and maintenance to receive pollutant reduction credit (Collins, et al. 2009).

8.1.7 Environmental Site Design

Small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources (MDE, 2000 Maryland Stormwater Design Manual 2000).

8.1.8 Street Sweeping and Inlet Cleaning

Street sweeping measured by the weight of street residue collected. Street sweeping and storm drain cleanout practices rank among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with their National Pollutant Discharge Elimination System stormwater permits.

8.1.9 Tree Planting

Tree planting includes any tree planting, except those used to establish riparian forest buffers.

8.1.10 Urban Forest Buffers

An area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.

8.1.11 Impervious Surface Removal

Reducing impervious surfaces to promote infiltration and percolation of runoff storm water.

8.1.12 Stream Restoration

Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.

Stream Restoration in Non-Tidal 1st through 4th Order Streams

Crediting for the benefit of stream restoration to non-tidal 1st through 4th order streams is done in a slightly different manner than it is for tidal waterways. The pollutant loading modeled, for a TMDL such as this, does not address or account for the reduced pollutant delivery to the downstream tidal embayment. Therefore, in modeling the benefits of stream restoration, credit may be given which better reflects the benefit to the local non-tidal stream which may be greater than the restoration benefit experienced by the tidal embayment.

8.1.13 Redevelopment

Redevelopment consists of applying new uses to previously occupied urban space. This can sometimes involve a change in zoning or land use all together, or simply finding new uses for existing structures. In many cases this can allow for a site that previously had no water quality treatment practices to incorporate them into the new development.

Table 8-1: Pollutant Reductions of BMPs

Practice	Nitrogen	Phosphorus	Sediment	Bacteria
Dry Detention Ponds and Hydrodynamic Structures	✓	✓	✓	✓
Dry Extended Detention Ponds	✓	✓	✓	✓
Wet Ponds & Wetlands	✓	✓	✓	✓
Infiltration Practices	✓	✓	✓	✓
Filtering Practices	✓	✓	✓	✓
Environmental Site Design	✓	✓	✓	
Street Sweeping and Inlet Cleaning	✓	✓	✓	✓
Tree Planting	✓	✓	✓	
Urban Forest Buffers	✓	✓	✓	✓
Impervious Surface Removal	✓	✓	✓	
Stream Restoration	✓	✓	✓	✓
Redevelopment	✓	✓	✓	✓

Table 8-2 shows how the BMP practices listed above are credited.

Table 8-2: Sediment Reduction Efficiencies of BMPs

Practice		
Dry Detention Ponds and Hydrodynamic Structures	Reduction Efficiency	10%
Dry Extended Detention Ponds	Reduction Efficiency	60%
Wet Ponds & Wetlands	Structural Treatment Curve	Varies
Infiltration Practices	Runoff Reduction Curve	Varies
Filtering Practices	Structural Treatment or Runoff Reduction Curve	Varies
Environmental Site Design	Runoff Reduction Curve	Varies
Street Sweeping and Inlet Cleaning	Load reduction (lbs) / ton of wet material	382.62
Tree Planting	Land use change	-
Urban Forest Buffers	Efficiency + Land use change	50%
Impervious Surface Removal	Land use change	-
Stream Restoration (default rate)	Load reduction (lbs)/length (linear ft)	248.0[1]
Stream Restoration (CBP Protocols)	Load reduction (lbs)	Varies
Redevelopment	Historical effectiveness	Varies

1. This value is significantly greater than other projections of TSS removal from stream restoration on account of this TMDL being specific for the non-tidal streams of Baltimore Harbor, and the pollutant reduction that would be experienced directly in those streams, rather than accounting for the pollutant reduction that is received at the end of the land-river segment. See also: Section 8.1.12.

8.2 BMP Calculations

Below is a description of the different types of reduction calculations used to estimate the amount of sediment removed by a BMP.

8.2.1 Reduction Efficiency Calculations

Pollutant reductions for practices with approved reduction efficiencies are calculated based on the approximate pollutant load received from the drainage area (DA) and removal efficiencies (RE) recommended by CBP for the various types of SWM facilities. The equation used to estimate sediment load reductions for a particular type of SWM facility is expressed as:

Equation 8-1

$$Sediment\ Load = [LR * DA] * RE$$

Where LR is the loading rate (lbs/acre/year), DA is the drainage area (acres), and RE is the pollutant reduction efficiency of the BMP in question in decimal format. The pollutant load received from the drainage area contributing to the SWM facility or other BMP is denoted by the first expression in brackets in the above Equation 8-1. The load must be calculated for each type of land use draining to the facility using the appropriate loading rate. The percent pollutant removal efficiency depends on the type of facility and is based on the values shown in Table 8-2. The pollutant removal efficiency of stormwater management facilities (other than dry detention, extended detention, and hydrodynamic facilities) vary based on the area of impervious surfaces contributing stormwater to the facility, the volume of water treated for water quality by the facility (calculated following the Maryland Stormwater Design Manual (MDE and Center for Watershed Protection, 2009)), and the appropriate BMP removal rate adjustor curve (stormwater treatment or runoff reduction) as per the Chesapeake Bay Program expert panel report (Comstock, et al., 2012).

8.2.2 Land Use Change Calculations

Pollutant reductions for practices like tree planting and impervious surface removal use a land use change calculation to estimate pollutant reductions. The equation used to estimate sediment load reductions for land use conversion is expressed as:

Equation 8-2

$$Land\ Use\ Conversion = (LR1 - LR2) * Area$$

Where LR1 is the loading rate of the previous land use, and LR2 is the loading rate of the new or projected land use. Pervious area reforestation for example would involve converting open pervious area to forest. Therefore, the loading rate would be reduced by a factor equal to the difference between pervious urban (LR1) and forest (LR2) loading rates used in the watershed pollutant analysis as shown in the first expression in brackets in the equations above. The approximate reduction in pollutant load would then be the reduced loading rate multiplied by the open pervious area available for reforestation. In determining the pollutant reduction for riparian stream buffer plantings there is a calculation which incorporates both a land use conversion and an added pollutant reduction efficiency.

8.3 Uncertainty and Research Needs

The sediment TMDL for Baltimore Harbor is based on impairment of the aquatic community identified through the Maryland Biological Stream Survey monitoring. The current listings for biological impairments represent degraded biological conditions for which the stressors, or causes, are unknown. The MDE Science Services Administration (SSA; now the Water and Science Administration) has developed a Biological Stressor Identification (BSID) analysis that uses a case-control, risk-based approach to systematically and objectively determine the predominant cause of reduced biological conditions, thus enabling the Department to most effectively direct corrective management action(s).

Data suggest that the degradation of biological communities in Baltimore Harbor is strongly associated with urban land use and its concomitant effects: altered hydrology and elevated levels of sediments, and inorganic pollutants (e.g. chlorides, and sulfates).

The results of the BSID analysis, and the probable causes and sources of the biological impairments in Baltimore Harbor, can be summarized as follows (excerpt from BSID):

- The BSID process has determined that the biological communities in the Baltimore Harbor watershed are likely degraded due to inorganics (i.e., chloride and sulfates). Chloride and sulfate levels are significantly associated with degraded biological conditions and found in approximately 79% and 29% of the stream miles with poor to very poor biological conditions in the watershed. The BSID results thus support a Category 5 listing of chloride and sulfates for the non-tidal portion of the 8-digit watershed as an appropriate management action to begin addressing the impacts of these stressors on the biological communities in the Baltimore Harbor watershed. Impervious surfaces and urban runoff cause an increase in contaminant loads from point and nonpoint sources by delivering an array of inorganic pollutants to surface waters. Discharges of inorganic compounds are very intermittent; concentrations vary widely depending on the time of year as well as a variety of other factors which may influence their impact on aquatic life. Future monitoring of these parameters will help in determining the spatial and temporal extent of these impairments in the watershed.
- The BSID process has determined that biological communities in Baltimore Harbor watershed are also likely degraded due to sediment and in-stream habitat related stressors. Specifically, altered hydrology and increased runoff from urban and impervious surfaces have resulted in channel erosion, scouring, and transport of suspended sediments in the watershed, which are in turn the probable causes of impacts to biological communities. The BSID results thus confirm the establishment of a total suspended solids (TSS) TMDL in 2010 through the Chesapeake Bay TMDL was an appropriate management action to begin mitigating the impacts of sediments on biological communities in the Baltimore Harbor watershed. The BSID results thus support a Category 5 listing of TSS for the non-tidal portion of the 8-digit watershed as an appropriate management action to begin addressing the impact of these stressors on the biological communities in the Baltimore Harbor watershed.
- The BSID process has also determined that biological communities in the Baltimore Harbor watershed are likely degraded due to anthropogenic channelization of stream segments. MDE considers channelization as pollution not a pollutant; therefore, a Category 5 listing for this stressor is inappropriate. However, Category 4c is for waterbody segments where the State can demonstrate that the failure to meet applicable water quality standards is a result of pollution. Category 4c listings include segments impaired due to stream channelization or the lack of adequate flow. MDE recommends a Category 4c listing for the Baltimore Harbor watershed based on channelization being present in approximately 37% of degraded stream miles.
- The BSID process has also determined that biological communities in the Baltimore Harbor watershed are likely degraded due to anthropogenic alterations of riparian buffer zones. MDE considers inadequate riparian buffer zones as pollution not a pollutant; therefore, a Category 5 listing for this stressor is inappropriate. However, Category 4c is for waterbody segments where the State can demonstrate that the failure to meet applicable water quality standards is a result of pollution. MDE recommends a Category 4c listing for the Baltimore Harbor watershed based on inadequate riparian buffer zones in approximately 28% of degraded stream miles.

(MDE, 2014b)

The sediment TMDL was developed to address the degradation of the aquatic community. With the above stressors in mind, meeting the sediment TMDL reduction requirements may not result in improvement of the aquatic community to fair or good conditions due to the existence of additional impairing factors for which TMDLs have yet to be developed. However, improvement of aquatic habitat and reduction of sediment are necessary components to any aquatic community improvement.

In this section you will find a list of actions that together become one scenario as to how the county could reach the pollutant load target. While EPS has developed this scenario, progress will be assessed on an annual basis through results of implementation actions and monitoring data. It is intended that the IP will be reviewed on a five-year cycle for potential revisions. The county takes an adaptive management approach to all watershed planning efforts.

Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood (U.S Department of the Interior 2009). The tools that Baltimore County will use in adaptive management are the tracking of implementation progress through the various actions proposed in the strategy in this section, identification of barriers that prevent targeted actions from occurring, and an enhanced monitoring program to measure progress in both reductions and meeting water quality standards. While this will be an on-going process, there will be a formal review of the strategy at five year intervals to determine if changes are needed or if the strategies are on track.

The list of actions provides all of the numeric load reductions necessary to prove that the actions will bring the county to its TMDL target. Finally, you can find a discussion of the reductions, which states the year by which the reduction load will be met and describes other factors that play into meeting the water quality criteria.

9.1 Implementation Actions

For this IP we will categorize the actions to be taken with respect to addressing source reduction. Implementation actions have been pulled directly from the SWAPs within the watershed area. These actions have been carefully analyzed for their projected participation rates and feasibility during the SWAP development process. Please refer to the associated SWAPs for further explanation of the scientific development process: Baltimore County SWAPS.

There are many actions that may be taken that would have an explicitly indirect impact on sediment, however with no ability to prove the cause/effect relationship of these actions, they will be omitted from this plan (e.g. storm drain marking).

The actions are broken out into three separate sections. Programmatic actions are actions that do not have a measurable load reduction, but create conditions necessary to reduce the pollutant. Some of these actions require a plan for program development because they are new programs that have not yet been developed by the county. Management actions are actions that require regular actions on county property. Restoration actions are new control measures aimed to reduce pollutant loads.

9.1.1 Programmatic Actions

Programmatic actions are those that do not directly result in load reductions, but create the necessary conditions for load reduction. Actions within this category might include public education and outreach activities, monitoring, or supporting specific legislation. These actions will move Baltimore County closer to achieving TMDL targets; however, there is currently no way to attribute a predictable pollutant load reduction to programmatic actions. Some programmatic actions, such as investigation and monitoring, are necessary to implement management and restoration actions or make those actions more efficient. In Baltimore Harbor's non-tidal drainage there is limited opportunity for restoration actions to be installed based on the restricted geographic area, and so a study will assist with determining the maximum restoration practicable that may be achieved. Other programmatic actions, such as education and outreach actions, are predicted to increase the load reduction over time through BMP implementation by individual citizens. The exact load reduction is not predictable because the participation rate for individual home owners installing BMPs, as a result of public education, is not yet known. Educated citizens may support load reductions in other ways such as educating other citizens about watershed management actions, supporting legislation that improves watershed management, and other actions that do not have associated load reductions but support the necessary condition for pollutant reduction. Programmatic actions can be found in Table 9-1.

9.1.2 Management Actions

Management actions are those where there is regular management of county property, such as, street sweeping. It does not include the development of new control measures, such as, retrofitting highway yards. Management actions have predictable load reductions, which can be used to calculate the contribution of each action toward meeting the overall load reduction required by the TMDL. Management actions can be found in Table 9-2.

9.1.3 Restoration Actions

Restoration actions include the development of new control measures aimed to reduce pollutant loads as well as retrofits of existing stormwater management facilities. It may include reforestation actions as well as any stormwater control measures that do not require regular management on county property. Restoration actions will have predictable load reductions, which will be used to calculate the contribution of each action toward meeting the overall load reduction required by the TMDL. These actions are also found in Table 9-2.

9.1.4 Implementation Actions Tables

The following Table 9-1 and Table 9-2 collectively describe the actions that will be taken to reach the TMDL reduction goal as stated in the TMDL document issued by MDE.

Table 9-1: Programmatic TMDL Implementation Actions for Non-Tidal Sediment in Baltimore Harbor

Action	Time Frame	Performance Standard	Responsible Party
Programmatic Actions			
Coordinate restoration activities between and among Baltimore County and other local project partners.	On-going	Documented in NPDES Report	EPS
Complete a study to provide guidance on maximum practicable reductions from redevelopment, retrofits, and other best management practices.	5 years	Study completed; implementation plan revised to incorporate report results. Determination of additional potential restoration activity within 8-digit watershed.	EPS
Track progress toward meeting TMDL reduction requirements using a unified restoration tracking system.	On-going	None	EPS
Monitoring Actions			
Random Point and/or Subwatershed Biological Monitoring	On-going	Benthic macro-invertebrate samples collected as practicable (see Section 10).	EPS
Continue Chemical Trend Monitoring Program	On-going	Samples collected monthly.	EPS
Explore feasibility of installing turbidity meters	2 years	Feasibility report generated, if feasible, monitoring plan developed.	EPS
Reporting Actions			
Develop a continued plan for public involvement.	5 years	Public involvement plan developed.	EPS
Continue to update status of restoration projects and BMPs in the Annual MS4 Report.	Annually	MS4 Report submitted to MDE and posted on county website.	EPS
Implement the Continuing Public Outreach Plan	On-going	Number of actions per year.	EPS
Adaptive Management assessment of the Implementation Plan	5 year interval	Assessment complete.	EPS

The following pollutant load reductions were calculated using accepted loading rates for land uses in this watershed, coupled with expected percentages of reduction as discussed in Section 8 of this Implementation Plan. For calculating specific load reduction achievements the MDE-developed TMDL Implementation Progress and Planning (TIPP) Tool (updated 4/6/2022) was utilized. https://mde.maryland.gov/programs/water/tmdl/datacenter/pages/tmdlstormwatertoolkit.aspx

Table 9-2: TMDL Implementation Actions with Measurable Load Reductions for Baltimore Harbor Non-Tidal Sediment

Action	Area Addressed[1]	Time Frame	Performance Standard	Responsible Party	Projected 2052 Load Reductions (lbs/year)
Management Actions					
Street Sweeping Existing	N/A[2]	Ongoing	Pounds removed	Baltimore County	N/A[2]
Storm Drain Cleaning	N/A	Ongoing	Pounds removed	Baltimore County	2,113.1[3]
Restoration Actions					
Stream Restoration	4,000 linear feet	30 years	Stream restoration projects completed	Baltimore County EPS	992,000
Downspout Disconnection	0.44 acres	30 years	Acres of rooftop disconnected	Maryland Waterways Foundation, SWAP Implementation Committee	277.03
Stormwater Retrofits	132 acres	30 years	Acres retrofit	Baltimore County EPS, DPW	319,647.7
Stream Buffer Reforestation	10 acres	30 years	Acres reforested	Baltimore County EPS	11,996.75
Urban Tree Canopy	9.24 acres	30 years	Acres reforested	Baltimore County EPS	478.6
Redevelopment[4]	528 acres	30 years	Acres redeveloped	Baltimore County	798,160.3
Additional Restoration Opportunities[5]	N/A	30 years	Equivalent pounds of sediment removed by additional restoration actions.	Baltimore County	500,000
Total Projected Sediment Reductions by 2052					**2,624,674**

1. Extent of projected implementation sourced from a combination of estimated future capacity by EPS staff, the Small Watershed Action Plan for Baltimore Harbor, and planning documentation for the TMDL Implementation Plan for nutrients in Baltimore Harbor (this non-tidal planning area represents 22% of the Baltimore Harbor watershed within Baltimore County, and in some situations the estimates of actions which may be taken to support this plan represent 22% of those actions originally intended to address the nutrient impairment).
2. While Baltimore County plans to continue with street sweeping operations, the method of allocating pollutant reduction credits is currently under review. Until this review is completed, we will not be considering street sweeping credits as providing progress toward meeting the TMDL and may for now be considered as an additional margin of safety.
3. 22% of five year average TSS removal from Baltimore Harbor (2018-2022) to be counted as additional margin of safety – this plan still meets the required TSS load reduction without counting storm drain cleaning activities.
4. Expected to provide 1" of runoff reduction for half the acreage being redeveloped.
5. Additional opportunity within the 8-digit watershed to be evaluated and implemented in order to meet a gap between currently assumed opportunity referenced in past planning documentation and the goals of this plan.

9.2 Sediment Baseline Load and TMDL Required Reductions

Total TSS Baseline Load (lbs/yr)	4,635,404
Total Reduction Required (lbs/yr)	2,688,534
TMDL Target Load (lbs/yr)	1,946,870
Reduction Achieved Through FY22 (lbs/yr)	66,143
Adjusted Baseline Load (Total baseline less the reductions achieved through FY22; Baltimore County Data; lbs/year)	4,569,261
Remaining TSS Load Reduction Goal to Meet TMDL Target Load (lbs/year)	2,622,391
Projected Load Reduction from this TMDL IP (lbs/year; Table 9-2)	**2,624,674**

* Additional details on how the TMDL target and pollutant loads and reductions were calculated can be found in Section 5.

9.3 Interim Milestones

The reductions for sediment in Baltimore Harbor will not initially have measurable milestones but they are expected to be available upon document revision, after monitoring sites have been identified and data collection has begun. Those milestones will and data collection will continue until the 2052 implementation goal is reached. Due to the need to meet other TMDL reduction requirements, such as, the Chesapeake Bay TMDL nitrogen and phosphorus, it is anticipated that all of the actions needed will be completed to meet those requirements. The current Mean BIBI for the Baltimore County portions of the non-tidal Baltimore Harbor drainage are currently unknown as neither MDE nor Baltimore County collected any benthic data from this area to develop this TMDL. The following table depicts an example of interim milestones with an assumed starting point of a 2.00 BIBI to meeting the TMDL goal by 2052.

Table 9-3: Example Interim Milestones

Year	2022	2028	2034	2040	2046	2052
Implementation			50%			100%
Example Mean BIBI Score[1]	2.00	2.20	2.40	2.60	2.80	3.00

1. For example and illustrative purposes only until data collection has commenced. See discussion in Section 9.4 on lag times

9.4 Reductions Discussed

The reductions in the given scenario meet the reductions necessary for satisfying the TMDL target. The timeline to implement all of the future actions with measurable reduction extends over the next 30 years. That means that all actions will be implemented by 2052. However, it is important to understand the role of lag times in watershed management and planning. Lag time is the delay from when a pollution control action is taken to when it actually results in water quality improvements. It is the sum of time required for practices to take desired effect, time required for effect to be delivered to the water source, and time required for the waterbody to respond to the effect (Meals, Dressing and Davenport 2010). Lag times will vary depending on the watershed, the management action, and the pollutant type. According to the Chesapeake Bay STAC Program Report from 2012, the lag time for sediment from source to stream in the Chesapeake Bay region is less than 1-5 years, but the lag time for sediment transport from stream to Bay is 5-100 years (Chesapeake Bay Program 2012). The report also states approximate lag times for various sediment reduction actions. The lag time for an urban sediment pond was reported to be approximately 1-3 years, while the lag time for a riparian forest was approximated at 2-10 years (Chesapeake Bay Program 2012). Given this data, it is reasonable to assume that in-stream reduction will not necessarily be measurable by 2052 when all actions will be implemented. What this means is that Baltimore County may implement all of the necessary measures to meet the TMDL reductions by 2052, as a TMDL is actually a limit on the amount of pollutant that is allowed to enter the stream from upland sources, but measurable in-stream effects on water quality may take a decade or more to fully reflect the load reductions. Expectations for water quality improvement should be reasonably based on the effects of lag time.

Another factor that must be considered when forming expectations about water quality improvements is the vulnerability of the end goal to other disturbances. The water quality criterion for sediment is not a measurable load, but it is to reach a fair or good IBI score. The IBI score is a measure of the diversity of the macro-invertebrate community. Sediment is not the only threat to that community. They can also be affected by excessive nutrients, low dissolved oxygen, and other disturbances in the water. The biostressor analysis indicated that chlorides, sulfates, channelization, and anthropogenic alterations of the riparian buffer are also impacting the aquatic biological community. It is highly possible that the sediment load target will be reached, but that IBI scores could remain below fair or good condition due to other environmental factors.

9.4.1 Attainability and Adaptive Management

Baltimore County expects that a combination of programmatic and monitoring actions will provide near-term guidance on adaptive management, provide further certainty on wasteload allocation responsibilities, and ability of Baltimore County to meet the numeric load requirements of the TMDL for the small portion of the watershed for which the County is responsible. The proposed study on maximum practicable reductions in this planning area, and initial collections of biological data, will help Baltimore County determine if current best management practice implementation strategies will be adequate for this TMDL or if consideration will be needed for additional pollutant reduction approaches.

The assessment of implementation progress is based on two aspects; progress in meeting programmatic, management, and restoration actions; and progress in meeting water quality standards and any interim water quality benchmarks. The assessment of progress in meeting the restoration actions; includes setting up methods of data tracking, validation of projects, and pollutant load reductions associated with the actions (10.1) and will be consistent across all TMDL Implementation Plans. The assessment of progress in meeting water quality standards and interim milestones (10.2) is the data analysis associated with the monitoring plan specific to each TMDL Implementation Plan.

10.1 Implementation Progress: Data Tracking, Validation, Load Reduction Calculation, and Reporting

The Baltimore County Department of Environmental Protection and Sustainability – Watershed Management and Monitoring Section is currently working toward forming a document entitled *Baltimore County Method for Pollutant Load Calculations, Pollutant Load Reduction Calculations, and Impervious Area Treated*. This document will detail the data sources, data analysis (including pollutant load calculations, and pollutant load reductions calculations), validation of the practices, and reporting of progress made. It was determined that a document was needed to document how Baltimore County calculated pollutant loads and pollutant load reductions from the implementation of various best management practices, as guidance from the state and Chesapeake Bay Program continue to evolve. The document will be updated regularly to account for any changes that may occur over time. Due to the fact that implementation is being achieved through the actions of many county agencies, it was also determined that the means of data acquisition, any data manipulation, and the means of data analysis needs to be documented on an annual basis to provide consistency in the data acquisition and analysis and to document any changes in the process over time. The overall result is intended to provide transparency for the general public and users of reports on progress generated as a result of the analysis. In the meantime of working toward a unified document, Baltimore County EPS has developed a series of Standard Operating Proceedures (SOPs) for calculating pollutant loads and reductions credits. Many of these SOPs are in draft form and are provided to Maryland Department of the Environment for review and comment. These SOPs will be modified as needed to take into account future Expert Panel guidance or changes in modeling requirements.

The Maryland Department of the Environment (MDE) has provided a guidance document for NPDES – MS4 permits entitled: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*. The updated document was released in June 2020. The document is intended to provide consistency among the MS4 jurisdictions in calculating baselines and reporting implementation progress. The August 2014 edition includes the Chesapeake Bay Program (CBP) recent recommendations for nutrient and sediment reductions for various practices. It is anticipated that the document will be updated on a periodic basis to reflect new information on restoration practice efficiencies in pollutant load reductions. MDE also provides guidance through its web site, with a webpage entitled *Maryland TMDL Data Center*. This site provides guidance on the development of the TMDL Implementation Plans and is updated on a regular basis.

The CBP has developed a process whereby through the formation of Expert Panels, the scientific literature is reviewed to determine pollutant load reductions for various types of restoration practices. The Expert Panels provide reports on the load reduction calculations for the various practices, along with supporting documentation; these reports are then reviewed by a series of CBP workgroups and when approved, become the basis for pollutant load reduction credits. The completed documents are posted on the web along with a description of the process, see: http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=3 Completed reviews of restoration practices applicable to the urban sector include:

- New State Stormwater Performance Standards,
- Urban Stormwater Retrofits,
- Urban Nutrient Management,
- Urban Stream Restoration,
- Enhanced Erosion and Sediment Controls, and
- Urban Filter Strip/Stream Buffer Upgrades.
- Expert Panel reports essentially complete and awaiting approval include:
- Urban Shoreline Management, and
- Illicit Discharge Elimination (Nutrient Discharges from Grey Infrastructure).
- Expert Panel reports developing recommendations include:
- Street Sweeping (including catch-basin clean outs and bulk sediment removal),
- Floating wetlands,
- Urban Tree Planting/Expanded Tree Canopy, and
- Riparian Forest Buffers.

In addition to the changes in the pollutant removal efficiencies, the CBP has rolled out the next phase of the Watershed Model (Phase 6) to be used to determine progress being made for the Chesapeake Bay TMDL. The updates to the Chesapeake Bay Watershed Model have necessitated recalculations of pollutant loading and restoration progress from existing and planned BMPs.

10.1.1 Reporting

Reporting will be done through the annual NPDES – MS4 Permit Report. The report will detail progress made in meeting each of the local TMDLs and the Chesapeake Bay TMDL. It will also present the results of the monitoring conducted the previous year. See below for TMDL specific monitoring.

10.2 Implementation Progress: Water Quality Monitoring

The rationale for the development of the Baltimore Harbor Non-Tidal Sediment TMDL was an impairment of the aquatic biological community with sediment identified as a stressor of that community. This was determined through the biostressor analysis conducted on the biological data, and associated data, collected as part of the Maryland Biological Stream Survey (MBSS). The biostressor analysis indicated that chlorides, sulfates, channelization, and anthropogenic alterations of the riparian buffer are also impacting the aquatic biological community. These additional stressors will have to be taken into account when determining whether actions taken to address the sediment TMDL alone have met the aquatic biological community water quality end point. The full Biological Stressor Identification may be reviewed on the main MDE Baltimore Harbor non-tidal sediment TMDL page, here:
https://mde.maryland.gov/programs/water/TMDL/Pages/Baltimore-Harbor.aspx

10.2.1 Biological Monitoring

The Random Point Biological Monitoring Program will continue with monitoring throughout Baltimore County as prescribed by the MS4 permit. To make determinations of progress on a subwatershed scale, Baltimore County has developed a biological monitoring program entitled, Subwatershed Biological Condition Monitoring Program. This program targets watersheds that have a TMDL associated with aquatic biological community impairment.

This Subwatershed Biological Condition Monitoring Program will monitor every subwatershed practicable within the impaired watershed or a subset depending on the results of the TMDL analysis every three years. There is no existing biological data from the non-tidal drainage areas available from the County or the State, and there are very limited lengths of stream coverage displayed on the 1:24,000 National Hydrography Dataset within the TMDL area.

Typically, a stratified random design would be used, where one random site will be sampled for each 1,000 acres within the subwatershed, rounded to the nearest 500 acres; with at least one sample per subwatershed. Given the geographic limitation of this TMDL area, Baltimore County will assess stream reaches available for sampling feasibility on a case-by-case basis, and sampling will occur where practicable. Using MBSS methods benthic macroinvertebrate community will be sampled during the spring index period fitting into the multiannual schedule discussed above. The results will be compared to the current condition to assess changes in the subwatershed condition. It is important to note that not all subwatersheds, and not all areas of selected subwatersheds, are relevant for monitoring under this TMDL, which covers only non-tidal 1^{st}-4^{th} order streams and their drainages.

10.2.2 Chemical Monitoring

Full chemical monitoring will continue through the Chemical Trend Monitoring Program at the site located within the nontidal Baltimore Harbor watershed (see Section 6, 6.2 for description). This program monitors TSS, chlorides, and sulfates, but does not give full coverage of all of the subwatersheds in nontidal Baltimore Harbor watershed.

10.2.3 Continuously Recording Turbidity Meters

Baltimore County EPS will explore the utility of deploying continuously recording turbidity meters as a surrogate means of determining TSS concentrations without having to acquire samples for analysis. Sampling all subwatersheds for TSS, other than by grab samples; is not possible. Continuously recording turbidity meters offers an alternative that may provide the needed information in a more consistent fashion. This option and any technical difficulties will be explored within two years of the acceptance of this TMDL Implementation Plan.

10.2.4 Other MS4 Related Monitoring

Baltimore County will continue to provide its street sweeping, storm drain cleaning, and stormwater management pond cleanout operations in relation to sediment reduction.

In order to engage the public in the TMDL implementation process this continuing public outreach plan will be implemented upon approval of this TMDL Implementation Plan. The continuing public outreach plan is applicable to all TMDL Implementation Plans that are currently being developed and those developed in the future, as well as the Trash and Litter Reduction Strategy. This continuing public outreach plan is meant to engage county agencies, environmental groups, the business community, and the general public.

11.1 County Agencies

County agencies will be engaged through two regularly scheduled NPDES Management Committee meetings per year and other agency meetings as necessary to move implementation forward.

11.1.1 NPDES Management Committee

The NPDES Management Committee is composed of representative agencies that are involved in meeting the NPDES – MS4 Permit requirements. This committee has met irregularly in the past, generally to review information on permit requirements and other upcoming regulatory requirements, such as, the General Industrial Stormwater Discharge Permit. In the future this committee will meet twice per year and will discuss not only the NPDES – MS4 Permit requirements, but also the TMDL Implementation Plans and progress being made in meeting the implementation strategy. In order to address all components of the TMDL Implementation Plans the committee membership will be expanded to include any county agency that has some responsibility for TMDL implementation. Examples being, the County Police Department and the Department of Environmental Protection and Sustainability – Groundwater Management Section. Prior to the development of the TMDL Implementation Plans and the Trash and Litter Reduction Strategy, these agencies were not specifically engaged in NPDES – MS4 Permit activities.

The first yearly meeting will be held in January of each year. The focus of this meeting will be to review the implementation plan 2-year milestones for each plan; provide a forum for discussion of the ability to meet the implementation actions; and determine any revisions necessary to meet the interim implementation milestones set in the plan. This meeting is also the forum for discussion of data tracking and reporting to ensure that the implementation actions are properly credited.

The second yearly meeting will be held in July of each year and will provide the forum for determining data submittal for the yearly progress report on the implementation actions and the resulting load reductions. The monitoring data from the previous calendar year will be presented and contrasted with the interim water quality milestones that are detailed in each implementation plan.

11.1.2 Other Agency Meetings

In order to move forward with implementation, agency meetings regarding specific implementation actions are anticipated. These will be scheduled as needed, and tracked by meeting date, attendance, TMDL Implementation Plans discussed, and topic. Meeting minutes will be reported in the Annual NPDES – MS4 Report submitted to Maryland Department of the Environment. This report is also posted on the County website for public access.

11.2 Environmental Groups

Baltimore County is currently engaged with local watershed associations through its funding of *Watershed Association Restoration Planning and Implementation Grants*, and through inclusion of watershed association members on the Steering Committees of the Small Watershed Action Plans. Formerly, this engagement and support was coordinated through the *Baltimore Watershed Agreement*. As part of that engagement, periodic Watershed Advisory Group (WAG) meetings were held. As part of this continuing public outreach plan, WAG participation will be formalized with two meetings per year.

The first meeting will be held in March of each year and focus on the local and Chesapeake Bay TMDL implementation actions and implementation progress, including an analysis of the pollutant load reduction calculations from the previous fiscal year. The watershed associations are currently engaged in citizen-based restoration activities and report their implementation progress to the county for inclusion in the Annual NPDES – MS4 Report. This meeting will provide a forum for discussion of the progress being made, coordination between the watershed associations, and any changes to the *Watershed Association Restoration Planning and Implementation Grant* being considered for the next grant period.

The second meeting will be held in November of each year and will focus on the water quality monitoring results from the previous calendar year. The results presented will compare trends and measures against the TMDL Implementation Plans water quality benchmarks and water quality standards.

11.3 Business Community

The business community will be engaged through various business forums, targeted outreach and education efforts on specific topics, and hosting workshops on specific topics as necessary.

11.3.1 Business Forums

Business forums, such as the Hunt Valley Business Forum with greater than 200 business members, provide opportunities to present the TMDL Implementation Plans and the Trash and Litter Reduction Strategy, and discuss the role of business in helping improve water quality. These forums will be convened as the opportunities arise. Summaries of these meetings will be reported in the annual NPDES – MS4 Report and will include the name of the forum (or other business organization), approximate number in attendance, the topic presented, and audience responses.

11.3.2 Targeted Business Outreach and Education

The Small Watershed Action Plan (SWAP) process includes an upland assessment of potential pollution hotspots. Often, these potential hotspots are commercial or industrial sites. The information derived from this assessment will be used to target outreach and education to businesses specific to the issue(s) at the location identified in each SWAP. These actions will be tracked and reported in the annual NPDES – MS4 Report.

11.3.3 Business Workshops

There are certain issues that may be pervasive through a segment of the business community that can most effectively be addressed through hosting workshop education on the specific topic. These issues will be identified as SWAP implementation moves forward, but one potential topic for a business workshop is related to the recently renewed *General Discharge Permit for Stormwater Associated with Industrial Activities.* A workshop designed in conjunction with

Maryland Department of the Environment would not only result in improved water quality, but it would also benefit the business community through increased understanding of the requirements of the permit.

11.4 General Public

The general public will be engaged through a number of mechanisms, including:

- Targeted outreach and education efforts on specific topics
- Steering Committee meetings and stakeholder meetings in the development of Small Watershed Action Plans
- Meetings of the Implementation Committee for completed Small Watershed Action Plans
- Displays at various events
- Annual progress reports posted on the county website

11.4.1 Targeted Outreach and Education

The Small Watershed Action Plan development process includes upland assessments of neighborhoods to identify pollution sources and restoration opportunities. This information will be used to prioritize and target outreach and education efforts specific to the issue(s) in neighborhoods with the intent to affect behavioral change and/or increase citizen based restoration actions. These actions will be tracked and reported in the annual NPDES – MS4 Report.

11.4.2 Small Watershed Action Plans (SWAPs)

Baltimore County has been developing Small Watershed Action Plans since 2008. These planning areas cover the entire county. The planning process includes the development of a steering committee, the composition of which is determined by the issues, and land ownership within the planning area. At a minimum membership consists of agency representatives, watershed associations, and citizen representatives. The process also includes a number of stakeholder meetings, open to all planning area residents and businesses, which provide information on the plan and solicit input. Once the SWAP is complete, the steering committee becomes the implementation committee. As designed the implementation committee is to meet twice per year, however, most implementation committees have not met this goal.

The plans have addressed to varying degrees the TMDLs that are applicable within the planning area. Some of the TMDLs have been developed subsequent to the specific SWAP development or did not address the full range of TMDLs that were applicable to the planning area. The TMDL Implementation Plans are built on incorporation of the actions from each SWAP within the applicable TMDL area. In some cases, additional actions have been identified in order to meet water quality standards.

11.4.2.1 Future Watershed Plans

For watershed plans developed in the future, the steering committee and stakeholder meetings will be used for outreach regarding the TMDL Implementation Plans and the progress being made in achieving water quality standards. The meeting participants will be informed on where they can access TMDL Implementation Plans, the Trash and Litter Reduction Strategy, and any Progress Reports that have been developed.

Applicable TMDL Implementation Plan actions will be incorporated into the SWAP based on the assessment of applicable restoration actions within the SWAP planning area. Since the

SWAPs incorporate field assessments of streams and uplands, they provide more detailed information on applicable restoration actions, both on quantity and location. The accelerated schedule for developing TMDL Implementation Plans precluded conducting field work to build the plans.

11.4.2.2 Small Watershed Action Plans Already Developed

For those plans already developed, the implementation committee meetings will be scheduled for regular occurrence. These meetings will provide the opportunity to discuss any changes in the SWAPs or the TMDL Implementation Plans based on an analysis of what actions have been successful and what actions have been more difficult to implement. The meetings will additionally be used to present monitoring data and analysis of progress being made toward relevant water quality goals. Educational Displays at Events

Educational displays and handouts will continue to be used at applicable events as they occur. The particular display and handout materials will be determined by the location and focus of the event. The location and focus of the event, number of citizens engaging staff at the display, and the number of handouts taken by citizens will be tracked for annual reporting in the NPDES – MS4 Report.

11.4.3 TMDL Implementation Plan, Trash and Litter Reduction Strategy, and Progress Report Availability

The TMDL Implementation Plans and the Trash and Litter Reduction Strategy will be posted on the Baltimore County website with hard copies placed in county libraries. The hard copies in the libraries will be specific to the watershed in which the library is located. Progress reports will be posted on the County website. A set of hard copy plans will be kept at the Baltimore County Department of Environmental Protection and Sustainability.

11.4.4 Biennial State of Our Watersheds Conference

Baltimore County, in conjunction with Baltimore City, has held *State of Our Watershed* conferences in the past to present information to county and city citizens on water quality issues applicable to the watersheds in these jurisdictions. Future conferences will be held every other year, ideally in the months shortly following the completion of the County's most recent annual report. Information on implementation progress for local TMDLs and the Bay TMDL will be presented, along with other topics of interest. These conferences will be organized with the assistance of the Watershed Advisory Group (WAG), and the surrounding local jurisdictions (Baltimore City, Howard County, Carroll County, Harford County, and York County, PA) will be invited to participate in the organization and presentation of the conference.

The timing of even years is related to the 2-year milestone process set up by the Maryland Chesapeake Bay TMDL Watershed Implementation Plan (WIP) whereby in January of even calendar years, progress in meeting the previous 2-year milestone programmatic and restoration implementation is reported and the next 2-year programmatic and restoration implementation milestones are proposed by the local jurisdictions. The timing of the conference not only permits reporting on the progress made in meeting the previous 2-year milestones but also what is planned for the next two years.

11.5 Adaptive Management

As Baltimore County moves forward to meet its pollutant reduction goals, there will be consideration of the elements of public outreach as they pertain to this Implementation Plan.

During implementation, a more specific, and tailor-made outreach plan will be developed to address the various pollutants and watersheds impacted by them. A sampling of the types of outreach elements Baltimore County currently intends to employ is presented in Table 11-1.

Table 11-1: Continuing Public Outreach Plan Summary

Plan Component	Plan Element
Agencies	NPDES Management Committee
	Other Agency meetings
Environmental Groups	Watershed Advisory Group (WAG) meetings
Business Community	Business Forums
	Targeted Business Outreach and Education
	Topical Workshop
General Public	WIP Team meetings
	Targeted Outreach and Education
	SWAP – Steering Committee meetings
	SWAP – Stakeholder meetings
	SWAP – Implementation Committee meetings
	Educational Displays at Events
	Document availability (various)
	Biennial Conference

Berry, W., Rubinstien, N., & Melzian, B. (2003). The Biological Effects of Suspended and Bedded Sediment (SABS) in Aquatic Systems:A Re. Narragansett: US Environmental Protection Agency Office of Research and Development .

Booth, D. B., & Henshaw, P. C. (2000). Rates of Channel Erosion in Small Urban Streams. Stream Channels in Disturbed Environments: AGU Monograph Series.

Cerco, C. F., & Noel, M. R. (2005). Evaluating Ecosystem Effects of Oyster Restoration in Chesapeake Bay. Retrieved from https://www.chesapeakebay.net/content/publications/cbp_13361.pdf

Chesapeake Bay Program. (2012). Incorporating Lag Times in the Chesaeake Bay Program. Annapolis : Chesapeake Bay Program .

Collins, K., Davis, A., Kloss, C., Simpson, T., & Weammert, S. (2009). Infiltration and Filtration Practices.

Colorado Department of Public Health and the Environment Water Quality Control Commission Water Quality Control Division. (2005). Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers. Denver, CO: Colorado Department of Public Health and the Environment.

Comstock, S., Crafton, S., Greer, R., Hill, P., Hirschman, D., Karimpour, S., ...Wilkins, S. (2012). Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards. Annapolis, MD: Chesapeake Bay Program.

Davis, L. (2009). SEDIMENT ENTRAINMENT POTENTIAL IN MODIFIED ALLUVIALSTREAMS: IMPLICATIONS FOR RE-MOBILIZATION OF STOREDIN-CHANNEL SEDIMENT. Physical Geography, 30, 3, pp. 249–268.

DEPRM. (1997). Back River Water Quality Management Plan. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/BackRiverExecSummary.pdf

EPS. (2018). Small Watershed Action Plans. Retrieved from https://www.baltimorecountymd.gov/Agencies/environment/watersheds/swap.html

EPS. (2018). Total Maximum Daily Load Implementation Plans by Watershed. Retrieved from https://www.baltimorecountymd.gov/Agencies/environment/monitoring/tmdlplans.html

Jin, S. Y. (2013). . *A comprehensive change detection method for updating the National Land Cover Database to circa 2011. Remote Sensing of Environment.*

Lester, L. (2013, January 11). A Yellow Perch in Murky Water. Retrieved March 1, 2014, from Ecological Society of America: http://www.esa.org/esablog/research/a-yellow-perch-in-murky-water/

Lisle, T. E. (1989). Sediment Transportation and Resulting Deposition in Spawning Gravels, North Costal California. Arcata, CA: Pacific Southwest Experiment Station, Forest Service, U.S. Department of Agriculture.

MDE and Center for Watershed Protection. (2009). 2000 Maryland Stormwater Design Manual, 2009 Revision. Baltimore, MD: MDE.

MDE. (2000). 2000 Maryland Stormwater Design Manual.

MDE. (2014a, June 4). *Biological Assessment Methodology for Non-Tidal Wadeable Streams.* Retrieved May 2022, from https://mde.maryland.gov/programs/water/TMDL/Integrated303dReports/Documents/Assessment_Methodologies/Biological_Listing_Methodology-non-tidalwadeablestreams_2014_Final%20(New%20links).pdf

MDE. (2014b, March). Watershed Report for Biological Impairment of the Baltimore Harbor Watershed in Baltimore City, Baltimore, and Anne Arundel Counties, Maryland; Biological Stressor Identification Analysis - Results and Interpretation. Retrieved May 2, 2022, from https://mde.maryland.gov/programs/water/TMDL/Baltimore_Harbor_02130903/Baltimore_Harbor_BSID_Report_032814.pdf

MDE. (2021). *Technical Memorandum: Point Sources of Sediment in the Non-Tidal Baltimore Harbor Watershed.* Baltimore, MD: MDE. Retrieved from https://mde.maryland.gov/programs/water/TMDL/Baltimore_Harbor_02130903/BaltHarbor_Sed_TMDL_PS_TechMemo_final.pdf

MDE. (2021, December). Total Maximum Daily Load of Sediment in the Baltimore Harbor Watershed, Baltimore City, Baltimore County, and Anne Arundel County, Maryland. Retrieved from https://mde.maryland.gov/programs/water/TMDL/Pages/Baltimore-Harbor.aspx ; https://mde.maryland.gov/programs/water/TMDL/Baltimore_Harbor_02130903/Balt_Harbor_SedTMDL_final.pdf

MDE; Devereux Environmental Consulting. (2014). MAST Documentation. Retrieved from MAST: http://www.mastonline.org/Documentation.aspx

Meals, D. W., Dressing, S. A., & Davenport, T. E. (2010). Lag Time in Water Quality Response to Best Management Practices: A Review. J. Environ. Qual., 39:85–96.

Nelson, E. J., & Booth, D. B. (2002). Sediment sources in an urbanizing, mixed land-use watershed. Journal of Hydrology, 51-68.

U.S. EPA. Chesapeake Assessment Scenario Tool. Chesapeake Bay Program Office. https://cast.chesapeakebay.net/

U.S. Department of the Interior. (2009). Adaptive Management. https://www.doi.gov/sites/doi.gov/files/uploads/TechGuide-WebOptimized-2.pdf

U.S. Geological Survey and U.S Department of the Interior. (2003). A Summary Report of Sediment Processes in the Chesapeake Bay Watershed. New Cumberland, PA: U.S. Geological Survey.