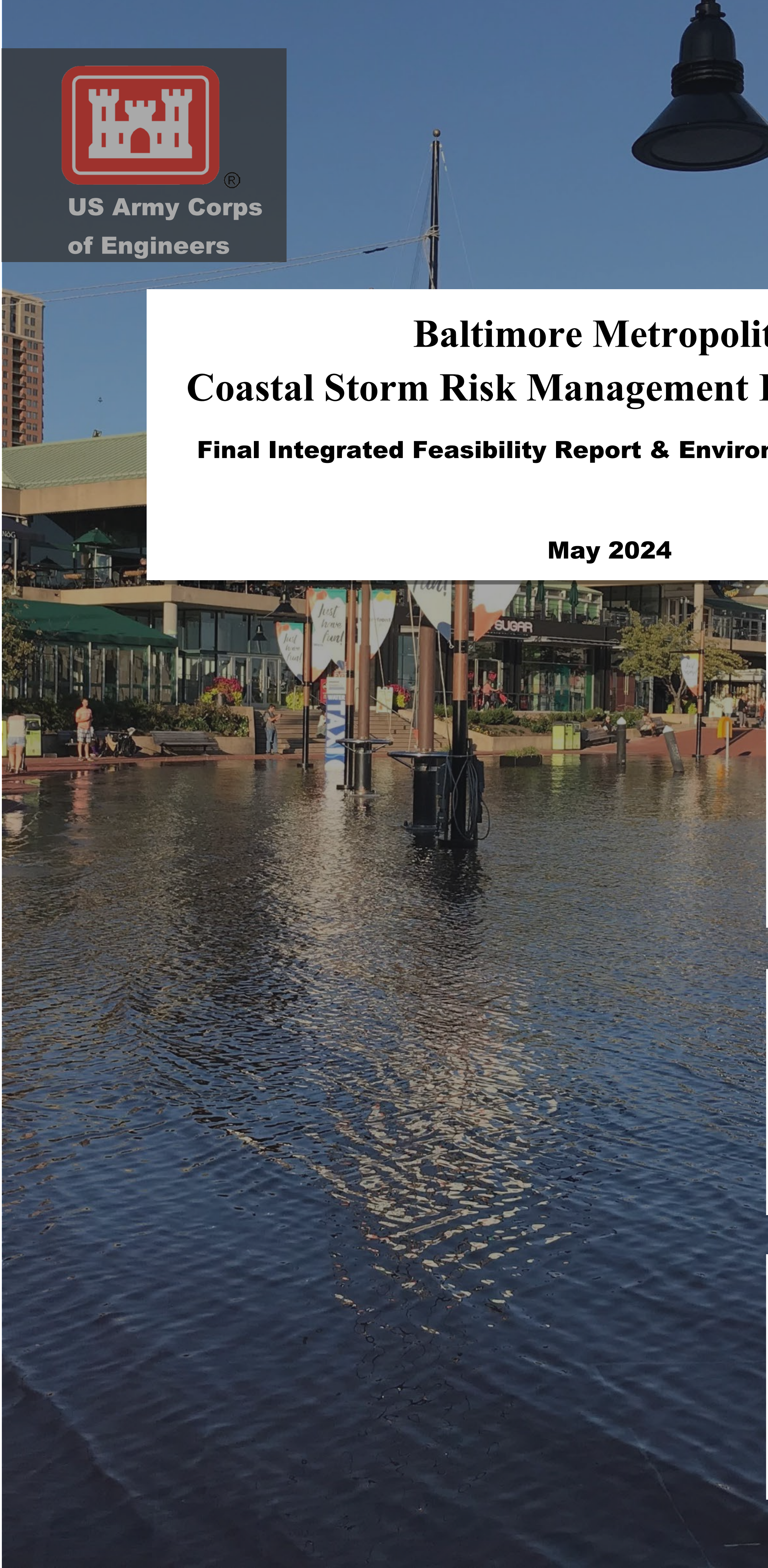
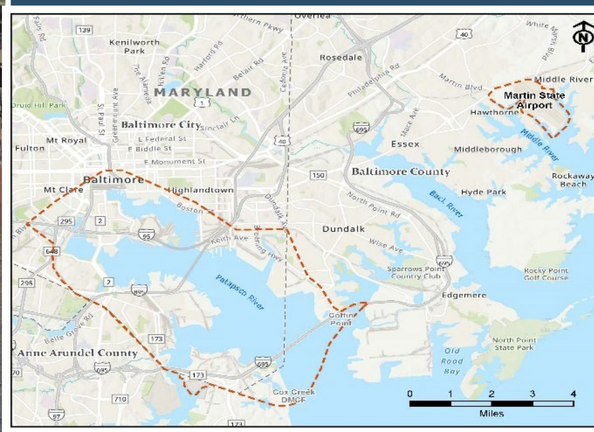


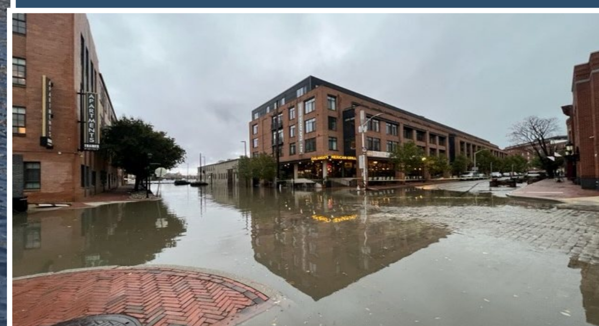
US Army Corps of Engineers

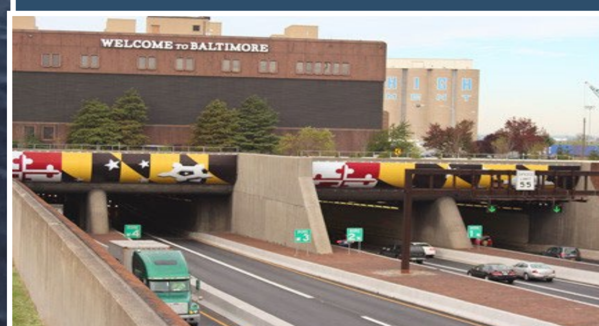
Baltimore Metropolitan Coastal Storm Risk Management Feasibility Study

Final Integrated Feasibility Report & Environmental Assessment

May 2024







Baltimore Coastal Storm Risk Management

Feasibility Study

Final Integrated Feasibility Report and Environmental Assessment

May 2024

MARYLAND DEPARTMENT OF TRANSPORTATION

US Army Corps of Engineers
Baltimore District

Front cover: Study area map and flooding in Baltimore City (credit: USACE). Fort McHenry Tunnel entrance (photo credit: Maryland Department of Transportation).

Back cover: Baltimore Inner Harbor, flooding in Baltimore City (photo credit: USACE).

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EXECUTIVE SUMMARY

This Final Integrated Feasibility Report and Environmental Assessment (IFR/EA) documents the U.S. Army Corps of Engineers (USACE) feasibility study planning process for the Baltimore Coastal Storm Risk Management Feasibility Study (Baltimore Coastal Study) and compliance with the National Environmental Policy Act (NEPA) and other environmental laws as integrated into the planning process.

Following Hurricane Sandy in 2012, the USACE completed the North Atlantic Coast Comprehensive Study (NACCS), which identified nine high-risk areas on the Atlantic Coast that warranted further investigation of coastal storm risk management (CSRM) solutions. The Baltimore Metropolitan area, which includes the City of Baltimore, Baltimore County, and Anne Arundel County, was identified as one of the nine high-risk areas recommended by NACCS for a secondary feasibility study to investigate solutions to CSRM problems.

The North Atlantic Coast is vulnerable to the impacts of coastal flooding and the potential for future, more devastating events due to rising sea levels. The Metropolitan Baltimore region supports densely populated areas encompassing billions of dollars of largely fixed public, private, and commercial investment. Coastal communities in this region must begin to consider long-term coastal storm risk.

The Baltimore Coastal Study Feasibility Cost Sharing Agreement (FCSA) was signed by USACE and the Maryland Department of Transportation (MDOT) on August 5, 2019. MDOT is the non-federal sponsor (NFS) for the Baltimore Coastal Study.

The study authority is under the Baltimore Metropolitan Water Resources authority, which was adopted by a resolution of the Committee on Public Works and Transportation of the United States House of Representatives on April 30, 1992. This study authority was identified by the Baltimore District Office of Counsel (in a memorandum dated April 22, 2014) as the most recent authority that includes the study area, with the ability to investigate solutions to coastal flooding problems leading to a USACE recommendation for implementation. Although the study authority also identifies other purposes, this study will focus solely on CSRM. This final IFR/EA will culminate in a Chief's Report in 2024, as an interim response to the authority.

The purpose of the study is to evaluate the feasibility of federal participation in implementing solutions to problems and opportunities associated with coastal storm damage to reduce coastal flood risk, risk to vulnerable populations, properties, infrastructure, and environmental and cultural resources along the banks of the Patapsco River in the vicinity of Baltimore City including northern Anne Arundel County and eastern Baltimore County, Maryland and Martin State Airport (MSA) in Baltimore County, Maryland. Coastal storms have produced extensive property damage and loss of life resulting from storm surge and flooding in the recent past, particularly from Hurricane

Isabel in 2003, which resulted in costs of $4.8 million to the City of Baltimore, up to $252 million in total damages in Southern Baltimore County, and one fatality.

The study area encompasses the portion of the City of Baltimore and surrounding metropolitan areas to the Francis Scott Key Bridge (I-695) and along the tidally influenced areas that were subject to flooding, storm surge, and damages because of Hurricane Sandy and other recent storms (Figure E-1). The study area was defined to also include assets of importance to MDOT, including MSA in Baltimore County. Within the study area, Baltimore City contains approximately 69 miles of Patapsco River shoreline. The Baltimore County study area contains approximately 4 miles of shoreline along Martin State Airport. The study area is located in a densely populated urban setting with residential/mixed-use neighborhoods in areas further inland along the Inner Harbor, and industrial facilities primarily serving the Port of Baltimore and associated facilities in the City of Baltimore. Notable historic resources include the Fells Point, Canton, Federal Hill, and Locust Point Historic Districts, the Baltimore Municipal Airport Harbor Field, the Baltimore Municipal Airport Air Station, the Western Electric Company/Point Breeze Historic District, the Canton Grain Elevator, and the Fort McHenry National Monument and Historic Shrine (Fort McHenry). Important cultural resources include the Star-Spangled Banner National Historic Trail and the Captain John Smith Chesapeake National Historic Trail.

The Baltimore Coastal study area has experienced an increase in the number of days of minor tidal flooding over time, which will be exacerbated by rising sea levels.

The historic relative sea level rise (SLR) trend is 0.01 feet/year based on the record for the National Oceanic and Atmospheric Administration's (NOAA)'s Baltimore, MD NOAA gauge 8574680, which is closest to the study area. The projected or future USACE low, intermediate, and high sea level change scenarios were evaluated for the without and with-project conditions, and with respect to determining tipping points/thresholds for impacts over the 50-year period of analysis and 100-year adaptation timeframe, and at multiple storm frequencies.

The period of analysis for this study is 50-years per Engineer Regulation (ER) 1105-2-100 Planning Guidance Notebook, April 22, 2000[1]. The planning horizon starts in baseline year 2031, when the project is anticipated to begin accruing CSRM benefits and ends in year 2080. Existing conditions reflect the conditions in place during the feasibility study through year 2024. Future without project (FWOP) conditions consider a range of activities from year 2021, the most recent year for which complete data was obtained, and projects that are planned to be implemented or are already underway that would be constructed in the absence of this project. Future with-project (FWP) conditions are the

[1] The Planning Guidance Notebook was updated on 7 December 2023 as ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The PDT is aware of this new guidance and consulted the draft guidance while completing the study.

conditions forecasted during the planning horizon, from years 2031 to 2080, with implementation of the Recommended Plan. The Recommended Plan will also be assessed for engineering and environmental performance out to 100 years from the baseline year, to ensure resiliency of the Recommended Plan and adaptation to SLR.

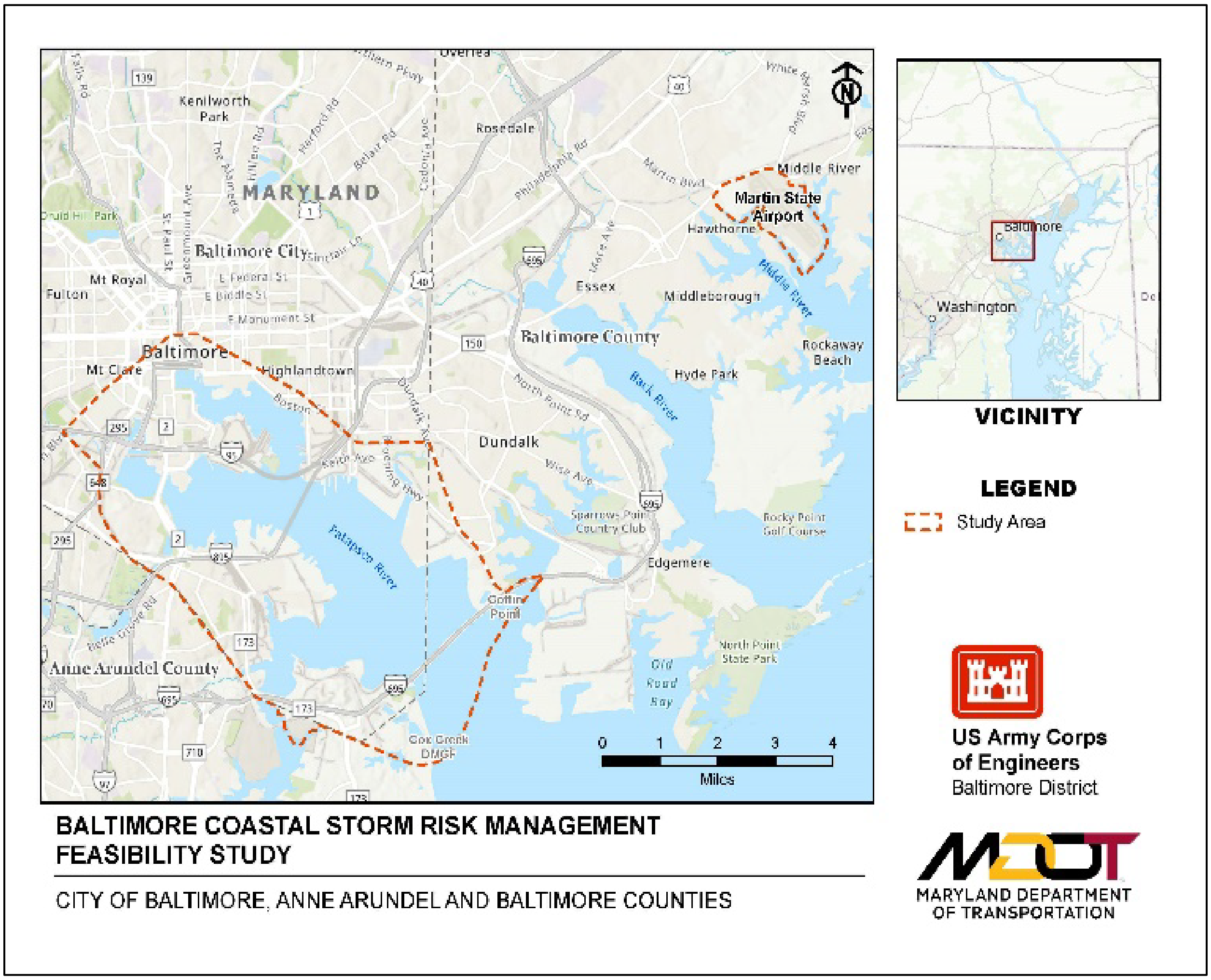

Figure E-1. Study Area

Plan formulation was conducted with a focus on achieving the federal objective of water and related land resources project planning, which is to contribute to National Economic Development (NED) consistent with protecting the Nation’s environment, pursuant to national environmental statutes, applicable executive orders (EO), and other federal planning requirements. Plan formulation considers the four systems of accounts: NED, Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). The plan formulation process focuses on establishing alternatives considering nonstructural, structural measures and natural and nature-based features (NNBF).

The development and screening of measures and formulation of alternatives went through several iterations starting with an initial array of 10 alternatives in addition to the no action alternative. The alternatives are detailed in Section 3 of this IFR/EA. These alternatives were screened to a final array of six alternatives including the no action alternative and five action alternatives that propose structural and nonstructural measures to address CSRM impacts to critical infrastructure and mixed-use/residential areas within the study area. Of these five action alternatives, three resulted in positive net benefits; Alternative 4: Critical Infrastructure Plan, Alternative 5: Critical Infrastructure and Nonstructural Measures Plan, and Alternative 5A: Critical Infrastructure with Select Nonstructural Measures Plan. Alternative 5A: Critical Infrastructure with Select Nonstructural Measures Plan was identified as the NED Plan because it reasonably maximizes net benefits and is also identified as the maximum net benefits plan, maximizing benefits across three of the four accounts. Alternative 5A – Critical Infrastructure Plan with Select Nonstructural Measures was selected as the Recommended Plan at the ADM.

Following the selection of the Alternative 5A as the Recommended Plan, the study area was limited (scaled down) with a refined clustering approach to optimize the nonstructural plan. During the internal agency reviews of this final IFR/EA, modeling input errors were found in the data used to perform the economic analysis of the final array of alternatives. Following correction of the model inputs, the model was re-run; however, due to time and funding limitations, only the Recommended Plan was re-analyzed because it is immediately actionable. As a result of these errors, the Recommended Plan was compared to FWOP economic conditions within this limited study area.

Due to multiple factors including limited design information, high cost contingency/uncertainty, evolving agency policy and guidance regarding nonstructural measures and lack of time and funding to gather additional information for a 2024 Chief's Report that could be considered for inclusion in anticipated 2024 Water Resources Development Act legislation, the nonstructural measures have been removed from the Recommended Plan. Therefore, the final Recommended Plan is an interim response and only includes the structural measures of Alternative 5A, which proposes floodwalls and closure structures at the I-95 and I-895 Tunnels and supporting infrastructure (Fort McHenry and Harbor Tunnels). The Recommended Plan improves community and critical infrastructure resilience, ensures connectivity between communities along the Baltimore metropolitan area, and access to jobs through these transportation routes.

This document follows the 1978 NEPA implementing regulations, as amended (40 CFR Parts 1500-1508). Evaluations of the final array of alternatives revealed no significant effects to environmental and cultural resources or the human environment. For this reason, an Environmental Impact Statement (EIS) is not required.

The Recommended Plan incorporates structural measures of floodwalls and closure structures at the Interstate (I)-95 and I-895 Tunnels and supporting transportation critical facilities (the Fort McHenry and Harbor Tunnels ventilation buildings). In all, the Recommended Plan includes the construction of approximately 9,559 linear feet of fixed floodwalls with 6 closure structures. Two different types of floodwalls were selected and referenced as Type 1 and Type 2. Floodwall Type 1 would be constructed around tunnel entrances while Type 2 would be constructed to protect the two tunnel ventilation buildings. Type 1 floodwall height ranges from 5.5 ft to 6.5 ft while Type 2 varies between 2.5 ft and 3.5 ft. The design elevation is 12.5 feet NAVD88. The level of performance is, equivalent to the 100-year or 1 percent AEP storm based on the NACCS 100-year water surface elevation with approximately 90% confidence level. The project is anticipated to reduce coastal storm risk under the intermediate SLC scenario up to the year 2080 and under the low SLC scenario up to year 2130. The floodwall limits were based on tying into high ground at elevation 12.5 feet NAVD88. The Recommended Plan has net annual benefits of $61.4 million and a benefit-to-cost ratio (BCR) of 20.9 based on fiscal year 2024 discount rate of 2.75 percent (October 2023 price level). The total cost, including project first cost, interest during construction (IDC) and Operations and Maintenance (O&M) for the Recommended Plan is approximately $83.5 million. Table E-1 shows the economic summary of the Recommended Plan.

Table E-1. Recommended Plan Economic Summary

Economic Summary*	
First Cost	$77.5 M
IDC	$871,000
O&M	$5.1M
Total Cost**	$83.5 M
Total Net Annual Benefits	$61.4 M
BCR	20.9

* Based on fiscal year 2024 discount rate of 2.75 percent (October 2023 price level)

***Total cost includes first cost, IDC and O&M.*

Figure E-2 shows the location of the proposed structural measures.

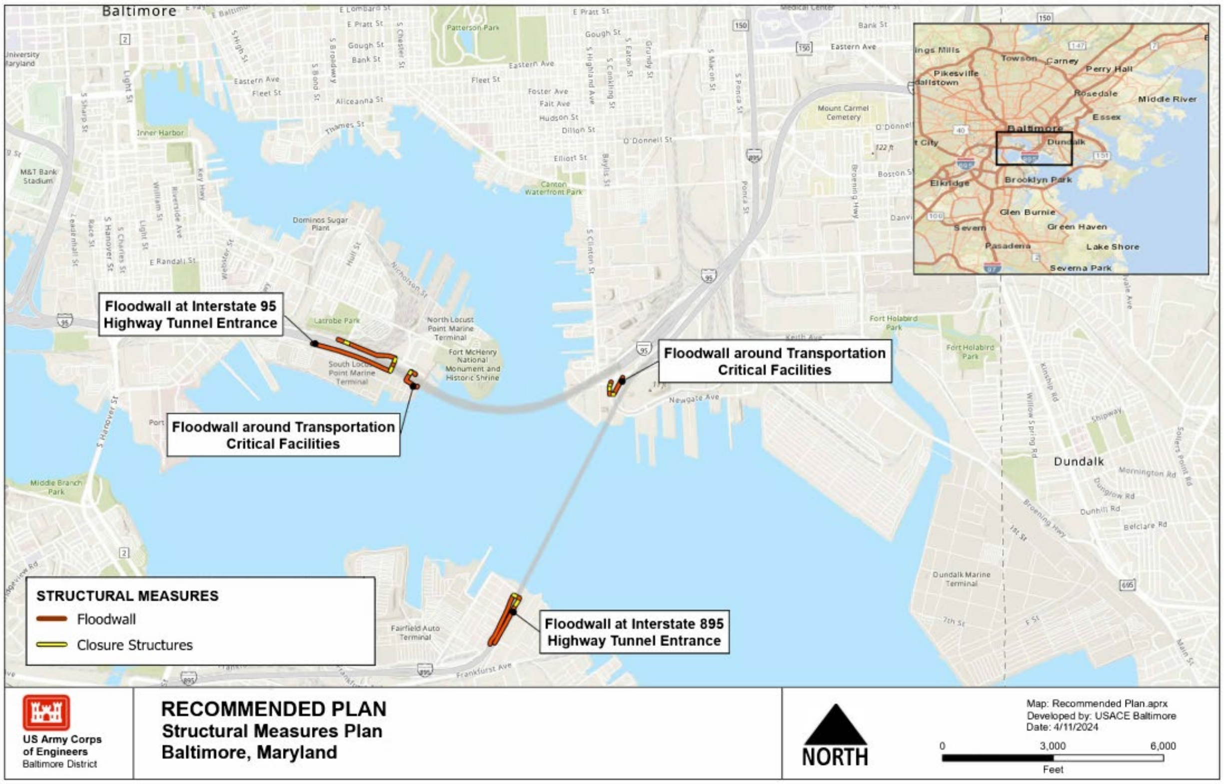

Figure E-2. Recommended Plan – Alternative 5A Structural Measures Only Plan

During the Pre-Construction Engineering and Design (PED) and construction phases, the project would be cost shared 65 percent federal and 35 percent non-federal. The NFS for the Recommended Plan will be the Maryland Transportation Authority (MDTA), which is an authority under MDOT. The estimated total project first cost for the Recommended Plan is $77.5 million at a Class 3 level of technical information and design reflecting approximately a 10 percent level of project definition. The total project first cost includes a contingency value of $21.8 million, which is approximately 39 percent of the estimated base project cost of $55.7 million. The cost contingencies reflect an 80 percent confidence level in estimated total project first cost and are intended to cover cost and schedule increase due to the identified project risks and their probability of occurrence. Based on October 2023 price levels, the estimated total project first cost is $77,489,000. The total project first cost includes the value of Lands, Easements, Right-of-Ways and Relocations (LERR).

The LERR required for project construction must be provided by the NFS as part of the non-federal construction cost-share amount shown above. At this preliminary stage, the lands and damages real estate cost estimate is approximately $6,757,000. These costs include contingency and estimated damages. The non-federal sponsor may be credited for LERR, reducing the non-federal cost share cash contribution. The federal share of the project first cost for initial construction (including LERR) is estimated at $50,368,000.

The non-federal cost of the project first cost for initial construction (including LERR) is estimated at $27,121,000.

The annualized O&M for the I-895 tunnel floodwall and associated transportation critical facility is estimated to be $130,000. The annualized O&M for the I-95 tunnel floodwall and the associated transportation critical facility floodwall is estimated to be $60,000. The concrete floodwalls at the tunnel entrances and support facilities would require minimal maintenance over the 50-year period of analysis. The stoplog structures would be deployed during flood events and would be operated and maintained in accordance with the O&M specifications. O&M on the floodwalls at the tunnel entrances and the tunnel support facilities would be managed by the MDTA.

The structural measures of the Recommended Plan consist of three components: the I-95 Fort McHenry Tunnel in Locust Point, the I-895 Tunnel in Fairfield, and their associated transportation critical facilities. It is estimated that the construction duration at the I-95 Fort McHenry Tunnel in Locust Point, including the associated transportation critical facilities would be 42 months. Duration of construction at the I-895 Tunnel in Fairfield, including the associated transportation critical facilities would be approximately 42 months. The cost estimate assumes 8-hour days for all areas, except for the Harbor Tunnel entrance, which may require 12-hour days to avoid heavy daytime traffic. Materials would be brought in by land via by flatbed trucks, trailers, and dump trucks. The design phase for the structural measures assumes two years to start in October 2024 and end in September 2026. The construction window for all areas would likely start in 2027 and end in 2029 and construction in all project areas would occur nearly concurrently.

The Recommended Plan design elevation of 12.5 feet NAVD88, equivalent to the 100-year or 1 percent annual exceedance probability (AEP) storm event, is anticipated to reduce coastal storm risk under the intermediate SLC scenario up to the year 2080 and under the low SLC scenario up to year 2130. Adaptation capacity has been evaluated in the final feasibility-level design and the structural components could be adapted to maximize the overall usefulness of the system over the life of the project by including redundancy and robustness in the design, so they are adaptable to future conditions including high-rate sea level change.

The recommended plan reduces expected annual damages by approximately 52 percent relative to the without project conditions. The residual risk of the project is represented by the average annual damages remaining in the study area with the implementation of the Recommended Plan. This residual risk is $58.7 million, which represents a 48 percent of the FWOP condition within the limited study area or potential flood damages remaining. Because this residual risk analysis included only the limited study area of the Recommended Plan, the residual risk for the larger study area is not analyzed and may be much higher. Residual risk in the larger study area may be understated. Residual risk for the larger study area should be analyzed in any future re-analysis of the final array of alternatives.

This feasibility study is an interim response to the study authority. Because only the Recommended Plan was re-analyzed following discovery of the modeling input issues, other measures in the final array of alternatives were not adequately evaluated, and there is an opportunity for general re-analysis within the greater study area. Any re-analysis of the greater study area within the scope of this feasibility study would have required additional time and funding and would have delayed the implementation of the actionable items that are part of the Recommended Plan.

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Acronyms

ACHP	Advisory Council for Historic Preservation
ADM	Agency Decision Milestone
AEP	Annual Exceedance Probability
AGST	Above Ground Storage Tanks
AMM	Alternatives Milestone Meeting
APE	Area of Potential Effects
ASA(CW)	Assistant Secretary of the Army Civil Works
ASMFC	Atlantic States Marine Fisheries Commission
BCC	Birds of Conservation Concern
BCR	Benefit Cost Ratio
BGE	Baltimore Gas and Electric
BH	Bulkhead
BMP	Best Management Practices
C-STORM	Coastal Storm Modeling System
CAP	Continuing Authorities Program
CBP	Chesapeake Bay Program
CENAB	U.S. Army Corps of Engineers, Baltimore District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	Carbon Dioxide
CSRM	Coastal Storm Risk Management
CSX	CSX Corporation
CSVR	Content-to-Structure Value Ratios
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
dBA	Decibel
DFE	Design Flood Elevation

DMCF	Dredged Material Containment Facility
DO	Dissolved Oxygen
DP3	Baltimore's Disaster Preparedness and Planning Project
DRV	Depreciated Replacement Value
EA	Environmental Assessment
EAD	Equivalent Annual Damages
ECB	Engineering Construction Bulletin
EDR	Environmental Data Resources
EFH	Essential Fish Habitat
EIP	Environment Integrity Project
EIS	Environmental Impact Statement
EJ	Environmental Justice
EO	Executive Order
EOP	U. S. Army Corps of Engineers Environmental Operating Principles
EPZ	Evacuation Planning Zone
EQ	Environmental Quality
ER	Engineer Regulation
ERDC	Engineering Research and Development Center
ESA	Endangered Species Act
F	Fahrenheit
FAA	Federal Aviation Administration
FCSA	Feasibility Cost Share Agreement
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FPRP	Flood Preparedness and Response Plan
FRAM	Flood Risk Adaptive Measures
FRM	Flood Risk Management
FRMP	Flood Risk Management Program
ft	foot/feet

FWCA	Fish and Wildlife Coordination Act
FWOP	Future Without Project
FWP	Future With-Project
G2CRM	Generation II Coastal Risk Model
GCR	General Conformity Rule
GIS	Geographic Information System
GHG	Green House Gases
CHS	Coastal Hazards System
GWMP	George Washington Memorial Parkway
HTRW	Hazardous, Toxic, and Radioactive Waste
H&H	Hydrologic and Hydraulic
I	Interstate
IDA	Intensively Developed Area
IDC	Interest During Construction
IFR/EA	Integrated Feasibility Report and Environmental Assessment
IPaC	Information for Planning and Consultation
LDA	Limited Development Area
LiDAR	Light Detection and Ranging
LOD	Limits of Disturbance
MA	Model Area
MAA	Maryland Aviation Administration
MARC	Maryland Area Regional Commuter
MBRI	Middle Branch Resiliency Initiative
MDDNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
MES	Maryland Environmental Service
MHT	Maryland Historical Trust

MHHW	Mean Higher High Water (MHHW)
MSA	Martin State Airport
MSL	Mean Sea Level
MDTA	Maryland Transportation Authority
N/A	Not Applicable
NAAQS	National Ambient Air Quality Standards
NACCS	North Atlantic Coast Comprehensive Study
NAVD88	North American Vertical Datum of 1988
NCC	Notice of Construction Completion
NED	National Economic Development
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NLEB	Northern Long-eared Bat
NMFS	National Marine Fisheries Service
NNC	National Nonstructural Committee
NNBF	Natural and Nature-Based Features
NOAA	National Oceanic and Atmospheric Administration
NO_X	Nitrogen oxides
NO_2	Nitrogen dioxide
NPL	National Priorities List
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
NWR	National Wildlife Refuge
O&M	Operation and Maintenance
OMRR&R	Operation, Maintenance, Repair, Rehabilitation, and Replacement
OSE	Other Social Effects
P&G Criteria	Principles & Guidelines for Federal Investments in Water Resources
PA	Programmatic Agreement

PCB	Polychlorinated Biphenyls
PDT	Project Delivery Team
PED	Pre-construction Engineering, and Design
PGN	Planning Guidance Notebook
P.L.	Public Law
PLCA	Probabilistic Life Cycle Analysis
PPA	Project Partnership Agreement
Ppb	Parts Per Billion
PSE	Protective System Element
PV	Present Value
RCA	Resource Conservation Area
RCRA	Resource Conservation and Recovery Act
RED	Regional Economic Development
RECONS	Regional Economic System
ROI	Region of Interest
ROM	Rough Order of Magnitude
SAV	Submerged Aquatic Vegetation
SIP	State Implementation Plan
SHPO	State Historic Preservation Office
SLC	Sea Level Change
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
SLR	Sea Level Rise
SMART	Specific, Measurable, Attainable, Risk Informed, Timely
SPGP	State Programmatic General Permit
sqft	Square Feet
SVOC	Semi-volatile Organic Compounds
SWL	Sea Water Level
TMDL	Total Maximum Daily Load
TSDF	Treatment, Storage, and Disposal Facilities
TSP	Tentatively Selected Plan

U.S.	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
U.S.C.	United States Code
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tanks
VOCS	Volatile Organic Compounds
WIP	Watershed Implementation Plan
WQC	Water Quality Certification
WRDA	Water Resources Development Act
WSEL	Water Surface Elevation
WWTP	Wastewater Treatment Plant

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1 INTRODUCTION

1.1 Introduction

This Final Integrated Feasibility Report and Environmental Assessment (IFR/EA) documents the U.S. Army Corps of Engineers (USACE) feasibility study planning process for the Baltimore Coastal Storm Risk Management Feasibility Study (Baltimore Coastal Study) and compliance with the National Environmental Policy Act of 1969, as amended (NEPA) and other environmental laws as integrated into the planning process. The sections of this report that satisfy the NEPA requirements, as outlined in 40 Code of Federal Regulations (CFR) 1501.5(c), are marked with an asterisk (*). Evaluations of the final array of alternatives revealed no significant effects to environmental and cultural resources or the human environment. For this reason, an Environmental Impact Statement (EIS) is not required.

The purpose of the study is to evaluate the feasibility of federal participation in implementing solutions to problems and opportunities associated with coastal storm damage and to reduce coastal flood risk to vulnerable populations, properties, infrastructure, and environmental and cultural resources along the banks of the Patapsco River in the vicinity of Baltimore City including northern Anne Arundel County and eastern Baltimore County, Maryland and Martin State Airport (MSA) in Baltimore County, Maryland. Coastal storms have produced extensive property damage and loss of life resulting from storm surge and flooding in the recent past, particularly from Hurricane Isabel in 2003, which resulted in costs of $4.8 million to the City of Baltimore, up to $252 million in total damages in Baltimore County, and one fatality.

Project costs and benefits associated with each alternative solution were compared to identify and recommend a plan. The models used to forecast the future conditions and changes for the Baltimore Coastal study are consistent with those used on other Coastal Storm Risk Management (CSRM) projects and have been certified by USACE.

The Baltimore Coastal Study Feasibility Cost Sharing Agreement (FCSA) was signed by USACE and the Maryland Department of Transportation (MDOT) on August 5, 2019. MDOT is the non-federal sponsor for the Baltimore Coastal Study. The study area encompasses the portion of the City of Baltimore and surrounding metropolitan area from approximately the Francis Scott Key Bridge (I-695) to the Inner Harbor and MSA, which includes the tidally influenced areas that were subject to flooding, storm surge, and damages because of Hurricane Sandy and other recent storms.

This final IFR/EA will culminate in a Chief’s Report in 2024, as an interim response to the authority.

1.2 USACE Planning Process

The SMART (Specific, Measurable, Attainable, Risk Informed, Timely) planning process is used for conducting Civil Works feasibility studies for water resources development projects. The purpose of this process is to improve and streamline feasibility studies, reduce cost, and expedite completion of the study. The SMART planning process follows a 3x3x3 approach with the goal of completing the study in 3 years, for no more than $3 million dollars and with three levels of review.

Due to study delays and interruption in funding of the Baltimore Coastal study, the project delivery team (PDT) requested a 3x3x3 exemption for time, which was approved on July 11, 2022.

The feasibility study is broken into 4 segments: Scoping, Alternatives Evaluation and Analysis, Feasibility Analysis of Selected Plan, and Washington Level Review (Figure 1-1). The Alternatives Milestone Meeting (AMM) was achieved on November 18, 2019. The Tentatively Selected Plan (TSP) was confirmed at the milestone meeting completed on May 2, 2022. At the Agency Decision Milestone (ADM) meeting held on November 07, 2022, which marked the end of segment 3, USACE confirmed the TSP as the Recommended Plan. The feasibility study phase of the Baltimore Coastal study concludes with the Chief's Report milestone.

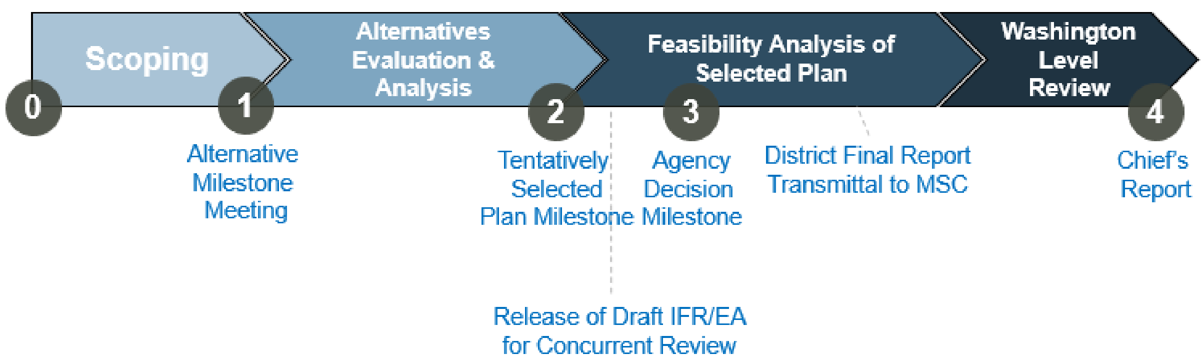

Figure 1-1. Feasibility Study Timeline

This final IFR/EA was prepared in accordance with the Principles and Guidelines for Water and Land Related Resources Implementation Studies (P&G) and Engineer Regulation (ER) 1105-2-100 Planning Guidance Notebook (PGN), dated April 22, 2000[2], and follows the Final Feasibility Report Format and Content Guide, dated October 26, 2021. To ensure sound decisions are made with respect to the development of alternatives, and with respect to plan selection, the plan formulation process requires a systematic and repeatable approach. This final IFR/EA presents the CSRM problem to be addressed by the study, lays out the plan formulation process leading to the final array

[2] The Planning Guidance Notebook was updated on 7 December 2023 as ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The PDT is aware of this new guidance and consulted the draft guidance while completing the study.

of alternatives, discusses the existing and future with and without-project conditions, evaluates environmental effects and consequences of the alternatives, and explains the decision leading to the selection of the Recommended Plan. This final IFR/EA includes all NEPA sections for an EA.

1.3 Study Authority

The study authority is under the Baltimore Metropolitan Water Resources authority. The Committee on Public Works and Transportation of the United States House of Representatives adopted a House resolution on April 30, 1992:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on the Baltimore Metropolitan Area, Maryland, published as House Document 589, Eighty seventh Congress, Second Session, and the reports of the Chief of Engineers on Baltimore Harbor and Channels, Maryland, and Virginia, published as House Document 181, Ninety fourth Congress, First Session, and House Document 86, Eighty fifth Congress, First Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of flood control, hurricane protection, navigation, erosion, sedimentation, fish and wildlife, water quality, environmental restoration, recreation, and other related purposes.*

This study authority was identified by the U.S Army Corps of Engineers, Baltimore District (CENAB) Office of Counsel (in a memorandum dated April 22, 2014) as the most recent authority that includes the study area, with the ability to investigate solutions to coastal flooding problems leading to a USACE recommendation for implementation. Although the study authority also identifies other purposes, this study will focus solely on CSRM. This study is an interim response to the study authority.

1.4 Study Area (Planning Area)

The study encompasses the portion of the City of Baltimore and surrounding metropolitan areas in eastern Baltimore County and northern Anne Arundel County to approximately the Francis Scott Key Bridge (I-695) and along the tidally influenced areas that were subject to flooding, storm surge, and damages because of Hurricane Sandy and other recent storms (Figure 1-2). The study area includes the coastline from Coffin Point to the Cox Creek Dredged Material Containment Facility (DMCF). The study area was defined to also include assets of importance to MDOT, including MSA in Baltimore County. Within the Patapsco River study area, Baltimore City contains approximately 69 miles, Anne Arundel contains 1.5 miles, and Baltimore County contains 4 miles of shoreline. The Baltimore County study area contains approximately 4 miles of shoreline along MSA.

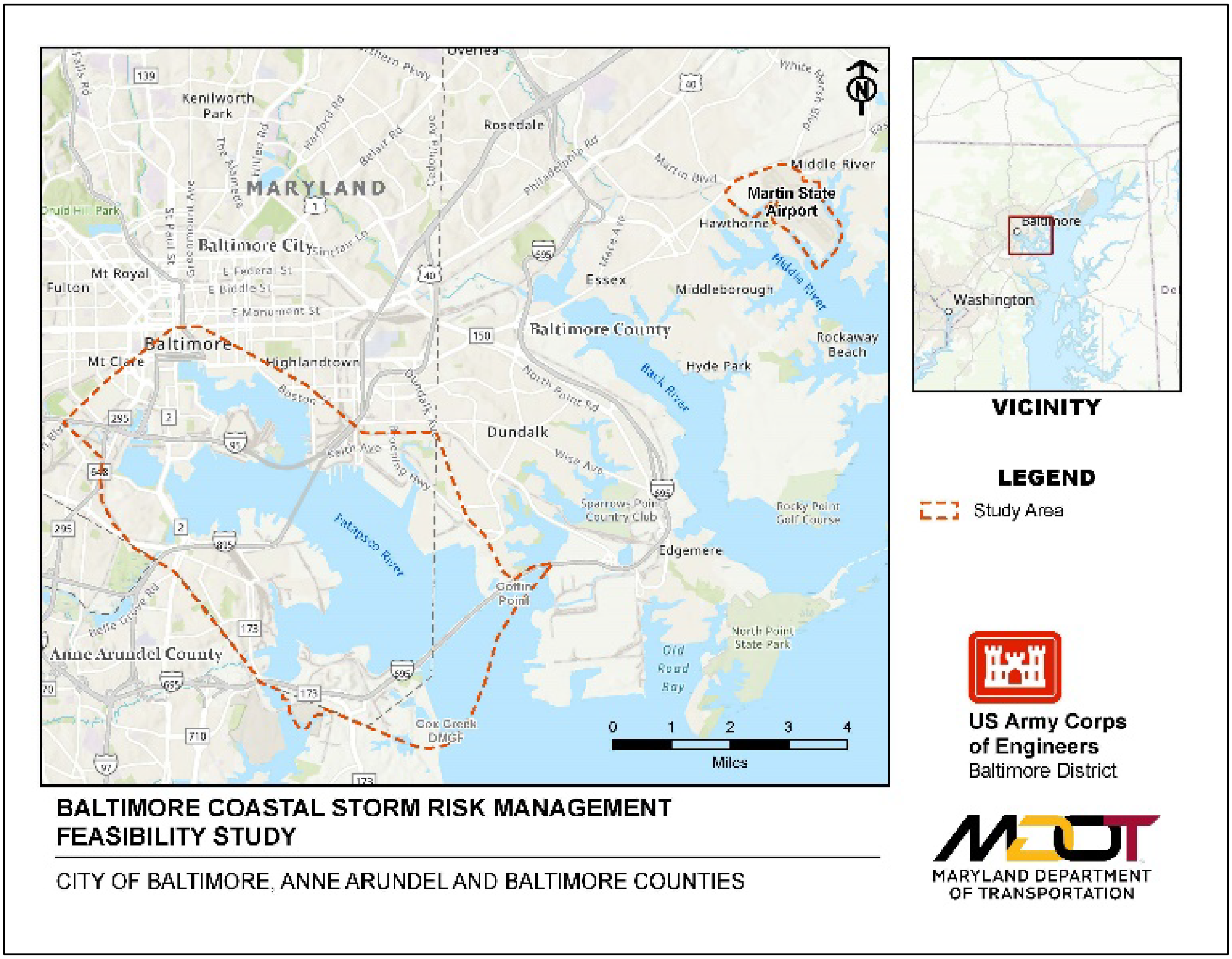

Figure 1-2. Study Area

1.5 Background and History

Following Hurricane Sandy in 2012, USACE completed the North Atlantic Coast Comprehensive Study (NACCS), which identified nine high-risk areas on the Atlantic Coast, including the Baltimore Metropolitan region, that warranted further investigation of coastal flood risk management (FRM) solutions. For a comprehensive overview of NACCS, please refer to the NACCS Main Report, appendices, and associated study products at: https://www.nad.usace.army.mil/CompStudy/ (USACE, 2015).

1.6 Study Purpose and Need for the Action*

The purpose of the study is to evaluate the feasibility of federal participation in implementing solutions to problems associated with coastal storm damage and to support resilient communities in the study area. The study is needed to consider alternatives to reduce coastal flood risk to vulnerable populations, properties, infrastructure, and environmental and cultural resources in the study area, considering future climate and sea level change (SLC) scenarios.

The study area has been impacted by numerous major tropical and extratropical events, most notably by Hurricane Able (September 1952), Hurricane Hazel (November 1954), Hurricane Connie (August 1955), Tropical Storm Agnes (June 1972), Tropical Storm David (September 1979), Hurricane Isabel (September 2003), Tropical Storm Ernesto (September 2006), Tropical Storm Hanna (September 2008), and Hurricane Irene (August 2011). Hurricane Isabel in 2003 resulted in extreme water levels and caused millions of dollars of damage to residences, businesses, and critical infrastructure. High storm surges occurred along the Chesapeake Bay and its tributaries. Over 570 homes and 15 businesses were declared uninhabitable from flooding. The problem in the study area is economic damages caused by storm surge and waves from coastal storms, that produce flooding in low lying areas.

1.7 Problems and Opportunities

The problem in the study area is economic damage and life loss resulting from inundation caused by coastal storms. The following have been identified as particular problems in the study area:

Life Safety

- Coastal flooding in the densely populated study area endangers lives; socially vulnerable populations may not be able evacuate ahead of storm surge.

Property and Critical Infrastructure

- Shorelines are developed with limited opportunity for storm surge and wave attenuation and storage of floodwaters. There is limited opportunity for application of natural and nature-based features (NNBF) in most of the study area.
- Storm surge inundation results in:
    - Damages to residential, commercial, industrial, government, and port and airport properties.
    - Disruption to critical infrastructure including water, electric and communication services, evacuation and transportation routes, and drainage systems.
    - Hindering the delivery of emergency services and other essential goods and services, disaster response, recovery, and overall resiliency.
    - Damage to important cultural and historic properties.

Opportunities exist to:

- Reduce vulnerability of coastal population and properties.
- Identify critical infrastructure vulnerabilities and improve resiliency.
- Increase public understanding of flood risk.
- Incorporate NNBF to reduce risk from storm surge inundation due to coastal storms and provide improved habitat.

- Identify beneficial reuse opportunities (e.g., wetland restoration within Middle Branch).

1.8 Objectives and Constraints

The goal of the study is to support resilient communities by recommending actions to manage flood risk to vulnerable populations, properties, infrastructure, transportation assets, and environmental and cultural resources. Planning objectives are summarized in statements that describe the desired results from solving or alleviating problems or realizing opportunities. All objectives for this study apply to the 50-year period of analysis, beginning in 2031.

1.8.1 Objectives

Baltimore City:

- Reduce risk to **human health and safety** from coastal storm impacts in the study area.
- Reduce **economic damages** from coastal storms in the study area to residential, commercial, industrial, and government buildings.
- Reduce disruption of **critical infrastructure** assets, services, and interdependent systems caused by coastal storms in communities throughout the study area.
- Improve the **resiliency of critical infrastructure** in the study area to impacts from coastal storms.

Martin State Airport:

- Reduce coastal storm impacts that disrupt or damage **transportation and emergency service infrastructure** and assets at supporting operations at Martin State Airport.

1.8.2 Planning Constraints and Considerations

Constraints are restrictions that limit the extent of the planning process. Floodproofing of row homes within the study area emerged as a constraint later on during the feasibility study process. Interim USACE guidance provided during the Nonstructural Summit held with Gen. Graham on July 2023, does not recommended floodproofing as a nonstructural measure for residential properties due to structural and safety concerns. Further guidance addressing nonstructural floodproofing is anticipated in FY24.

Several considerations were identified. The PDT identified the following considerations:

- Minimize impacts to operations at the Port of Baltimore, specifically the Seagirt Terminal.
- Minimize impacts to major transportation assets (Interstate [I]-95, I-895).
- Avoid exacerbating contaminated brownfield and Superfund sites.
- Minimize adverse effects to historic structures and districts.

- Avoid adverse effects to other properties and vulnerable populations within the study area.

1.9 Study Scope

ER 1105-2-103, PGN defines the policy for conducting Civil Works planning studies. This IFR/EA documents analyses and coordination conducted to determine whether the federal government should participate in CSRM in Baltimore City and surrounding metropolitan areas. Studies of potential CSRM consider a wide range of alternatives and environmental consequences but focus mainly on coastal storm risk and flooding.

The study area encompasses the portion of Baltimore City and the surrounding metropolitan area along the tidally influenced areas that were subject to flooding, storm surge, and coastal storm damages because of Hurricane Sandy and other recent storms. The study area includes the coastline from Coffin Point, the site of Maryland Transportation Authority (MDTA) offices at the Francis Scott Key Bridge (I-695) to the Cox Creek DMCF, just south of the Francis Scott Key Bridge and, at the request of our non-federal sponsor, MSA because it is a critical transportation asset. The study area was defined to include many assets of importance to MDOT.

1.10 Prior Studies and Reports

An extensive set of prior reports for this study area have been completed, including those produced by USACE and other agencies and jurisdictions. The most recent and/or relevant to the evaluation of CSRM within the study area are included below.

USACE

- *Assessment of Flood Risk Adaptive Measures, Baltimore City, Maryland (2019)*: This report, produced by CENAB for the Maryland Silver Jackets Team evaluated and recommended "flood risk adaptive measures" (FRAMs) for use on properties for residential, commercial, and public buildings. FRAMs are physical and nonphysical FRM measures that reduce flood risk by modifying the characteristics of structures or modifying the behavior of people living in or near floodplains. The assessment evaluated and recommended FRAMs for features on nine sample buildings. Baltimore City plans to incorporate the results of the assessment into a design guidance manual for floodproofing historic buildings.
- *North Atlantic Coast Comprehensive Study (NACCS; 2015)*: In 2015, the U.S. Army Corps of Engineers completed a report detailing the results of a two-year study to address coastal storm and flood risk to vulnerable populations, property, ecosystems, and infrastructure affected by Hurricane Sandy in the United States' North Atlantic region. The NACCS study was designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. It builds on lessons learned from Hurricane Sandy and attempts to bring to bear the

latest scientific information available for state, local, and tribal planners. The Baltimore Metropolitan study area was included as part of the NACCS Focus Area analysis.

- *Tidal Middle Branch, Baltimore, MD Section 206 (2009)*: The Middle Branch is one of the major tidal portions of the Patapsco River and is the receiving body of water for the Gwynns Falls and Patapsco River. The Middle Branch is located entirely within the City of Baltimore; thus, the watershed consists of a highly urbanized metropolitan setting. The Middle Branch study included the area upstream of Fort McHenry and the Fairfield Auto Terminal and continues north up the Gwynns Falls to Washington Boulevard and the I-395 exchange. Implementation of the project was not recommended due to the high cost of the project, which was shown to have minimal environmental benefits.
- *Warner Street, Middle Branch of the Patapsco River, Section 510 (2006)*: The Warner Street project consists of two phases. Phase I called for the design and construction of a trash interceptor to prevent trash and debris from smothering wetland vegetation along the shoreline of the river. Phase II called for the design and construction of a tidal emergent wetland along the shoreline. Phase I was completed in September 2006. Phase II was not constructed. Tidal Wetlands (Phase II) was terminated prior to design agreement execution given the need for the City of Baltimore to finalize area redevelopment plans and remove contaminated soils from the project site.
- *Hanover Street Wetlands Environmental Restoration Project Baltimore, Maryland Section 206 (2004)*: Under the Continuing Authorities Program Section 206, Aquatic Ecosystem Restoration authority, a three-acre wetland restoration project was proposed to be constructed between Hanover Street and land adjacent to City Garage. The project also proposed the construction of a trash interceptor on a stormwater outfall near Warner Street in Ridgeley's Cove. The trash interceptor was constructed while no wetland restoration was undertaken due to concern over mud-waving impacts to the Hanover Street Bridge. The project was terminated in 2011.
- *Baltimore Metropolitan Water Resources Study, Reconnaissance Report (1994)*: This reconnaissance report examined water resource problems in the Patapsco and Gunpowder River watersheds, including shallow draft navigation, flood damage reduction, and environmental restoration. The report concluded that there was federal interest in preparing water resource plans for various sub-basins. The report also recommended floodproofing for individual structures and updating existing flood warning systems.
- *Gwynns Falls, Baltimore, Maryland Local Flood Protection (1991)*: This feasibility study recommended the construction of a levee, starting at the embankment of I-95 on the left bank of the Gwynns Falls and extending downstream a distance of

400 feet to the CSX Corporation (CSX) Railroad tracks. From that point, the existing levee constructed by the City of Baltimore in 1987 would be raised about 2 feet for a distance of 1000 feet. Two closure structures would be needed where the line of protection crosses railroad tracks. The project was not constructed due to issues with CSX.

- *Flood Insurance Study, City of Baltimore, MD (1973)*: The study analyzed the flood potential of the City of Baltimore, Maryland at the request of the Federal Insurance Administration of the Department of Housing and Urban Development.
- *Hurricane Survey Baltimore Metropolitan Area (1960)*: Several alternative plans for preventing hurricane tidal damage in the study area were examined but none were found to be economically justified. The alternative plans included several plans of surge barriers and a brief examination of floodwalls. Because the alternatives were not justified economically, and local interests did not desire the protection studied, no improvements were made.
- *Martin State Airport Flood Preparedness and Response Plan (2005)*: This Flood Preparedness and Response Plan (FPRP) provides information and tools for use in preparing for and responding to flooding threats at MSA, Baltimore County, Maryland, especially those due to tropical storms, hurricanes, and Nor'easters. The goals of this plan are to protect life, preserve property and assets, and to limit the impacts to operation before, during, and after a storm event by recognizing the threats of flooding to MSA and mitigating the effects of those threats. This plan was requested by the Maryland Aviation Administration (MAA).

Baltimore City

- *Baltimore City Nuisance Flood Plan (2020)*: Maryland lawmakers, local and state governments, and citizens recognize that tidally-driven flood events are happening with more frequency. While "nuisance flooding" may not pose a serious threat or result in major damage, it interrupts daily routines and can negatively impact businesses. The definition of nuisance flooding, for the purpose of this plan and in accordance with §3-1001 of the Natural Resource Article of the Maryland Annotated Code, is "high tide flooding that causes a public inconvenience." The legislation requires that the Nuisance Flood Plan include three critical components: 1) Inventory of known flood hazard areas where tidal nuisance flooding occurs; 2) Identification of flood thresholds/ water levels/ conditions that lead to tidal nuisance flooding; and 3) A mechanism to document tidal nuisance flood events from 2020 to 2025.
- *Disaster Preparedness and Planning Project (DP3) (2018)*: Baltimore's Disaster Preparedness and Planning Project (DP3) was first produced by the Department of Planning in 2013 to address both existing hazards and the predictions of the impacts of climate change on these natural hazards, including but not limited to

heat waves, sea level rise (SLR), increased precipitation, and flooding. Hazard mitigation planning is a continuous process for the City of Baltimore. This 2018 update fulfills Federal requirements to regularly update the formal plans, but the City includes additional elements it plans to develop over the next 2-3 years.

- *City of Baltimore Commission for Historical & Architectural Preservation Fells Point Flood Mitigation Guidelines (2018)*: Many of Baltimore's historic neighborhoods are vulnerable to flooding, particularly those close to waterfronts such as Fells Point. Whether on the roads, sidewalks, or directly impacting buildings, flooding is becoming a more common problem across the City of Baltimore. The historic, attached rowhouse buildings of Fells Point are particularly vulnerable and pose a real challenge for owners seeking to minimize flood damage. The information presented in this guide is intended to provide information to property owners and tenants on evaluating options to minimize the impact of flooding to their historic rowhouse properties in Fells Point.

1.11 Current Projects and Initiatives

Reimagine Middle Branch

Reimagine Middle Branch (Figure 1-3) is a community-driven initiative to reconnect South Baltimore with a system of parks, trails, programs, and economic development plans along the 11-mile shoreline of the Middle Branch shoreline of the Patapsco River. The Middle Branch is the place where the intersection of industry and ecology, Baltimore and the Bay, is most evident and within close reach of tens of thousands of city residents. Unlike Baltimore's Inner Harbor or the working waterfront with the port facilities, many sections of the Middle branch's once-industrialized shoreline have returned to a natural form. Reimagine Middle Branch offers the opportunity to take advantage of this unique environment and achieve multiple goals: improving the water quality of the Patapsco and the Bay, restoring local habitat and environmental health for biodiversity within the Middle Branch, securing South Baltimore's resilience in the face of climate change and increasing natural disasters, and bringing the beauty and health-benefits of a restored ecology to within reach of South Baltimore's communities. More than $150 million in Federal, State, Local, Casino, and Philanthropic funds have been raised as of late 2022, and a number of projects are already underway or completed.

The Middle Branch Resiliency Initiative (MBRI) is a part of the Reimagine Middle Branch plan and is a comprehensive implementation strategy for mitigating flood risks to public utilities, hospitals, transportation infrastructure, and communities surrounding the Middle Branch of the Patapsco River in Baltimore, Maryland. Through a coordinated network of vegetated berms, living shorelines, restored wetlands/aquatic habitats, and public space enhancements, the MBRI will protect critical infrastructure elements and community lifelines. The MBRI is a comprehensive set of shoreline protection, marsh re-establishment, and stormwater management projects located throughout the Middle Branch shoreline. The MBRI will generate community resilience to climate change and sea level rise in several neighborhoods in South Baltimore, which have complex histories fraught with environmental and economic challenges. The project will also generate significant water quality and habitat improvements while providing opportunities for recreation and education.

The MBRI's first project will be initiated at the mouth of the Patapsco River—Site 5a—and includes 12.5 acres of re-established coastal marsh and over a half-mile of shoreline stabilization. This project will re-establish the transitional shoreline and marsh landscape which was lost through decades of industrialization and development. The Project will provide climate resilience by buffering against coastal storm damage, to nearby business, homes, and infrastructure. This nature-based solution will improve water quality in the Middle Branch and the Chesapeake Bay by eliminating shoreline erosion and re-establishing functional coastal marsh that filters, uses, and sequesters harmful excess nutrients out of open water fueling sustainable ecological process.

Figure 1-3. Reimagine Middle Branch Vision.

(Areas highlighted in green are targeted for current or future projects. Source: The Reimagine Middle Branch Plan [Reimagine Middle Branch, 2023]).

Turner Station

Turner Station, a historically African American community, which lies north of the study area in Baltimore County on Bear Creek, is subject to coastal flooding. A technical assistance report produced by CENAB states that a lack of stormwater quantity management, undersized drain lines, and sunken stormwater infrastructure contributes to flooding in the community. In January 2023 Baltimore County announced plans to develop a framework for a Resilience Authority that will finance and support sustainability infrastructure projects to protect the County's shorelines, communities, and residents from climate threats. Additionally, nearly $2 million has been awarded in funds from the Federal Government and the National Fish and Wildlife Foundation to develop a climate resilience roadmap for the Turner Station community. This funding will support efforts to incorporate green stormwater solutions to improve aquatic habitat and community resilience while engaging the community through small workings groups to understand future coastal hazards and identify resilience priorities.

1.12 Public and Agency Coordination

In compliance with NEPA, coordination was conducted with Federal, state, and local resource agencies (Appendix H). USACE Baltimore coordinated with the Maryland State Historic Preservation Office (SHPO) to ensure compliance with Section 106 of the National Historic Preservation Act (Appendix H). CENAB also coordinated with Baltimore County Department of Planning, the Commission for Historical and Architectural Preservation Consultation, National Park Service (NPS), and Preservation Maryland. Subsequently, a Programmatic Agreement (PA) was developed by CENAB to determine the potential for the Project to affect historic properties in consultation with the Signatories and Concurring Parties of the PA pursuant to 36 CFR Part 800.3 – 800.5.

Consultation letters were electronically mailed on 10 June 2022 by the CENAB to the Delaware Nation, Delaware Tribe of Indians, and the Seneca-Cayuga Tribe of Oklahoma. Responses can be found in Appendix H.

Agency coordination was conducted by CENAB through several various state and Federal agencies including the United States Environmental Protection Agency (USEPA), Federal Emergency Management Agency (FEMA), Federal Highway Administration (FHA), National Marine Fisheries Service (NMFS) Habitat & Ecosystem Services Division and Protected Resources Division, the U.S. Fish and Wildlife Service (USFWS), Maryland Department of Natural Resources (MD DNR), Maryland Department of the Environment (MDE) (Appendix H).

The draft IFR/EA was available for public and agency review July 01, 2022, to August 19, 2022. Public meetings were held following release of draft IFR/EA in person on August 01, 2022, and virtually on August 02, 2022. See Appendix H: Agency and Public coordination for public comments received and responses.

2 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

This section describes the Existing Conditions, as well as a forecast of the Future Without Project (FWOP) Conditions, that together provide a basis for plan formulation discussed in Section 3. The Existing Conditions and the FWOP Conditions provide a description of the human environment, which is subdivided into the natural, physical, economic, and built environments. The Existing Conditions represent the Affected Environment for NEPA purposes. The Existing and FWOP Conditions serve as a baseline that are compared to the Future With-Project (FWP) Condition to evaluate and compare the alternative plans. This comparison is integral to the selection of the Recommended Plan (Section 6). The final array of alternatives does not include in-water work and impacts for the final array of alternatives are considered minimal. Therefore, impacts to in-water resources including submerged aquatic vegetation (SAV), benthic resources, and fish and fishery resources are not anticipated and are not discussed in this report.

2.1 Period of Analysis

The period of analysis for this study is 50-years per ER 1105-2-100 PGN[3]. The planning horizon starts in baseline year 2031 (when the project is anticipated to begin accruing FRM benefits) and ends in year 2080. Existing conditions reflect the conditions in place during the feasibility study through year 2024. FWOP conditions consider a range of activities from year 2021, the most recent year for which complete data was obtained, and projects that are planned to be implemented or are already underway that would be constructed in the absence of this project. FWP Conditions are the conditions forecasted during the planning horizon, from years 2031 to 2080, with implementation of the Recommended Plan. The Recommended Plan will also be assessed for engineering and environmental performance out to 100 years from the baseline year, to ensure coastal resilience of the Recommended Plan and adaptation to SLR.

2.2 General Setting

The study area located in Baltimore City is characterized as a densely populated urban setting, consisting of commercial, industrial, and residential areas. The study area located at MSA includes a runway, multiple hangars, and areas leased by the Maryland Air National Guard.

There are several locations of national significance in the study area, including Fort McHenry (a national monument), historic structures and districts, and an important U.S. Coast Guard (USCG) boatyard and drydock facility. Critical infrastructure in the study area includes the Port of Baltimore, I-95 and I-895 tunnels and bridges, Fort McHenry Tunnel, Harbor Hospital, Martin State Airport, electrical generation and transmission

[3] The Planning Guidance Notebook was updated on 7 December 2023 as ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The PDT is aware of this new guidance and consulted the draft guidance while completing the study.

systems, water and communications utilities, and cargo and commuter rail systems. The general setting of the study area is not expected to change under the FWOP Condition.

2.3 Natural Environment*

2.3.1 Wetlands

2.3.1.1 Existing Conditions

Most wetlands within the Baltimore Metro study area exist along the Patapsco River and Inner Harbor coastlines and consist of estuarine, tidally influenced systems. A tidal wetland is located southwest of Fort McHenry and east of the Fort McHenry Tunnel Ventilation Building (referred to as the Fort McHenry West Ventilation building). The MSA study area contains similar wetland systems surrounding the property, with additional palustrine systems located within the interior.

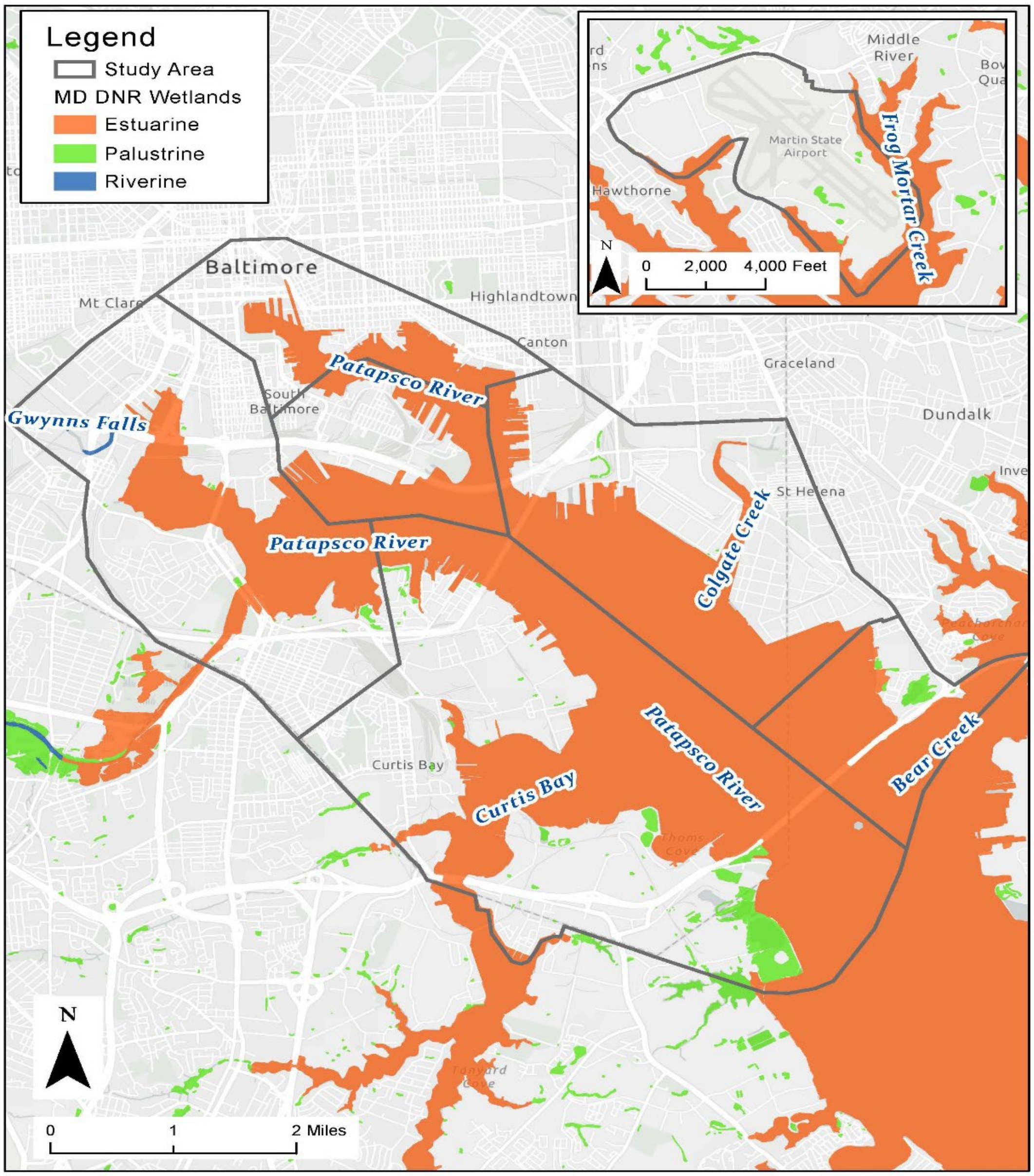

Figure 2-1 MD DNR Mapped Wetlands of Baltimore City and Martin State Airport

2.3.1.2 FWOP Condition

Wetlands that exist within the vicinity of the MSA study area may continue to receive brackish water inflow during storm surge, high tides, heavy rain events, and sea level rise which has the potential of disrupting the current hydrologic regime and hydrophytic vegetation within the wetlands. Conversely, the State of Maryland continues to work with State and local agencies to implement wetland restoration and conservation programs in an effort to protect the state's remaining coastal wetlands from climate change (USEPA, January 2021c). The Port of Baltimore partnered with the Living Classrooms Foundation, the National Aquarium, Maryland Environmental Service (MES), and USFWS to create Masonville Cove, the nation's first Urban Wildlife Refuge Partnership. One of Masonville Cove's objectives is to promote conservation through education and experiences. Masonville Cove contains 251 bird species and is named one of the state's top birding spots (Masonville, 2022). In addition, Reimagine Middle Branch, an initiative led by the City of Baltimore, South Baltimore Gateway Partnership, and the Parks & People Foundation, is expected to restore existing marshes and Chesapeake maritime forests along the Middle Branch area (Lynch, 2022). With on-going and proposed conservation and restoration programs, wetlands are anticipated to, at best, remain consistent in the area with goals of gradual improvement.

2.3.2 Wildlife

2.3.2.1 Existing Conditions

Wildlife within the vicinity of Baltimore City and the MSA is typical of urban wildlife species and can include raccoons, squirrels, chipmunks, opossum, snakes, rats, mice, moles, voles, songbirds, geese, pigeons, starlings, bats, moths, beetles, bees and other common insects. More suburban areas in Baltimore County around MSA may host white-tailed deer, fox, skunks, gophers, turtles, snakes, frogs and rabbits. CENAB submitted an online request in February 2022 through the USFWS Information for Planning and Consultation (IPaC) online web service to determine the presence of protected resources and species (under jurisdiction of the USFWS) within the Baltimore and MSA study areas. As reported through the USFWS IPaC Resource List, there are no critical habitats, fish hatcheries or National Wildlife Refuge (NWR) lands within the study areas. The IPaC report is in Appendix H: Agency and Public Involvement Coordination.

In accordance with Section 2(b) of the Fish and Wildlife Coordination Act (16 U.S.C. 1513 et seq.) and Section 7 of the Endangered Species Act (16 U.S.C. 1513 et seq.), the USFWS provided a Fish and Wildlife Coordination Act (FWCA) letter to CENAB on April 6, 2022. The FWCA letter is located in Appendix H.

2.3.2.1.1 Threatened and Endangered Species

The IPaC report identified one endangered species and one threatened species as having the potential to occur in the study areas: the endangered northern long-eared bat (NLEB)

(*Myotis septentrionalis*) and the threatened Eastern Black Rail (*Laterallus jamaicensis ssp. jamaicensis*). The USFWS announced a final rule to reclassify the NLEB as endangered under the Endangered Species Act (ESA). The NLEB was officially listed as threatened in 2015, but now faces extinction due to the impacts of white-nose syndrome, a deadly disease that affects hibernating bats across North America. The rule took effect on March 31, 2023. Although the status of the species has changed, no impacts are anticipated (USFWS, Nov 2022). The species was identified in the screening, but the developed nature of the study area is not a suitable habitat for this species; therefore, it would be uncommon to identify threatened and/or endangered species within the study area. Additionally, there are no hibernacula or maternity roosts located within or nearby the study areas.

The Eastern black rail is identified in the USFWS IPaC (February 2024 – Appendix H). Eastern black rail typically find habitat in tidal or non-tidal salty to brackish marshes. Black rails require dense vegetative cover that allows movement underneath the canopy. Plant structure is more important than plant species composition in predicting habitat suitability for the black rail. Although there are brackish marshes near or around the project area, the proposed work is not expected to impact eastern black rail species based on the proximity to urban land with the project area.

The FWCA letter identified the monarch butterfly (*Danaus plexippus*) as a candidate species, though it is not yet listed or proposed for listing. There are no requirements under Section 7 of the ESA for candidate species.

2.3.2.1.2 At-Risk Species

Several at-risk species, or species whose populations are in decline but are not yet determined to be threatened or endangered, were identified in the IPaC report. Species include the monarch butterfly, American oystercatcher (*Haematopus pilliatus*), cerulean warbler (*Dendrocia cerulea*), eastern whip-poor-will (*Antrostomus vociferus*), ruddy turnstone (*Arenaria interpres morinella*) and wood thrush (*Hylocichla mustilina*). Common tern (*Sterna hirundo*) and royal tern (*Sterna Thalasseus maximus*) may also be present within the study area. Additionally, there is an annual nesting common tern colony on a barge off the coast of Masonville Cove, within the study area.

2.3.2.1.3 Migratory Birds

The IPaC report generated a list of migratory birds and Birds of Conservation Concern BCC) within the study area. This list is located in the IPaC report in Appendix H.

The Patapsco River portion of the study area is a maintenance watershed for the American black duck (*Anas rubripes*). Maintenance areas currently contain enough food to support black duck populations.

The bald eagle (*Haliaeetus leucocephalus*) was identified by IPaC due to its protection under the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act. The nearest bald eagle nest is located near Masonville Cove, which is within the study area. However, no work is being proposed in Masonville Cove; therefore, no impacts to bald eagles or common tern colonies are anticipated.

2.3.2.2 FWOP Conditions

The City of Baltimore, along with the Baltimore Waterfront Partnership and other Harbor stakeholders and business communities, have developed the Baltimore Inner Harbor 2.0 Master Plan. The framework of the Master Plan includes connecting the Baltimore Harbor Promenade with open spaces, integrating green infrastructure, and restoring native habitats. The Plan proposes the identification of potential locations for living shorelines, floating wetlands, rain gardens, enhanced tree canopy, and native plant habitat (Baltimore Waterfront, 2013). Over the last decade, the Master Plan has acted as a guideline for the City's future development plans. The goal for Baltimore and its surrounding areas is to improve its current state and establish beneficial habitats for all wildlife while also considering the urban environment and climate change. As mentioned in Section 2.3.1.1, projects and programs like Masonville Cove and Reimagine Middle Branch have set precedence for other initiatives to be instilled in and around the greater Baltimore area in an effort to create more sustainable habitats for wildlife.

2.4 Physical Environment*

2.4.1 Land Use

2.4.1.1 Existing Conditions

Land use within the Baltimore Metro study area consists of commercial, industrial, high and medium-density residential housing, as well as several other developed areas according to the Maryland Department of Planning and Maryland Environmental Resource & Land Information Network (MERLIN, 2010). The Patapsco River creates a peninsula around South Baltimore and is the main tributary to other waterways around the study area including Gwynns Falls, Colgate Creek and Bear Creek. The study area includes numerous shipping and transportation facilities such as the Port of Baltimore-Seagirt Terminal, Port of Baltimore- Chesapeake, Fairfield Auto Terminal, Port Covington, Locust Point Industrial Area, as well as CSX and Norfolk Southern railroad facilities. Notable landmarks within the Baltimore Metro study include the Inner Harbor, Fort McHenry National Monument and Historic Shrine, the National Aquarium, Horseshoe Casino, and M & T Bank Stadium. Baltimore City is also located within the Chesapeake Bay Critical Area – Intensively Developed Area (IDA), Limited Development Area (LDA), and Resource Conservation Area (RCA). Section 2.4.11 includes more details on the Chesapeake Bay Critical area.

MSA encompasses over 740 acres of land in Middle River, MD. The airport is bordered by Eastern Boulevard to the north, Frog Mortar Creek to the east, Stansbury Creek to the south, and Dark Head Creek and Wilson Point Road to the west. The three creeks surrounding the airport are all tidally influenced systems. The airport is operated by the

MAA and includes one runway, taxiways, a fuel storage facility, multiple hangars, and operations and maintenance buildings. The airport is utilized by private and corporate aircraft and is also used by the Maryland Air National Guard, which leases approximately 20 percent of the property from MAA (MAA, 2017). According to the Baltimore County Department of Zoning, MSA is zoned as Manufacturing, Heavy. Typical uses permitted by right include industrial uses requiring assembly, production, processing, packaging, or treatment of various elements, boat yard, laboratory, office, medical clinic, equipment, and material storage yard (Baltimore County, 2015).

Refer to the Baltimore Metropolitan Council's Land Use/Land Cover Map for land use maps of the Baltimore Metro Study Area and the Martin State Airport study area (Baltimore Metropolitan Council, 2018).

Additionally, the MSA is located within the Chesapeake Bay Critical Area – IDA. IDAs have the least restrictive land-use classifications and are designated for high-intensity development, which is encouraged to minimize forest destruction and impervious surface cover (CBF, 2004). IDA's can be described as "areas of twenty of more adjacent acres where residential, commercial, institutional or industrial land uses predominate. IDAs are areas of concentrated development where little natural habitat occurs. In IDAs, the main focus of the Critical Area Program is on improving water quality. The Law requires that new development and redevelopment include techniques to reduce pollutant loadings associated with stormwater runoff. These techniques include site design, infiltration practices, and structural stormwater treatment practices (CBF, 2004). Section 2.4.11 includes more information on the Chesapeake Bay Critical Area. The specific regulations of the Critical Area Act can be found in the Annotated Code of Maryland Regulations (COMAR 27.01.01).

2.4.1.2 FWOP Conditions

Within the Baltimore study area, future development is expected to reshape areas along Baltimore's waterfront. Construction is currently underway in the Warner Street district and is anticipated to transform Baltimore's old and underused industrial zone into a new, mixed-use entertainment center. Further development at Harbor Point, one of Baltimore's newest waterfront neighborhoods located between Harbor East and Fells Point, is continuing to transform the former industrial area into a mixed-use community of businesses, luxury apartments, and restaurants. The project is currently in Phase III of development and will include a 4.5-acre park space, an additional office building, and residential and retail facilities (Baltimore.org, 2022). The MSA and its surrounding areas are identified in Baltimore County's 2020 Master Plan proposed Middle River Redevelopment Area. The Redevelopment Area proposed for MSA will be classified as "T-Institutional", and more specifically, T-4 (General Urban Zone). The T-4 Zone is intended to be characterized by mixed-use but will focus on transit-oriented development (Martin, 2022). Continued land development and redevelopment within the Critical Area will adhere to the Critical Area Law, specifically towards developing or redeveloping within IDA areas and ensuring pollutant loading and stormwater runoff is mitigated in accordance with the Critical Area Law.

2.4.2 Geology

2.4.2.1 Existing Conditions

2.4.2.1.1 Physiography

The study area lies within the embayed section of the Atlantic Coastal Plain province, which extends along the east coast of the United States (U.S.) from Massachusetts to Florida. The Coastal Plain is underlain by a wedge of unconsolidated sediment that includes silt, gravel, sand, and clay. This area is characterized by nearly level to rolling topography, with elevations ranging from sea level to 330 feet. The lithology or physical characteristics of the rock formations in the area are mainly composed of fine to medium sand, often micaceous and gravel, with some lesser amounts of silt and clay (Maryland Geological Survey, 2020).

2.4.2.1.2 Soils

The study area consists of numerous types of soils. Soil is a mixture of mineral and organic ingredients, with the composition changing from one location to another. The soil-forming process is affected by a variety of factors including parent material, living organisms, landscape position, time, and climate. Within urban environments, soil composition may form as a result of different types of human-deposited material such as loamy fill over natural sand, dredge spoil, coal ash, chromium ore processing residue (COPR), or construction debris (USDA, 2020). Urban environments can contain non-soil areas with names such as urban land, dumps, water or rubble land. The designation of 'Urban land' indicates that an area is primarily covered with impervious materials such as pavement, driveways, and buildings.

Soil survey information retrieved from the U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) Web Soil Survey mapping tool, provides the soil types within the study area. Urban land (Soil Map Unit Symbol 44UC) is the primary soil type listed for the Baltimore study area. Urban land and Mattapex-urban land complex are the major soil types found within the MSA study area. Soil types found within both study areas are listed in Appendix G: Environmental and Cultural Resources Compliance.

2.4.2.1.3 Drainage and Watershed

The study area is within a dendritic drainage system, with numerous branching streams, eventually flowing into the Chesapeake Bay. The Chesapeake Bay watershed covers an area of 64,000 square miles (165,760 square kilometers) and includes parts of six states (Virginia, Maryland, Delaware, West Virginia, Pennsylvania, and New York), as well as all of the District of Columbia. The watershed's rivers all drain into one shallow tidal basin, the Chesapeake Bay, and the bay's tidal tributaries. There are more than 100,000 rivers, streams, and creeks within the Chesapeake Bay watershed. Each stream has its own watershed, which are part of larger watersheds that drain into larger streams or rivers. The Chesapeake Bay watershed is located in the middle of the Atlantic Coastal Plain province and was formed when the lower valley of the Susquehanna River was drowned as glaciers melted during the post-Wisconsin rise in sea level.

The study areas are located within the Gunpowder-Patapsco sub-watershed, which encompasses portions of Frederick, Carroll, Howard, Anne Arundel and Harford Counties, most of Baltimore County, and all of Baltimore City. The Baltimore City portion of the study area lies within Baltimore Harbor watershed of the Patapsco River (Maryland 8-digit watershed 02130903). The MSA is located within the Middle River/Browns watershed of the Gunpowder River (Maryland 8-digit watershed 02130807).

Due to the urbanized nature of the study areas, much of the local waterways and streams have been buried, concrete-lined, or altered in some shape or form over time. Jones Falls for example, flows underneath Baltimore City for several miles before it reaches the Inner Harbor. Baltimore City has a high percentage of impervious cover, about 45% is made up of impervious surfaces like streets, sidewalks and roofs. The City's infrastructure is not prepared to handle excessive amounts of flood waters with storm drains already being clogged with plastic and trash (Chesapeake Bay Magazine, 2019).

2.4.2.2 FWOP Conditions

Under the No Action Alternative/FWOP, conditions would remain the same for physiography. Continued urbanization, agriculture, and loss of forests, combined with sea-level rise and climate change may pose a negative threat to drainage within the various watersheds around Baltimore. As more natural areas are developed, sometimes without proper planning mechanisms, local streams and waterways become overloaded from runoff that may have once been absorbed by pervious areas. According to the National Climate Assessment, storms that are capable of producing flash flooding and heavy rainfall events have increased in the northeast – which the assessment defines as the area spanning from Maryland to Maine – more than any other region in the country (National Climate Assessment, 2014). Areas in Maryland have seen recurring 1,000-year storm events (storms that have a 0.1% chance of happening any given year), specifically in 2016 and 2018 which devasted the town of Ellicott City, MD. In a FWOP condition, proper planning mechanisms should be instilled during development to allow for natural resources to be maintained as much as possible with minimal alterations.

2.4.3 Water Quality

2.4.3.1 Existing Conditions

Water draining from the Chesapeake Bay watershed has a significant impact on water quality in the Chesapeake Bay. Within the study area, the urban nature of the Patapsco River watershed has detrimental impacts on the water quality of the Patapsco River and its tributaries, due to urban runoff and contaminants from industrial pollution.

Watershed implementation plans (WIP) are generated by each jurisdiction to outline steps, measures and practices that will be implemented to achieve the goals of the Chesapeake Bay total maximum daily load (TMDL) by the year 2025. The Maryland WIP Phase III, which outlines pollution reduction goals needed from 2018 to 2025, sets nutrient pollution limit goals of 45.8 million pounds of total nitrogen per year, 3.68 million pounds of total phosphorous per year, and sediment discharge limits of 1.3 billion pounds of sediments per year (MDE, 2019). The Patapsco and Middle Rivers are grouped under the western shore state basin, which has a pollution reduction target under the Maryland WIP Phase III of 9.0 million pounds per year for nitrogen and 0.96 million pounds per year for phosphorous.

The Patapsco and Middle Rivers are both designated as “Use Class II.” Use II waters are defined as supporting estuarine and marine aquatic life and shellfish harvesting. Within the study area this includes the following Use II subcategories: support of seasonal migratory fish spawning and nursery, seasonal shallow-water SAV, open-water fish and shellfish use, and shellfish harvesting use. The Patapsco River is also designated as suitable for the support of deep-water fish and shellfish and for deep channel refuge use. Frog Mortar Creek is designated as “Use I,” which is defined as supporting water contact recreation, fishing, growth and propagation of fish (not trout) and other aquatic life and wildlife, as well as agricultural and industrial water supply.

The Patapsco River is currently “listed” or included in the 303(d) list as being impaired and needing TMDLs for a variety of pollutants including polychlorinated biphenyls (PCBs), lead in sediment, zinc in sediment and chlorides. Middle River is listed for PCBs in fish tissue due to contaminated sediments. Table 2-1 presents a list of all impaired waterbodies within the study area that do not currently have a TMDL or do not have a TMDL that has been approved by the U.S. Environmental Protection Agency (USEPA).

TMDLs have been developed and approved for nitrogen and phosphorous pollution impacting fish and shellfish ecosystems within the Middle River. The Patapsco River also has approved TMDLs for a variety of pollutants, some of which are part of the “Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorous and Sediment” (Chesapeake Bay TMDL) (USEPA, 2010). Table 2-2 lists impaired waterbodies within the study area for which TMDLs have been approved, as well as their corresponding designated uses, causes of pollution, indicators, and pollution sources (if known).

Table 2-1. Impaired Waterbodies within the Baltimore Metro Study Area Currently in the 303 (d) list

Year First Listed	Basin Name	Designated Use	Cause/ TMDL Impairment	Indicator/Pollution Sources
1998	Patapsco River- Northwest Branch, Middle Harbor	Aquatic life and wildlife	Zinc in sediment	Direct measurement/ source unknown
1998	Patapsco River- Northwest Branch	Aquatic life and wildlife	Lead in sediment	Direct measurement/ source unknown
2004	Patapsco River	Aquatic life and wildlife	Cause unknown	Benthic Index of Biological Integrity (IBI)/source unknown
2006	Middle River- Browns	Fishing	PCBs in fish tissue	Direct measurement/ contaminated sediments
2010	Patapsco River- Middle Branch, Northwest Branch	Water contact sports	Enterococc us	Direct measurement/ source unknown
2014	Baltimore Harbor	Aquatic life and wildlife	Total suspended solids	Fish and benthic IBIs/ urban runoff & storm sewers
2014	Baltimore Harbor	Aquatic life and wildlife	Chloride	Direct Measurement/ urban runoff & storm sewers
2014	Baltimore Harbor	Aquatic life and wildlife	Sulfate	Direct measurement/ urban runoff &storm sewers

Table 2-2. Impaired Waterbodies within the Baltimore Study Area that have Approved TMDLs

Basin Name	Designated Use	Cause/ TMDL Impairment	Indicator/Pollution Sources
Middle River	Open-water fish and shellfish subcategory. Seasonal migratory fish spawning and nursery subcategory	Nitrogen	Dissolved oxygen
Middle River	Open-water fish and shellfish subcategory. Seasonal migratory fish spawning and nursery subcategory	Phosphorous	Dissolved oxygen
Patapsco River	Seasonal shallow-water SAV- SAV grow zone	Total suspended solids	SAV and water clarity/ source unknown
Patapsco River	Open-water fish and shellfish subcategory. Seasonal migratory fish spawning and nursery subcategory	Nitrogen, total	Dissolve oxygen/ municipal point source discharges
Patapsco River	Open-water fish and shellfish subcategory. Seasonal migratory fish spawning and nursery subcategory	Phosphorous, total	Dissolved oxygen/ municipal point source discharges
Patapsco River-Littoral zone of the Middle Branch and the Northwest Branch	Water contact sports	Trash	Direct measurement/ Illegal dumps or other inappropriate waste disposal
Patapsco River	Seasonal deep-water fish and shellfish subcategory	Phosphorous, total	Dissolved oxygen/ municipal point source discharges
Patapsco River	Seasonal deep-water fish and shellfish subcategory	Nitrogen, total	Dissolved oxygen/ municipal point source discharges

Basin Name	Designated Use	Cause/ TMDL Impairment	Indicator/Pollution Sources
Baltimore Harbor Watershed	Fishing	Chlordane	Direct measurement/ contaminated sediments
Baltimore Harbor Watershed	Fishing	PCBs in fish tissue	Direct measurement/ discharges from municipal separate storm sewer systems (MS4)
Patapsco River	Seasonal deep-channel refuse use, navigation channel	Phosphorous, total	Dissolved oxygen/ source unknown
Patapsco River	Seasonal deep-channel refuse use, navigation channel	Nitrogen, total	Dissolved oxygen/ source unknown
Patapsco River- lower North Branch	Aquatic life and wildlife	Total suspended solids	Habitat evaluation/ urban runoff, storm sewers
Patapsco River –North Branch	Water contact sports	*Escherichia coli* (E. Coli)	Sanitary sewer overflows (collection system failures)

2.4.3.2 FWOP Condition

The State of Maryland, as well as federal and local agencies, continue to strive towards improving water quality within the Chesapeake Bay watershed through WIPs as stated above. However, challenges arise when quantifying the effects that continued urbanization, climate change, and associated warming sea temperatures may have on local water quality standards.

Baltimore City specifically has several programs instilled to support improving the City's water quality. The Capital Improvement Program requires the Baltimore City Planning Commission to annually recommend a six-year Capital Improvement Program to the Board of Estimates. The Planning Department works with various City agencies to prepare a new six-year program. Some of the past projects included reducing stormwater sewer overflows, stormwater environmental site designs that began construction in 2019, and construction activities carried out as part of the MS4 permit will continue to be coordinated around the Capital Improvement Program. With various programs installed, the future goal is to control pollution and nutrients from entering into local waterways and the Bay and continue to achieve acceptable water quality standards. Additionally, Baltimore City implements four 'trash wheels' or trash interceptors that either sit stationary to collect trash from in-land waterways, or travel around the Inner Harbor. Locations of the four trash wheels include Jones Falls stream, Inner Harbor, Harris Creek, Canton Neighborhood, Masonville Cove and Gwynns Falls.

2.4.4 Floodplains

2.4.4.1 Existing Conditions

Floodplains are typically flat or gently rolling lands adjacent to streams and rivers that receive floodwaters once the waterway has overtopped the bank of the main channel. Overtopping is usually a result of a higher-than-normal influx of precipitation caused by intense meteorological events, tropical storms, and hurricanes. Overtopping can also be a result of excessive water moving from higher elevations to lower elevations, normally seen during flash flood events. Floodplains can often become vulnerable due to development directly adjacent to or within a designated floodplain area and is most seen in densely populated cities. Due to increased development, floodplains lose their proper functions and values of flood storage, nutrient reduction, and wildlife habitat, among others. The Baltimore Metro study area consists of hardened shorelines and minimal natural floodplains. There are several areas that are openly exposed to coastal flooding (Figure 2-2). The study areas fall within the Patapsco River estuary where the main component of flooding is caused by excessive runoff from impervious surfaces. In some instances, tidal storm surges can occur in some locations throughout the study area. Tidal storm surge is a result of constant, sustained winds pushing the water column landward from low elevations to high elevations due to coastal storms and hurricanes.

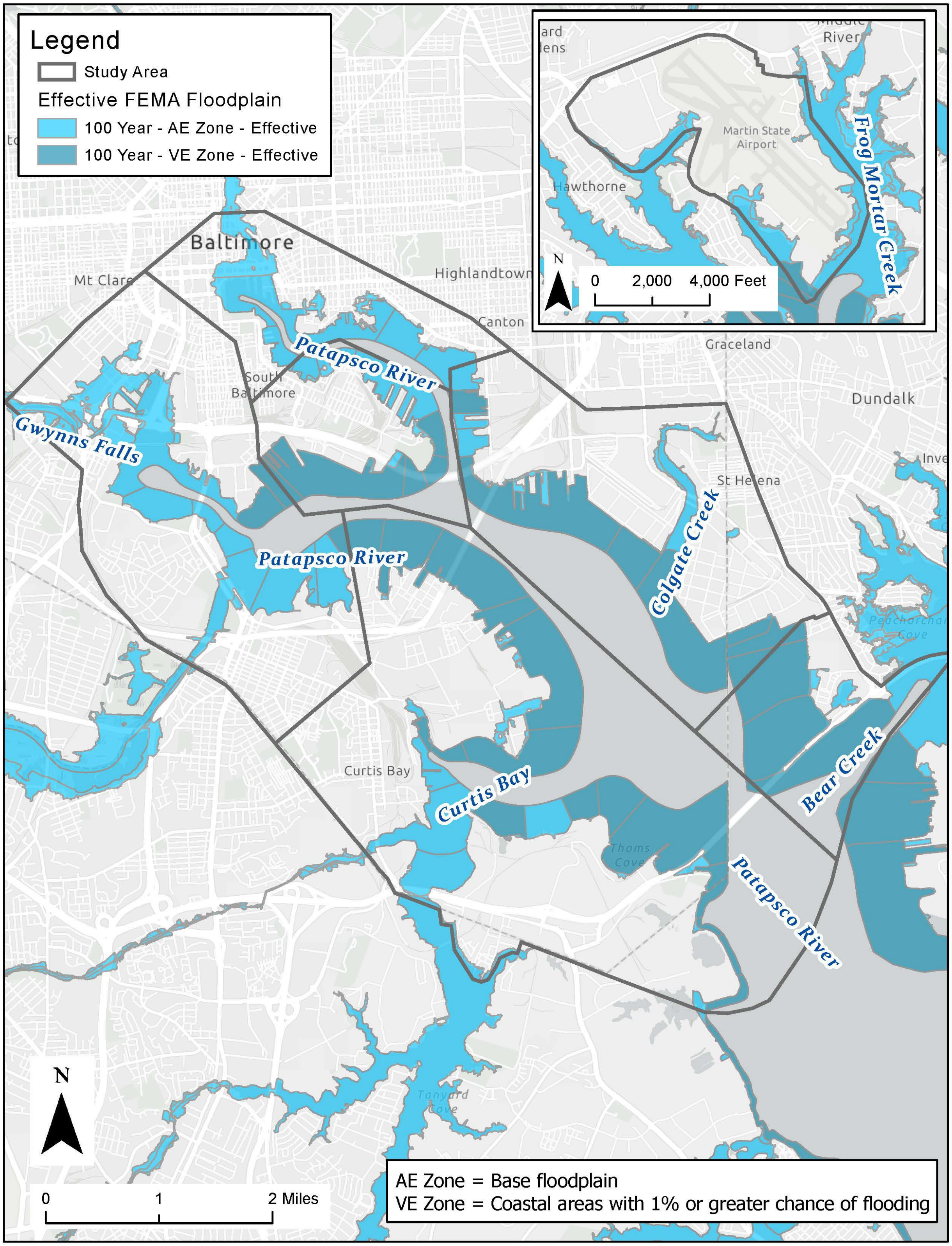

Figure 2-2. 100-year Floodplains of Baltimore City and Martin State Airport

2.4.4.2 FWOP Condition

As climate change and sea level rise continue to affect our coastal shorelines, Baltimore will remain susceptible to coastal flooding and inundation. For this study, the PDT used an intermediate sea level change scenario to determine the FWOP conditions at a 1 percent annual exceedance probability (AEP). For more details and figures concerning FWOP conditions, please refer to Section 3.3, as well as Appendix B: Hydrology and Hydraulics Analysis, for the FEMA Coastal Modeling.

2.4.5 Hazardous Materials and Wastes

2.4.5.1 Existing Conditions

According to the USEPA EJScreen report (USEPA, 2020), there are 34 hazardous waste treatment, storage, and disposal facilities (TSDF) within the 1-mile radius of the Baltimore Metro study area. Six similar facilities exist within the MSA 1-mile radius study area.

A Hazardous, Toxic, Radioactive Waste (HTRW) Investigation Report was completed by CENAB in March 2022 and can be found in Appendix G. CENAB reviewed Federal environmental records, State and Tribal environmental records, Environmental Data Resources, Inc (EDR®) proprietary records, aerial photographs, city directory abstract and historical topographic maps. The EDR® report includes properties within a one-quarter mile radius of the study area as required by American Society for Testing and Materials (ASTM) E1527-13. Several areas are identified in the EDR® report as having a history of contamination events. Numerous waste generators were listed within the MSA study area and range from Large Quantity Waste Generators to Very Small Quantity Waste Generators. The report identified Underground Storage Tanks (USTs) and Above Ground Storage Tanks (AGSTs) as containing heating oil, diesel fuel, gasoline, aviation jet fuel, used oil, and motor oil within the MSA study area. There have been cases of spills resulting in contamination of the soil and groundwater as well. Continued actions have occurred at MSA to investigate the extent of the presence of total petroleum hydrocarbon, volatile organic compounds (VOCs), semi volatile organic compounds, inorganic compounds, and PCBs in the groundwater and the soil. In addition, in 2000, a contractor uncovered pieces of unexploded ordnance at MSA. The Army's Explosive Ordnance Division investigated and found the items to be unfused, unarmed, and contained inert material. Any ground disturbance would need to take into consideration the location of the waste generators and any possible contamination in the path of the construction.

Additionally, there are several marine terminals and industrial complexes surrounding the entrance points of the Baltimore Harbor Tunnel and the Fort McHenry Tunnel. Many of these areas are listed in one or more of the above-mentioned categories. Due to the age of some of the existing properties within Baltimore City, there is a potential for asbestos and lead paint-containing material within some of the properties. The exact locations and properties would not be known until initial inspections take place as the project progresses.

2.4.5.2 FWOP Condition

Under the No Action Alternative/FWOP, the chance for hazardous materials and wastes to infiltrate the Chesapeake Bay or public water supply would remain a threat during flooding events. Hazardous materials and wastes, including gases and oils from the motor vehicles, USTs, and AGSTs could continue to impact the Bay and other local waterways during flooding events. The number of HTRW sites may increase as the potential for more frequent storms caused by climate change may cause coastal flooding to occur further inland; thus, creating new HTRW sites.

2.4.6 Transportation and Navigation

2.4.6.1 Existing Conditions

The City of Baltimore uses multi-modal transit systems throughout the study area and includes local and commuter buses, light rail, metro subway, Maryland Area Regional Commuter (MARC) train service, and a paratransit mobility system. Additionally, MDTA is responsible for maintenance of freight rail lines in Maryland and Delaware. Baltimore City currently has 60 bus lines that serve the City's transportation needs and include high frequency lines such as CityLink, LocalLink, and Express BusLink routes, which connect surrounding suburbs to downtown Baltimore. The Charm City Circulator is a free and widely used bus system that allows visitors and residents to travel throughout the city (Visit Baltimore, 2022). The Baltimore Metro system is comprised of 14 stations over 15.5 miles, from Owings Mills through downtown Baltimore to Johns Hopkins Hospital. The system is used to connect communities to major sports events, universities, and government and private businesses throughout the Baltimore City area. Each station contains at least one street level entrance at each end that leads down to the Mezzanine level via stairs, elevators, or escalators (Jacobs, 2006).

Several major interstates and highways intersect or bypass the Baltimore study area. I-895 and I-95 are vital interstates that connect commuters from southwest of Baltimore City to northeast via the Baltimore Harbor Tunnel and Fort McHenry Tunnels. The tunnels were completed and opened for public use in 1957 and 1985, respectively. The Baltimore Harbor Tunnel receives approximately 27.6 million vehicles per year, while the Fort McHenry Tunnel receives about 45.4 million vehicles per year (commuting both directions) (MDTA, 2021).

The MSA is located on a small peninsula adjacent to the Middle River with the nearest intersecting roadways being Eastern Boulevard (MD-150) and White Marsh Boulevard (MD-43), which ends directly outside of the airport's main gate. Strawberry Point Road and Lynbrook Road are located on either side of the airport and allow access to the airport's business park. During a traffic count study in 2020, MDOT State Highway Administration calculated approximately 5,315 cars traveling on Strawberry Point Road over a 48-hour period (MDOT SHA, 2021). Additionally, the MARC rail line runs perpendicular to MSA and contains a stop for commuters to board and un-board the train directly outside of the airport's main entrance.

The Port of Baltimore is operated by the Maryland Port Administration and is one of the largest port facilities on the eastern seaboard. Some of the leading cargo and transportation businesses in the world use the Port of Baltimore to transport goods and services and include Maersk Edinburgh, General Electric/Haier, Evergreen Line, Volkswagen, and Mercedes-Benz. The Port has five terminals: Dundalk Marine Terminal, Seagirt Marine Terminal, Fairfield Marine Automobile Terminal, North Locust Point, and South Locust Point (MPA, 2021).

2.4.6.2 FWOP Condition

Under the No Action Alternative/FWOP, areas such as the Inner Harbor and MSA would continue to experience localized flooding driven by high tides, coastal storms, and regular meteorological events. Local roadways would continue to be temporarily closed by flooding events, which would affect local businesses, commuter traffic, and tourism. Both the Fort McHenry and Baltimore Tunnels would continue to be susceptible to coastal flooding, particularly the MDTA-owned buildings that house mechanical and electrical support systems for the tunnels. Secondary and tertiary effects target the Port of Baltimore – Seagirt Terminal, and emergency air operations at the MSA. The former may continue to be vulnerable to coastal flooding in a FWOP condition. A wide array of vehicles, commercial, industrial, and agricultural machines and equipment remain susceptible to potential flood waters. Additionally, emergency air operations at the MSA may be stalled in the event of a coastal flooding event, inhibiting access to the helipad that houses the Maryland State Police 'MEDEVAC' helicopter.

2.4.7 Noise

2.4.7.1 Existing Conditions

To ensure a suitable living environment, the Department of Housing and Urban Development has developed a noise abatement and control policy, as seen in 24 CFR Part 51 – Environmental Criteria and Standards. According to this policy, noise not exceeding 65 decibels A (dBA) is considered acceptable. Noise above 65 dBA, but not exceeding 75 dBA is normally acceptable, but noise above 75 dBA is unacceptable. Normal freeway traffic noise levels range from 70 to 90 dBA. The Bureau of Transportation Safety publishes the National Transportation Noise Map, showing approximate noise exposure. In the Baltimore Metropolitan area, the highest noise exposures occur along commuter rail lines, CSX tracks, and Interstates I-95, I-895, and I-83 (Figure 2-3). The MSA is the primary source for the highest noise exposure in its respective study area (Figure 2-4). The airport has developed a Noise Abatement Plan which is established pursuant to the Maryland Environmental Noise Act of 1974 (Transportation Article 5-819, Annotated Code of Maryland). The Plan is formulated to minimize noise disturbance to neighboring communities while maintaining airport operations (Martin, 2004).

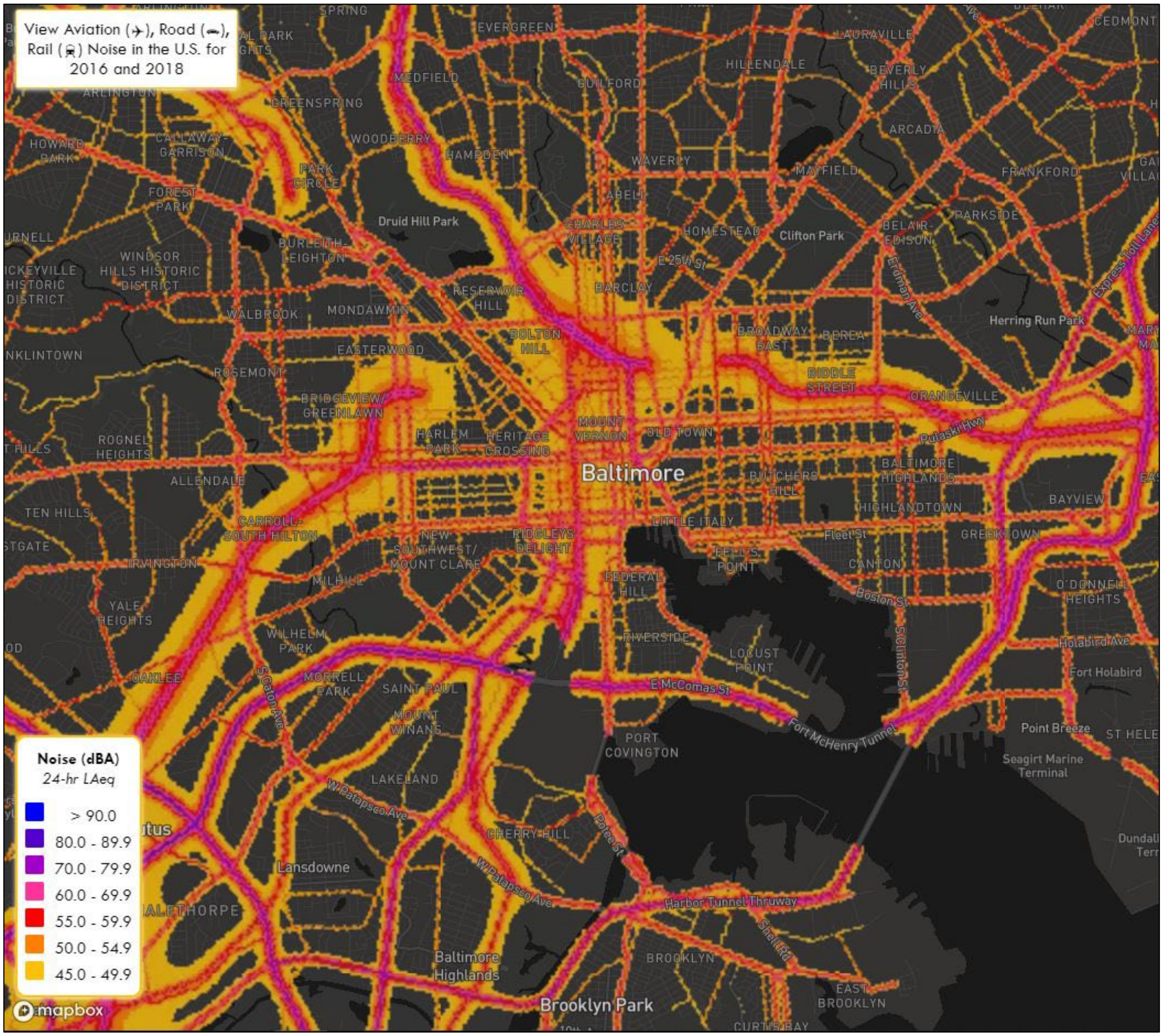

Figure 2-3. Noise Map of Baltimore Metropolitan area
Source: Bureau of Transportation Safety, 2018

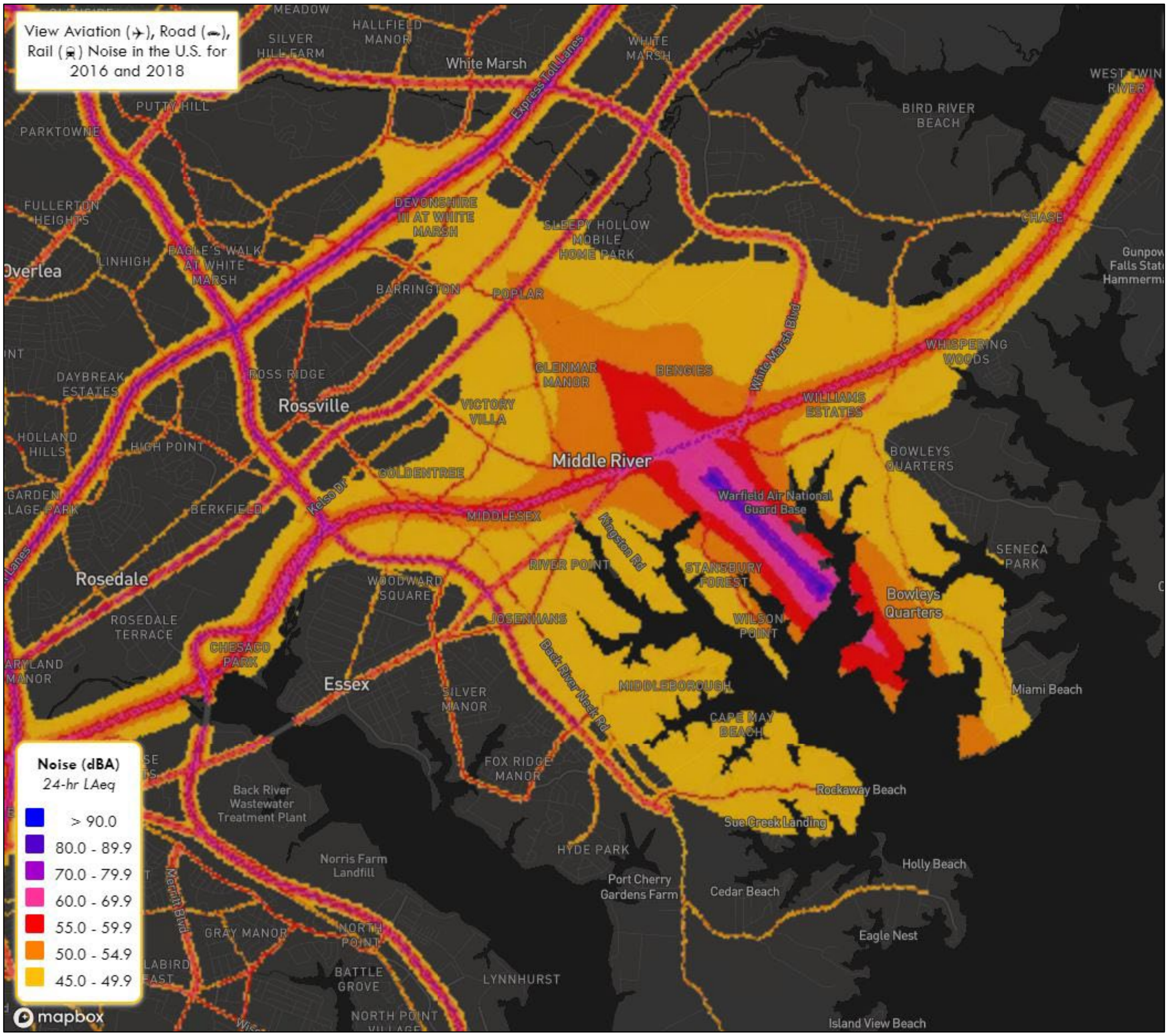

Figure 2-4. Noise Map of Martin State Airport

Source: Bureau of Transportation Safety, 2018

2.4.7.2 FWOP Condition

Under the No Action Alternative/FWOP, noise would remain the same or consistent with the continued urbanization and growth of the study area.

2.4.8 Air Quality

2.4.8.1 Existing Conditions

As of September 2022, Baltimore City is in nonattainment for the 8-hour Ozone pollutant, based on the 2015 standard. Nonattainment means that an area is not meeting or is above a given safe standard set by the USEPA for the particular criteria pollutant (USEPA, 2021a). State agencies develop air quality plans, which are also referred to as State Implementation Plans (SIPs), designed to attain and maintain National Ambient Air

Quality Standards (NAAQS) set by the USEPA and to prevent significant deterioration of air quality in areas that demonstrate air that exceeds the NAAQS. Maryland has individual SIPs for various pollutants, including nitrogen dioxide (NO_2), particulate matter ($PM_{2.5}$), 8-hour ozone (O_3), regional haze, lead, etc. Federal agencies must ensure that their actions conform to the SIP in a nonattainment area, and do not contribute to new violations of ambient air quality standards, or an increase in the frequency or severity of existing violations, or a delay in timely state and/or regional attainment standards.

The purpose of the General Conformity Rule (GCR) is to:

- Ensure Federal activities do not interfere with the budgets in the SIPs
- Ensure the attainment and maintenance of NAAQS
- Ensure actions do not cause or contribute to new violations of NAAQS

A general air conformity analysis was completed (Appendix G) with respect to the 8-hour ozone NAAQS. The results of this analysis are summarized in Section 4.2.8. Additionally, as of September 2022, Baltimore City and County are in attainment for NO_2 and $PM_{2.5}$.

2.4.8.2 FWOP Condition

The USEPA strengthened the health-based air quality standard for 8-hour ozone in Fall 2021, lowering the standards from 75 parts per billion (ppb) to 70 ppb. The updated standard will improve public health protection, particularly for at-risk groups such as children, older adults, and people with heart or lung diseases. Maryland has continued to enforce strong regulations and monitoring programs that introduce protective regulations and regional collaborations with assistance from the MDE (MDE, 2022).

2.4.9 Greenhouse Gas Emissions

2.4.9.1 Existing Conditions

Human activities account for almost all the increase in greenhouse gas emissions within the atmosphere over the last 150 years. Greenhouse gas emissions continue to increase and build up in the atmosphere causing increased climate warming. Greenhouse gases are produced from five major sources: transportation, electricity production, industry, commercial and residential, and agriculture (USEPA, 2021b). According to a World Resources Institute Report published in 2020, Maryland leads the nation in the number of emissions reductions (38 percent) in a 12-year period (MDE, 2021 & WRI, 2020). Over the past ten years, Maryland has orchestrated an extensive set of plans, action strategies, and legal authorities, as well as worked with other local, state, and federal agencies in an attempt to mitigate and adapt to climate change. Below are some initiatives and plans that the State of Maryland has developed from 2006-2016 (Table 2-3).

Table 2-3. Maryland Climate Change Plans and Initiatives

Year of Action	Plan/Action/Order/Act	Description
2006	Healthy Air Act – MD joins Regional Greenhouse Gas Initiative (RGGI)	Require regulation of carbon monoxide emissions. RGGI – a cooperative effort among nine northeastern states to reduce carbon dioxide emissions from fossil fuel-fired power plants.
2007	Clean Cars Act Commission on Climate Change Executive Order	Require regulation of carbon monoxide emissions.
2008	Climate Action Plan	Created to develop a Climate Action Plan to limit climate change by reducing greenhouse gas emissions and guide the state's efforts to adapt to the changing climate.
2009	Greenhouse Gas Emissions Reduction Act (GGRA)	Established the commitment to reduce emissions by 25% by 2020
2012	Climate Change and Coast Smart Executive Order	Developed to apply siting and design criteria to avoid or minimize impacts associated with sea-level rise and coastal flooding on state-funded capital projects.
2016	Greenhouse Gas Emissions Reduction Act extended	Extended from the 2009 act to achieve the goal of reducing emissions by 40% by 2030.

According to the CEQ, "Federal courts consistently have held that NEPA requires agencies to disclose and consider climate impacts in their reviews" (86 Federal Register 10252). On January 9, 2023, CEQ issued the "National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change" (CEQ, 2023). Although CEQ is currently working to finalize this guidance, in the interim, CEQ provides the steps that agencies should take in analyzing the effects of the proposed action on climate change: (1) quantify the reasonable foreseeable GHG emissions, (2), disclose and provide context fog GHG emissions and climate impacts, and (3) analyze reasonable alternatives, including those that would reduce GHG emissions relative to baseline conditions, and identify mitigation measures to avoid, minimize, or compensate for climate effects (88 Federal Register 1196).

Each GHG is assigned a global warming potential (GWP). The GWP is the ability of a gas or aerosol to trap heat in the atmosphere. The GWP rating system is standardized to CO2, which has a value of one. For example, CH4 has a GWP of 25, which means that it has a global warming effect 25 times greater than CO2 on an equal-mass basis.

To simplify GHG analyses, total GHG emissions from a source are often expressed as a CO2 equivalent (CO2e). The CO2e is calculated by multiplying the emissions of each GHG by its GWP and adding the results together to produce a single, combined emission rate representing all GHGs. While CH4 and N2O have much higher GWPs than CO2, CO2 is emitted in such higher quantities that it is the overwhelming contributor to CO2e from both natural processes and human activities. Per CEQ guidance, USACE is considering all available tools and resources in assessing GHG emissions and climate change related to the study.

2.4.9.2 FWOP Condition

In 2022, Maryland passed a significant environmental bill into law, called the Climate Solutions Now Act. The law calls for a 60 percent reduction in climate-warming carbon emissions by 2031 and net-zero emissions by 2045. This Act is one of the most ambitious greenhouse gas reductions of any state in the nation. Notable requirements within the Act include improving the energy efficiency of large existing buildings; thus, reducing carbon emissions. By 2030, all state facilities would be required to get at least 75 percent of their electricity from low-to zero-carbon sources. A five-million-dollar fund for climate projects was established in the Act and directed 40 percent to be spent in low-to moderate income neighborhoods (Wheeler, 2022).

In 2009, the Interagency Working Group on Social Cost of Greenhouse Gases (IWG) was established to ensure that Federal Agencies were using the best available science and to promote consistency in the values used across agencies. On January 20, 2021, President Biden issued E.O. 13990 which directed the IWG to ensure that the social cost of GHG (SC-GHG) estimates used by the U.S. Government reflect the best available science and the recommendations of the National Academies (2017) and work towards approaches that take account of climate risk, environmental justice, and intergenerational equity.

In February 2021, the IWG released the “Technical Document: Social Cost of Carbon, Methane, and Nitrous Oxide Estimates (SC-CO2, SC-CH4, and SC-N2O) under the EO 13990” (IWG, 2021). This document presents the IWG’s interim findings and provides interim estimates of the SC-CO2, SC-CH4, and SC-N2O that should be used by agencies until a comprehensive review and update is developed with the requirements in E.O. 13990.

2.4.10 Coastal Zone Management Program (CZMP)

2.4.10.1 Existing Conditions

The Coastal Zone Management Program (CZMP) includes goals to protect coastal land and water habitat. The program is a partnership among local, regional, and State agencies to ensure proposed Federal activities are consistent with Maryland's resource goals and policies. According to the National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management, Section 307 of the "Coastal Zone Management Act of 1972", called the "federal consistency" provision, gives states an opportunity to coordinate with Federal agencies within the decision-making processes for activities that may affect a state's coastal uses or resources. The Federal consistency provision is a major incentive for states to join the National CZMP and is a tool that state programs use to manage coastal activities and resources, as well as facilitate cooperation and coordination with Federal agencies.

The Federal consistency provision requires that any Federal actions, within and outside the coastal zone, that may have future effects on any coastal use (land or water), or natural resource of the coastal zone be consistent with the enforceable policies of a state's federally approved coastal management program. NOAA states, "Federal actions include federal agency activities, federal license or permit activities, and federal financial assistance activities. Federal agency activities must be consistent to the maximum extent practicable with the enforceable policies of a state coastal management program, and license and permit and financial assistance activities must be fully consistent" (National Oceanic and Atmospheric Administration [NOAA], 2021). Baltimore City and Baltimore County are both listed as Coastal Zone counties and may be subject to some of the Program's enforceable policies to coastal resources and uses, such as the Chesapeake and Atlantic Coastal Bays Critical Area, historical and archeological sites, and transportation. More information on Maryland's Coastal Zone Management Act (CZMA) and policy checklists can be found in Appendix G.

2.4.10.2 FWOP Condition

Under the No Action Alternative/FWOP, Maryland would continue coordination efforts with Federal agencies in an effort to ensure any new activities comply with the CZMA.

2.4.11 Chesapeake Bay Critical Area

2.4.11.1 Existing Conditions

In 1984, the Maryland General Assembly enacted the Critical Area Act to address the increasing pressures placed on Chesapeake Bay resources from an expanding population. The Act defines a critical area as "all land within 1,000 feet of the MHW [mean high water] Line of tidal waters or the landward edge of tidal wetlands and all waters of and lands under the Chesapeake Bay and its tributaries".

The Critical Area Law mandates that local governments preserve "Habitat Protection Areas", which include nontidal wetlands and a surrounding 25-foot buffer; a 100-foot vegetated buffer zone on the landward edge of tidal waters, wetlands, or tributary streams; threatened and endangered species and their habitat; significant plant and wildlife habitat; and anadromous fish spawning areas. Significant plant and wildlife habitat is defined as colonial water bird nesting areas, historic waterfowl concentration areas, riparian forests, undisturbed forest tracts (100 acres or more) containing breeding populations of forest interior-dwelling birds, areas that contain the "best examples" of plant and animal communities, and other areas determined to have local significance. The Critical Area Law also categorizes land as IDAs, LDAs, or RCAs, and regulates development that can occur in each. Baltimore City is located within the IDA, LDA and RCA. The MSA study area is located within the LDA and IDA (Figure 2-5). Habitat used by rare, threatened, or endangered species can be protected under critical area regulations (MDDNR, 2004).

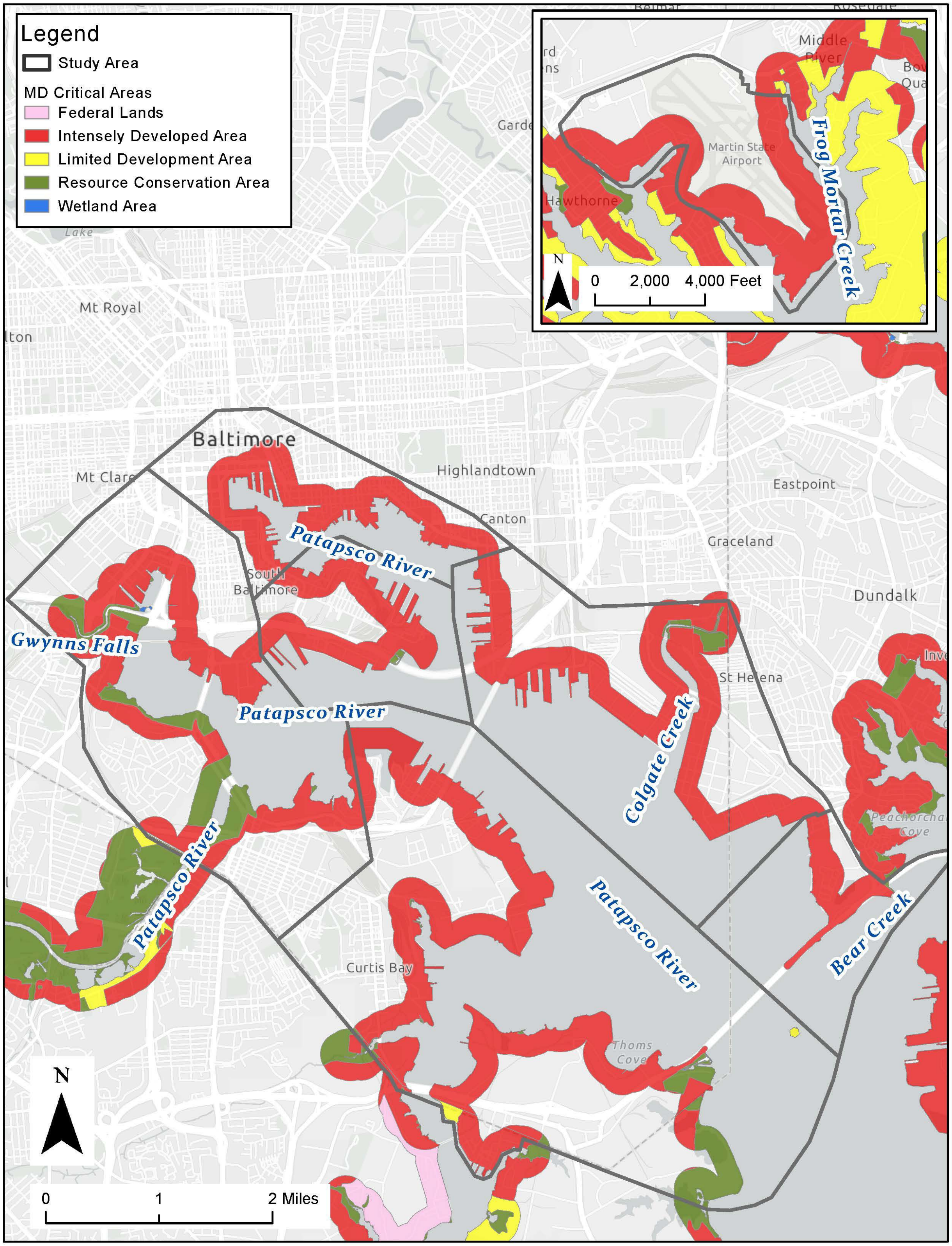

Figure 2-5 Critical Areas of Baltimore City and Martin State Airport

2.4.11.2 FWOP Condition

Future development within both Baltimore and MSA study areas is anticipated within the Chesapeake Bay Critical Area as stated in Section 2.4.1. Any new development or activities taking place in the Critical Area will have to comply with Maryland or Baltimore City Critical Area regulations.

2.4.12 Climate Change and Sea Level Change

2.4.12.1 Existing Conditions

Although initiatives have been developed to combat climate change at a regional scale, the City of Baltimore continues to deal with climate-related issues. Nuisance flooding, also known as tidal flooding or high tide flooding, is an issue that portions of Baltimore continue to experience. Nuisance flooding causes public inconveniences, such as road closures, blocks access to homes and businesses, and can lead to significant trash accumulation following its recession. Nuisance floods can be caused by a variety of weather-related events, including astronomically influenced extreme high tide cycles, long-sustained off-shore winds, and coastal storm systems. NOAA predicts that Baltimore could experience as many as 50-160 nuisance flooding events by 2050 (NOAA, 2019). Areas around Baltimore that have been most impacted by nuisance flooding are Lower Fells Point and areas along the Inner Harbor promenade. However, with climate change affecting sea-level rise in the near future, other areas that are expected to be influenced by flooding include, Canton, Locust Point, Middle Branch, Port Covington, Westport, Fairfield and Curtis Bay. All these areas have been identified as vulnerable locations and residential, commercial, industrial, and government properties all exist within these areas and could potentially be affected.

The MSA is also susceptible to climate change and SLR due to its proximity to Middle River, Frog Mortar Creek, and Stansbury Creek. A flood preparedness and response plan was prepared by CENAB in 2005, which identified the airport’s susceptibility to coastal and tidal flooding. Several of the airport’s hangars, administration buildings, and Marine Police Units were shown to be susceptible to flood damage during a 100-year storm event. An investigation performed by URS Greiner, Inc in 1998, found that the 100-year floodplain elevation at MSA was at 10.0-feet above mean sea level (MSL) and the 500-year floodplain elevation at 12.0 feet above sea level. Most of the buildings or units on the property range from 4-9 feet above MSL (MTN, 2005). FEMA study of the 1% annual chance Water Surface Elevation (WSEL) along Baltimore inner harbor varies from 7 to 10 feet North American Vertical Datum of 1988 (NAVD88) and it represent existing condition WSEL. As per FEMA flood hazard data, most of the inner harbor area has 1% annual chance WSEL of 8 feet NAVD88. FEMA study also shows 6-8 feet NAVD88 WSEL around MSA. The NACCS WSEL with adjustment for Sea Level Rise (SLR) is between 8 and 8.3 feet NAVD88. Additional details on FEMA and NACCS study is available in Appendix B: Hydrology and Hydraulic Analysis.

2.4.12.2 FWOP Condition

As part of its water resources management missions and operations, USACE has been working together with other federal agencies, academic experts, nongovernmental organizations, and the private sector to translate climate science into actionable science for decision-making. The USACE Civil Works Program has developed tools to analyze the potential effects and uncertainties associated with climate change and SLC relative to the USACE portfolio.

Engineering Construction Bulletin (ECB) no. 2018-14 provides guidance for incorporating climate change information in hydrological analysis in accordance with the USACE overarching climate change adaptation policy (USACE 2018). It calls for a qualitative analysis. The goal of a qualitative analysis of potential climate threats and impacts to USACE hydrology-related projects and operations is to describe the observed present and possible future climate threats, vulnerabilities, and impacts of climate change specific to the study. This includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant meteorological and hydrologic variables.

Sea level is projected to rise as shown on Table 2-4 and Figure 2-6, based on the records at the Baltimore, MD NOAA gauge 8574680, which is closest to the study area.

Table 2-4. SLC Based on USACE Scenarios in Feet Relative to NAVD88

Year	Low	Intermediate	High
2031	0.36	0.50	0.93
2080	0.86	1.55	3.73
2130	1.36	3.06	8.43

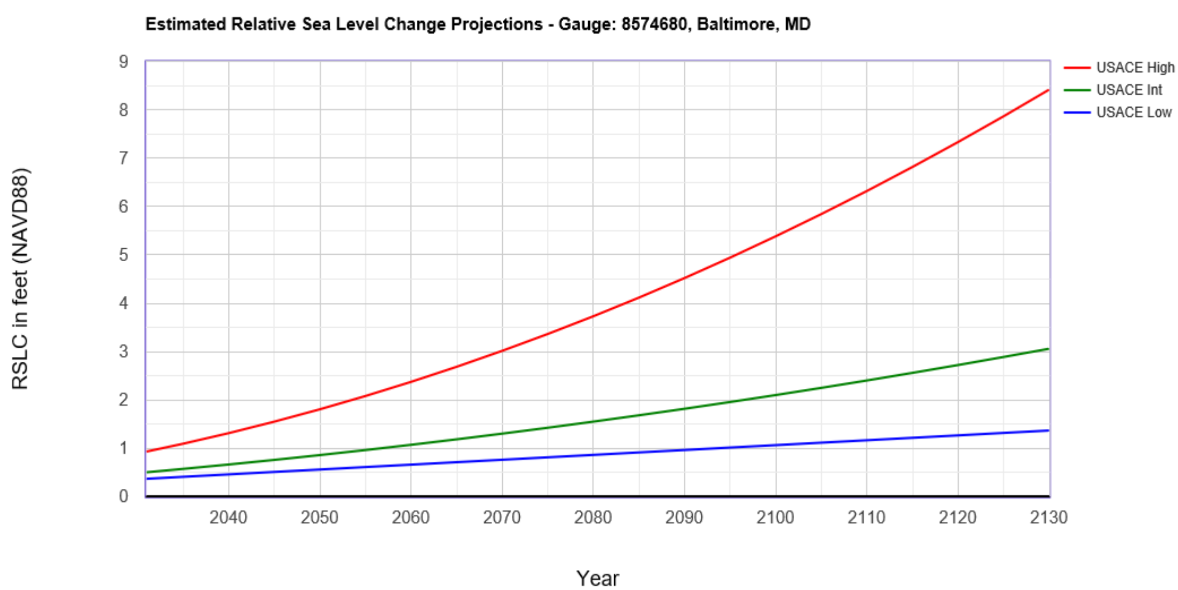

Figure 2-6. Sea Level Change Projections for Baltimore Harbor, 2031 to 2130

Details of the SLC scenarios are described in Appendix B: Hydrology and Hydraulic Analysis.

Below in Figures 2-7 and 2-8, the NOAA SLR Viewer was used as a tool to evaluate and understand what the effects of SLR would look like in the Baltimore Harbor and MSA study areas. Inundated areas are in blue, with deepest areas dark blue and a gradation to shallower areas shown in lighter blues. Areas in green are low-lying. The NOAA SLR viewer is a preliminary analysis and can be used for feasibility studies. The maximum observed water level for Baltimore was at 6.49-feet mean higher high water (MHHW) or 5.67 feet NAVD88 during Hurricane Isabel on September 19, 2003. Figure 2-7 shows inundation of the Baltimore Harbor area with WSEL of 4 feet MHHW (which is approximately 4.82 ft NAVD88) and 7 feet MHHW (which is approximately 7.82 NAVD88) mapping. These mapping represents approximate limit of inundation during a regular day in year 2030 for intermediate and high USACE scenarios. Similarly, Figure 2-8 represents inundation in MSA and surrounding area.

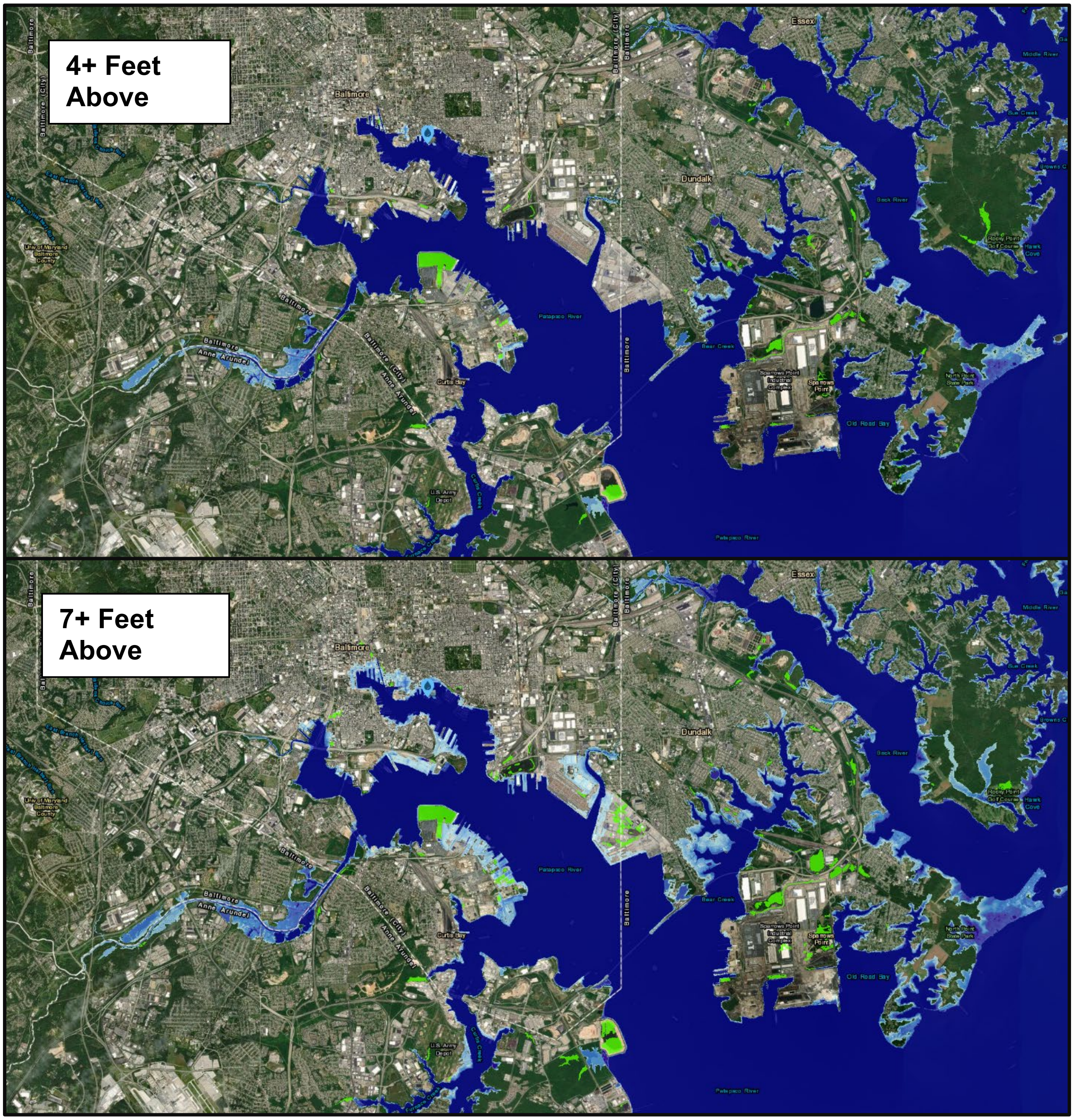

Figure 2-7. Sea Level Rise Viewer of Baltimore Study Area

The top figure shows the Baltimore Study Area at MHHW +4 feet of Sea Level Rise.

The bottom figure shows the existing water level at Mean High Higher Water +7 feet (epoch: 1983-2001) (NOAA 2022).

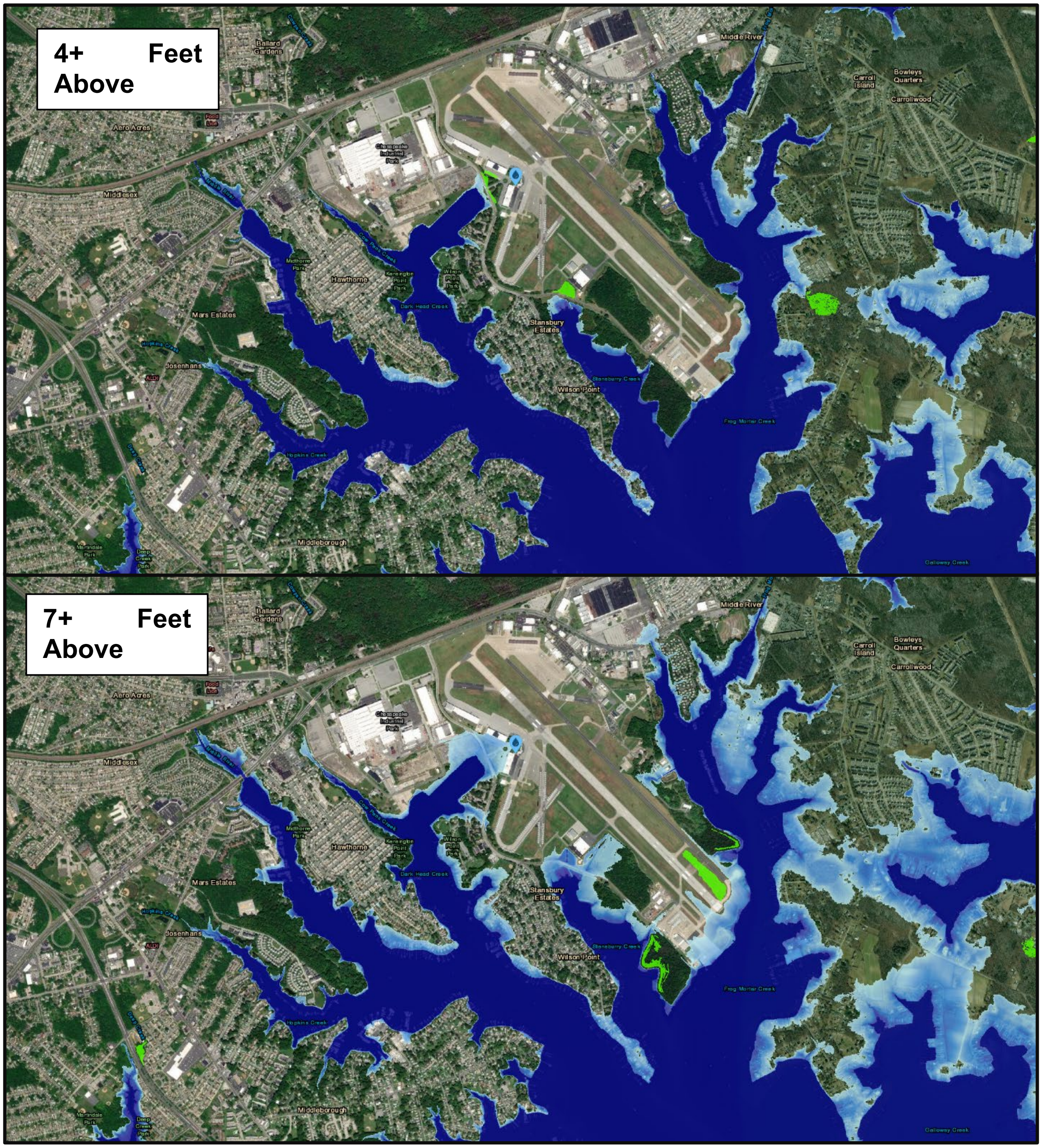

Figure 2-8. Sea Level Rise Viewer of Martin State Airport Area

The top figure shows the Martin State Airport Area at MHHW +4 feet of SLR.
The bottom figure shows the existing water level at Mean High Higher Water +7 feet (epoch: 1983-2001) (NOAA 2022).

2.4.13 Cultural Resources

2.4.13.1 Existing Conditions

This section identifies and describes the cultural resources within the study's area of potential effects (APE) that are either eligible for or listed in the National Register of Historic Places (NRHP).

Cultural resources are locations of human activity, use, or occupation. They can be defined by expressions of human culture and history in the physical environment such as prehistoric or historic archaeological sites, buildings, structures, objects, districts, sacred sites, among others. Cultural resources may also include natural features, plants, and animals that are deemed important or significant to a group or community. It is important to note that historic properties, as defined by 36 CFR Part 800, the implementing regulations of Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, are cultural resources that are eligible for or listed in the NRHP. Additionally, to be considered a historic property, the resource must possess at least one of the following significance criteria:

- Association with events that have made a substantial contribution to the broad patterns of our history; or,
- Association with the lives of persons substantial in our past; or,
- Embodiment of the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic value, or that represent a substantial or distinguishable entity whose components may lack individual distinction; or,
- Have yielded, or may be likely to yield, information important in prehistory or history.

A historic property must also possess enough integrity to portray its significance. A resource that retains integrity will embody several, and usually most, of the seven aspects of integrity:

- *Location* is the place where the historic property was constructed or the place where the historic event occurred.
- *Design* is the combination of elements that create the form, plan, space, structure, and style of a property.
- *Setting* is the physical environment of a historic property.
- *Materials* are the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property.
- *Workmanship* is the physical evidence of the crafts of a particular culture or people during a given period in prehistory or history.

- *Feeling* is a property's expression of aesthetic or historic sense of a particular period of time.
- *Association* is the direct link between an important historic event or person and a historic property.

Section 106 of the NHPA requires consultation with the SHPO, federally recognized Native American tribes, and other interested consulting parties for proposed federal actions that may affect historic properties. The MHT is designated as the SHPO for Maryland. CENAB initiated Section 106 consultation via letter dated February 3, 2022, with MHT, Baltimore City Commission for Historical and Architectural Preservation, Baltimore County Department of Planning, Delaware Nation, Delaware Tribe of Indians, and the Seneca-Cayuga Tribe of Oklahoma (Appendix H). Throughout 2022 and 2023, consultation focused on the development of a PA for the project, with NPS added as a consulting party on June 30, 2022.

As part of Section 106 consultation, a preliminary APE was defined to identify any potential historic properties that could be affected by the proposed project alternatives. The preliminary APE includes those areas where direct impacts are proposed and areas within which the undertaking may directly cause alterations in the character or use of historic properties, including visual effects. For this project the preliminary APE includes construction areas of proposed floodwall, any associated staging areas, properties proposed for nonstructural measures, and the viewsheds of any nearby historic properties. Due to future voluntary participation in the non-structural projects, and pursuant to 54 U.S.C. 306108 and 36 CFR 800.14(b)(1)(ii), further evaluation of historic properties will occur prior to construction. A PA with the MD SHPO was executed on January 30, 2024, and all terms and conditions included in the PA shall be implemented in order to minimize adverse impacts to historic properties (Appendix G).

Additionally, Section 110(f) of the NHPA requires that Federal agencies, to the maximum extent possible, minimize harm to any National Historic Landmark (NHL) that may be directly or adversely affected by an undertaking.

2.4.13.1.1 Cultural Contexts

Precontact Cultural Context

In brief, the prehistoric cultural sequence for Maryland generally conforms to that defined for other areas in the Middle Atlantic region, although there was some divergent regional development in later prehistory. This sequence can be divided into seven periods: Paleoindian (9000 Before Common Era (BCE) to 8000 BCE), Early Archaic (8000 BCE to 6500 BCE), Middle Archaic (6500 BCE to 3000 BCE), Late Archaic (3000 BCE to 1200 BCE), Early Woodland (1200 BCE to 300 Common Era (CE)), Middle Woodland (300 CE to 1000 CE), and Late Woodland (1000 CE to 1600 CE).

The earliest convincingly attested occupants of the Middle Atlantic region were Paleoindian hunters, who entered the region around 11,000 BCE (Dent 1999; Gardner 1974). The Paleoindians arrived at a time of abrupt climate changes at the end of the Wisconsin glacial, as spruce-dominated boreal vegetation was replaced by northward expansion of deciduous trees, and large mammals migrated to new ranges or were driven to extinction. The diagnostic Paleoindian artifact is the basally fluted, lanceolate Clovis point; typically, associated tools include scrapers and gravers for working hides and bones. In the high Plains of the western United States, Clovis points have been found at kill sites alongside the skeletons of mammoths, but east of the Mississippi, there is no unequivocal evidence of mammoth or mastodon hunting by Eastern Paleoindians, even though radiocarbon dates show that mastodons and other Pleistocene megafauna persisted in the East at least as late as 10,800 BCE. Bone is usually very poorly preserved on Eastern Paleoindian sites; the few odd bits of identifiable calcined bone that have been recovered indicate hunting of caribou or other cervids by the more northern bands; deer may have been a staple in the diet of more southern groups. Finds at the Shawnee-Minisink site in the upper Delaware Valley show that the Paleoindian diet also included fish as well as berries and fruits (Dent 1999; McNett 1985). Population density must have been very low, perhaps on the order of 0.0125 to 0.0250 persons per square mile (Turner 1989:84). State files record about 120 surface finds of fluted points in Maryland, the great majority of them from the Coastal Plain. Most of the rest were found along the Potomac. The Eastern Shore contains an astonishing number of Paleoindian points as well as Early Archaic material, mostly manufactured on local pebble jaspers (Lowery 2005-2006). On the Western Shore at the Higgins Site (18AN489) in Anne Arundel County, Paleoindian point fragments were found in subsurface contexts (Ebright 1992).

Occupation and land use throughout the Paleoindian period in the Middle Atlantic region appears to have consisted of small, highly mobile bands following major drainage systems, with a notable absence along the central spine of the Appalachians (Lane and Anderson 2001). Sites are often found on high terraces and upland bluffs in stream valleys and near wetland basins. Site types for the Paleoindian period include base camps, quarry sites, quarry reduction stations, quarry-related base camps, base camp maintenance stations, and outlying hunting stations, though Paleoindian sites often consist of isolated projectile point finds. The largest and most intensively used sites have been found near high-quality lithic resources. Unlike later populations, Paleoindians made limited use of caves and rock shelters, apparently preferring open-air locations (Custer 1989; Gardner 1974; Walthall 1998).

After 9,500 BCE – the end of the Younger Dryas, marked by abrupt warming – the regional population seems to have rebounded rapidly. A marked stylistic change is evident in the projectile points of the early Archaic (9500 to 8000 BCE); they begin to be notched near the base, either in the sides or the corners, instead of basally thinned. The meaning of this change in hafting technique is unclear. Because the spear thrower or atlatl was probably already used by Paleoindians, the new point styles cannot indicate its introduction, as was formerly speculated (Gardner 1974). Side notching seems to be slightly earlier than corner notching (Kimball 1996); radiocarbon dates of circa 10,200 to 10,000 radiocarbon years before present (rcbp) are associated with side-notched forms in Alabama and Florida. At the St. Albans Site in West Virginia, a Kessell Side-Notched point came from one of the deepest levels (Broyles 1971). Side-notched Taylor, Warren, and Big Sandy points may be comparably early, but few radiocarbon dates for these types are available. In any case these points seem to be rare in Virginia and northward. Corner-notched Palmer points, which are much more common in this area, seem to be of about the same age as Kessell points (circa 9500 to 9000 BCE). Corner-notched Charleston, Kirk, and Amos types date to about 9000 to 8000 BCE. Although high-quality lithic materials were preferred for points and other tools, Early Archaic groups also began to exploit local stones, such as quartz and quartzite, and rhyolite was obtained from the Catoctin area to make some Kirk points (Custer 1990). Throughout the Middle Atlantic region, Early Archaic sites, which frequently occur on large river terraces or upland surfaces, are more numerous than Paleoindian sites (Johnson 1986); "...literally thousands upon thousands of Palmer projectile points alone exist in private and public collections from Virginia" (Turner 1989:79). Lowery and local avocational archaeologists have collected many Early Archaic points along the Eastern Shore of the Chesapeake (Lowery 2005-2006).

The Middle Archaic cultural period roughly corresponds to the Hypsithermal, a climatic episode marked by rising temperatures, decreasing precipitation, and the development of a more seasonally variable climate. The warmest temperatures of the entire Holocene actually occurred at the beginning of this period, around 7500 BCE. An oak-hemlock-hickory forest dominated the region, and deer became the dominant large mammal. The growing human population changed its subsistence- settlement patterns. Sites are larger and more numerous, and a more diverse toolkit implies a broader range of subsistence activities than in the Early Archaic. During the Middle Archaic period sites began to appear in locations that had been previously ignored, such as upland swamps and interior ridgetops (Gardner 1987); however, base camps were still located primarily in the floodplains of major drainages. The appearance of new tool types specifically designed for woodworking, seed grinding, and nut cracking (e.g., axes and adzes, mauls, grinding slabs, and nutting stones) and the location of sites in previously unutilized locations indicate an increasing reliance on plants for food and construction materials.

During the Middle Archaic period, procurement of high-quality lithic material was no longer an important component of the settlement pattern as most artifacts were manufactured from locally available lithic materials. One indicator of this trend is the abandonment of the jasper source at Flint Run in the Shenandoah Valley (Gardner 1974). This change may reflect increasing circumscription of band territories as a growing population filled in available environments and their movements became restricted. A noteworthy technological change is the shift from carefully made and curated unifacial scrapers of the Early Archaic to the expedient tools found in Middle Archaic and later assemblages (Gardner 1989).

There is a very sharp break in material culture and settlement patterns at 2200 BCE, when the Savannah River broadspear complex replaces Halifax in the Potomac Piedmont. This cultural transition closely coincides with a pan-continental, possibly even global "megadrought." Gardner, in his various regional syntheses, set the Middle to Late Archaic transition at 2500 bc; his Late Archaic I encompassed the Savannah River complex, and Late Archaic II was equivalent to Susquehanna Broadspear. Rather than lump together the very different small-point Halifax and Broadspear complexes, it makes more sense to regard 2200 BCE as dividing the Late Archaic from the subsequent Terminal Archaic. Thus, both Savannah River and Susquehanna Broadspear complexes (2200 to 1200 BCE) will be referred to here as Terminal Archaic. This is preferable to the alternative term "Transitional" because the steatite bowls of this period are apparently not precursors of ceramic vessels (Sassaman 2006); furthermore, there are no attested incipient proto- horticultural practices in this period.

During the Late Archaic period (5000 to 2200 BCE) groups that manufactured Halifax points maintained a "sylvan" adaptation (Mouer 1991) to the eastern deciduous forest, focusing on nut- bearing trees. Deer and turkey probably provided most of the meat in their diet. Piedmont Archaic sites in Albemarle County, Virginia, are strongly associated with soils that are best suited to support nut-bearing hardwood trees (Mouer 1991, citing Holland 1978). In Virginia's Powhatan, Goochland, and Cumberland counties, Middle and Late Archaic sites cluster on the upper and middle terraces of the James River, while Terminal Archaic and Woodland sites (after 2200 BCE) generally are found on the floodplain (Mouer 1991:5).

A major change in settlement pattern is associated with the appearance of Savannah River points, which mark the onset of the Terminal Archaic period. These large, broad-bladed stemmed points were typically made of quartzite. It is not certain if they were used as projectile points or as specialized knives for fish processing or for some other task. Although broadspear points are sometimes found in ritual mortuary contexts, they apparently were utilitarian objects, as shown by occasional breakage and edge attrition.

The widespread appearance of broadspear points at about 2200 BCE has been interpreted alternatively as indicating the rapid adoption of an innovative weapon or processing tool by indigenous populations (Custer 1991), or as the marker of rapid intrusive expansion northward by a population originating in the coastal plain of Georgia and the Carolinas (Mouer 1990). The evidence of a radical change in settlement and subsistence patterns circa 2200 BCE is more consistent with the intrusion/migration hypothesis. It is probably not a coincidence that the spread of this new tool type is contemporaneous with a global climate event that was manifested as a centuries-long “megadrought” in North America and elsewhere (Booth et al. 2005). This abrupt change may have destabilized the local culture and thus facilitated northward expansion by the broadspear makers. The latter had previously adapted to the estuarine environments of the southern coast, newly created circa 4000 BCE as the rate of sea-level rise slackened. Recent renewed investigations at the Stallings Island Site on the Savannah River in Georgia have shown that the people (locally known as the Mill Branch phase) who made Savannah River broadspears from metavolcanic stone began to collect shellfish at about 4200 rcbp (2600 BCE) (Sassaman et al. 2006).

Terminal Archaic populations seem to have been much more numerous than their Late Archaic predecessors. Although some upland sites are known, most occur in riverine settings. Large sites ranging in extent from 0.5 acre to more than 5 acres, probably representing macroband encampments to exploit seasonal fish spawning runs, are known in the James River Piedmont and Coastal Plain. Smaller sites about 5,000 square feet in size, which may represent single band camps, are a more common site type in the Piedmont; very small microband camps are also known (Mouer 1991).

Apart from broadspears, Terminal Archaic assemblages include two other significant new artifact types: grooved groundstone axes, which replace earlier chipped-stone forms, and carved soapstone (steatite) bowls. Soapstone was quarried in the Piedmont of Virginia, Maryland, and Pennsylvania (Luckenbach et al. 1975). W.H. Holmes (1897) recorded quarries within present Washington, D.C., at Rose Hill on Connecticut Avenue, and in Fairfax County, Virginia, at the Clifton, Holmes Run, and Falls Church sites. Vessels were carved at the quarries and transported in finished form, probably by canoe. Soapstone pots were clearly used for cooking, but it is not yet known which foods (fish, meat, seeds, tubers, or nuts) were processed in them, or why such containers suddenly became necessary or desirable. Soapstone vessels apparently were not part of the Savannah River complex; they seem later, with radiocarbon dates on external soot residues clustering between 3700 and 2800 rcbp, coeval with the Susquehanna Broadspear complex (Sassaman 2006). The use of ceramics preceded manufacture of soapstone vessels along the lower Savannah River; however, the earliest ceramic pots in the Middle Atlantic seem to be imitative of soapstone pots.

The Early Woodland began with the adoption of ceramic technology in the Middle Atlantic region. The earliest modeled clay vessels of the Marcey Creek type (circa 1200 to 800 bc, 1450 to 1000 BCE) imitated the shapes of flat-bottomed soapstone pots, including lug handles, and were even tempered with bits of soapstone. A brief period of experimentation with ceramic technology ensued, resulting in creation of several new types. Flat-bottomed vessels resembling Marcey Creek ware, but tempered with grit or sand instead of soapstone pieces, were produced in Delaware (Dames Quarter type) and on the lower Potomac (Bushnell Plain type) by 1000 bc or earlier. Bushnell Plain ware is associated with 14C dates of 1110±75, 1160±70, and 1070±70 bc (circa 1400 to 1300

BCE) at the White Oak Point Site (Waselkov 1982a and b). Selden Island ceramic vessels (1000 to 750 bc), although steatite-tempered like Marcey Creek ware, were conoidal and were constructed by coiling (Slattery 1946). These attributes (probably imitative of basketry prototypes) are characteristic of pottery in the Northeast and interior Piedmont. Accokeek pottery is a thin-walled, cord marked, sand or grit-tempered, conical or round-bottomed ware, found in the Potomac basin from circa 800 to 300 BC (1000 to 400 BCE). Similar ceramics from the James River Piedmont have been classified as Elk Island 1 and 2 (900 to 600 bc, 1100 to 800 BCE) (Egloff and Potter 1982; Mouer 1991). Elk Island 3, estimated to date to 600 to 200 bc (800 to 200 BCE), is characterized by ceramics that appear to be transitional to Popes Creek wares and by points resembling Rossville and Adena types.

Early Woodland sites are often located along the tidal creeks that feed into the Potomac. Marcey Creek sites appear to represent short-term camps of small bands in riverine settings in the Piedmont and Fall Line zones. The Selden Island type site on the Potomac was a large site with probable storage pits indicative of an occupation of some duration. An Accokeek component at the 522 Bridge Site in Front Royal, 14C-dated to circa 900 bc, includes storage pits, pieces of burnt daub, and traces of nine oval houses. Flotation of pit contents yielded carbonized seeds of amaranth, Polygonum, mustard, and grape (all wild plants). Large Elk Island sites seem to represent semi-permanent villages in the floodplain; smaller foray camps, used while harvesting nuts and hunting deer and turkey, occur in upland and Inner Coastal Plain settings (Mouer 1990, 1991). Small Savannah River points, Calvert points, and forms reminiscent of the Orient Fishtail type of New York and the Delaware Valley are found in association with Marcey Creek pottery, demonstrating the in-situ transformation of Terminal Archaic into Early Woodland cultures. Point types associated with other Early Woodland ceramics include Piscataway/Rossville, Teardrop or ovoid, Calvert, and possibly Clagett and Vernon. At White Oak Point, Calvert points were associated with Popes Creek ceramics (Waselkov 1982a).

During the Middle Woodland the regional population grew as bands became more sedentary and participated in regional exchange networks. Continuity in site location between the Early and Middle Woodland periods implies that earlier subsistence-settlement systems persisted. Early Middle Woodland groups in the northern Virginia Piedmont appear to have been mobile, exploiting diverse and dispersed resources, but focusing on riverine environments. The number of sites in the Maryland Piedmont increases between ad 300 and 900, but they are more dispersed (Kavanagh 1982). The eastern Piedmont may have been utilized seasonally as part of the settlement round of groups based in the Coastal Plain (Stewart 1992:15). Potter (1982, 1993:142) sees evidence of concentration of a growing population into large semi-sedentary villages, with intensified oyster harvesting, represented by middens such as Boathouse Pond (Site 44NB111) on the Northern Neck around 700 CE.

Around 1000 CE maize horticulture was adopted by many Middle Atlantic groups. Although actual remains of cultigens are very rare, inception of maize cultivation in the Piedmont Potomac is inferred from skeletal evidence (Chase 1988) and settlement patterns, which show that Late Woodland sites are located in floodplains of higher-order streams and adjacent to high-yield agricultural soils (Hantman and Klein 1992). Hunting, gathering, and fishing provided important dietary supplements; in fact, groups occupying the Coastal Plain may have relied very little on cultivated crops. Storage of surplus crops permitted the establishment of small permanent hamlets and larger villages. Prior to 1300/1400 CE, settlements were not stockaded, suggesting that inter- and intra-group hostilities did not play a significant role in the settlement pattern (Stewart 1993:171- 173).

Around 1300 to 1400 CE throughout the Middle Atlantic region, population density increased, nucleated settlements and stockaded villages were established, and there is evidence of population movement and displacement (Stewart 1993:172-173). Palisaded villages have been excavated both on the lower Potomac (e.g., Piscataway Creek [Stephenson and Ferguson 1963] and Patawomeke on Potomac Creek in Stafford County [Blanton et al. 1999]) and on the mid-Potomac (e.g., Gore Site, Shepard Barracks, and Hughes Site) (Slattery and Woodward 1992). The Cumberland Site (18CV171) on the lower Patuxent was also palisaded; it dates to about 1300 to 1600 CE (Reeves n.d.).

The changes in cultural patterns observed throughout the Middle Atlantic region may have occurred in response to climatic changes. The Late Woodland corresponds to the Scandic and Recent climatic episodes. Stewart (1993:165) notes that the period between 1000 CE and 1200 may have been characterized by increased dryness (the Medieval Climatic Optimum), whereas cool-moist to cool- dry conditions prevailed between ad 1300 and 1800 (the Little Ice Age). Climatic changes may have resulted in decreased agricultural productivity and a concurrent increase in the availability of game animals (Gardner 1986:88; Walker and Miller 1992). A greater reliance on hunting may have aggravated competition for hunting territories, but more importantly, the increasing population and reduced agricultural productivity would have exacerbated competition for arable land (Custer 1986:135-136). On the Northern Neck of Virginia, it seems that the initial response to arid conditions and concomitant introduction of agriculture, around ad 900 to 1000, was abandonment of the large late Middle Woodland villages. Large villages were not occupied again until ad 1300 (Potter 1993:142).

The dramatic increase in the number of small villages and the deep cultural deposits and numerous storage pits found at these sites suggest that Late Woodland populations were not only sedentary but were also expanding both spatially and in absolute numbers. In response to population growth, establishment of sedentary villages, and availability of food surpluses, more complex sociopolitical structures developed during this period. Thus, the middle Late Woodland period (around ad 1300) is characterized by the emergence, or in some cases the reappearance, of ranked societies. These ranked societies developed into the complex tribes and chiefdoms encountered by the Europeans in the late sixteenth and early seventeenth centuries (Potter 1993; Turner 1976).

2.4.13.1.2 Historic Context

Colonial Maryland

Spanish, Portuguese, and French sailors explored the Middle Atlantic coast for several decades, beginning with Gordillo's slave raid in South Carolina in 1521. Verrazano stopped at the mouth of the Chesapeake Bay in 1524. The Spaniards made an abortive attempt to set up a Jesuit mission at the foot of the bay, perhaps at the mouth of the York or the James, in 1570 (Kraft 1989). The ill-fated English colonists at Roanoke made contact with Accomac villages on the Eastern Shore of Virginia in the 1580s. In 1608 Captain John Smith explored the northern reaches of the bay. At the mouth of the Susquehanna, he encountered the Iroquoian-speaking Susquehannocks, whom he described as giants. The Susquehannocks were already well equipped with European trade goods, obtained from the French in Canada. They had been expanding southward since around 1575 to gain control over trade routes. Pressure from these intruders probably accounts for the apparent abandonment of the western shore of the Chesapeake, north of the Patuxent's mouth, by the native Algonquian speakers. Smith's 1624 map shows this area as conspicuously vacant. Smith appears to have explored as far as the headwaters of the Patapsco River (the river called "Bolus flu." on his map) without encountering any native settlements. The Susquehannocks remained a force to be reckoned with in the region until 1652, when under pressure both from the English and rival Iroquois tribes, they withdrew from the western shore of the Chesapeake (Bedell et al. 2008).

In 1634, 140 Catholic and Protestant settlers settled at the mouth of the Potomac. The colony was under the control of the Calvert family, which established the settlement under grant from the English crown. Cecil Calvert, Lord Baltimore, named the colony Maryland, allegedly after a Stuart princess but actually a subtle advertisement for the Calverts' Catholic faith. The Calverts initially set up a system of feudal land tenure in which they retained the actual ownership of all the land but allowed others to become tenants with very low ground rents. They hoped, it seemed, to recreate the manorial society of England; however, the economy that developed in Maryland was quite different. Most of the Calverts' tenants focused on growing tobacco for export, and in the 1640 to 1670 period this trade was highly profitable. Initially the workforce was made up primarily of indentured servants from England, most of them young men. In the rapidly expanding tobacco economy of the 1640 to 1670 period, many of these men were eventually able to acquire their own farms and set themselves up as independent yeomen (Carr et al. 1991). The plantations of these "ordinary planters" gradually spread across the Tidewater landscape. Rather than a manorial land in which a mass of poor people labored under a privileged few, Maryland in the 1660s was a relatively open society of small farmers, “a good poor-man’s country” (Bedell et al. 2008; Carr et al. 1991:15). Because their economic focus was on growing tobacco for export, English settlement in Maryland and Virginia initially spread out along the rivers and creeks. Most people lived on separate plantations, each with its own dock or landing, and towns were slow to develop. The first roads were “rolling roads” down which hogsheads of tobacco could be rolled to a landing place and loaded on ships (Bedell et al. 2008).

Meanwhile, civil war had broken out in England between the king and his allies, who included almost all of Britain’s Catholics, and the strong Protestant faction that controlled Parliament. In 1649 the Protestant Parliamentarians sealed their victory by executing the king, and they instituted political and religious reforms that threatened the Calverts’ position. To secure the Maryland colony, Cecil Calvert took several measures with important consequences for Maryland. In 1649 the Maryland General Assembly enacted “An Act Concerning Religion,” which legislated some degree of religious protection to all Christians. Calvert replaced the Catholic Acting Governor, Thomas Greene, with the Virginia Protestant, William Stone, with the understanding that Stone would help populate his colony. Stone approached a group of nonconformist Virginia Puritans and offered them land and guaranteed freedoms in Maryland. In December 1649 the Puritans established their settlement on the north shore of the Severn River, opposite present-day Annapolis. It was called Providence (Bedell et al. 2008).

However, Maryland’s religious and political troubles did not end in 1650. The Puritans at Providence found Maryland’s government too royalist and Catholic for their taste, despite Cecil Calvert’s compromises, and they tried to institute a revolutionary government in Maryland on the model of the one in England. Calvert ordered Governor Stone to suppress them. Stone led a ship-borne force to the mouth of the Severn in March 1655, but the Puritans decisively defeated him and gained temporary control over the whole colony. The Puritans repealed the “Act Concerning Religion” and passed a new law banning Catholics, Quakers, and all other non-Puritans. This was too extreme even for Oliver Cromwell, England’s new Puritan leader, and in 1657 he brokered a compromise under which the Calverts regained control of the colony, and their policy of religious toleration was confirmed (Bedell et al. 2008; Read 1993).

In 1661 Lord Baltimore sent his son, Charles Calvert, to serve as Maryland’s governor, and a period of political quiet followed. When Lord Baltimore died in 1675, Charles Calvert became the Lord Proprietor, the only one ever to reside in the colony. He held this office until he was displaced by further political troubles. In 1685 Oliver Cromwell died, and the executed king’s son assumed power as James II. James was a Catholic, and England’s remaining Catholic nobles were among his strongest supporters. However, in 1688 Parliament overthrew James and put Protestants William and Mary on the throne. The Calverts did not overtly oppose William and Mary, but neither did they move quickly to support the new rulers. William annulled the Calvert Charter and declared Maryland a royal colony. The Calverts' government had actually already been overthrown by a group of Protestant planters who called themselves the "Associators," who governed Maryland on their own authority until a royal governor arrived. One of the first acts of the new government was to make the Church of England the official church of the colony, supported by mandatory church taxes, and to strip Catholics and Quakers of their political rights. In 1694 the capital of the colony was moved from St. Mary's City, with its Catholic associations, to the Puritan stronghold on the Severn River. This new capital was named "Anne Arundel Towne." In 1695 the town was renamed "Annapolis" in honor of then Princess Anne, daughter of Queen Mary. Annapolis became the economic, social, and political center of the colony and remained the capital and seat of government when statehood was achieved on April 28, 1788. The Calverts regained their title to Maryland in 1715, but the price was recognition of the power of the Protestant majority in the colony; by that time Catholics made up no more than half of the population (Bedell et al. 2008).

While attention was focused on these political and religious struggles, economic and social changes were transforming the colony in a more profound way. After 1670 the Chesapeake economy entered a period of stagnation. Prices for tobacco fell, and the volume of exports ceased to grow. As a result, opportunities for landless young men were greatly reduced. Word of the change made it back to England, where times were comparatively good, and after 1670 fewer Englishmen came to the colony. Their place in the labor force was more and more taken by enslaved Africans. When the Maryland economy began to grow again after 1710, the larger plantations were primarily worked by slaves. The stabilization of the population and the increasing number of slaves made possible the growth of a native gentry in the colonies. In the eighteenth century the owners of slave-run plantations began to invest the profits of reviving trade in grand houses and the other accoutrements of fine living, and something like the elite-dominated society originally imagined by Lord Baltimore actually developed.

During the second half of the seventeenth century, the Maryland General Assembly began to create new counties as the population expanded. Anne Arundel County was formed in 1650, Baltimore County was established by 1660, Prince George's County was formed from portions of Calvert and Charles counties in 1695, Montgomery County was formed from part of Frederick County by 1775, and Allegany County was formed from Washington County in 1789. In addition, what would become the City of Baltimore was initially established by French settlers circa 1750, subsequently expanding in size until its formal incorporation in 1796.

Rural Agrarian Intensification

Baltimore's geographic location influenced the economic development of the upper Chesapeake, and the city gradually came to dominate the economic life of the region. The emergence of a diverse regional economy assured the town's role as a mercantile manufacturing and shipping center. During this period, the upper Chesapeake Bay economy included agriculture, mining, and the procurement of other natural resources such as lumber. As eighteenth-century farmers in western Maryland and southern Pennsylvania cultivated grain for export, Baltimore became a major shipping center. International and domestic trade fueled Baltimore's growth during this period. Merchants, sea captains, and shipbuilders bought property lots and constructed homes and businesses along the city's waterfront. The shoreline was extended, and wharves and piers were built to accommodate larger ships. By the mid-eighteenth century, Baltimore Town recorded a population of 200 and contained 25 dwellings, a church, two taverns, a potter, and a distiller (Papenfuse et al. 1976). By 1758, the town had become such a regional center that the county seat was once again relocated there from Joppa Towne (Ruckert 1976).

The American Revolution added more fuel to the economy of the Patapsco region. Residents supported the war effort by opposing the Townshend Acts and forming a local militia in 1774, by forging cannon and munitions for the American armies, and by outfitting vessels for the Continental Navy (Papenfuse et al. 1976). The commercial and economic boom caused by the war attracted new residents to the area, especially to Baltimore. Exiled Acadians, German, Scottish, and Irish immigrants swelled the town's population. African-Americans, both enslaved and free, also comprised a significant proportion of Baltimore's population (Goldfield 1991). Merchants, millers, and manufacturers became the city's social and economic elite.

The economic boom generated during the American Revolution continued after the war. In 1798, the value of Baltimore's exports exceeded $121 million (Ruckert 1976). By 1799, the city had become the third largest commercial port in the United States (Hall 1912). By 1804, 50 gristmills within an 18-mile radius of the city were producing flour for export (Bieme 1968). During the War of 1812, the upper Chesapeake became a target of British incursions. British vessels patrolled the Chesapeake waters, and British troops ransacked plantations and burned towns along the shorelines of the Chesapeake Bay (Miller 1949).

Agricultural to Industrial Transition

Baltimore City's growth was accelerated by its role in the American Revolution and the War of 1812 and continued at a rapid pace in the following years. From an original population of 200 in the mid-eighteenth century, Baltimore's population increased to 13,500 by 1790 and eventually to 26,500 by 1800. In 1840, there were 102,313 people living in the city and only 32,066 residing in the remainder of the county.

Between the War of 1812 and the end of the Civil War, industry and commerce were central components of the Baltimore region's economy. Sugar refineries, fertilizer plants, and cotton textile factories produced products for export markets. The shipyards made famous during the American Revolution and the War of 1812 were replaced by coal yards, lumberyards, and oyster and vegetable canneries.

After the War of 1812, as tobacco became increasingly less profitable, farmers in the region turned to producing other agricultural commodities, especially grain (Ballweber 1988). Farming and fishing remained the primary occupation of most residents living in the rural areas surrounding the city of Baltimore. Baltimore's superior transportation facilities propelled the city's nineteenth century economic development, which was based on the agricultural output from rich fruit orchards and truck gardens of locales like the Patapsco and Bush River necks (Brooks and Rockel 1979).

The American Civil War temporarily interrupted the region’s economy. When the war began in 1861, the loyalties of Maryland's citizens were divided, because some of the large landowners owned slaves, while others violently opposed slavery or did not want to leave the Union. Such divided loyalties produced turmoil in and around Baltimore near the beginning of the war, particularly as Union troops were transported by rail through the county in route to action farther south.

There were limited armed encounters in the Baltimore area during the Civil War, with one exception. In 1864, following the Union defeat at the Battle of Monocacy, Confederate cavalry, under the command of General Bradley Johnson, conducted guerilla operations around Baltimore. One of their objectives was to sever the lines of communication that linked Baltimore and Washington with cities north. Major Harry Gilmore was ordered to capture the Baltimore Express train at Magnolia Station, located on the north part of Gunpowder Neck, just north of the Baltimore County border. After capturing the train, Gilmore's Confederate troops set fire to it and placed the train on the railroad bridge over the Gunpowder River, effectively destroying both the train and the bridge (Grandine et al. 1982).

Industrial/Urban Dominance

Once the Civil War ended and transportation routes were reestablished, the Baltimore region resumed its commercial expansion; however, while industries expanded within the City of Baltimore, the economy of the surrounding rural areas remained largely dependent on agriculture, fishing and commerce in agricultural produce.

New industries developed during this period, including flint mining, flint powder milling, and increased vegetable canning. The canning industry employed large numbers of people and brought significant commerce to the region. Large canneries spurred agriculture in the area, due to the large quantities of fruits and vegetables needed from local farms for processing. Canning allowed larger volumes of agricultural goods to be shipped to markets at a lower price. In addition, the industry was successful because the area railroads could carry the canned goods to important markets, including the nation's largest cities (Grandine et al. 1982).

The expansion and improvement of regional transportation networks and facilities were crucial to supporting the continued industrial and commercial expansion of the urban core.

Many transportation improvements affected the peripheral regions surrounding Baltimore City. The Philadelphia, Wilmington, Baltimore Railroad, established before the American Civil War, continued to play a major role in regional transportation.

Modern Period

During the Modern Period, the economic base of the Upper Chesapeake region shifted, as local manufacturers imported their raw materials from outside the United States rather than obtaining them domestically. Suburbanization continued around Baltimore, and shopping centers and housing subdivisions proliferated outside of the city's boundaries as more middle-class residence moved out of Baltimore City. Suburbanization, particularly the post-World War II increase in motor vehicle traffic, led to significant changes in the region. The area's road networks proliferated, with the interstate highway system providing routes both into and around Baltimore's downtown core.

2.4.13.2 Archaeological and Architectural/Above-Ground Resources

The potential for historic properties within the APE was assessed primarily using MHT's cultural resources information database, Medusa. Information gathered from Medusa included files pertaining to previously mapped archaeological and architectural/above-ground resources within 0.5 miles of the APE. These are listed and discussed in Section 2.4.13.3 below.

CENAB used Medusa to gather existing information on previously identified archaeological and architectural/above-ground resources within 0.5 miles of the APE associated with structural measures. Structural measures and alternatives referenced in this section are presented in Section 3 of this IFR/EA. This information is presented in Tables 2-5 and 2-6, and only resources noted as potentially eligible for, eligible for, or listed in the NRHP, or listed as an NHL, are featured below. No archaeological sites within 0.5 miles of the APE are currently noted as potentially eligible for, eligible for, or listed in the NRHP, or listed as an NHL.

One hundred and three (103) historic properties are located within 0.5 miles of the project alternatives, consisting of individual properties and historic districts; however, many individual archaeological sites or resources contributing to historic districts remain unevaluated for the NRHP. Factoring in unevaluated resources, the total number of resources within 0.5 miles expands to 471. Of the 103 historic properties within 0.5 miles, 31 are within, or in the immediate vicinity of, the currently proposed alternative alignments.

Within the immediate vicinity of Alternatives 4 and 5 are the Locust Point Historic District, the I-95 Fort McHenry Tunnel, and the I-895 Baltimore Harbor Tunnel. These are the only known historic properties within the vicinity of Alternatives 4 and 5, but are also within the vicinity of components included in each alternative. Table 2-5 lists the associated alternative and project component for each historic property. The Locust Point Historic

District is an urban residential area consisting of two- and three-story brick rowhouses, churches, commercial buildings, meeting halls, and intact streetscapes. The district is significant under Criterion A and C for its development as a center of transportation and industry from the 1840s through the 1920s.

I-895 (Baltimore Harbor Tunnel milepost range 2.4 – 3.8) was determined eligible for the NRHP in 2020 under Criterion A for its significant association with twentieth-century automotive transportation improvements in Maryland and the Baltimore region, and Criterion C for its significant engineering design. I-95 (Fort McHenry Tunnel milepost 4.8 – 6.1) has not been formally evaluated for the NRHP, but the ACHP's Interstate Highway System Exemption List notes that it is significant in the area of engineering design since it is the longest and widest vehicular tunnel ever built with the immersed tube method. It is also the first tunnel in the world to have sections with both horizontal and vertical curvature.

Alternative 6 adds and incorporates a floodwall around the Seagirt Marine Terminal. Within the immediate vicinity of this structural measure is the Canton Grain Elevator, Baltimore Municipal Airport Harbor Field, and Western Electric Company Point Breeze Plant Historic District.

The Canton Grain Elevator is a remnant of a larger complex that received, processed, and shipped grain between 1922 and 1994. The complex once consisted of a workhouse, drying house, boiler room, grain storage bins, railroad car shed, and a wharf. The Canton Grain Elevator is recommended NRHP eligible under Criterion A for its association with Baltimore's industrial growth, and under Criterion C for its design and construction.

The Baltimore Municipal Airport Harbor Field operated as Baltimore's major commercial airport in the 1940s and is eligible under Criteria A and C for its contribution to local transportation history and for architectural and engineering innovations.

The Western Electric Company Point Breeze Plant Historic District is a manufacturing complex consisting of large-scale industrial buildings and associated facilities constructed between 1930 and 1970. The company's Point Breeze Plant served as a producer and supplier of telecommunications products and equipment. With nine contributing buildings and nine contributing underpass entrances, the historic district is NRHP eligible under Criterion A for its association with the history of the manufacture of telephone and communications equipment by the Western Electric Company. It is eligible under Criterion C for its predominant display of the Art Deco style.

Alternative 7 adds and incorporates a floodwall and elevated walkway in the Inner Harbor, Fell's Point, and Canton areas. Within the immediate vicinity of this component is the Business and Government Historic District, Federal Hill Historic District, Fell's Point Historic District, Canton Historic District, Seven-Foot Knoll Lighthouse, Pratt Street Power Plant, Baltimore Copper Paint Company, Candler Building, Eastern Avenue Pumping

Station, William G. Scarlett Seed Company South Building, Procter and Gamble Baltimore Plant, and five significant ships. Alternative 7 also adds and incorporates a floodwall at North Locust Point and an elevated roadway at the Martin State Airport. Resources within the immediate vicinity of the Locust Point floodwall is the Procter and Gamble Baltimore Plant and the Fort McHenry National Monument and Historic Shrine. The elevated roadway component at Martin State Airport is wholly within the Glenn L. Martin Airport Historic District. Descriptions of these resources are provided in Table 2-5.

Table 2-5. Archaeological and Architectural/Above-ground Resources within the immediate vicinity of the APE

Historic Property	Description and Significance	Associated Alternative and Component	Distance from Alternative
Business and Government Historic District	The district is a collection of classically influenced governmental and commercial buildings in Baltimore's historic center near the Inner Harbor. It is NRHP listed under Criteria A and C for its association with and embodiment of the economic, commercial, and physical growth of Baltimore.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall and Nonstructural Measures	Less than 500 feet
Federal Hill Historic District	The district consists mainly of nineteenth century rowhouses and an elevated park that was previously a fortified site during the American Civil War. It is NRHP listed under Criterion A for its association with the development of Baltimore.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Resource is within alternative boundaries.
Fell's Point Historic District	The district is a dense development of industrial and commercial buildings and rowhouses that reflect Baltimore's role in shipbuilding, shipping, and food processing from the late eighteenth century through the 1930s. It is NRHP	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall and Nonstructural Measures	Resource is within alternative boundaries.

Historic Property	Description and Significance	Associated Alternative and Component	Distance from Alternative
	listed under Criterion A and C for its association with the early establishment of Baltimore as a center of maritime, industrial, and commercial activity.		
Canton Historic District	The district is a nineteenth and early twentieth century urban-residential neighborhood reflecting over a century of planned development by the Canton Company. It is NRHP listed under Criterion A for its association with Baltimore's industrial development.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall and Nonstructural Measures	Resource is within alternative boundaries.
Seven-Foot Knoll Lighthouse	The lighthouse is a replacement of the original that was constructed in 1856. The present structure, a wrought iron screwpile design, was constructed in the late nineteenth century and represents a historic link to the development of the Port of Baltimore. It is an NRHP listed resource	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet
Pratt Street Power Plant	The Pratt Street Power Plant is a complex of three structures associated with Baltimore's industrial development. It is an NRHP listed resource under Criterion A, B, and C for its association with industrial and transportation history, its affiliation with architects Baldwin and Pennington, and	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet

Historic Property	Description and Significance	Associated Alternative and Component	Distance from Alternative
	its embodiment of Neo-Classical design.		
Baltimore Copper Paint Company	The resource is a three-story commercial building constructed in 1913 to provide office and warehouse space for a manufacturer of marine coatings. It is NRHP eligible under Criteria A for its association with ship construction, and maintenance industries. It is eligible under Criteria C as an example of a type of office and warehouse associated with an early twentieth century industrial enterprise.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet.
Candler Building	The resource is the earliest Baltimore example of an industrial building constructed to offer smaller manufacturers office and work spaced for their products. It is NRHP under Criterion C for its embodiment of an outstanding example of an early type of office building.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet.
Eastern Avenue Pumping Station	The resource is a monumental Classical Revival municipal building constructed in 1910-1911 to process Baltimore's sewage and improve sanitary conditions. It is NRHP eligible under Criterion A for its association with the widespread installation of	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Resource is within alternative boundaries.

Historic Property	Description and Significance	Associated Alternative and Component	Distance from Alternative
	indoor plumbing and modern municipal sewage disposal. It is eligible under Criterion C as an example of a Neoclassical municipal facility.		
William G. Scarlett Seed Company South Building	The resource is a multi-story manufacturing and warehouse building constructed in 1910. It is NRHP eligible under Criteria A and C as the site of one of the oldest seed processing company, and for its embodiment of early twentieth century manufacturing and warehouse structures.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Resource is within alternative boundaries.
Procter and Gamble Baltimore Plant	The resource is an industrial complex consisting of a warehouse and five buildings that housed Procter & Gamble's soap-making operations. It is NRHP listed under Criterion A for its association with Baltimore's industrial development during the early twentieth century.	Alternative 7 – Locus Point North Floodwalls	Resource is within alternative boundaries.
U.S.S. Torsk	The resource is a tench class fleet submarine significant for its role in combatting Japanese forces during World War II. It is an NHL.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet.
U.S.S. Constellation	The resource is a sloop-of-war vessel that was the last all sail ship designed by the Navy. It is an NHL and is NRHP listed under Criterion A for its	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet.

Historic Property	Description and Significance	Associated Alternative and Component	Distance from Alternative
	significance as a turning point in U.S. naval architecture. It is also significant for its American Civil War activities, late-nineteenth century missions, and for its contributions to international relations.		
Chesapeake (lightship)	The resource was constructed in 1930 as a steel-hulled lightship and is significant as one of a small number of preserved American lightships used for navigational aid. It is an NHL and listed on the NRHP.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet.
U.S.C.G. Taney	The resource is High Endurance Cutter of the Treasury Class that saw conflict at Pearl Harbor during World War II. It is listed as an NHL and is significant as the last surviving warship present during Pearl Harbor.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet.
Baltimore (Tug)	The resource was built in 1906 and served as the oldest operating steam tugboat in the United States. It is an NHL and is significant for its role in transportation and boating history.	Alternative 7 - Inner Harbor Elevated Walkway and Floodwall	Less than 500 feet.
Fort McHenry National Monument and Historic Shrine	The resource is an earthen and masonry star fort recognized for its defense of Baltimore against the British during the War of 1812. It is NRHP listed	Alternative 7 – Locus Point North Floodwalls and	Less than 500 feet.

Historic Property	Description and Significance	Associated Alternative and Component	Distance from Alternative
	under Criterion A, B, C, and D for its associations with military engagements and engineering, literature, sculpture, conservation, and archaeological information potential.	Nonstructural Measures	
Glenn L. Martin Airport	The resource is a district consisting of five contributing buildings, one contributing structure, and sixty-eight noncontributing buildings. It is NRHP eligible under Criterion A for its role as a war production installation during World War II, and as an important flight testing and design facility. It is significant under Criterion B for its association with aviation pioneer Glenn L. Martin. It is eligible under Criterion C as an important example of the work of architect Albert Kahn.	Alternative 7 – Martin State Airport Road Elevation and Nonstructural Measures	Resource is within alternative boundaries.
Star-Spangled Banner National Historic Trail	The Star-Spangled Banner National Historic Trail is an approximately600-mile land and water route connecting various sites in Maryland, Virginia, and the District of Columbia that commemorate the events leading up to the writing of “The Star-Spangled Banner” during the 1814 Chesapeake Campaign of the War of 1812.	Alternative 7 – Locus Point North Floodwalls and Nonstructural Measures	Less than 500 feet

Historic Property	Description and Significance	Associated Alternative and Component	Distance from Alternative
Captain John Smith Chesapeake National Historic Trail	The Captain John Smith Chesapeake National Historic Trail is a series of water trails spanning approximately 3,000 miles along the Chesapeake Bay and its tributaries. The National Historic Trail commemorates John Smith's voyages between 1607 and 1609. It also recognizes the interactions between his crew and seventeenth-century American Indian communities and highlights the Chesapeake Bay's natural history.	This is a water-based route that is not directly associated with any alternative.	Greater than 500 feet

2.4.13.3 Potential for Unidentified Cultural Resources

Fifty-two cultural resources investigations have been conducted within 0.5 miles of the project areas (Appendix G); however, only four of these have taken place within currently proposed limits of disturbance. The first was a terrestrial and maritime survey of the nineteenth century Henderson's Wharf Site along the Fell's Point Historic District. No additional archaeological sites were documented during this survey.

The second investigation was a terrestrial and maritime survey of resources associated with the Browns Wharf Site in advance of a redevelopment project. Few intact archaeological deposits were documented, but noted artifacts did include gunflints, spalls, and debitage made from non-local flint sources, and a complete wooden barrel filled with a sticky sand/tar matrix.

The third investigation was a terrestrial survey of an anchorage site along the Canton waterfront. No archaeological sites were documented during this survey.

The fourth investigation was another terrestrial and maritime survey of an anchorage project area along the Canton waterfront. No archaeological sites were documented during this survey.

The remaining investigations are outside of currently proposed limits of disturbance and tend to focus on urban growth projects, such as the industrial development of Baltimore, infrastructure expansion, building redevelopment. Other investigations are focused on the maritime trade, such as investigations of piers and wharfs or submerged resources within the Patapsco River. A review of the investigations and historic maps further supports the enduring history of human occupation in this region, association primarily with the growth of Baltimore. There is still the potential to encounter significant archaeological resources in undisturbed portions of the project area. Additionally, not every building has been formally evaluated for inclusion in the NRHP. Although dependent on final project designs, ground disturbing activities could potentially affect archaeological sites, and above-ground features could diminish the characteristics of historic properties that would make them eligible for inclusion in the NRHP.

Table 2-6. Previously Identified Resources within 0.5 miles of APE

MIHP/Archaeological Site Number	Resource Name	NRHP/NHL Eligibility	Associated Alternative
B-3685	Coca-Cola Company Baltimore Branch	Listed	Alternatives 4-7
B-8	Fort McHenry National Monument & Historic Shrine	Listed	Alternatives 4-7
B-1367	Baltimore & Ohio Locust Point Grain Terminal Elevator	Listed	Alternatives 4-7
B-5223	Locust Point Historic District	Listed	Alternatives 4-7
B-4584	Bridge 8022	Eligible	Alternatives 4-7
B-1343	USS SANCTUARY	Eligible	Alternatives 4-7
B-5094	Naval Reserve Readiness Center, Building 3, Fort McHenry	Eligible	Alternative 7
B-5333	Baltimore Harbor Tunnel	Eligible	Alternatives 4-7
B-4611	S.S. John W. Brown	Listed	Alternatives 4-7
B-5268	Clinton Street Marine Terminal Pier 1	Eligible	Alternatives 4-7
B-985	Canton Grain Elevator	Eligible	Alternatives 6-7
B-5298	Western Electric Company, Point Breeze Plant Historic District	Eligible	Alternatives 6-7
B-3603	Baltimore Municipal Airport, Harbor Field	Eligible	Alternatives 6-7
B-3935	Business and Government Historic District	Listed	Alternative 5-7
B-1400	Little Montgomery Street Historic District	Listed	Alternative 7
B-4112	U.S.S. TORSK (submarine)	Listed	Alternative 7
B-5139	Riverside Historic District	Listed	Alternative 7
B-11	Otterbein Church	Listed	Alternative 7
B-29	U.S.S. CONSTELLATION	Listed	Alternative 7

MIHP/Archaeological Site Number	Resource Name	NRHP/NHL Eligibility	Associated Alternative
B-5313	Union Brothers Furniture Company	Listed	Alternative 7
B-3713	Federal Hill Historic District	Listed	Alternatives 5-7
B-3718	CHESAPEAKE (lightship)	Listed	Alternative 7
B-5092	Federal Hill South Historic District	Listed	Alternative 7
B-79	Howard Street Tunnel	Listed	Alternative 7
B-4222	Seven-Foot Knoll Lighthouse	Listed	Alternative 7
B-1021	Pratt Street Power Plant	Listed	Alternative 7
B-4289	Southern District Police Station	Listed	Alternative 7
B-2934	Leadenhall Street Baptist Church	Listed	Alternative 7
B-36	United States Custom House	Listed	Alternative 7
B-5081	Holy Cross Church Complex	Listed	Alternative 7
B-4200	U.S.C.G. TANEY (WHEC-37)	Listed	Alternative 7
B-1042	Baltimore Copper Paint Company	Eligible	Alternative 7
B-148	Camden Station	Eligible	Alternative 7
B-5286	George Hyde (G.H.) Fallon Federal Building	Eligible	Alternative 7
B-5319	Sheppard Katzenstein Building/Moses Sheppard House	Eligible	Alternative 7
B-5318	U.S. Fidelity and Guaranty (USF&G) Building	Eligible	Alternative 7
B-3687	Merchants & Merchants National Bank, site	Eligible	Alternative 7
B-15	Flag House	Listed	Alternative 7
B-61	St. Vincent de Paul Church	Listed	Alternative 7
B-3691	St. Leo’s Church	Listed	Alternative 7

MIHP/Archaeological Site Number	Resource Name	NRHP/NHL Eligibility	Associated Alternative
B-5098	South Central Avenue Historic District	Listed	Alternative 7
B-3709	Continental Trust Company Building	Listed	Alternative 7
B-3726	United States Post Office and Courthouse	Listed	Alternative 7
B-33	Zion Lutheran Church	Listed	Alternative 7
B-60	Baltimore City Hall	Listed	Alternative 7
B-4293	239 North Gay Street	Listed	Alternative 7
B-3706	Chamber of Commerce Building	Listed	Alternative 7
B-40	Mercantile Trust and Deposit Company	Listed	Alternative 7
B-42	Eastern Female High School	Listed	Alternative 7
B-9	Old Town Friends' Meeting House	Listed	Alternative 7
B-117	Alex Brown Building	Listed	Alternative 7
B-3714	Fells Point Historic District	Listed	Alternative 7
B-3705	Canton House	Listed	Alternative 7
B-1020	Hendler Creamery	Listed	Alternative 7
B-3707	Chizuk Amuno Synagogue	Listed	Alternative 7
B-14	Battle Monument	Listed	Alternative 7
B-4294	Old Town Savings Bank	Listed	Alternative 7
B-3688	Garrett Building	Listed	Alternative 7
B-13	Peale's Baltimore Museum	Listed	Alternative 7
B-16	Shot Tower	Listed	Alternative 7
B-3741	President Street Station	Listed	Alternative 7

MIHP/Archaeological Site Number	Resource Name	NRHP/NHL Eligibility	Associated Alternative
B-3699	Baltimore Branch of the Federal Reserve Bank of Richmond	Listed	Alternative 7
B-1011	Bagby Furniture Company Building	Listed	Alternative 7
B-3994	Gay Street Historic District	Listed	Alternative 7
B-19	McKim’s School	Listed	Alternative 7
B-1002	Candler Building	Eligible	Alternative 7
B-5054	Harford Run Headwall & Drain, under Central Avenue	Eligible	Alternative 7
B-5283	North Gay Street Survey Area	Eligible	Alternative 7
B-2784	Jonestown Historic District	Eligible	Alternative 7
B-1047	Eastern Avenue Pumping Station	Eligible	Alternative 7
B-1099	William G. Scarlett Seed Company (South Building), site	Eligible	Alternative 7
B-5192	Jones Falls Conduit	Eligible	Alternative 7
B-5121	Little Italy Historic District	Eligible	Alternative 7
B-4285	BALTIMORE (tug)	Listed	Alternative 7
B-3694	Douglass Place	Listed	Alternative 7
B-3700	BANCROFT (motor vessel)	Listed	Alternative 7
B-3928	Public School No. 25	Listed	Alternative 7
B-1009	Procter and Gamble Baltimore Plant	Listed	Alternative 7
B-5055	Hercules Company Office Building	Eligible	Alternative 7
B-3704	Canton Historic District	Listed	Alternative 7
B-5123	Upper Fells Point Historic District	Listed	Alternative 7
B-3703	Butchers Hill Historic District	Listed	Alternative 7

MIHP/Archaeological Site Number	Resource Name	NRHP/NHL Eligibility	Associated Alternative
B-5122	Holy Rosary Roman Catholic Church Complex	Eligible	Alternative 7
B-4607	Patterson Park	Eligible	Alternative 7
B-3704-1	St. Brigid's School and Covent	Listed	Alternative 7
B-996	The National Brewing Company	Listed	Alternative 7
B-998	Gunther Brewing Company	Listed	Alternative 7
B-5169	Highlandtown-Brewers Hill Historic District	Listed	Alternative 7
B-992	Atlantic Southwestern Broom Company	Eligible	Alternative 7
B-5161	Kauffman Electric Company	Eligible	Alternative 7
B-1013	Maryland White Lead Works	Listed	Alternative 7
B-5309	Gould Street Generating Station	Eligible	Alternative 7
B-1394	Pigtown Historic District	Listed	Alternative 7
NR	Equitable Gas Works	Listed	Alternative 7
B-1086	Hanline Paint Company	Eligible	Alternative 7
B-1025	United Railway & Electric Carroll Park Shops	Eligible	Alternative 7
B-1342	Westport Historic District	Eligible	Alternative 7
B-1097	Baltimore Novelty Steam Boiler Works	Eligible	Alternative 7
B-1062	Westport Power Station	Eligible	Alternative 7
B-3668	Spring Garden Bridge	Eligible	Alternative 7
BA-2081	Glenn L. Martin Airport	Eligible	Alternative 7
BA-2824	Glenn L. Martin Company Plant No. 2	Eligible	Alternative 7
BA-2094	Baltimore Municipal Airport, Air Station	Eligible	Alternative 7

2.4.13.4 FWOP Condition

Significant cultural resources would likely be affected by ongoing coastal flooding and SLR under the FWOP condition due to the lack of protective infrastructure around the resources.

2.4.14 Socioeconomics

2.4.14.1 Existing Conditions

Socioeconomics describes a community by examining its social and economic characteristics. Demographic variables such as population size, level of employment, and income range assist in analyzing the fiscal condition of a community and its government, school system, public services, healthcare facilities and other amenities. For this study, a one-mile radius was added to the proposed Region of Interest (ROI) (see figures in section 2.4.15) from the study area boundaries. The total population and population breakdown by ethnicity based on data from the 2019 American Community Survey (ACS) are shown on Table 2-7 for the ROI and compared with Baltimore City, Baltimore County, the State of Maryland, and the United States (USCB, 2019). The population in the ROI is estimated to be 107,380 and is provided from the USEPA EJScreen ACS Summary Report 2014-2018 (USEPA EJScreen, 2022).

Table 2.7. Study Area Demographic Characteristics

Geographic Area	Total Population	Ethnicity						
		White	Black	Hispanic	American Indian	Asian	Pacific Islander	Other
Baltimore City ROI	107,380	64,976 (61%)	31,723 (30%)	8,342 (8%)	503 (0%)	4,631 (4%)	66 (0%)	2,082 (2%)
Baltimore City	609,032	185,489 (31%)	379,751 (62%)	32,183 (5%)	1,732 (0%)	15,693 (3%)	229 (0%)	10,972 (2%)
Martin State Airport ROI	12,255	8,891 (73%)	2,597 (21%)	429 (4%)	104 (1%)	114 (1%)	30 (0%)	126 (1%)
Baltimore County	828,018	501,423 (61%)	239,308 (29%)	44,807 (5%)	2,460 (0%)	49,885 (6%)	726 (0%)	11,104 (1%)
Maryland	6,018,848	3,343,003 (56%)	1,799,094 (30%)	606,482 (10%)	16,762 (0%)	378,126 (6%)	3,034 (0%)	1,011 (0%)
United States	324,697,795	235,377,662 (73%)	41,234,642 (13%)	58,479,370 (18%)	2,750,143 (0%)	17,924, 209 (6%)	599,868 (0%)	16,047,369 (5%)

Table 2-8 below presents data on educational attainment for the ROI, Baltimore City, the State of Maryland, and the United States based on the 2019 ACS 5-year estimates.

Table 2.8. Education Attainment, 2019 ACS 5-Year Estimates

Level of Education	High School or equivalent, no college	Some college or Associate's Degree	Bachelor's degree or higher
Baltimore City ROI	14,854 (18%)	15,521 (19%)	42,881 (53%)
Baltimore City	15,956 (28.6%)	23,659 (42.0%)	9,619 (17.1%)
Martin State ROI	3,702 (43%)	2,787 (32%)	1,357 (16%)
Baltimore County	24,049 (33.2%)	31,589 (43.6%)	9,313 (12.9%)
Maryland	161,982 (30.6%)	219,949 (41.5%)	84,975 (16.0%)
United States	9,921,331 (32.7%)	13,168,280 (43.4%)	3,621,479 (11.9%)

Source: U.S. Census Data, Educational Attainment 2019 ACS 5-Year Estimates. Educational attainment for individuals aged 18-24 years old. The ROI data based on the USEPA EJScreen does not provide fractions of percentages.

Table 2-9 below shows the labor force, employment and unemployment estimates for ROIs, Baltimore city, Baltimore County, the State of Maryland, and the United States.

Table 2-9. Labor Force, Employment, and Unemployment. 2019 ACS Estimates

Area	Labor Force	Employed (%)	Unemployed (%)
Baltimore City ROI	63,586	69	31
Baltimore City	306,279	61.8	5.1
Martin State ROI	6,422	65	35
Baltimore County	446,676	64	2.8
Maryland	3,269,234	67.7	3.4
United States	164,629,492	63.4	3.4

Source: U.S. Census Data, Comparative Economic Characteristics, 2019 ACS 5-Year Estimates. The ROI data based on the EPA EJScreen does not provide fractions of percentages. EPA EJ Screen reports only reports Employed population age 16+ years. For ROI reports, it does not include those who are retired, not looking for employment, etc.

Table 2-10 below presents the percentage of the population under 5 years for age and percentage of the population over 64 years of age for the ROIs, Baltimore City, Baltimore County, the State of Maryland, and the United States.

Table 2-10. Population Breakdown by Age Groups

Area	Under 5 Years of Age (%)	Over 64 Years of Age (%)
Baltimore City ROI	6%	9%
Martin State ROI	6%	9%
Baltimore County	6%	17%
Baltimore City	6%	14%
Maryland	6%	15%
United States	6%	16%

2.4.14.2 FWOP Condition

Under the No Action Alternative/FWOP, socioeconomic trends would remain consistent within each representative area. However, a FWOP condition may lead to displacement of residents and communities based on severity and frequency of coastal flooding events.

2.4.15 Environmental Justice

2.4.15.1 Existing Conditions

Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" was signed in 1994, declaring that each federal agency make environmental justice (EJ) part of its mission. The USEPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies. Analysis of EJ is initiated by determining the presence and proximity of "underserved communities", which are communities that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life. As of July 2021, USACE began implementing the Justice40 Initiative to Civil Works projects. The goal of the Justice40 Initiative is to deliver at least 40 percent of the overall benefits from Federal investments in climate and critical clean water and waste infrastructure for disadvantaged communities. The Justice40 Initiative prioritizes EJ in Civil Works areas that include design, construction, and operation phases of projects primarily for FRM, CSRM, and aquatic ecosystem restoration. (USACE, 2021).

In accordance with current EO's and initiatives (as of 2023), the UESPA EJ Screen was used to identify census block groups located within one mile of the Baltimore City and MSA study areas. One-hundred and sixty block groups were identified through this investigation. Of the 160 block groups, 88 census block groups were identified within the Baltimore City and MSA study areas (USEPA, 2022). EJ Screen 2021 data was used to identify block groups in the 80th percentile nationwide for percent low-income, minority, linguistically isolated, over age 64, and/or with less than a high school education. For the purposes of this analysis, the following definitions and descriptions apply:

Underserved Community. The term “underserved communities” refers to communities that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life. For purpose of this analysis, a community with a disproportionate percentage (80th percentile nationwide or above) of *any* of the following populations may be considered an underserved community:

- People-of-color population
- Low-income population
- Linguistically isolated population
- Population with less than high school education
- Population over age 64

People-of-Color Population. Refers to the proportion of individuals in a geographic area who are not non-Hispanic whites, as defined by the Census Bureau. Forty-three census block groups within the study area and 1-mile buffer are in the 80th percentile or greater nationally for percent people-of-color population (Figure 2-9)

Low-Income Population. Refers to the proportion of individuals in a geographic area whose income is at or below 200 percent of the poverty line, as defined by the Census Bureau. Forty-nine census blocks within the study area and 1-mile buffer are in the 80th percentile or greater nationally for percent of the population that is at or below 200 percent of the federal poverty line (Figure 2-10). For a household of 4 people, the 200 percent of the federal poverty level is equal to $53,000.

Linguistically Isolated Population. Refers to the proportion of households in a geographic area in which no one over the age of 14 speaks English “very well,” as defined by the Census Bureau. Seventeen census blocks within the study area and 1-mile buffer are in the 80th percentile or greater nationally for percent of the population that is linguistically isolated (Figure 2-11).

Population with Less than High School Education. Refers to the proportion of individuals in a geographic area who are over age 25 and have not attained a high school diploma. Forty-nine census blocks within the study area and 1-mile buffer are in the 80th percentile or greater nationally for percent of the population over age 25 with less than a high school diploma (Figure 2-12).

Population over Age 64. Refers to the proportion of individuals in a geographic area who are age 64 or older. Twenty census blocks within the study area and 1-mile buffer are in the 80th percentile or greater nationally for percent of the population over age 64 (Figure 2-13).

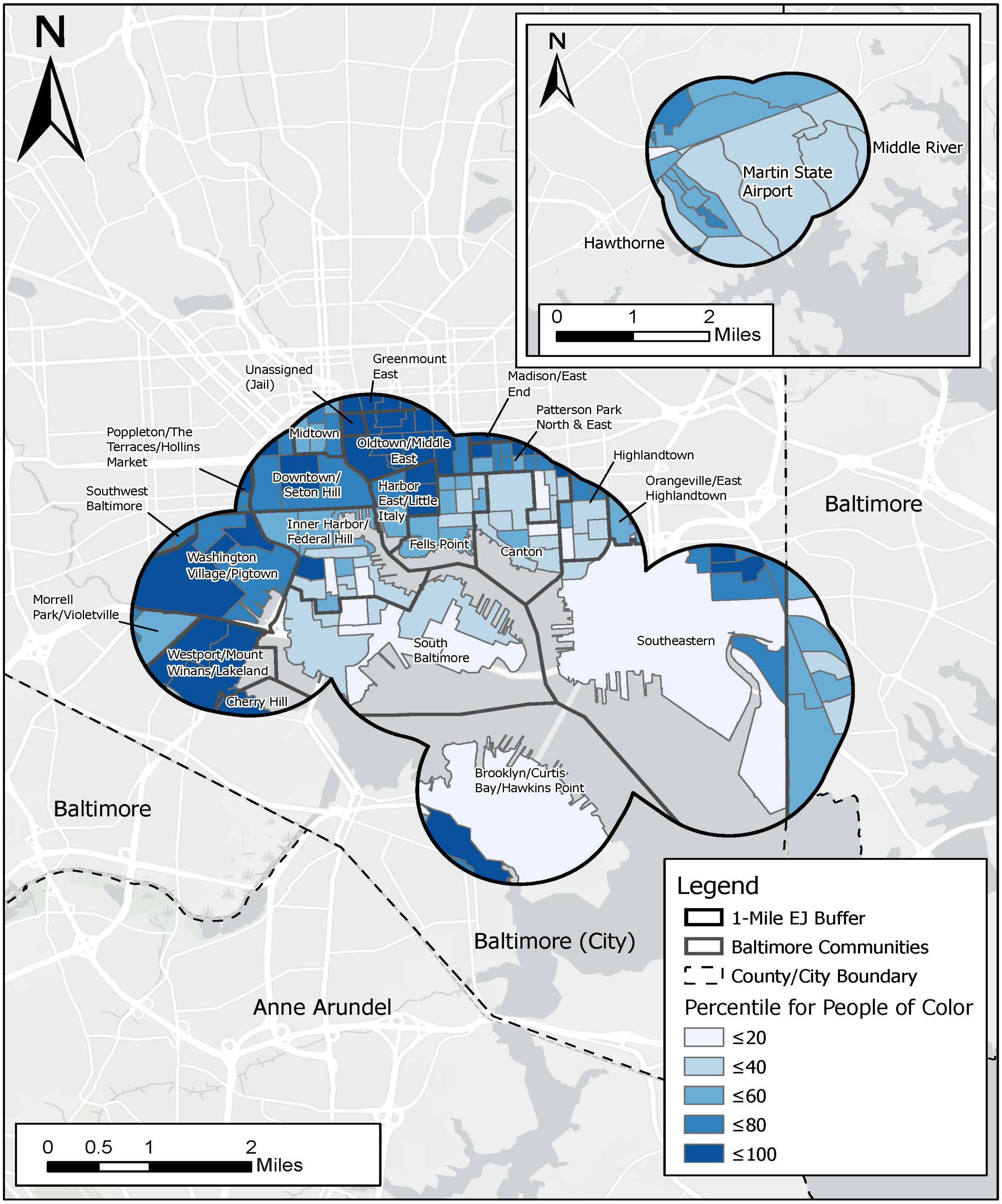

Figure 2-9. Census block groups located within the Baltimore City and MSA study areas with a one-mile buffer of the study areas, which represents the percent people of color population (percentile) in each census tract (USEPA, 2022)

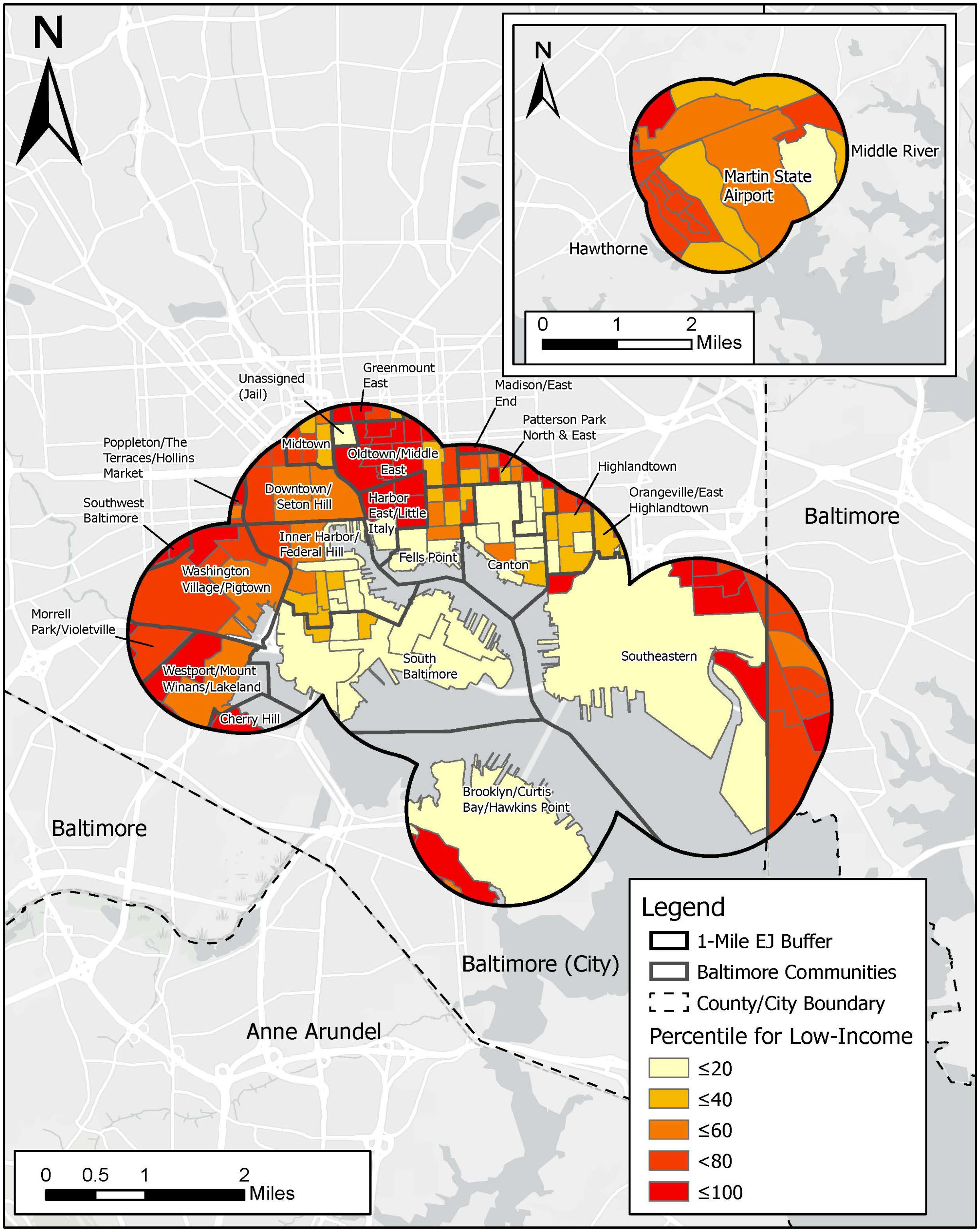

Figure 2-10. Census block groups located within the Baltimore City and MSA study areas with a one-mile buffer of the study areas, which represents the percent low-income population (percentile) in each census tract (USEPA, 2022)

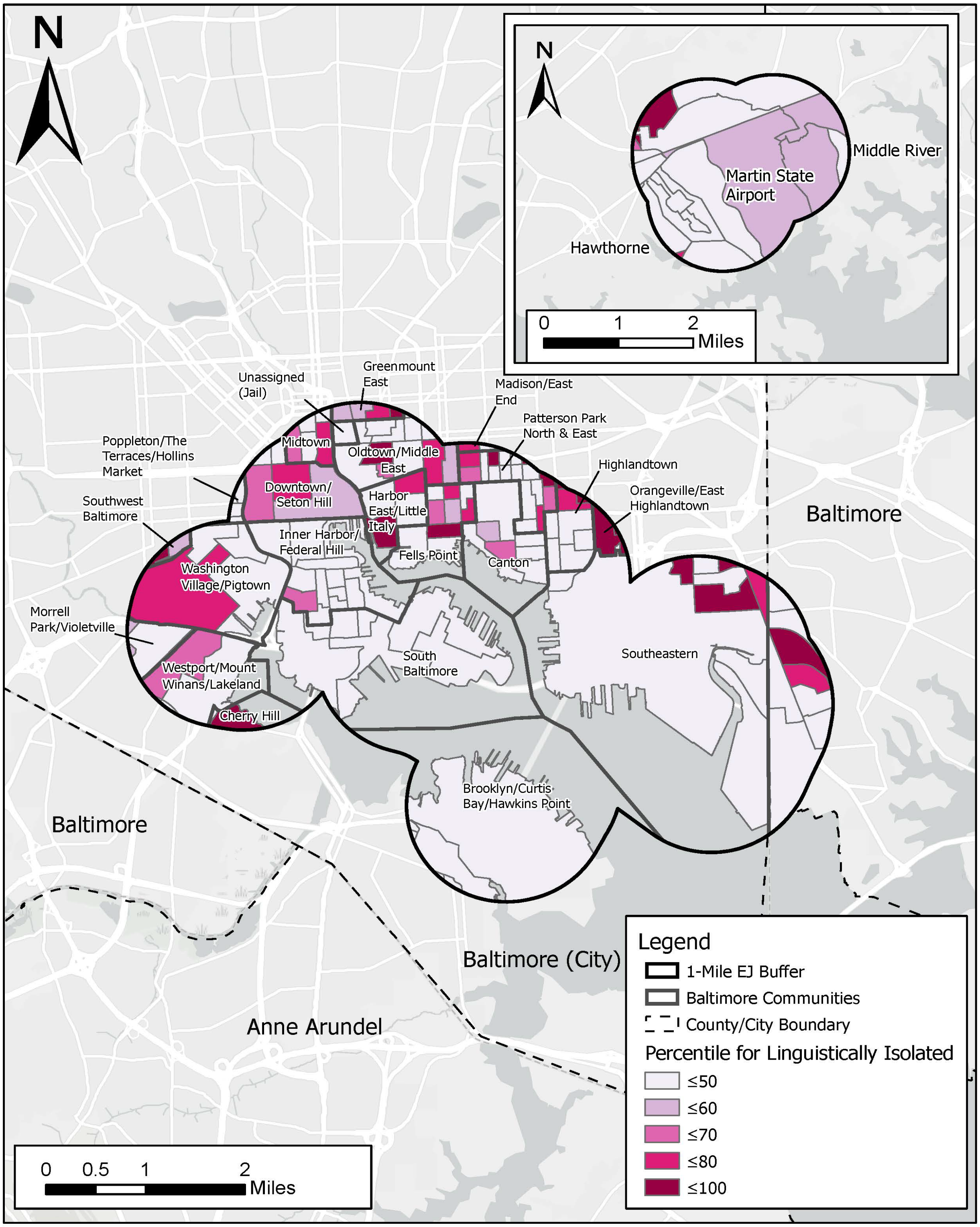

Figure 2-11. Census block groups located within the Baltimore City and MSA study areas with a one-mile buffer of the study areas, which represents the percent linguistically isolated population (percentile) in each census tract (USEPA, 2022)

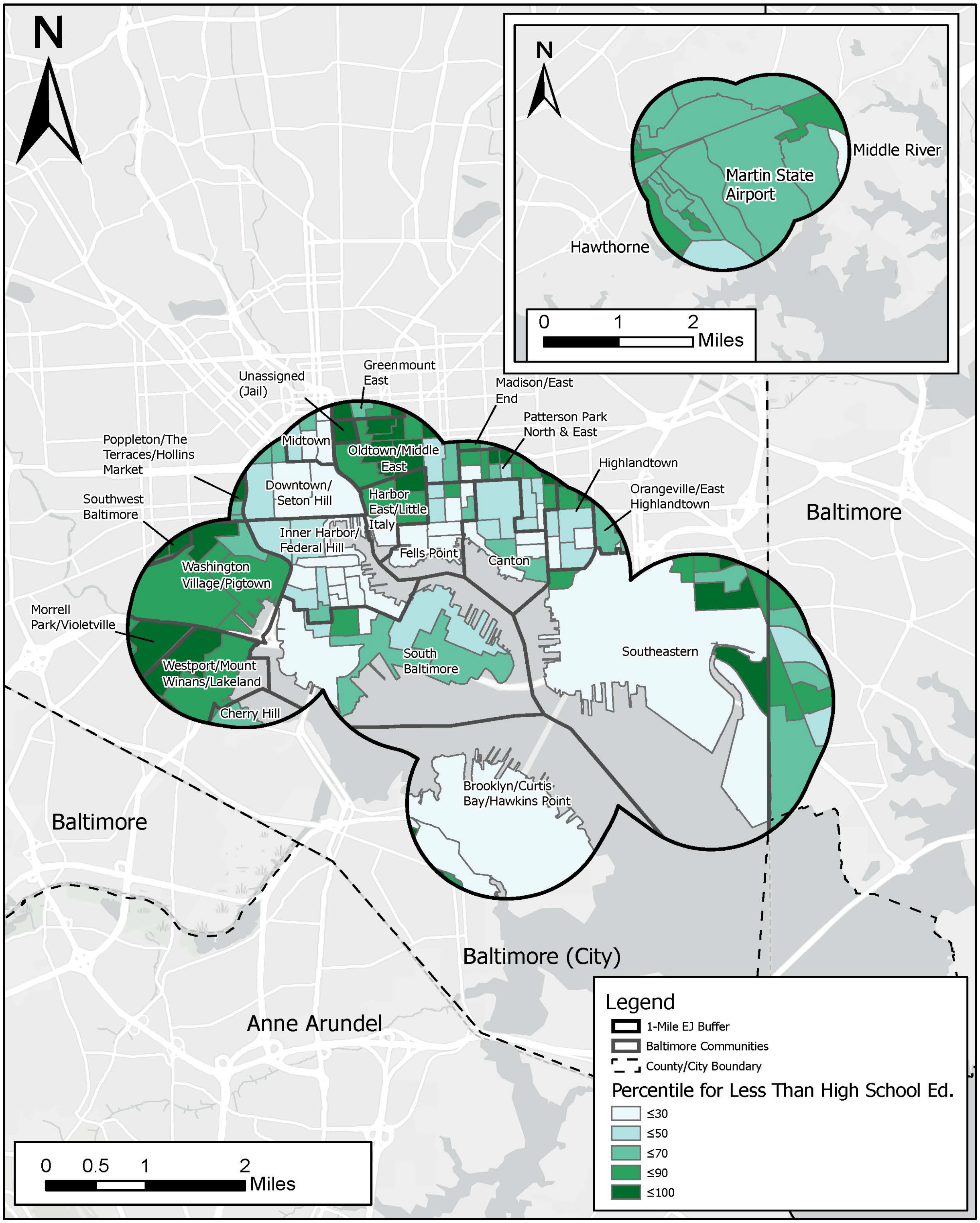

Figure 2-12. Census block groups located within the Baltimore City and MSA study areas with a one-mile buffer of the study areas, which represents the percent population with less than a high school education (percentile) in each census tract (USEPA, 2022)

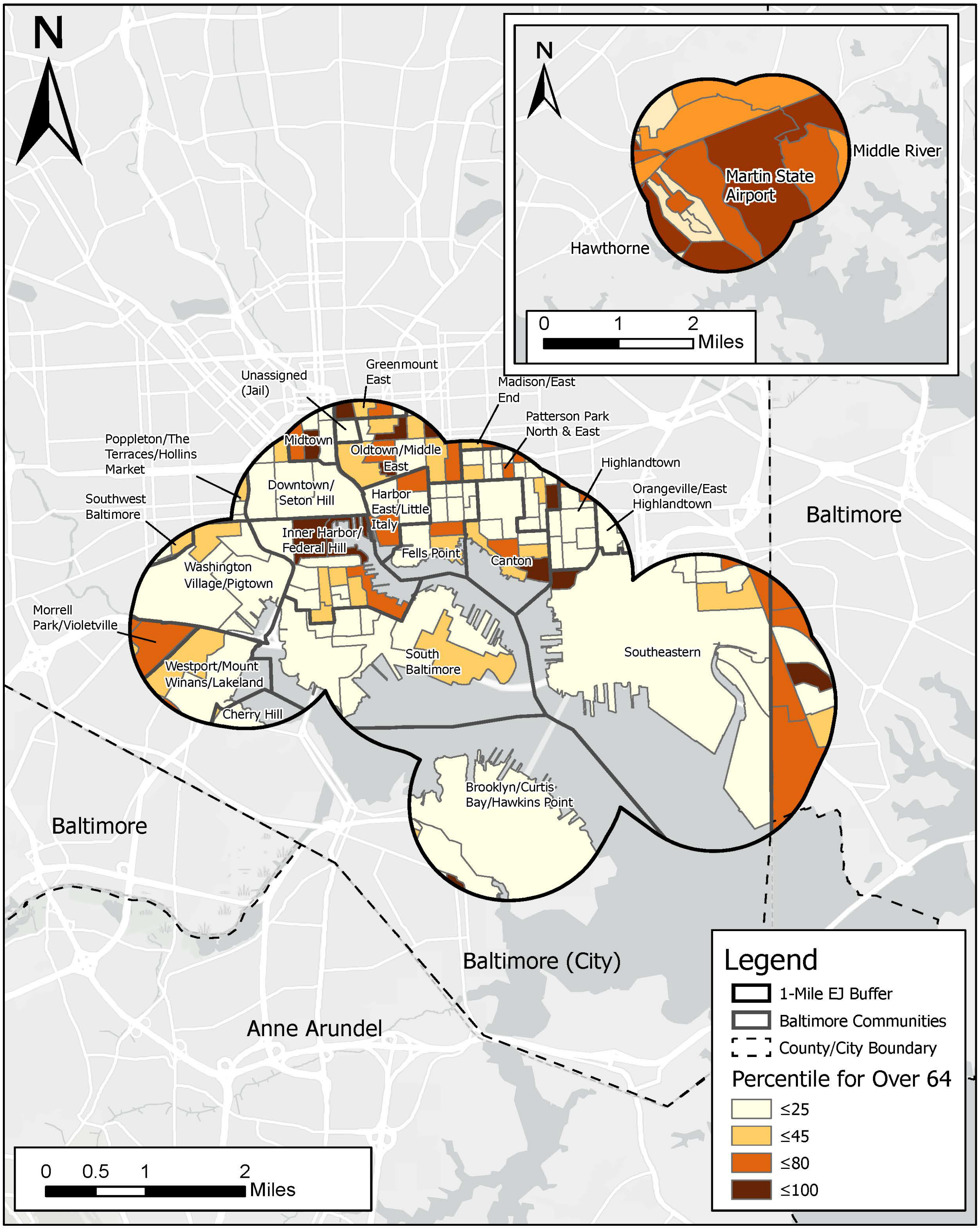

Figure 2-13. Census block groups located within the Baltimore City and MSA study areas with a one-mile buffer of the study areas, which represents the percent population over age 64 (percentile) in each census tract (USEPA, 2022)

Table 2-11 represents Baltimore City communities and how they correlate to individual neighborhoods and their associated census tracts.

Table 2-11. Baltimore City Community Breakdown

Community	Neighborhood	Census Tracts
Brooklyn/Curtis Bay/Hawkins Point	Brooklyn, Curtis Bay, Fairfield Area, Hawkins Point, Curtis Bay Industrial Area	250500, 250600, 250401, 250402
Canton	Canton, Patterson Park	010400, 010300, 010100
Cherry Hill	Cherry Hill, Middle Branch/Reedbird Parks	250207, 250204, 250203
Downtown/Seton Hill	Downtown, Seton Hill, University of Maryland	170100, 040100, 040200
Fells Point	Butcher’s Hill, Fells Point, Upper Fells Point	020200, 020300, 020100, 010500
Highlandtown	Brewers Hill, Highlandtown	260900, 261100, 260800
Inner Harbor/Federal Hill	Federal Hill, Inner Harbor, Otterbein, Ridgely’s Delight, Riverside, Sharp-Leadenhall, Stadium Area, Downtown West, SBIC (now South Baltimore), South Baltimore	220100, 240200, 240300, 230100, 230200
Madison/East End	Madison-Eastend, McElderry Park, Milton-Montford	070200, 070100, 070300
Morrell Park/Violetville	Morrell Park, Oaklee, Saint Agnes, Saint Paul, Violetville, Wilhelm Park	250303, 250103, 250206
Orangeville/East Highlandtown	Greektown, Orangeville, Eastwood, Joseph Lee (now Bayview), Kresson, Baltimore Highlands, Hopkins Bayview, Bayview, Orangeville Industrial Area, Pulaski Industrial Area	260404, 260501, 260700
Patterson Park North & East	Baltimore-Linwood (now Patterson Park Neighborhood), Patterson Place, Ellwood Park/Monument	261000, 060200, 060100, 010200, 060300
Poppleton/The Terraces/Hollins Market	Hollins Market, Poppleton	180200, 180300, 180100
South Baltimore	Locust Point, Port Covington, Locust Point Industrial Area	240400, 240100, 230300
Southeastern	Spring Garden Industrial Area, Canton Industrial Area, Graceland Park, Holabird Industrial Park,	260605, 260604

Community	Neighborhood	Census Tracts
	Medford, O'Donnell Heights, Saint Helena, Dundalk Marine Terminal	
Southwest Baltimore	Booth-Boyd, Carrollton Ridge, Franklin Square, Millhill, Penrose/Fayette Street Outreach, Shipley Hill, Union Square, New Southwest/Mt. Clare	200400, 200500, 190100, 200200, 190200, 200300, 200100, 190300
Washington Village/Pigtown	Barre Circle, Carroll Park, Caroll-Camden Industrial Area, Washington Village/Pigtown	210100, 210200
Westport/Mount Winans/Lakeland	Lakeland, Mt. Winans, Westport	250301, 250205
Unassigned – Jail		100300
Oldtown/Middle East	Dunbar-Broadway, Gay Street, Middle East, Oldtown, Penn-Fallsway, Pleasant View Gardens, CARE	100200, 060400, 070400, 280500, 080800
Harbor East/Little Italy	Washington Hill, Jonestown, Little Italy, Perkins Homes	030100, 030200
Midtown	Bolton Hill, Charles North, Greenmount West, Mid-Town Belvedere, Mount Vernon	110100, 110200, 140100, 120500
Greenmount East	Greenmount Cemetery, Johnston Square, Oliver	080700, 090900, 100100, 080600

Traffic

The EJ communities experience some of the most notable traffic routes in the Baltimore Metro area due to their proximity to major roadways including I-95, I-895, I-295, and I-83, in addition to Routes 1, 2, and 40. Figure 2-14 shows the census tracts in the Baltimore Metro area, outlined in yellow, and their proximity to traffic noise and volume. These communities are likely affected by higher-than-average noise levels.

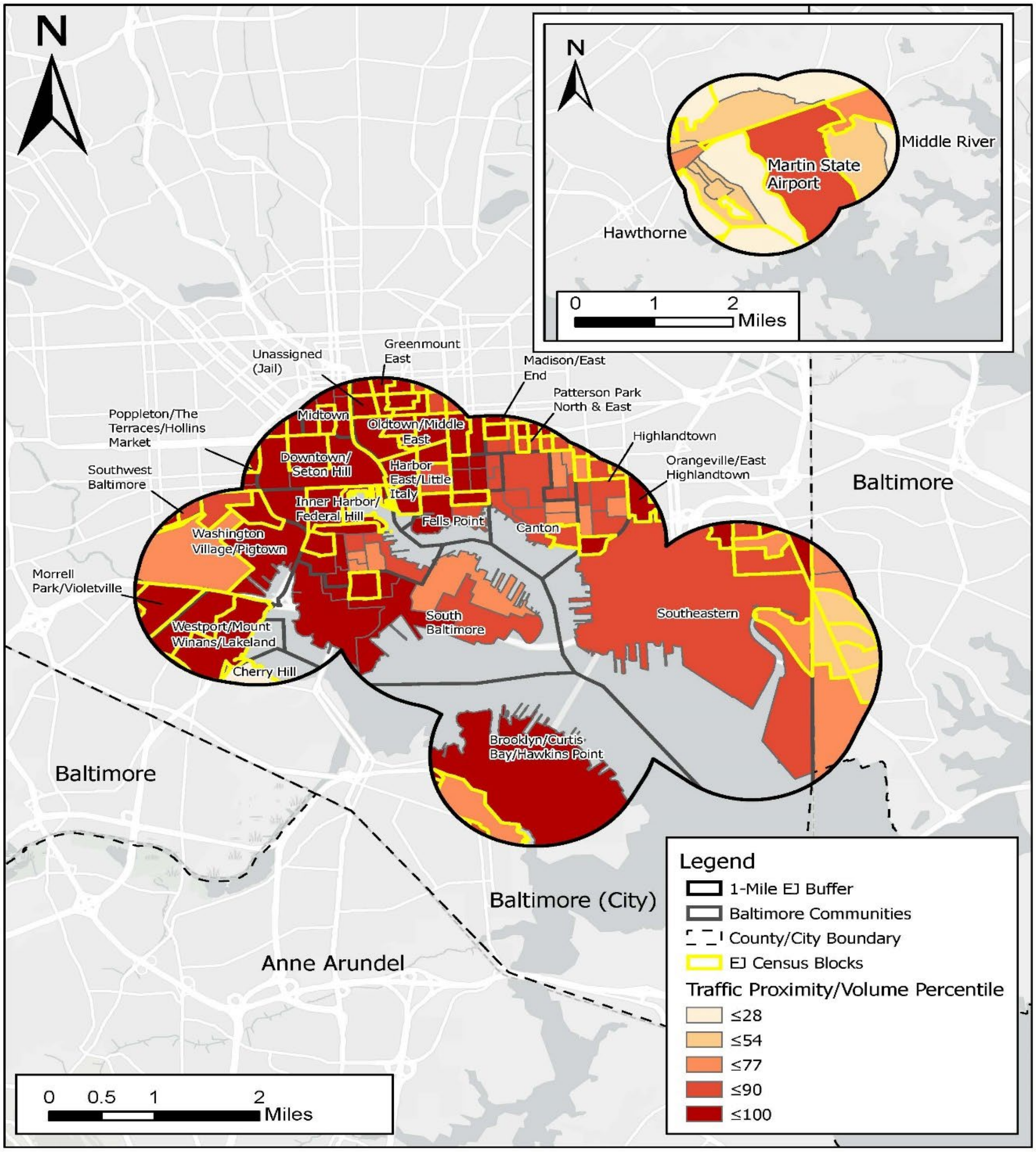

Figure 2-14. Environmental Justice Census Block Groups Proximity to Traffic (USEPA, 2022)

Air Quality

The Baltimore City Planning Unit is in non-attainment for the 8-hour ozone pollutant based on the NAAQS 2015 standard. Figure 2-15 below shows the EJ communities and their exposure to ozone in percentiles. In general, EJ communities located closer to Baltimore City industrial areas have a higher exposure to ozone than EJ communities located farther away from the city center.

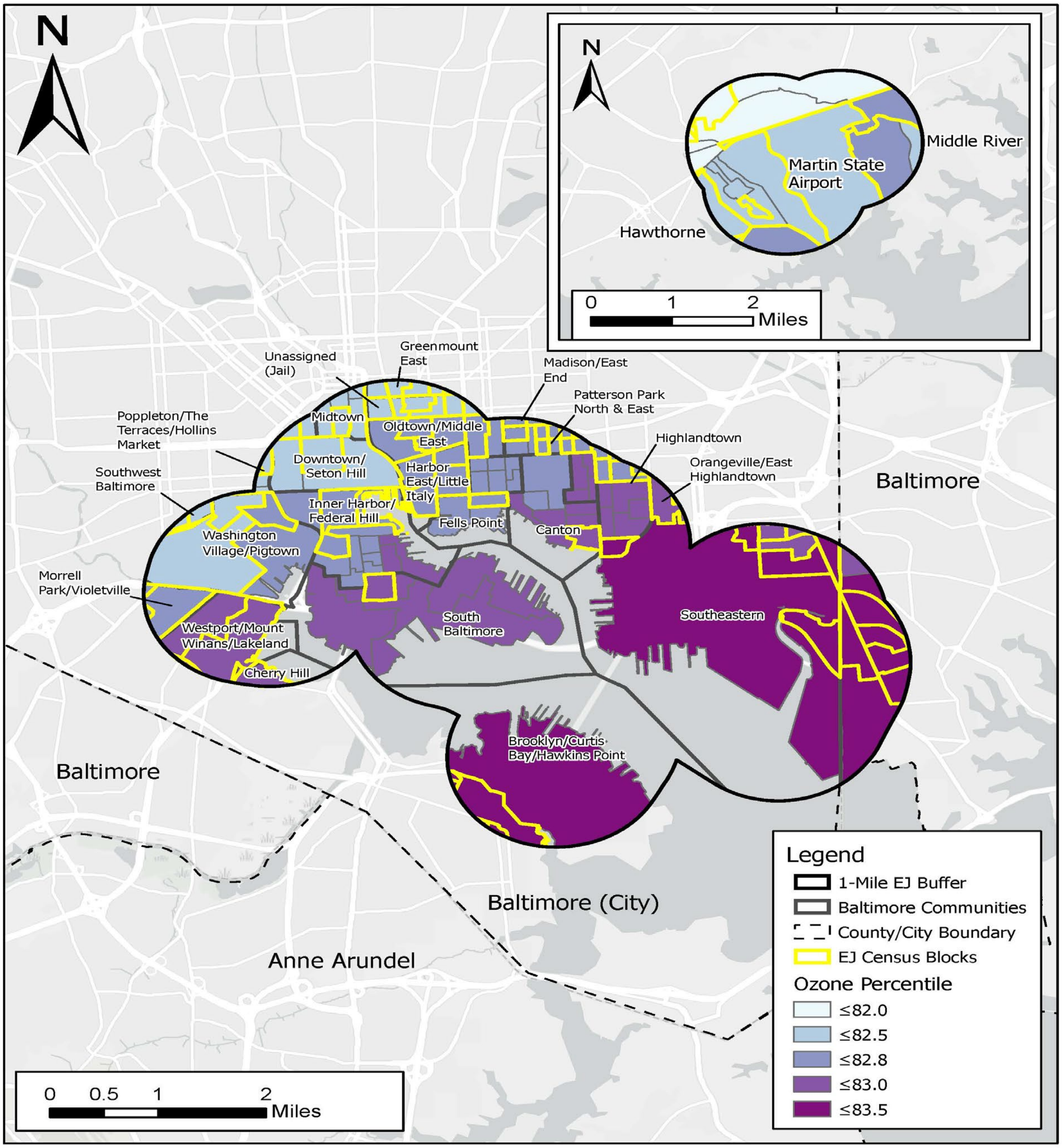

Figure 2-15. Environmental Justice Census Block Groups and their Exposure to Ozone (USEPA, 2022)

Hazardous Waste

There are several TSDF that exist within the Baltimore City and MSA study areas. Nearly all EJ communities identified in the Baltimore Metro area are in close proximity to a TSDF. Figure 2-16 shows these communities and their proximities to the areas.

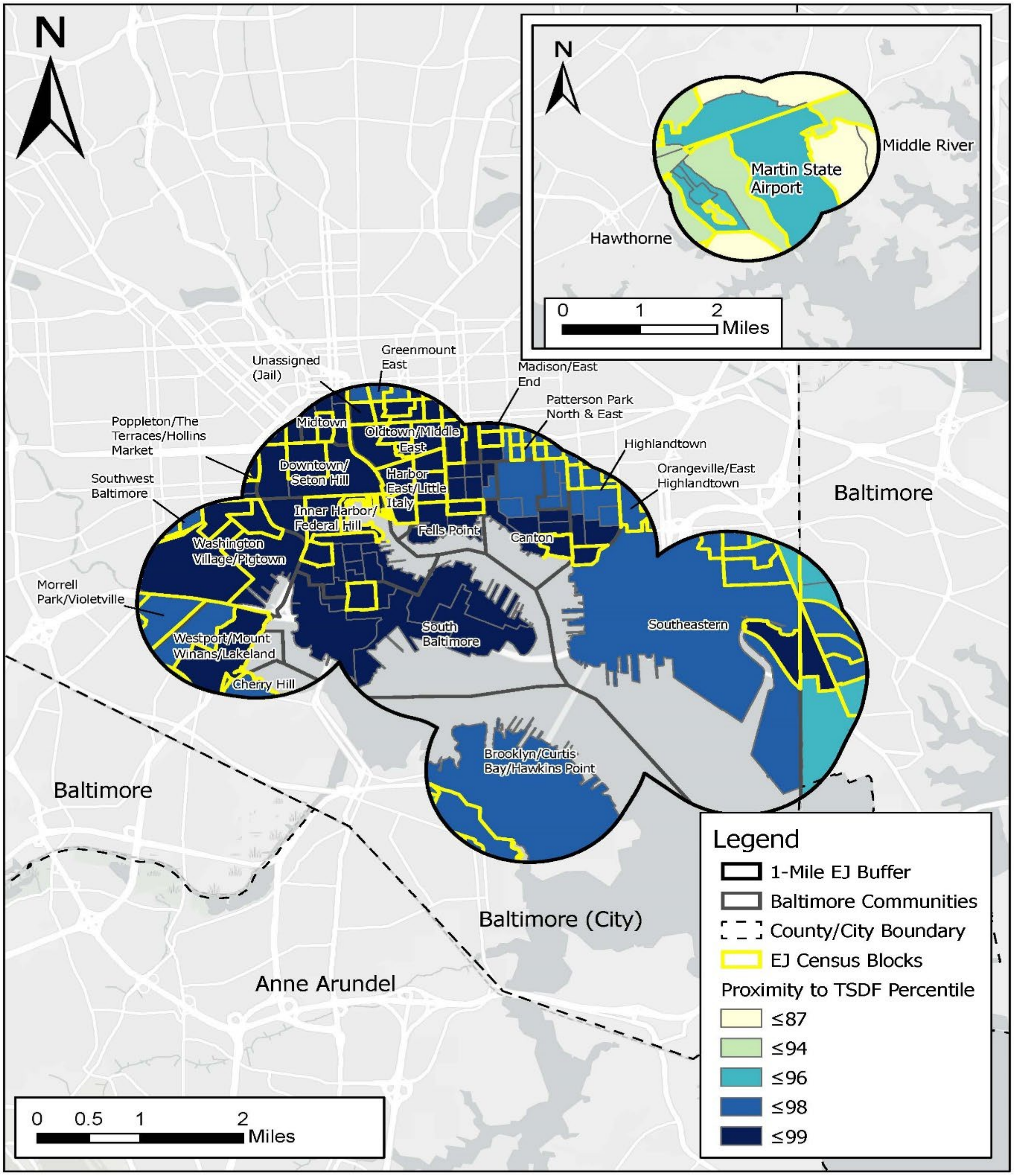

Figure 2-16. Environmental Justice Census Block Groups and their Exposure to Ozone (USEPA, 2022)

Additionally, the Council of Environmental Quality (CEQ) Climate and Economic Justice Screening Tool (CEJST), Version 1.0 (November 22, 2022), was used to identify vulnerable communities within the project area. A community is highlighted as disadvantaged on the CEJST map if it is in a census tract that is (1) at or above the threshold for one or more environmental, climate, or other burdens, and (2) at or above the threshold for an associated socioeconomic burden (CEJST, 2022). Thirteen tract areas were identified as being disadvantaged within the study area (Figure 2-17) Combining the burden thresholds and socioeconomic thresholds throughout the 14 tract areas, eight burden thresholds and two socioeconomic thresholds were identified within the study area as a whole (Table 2-12). Of the burden thresholds, 22 subcategories (such as, asthma, lack of green space, etc..) were identified. The subcategories are equal to or above the CEQ defined 90th percentile threshold, with exception to the socioeconomic the (65th percentile) and less than high school education threshold (10th percentile).

Table 2-12. CEQ Climate and Environmental Screening Tool Burden Thresholds

Burden Thresholds									
Planning Units	**Tract Areas**	**Climate Change**	**Energy**	**Health**	**Housing**	**Legacy Pollution**	**Transportation**	**Water and Wastewater**	**Workforce Development**
Inner Harbor	24510030100		✓	✓	✓	✓	✓		✓
	24510030200				✓	✓	✓		
	24510280500		✓	✓	✓	✓	✓	✓	✓
Locust Point	24510260605			✓	✓	✓		✓	✓
Middle Branch Patapsco River	24510250200			✓		✓			✓
	24510250203			✓	✓	✓		✓	✓
	24510250204		✓	✓	✓	✓		✓	✓
	24510250205			✓	✓	✓			✓
	24510250207			✓	✓	✓			✓
	24510250301		✓	✓		✓	✓		✓
	24510250303			✓	✓	✓	✓		✓
	24510250401			✓	✓	✓	✓	✓	
	24510250402			✓	✓	✓		✓	✓
Patapsco East	24005421300	✓		✓	✓	✓		✓	✓
Patapsco North	24510260605			✓	✓	✓		✓	✓
	24005421300	✓		✓	✓	✓		✓	✓
Patapsco South	24510250500		✓	✓	✓	✓		✓	✓

Table 2-13. CEQ Climate and Environmental Screening Tool Burden Threshold Definitions Associated with Study Areas

Burden Thresholds Definitions
Climate Change
Projected flood risk
Projected risk to properties from projected floods, from tides, rain, riverine and storm surges within 30 years.
Energy
Energy Cost
Average annual energy costs divided by household income
Health
Asthma
Share of people who have been told they have asthma.
Diabetes
Share of people ages 18 years and older who have diabetes other than diabetes during pregnancy.
Heart Disease
Share of people ages 18 years and older who have diabetes other than diabetes during pregnancy.
Low Life Expectancy
Average number of years a person can expect to live.
Housing
Historic Underinvestment
Census tracts with historically high barriers to accessing home loans.
Housing Cost
Share of households making less than 80% of the area median family income and spending more than 30% of income on housing
Lack of Indoor Plumbing
Share of people ages 18 years and older who have been told they have heart disease.
Lack of Green Space
Amount of land, not including crop land, that is covered with artificial materials like concrete or pavement.
Lead Paint
Share of homes that are likely to have lead paint
Legacy Pollution
Formerly Used Defense Sites
Presence of one or more Formerly Used Defense Site within the tract.
Proximity to hazardous waste facilities
Count of hazardous waste facilities within 5 kilometers.
Proximity to Risk Management Plan facilities
Count of Risk Management Plan (RMP) facilities within 5 kilometers.

Proximity to Superfund Sites
Count of proposed or listed Superfund (or National Priorities List (NPL)) sites within 5 kilometers
Transportation
Diesel Particulate Matter Exposure
Amount of diesel exhaust in the air.
Traffic proximity and volume
Count of vehicles at major roads within 500 meters.
Water and Wastewater
Underground storage tanks and releases
Formula of the density of leaking underground storage tanks and number of all active underground storage tanks within 1500 feet of the census tract boundaries
Wastewater Discharge
Modeled toxic concentrations at parts of streams within 500 meters.
Workforce Development
Low Median Income
Modeled toxic concentrations at parts of streams within 500 meters.
Unemployment
Number of unemployed people as a part of the labor force.
Poverty
Share of people in households where income is at or below 100% of the Federal poverty level.
Socioeconomic Thresholds
Low Income
People in households where income is less than or equal to twice the federal poverty level, not including students enrolled in higher ed.
High school education
Percent of people ages 25 years or older whose high school education is less than a high school diploma.

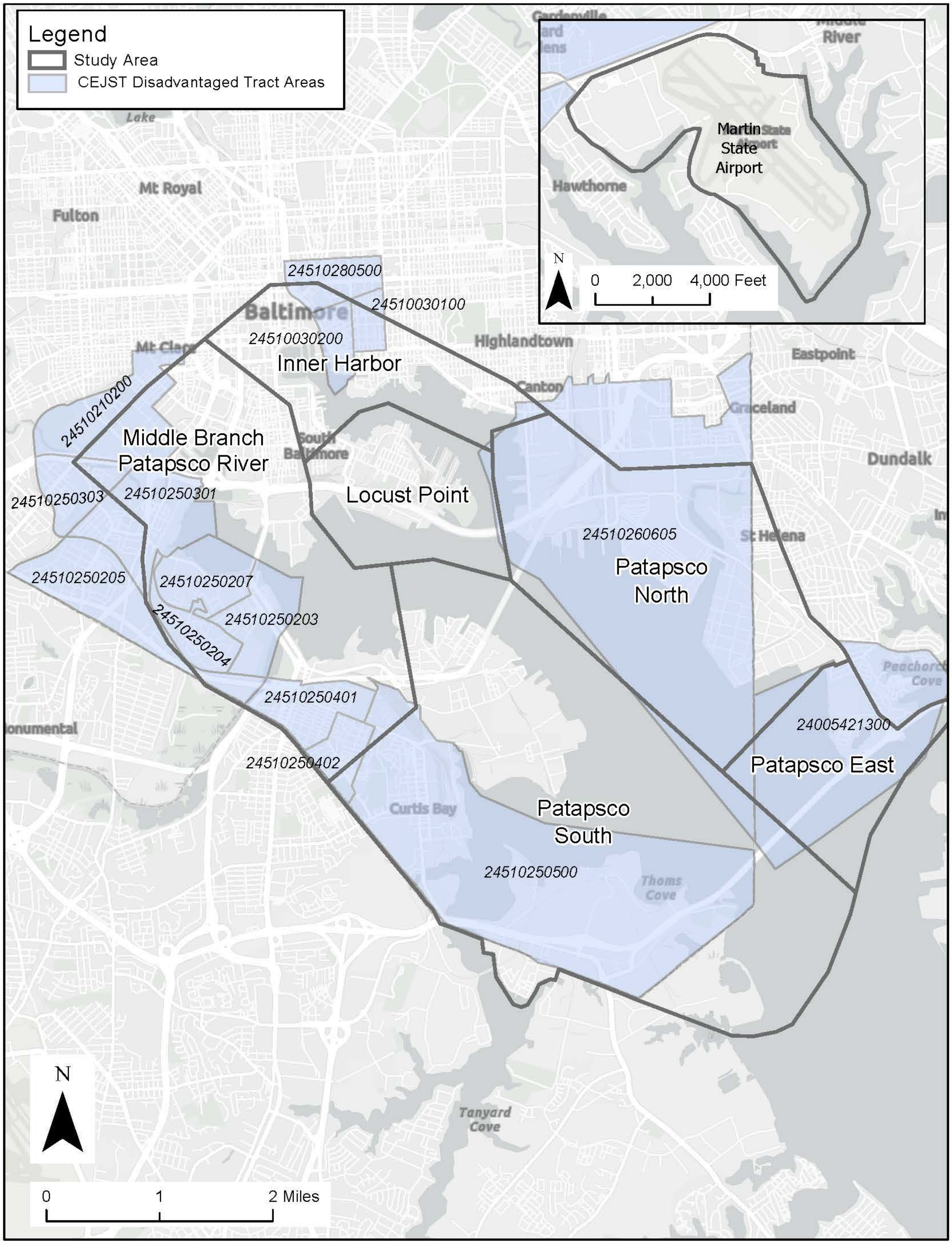

Figure 2-17. CEJST Disadvantaged Tract Areas (CEJST, 2022)

2.4.15.2 FWOP Condition
Coastal flooding may disproportionately displace communities that have the potential to fall within an EJ criterion. Potential future flooding events may impact communities who lack appropriate transportation mechanisms if or when evacuation is needed. Flooding events may also isolate communities if transportation corridors are impassable. Flash flood warning systems are used by local media outlets but residents in low-income areas who may not have access to internet or cable may be unable to sufficiently receive warnings in a timely manner. Flooding events also have the potential of causing long-term mold damage to residential properties and local businesses if flood damage is not remediated in a timely and effective manner. Additionally, in areas specific to Baltimore City, residents continually experience overloaded sewer systems that routinely release high volumes of raw human waste into neighborhood streams, Baltimore Harbor, and the Chesapeake Bay. During flooding events, sewage releases may be amplified by surface and groundwater infiltration into exposed sewer lines which can often create back-ups in residential houses. EJ communities are particularly vulnerable as remediation methods may not be attainable in low-income areas. Organizations like the Environmental Integrity Project (EIP), who are a 501(c)(3) nonpartisan, nonprofit watchdog organization would continue to advocate for EJ communities and ensure residents are represented fairly. EIP is comprised of former USEPA enforcement attorneys, public interest lawyers, analysts, and community organizers. The EIP has three main goals:

- Illustrate how the failure to enforce or implement environmental laws increases pollution and harms public health,
- Identify federal, state, and individual corporations and hold them accountable for failing to enforce or comply with environmental laws, and
- To help communities obtain the protections of environmental laws.

The EIP serves the EJ communities by engaging directly with residents, making air and water pollution data more accessible. In addition, the EIP examines permits for current and proposed projects that would impact EJ communities (EIP, 2022).

2.4.16 Recreational Resources
2.4.16.1 Existing Conditions
Recreational uses of the study area consist of general tourism, running, walking, hiking, kayaking, fishing, boating, and sightseeing. Baltimore has several historic and cultural districts within the study area that appeal to a range of local audiences as well as national and international interests. Entertainment attractions include two major sport venues in the heart of the city, M & T Bank Stadium and Oriole Park at Camden Yards, Horseshoe Casino, the National Aquarium, Pier Six Pavilion, and Maryland Science Center, among many others. Several recreational fields, parks, and waterfront promenades exist within the study area and include the Canton Waterfront Park, Patterson Park, Federal Hill Park, and the Baltimore Waterfront Promenade. The Promenade is a brick-paved, public

pedestrian walkway/shared use bicycle path that follows the water's edge for approximately eight miles around the Inner Harbor, from Fort McHenry to the Canton Waterfront Park. Areas along the east side of the Promenade contain a boardwalk and are accessible by foot or wheelchair (Baltimore Planning, 2018).

2.4.16.2 FWOP Conditions

Recreational resources may continue to be at risk and incur damages during flooding events. Areas around the Inner Harbor, Canton, Fells Point, Locust Point, and Fort McHenry may continue to be affected during high tide events, coastal storms, and other meteorological events. In early 2022, the State of Maryland assigned a $166 million investment to revitalize Baltimore's downtown area and the Inner Harbor. Funding will be dispersed to several areas and businesses, including the Inner Harbor Promenade, National Aquarium, Port Discovery, the Maryland Science Center, and the Downtown Partnership for Baltimore, among others. Other initiatives like Reimagine Middle Branch are currently being developed as well. The goal of Reimagine Middle Branch is to reconnect South Baltimore to its shoreline, with the study area containing 19 neighborhoods, 30 parks, and more than 11 miles of shoreline. Reimagine Middle Branch includes expanding Middle Branch Park and adding improved boating and fishing piers along with an expanded playground, improving areas around Ridgley's cove to include a "maritime park", and creating a new trail (The Loop Trail), that would connect all of the new parks and open spaces with bike and walking trails (Lynch, 2022). Rash Field is another example of a project that was included in the Master Plan and has been brought to fruition. The field is the first large-scale public space redevelopment at the Inner Harbor in decades. The 8-acre park includes a nature walk trail, bioretention ponds, rain garden, café, two playgrounds and a year-round skatepark (Cassie, 2021).

2.4.17 Visual Aesthetics

2.4.17.1 Existing Conditions

Visual resources can be defined as the natural and man-made features that constitute the aesthetic qualities of an area. Natural visual resources occur in the landscape, typically without human assistance, and include native or mostly undisturbed landforms, water bodies, vegetation, and animals, both wild and domesticated. The MSA study area rests on a peninsula in eastern Baltimore County. While the visual aesthetics around the airport are limited to an industrial and residential setting, natural resources and wildlife can be spotted along Frog Mortar Creek, Stansbury Creek, and Middle River. Baltimore City consists of a similar industrial/commercial setting. Viewers can generally see several historic and culturally significant landmarks from the Harbor and its surrounding areas. Elevated roads, highways, and bridges can provide views of the study area. The Francis Scott Key Bridge which connects Hawkins Point and Sollers Point in Baltimore County provides a panoramic view of Baltimore City.

2.4.17.2 FWOP Condition

Local organizations, like The Baltimore Waterfront Partnership, continue efforts to beautify Baltimore through initiatives like ‘Healthy Harbor’, ‘Mr. Trash Wheel’, ‘Floatilla’, and ‘Mr. Trash Wheel’s Community Beautification Grant’. However, without proper flood control measures, visual aesthetics around locations such as the Baltimore Waterfront Promenade and Inner Harbor, Canton, Fells Point, and Locust Point, as well as historic districts, structures, and piers may be continually impeded by future flood events. As mentioned in Section 2.4.17, Reimagine Middle Branch is expected to increase visual aesthetics around South Baltimore with the implementation of boardwalks, trails, overlooks, and living shorelines.

2.4.18 Utilities

2.4.18.1 Existing Conditions

The Baltimore City and MSA study areas contain an abundance of utility lines and services to support its industrialized and urban settings. Utilities range from underground fiber optic cables, storm drains, telecommunications, gas, water, sewer, and electric lines. Some underground utility lines in Baltimore City are still in place dating back from the early 1900s, although they’re not in use today.

2.4.18.2 FWOP Condition

Under the No Action Alternative/FWOP, utilities may continue to be exposed to flooding events and would continue to degrade with brackish water intrusion from the bay. Baltimore continues to deal with impaired sewer lines, and the likelihood of untreated sewage leaking from corroded or unrepaired pipes remain high during flood events. This also introduces issues to potable water lines that may have openings within their lines and would continue to be infiltrated by polluted flood waters. Underground fiber optic cables, electrical, and gas lines are also at risk of being damaged if not protected from flood waters.

2.5 Built Environment

The Baltimore Coastal study area is exposed to coastal storm risk as the Patapsco River meets the Chesapeake Bay. FRM infrastructure for coastal flooding is being pursued at the following locations:

<u>Middle Branch</u>: The Middle Branch Resiliency Initiative (MBRI) is a comprehensive approach to mitigating hazards from storm surge, tidal flooding, and SLR around the entire shoreline of the Middle Branch of the Patapsco River. It is the natural outgrowth of 13 years of focused planning work by a range of different agencies and community leaders, including the FEMA-approved Baltimore City Disaster Preparedness and Planning Project (DP3), the Maryland Hazard Mitigation Plan, and Baltimore’s 2019 FEMA Advance Assistance award. It is also the logical outgrowth of a wide range of Federal, State, and Local laws, regulations, and policies prioritizing nature-based infrastructure to provide shoreline resiliency. Stage I of the MBRI uses nature-based

infrastructure to protect two critical Community Lifelines: Baltimore Gas and Electric (BGE) Spring Gardens and MedStar Harbor Hospital. Stage I of MBRI has received funding from the FEMA Building Resilient Infrastructure and Communities grant program. Several other projects in the Middle Branch addressing coastal resiliency are also funded through multiple different sources.

Martin State Airport: A Final Environmental Assessment (EA) was signed February 23, 2022 for Phase I Improvements at MSA. Proposed actions in the EA include shifts to Runway 15-33 location, modification to Runway 15-33 grade, and modifications to General Aviation and Landside facilities at the Strawberry Point Complex among many other actions. The purpose of implementing the proposed action of the EA is to meet various Federal Aviation Administration (FAA) standards, enhance airfield safety; improve airfield efficiency; accommodate existing and anticipated demand at MTN; and acquire property for drainage improvements and future mitigation.

Dundalk Marine Terminal: The Dundalk Marine Terminal Resiliency and Flood Mitigation Improvement project will enable MDOT MPA to provide resiliency and flood mitigation improvements at the Dundalk Marine Terminal. The project will install sea curbs to prevent the terminal from flooding during storm surges; install back flow preventers on 15 existing storm drain outfalls to prevent storm surges from flooding low level areas on the terminals; and install a new 10 foot by 5-foot concrete box culvert to increase the capacity of the existing collection system to handle extreme rainfall events. The project is expected to be completed in 2026.

2.6 Economic Environment

2.6.1 Existing Conditions

2.6.1.1 Economic Modeling Description

The Generation II Coastal Risk Management (G2CRM) model is used to estimate economic damages from coastal storm impacts in this study. G2CRM is a desktop computer model that implements an object-oriented probabilistic life cycle analysis (PLCA) model using event-driven Monte Carlo simulation. Monte Carlo simulation is a method for representing uncertainty by making repeated runs (iterations) of a deterministic simulation, varying the values of the uncertain input variables according to probability distributions. A triangular distribution is a three-parameter statistical distribution (minimum value, most likely value, maximum value) used throughout G2CRM to characterize uncertainty for inputs in the model. This allows for incorporation of time-dependent and stochastic event-dependent behaviors such as sea level change, tide, and structure raising and removal. The model is based upon driving forces (storms) that affect a coastal region (study area). The study area is comprised of individual sub-areas (modeled areas) of different types that may interact hydraulically and may be defended by coastal defense elements that serve to shield the areas and the assets they contain from storm damage. Within the specific terminology of G2CRM, the important modeled components are:

- *Driving forces* - storm hydrographs (surge and waves) at locations, as generated externally from high fidelity storm surge and nearshore wave models.
- *Assets* – spatially located entities that can be affected by storms. Damage to structures and contents is determined using damage functions. For structures, population data at individual structures allows for characterization of loss of life for storm events.
- *Modeled areas* - areas of various types (coastal upland, unprotected area) that comprise the overall study area. The water level in the modeled area is used to determine consequences to the assets contained within the area.
- *Protective system elements* - the infrastructure that defines the coastal boundary be it a coastal defense system that protects the modeled areas from flooding (levees, pumps, closure structures, etc.), or a locally developed coastal boundary comprised of bulkheads and/or seawalls.

The model deals with the engineering and economic interactions of these elements as storms occur during the life cycle, areas are inundated, protective systems fail, and assets are damaged, and lives are lost. A simplified representation of hydraulics and water flow is used. Modeled areas currently include unprotected areas and coastal uplands defended by a seawall or bulkhead. Protective system elements (PSE) are limited to bulkheads/seawalls.

Damages to structures and contents have been modeled in G2CRM software. Hydraulic and Hydrology storm data was input into G2CRM from NACCS C-STORM modeling. The C-STORM modeling combines the Ocean Circulation Model and STWAVE (wave modeling). A discussion of these models may be found in Appendix B: Hydrology and Hydraulics Analysis and their application to economic modeling in Appendix E: Economic Analysis.

The following damage categories were investigated using the economic modeling:

Physical Damages

- Structures and Contents
- Vehicles
- Roads/bridges
- Runways
- Rail
- Airport equipment
- Wastewater treatment facilities and infrastructure

Loss of Functionality or Transportation Delays

- Roads

- Heavy Rail (passenger/freight)
- Airport
- Light Rail

Emergency Costs

- HTRW cleanup (e.g., petroleum/chemicals)
- FEMA Housing Assistance (repair to damaged homes, temporary housing)
- FEMA Other Needs Assistance (cleanup items, personal property, moving and storage, medical expenses)

Life Safety

2.6.1.2 Assets

Parcel and building data were obtained from the Baltimore City, Baltimore County, and Anne Arundel County tax assessor's office and used to build a Geographic Information System (GIS) database identifying which parcels and structures fell within the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Category 4 maximum of maximum inundation extent. The structure inventory identified 8,917 structures and vehicles. The structures are broken down as residential and commercial structures with their structure and content values. The inventory also included assets representing infrastructure and cargo at the Port of Baltimore facilities, the Fort McHenry Tunnel with the depreciated replacement value (DRV) with $4.1 billion on I-95 and Harbor Tunnel with DRV of $2.2 billion on I-895, Baltimore Shot Tower Metro Station with DRV of $60.5 million, and the munition depot with $50 million at MSA. The office of engineers at MSA provided the DRV of the munition depot. The tunnels' replacement values are prepared by the MDTA consultant. The consultant used National Highway Consultation Cost Index (NHCCI) to develop the DRV. Table 2-14 summarizes the asset inventory for the study area.

Table 2-14. Asset Count by Jurisdiction

Jurisdiction	Number of Structures	Number of Vehicles	Total Number of Assets
Baltimore City	5,115	3,515	8,630
Baltimore County	150	96	246
Anne Arundel County	41	0	41
Total	5,304	3,611	8,917

The Baltimore Metropolitan study area structure inventory, as modeled, contains 8,917 structures. Out of those residential and nonresidential structures, the occupancy types most found were single Family Residential, Residential Vehicles, Condominium Living Area and Retail Stores, Wholesale, Professional and Technical Services.

2.6.1.3 Content-to-Structure Value Ratios (CSVR)
Site-specific Content-to-Structure Value Ratios (CSVR) information was not available for the study area. The nonresidential CSVR were taken from Appendix E, Table E-1 of the Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation Draft Report, revised 2013. Moreover, these functions contained a triangular distribution (i.e., minimum, maximum, most likely) to account for the uncertainty surrounding the ratio for each nonresidential occupancy type. The residential CSVR used a combination of both the Expert Elicitation Draft Report and EGM 01-03 and 04-01. Moreover, both EGMs contained guidance to account for uncertainty associated with content/structure value ratio, which implies that the uncertainty in the content-to-structure value ratio should be inherent in the content depth-damage relationship as contained in both respective EGMs. Additional information on CSVR can be found in Appendix E: Economic Analysis.

2.6.1.4 Summary of the Inventory
The assets were categorized as residential or nonresidential, which were then further categorized into occupancy types. Table 2-15 below displays the count and structure value by the occupancy types.

Table 2-15. Structure Inventory by Occupancy Type

Occupancy Type	Description	Count	Total Structure Value	Content Value
AUTO-N	Auto/Commercial	207	$825,080,000	$0
AUTO-R	Auto/Residential	3,404	$17,947,000	$0
COM1	Average Retail	548	$404,075,000	$181,834,000
COM10	Garage	13	$41,761,000	$15,452,000
COM2	Average Wholesale	161	$499,216,000	$184,710,000
COM3	Average Personal & Repair Services	123	$131,887,000	$87,046,000
COM4	Average Professional/Technical Services	143	$447,510,000	$80,552,000
COM5	Bank	10	$7,119,000	$1,281,000
COM7	Average Medical Office	15	$36,205,000	$21,723,000
COM8	Average Entertainment/Recreation	44	$225,359,000	$56,340,000
COM9	Average Theatre	3	$51,487,000	$9,268,000
EDU1	Average School	12	$61,738,000	$4,322,000
GOV1	Average Government Services	81	$295,814,000	$53,246,000
GOV2	Average Emergency Response	2	$1,104,000	$773,000
HRISE	Average Urban High-Rise, More Than 4 Floors	635	$7,480,368,000	$1,241,765,000
IND1	Average Heave Industrial	79	$263,301,000	$100,054,000
IND2	Average Light Industrial	347	$1,003,586,000	$441,840,000
IND3	Average Food/Drugs/Chemicals	37	$28,570,000	$55,195,000
IND4	Average Metals/Minerals Processing	25	$21,479,000	$3,866,000
IND5	Average High Technology	20	$175,917,000	$31,665,000
IND6	Average Construction	34	$73,199,000	$6,363,723,000
REL1	Church	16	$27,404,000	$1,918,000

Occupancy Type	Description	Count	Total Structure Value	Content Value
RES1-1SNB	Single Family Residential, 1 Story, No Basement	36	$11,783,000	$5,892,000
RES1-1SWB	Single Family Residential, 1 Story, With Basement	18	$3,432,000	$1,716,000
RES1-2SNB	Single Family Residential, 2 Story, No Basement	1,024	$239,046,000	$119,523,000
RES1-2SWB	Single Family Residential, 2 Story, With Basement	1,755	$353,197,000	$176,599,000
RES3A	Condominium, Living Area, 1-2 Floors	4	$1,361,000	$136,000
RES3B	Condominium, Living Area, 3-4 Floors	117	$64,897,000	$5,768,000
RES4	Average Hotel, & Motel	4	$31,330,000	$8,146,000
Total		**8,917**	**$12,825,175,000**	**$9,254,351,000**

Critical infrastructure in the Baltimore Metropolitan area includes Baltimore City fire stations, Baltimore City Police Department Headquarters, Maryland Transportation Authority Police - Dundalk Marine Terminal, U.S Customs and Border Protection Field Office, Maryland Port Administration World Trade Center Building. Baltimore City is also home to medical facilities in the study area which include MedStar Harbor Hospital, and Mercy Medical Center. Schools such as The Crossroads School, Mother Seton Academy, and New Century School are in 1 percent AEP areas except Sharp Leadenhall which is in 0.2 percent AEP. Industrial sites such as Domino Sugar Baltimore, Inner Harbor East Heating Plant, Wheelabrator Baltimore Refuse incineration plant and the Patapsco Wastewater Treatment Plant are subject to flooding. The other critical infrastructure in the Baltimore Metropolitan area includes MSA in Baltimore County and the Curtis Bay USCG yard in Anne Arundel County. The water-dependent Baltimore City Fire Boat Station, two power-plants supplying power and hot water to private businesses, and the field office for U.S. Customs and Border Protection are also at risk at the 1 percent AEP. The historic relative sea level trend is 0.01 feet/year based on NOAA's Baltimore MD tide gauge.

2.6.1.5 Model Areas

Model areas (MA) are established to represent the various geographic parts of the study area that have uniform flood elevations. Boundaries are defined by natural or built topological features (e.g., a ridge, highway, or railway line), therefore, correspond to the drainage divides separating local-scale watersheds. This facilitates analysis by grouping MAs into areas that share common features, as well as accelerates the economic modeling process. A storm event is processed to determine the peak stage in each defined MA, and it is this peak stage that is used to estimate consequences to assets within the MA.

The study area consists of 25 MAs. Additional details and maps of the MAs can be found in Appendix E: Economic Analysis. These MAs are spatial areas defined by geospatial polylines. There are two types of MAs: unprotected MAs and upland MAs. An unprotected modeled area is a polygonal boundary within G2CRM that contains assets and derives associated stage from the total water level (i.e., storm surge, wave contribution, SLC contribution, plus tide contribution) calculated for a given storm, without any mediation by a PSE. An upland modeled area is a polygonal boundary within G2CRM that contains assets and derives associated stages from the total water level calculated for a given storm, as mediated by a PSE (such as a bulkhead/seawall or flood barrier), that must be overtopped before water appears on the modeled area. It also has an associated volume-stage relationship to account for filling behind the bulkhead/seawall or flood barrier during the initial stages of overtopping. It is important to note that there is no PSE that exists in the Baltimore Coastal study area before this study began. Hence, the PSEs were developed in the upland shapefile in the existing and the FWOP conditions by setting their height lower than the lowest structure first-floor elevation. Therefore, having each MA be a component of an upland MA in the existing and the FWOP conditions was a model strategy utilized in order to model the FWP condition, since only one of both shapefiles (upland MA or unprotected MA) can be used in the existing, the FWOP, and the FWP conditions. Protective System Elements

Flood hazard manifested at the storm location is mediated by the PSE such as bulkhead/seawall or flood barrier. The PSE prevents transmission of the flood hazard into the MA until the flood hazard exceeds the top elevation of the bulkhead/seawall or flood barrier. When the flood hazard exceeds the bulkhead/seawall or flood barrier top elevation the flood hazard is instantaneously transmitted into the MA unmediated by the bulkhead/seawall or flood barrier.

PSEs are defined in G2CRM to capture the effect of built FRM infrastructure (i.e., what in G2CRM is categorized as a bulkhead/seawall or a flood barrier).

The top elevation is specified at the approximate existing ground elevation within the MA for both the existing and FWOP condition simulation, in G2CRM. In this way, the bulkhead/seawall or the flood barrier does not influence the existing condition consequences of the flood hazard. For the FWP condition the bulkhead/seawall or the flood barrier top-elevation is raised in the alternative file and its influence is captured.

2.6.1.6 Volume Stage Functions

Volume-stage functions also called stage-volume functions are associated with an upland MA. For the study area, the volume-stage functions were derived from the digital terrain model generated from the Baltimore Metropolitan Area Light Detection and Ranging (LIDAR) (Baltimore City-Baltimore County-Anne Arundel County) collected and published by MDDNR in 2017 and provided by the non-Federal sponsor for this study. Volume-stage functions describe the relationship between the volume contained in the MA and the associated stage (water depths) for each MA. Water level within the MAs is computed by first estimating the volume of water passing over the PSEs and then using the stage-volume relationship to determine water level within the MAs. Once the storage area in the MAs is filled, the flood hazard is transmitted into the MAs unmediated by the bulkhead/seawall or the flood barrier.

2.6.1.7 Evacuation Planning Zones (EPZ)

Communities in the Baltimore Metropolitan area are vulnerable to flooding. There are approximately 48,000 people in the study area that are within the extent of a Category 4 hurricane, based on NOAA's SLOSH model. In addition, thousands of commuters and tourists are in the Baltimore Metropolitan area daily. During storm surge events, the ability of first responders to reach the location of need and the ability of individuals to reach medical facilities can be limited or cut off entirely.

Extreme weather and climate-related events can have lasting mental health consequences in affected communities, particularly if they result in degradation of livelihoods or community relocation. Populations including older adults, children, many low-income communities, and communities of color are often disproportionately affected by, and less resilient to, the health impacts of climate change. Lessons from numerous coastal storm events have made it clear that if the elderly, functionally impaired persons, and/or low-income residents who wish to evacuate from areas at risk from a pending coastal storm may sometimes be unable to evacuate due to their physical or socioeconomic condition. Flooding in urban areas can cause serious health and safety problems for the affected population. The most obvious threat to health and safety is the danger of drowning in flood waters. When people attempt to drive through flood waters, their vehicles can be swept away in as little as one foot of water (FEMA, 2023).

An evacuation planning zone (EPZ) is a spatial area, defined by a polygon boundary that is used within loss of life calculations in G2CRM and used to determine the population remaining in structures during a storm (i.e., population that did not evacuate). Therefore, in G2CRM, each asset is assigned to an MA which is then assigned to an EPZ and modeled in G2RM for potential life loss given a storm event.

In G2CRM, life loss calculations are performed on a per-structure per-storm basis. In order for life loss calculations to be made, the maximum stage in the modeled area has to be greater than the foundation height plus the ground height.

Loss of life calculations are separated by age categorization into under 65 and older. They are also categorized as daytime or nighttime. There are three possible lethality functions for structure residents: safe, compromised, and chance. Safe would have the lowest expected life loss, but not implying no life loss, and chance would have the highest expected life loss.

2.6.2 Existing Condition Modeling Results

The assets assigned to each MA and EPZ were modeled in G2CRM using the 291 tropical storms and 100 extra tropical storms with its relative probability-water level relationship.

G2CRM used the economic (e.g., Assets) and engineering inputs (e.g., Storms) to generate expected present value (PV) damages for each structure throughout the life cycle (i.e., the period of analysis). The possible occurrences of each economic (i.e., triangular distribution) and engineering (i.e., relative probabilities) variables were derived through the use of Monte Carlo simulation and a total of 100 iterations were executed by the model for this analysis. Every iteration represents expected PV damages for the period of analysis and cumulative damages of assets converged at approximately 100 iterations.

The sum of all damages for each life cycle was divided by the number of iterations to yield the expected PV damages for that modeled simulation. A mean and standard deviation were automatically calculated for the PV damages for each MA. For this analysis, G2CRM used 291 tropical storms and 100 extra tropical storms produced by high fidelity coastal modeling (see Appendix E: Economic Analysis) for each MA. Seven of 291 tropical storms have zero water level. Each storm had a relative probability associated with it. Any chance of that storm happening in the model simulation was based on that relative probability. Moreover, each storm given its relative probability had an equivalent specific peak water level. These water levels were applied to each structure in each MA and EPZ to determine damages and consequences.

2.6.3 Economic FWOP

2.6.3.1 Background

According to the Fourth National Climate Assessment (4th NCA) report on Region 2, the Chesapeake Bay watershed is experiencing stronger and more frequent storms, an increase in heavy precipitation events, increasing bay water temperatures, and a rise in sea level. These trends vary throughout the watershed and over time but are expected to continue over the next century.

The USACE low, intermediate, and high SLC scenarios were evaluated for the FWOP and FWP condition, and with respect to determining tipping points/thresholds for impacts over the 50-year period of analysis and the 100-year adaptation timeframe, and at multiple storm frequencies as shown in Section 2.4.12.2 of this IFR/EA. The historic relative sea level trend is 0.01 feet/year based on NOAA’s Baltimore MD tide gauge.

2.6.3.2 FWOP Condition Modeling Results

The years 2031-2080 were selected to represent the FWOP project condition. No additional development within the study area is anticipated to be at risk since it was assumed that no new development would be subject to future flood risk during the period of analysis. However, a combination of both wealth and complementary effects are likely to contribute to growth in the value of the assets at risk in the study area. The same structures in the Baltimore Metropolitan area would continue to be affected by the flooding from coastal storms and suffer increasing losses each year. Modeling results anticipate the highest flood damages of structures to occur within the Inner Harbor MAs followed by the tunnels MAs.

G2CRM used Monte Carlo simulation to derive the expected PV damages with 100 iterations completed. The sum of all damages for each life cycle were divided by the number of iterations to yield the expected PV damages for that modeled simulation. A mean and standard deviation were automatically calculated for the PV damages for each MA to account for uncertainty. These PV damages for each MA were summed to derive the study area expected PV damages. Sea level change used in the calculations follows the USACE Intermediate Curve. For G2CRM modeling, the SLC rate of 0.00994 feet per year was used. Further information and a list of FWOP PV damages per MA can be found in Appendix E: Economic Analysis.

The forecasted SLR in the future, without a project in place, resulted in higher expected average PV damages. The total FWOP PV damages are approximately $817.2 million or about $27.4 million EAD. The forecast of the FWOP project condition reflects the conditions expected during the period of analysis (2031-2080) and provides the basis from which alternative plans are evaluated, compared, and selected since a portion of the flood damages would be prevented (i.e., flood damages reduced) with a federal project in place.

3 PLAN FORMULATION AND EVALUATION

3.1 Planning Framework

The guidance for conducting Civil Works planning studies, ER 1105-2-100[4], Planning Guidance Notebook, requires the systematic formulation of alternative plans that contribute to the federal objective. To ensure sound decisions are made with respect to the development of alternatives, and with respect to plan selection, the plan formulation process requires a systematic and repeatable approach. This chapter presents the results of the plan formulation process leading to the selection of the Recommended Plan.

Plan formulation was conducted with a focus on achieving the federal objective of water and related land resources project planning, which is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable EOs, and other federal planning requirements. Plan formulation also considers the four economic accounts: NED, Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). The plan formulation process focuses on establishing alternatives with structural, nonstructural measures and NNBF.

Structural CSRM measures are man-made, constructed measures that counteract a flood event in order to reduce the hazard or to influence the course or probability of occurrence of the event. This includes gates, levees, and flood walls (permanent and deployable) that are implemented to reduce risk to people and property.

Nonstructural CSRM measures are permanent or temporary measures applied to a structure and/or its contents to minimize flood risk. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the probability of flooding. Relocation, home elevation, and floodproofing are examples of nonstructural measures.

NNBF CSRM measures work with or restore natural processes to attenuate or minimize wave and storm surge energy.

The planning process for formulating alternatives is summarized in Figure 3-1, which is a distillation of the planning process used by USACE. The PDT participated in weekly meetings to discuss and evaluate existing information and coastal storm risk in the study area. USACE reports including those listed in Section 1.10 of this IFR/EA and reports generated by MDOT, Baltimore City, and stakeholder groups, include important information about existing conditions and proposed future conditions for project alternatives.

[4] The Planning Guidance Notebook was updated on 7 December 2023 as ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The PDT is aware of this new guidance and consulted the draft guidance while completing the study.

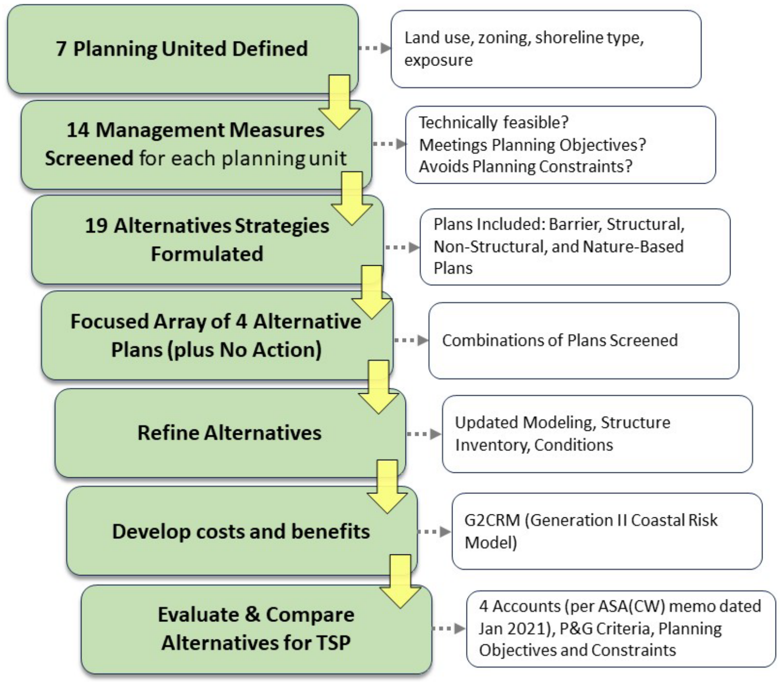

Figure 3-1. Plan formulation process for developing alternatives

3.2 Assumptions

Within Baltimore City, it is assumed that all new or substantially improved construction projects for residential and non-residential structures would adhere to Baltimore City floodplain policy (Article 7 Nat. Res, Division 1 Floodplain Management of the Baltimore City Code). As such, it is assumed that new and substantially improved structures are protected to the flood-protection elevation, which is the modeled elevation of the 0.2 percent chance of flood plus 2 feet of freeboard in the tidal floodplain as listed on the current FEMA Flood Insurance Study. Therefore, several development projects currently underway or recently constructed have been excluded from consideration because floodplain management and flood risk management will be up to date.

The eight-mile waterfront promenade in Baltimore City is a public pedestrian walkway/shared use bicycle path and is within this study's planning areas: The promenade represents a mixture of public and privately owned land, and development along the promenade must conform to various City policies (Figure 3-2). As such, this study assumes that all public access corridors to the promenade, as outlined in Article 32 Zoning, Division 12 Special Purpose Districts, § 12-906 of the Baltimore City Code, must be open to the public 24 hours a day, 7 days a week unless agreed to by the Director of Planning and must be free of other impeding obstacles.

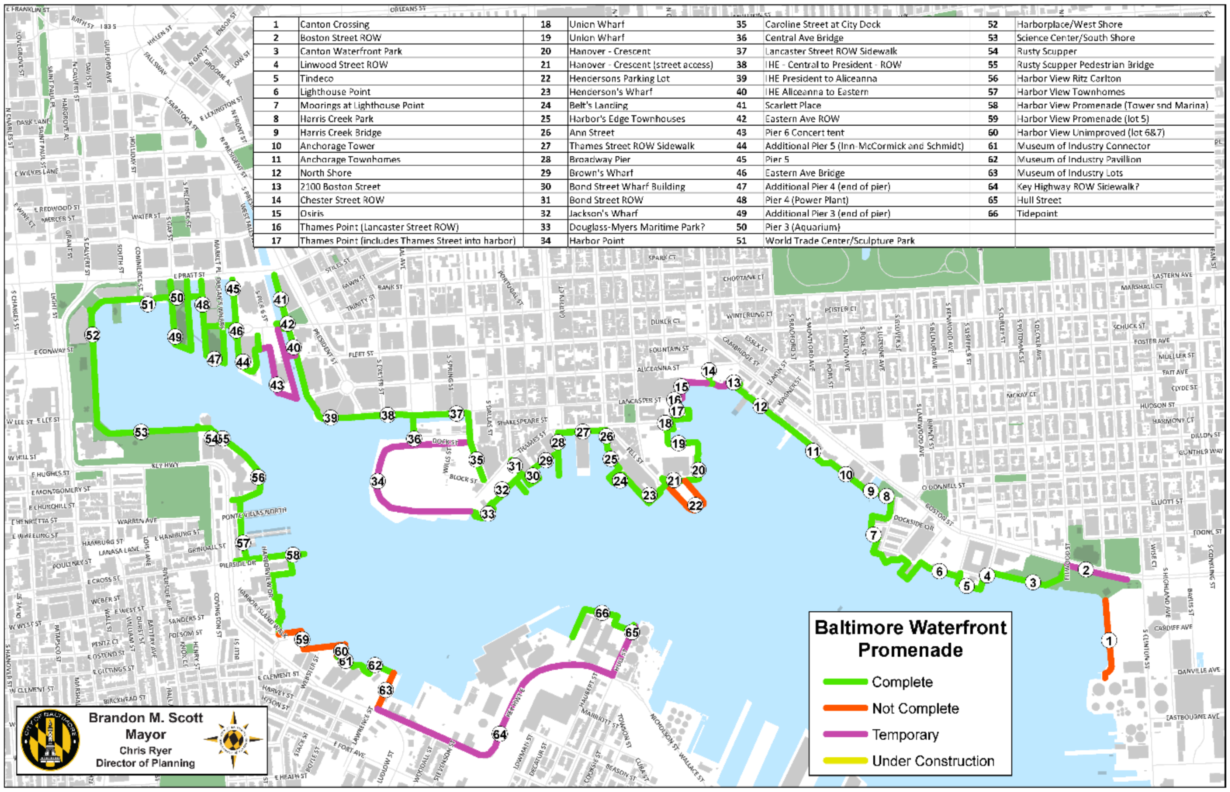

Figure 3-2. Baltimore Waterfront Promenade (Baltimore City Department of Planning)

3.3 Planning Units

The study area was segmented into seven planning units (Figure 3-3). Each planning unit has similar land use, shoreline type, zoning, opportunities, and constraints. The planning units are Patapsco East, Patapsco North, Inner Harbor, Locust Point, Middle Branch, Patapsco South, and Martin State Airport. Planning units were the initial subdivision of the study area. For economic modeling, the planning units were further subdivided into model areas (MAs) which will be described separately.

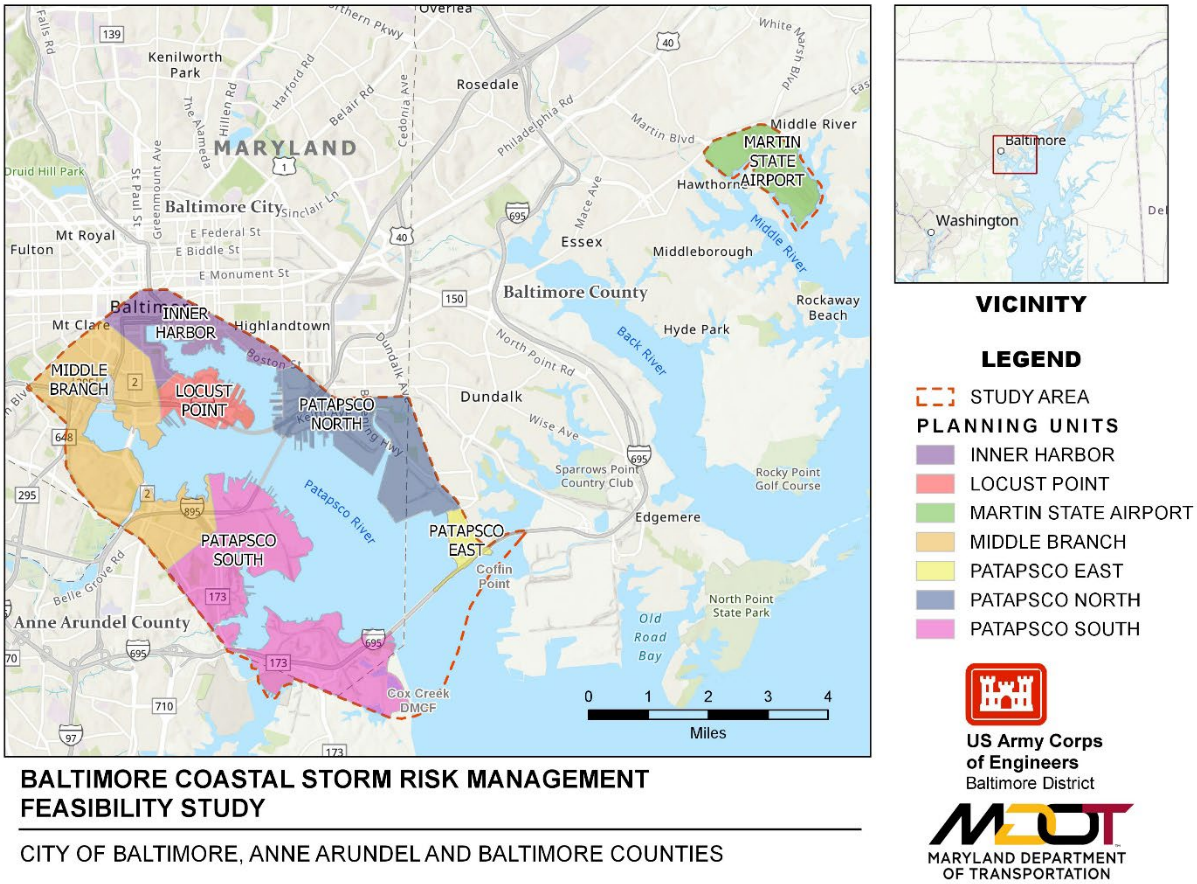

Figure 3-3. Planning Units

The years 2031-2080 were selected to represent the FWOP condition. If no federal action is taken, more than 1,200 structures would be subject to coastal storm inundation with present sea level conditions during a storm with a 1 percent AEP. Using the intermediate SLR curve, more than 1,400 structures are expected to be subject to coastal storm inundation in 2080, fifty years from the project base year.

A description of the planning units is included below, as well as the modeled inundation extent for each planning unit under the 1 percent AEP for the base year (2031) and for year 2080.

3.3.1 Patapsco East

This planning unit includes the northern shorelines of the Patapsco River, from Coffin Point (including the I-695 bridge to Sparrows Point) to the Dundalk Marine Terminal. This planning unit is in Baltimore County. The shoreline contains the Francis Scott Key Bridge (I-695) toll plaza, MDTA Offices, the Riverside Generating Station (retired) and electrical distribution facility, and a residential neighborhood adjacent to the Dundalk Marine Terminal. For the existing and FWOP condition, the primary impact would be to the retired

Riverside Generating Station and electrical distribution facility. As part of BGE's Key Crossing Reliability Initiative, the electrical distribution facility is currently being upgraded. The residential neighborhood occupies higher ground along the shoreline. Figure 3-4 shows the coastal flood inundation extent in the Patapsco East planning unit.

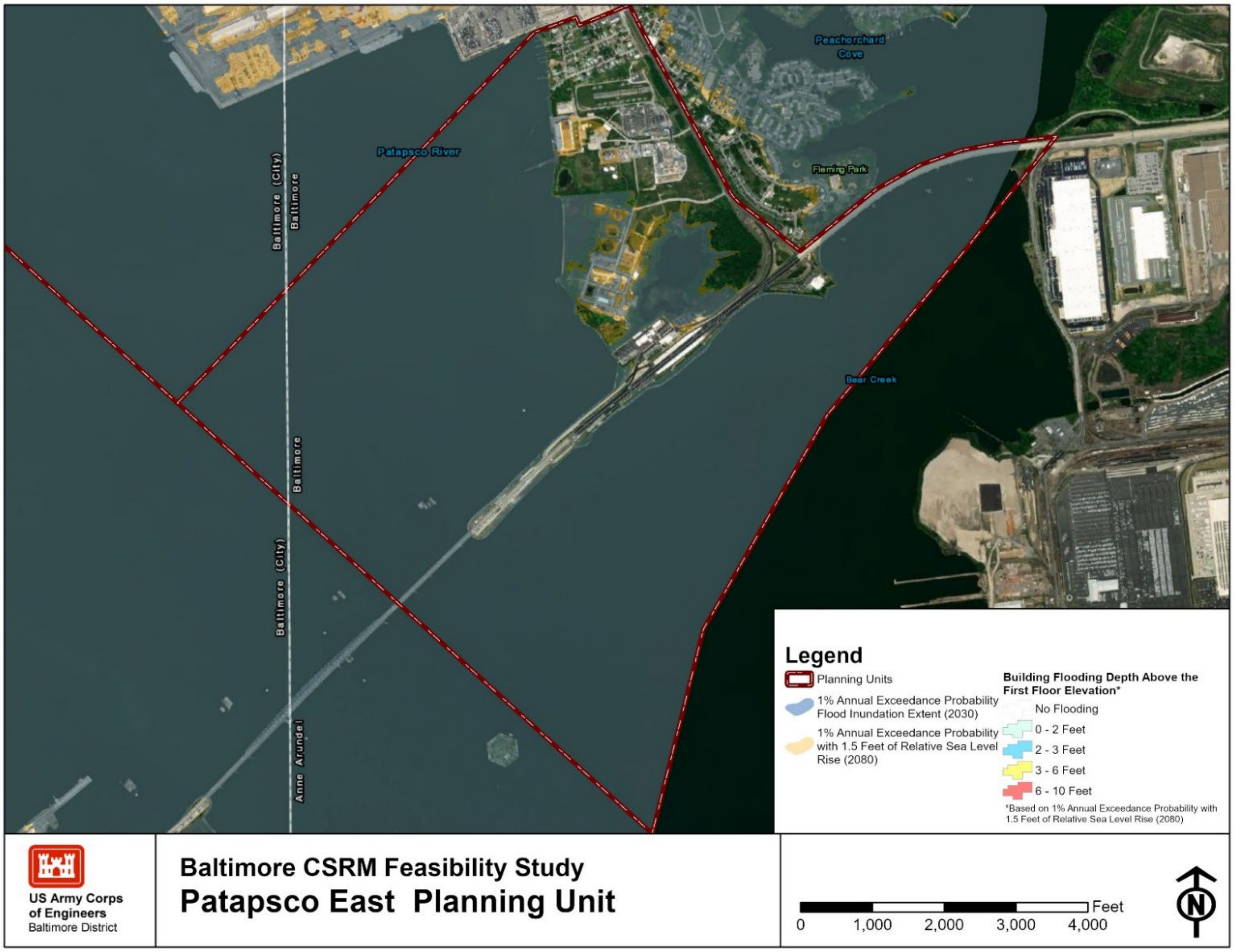

Figure 3-4. Patapsco East Planning Unit Coastal Flood Inundation Extent

3.3.2 Patapsco North

The Patapsco North planning unit includes the Dundalk Marine Terminal on the east and includes a small portion of Baltimore County while the rest of the area is within Baltimore City. The shoreline is characterized by marine terminals and marine activity and also includes the northern entrances and facilities of the I-895 and I-95 (Baltimore Harbor and Fort McHenry) tunnels. Colgate Creek divides the Dundalk and Seagirt Marine Terminals. Much of the Dundalk and Seagirt Marine Terminals may be inundated in the FWOP conditions under 1 percent and 0.2 percent AEP, as would be piers and associated marine infrastructure. Support facilities for the I-895 Baltimore Harbor Tunnel may also be vulnerable under the FWOP conditions. Figure 3-5 shows the coastal flood inundation extent in the Patapsco North planning unit.

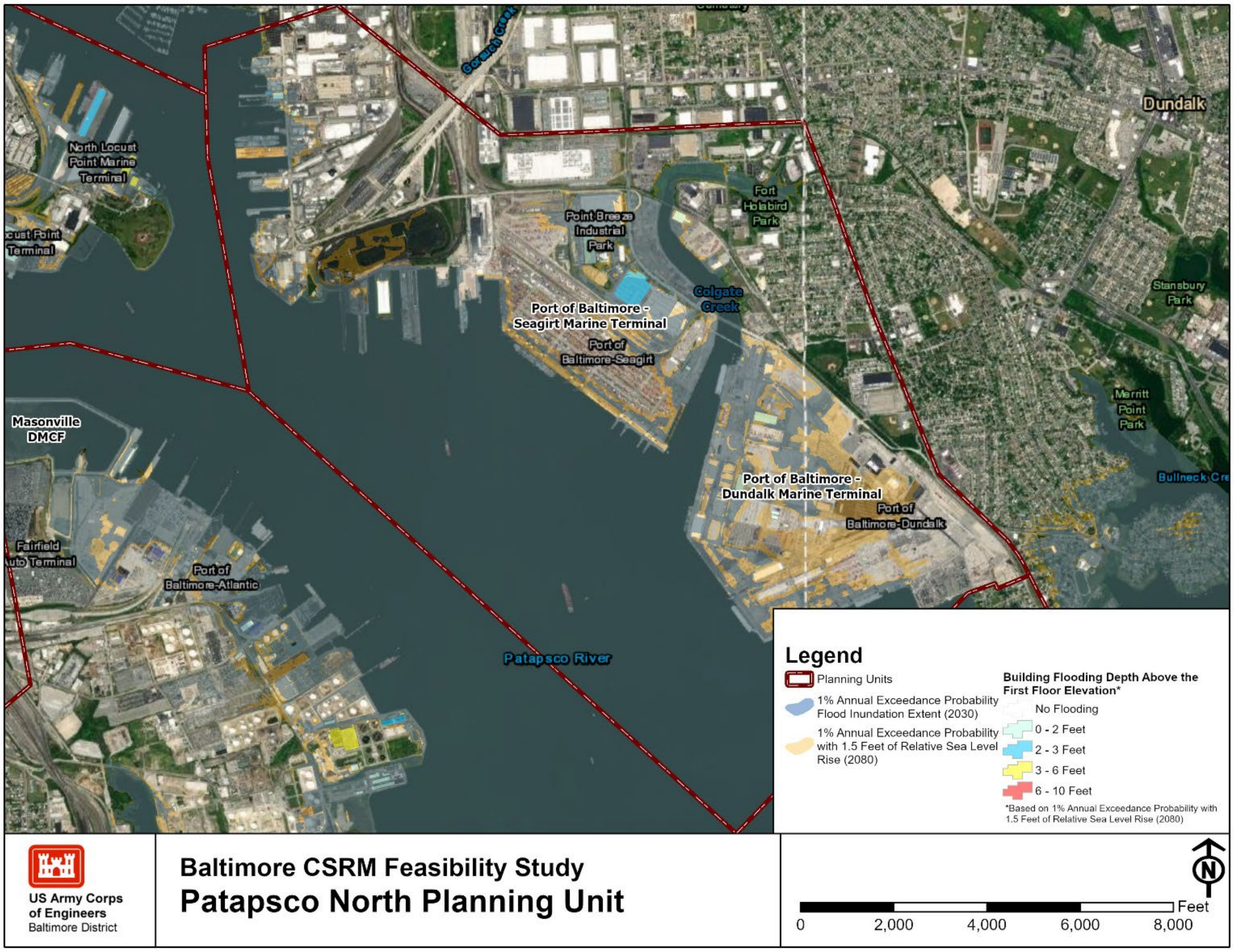

Figure 3-5. Patapsco North Planning Unit Coastal Flood Inundation Extent

3.3.3 Inner Harbor

The Inner Harbor planning unit includes much of what is considered the downtown Baltimore City waterfront. The Inner Harbor planning unit encompasses the majority of Baltimore's Waterfront Promenade (see Figure 3-2). Included within this planning unit are the Baltimore City Police Marine Unit, the neighborhoods of Canton, Fells Point, Harbor Point, Harbor East, and the Inner Harbor. The Shot Tower Metro station and its supporting infrastructure is also located in the planning unit and was identified by MDOT as a very high-risk site for inundation due to coastal storms and sea level rise (MDOT, 2016). Land use in the area is primarily residential and commercial, with a walkable/bikeable Waterfront Promenade along nearly the entire waterfront.

Inundation for the 1 and 0.2 percent AEP with SLC would result in extensive inundation in Fells Point, Harbor East, and the Inner Harbor. Harbor Point is a redevelopment of former contaminated industrial site and buildings are generally elevated. Figure 3-6 shows the coastal flood inundation extent in the Inner Harbor planning unit.

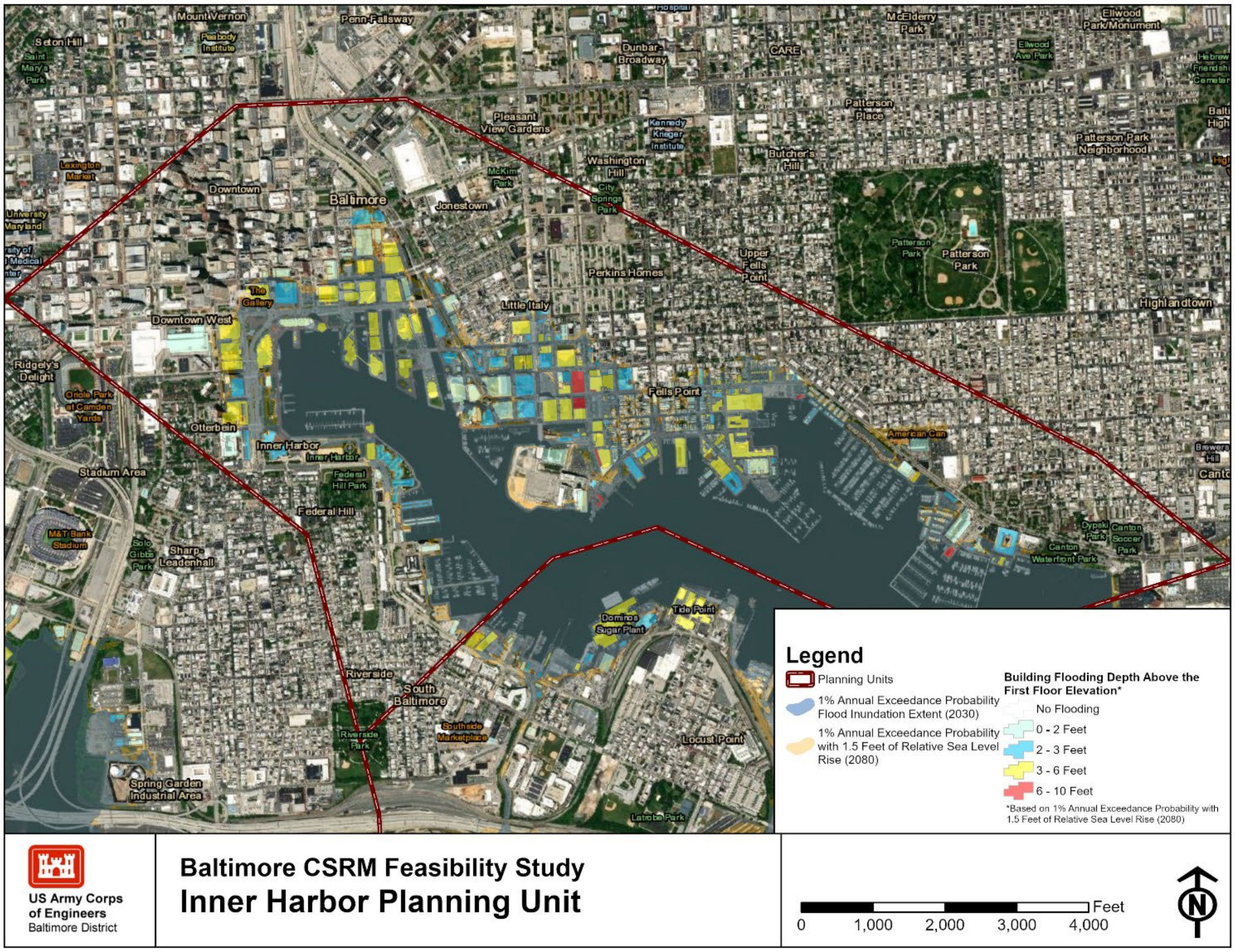

Figure 3-6. Inner Harbor Planning Unit Coastal Flood Inundation Extent

3.3.4 Locust Point

The Locust Point planning unit includes the Locust Point Peninsula, which separates the Inner Harbor from the Middle Branch of the Patapsco River. The planning unit extends around the peninsula to the beginning of the Port Covington development. Areas that would be inundated under FWOP conditions are primarily industrial, commercial, port facilities, and transportation assets. Flooding would affect the Domino Sugar Plant, the Tide Point office complex, the Baltimore Fire Department Marine Unit, CENAB Fort McHenry facility, and the public marine terminals of North and South Locust Point Marine Terminals. The area also contains the southern entrance to the I-95 Fort McHenry Tunnel and its support facilities.

The Locus Point Peninsula is also home to Fort McHenry, administered by the NPS. The I-95 Fort McHenry Tunnel and its support facilities would be vulnerable under the 1 percent AEP with SLC. Figure 3-7 shows the coastal flood inundation extent in the Locust Point planning unit.

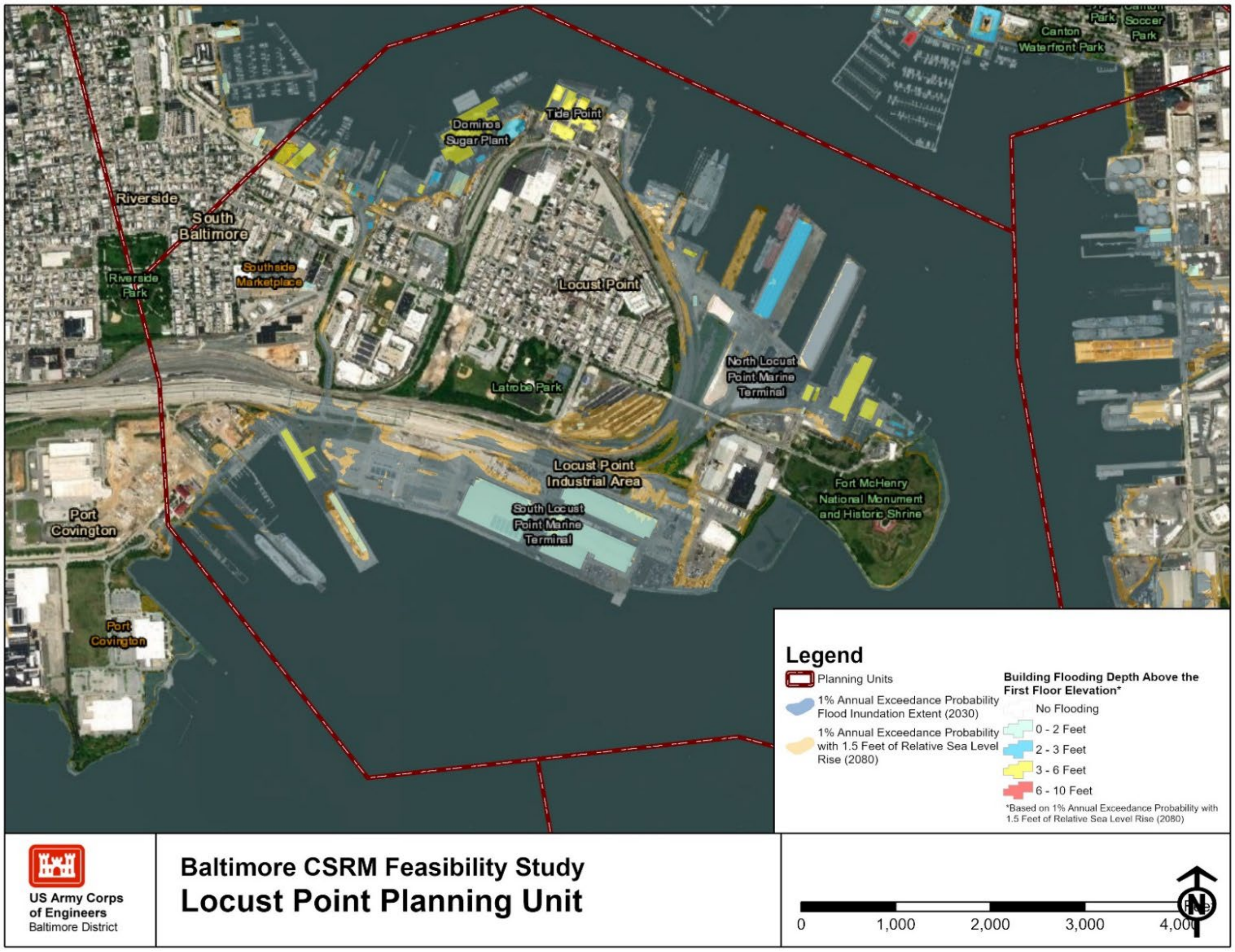

Figure 3-7. Locust Point Planning Unit Coastal Flood Inundation Extent

3.3.5 Middle Branch

The Middle Branch Planning unit encompasses much of the waterfront areas of the Middle Branch of the Patapsco River. The waterfront area extends from Port Covington to the Masonville DMCF. There is an existing effort within much of the area to enhance the shoreline for coastal resiliency, enhancing recreation, reconnecting people to the water, and ecosystem restoration. The Reimagine Middle Branch Project has secured funding to begin development of elements of the master plan, including protection of the vulnerable BGE Spring Garden natural gas facility.

This planning area includes a mix of industrial and commercial uses, previously developed shoreline, and public parks. Multiple large development projects are underway or in the planning phases and new development will incorporate design to protect against flooding and SLC. Projects include Port Covington and the Under Armour Campus, Casino Entertainment District, and Westport waterfront redevelopment. Parts of the Casino Entertainment District would be inundated under the FWOP 1 percent scenario. Under the 0.2 AEP scenario, inundation would extend further into the entertainment district and into a small portion of the Carroll Camden Industrial Area. A portion of the southern parking lot of Harbor Hospital would also be inundated under the 0.2 percent AEP scenario. The Baltimore Light Rail system runs through the Westport community and above part of the Middle Branch but was not found to be vulnerable in this analysis. Figure 3-8 shows the coastal flood inundation extent in the Middle Branch planning unit.

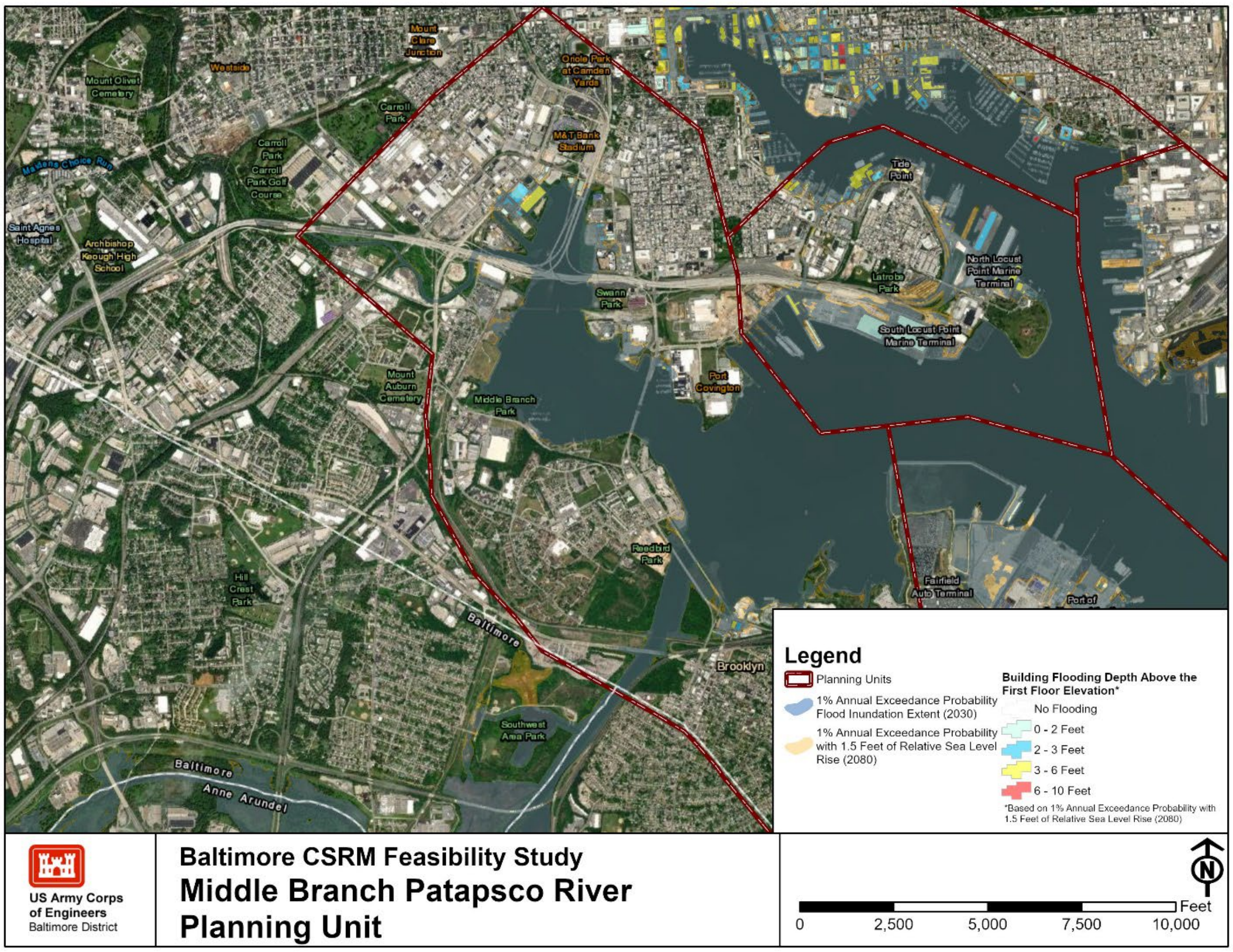

Figure 3-8. Middle Branch Planning Unit Coastal Flood Inundation Extent

3.3.6 Patapsco South

The Patapsco South planning unit includes the shoreline of the Patapsco River from the Masonville Dredged Material Contain Facility to the Cox Creek DMCF. Most of the area is in Baltimore City, though a small portion extends into Anne Arundel County. The shoreline is largely industrial. Areas at risk of inundation under FWOP conditions include Fairfield Marine Terminal, multiple private marine terminals, the Patapsco wastewater treatment plant, and the southern tunnel entrance for the I-895 tunnel (Baltimore Harbor Tunnel). The Curtis Bay Coast Guard Yard also has portions of its facility that are at risk of inundation. Figure 3-9 shows the coastal flood inundation extent in the Patapsco South planning unit.

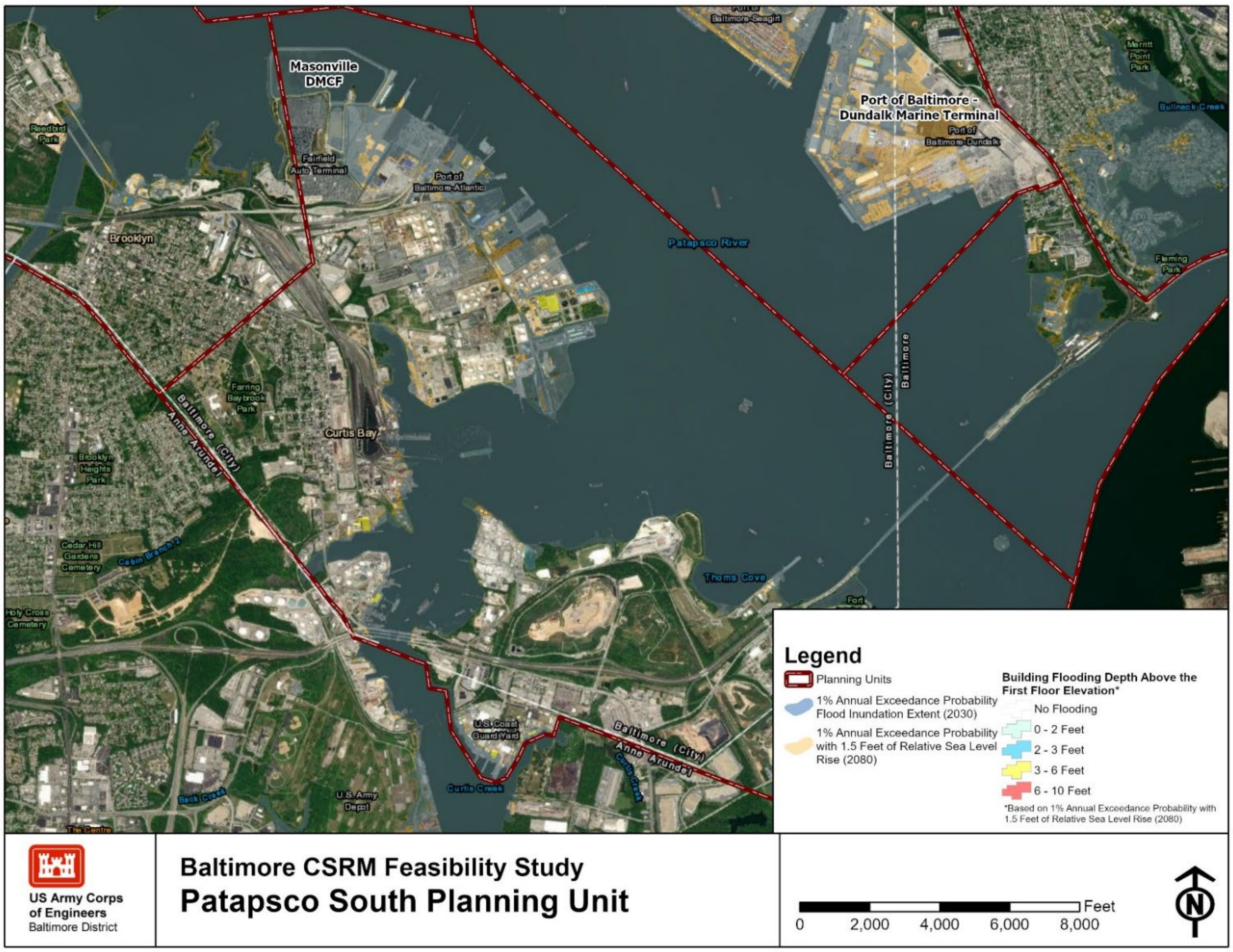

Figure 3-9. Patapsco South Planning Unit Coastal Flood Inundation Extent

3.3.7 Martin State Airport

The MSA planning unit is not contiguous with the other planning units and lies to the northeast of Baltimore City in Baltimore County on Middle River. The planning unit includes the Maryland State-owned MSA, the Warfield Air National Guard Base, and Chesapeake Industrial Park.

For the 1 percent AEP FWOP conditions, supporting infrastructure at the southern portion of the airport would be inundated, including hangers for the Baltimore City Police aviation unit and Baltimore County Police aviation unit, and the airport fuel facility. Several structures at the Air National Guard base would also be inundated. Additionally, Wilson Point Road, which is the main access to Wilson Point, would be inundated at the entrance to Martin State Airport. In the 0.2 AEP scenario, the main buildings of MSA would be inundated as would the main entrance road to the Warfield Air National Guard Base. Figure 3-10 shows the coastal flood inundation extent in the MSA planning unit.

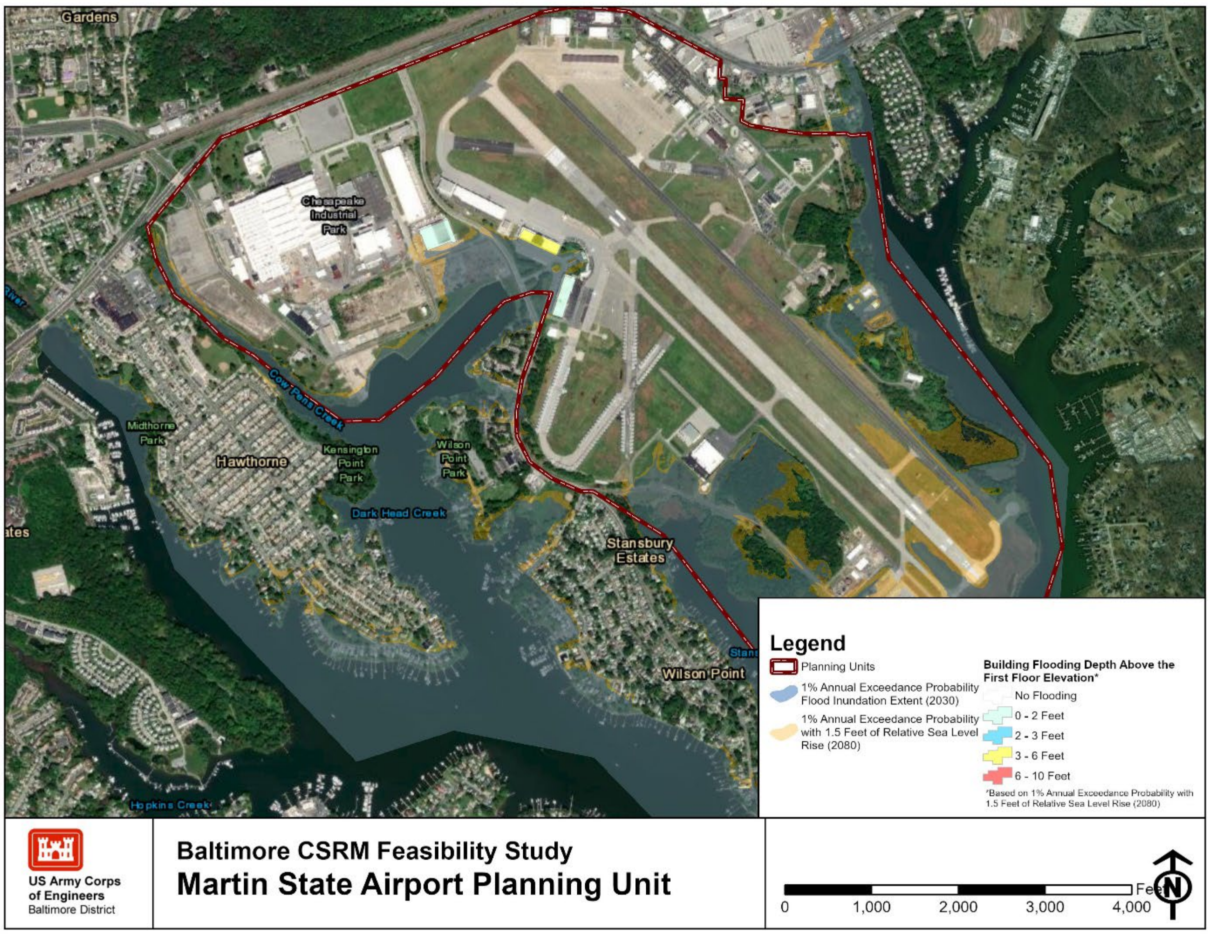

Figure 3-10. Martin State Airport Planning Unit Coastal Flood Inundation Extent

3.3.8 Summary of Flooding Impacts

Infrastructure and cargo at the Port of Baltimore are vulnerable to coastal flooding and could be damaged. Of particular concern are parked vehicles waiting for import/export on exposed parking lots at the Dundalk, South Locust Point, and Fairfield terminals. At any given time, these terminals have thousands of vehicles that are vulnerable to damage from coastal flooding.

Maryland State Highway Administration assets are vulnerable to damage from coastal flooding. Of particular concern are the I-95 and I-895 tunnels (Fort McHenry and Harbor Tunnels respectively) and their supporting transportation critical facilities (the tunnel ventilation buildings). Flood waters may enter the tunnels and the transportation critical facilities. In addition to severe transportation disruption, flooding could cause damage to the tunnels, systems in the tunnels, and structures on land housing ventilation and other critical equipment.

The southern portion of the MSA runway would be inundated in a coastal storm and is susceptible to damage. Strawberry Point at the southern end of the airport houses the Maryland State Police aviation unit's hangers, which would be damaged and for which operations would need to be relocated in the event of storm damage. The airport's fuel farm would be inundated. Wilson Point Road would be inundated, cutting off access to the residential community of Wilson Point. Facilities of the Maryland Air National Guard, a tenant of the airport, would be damaged, including munitions storage, and the primary access road to the base would be inundated. Finally, coastal flooding could damage mitigation systems in place for the remediation of groundwater contamination at MSA.

There are numerous development projects, both proposed and under construction, within the Baltimore City study area. They are all expected to be built to Baltimore City code with a first-floor elevation 2 feet above 0.2 percent AEP in the tidal floodplain. No damages are forecast from these developments.

Baltimore Gas and Electric (BGE) replaced underwater high voltage transmission cables at the Key Bridge with an overhead crossing of the Patapsco River in 2022. When the transmission line was replaced, the existing Sollers Point terminal station was deactivated. This terminal station was at risk of flooding from coastal storms.

As previously mentioned, the Reimagine Middle Branch initiative is being undertaken by the South Baltimore Gateway Partnership using multiple sources of funding, including federal funds from FEMA to enhance coastal resilience in the Middle Branch area, including the BGE Spring Gardens natural gas storage and distribution facility.

The Port of Baltimore is expected to continue to attract a diverse array of vessels transporting containers, coal, vehicles, and general cargo. Maryland Port Administration and its partners upgraded Berth 3 at the Seagirt Marine Terminal in 2022, which would allow for two berths to service large container ships of around 14,000 TEU capacity. Maryland Port Administration has partnered with U. S. Maritime Administration to provide upgrades to all berths at the Dundalk Marine Terminal, installing a "sea curb" during the upgrade process which would provide some risk reduction to coastal flooding.

3.4 Management Measures

The PDT identified management measures in accordance with the study-specific planning objectives, existing plans, analyses, and studies. For each planning unit, a list of FRM measures were evaluated and screened. Measures that were evaluated include:

Structural:

- Storm surge barrier (large, e.g., regional)
- Tide gates
- Seawall, bulkheads
- Groins, breakwaters
- Floodwalls & levees
- Deployable floodwalls
- Drainage improvements (e.g., pump house)
- Channel improvements
- Shoal removal/dredging (in-channel)
- Road raising/elevation

Nonstructural:

- Floodproofing
- Building elevation
- Acquisition & relocation
- Enhanced warning systems

NNBF*

- Living shoreline
- Wetland restoration
- Reefs
- SAV
- Beach restoration (dunes)

*NNBF features were considered as standalone measures where feasible, and for optimization of alternatives

3.4.1 Description of Structural Measures Considered

Structural measures are engineering features that help reduce damage from coastal storms and erosion as well as to manage flood risk from coastal storms.

3.4.1.1 Storm Surge Barrier

Storm surge barriers reduce risk to estuaries against storm surge flooding and waves. In most cases the barrier consists of a series of movable gates that stay open under normal conditions to let the flow pass but are closed when storm surges are expected to exceed a certain level. Four alignments of a storm surge barrier were considered in the Baltimore Metropolitan Area Survey Report, 1960. At each location a rock-faced hydraulic fill barrier with a navigation opening was considered. No plan was found to be economically justified in 1960 and none were supported by local interests.

3.4.1.2 Tide Gates

Tide gates are coastal storm flood risk reduction measures that provide a barrier between a tidally influenced waterbody and a waterbody at a location that is considered or designed to be non-navigable. Tide gates are designed to stay open under normal conditions to let tidal flow pass but are closed when water levels are expected to exceed a certain level. Tide gates do not allow for navigation or passage of vessels or small boats. A tide gate is typically a reinforced concrete superstructure supported on steel pipe piles, with a steel sheet pile cut-off wall as a seepage control measure. In some instances, tide gates are accompanied by a pump station that is operated in the event of gate closure to discharge stream flows from the upstream waterbody and maintain safe water levels.

3.4.1.3 Seawall and Bulkheads

Seawalls and bulkheads are often large concrete, wood, or metal structures designed to withstand storm waves (Hayes and Michel 2010). Once constructed, seawalls can have three potential impacts: impoundment, passive erosion, and active erosion. Impoundment is the area lost because of the structure itself. Passive erosion results when there is landward shoreline migration after a hard structure is built. The result would be the gradual loss of the beach in front of the seawall as the water deepens and the shoreface migrates landward. Active erosion occurs downcoast of the seawall. Bulkheads are typically made of wood or sheet-piling and are generally much smaller than seawall structures.

3.4.1.4 Groins and Breakwaters

Groins are common shore protection structures built connected to the shore and perpendicular to the shoreline to trap sediment conveyed by littoral transport. They sometimes are made of rubble, but other materials such as wood, rocks, sandbags, or gabions are also used. Multiple groins are usually installed to increase beach sedimentation along a stretch of shoreline with a terminal groin being the most downcoast structure in the groin field. Groins are typically only used on sandy shorelines. Breakwaters are constructed offshore to dissipate the energy of approaching waves and form a protected shadow zone on their landward sides. Breakwaters attenuate wave energy and can provide additional recreational opportunities, novel aquatic habitat, and carbon or nutrient sequestration with wetlands incorporated into the design.

3.4.1.5 Floodwalls and Levees

Floodwalls are structures used to reduce flood risk in small areas or areas with limited space for large flood risk management measures. Floodwalls are most frequently used in urban and industrial areas. Levees are embankments constructed along a waterfront to prevent flooding in relatively large areas for high levels of flood risk.

3.4.1.6 Deployable Floodwalls

Rapid deployment floodwalls are structures that are temporarily erected along the banks of a river or estuary, or in the path of floodwaters. Rapid deployment floodwalls prevent water from reaching the area behind the structure and are usually used in location where space is limited.

3.4.1.7 Drainage Improvements (e.g. pump station)

A drainage system can carry water away via conveyance systems and, during times of high water, may store water until it can be carried away. Conveyance systems utilize measures such as pump stations, culverts, drains, and inlets to remove water from a site quickly and send it to a larger waterbody. Storage facilities are used to store excess water until the storm or flood event has ended. Pump stations are typically used in conjunction with other measures which can impound water.

3.4.1.8 Channel Improvements

Channel modifications are measures carried out to reduce out-of-bank stage (and hence, damage) by modifying the geometry or by reducing the energy loss. The out-of-bank stage can be reduced for a given discharge rate if the channel is modified to increase the effective cross-sectional area. As water is conveyed in a channel, energy is converted from one form to another or “lost”. As this loss of energy results in increased stage, stage may be reduced by reducing the energy loss. This may be accomplished by smoothing the channel boundary, straightening the channel, or minimizing the impact of obstructions in the channel. These measures may be effective when water volume is relatively low.

3.4.1.9 Shoal Removal/Dredging (in-channel)

Increasing channel volume through the removal of shoals or dredging channels deeper are measures similar to channel improvements in that the out-of-bank stage can be reduced for a given discharge rate if the effective cross-sectional area is increased. These measures may be effective when water volume is relatively low.

3.4.2 Description of Nonstructural Measures Considered

Nonstructural CSRM measures are intended to reduce the consequences of flooding to buildings and other assets in areas prone to flood inundation. Nonstructural CSRM measures include floodproofing (wet and dry), acquisition and relocation, elevation of buildings, basement filling, and programmatic considerations including enhanced flood warning systems, land use regulations, and floodplain management and zoning. The PDT considered nonstructural measures identified in NACCS and determined if they meet planning objectives for flood risk reduction for the different planning units in the study area. This section discusses nonstructural measures considered during plan formulation in this study.

3.4.2.1 Floodproofing

Floodproofing involves reducing damage to buildings by waterproofing, shields, or other means that allow floodwaters to pass through or around the building unimpeded. Floodproofing offers the opportunity to reduce flood damages to structures and contents for an individual structure-by-structure basis or for a group of structures. Floodproofing costs can vary substantially depending on the type of floodproofing method being considered and the type, size, age, and location of the structure(s).

3.4.2.1.1 Dry Floodproofing

Dry floodproofing of existing structures is a common floodproofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Dry floodproofing involves sealing building walls by waterproofing, thereby preventing the entry of floodwaters into a structure. Installation of temporary closures or flood shields is a commonly used floodproofing technique. A flood shield (sometimes termed flood gate) is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to anticipated flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable to areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. Dry floodproofing is not recommended for single-family homes due to structural integrity and life safety concerns. Dry floodproofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention to fully implement the solution, and this action would have to occur in a relatively short timeframe.

3.4.2.1.2 Wet Floodproofing

Wet floodproofing is also a common way of reducing flood damages for structures with an uninhabited basement or other subgrade portion of a building. Wet floodproofing involves modifications of structures to allow for flood waters to enter and inundate portions of the building to minimize structural damage. This type of floodproofing can include raising of utilities, raising building contents above the flood elevation, or moving to higher floors, using flood damage-resistant materials in the building interior and exterior, and installing flood opening in the structure foundation walls to reduce water pressure on the structure. This approach can minimize but would not eliminate flood damages to the structure and requires extensive cleanup and maintenance. Wet floodproofing may not be feasible in certain areas based on the velocity and volume of the flood source.

3.4.2.2 Building Elevation

Elevation of structures is a common CSRM measure that requires raising of the structure in place above the design flood elevation (DFE). Elevation is most suitable for single family houses with good structural integrity. Buildings are elevated by raising on temporary framing followed by extending foundation walls or structural fill up to the design elevation. Another option common in coastal areas is to elevate buildings on pilings, which may not be suitable for low flood elevations.

3.4.2.3 Acquisition and Relocation

Acquisition consists of buying out buildings and associated land parcels located within the floodplain. After acquisition, the building is demolished or relocated outside of the floodplain, reducing flood risk to communities. Acquisitions are generally implemented to structures at extreme risk of flooding that have been flooded one or more times. While acquisition with demolition or relocation reduces flood risk and restore floodplains, it can have a negative impact on neighborhood cohesion and the vitality of coastal communities.

Relocation involves physically moving a building at-risk of flooding to an area of lower risk, typically outside of the floodplain. This measure can eliminate flood risk while restoring the floodplain, but it can be costly and time consuming.

3.4.2.4 Enhanced Warning Systems

Despite improved tracking and forecasting techniques, the uncertainty associated with the size of a storm, the path, or its duration necessitate warnings be issued as early as possible. Evacuation planning is imperative for areas with limited access, such as high-density housing areas, elderly population centers, cultural resources, and areas with limited transportation options.

3.4.2.5 Policy and Programmatic

Policy and programmatic measures include actions that can be taken related to land use management, zoning, and flood insurance. Baltimore City requires that all new or substantially improved construction projects for residential and non-residential structures adhere to Baltimore City floodplain policy (Article 7 Nat. Res, Division 1 Floodplain Management of the Baltimore City Code). As such, it is assumed that new and substantially improved structures are protected to the flood-protection elevation, which is the modeled elevation of the 0.2 percent chance of flood plus 2 feet of freeboard in the tidal floodplain as listed on the Flood Insurance Study. No additional policy or programmatic actions were evaluated.

3.4.3 Description of Natural and Nature Based Features Considered

NNBF mimics natural features or processes to prevent erosion and reduce damage to shorelines through restoration of coastal habitats or creation of reefs, wetlands, or living shorelines.

3.4.3.1 Living Shoreline

Living shorelines are essentially tidal wetlands constructed along a shoreline to reduce coastal erosion. Living shorelines maintain dynamic shoreline processes, and provide habitat for organisms such as fish, crabs, and turtles. As essential component of a living shoreline is constructing a rock structure (breakwater/sill) offshore and parallel to the shoreline to serve as protection from wave energy that would impact the wetland area and cause erosion and damage or removal of the tidal plants.

3.4.3.2 Wetland Restoration

The dense vegetation and shallow waters within wetlands can slow the advance of storm surge somewhat and slightly reduce the surge landward of the wetland or slow its arrival time. Wetlands can also dissipate wave energy; potentially reducing the amount of destructive wave energy propagating on top of the surge, though evidence suggests that slow-moving storms and those with long periods of high winds that produce marsh flooding can reduce this benefit.

3.4.3.3 Reefs

The development of artificial reefs provides a means to reestablish and enhance reef communities. Artificial reefs provide shoreline erosion protection and may provide wave attenuation.

3.4.3.4 Submerged Aquatic Vegetation

SAV performs many important functions, including wave attenuation and sediment stabilization; water quality improvement; primary production; food web support for secondary consumers; and provision of critical nursery and refuge habitat for fisheries species.

3.4.3.5 Beach Restoration (dunes)

Beach and dune restoration is the supply of sand to the beach to increase or restore its width. A wider beach can reduce storm damage to coastal structures by dissipating energy across the surf zone and protecting upland structures and infrastructure from storm surges. The dunes that may back a beach act as a physical barrier that reduces inundation and wave attach to the coast landward of the dune. Although the dune may erode during a storm, it provides a sediment source for recovery after a storm passes.

3.4.4 Measures Screening Criteria

Management measures were evaluated and screened using several criteria. In the first screening iteration, criteria evaluation was qualitative. Measures were first screened if the measure is technically feasible. For each planning unit the measure was evaluated on shoreline type and characteristics, engineering feasibility and Tier I & II NACCS information. Those that met the screening criteria are marked with an “X” under the applicable planning units as shown in Table 3-1. Measures were also evaluated and screened using the feasibility study’s planning objectives (Table 3-2) and to ensure they avoided planning constraints.

Plan formulation is the process of building alternative plans that meet planning objectives and avoid planning constraints. Alternatives are a set of one or more management measures functioning together to address one or more planning objectives. A management measure is a feature or activity that can be implemented at a specific geographic location to address one or more planning objectives. A feature is a “structural” element that requires construction or assembly on-site whereas an activity is defined as a “nonstructural” action.

These measures were investigated to identify means in which they could be combined to improve resiliency from coastal storm risk in the Baltimore area. The combined measures formed the initial array of alternatives described in the next section.

Table 3-1. Measures Screening Matrix (X-retained)

MEASURES		PLANNING UNITS						
		Patapsco E. (Sollers Pt)	**Patapsco N. (Canton/ Dundalk)**	**Inner Harbor**	**Locust Point**	**Middle Branch**	**Patapsco S. (Fairfield/ Hawkins Pt)**	**Martin State Airport**
Structural	Storm Surge Barrier – Regional	X	X	X	X	X	X	
	Tide Gates – Inlet		X			X		
	Shoreline Stabilization (Seawall, revetment, bulkheads)	X	X	X		X	X	X
	Beach Fill Stabilization – Breakwaters*					X		
	Beach Fill Stabilization – Groins*							
	Floodwall (levee, dike, berm)	X	X	X	X	X	X	X
	Deployable Floodwall		X	X	X	X	X	X
	Drainage Improvements (Pumps, Culverts, Storage)	X	X	X	X	X	X	X
	Channel Improvements							
	Shoal Removal/Dredging							
Nonstructural	Structure Elevation	X	X	X	X	X	X	X
	Acquisition/Relocation	X	X	X	X	X	X	X
	Flood Proofing	X	X	X	X	X	X	X
	Enhanced Warning Systems	X	X	X	X	X	X	X
NNBF	Living Shoreline	X			X	X	X	X
	Wetland Restoration	X			X	X	X	X
	Reefs					X	X	
	SAV					X	X	X
	Beach Restoration							
Policy/Programmatic		X	X	X	X	X	X	X

*Provides level of protection only when in combination with beach dune

**NNBF were evaluated as individual features but would not meet planning objectives on their own and therefore, are considered for optimization of other alternatives.

Table 3-2. Management Measures Screened with Study Objectives

	Study Objectives			
	Reduce risk to human health and safety	Reduce economic damages	Reduce disruption of critical infrastructure	Improve resiliency of critical infrastructure
Measure Name	Do the following measures meet the study objectives? (Yes/No)			
Storm surge barrier	Yes	Yes	Yes	Yes
Tide gates	Yes	Yes	Yes	Yes
Shoreline stabilization	Yes	Yes	Yes	Yes
Groins, breakwaters	No	No	No	No
Floodwalls and levees	Yes	Yes	Yes	Yes
Deployable floodwalls	Yes	Yes	Yes	Yes
Drainage improvements	Yes	Yes	Yes	Yes
Channel improvements	No	No	No	No
Shoal removal/dredging	No	No	No	No
Flood-proofing	Yes	Yes	Yes	Yes
Building elevation	Yes	Yes	Yes	Yes
Acquisition & relocation	Yes	Yes	Yes	Yes
Enhanced warning systems	Yes	No	No	Yes
Living shoreline	Yes	No	No	Yes
Wetland restoration	No	No	No	Yes
Reefs	No	No	No	No
SAV	No	No	No	No
Beach restoration (dunes)	No	No	No	No

The management measures that met the screening criteria are storm surge barriers and tide gates, shoreline stabilization, deployable floodwalls, floodwalls and levees, drainage improvements, floodproofing, building elevation, and relocation/acquisition, living shorelines, and wetland restoration. It was determined that concrete T-walls were best suited for most developed areas, as compared to a seawall or bulkhead. Bulkheads may be more suitable for areas with waterborne vessel traffic. Structure elevation is not suitable for many parts of the study area due to the building types (connected rowhouses, large commercial structures, warehouses). Inundation from three flood scenarios: 5 percent (20-year storm), 2 percent (50-year storm), and 1 percent AEP (100-year storm), did not result in a high hazard condition in water level to warrant relocation/acquisition of any structures. Therefore, relocation/acquisition was not further evaluated and instead the nonstructural plan focused on floodproofing.

3.4.5 Arrays of Alternatives

From the compiled table of management measures, the team formulated “lines of defense” representing alternative plans, based on logical groupings of measures and planning units. Lines of defense is the plan formulation strategy. Lines of defense are shown in Table 3-3 and include storm surge barriers, floodwalls along the shoreline, critical infrastructure, and a nonstructural plan. Alternatives were formulated using the 1 percent AEP and the intermediate SLC curve in 2080. Coastal storm risk benefits were developed for the initial alternatives using G2CRM and Class 5 costs were developed based on NACCS costs inflated to year 2019. Class 5 costs are commonly referred to as Rough Order of Magnitude (ROM) costs and include high contingencies due to a higher level of uncertainty. Class 5 or ROM costs use broad-based assumptions, costs from comparable projects and data, and cost engineering judgment. Initial alternative benefits and costs are available in Appendix E: Economic Analysis.

Table 3-3. Lines of Defense

Line of Defense	Strategy	Planning Unit
Storm Surge Barrier	Construction of a coastal **storm surge barrier** at a strategic location near the opening of the Patapsco River, to provide comprehensive protection.	Inner Harbor, Locust Point, Middle Branch, Patapsco North, Patapsco South, Patapsco East
Shoreline line of defense (floodwall)	Reduce risk to property and infrastructure through **structural** features (floodwall)	Inner Harbor, Locust Point, Patapsco North
Critical Infrastructure	Reduce risk to critical infrastructure through structural features (levees, floodwall)	Locust Point, Patapsco North, Patapsco South, Martin State Airport
Nonstructural plan	Application of **nonstructural** measures to reduce damages and increase resilience to coastal communities	Inner Harbor, Locust Point, Patapsco South, Matin State Airport
Natural Areas Plan* **For optimization of above plans, not stand alone*	Restoration of **natural features**, such as living shorelines and wetlands, where possible.	Entire Study Area

The following sections show the iterative planning process, starting with the initial array of alternatives developed for the AMM held in November 2019, through the final array of alternatives evaluated and compared for the TSP Milestone held in May 2022. Each section builds upon the former with additional details added to alternative plan descriptions, applied screening criteria, revisions to alternatives alignments, limits of disturbance (LOD) and optimization of alternatives.

3.4.6 Initial Array of Alternatives

The Initial Array of Alternatives are shown in Table 3-4. Figure 3-10 to 3-18 illustrate each alternative. Descriptions of the Initial Array of Alternatives are provided below, and include features originally presented at the AMM.

Table 3-4. Initial Array of Alternatives

Alternative Plan Number	Description
No Action	No Action
1	Surge Barrier 1 (Outer)
2	Surge Barrier 2 (Inner)
3	Nonstructural Only
4	Critical Only
5	Critical & Nonstructural
6	Critical Balanced
7	Mid-tier Balanced
8	Mid-tier w/NNBF
9	Mid-tier, Max NNBF
10	High-tier

3.4.6.1 Alternative Plan 0: No Action or Future Without Project Condition

Under the No Action or FWOP condition, no federal action would be undertaken to address coastal storm risk in the study area. FWOP conditions are presented in Section 2.

3.4.6.2 Alternative Plans 1 and 2: Surge Barrier Plans

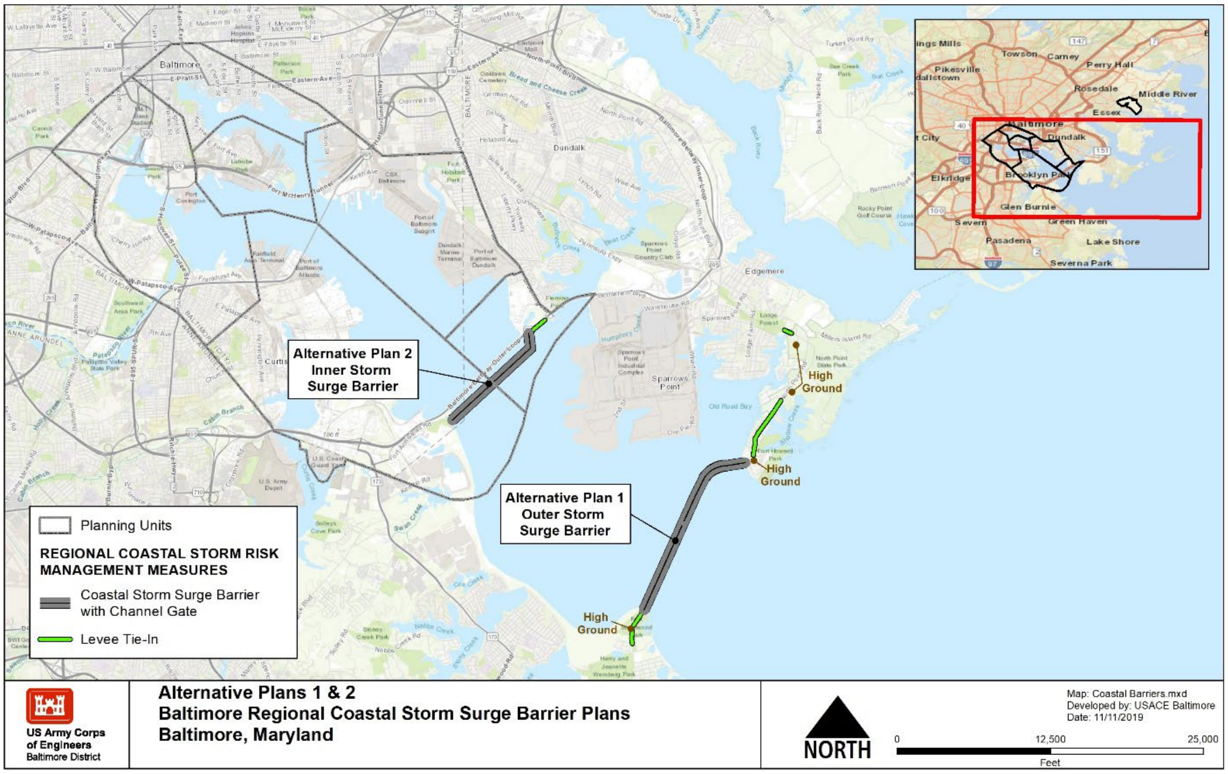

Figure 3-11. Alternative Plans 1 & 2 – Regional Barrier Plans

These alternatives include the storm surge barrier plans (Figure 3-11). Alternative Plan 1 (Outer Coastal Surge Barrier Plan) consists of a proposed storm surge barrier from Fort Smallwood Park to Fort Howard. Alternative Plan 2 (Inner Coastal Surge Barrier Plan) consists of a surge barrier running parallel to and just outside the Francis Scott Key Bridge, from Fort Armistead Park to Coffin Point. Both plans consist of surge barriers with 1,000-foot-long sector gate openings.

Both plans would protect 6 of the 7 planning units with a coastal surge barrier and would protect MSA with a flood levee. The ROM costs for the Outer Coastal Barrier (Alternative Plan 1) and Inner Coastal Barrier (Alternative Plan 2) were estimated by escalating costs developed for the same alignments from a prior CENAB study (Baltimore Metropolitan Area Hurricane Survey, CENAB 30 NOV 1960), and incorporating a 1,000-foot sector gate closure with costs derived from modern USACE barrier projects in other regions. Base capital costs were estimated at approximately $1.4 billion for the outer barrier (Fort Smallwood Part to Fort Howard) and approximately $1.3 billion for the inner barrier (Fort Armistead Park to Coffin Pt.). The ROM benefits for these alternatives were barely positive (low NED benefits and preliminary Benefit-to-Cost Ratio [BCR] of 1.03 and 1.10, respectively). The assessed risk for both of these plans was unacceptably high. Environmental impacts are of great concern as a “fishable, swimmable” harbor is a goal of many stakeholders. Due to the all-or-nothing nature of these plans in contrast to other alternative plans, benefits would not begin to accrue until the entire plan is implemented. Because of the low likelihood of implementation, the structure inventory was not expanded to include damages in the impacted area between the outer and inner surge barriers. Given the magnitude of the total cost estimated for this alternative, the uncertainty about whether these ROM costs adequately captured the full costs of construction (e.g., additional gate closures, environmental mitigation costs, real estate acquisition, etc.), the high risks that these plans would not be found acceptable, and the likelihood that the realized benefits would be significantly below the theoretical maximum damages (particularly with respect to high-frequency, lower-intensity events), these alternative plans were screened from consideration.

3.4.6.3 Alternative Plan 3: Nonstructural Plan

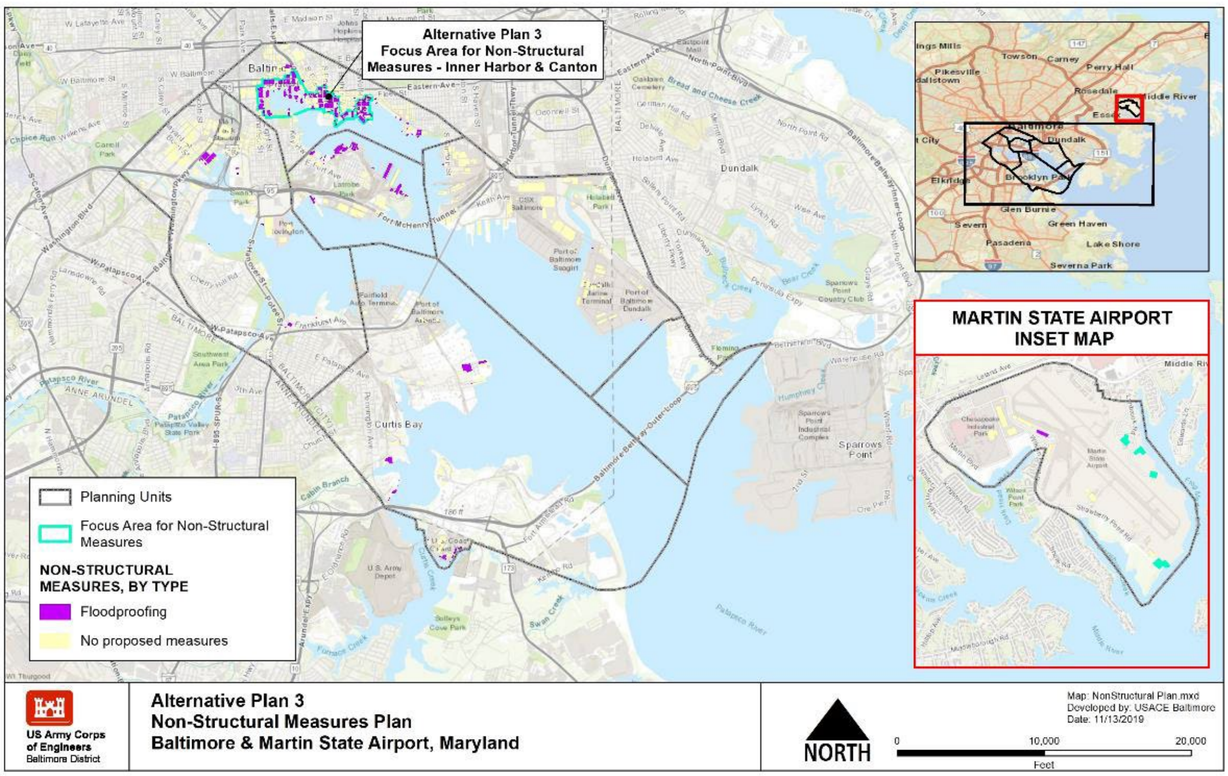

Figure 3-12. Alternative Plan 3 – Nonstructural Plan

Alternative Plan 3 (Figure 3-12) consists solely of the use of nonstructural measures to reduce flood risk to structures. Over 1,400 structures have been identified as being at risk within the study area by 2080, under the one percent AEP with intermediate SLC scenario. These include commercial, residential, industrial, and institutional structures.

This plan consists of the exclusive use of nonstructural measures. Due to the number of structures at risk and uncertainty regarding critical parameters (first floor elevation, structure construction and condition, etc.), detailed costs were not developed for this plan. ROM costs were estimated for the at-risk structures under the 1 percent AEP. The NACCS nonparametric cost of $100K for floodproofing was used for structures with occupancy type “residential”, “commercial”, or “high-rise”. The NACCS nonparametric value of $3.74M for ring wall-type structures was used for “educational” and “government” structures. Costs were not estimated for “industrial” structures. This plan was determined to be unlikely to adequately protect certain critical infrastructure elements (i.e., the interstate highway tunnel entrances), and therefore could not fully meet the study objectives. This alternative plan was therefore screened from further consideration.

3.4.6.4 Alternative Plan 4: Critical Infrastructure Plan

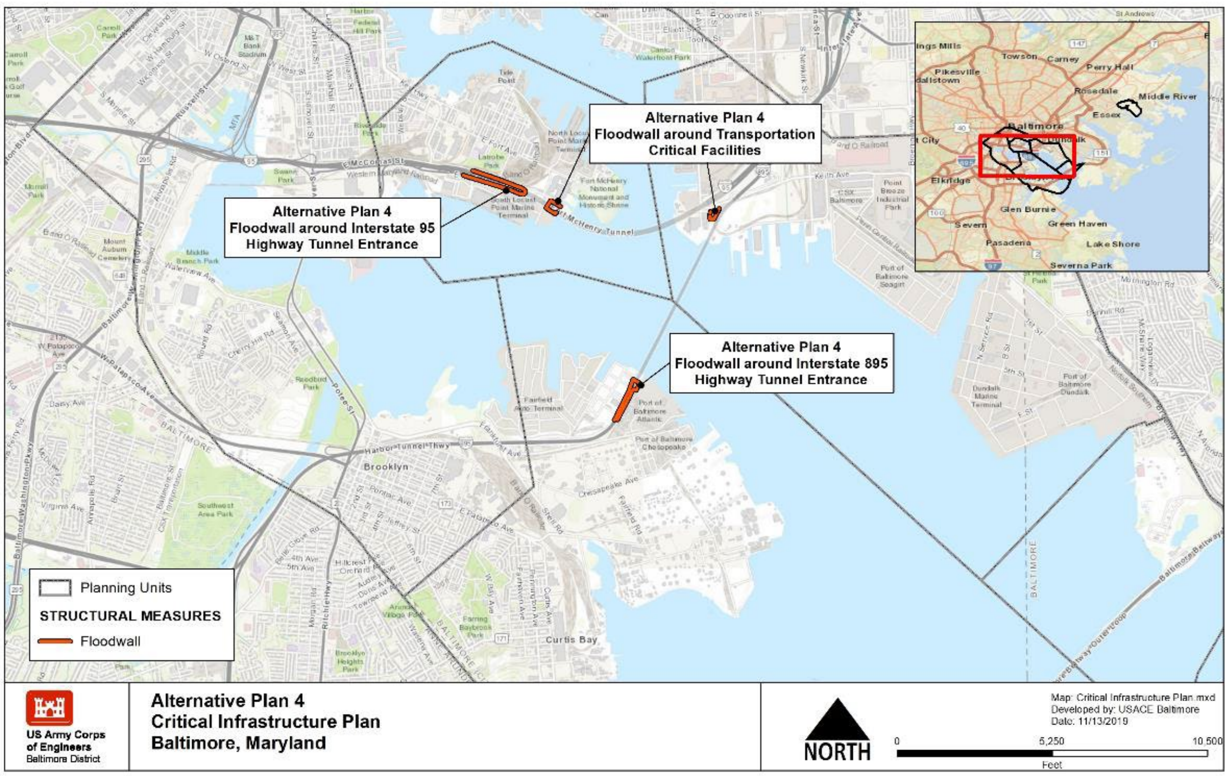

Figure 3-13. Alternative Plan 4 – Critical Infrastructure Plan

Alternative Plan 4 (Figure 3-13) is the Critical Infrastructure Plan. This plan would protect some of the most critical transportation assets in the study area: the Fort McHenry Tunnel that connects I-95 and the Baltimore Harbor Tunnel that connects I-895. The components of this alternative would include floodwalls along the tunnel entrances on the southern approach of I-895 and I-95 and their associated transportation critical facilities.

This plan achieves the planning objectives, avoids constraints, has acceptable levels of risk, appears to provide strong benefits and is likely to have a favorable BCR. This plan was retained for the focused array of alternatives.

3.4.6.5 Alternative Plan 5: Critical Infrastructure and Nonstructural Plan

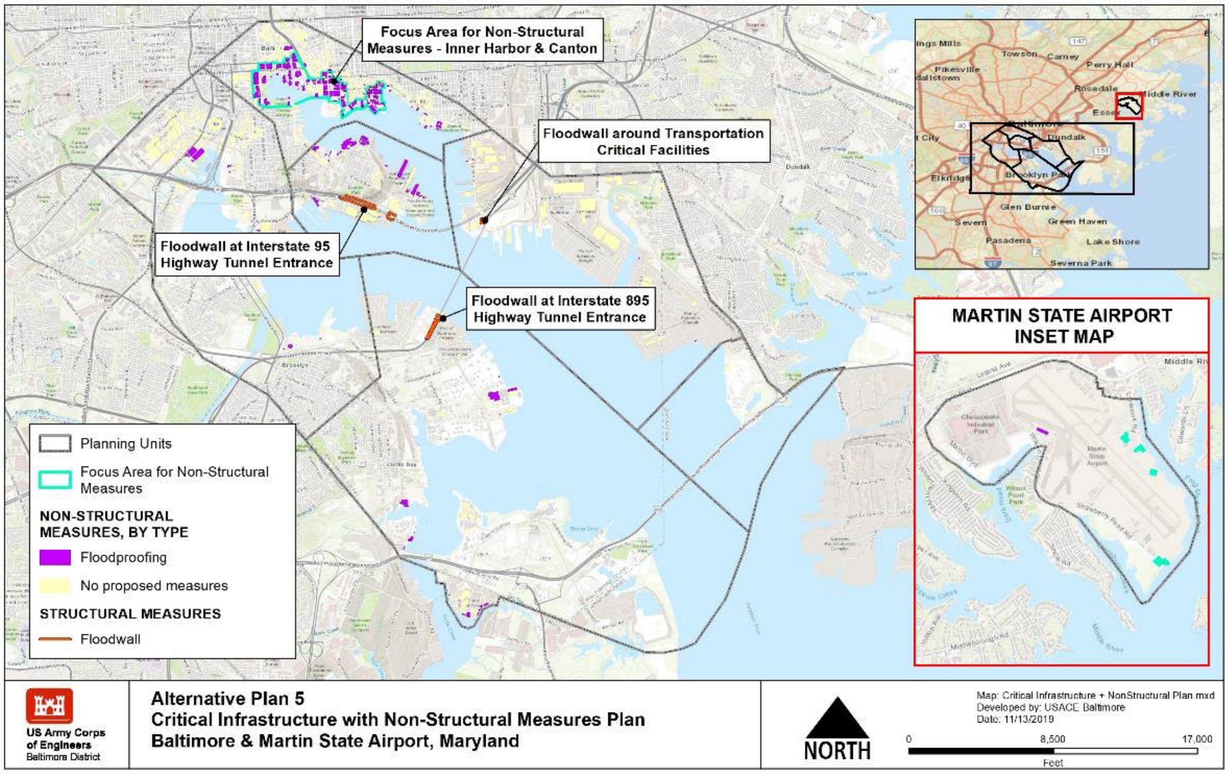

Figure 3-14. Alternative Plan 5 – Critical Infrastructure with Nonstructural Measures Plan

Alternative Plan 5 (Figure 3-14) includes all elements of Alternative Plan 4 as well as nonstructural measures for remaining at-risk structures, as described in Alternative Plan 3.

This plan achieves the planning objectives, avoids constraints, has acceptable levels of risk, appears to provide strong benefits and appears likely to have a favorable BCR. This plan was retained for the focused array of alternatives. Note that this plan still includes extensive use of nonstructural measures for vulnerable properties, and the same limitations described under Alternative Plan 3, above, apply to this plan.

3.4.6.6 Alternative Plan 6: Critical Infrastructure Balanced Plan

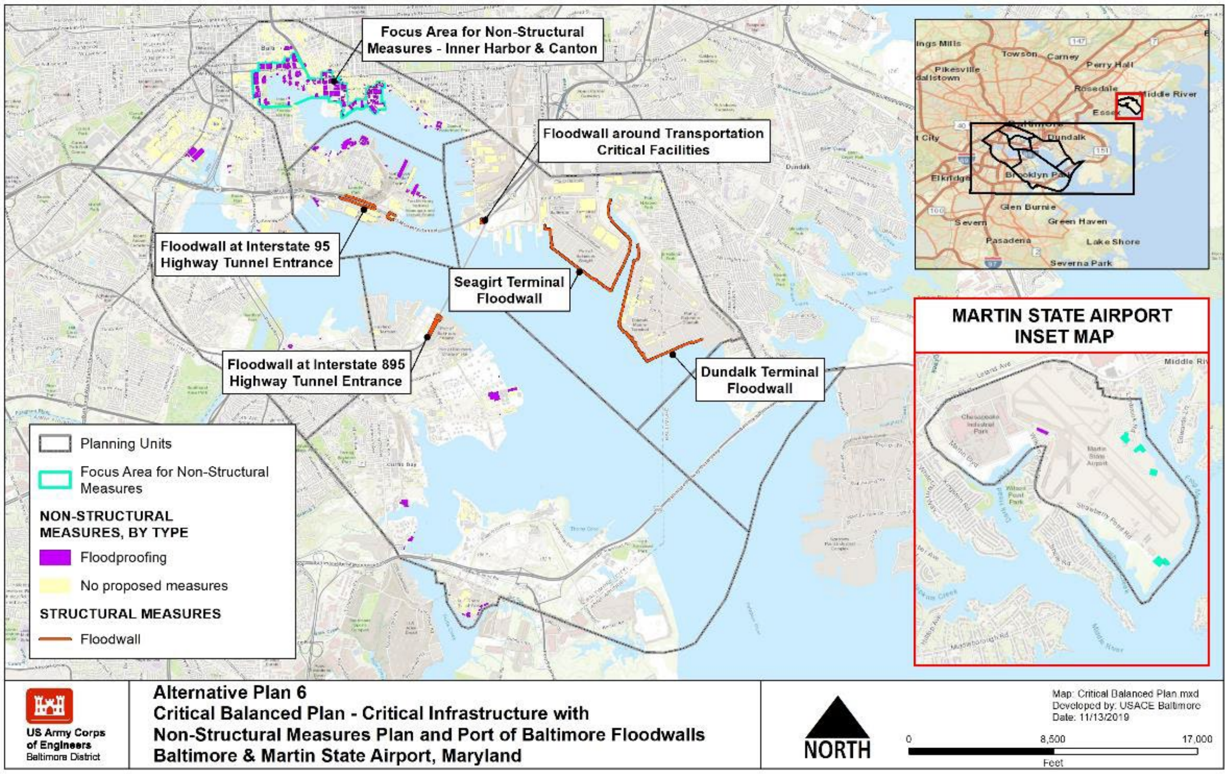

Figure 3-15. Alternative Plan 6 – Critical Infrastructure with Nonstructural Measures Plan and Port of Baltimore Floodwalls

Alternative Plan 6 (Figure 3-15) includes all elements of Alternative Plan 5 and incorporates a coastal floodwall at Seagirt Marine Terminal and an elevated road-on-levee at Martin State Airport. An elevated bulkhead along the shoreline of Port of Baltimore's Seagirt terminal would reduce the facility's vulnerability to coastal flooding, thereby improving the economic resilience of this transportation node. A coastal floodwall at the Dundalk Marine Terminal was also part of this plan during initial formulation but was dropped from consideration because funding was secured by Maryland Port Administration for this project element to initiate design and construction activities. Construction of the project at Dundalk Marine Terminal is not expected to affect flood elevations or project performance elsewhere in the study area.

This plan achieves the planning objectives, avoids constraints, has acceptable levels of risk, appears to provide strong benefits and appears likely to have a favorable BCR. This plan was retained for the focused array of alternatives.

3.4.6.7 Alternative Plan 7: Mid-Tier Plan

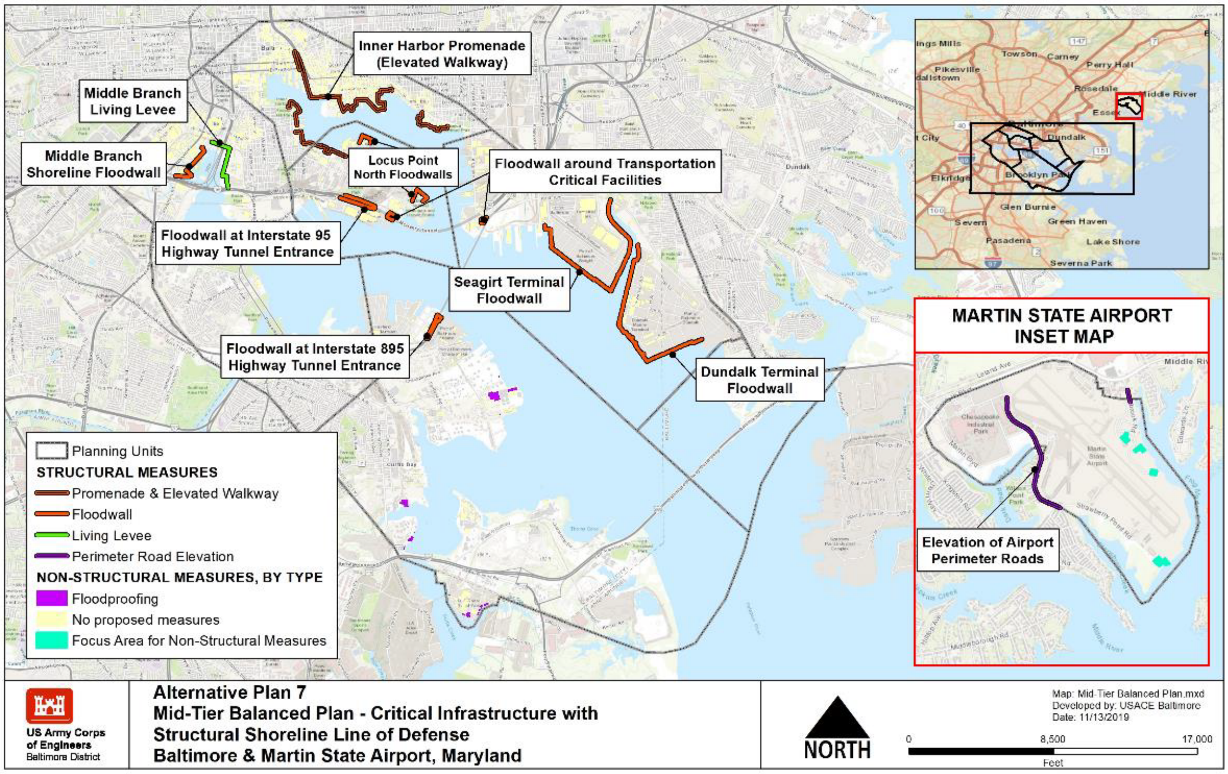

Figure 3-16. Alternative Plan 7 – Mid-Tier Plan

Alternative Plan 7 (Figure 3-16) includes all structural elements of Alternative Plan 6, except that, within the Inner Harbor planning unit (Inner Harbor, Canton, Fells Point), linear floodwalls are proposed instead of nonstructural measures. This plan also proposes the creation of a drive-on levee through the elevation of the airport perimeter road (Wilson Point Rd) at the Martin State Airport, which provides protection to the airport from flooding from Dark Head Cove and ensures that residents of Wilson Point can safely evacuate or be reached by emergency responders.

This plan previously included a living levee proposed in the Middle Branch planning unit and a floodwall along Dundalk Terminal at the Port of Baltimore. However, these components have been approved under separate initiatives and were not carried forward as part of the final array of alternatives.

This plan achieves the planning objectives, avoids constraints, has acceptable levels of risk, appears to provide strong benefits and appears likely to have a favorable BCR. This plan was retained for the focused array of alternatives.

3.4.6.8 Alternative Plan 8: Mid-Tier with Enhanced NNBF Plan

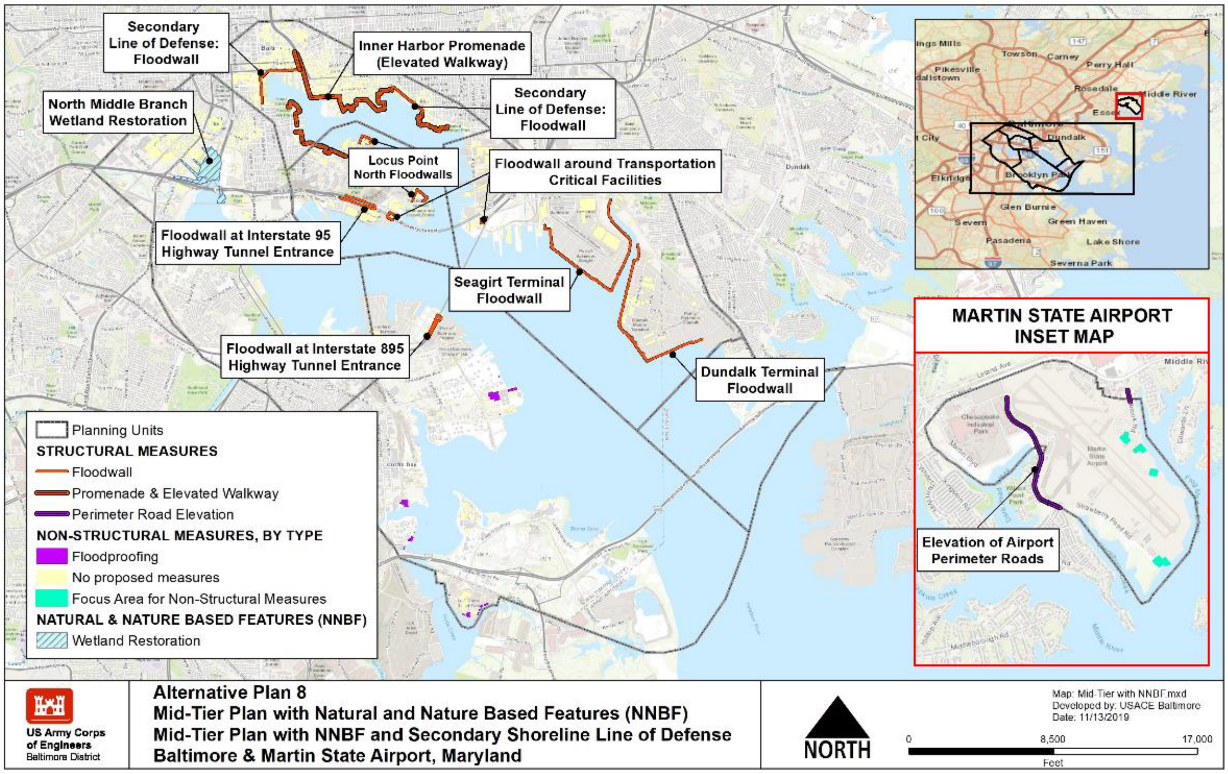

Figure 3-17. Alternative Plan 8 – Mid-Tier with NNBF Measures Plan

Alternative Plan 8 (Figure 3-17) includes all elements of Alternative Plan 7 and incorporates expanded NNBF wetland and coastal upland creation elements within upper Middle Branch where there is the greatest opportunity for NNBF implementation in the study area.

This plan achieves the planning objectives, avoids constraints, appears to provide benefits and appears likely to have a favorable BCR. However, this plan has higher risk, higher costs, weaker NED benefits and lower BCR than Alternative Plan 7. Additionally, funding for elements of the Reimagine Middle Branch plan has been secured. Funded elements would address coastal flooding in the Middle Branch utilizing NNBF solutions. This plan was screened from further consideration.

3.4.6.9 Alternative Plan 9: Mid-Tier with Maximum NNBF Plan

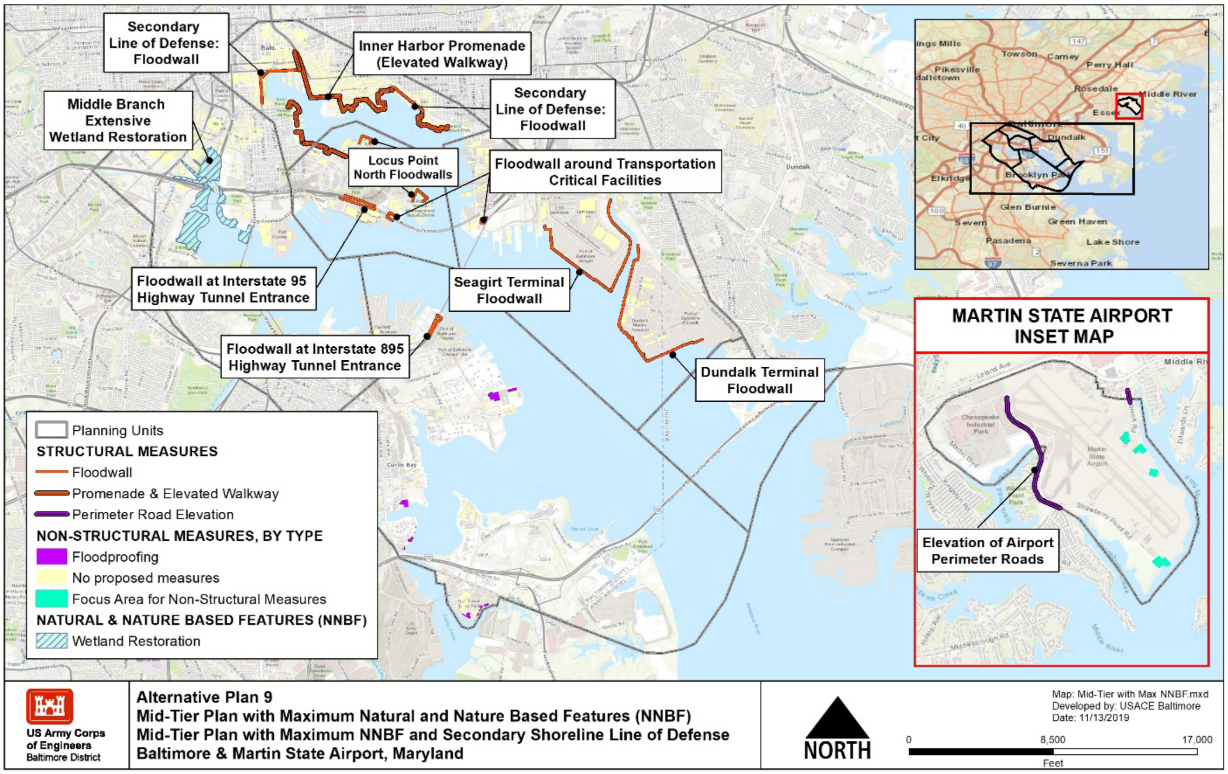

Figure 3-18. Alternative Plan 9 – Mid-Tier with Maximum NNBF Measures Plan

Alternative Plan 9 (Figure 3-18) includes all elements of Alternative Plan 8 but greatly expands the proposed use of NNBF wetland and coastal upland creation elements within Middle Branch, where there is the greatest opportunity for NNBF implementation in the study area.

This plan achieves the planning objectives, avoids constraints, appears to provide strong benefits and appears likely to have a favorable BCR. However, this plan has higher risk, higher costs, weaker NED benefits and lower BCR than Alternative Plan 7. Additionally, funding for elements of the Reimagine Middle Branch plan has been secured. Funded elements would address coastal flooding in the Middle Branch utilizing NNBF solutions. This plan was screened from further consideration.

3.4.6.10 Alternative Plan 10: High-Tier with Maximum NNBF Plan

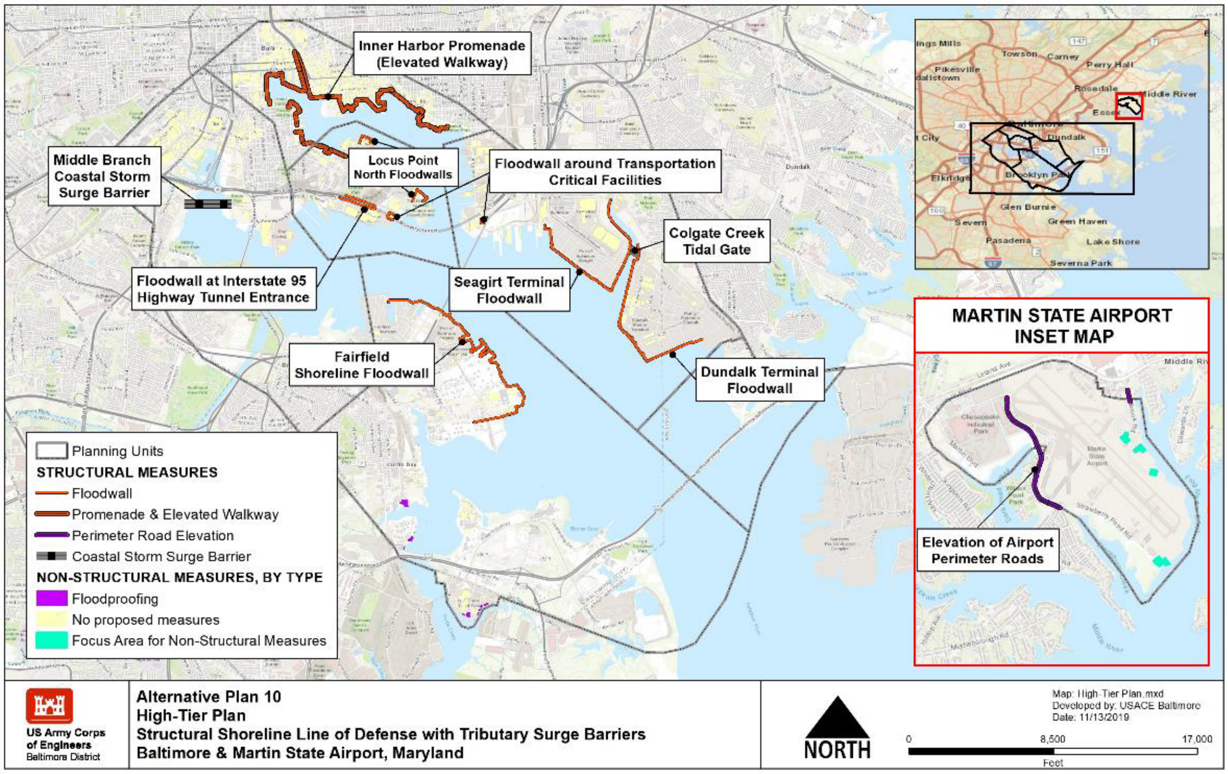

Figure 3-19. Alternative Plan 10 – High-Tier Measures Plan

Alternative Plan 10 (Figure 3-19) includes all elements of Alternative Plan 7 but further adds extensive shoreline floodwall structures around Fairfield Marie Terminal and nearby properties and replaces the proposed levee and floodwall structures in Middle Branch with a local surge barrier structure.

This plan achieves the planning objectives, avoids constraints, has acceptable levels of risk, appears to provide strong benefits and appears likely to have a favorable BCR. However, this plan has higher costs, weaker NED benefits and lower BCR than Alternative Plan 7. Additionally, funding for elements of the Reimagine Middle Branch plan has been secured. Funded elements would address coastal flooding in the Middle Branch utilizing NNBF solutions. This plan was screened from further consideration.

3.4.7 Nonstructural measures refinement

Nonstructural measures can vary based on planning objectives, building characteristics, and flood exposure. The planning objectives were used for initial scoping and screening of measures for planning units. Further breakdown of planning units by neighborhoods was based on information from local jurisdictions and used to cluster buildings that are appropriate for nonstructural measures in the study area. Buildings in these neighborhoods were clustered for suitability of nonstructural measures using flood inundation mapping from surface water levels (SWLs) in the C-STORM modeling completed for NACCS in 2014. Other factors considered for clustering include land use, nuisance flooding, flood frequency and SLC impacts. The buildings selected for each cluster were based on flood inundation depth for the 1 percent AEP (100-year storm) with consideration for the 5 percent and 2 percent AEP in base year 2031.

The nonstructural measures were formulated using flood inundation mapping developed based on SWLs in the NACCS C-STORM modeling for the study area. The PDT examined inundation associated with the 5 percent (20-year storm), 2 percent (50-year storm), and 1 percent AEP (100-year storm) flood inundation scenarios. Flood inundation scenarios were used for the base year condition in 2031 (nominal differences in SLC from current condition of 2020) and 50-years from project implementation accounting for SLC using the USACE intermediate and high curve in 2080.

Nonstructural measures were selected based on the building characteristics and the inundation depth as some measures may not be suitable for specific building types based on the foundation of the building, building use, or the inundation depth experienced by that building.

The PDT identified neighborhoods with known nuisance flooding issues using previous reports, media sources, and flood inundation mapping developed during the feasibility study. The neighborhoods were primarily selected for high frequency of flooding (5 percent to 1 percent AEP), which is likely to benefit from nonstructural measures. Neighborhoods with known nuisance flooding issues including Canton, Inner Harbor, and Locust Point. The PDT also included the Patapsco Wastewater Treatment Plant (WWTP), the USCG Curtis Bay Facility, and MSA for nonstructural measures due to flooding concerns to critical infrastructure. Floodproofing was the only feasible nonstructural measure for rowhomes, which are the primary type of residential properties, found within the study area evaluated. Although floodproofing of residential structures was initially evaluated during the feasibility study process, these were later removed from analysis. Interim USACE guidance provided during the Nonstructural Summit held with Gen. Graham on July 2023, does not recommended floodproofing as a nonstructural measure for residential properties due to structural and safety concerns. Further guidance addressing nonstructural floodproofing is anticipated in FY24.

3.4.8 Final Array of Alternatives*

The initial array of alternatives was screened based on overall cost supported by modeled damages. The design elevation that was used when designing structural components in the study area was 12.5 feet NAVD88. This was based on the NACCS 100-year WSEL with approximately 95 percent confidence level and intermediate SLC curve through year 2080.

The alternatives retained in the focused array of alternatives (Table 3-5) were refined in response to additional data generated in later study phases. The structure inventory was refined, including adding residential vehicles as a proportion of housing units, adding assets at the Port of Baltimore Terminals, adding significant transportation assets, and adding assets at Martin State Airport. Ground elevations were also revised and backchecked against the best available topographic data. Hydrologic and economic models were updated, which resulted in new estimates for potential FWOP damage areas. And finally, resilience projects were undertaken by other entities within the study area, necessitating changes to FWOP conditions. The final array of alternatives is described below.

Table 3-5. Final Array of Alternatives

Alternative Plan Number	Description
No Action	No Action
4	Critical Infrastructure Plan
5	Critical Infrastructure & Nonstructural Plan
5A	Critical Infrastructure with Select Nonstructural Plan
6	Critical Infrastructure Balanced Plan
7	Mid-Tier Plan

3.4.8.1 Alternative Plan 4: Critical Infrastructure Plan

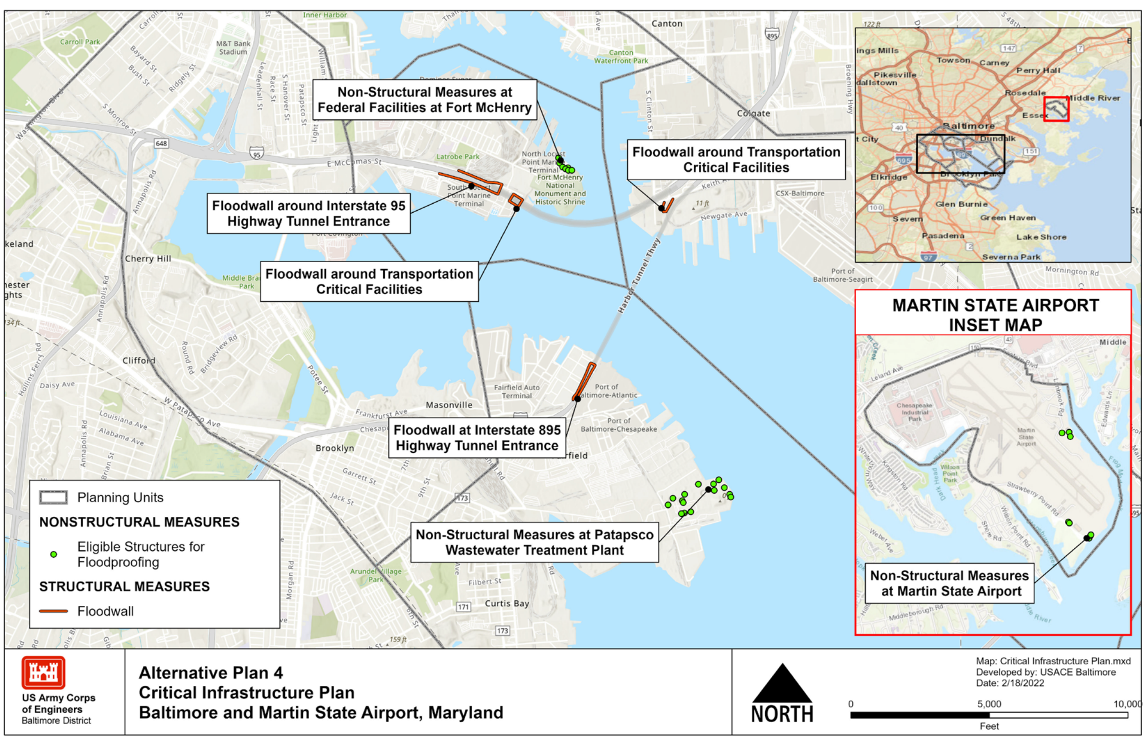

Figure 3-20. Final Array Alternative Plan 4 – Critical Infrastructure Plan

In the final array of alternatives, Alternative Plan 4 was optimized to include nonstructural measures (floodproofing) of critical infrastructure at Fort McHenry, the Patapsco Wastewater Treatment Plant, and at the Martin State Airport, in addition to the structural measures proposed at the I-895 and the I-95 tunnels and associated transportation critical facilities. Figure 3-20 shows the location of the nonstructural and structural measures proposed under Alternative Plan 4. Table 3-6 outlines the changes made to Alternative Plan 4 as it evolved from the initial array of alternatives to the final array of alternatives.

Table 3-6. Changes in Alternative Plan 4 from the Initial Array of Alternatives

Measure	Location	Change
Nonstructural	Fort McHenry; Patapsco Wastewater Treatment Plant; Martin State Airport	Identified and added nonstructural measures
Floodwall	Tunnels	Revised proposed alignment

3.4.8.2 Alternative Plan 5: Critical Infrastructure and Nonstructural Plan

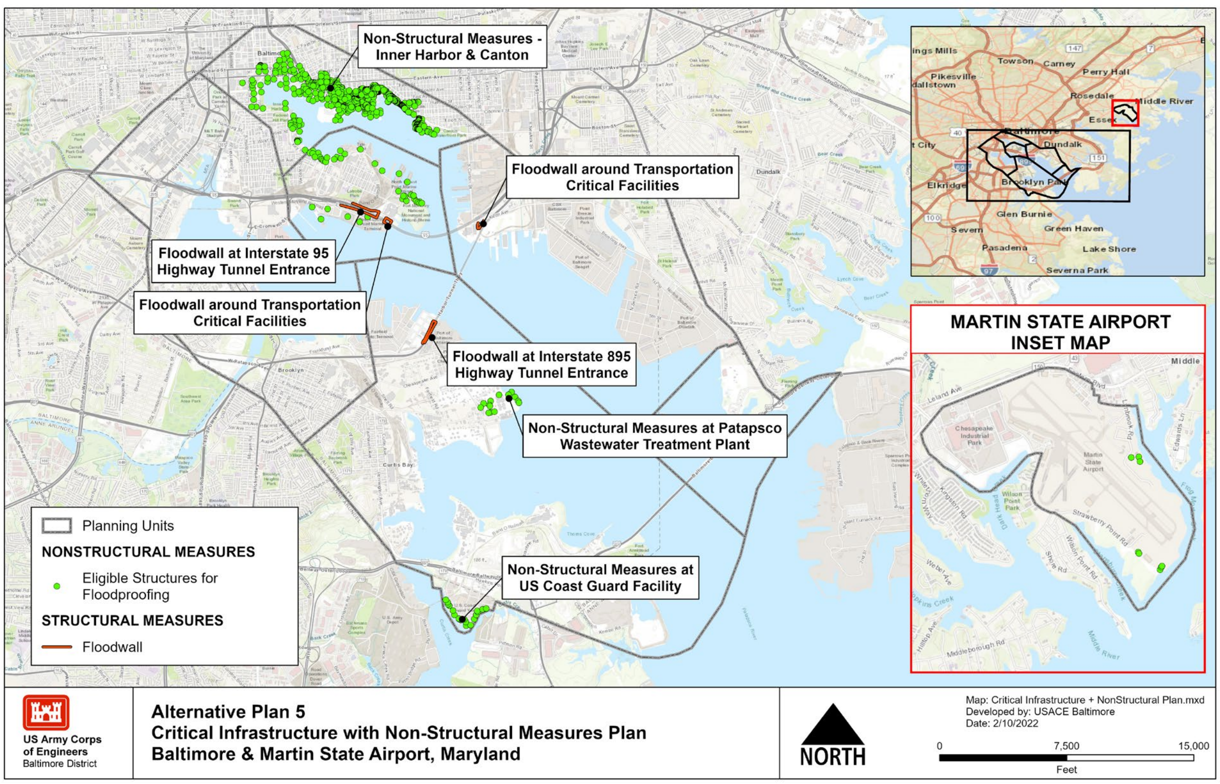

Figure 3-21. Final Array Alternative Plan 5 – Critical Infrastructure with Nonstructural Measures Plan

Alternative Plan 5 includes the elements of Alternative Plan 4, with the addition of the nonstructural plan along the Inner Harbor and Locust Point planning units (Figure 3-21).

The nonstructural plan consists solely of the use of nonstructural measures to reduce flood risk to structures. Over 1,400 structures have been identified as being at risk within the study area by 2080, under the 1 percent AEP with intermediate SLC scenario. These include commercial, residential, industrial, and institutional structures. Floodproofing of structures was determined to be the most feasible nonstructural measures in the study area, due to the characteristics of the existing structures and limitations from presence of historic districts in the Inner Harbor planning unit. Table 3-7 outlines the changes made to Alternative Plan 5 as it evolved from the initial array of alternatives to the final array of alternatives.

Table 3-7. Changes in Alternative Plan 5 from the Initial Array of Alternatives

Measure	Location	Change
Nonstructural	Throughout Study Area	Refined structural inventory; refined modeling; increased number of potentially eligible structures
Floodwall	Tunnels	Revised proposed alignment

3.4.8.3 Alternative Plan 5A: Critical Infrastructure with Select Nonstructural Plan

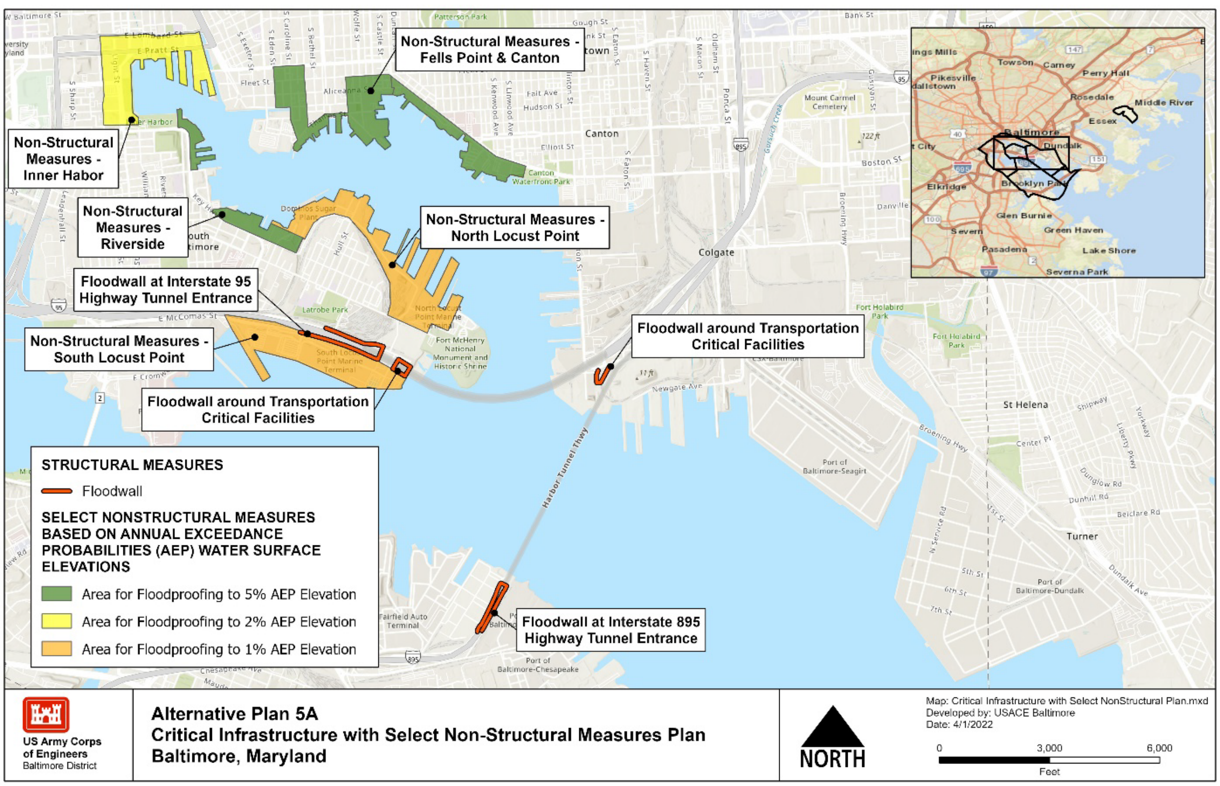

Figure 3-22. Final Array Alternative Plan 5A – Critical Infrastructure Plan with Select Nonstructural Measures Plan

Alternative Plan 5A is an optimization of Alternative Plan 5. It also includes the critical infrastructure measures of Alternative Plan 4: the I-895 and I-95 tunnels and their support facilities. Alternative Plan 5A increases overall net benefits of the critical infrastructure and the nonstructural plan by creating focus areas for floodproofing of structures vulnerable under three AEPs: the 1 percent AEP, 2 percent AEP, and 5 percent AEP (Figure 3-22). The PDT evaluated the economic analysis results of Alternative 5 and selected those AEPs for the focus areas that yielded the highest net benefits for inclusion in Alternative 5A. The focus areas included in Alternative 5a and their associated AEPs are:

- North Locust Point (1 percent AEP)
- South Locust Point (1 percent AEP)
- Inner Harbor area (2 percent AEP)
- Fells Point, Canton (5 percent AEP)
- Riverside areas (5 percent AEP)

The focus areas under these AEPs yield the highest net benefit, while improving the resiliency of these structures against coastal flood risk.

3.4.8.4 Alternative Plan 6: Critical Infrastructure Balanced Plan

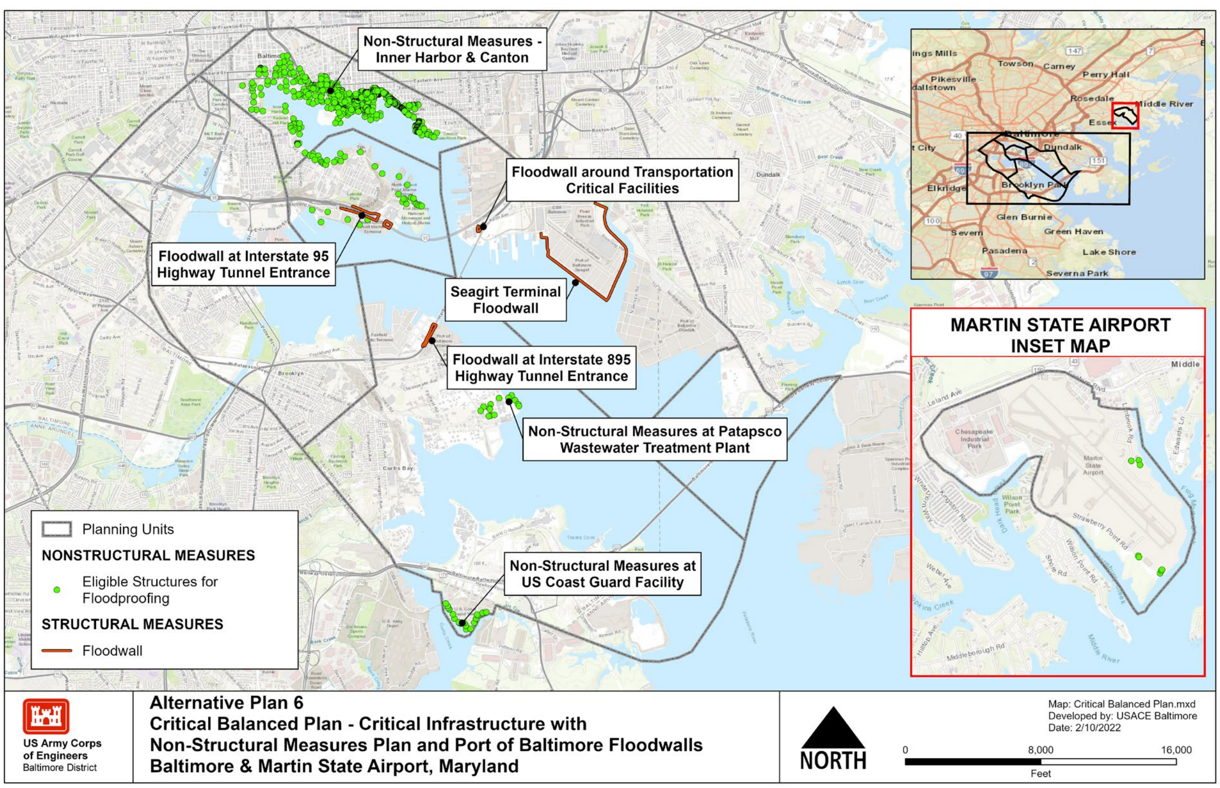

Figure 3-23. Final Array Alternative Plan 6 – Critical Infrastructure Balanced Plan

Alternative Plan 6 expands on Alternative Plan 5, to include the addition of a structural line-of-defense, in the form of an elevated bulkhead (or "sea curb") along the shoreline of the Port of Baltimore's Seagirt terminal (Figure 3-23). Table 3-8 outlines the changes made to Alternative Plan 6 as it evolved from the initial array of alternatives to the final array of alternatives.

Table 3-8. Changes in Alternative Plan 6 from the Initial Array of Alternatives

Measure	Location	Change
Nonstructural	Throughout Study Area	Refined structural inventory; refined modeling; increased number of potentially eligible structures
Floodwall	Tunnels	Revised proposed alignment
Floodwall	Dundalk Marine Terminal	Measure was removed because MPA secured funding and began design and construction

3.4.8.5 Alternative Plan 7: Mid-Tier Plan

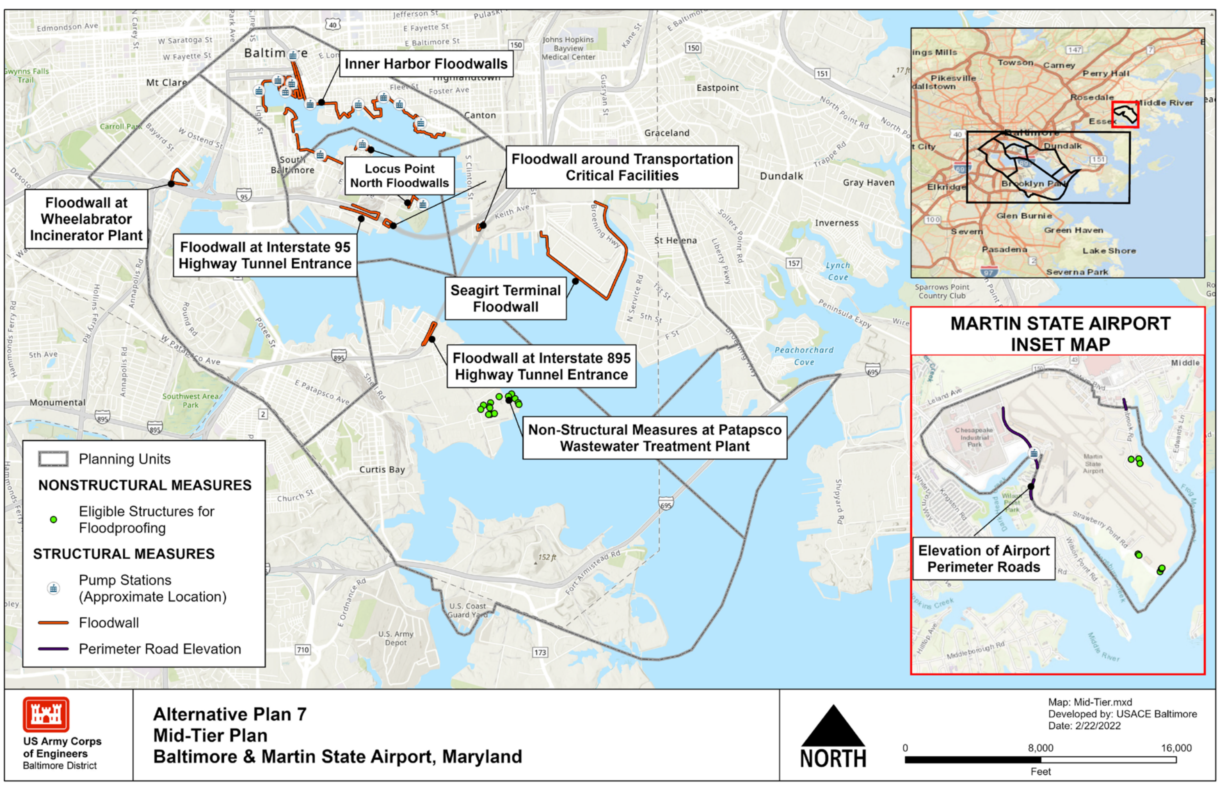

Figure 3-24. Final Array Alternative Plan 7 – Mid-Tier Plan

In Alternative Plan 7, structural lines of defense are proposed along vulnerable portions of the Inner Harbor, Canton, Fells Point and Locust Point areas, instead of nonstructural measures. These structural lines of defense would primarily be permanent floodwalls and could include elevated walkways and deployable floodwalls at certain locations. The floodwalls would generally be located along the shoreline and would include stoplog structures and permanent and temporary pump stations, where needed.

A floodwall around the Wheelabrator Incinerator is also proposed under this alternative. The Wheelabrator Incinerator is a waste-to-energy facility that services Baltimore City and provides steam to the local heating loop and electricity to about 40,000 homes.

In the MSA planning unit, this alternative proposes the creation of a levee via the elevation of Wilson Point Road, which would provide protection to the airport from flooding from Dark Head Cove and would ensure that residents of Wilson Point can safely evacuate or be reached by emergency responders.

Alternative Plan 7 includes some limited non-structural floodproofing, specifically at the Patapsco Wastewater Treatment Plant and at the Martin State Airport. Figure 3-24 shows the locations of the nonstructural and structural measures proposed under Alternative Plan 7, as well as approximate locations of the pump stations required for the structural components in the Inner Harbor and Locust Point planning units. Table 3-9 lists the changes made to Alternative Plan 7 as it evolved from the initial array of alternatives to the final array of alternatives.

Table 3-9. Changes in Alternative Plan 7 from the Initial Array of Alternatives

Measure	Location	Change
Nonstructural	Fort McHenry; Patapsco Wastewater Treatment Plant; Martin State Airport	Identified and added nonstructural measures
Floodwall	Tunnels	Revised proposed alignment
Floodwall	Dundalk Marine Terminal	Measure was removed because MPA secured funding and began design and construction
Floodwall	Inner Harbor	Revised alignment, length, and changed from elevated walkway to floodwall based on updated analysis
Floodwall	Middle Branch	Revised Floodwall at Wheelabrator Incinerator based on updated analysis
Living Levee	Middle Branch	Removed measure because a similar project has been funded through other sources.

3.5 Alternative Modeling

The final array of alternatives was modeled using G2CRM to determine the life-cycle damage reduction benefits provided. Class 3 cost estimates were developed for alternative features, along with preliminary design and real estate costs. Class 3 costs use a higher level of technical information including preliminary project designs, project planning and scope, construction elements, and quantity development, to generate cost estimates. Floodproofing costs include aggregated estimates of real estate transaction costs, easement costs, and floodproofing measure costs.

3.6 Plan Evaluation

The Economic and Environmental Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies, dated 10 March 1983, established the P&G criteria used to evaluate water resources projects pursuant to the Water Resources Planning Act of 1965 (Public Law 89-8). The PDT used the P&G Criteria to evaluate the initial array of alternatives while additional engineering information was developed by various disciplines to inform decision-making. The P&G criteria are described below.

3.6.1 P&G Criteria

- **Completeness** - Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.
- **Effectiveness** - Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
- **Efficiency** - Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.
- **Acceptability** - Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

The results of this P&G evaluation of the array of alternatives are presented in Table 3-10.

Table 3-10. P&G Criteria Evaluation of Final Array of Alternatives

Alternative Plan	Completeness	Effectiveness	Efficiency	Acceptability
No Action	No	No	Yes	No
4 – Critical Only	Yes	Yes	Yes	Yes
5 – Critical & Nonstructural	Yes	Yes	Yes	Yes

5A – Critical with Select Nonstructural	Yes	Yes	Yes	Yes
6 – Critical Balanced	Yes	Yes	Yes	Yes
7 – Mid-tier Balanced	Yes	Yes	Yes	Yes

3.6.2 System of Accounts

3.6.2.1 National Economic Development

Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct benefits that accrue in the planning area and the rest of the nation. Contributions to NED include increases in the net value of goods and services.

3.6.2.2 Regional Economic Development

The RED account registers changes in the distribution of regional economic activity that result from each alternative plan. Two measures of the effects of the plan on regional economies are used in the account: regional income and regional employment.

3.6.2.3 Environmental Quality

Beneficial effects in the EQ account are favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Adverse effects in the EQ account are unfavorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources.

3.6.2.4 Other Social Effects

The OSE account is a means of displaying and integrating into water resource planning information on alternative plan effects from perspectives that are not reflected in the other three accounts. The categories of effects in the OSE account include the following: Life loss; health and safety; and social vulnerability and resilience; economic vitality; community identity; and recreation.

The OSE account is expected to focus on the social vulnerability and resilience of the study area community. Social vulnerability is a key dimension for project development in the area and is a focus for many area stakeholders. In particular, alternative plan effects on health and safety, equity, and effects on emergency preparedness are planned to be addressed. Past storm events have resulted in extensive economic damage in the study area, however life lost has been minimal. Life loss estimates have been derived from G2CRM.

3.6.3 Risk and Uncertainty

During the formulation process, there are planning decisions and uncertainties that must be considered and documented. This study uses many sources of existing data for the analysis. For example, the study team determined existing topographic and geotechnical data are sufficient to distinguish between the alternatives considered. Collecting new data was deferred to the Pre-construction Engineering and Design (PED) phase, which is the next phase of the project after the IFR/EA document has been completed and approved. Additional data, such as building-specific elevation data, is also needed for the nonstructural plans to further evaluate structures that are eligible for floodproofing.

The team recognizes that risks to human life are a fundamental component of all flood risk management studies and must receive explicit consideration in the planning process. SLC was evaluated across multiple modeling scenarios utilizing the USACE intermediate curve of 1.55 feet for the year 2080. It is broadly recognized that SLR is above historical trends (low curve) so it was decided that the low curve was not appropriate for this study. The high curve utilizes projected worst-case scenarios for SLR and exponentially increases towards the year 2100, so it was determined that the high curve was not an accurate representation of the SLR likely to occur over the 50-year period of analysis. The level of performance is based on the 1% AEP with 90% confidence level and intermediate SLC curve through year 2080.

Hence, the design elevation (the elevation the floodwalls would tie into) is 12.5 feet NAVD88 and is designed to reduce flood risk to both tunnels and their ventilation buildings from an intermediate SLC event over the 50-year period of analysis according to USACE Guidance document ER 1100-2-8162 that requires evaluating alternative plans based on future local mean SLC. There is a low likelihood of life safety risk and economic consequences' assessment during a high SLC event toward the end of the period of analysis based on the tunnel closure plan provided by the MDTA.

Based on the MDTA's Flood Preparedness for the Fort McHenry and Baltimore Harbor Tunnels, tunnel closures in preparation for costal events are based on water levels and begin at water level 6 feet NAVD88. Tunnel tubes are progressively closed as water levels increase with full closure of the Baltimore Harbor Tunnel at water level 8 feet NAVD88. The Fort McHenry Tunnel begins closures at water level 8 feet NAVD88 with tunnel use limited to emergency and responder traffic at water level 11 feet NAVD88. The Fort McHenry Tunnel is closed to all traffic at water level 12 feet NAVD88.

4 ENVIRONMENTAL EFFECTS AND CONSEQUENCES*

This section describes the environmental consequences or impacts to the resources described in Section 2. This section presents the effects analysis of the final array of alternatives, which includes Alternative 4 (Critical Infrastructure Only), Alternative 5 (Critical Infrastructure and Nonstructural), Alternative 5A (Critical Infrastructure with Select Nonstructural Plan), Alternative 6 (Critical Balanced), and Alternative 7 (Mid-Tier Balanced) as required by NEPA (40 CFR 1502.16). Alternative 5A is the recommended alternative as discussed in Section 5 of this report. This section is organized by resource topic as described in Section 2 with the potential effects of each alternative described within the Baltimore City and MSA study areas. Installation of permanent floodwalls around critical infrastructure and facilities, along with nonstructural measures such as deployable floodproofing and elevating existing walkways were considered as part of the alternative analysis. For each environmental resource or issue, anticipated direct, indirect, and cumulative impacts were assessed. Potential impacts are described in terms of type (beneficial or adverse); duration (short- or long-term); and intensity (negligible, minor, moderate, or major). Explanations of these terms are as follows:

- Type: The impact type refers to whether it is adverse (negative) or beneficial (positive). Adverse impacts would potentially harm resources, while beneficial impacts would improve resource conditions. Within the analysis, impacts are assumed to be adverse unless identified as beneficial.
- Duration: Impacts resulting from construction are considered short-term and would occur during construction or site improvements. Long-term impacts would persist during the operation of properties and facilities.
- Intensity: The intensity of an impact describes the magnitude of change that the impact generates. The intensity thresholds are as follows:
    - Minor (not significant): The impact would be slight, but detectable, resulting in a small but measurable change in the resource.
    - Moderate (not significant): The impact would be readily apparent and/or easily detectable but would not substantially alter the resource or exceed regulatory thresholds.
    - Major (significant): The impact would be widespread and would substantially alter the resource or exceed regulatory thresholds. A major, adverse impact would be considered significant under NEPA.

4.1 Natural Environment

4.1.1 Wetlands

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced)

Alternatives 4, 5, 5A (Recommended Plan) and 6 are not expected to impact estuarine wetlands or their associated buffers within the Baltimore Metro study area since these alternatives would be outside of existing wetlands and their buffers.

Alternative 7 (Mid-Tier Balanced)

Alternative 7 has the potential to cause indirect, short term, minor adverse impacts to palustrine wetlands and/or buffers with construction of the elevated roadway along perimeter roads at the MSA. Most of the road work would be expected to stay within the road right-of-way and proper BMPs would be used to ensure sediment-laden runoff would not impact wetlands or their associated buffers. Construction of a proposed floodwall around the Fort McHenry West Ventilation Building would be located adjacent to an estuarine wetland and would have no direct or indirect impacts to the wetlands.

4.1.2 Wildlife

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Alternatives 4 through 7, including Alternative 5A (Recommended Plan) are not expected to impact wildlife or rare, threatened, or endangered species. Wildlife may temporarily avoid the construction areas during construction and for a short period of time following construction. Construction noise and disturbance should not adversely affect squirrels, chipmunks, opossum, and racoon because these animals thrive and are accustomed to the noise and activity typical of urban environments. There are several species identified as utilizing the overall study area that are at-risk or threatened/endangered. However, due to the alternatives being in highly developed areas with low fish and wildlife species, as reported in the FWCA Coordination Act Letter (Appendix H), the species identified to be within the study area are not likely to be negatively impacted by the alternatives. According to the MDDNR Wildlife and Heritage Service, in a letter dated July 15, 2022, no official records for State or Federal listed, candidate, proposed, or rare plant or animal species exist within the study area. Coordination with NOAA, NMFS has been completed and concurred that no impacts will occur to Essential Fish Habitat (EFH) or NMFS trust resources (Appendix H). BMPs will be implemented to avoid potential impacts to aquatic resources, i.e., monitoring any runoff that occurs due to construction. A determination was also reached through the FWCA letter that suitable habitat for the NLEB does not exist within the Baltimore study area and is not likely to affect the mammal. Alternatives 4 through 7 and Alternative 5A (Recommended Plan) are not anticipated to impact canopy trees within the MSA study area; therefore, any potential hibernacula are not anticipated to be impacted. Through the life of this report, CENAB has continually updated the IPaC species list to ensure construction would not likely and/or adversely effect any rare, threatened, endangered, or candidate species. The most recent species list was requested in February 2024. The designation of NLEB has now changed from threatened to endangered as of March 2023. However, the alternatives are not expected to result in any direct or indirect impacts to wildlife species, nor are they likely to cause and/or adversely effect rare, threatened, endangered, or candidate species.

4.2 Physical Environment

4.2.1 Land Use

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Alternatives 4 through 7 and Alternative 5A (Recommended Plan) are not expected to impact land use within the study areas.

4.2.2 Geology, Physiography, and Soils

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Alternatives 4 through 7, and Alternative 5A (Recommended Plan) are not expected to impact geology or physiography. However, direct, short term, minor adverse impacts during construction are expected to alter soils. Soils are expected to be returned to their existing conditions at the completion of construction. Soil testing is anticipated to be performed before construction to determine and classify potential levels of containments within the soils, including the potential for COPR-contaminated soils. More information regarding contaminated soil is described in Section 4.2.5.

4.2.3 Water Quality

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Alternatives 4 through 7 and Alternative 5A (Recommended Plan) are not expected to impact water quality within the Baltimore City and MSA study areas. No in-water construction or mobilization is anticipated within either study area. All necessary erosion and sediment control practices will be implemented during construction and will follow all state, county, and city BMP guidelines.

4.2.4 Floodplains

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Implementation of floodwalls would reduce the effective volume of available floodplain to coastal floodwaters during a storm event. Areas within the 100-year floodplain include the Inner Harbor, Fells Point, Canton, Locust Point, Seagirt, areas around Middle Branch, and MSA. Accreditation of the new floodwall by FEMA is needed to comply with federal regulation 44 CFR 65.10 – Mapping of areas protected by levee systems. Although the FEMA 100-year floodplain is located throughout the project area, these alternatives would have no direct and indirect impacts on natural floodplains. Although portions of the study areas are within the 100-year floodplain, the impervious surfaces do not adequately represent an efficient use or purpose of a floodplain.

4.2.5 Hazardous Materials and Wastes

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Direct and short-term, minor adverse impacts may occur during construction if tie-down anchoring, which is a method used for securing floodwalls, is required. Further investigations in the PED phase will be conducted to determine the extent of contamination where floodwall placement and anchoring may occur, to prevent any adverse impacts from potential releases of contaminates. If contamination is encountered during field sampling, safety precautions and appropriate disposal of contaminated material would be implemented. Per ER 1105-2-100[5], 2-13 (p) and ER 1165-2-132, any associated clean-up of HTRW would be the responsibility of the NFS. In an effort to minimize the potential for a release of petroleum-based fluids (i.e., diesel fuel, hydraulic fluid) from construction equipment to the environment, all construction equipment would be maintained in good working order by the contractor daily. If an accidental release of a hazardous material occurs, construction equipment would be equipped with an emergency spill kit and workers would be trained on how to properly deploy the equipment to respond to a release. Any solid waste, including excess vegetation or sediment debris, would be properly composted, reused, or disposed of at a permitted facility. Furthermore,

[5] The Planning Guidance Notebook was updated on 7 December 2023 as ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The PDT is aware of this new guidance and consulted the draft guidance while completing the study.

all contractors involved in the project would be responsible for adhering to state and Federal regulations for storage, handling, and disposal of hazardous wastes.

4.2.6 Transportation and Navigation

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan)

The proposed floodwalls around critical infrastructure in places such as the Baltimore and Fort McHenry Tunnels and their associated transportation critical facilities may cause direct and indirect, short term, minor adverse impacts with lane closures or traffic delays. Potential smoke and dust may cause temporary visual impairments during construction. Some construction vehicles and potentially large cranes may be seen from the adjacent roadway, causing a temporary distraction to motorists. Coordination with MDOT, State Highway Administration, Maryland Transit Administration, and Federal Highway Administration (FHWA) will continue as the project progresses and as the potential need for signage and digital warnings overhead of roadways may be needed during construction. Direct and indirect, long term, beneficial impacts include maintaining access to transportation corridors along I-95 and I-95, which are crucial for the shipping and cargo industries. Alternatives 4-7 & Alternative 5A (Recommended Plan) are expected to improve the long-term resilience of these corridors and their critical infrastructure to flooding events.

Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Similar actions are anticipated to occur as mentioned in the section above. Additionally, active construction along the shoreline at Seagirt terminal for the proposed sea curb in Alternatives 6 and 7 may cause short term, minor adverse disruptions to shipping and cargo that is being imported and exported out of the Port of Baltimore. Active construction and storage of construction equipment may temporarily displace cargo until the sea curb is completed and construction equipment is removed.

4.2.7 Noise

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Direct short term, minor adverse noise disturbances from construction equipment are expected to occur for all alternatives. All work is expected to be performed during an 8-hour period, except for the Harbor Tunnel entrance, which may require 12-hour days to avoid heavy daytime traffic. Construction equipment is expected to include gas and/or diesel-powered equipment such as dump trucks, excavators, backhoes, and devices used to delivery and lay concrete. Due to the proximity of residential neighborhoods, noise reducing techniques may be used to minimize disturbance. Such techniques include equipping construction equipment with sound-muffling devices available from the equipment manufacturer and limiting engine idling time. To ensure operational maintenance noises do not become a nuisance, equipment would be maintained in good working order and would only be operated during daylight working hours.

4.2.8 Air Quality/Greenhouse Gas Emissions

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

An air conformity analysis has been performed in conjunction with USEPA guidelines and standards. See Appendix G for the analysis and results. Alternatives 4-7 as well as Alternative 5A (Recommended Plan) are expected to have short-term, minor adverse impacts to air quality. Potential air quality impacts from construction activities would occur from: 1) combustion emissions due to the use of fossil-fuel-powered equipment and vehicles, and 2) particulate emissions from fugitive dust generated during ground-disturbing activities. Based on the calculations in the air conformity analysis, the total construction emissions for all criteria pollutants would be well below the General Conformity Rule *de minimis* thresholds, and therefore, direct and/or indirect, short-term, minor adverse impacts to air quality are expected, but no mitigation measures would be required. In response to E.O. 13990, this undertaking should not create long-term GHG emissions through implementation of any alternative. There may be a temporary increase in GHG emissions through construction, but no long-term emitter of GHG is proposed.

4.2.9 Coastal Zone Management Program

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Baltimore City and Baltimore County are coastal counties and fall within Maryland’s CZMP enforceable policies. Evaluated policies include the Critical Area, historical and archeological sites, and transportation assets. Based on a Federal Consistency Review by MDE, it was determined that the activities described in the CZMA July 2022 submittal are consistent with the enforceable coastal policies of the Maryland Coastal Zone Management Program subject to the project complying with all applicable Critical Area Policies under 5.2.1, “The Chesapeake and Atlantic Coastal Bays Critical Area” to the maximum extent practicable (Appendix G). No direct or indirect impacts are expected. The Tentatively Selected Plan (Alternative 5A) was used as the alternative to be analyzed through the CZMA analysis. The other alternatives (Alternatives 4, 5, 6, and 7) were not analyzed separately for a federal consistency. Alternative 5A is a combination of

Alternatives 4 and 5 and thus, included in the overall analysis. Alternatives 6 and 7 were not analyzed through the CZMA due to their extensive structural components and would unlikely not be consistent with CZMA laws and regulations due to alternations to the floodplain and impacts to the Critical Area.

4.2.10 Chesapeake Bay Critical Area

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

The Baltimore City study area and MSA study area fall within the IDA, LDA, and RCA Critical Areas. Direct, long term, minor adverse impacts to the Critical Area 100-foot buffer are expected where structural floodproofing is anticipated – around the Baltimore and Fort McHenry tunnels and associated transportation critical infrastructure. Disturbance or impacts are anticipated to come in the form of maintained lawn disturbance where the new floodwall will tie-in to an existing elevated berm. CENAB is anticipated to implement the City of Baltimore's Critical Area Management Program Manual (CAMP Manual) during the PED phase of the project. The CAMP Manual has requirements that go beyond the State's threshold requirements, including the regulation of the entire extent of the city's Intensely Developed Area (IDA). The CAMP Manual categorizes the city's IDA into subsections, which includes the Shoreline Conservation Area that prohibits the expansion of bulkheads/hardened shorelines across the city. Coordination with the Baltimore City Critical Area Commission is on-going and will continue as the project progresses. A Critical Area Buffer Management Plan is also anticipated to address minor Critical Area 100-foot buffer impacts and would be completed during the PED phase. The Plan would include an existing conditions site plan, proposed conditions site plan, and any pertinent mitigation or landscape plans or specifications to address any impact.

4.2.11 Climate Change and SLC

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Alternatives 4 through 7 & Alternative 5A (Recommended Plan) are not anticipated to impact water levels from the existing water level elevation; therefore, SLC will have the same effect on Alternatives 4-7 & Alternative 5A. In accordance with Engineering Regulation ER 1100-2-8162 (incorporating SLC in Civil Works Program, 31 Dec 2013), CENAB performed a sensitivity analysis for SLC. The analysis is used for proposed projects that are subject to coastal storm surges and must be evaluated for a range of possible SLR rates: low, intermediate, and high. Details of this analysis and how Alternatives 4 through 7 and Alternative 5A correlate with climate change and SLC can be found in Appendices B and E. Direct, long-term, beneficial impacts are expected through implementation of the project to curb impacts of climate change and SLC through improved resiliency of critical infrastructure.

4.2.12 Cultural Resources

This section describes the potential effects that could occur to cultural resources that are either eligible for or listed in the National Register of Historic Places (NRHP) by the proposed alternatives. Due to the timing of the Project, USACE is currently unable to identify and evaluate cultural resources and determine effects to historic properties prior to completion of the EA. Therefore, pursuant to 54 U.S.C. 306108 and 36 CFR 800.14(b)(1)(ii), USACE is deferring final identification and evaluation of historic properties until after Project approval, when additional funding becomes available, and prior to construction by executing a PA with the SHPO and other consulting parties (Appendix G).

Alternative 4 (Critical Infrastructure Plan)

This alternative includes floodwalls around Interstates I-95 and I-895 tunnel entrances and associated transportation critical facilities, and nonstructural floodproofing to federal facilities north of Fort McHenry, at the Patapsco WWTP, and at the MSA.

The majority of the Interstate Highway system is exempt from consideration as a historic property under Section 106 of the NHPA under the Advisory Council for Historic Preservation (ACHP)'s *Section 106 Exemption Regarding Effects to the Interstate Highway System*. Some components of the system are excluded from the ACHP's exemption due to their exceptionalism or national significance and must be considered in the Section 106 process. In Maryland, portions of I-895 and I-95 are excluded from the exemption due to their engineering and national significance. I-895 (Baltimore Harbor Tunnel milepost 2.4 - 3.8) was determined eligible for the NRHP in 2020 under Criterion A for its significant association with twentieth-century automotive transportation improvements in Maryland and the Baltimore region, and Criterion C for its significant engineering design. I-95 (Fort McHenry Tunnel milepost 4.8 - 6.1) has not been formally evaluated for the NRHP, but the ACHP's Interstate Highway System Exemption List notes that it is significant in the area of engineering design since it is the longest and widest vehicular tunnel ever built with the immersed tube method. It is also the first tunnel in the world to have sections with both horizontal and vertical curvature.

The floodwalls proposed in Alternative 4 could have an adverse effect if they significantly alter the aspects of integrity that make a resource significant. For I-895 and I-95, this includes the roadway approaches on either side of the tunnel, the roadways' ability to convey their original construction and significance as major transportation and engineering features, and the associated transportation critical facilities.

For I-95, the floodwall is proposed in areas that were previously part of the Patapsco River. The land was built up and/or filled in when constructing the South Locust Point

Marine Terminal in the twentieth century. It is also along areas that were previously excavated for construction of the I-95 tunnel.

For I-895, at the tunnel entrance, this area was predominantly part of the Patapsco River and industrially developed and filled throughout the twentieth century. Its associated transportation critical facility is located in an area that was once in or directly adjacent to the Patapsco River. Throughout the twentieth century this area was filled in to create the piers and industrial areas now present at this location.

While archaeological concerns are not necessarily expected in areas that have been in-filled to create modern piers and terminals, final floodwall designs and limits of disturbance will need to be evaluated to determine any potential effects to resources that may be located under modern fill.

Additionally, the introduction of floodwalls may affect the viewshed of the I-95 and I-895 facilities. A viewshed analysis would need to be conducted incorporating final floodwall designs and limits of disturbance to evaluate its effect on the viewshed of historic properties.

Adverse effects to historic properties from implementation of nonstructural measures would be specific to the historic properties treated. Under Alternative 4, nonstructural floodproofing is proposed for federal facilities north of Fort McHenry (USACE and Navy Reserve buildings), the Patapsco WWTP, and the MSA. If floodproofing occurred to a building eligible for or listed in the NRHP, adverse effects would require avoidance, minimization, or mitigation. Adverse effects from nonstructural alternatives may also be avoided or minimized through the use of the Secretary of Interior’s Guidelines on Flood Adaptation for Rehabilitating Historic Buildings, the Secretary of Interior’s Standards for Rehabilitation, the Baltimore Historic Preservation Design Guidelines, or the Fell’s Point Flood Mitigation Guidelines. Buildings that have not been evaluated for the NRHP would need to be formally evaluated.

Alternatives 5 (Critical Infrastructure and Nonstructural) and 5A* (Recommended Plan) *(Critical Infrastructure with Select Nonstructural Measures Plan)

This alternative features everything included in Alternative 4; however, there are more properties proposed for nonstructural floodproofing measures. Additional nonstructural measures are proposed throughout the Inner Harbor, Fells Point Historic District, Canton Historic District, Locust Point Historic District, and at Curtis Bay. As mentioned previously, adverse effects to historic properties from implementation of nonstructural measures would be specific to the historic properties treated. If floodproofing occurred to a building eligible for or listed in the NRHP, impacts may require mitigation. Adverse effects from nonstructural alternatives may also be avoided or minimized through the use of the Secretary of Interior’s Guidelines on Flood Adaptation for Rehabilitating Historic Buildings, the Secretary of Interior’s Standards for Rehabilitation, the Baltimore Historic

Preservation Design Guidelines, or the Fell's Point Flood Mitigation Guidelines. Buildings that have not been evaluated for the NRHP would need to be formally evaluated.

Alternative 6 (Critical Balanced)

This alternative features everything included in Alternative 4 and Alternative 5; however, there is an additional proposed floodwall around the Seagirt Marine Terminal. The northern end of the proposed floodwall moves through the Western Electric Company, Point Breeze Plant Historic District, so there could be direct visual impacts to that resource. Additionally, the proposed floodwall is within the viewshed of the Canton Grain Elevator and the Baltimore Municipal Airport, Harbor Field, so updated designs would need to be evaluated for their visual effects to these resources.

Alternative 7 (Mid-Tier Balanced)

This alternative includes floodwalls around Interstates I-895 and I-95 tunnel entrances and associated transportation critical facilities, and elevated walkways and floodwalls within the Inner Harbor, Federal Hill, Locust Point, Fells Point, Canton, around the Wheelabrator Incinerator Plant, and around the Seagirt Marine Terminal. Nonstructural floodproofing measures are proposed at the Patapsco Wastewater Treatment Plant, throughout Curtis Bay. Additionally, road elevation is proposed at the MSA. Proposed walkway elevation and floodwalls could have a direct, adverse impact on the Locust Point Historic District, Federal Hill Historic District, Business and Government Historic District, Fells Point Historic District, and the Canton Historic District, along with at least thirteen known historic properties. Proposed road elevation at MSA may have an effect on the NRHP-eligible Glenn L. Martin Airport and would need to be evaluated as designs progress.

4.2.13 Socioeconomics

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Alternatives 4 through 6, including Alternative 5A (Recommended Plan) are expected to have direct and indirect, long term, beneficial impacts socioeconomics. The implementation of structural and nonstructural floodproofing may increase the value of properties and businesses. Alternative 7 may cause direct, long-term, moderate adverse impacts to businesses along the Inner Harbor with the implementation of floodwalls since it would block some of the visibility and access to the water. The structural component along the Harbor may cause a long-term loss of appeal to the area and potentially cause waterfront businesses to close or relocate.

4.2.14 Environmental Justice

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Although air quality and noise may cause temporary disruptions, Alternatives 4 through 7 and Alternative 5A (Recommended Plan) are not expected to disproportionately impact EJ communities. Further investigations would be needed to determine the presence of underground contaminants prior to construction of any permanent structures to ensure contaminants will not be discharged into local communities. Conversely, Alternatives 4 through 7 and Alternative 5A would provide direct and indirect, long-term, beneficial impacts to coastal resiliency to communities affected by flooding or coastal storms. Major transportation corridors would also be maintained and continue to be uninterrupted as climate change and sea-level rise continue to become a concerning factor for coastal infrastructure. The main socioeconomic inhibitor to communities within the project area are low-income and less than high school education according to the CEQ CEJST tool. This undertaking is not expected to impact those communities that fall within those two socioeconomic categories since those communities are not vulnerable to coastal flooding. Other burden thresholds such as climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development, although present, are not expected to be negatively impacted by the alternatives.

4.2.15 Recreational Resources

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Visual or access impacts to recreational resources may occur within the Baltimore Metro study area with Alternatives 4 through 6, including Alternative 5A (Recommended Plan). Some areas of impacts from nonstructural floodproofing mechanisms may impose direct long term, minor adverse impacts and access issues to walking trails adjacent to the Baltimore Harbor Promenade, intramural sports fields, and waterfront parks or sitting areas during potential nonstructural implementation including mobilization and set up of equipment. Alternative 7, and the implementation of structural mechanisms, may cause direct, long term, minor adverse access issues to some recreational businesses such as the Baltimore Water Taxi, kayak drop-in points, ‘Chessie Dragon Paddle Boats’, sailing tours, sightseeing cruises, and boat rentals.

4.2.16 Visual Aesthetics

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced)

Visual aesthetics are not expected to be impacted under Alternatives 4 through 6 or Alternative 5A (Recommended Plan). The proposed structural floodwalls in Alternatives 4 through 6 and 5A would be installed in urbanized and industrialized areas. Natural landscapes are limited in these areas and with the implementation of the structural components, these landscapes are not expected to be negatively impacted. Nonstructural floodproofing measures, such as deployable features and waterproofing residents and businesses are not expected to negatively impact visual aesthetics.

Alternative 7 (Mid-Tier Balanced) Visual aesthetics are expected to be impacted under Alternative 7. Areas that would receive direct, long term, moderate adverse impacts to visual aesthetics are around the Inner Harbor, Canton, Fells Point, and Locust Point. Elevated structural floodwalls with pumping stations are anticipated with this alternative and would cause disruptions to the viewshed. The visual aesthetics around the Inner Harbor are one of many attractions that bring tourists to Baltimore.

4.2.17 Utilities

Alternative 4 (Critical Infrastructure Only) Alternative 5 (Critical Infrastructure and Nonstructural) Alternative 5A (Recommended Plan) (Critical Infrastructure with Select Nonstructural Plan) Alternative 6 (Critical Balanced) and Alternative 7 (Mid-Tier Balanced)

Utilities within all alternatives have the potential to be impacted by structural and nonstructural floodproofing. Coordination with utility companies such as Baltimore City Department of Public Works, Baltimore County Department of Public Works, BGE, Miss Utility, and cable and internet providers. Coordination from the contractor will be especially prudent with any implementation of permanent structures or elevation of roadways. For flood control projects, the Sponsor is required to relocate affected facilities and utilities necessary for the construction, operation, and maintenance of a project. A relocation may take the form of an alteration, lowering, raising, or replacement of the affected facility/utility or part thereof, which could result in a direct, short-term, minor adverse impacts to utilities. As this planning stage no analysis to identify relocations was performed, and no compensability determinations were done.

4.3 Summary of Potential Effects

Table 4-1 summarizes the effects of the final array of alternatives.

Table 4-1. Summary of Potential Effects form the Final Array of Alternatives

Resource	No Action	4- Critical Infrastructure	5- Critical Infrastructure and Nonstructural Focus Areas	5A- Critical Infrastructure with Select Nonstructural Plan	6-Critical Balanced	7-Mid-Tier Balanced
Wetlands	No effect.	No effect.	No effect.	No effect.	No effect.	Indirect, short-term, minor adverse impacts from construction of elevated roadway (drive-on levee) at Martin State Airport
Wildlife	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.
Threatened and Endangered Species	Not likely to adversely effect.	Not likely to adversely effect.	Not likely to adversely effect.	Not likely to adversely effect.	Not likely to adversely effect.	Not likely to adversely effect.
Land Use	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.
Geology, Physiography, Soils	No effect.	No effect to geology or physiography. Direct, temporary, short-term, minor adverse impacts to soils.	No effect to geology or physiography. Direct, temporary, short-term, minor adverse impacts to soils.	No effect to geology or physiography. Direct, temporary, short-term, minor adverse impacts to soils.	No effect to geology or physiography. Direct, temporary, short-term, minor adverse impacts to soils.	No effect to geology or physiography. Direct, temporary, short-term, minor adverse impacts to soils.
Water Quality	Projects to improve water quality within the Chesapeake Bay and its watershed underway.	No in-water construction. No effects.	No in-water construction. No effects.	No in-water construction. No effects.	No in-water construction. No effects.	No in-water construction. No effects.

Resource	No Action	4- Critical Infrastructure	5- Critical Infrastructure and Nonstructural Focus Areas	5A- Critical Infrastructure with Select Nonstructural Plan	6-Critical Balanced	7-Mid-Tier Balanced
Floodplains	Floodplains expected to move inland as sea level rises.	Cumulative, short and long term, minor, adverse impacts.	Cumulative, short and long term, minor, adverse impacts.	Cumulative, short and long term, minor, adverse impacts.	Cumulative, short and long term, minor, adverse impacts.	Cumulative, short and long term, minor, adverse impacts.
Hazardous Materials and Waste	Potential infiltration of hazardous materials and wastes into the Chesapeake Bay or public water supply possible during flooding events.	Direct, short-term, minor, adverse impacts. Contaminated soils could be encountered directly when anchoring floodwalls. Further investigations to evaluate soils in anchoring areas would be completed prior to construction.	Direct, short-term, minor, adverse impacts. Contaminated soils could be encountered directly when anchoring floodwalls. Further investigations to evaluate soils in anchoring areas would be completed prior to construction. Potential for asbestos or lead paint-contaminated material.	Direct, short-term, minor, adverse impacts. Contaminated soils could be encountered directly when anchoring floodwalls. Further investigations to evaluate soils in anchoring areas would be completed prior to construction. Potential for asbestos or lead paint-contaminated material.	Direct, short-term, minor, adverse impacts. Contaminated soils could be encountered directly when anchoring floodwalls. Further investigations to evaluate soils in anchoring areas would be completed prior to construction.	Direct, short-term, minor, adverse impacts. Contaminants are likely to be encountered directly where floodwalls are proposed along the Inner Harbor areas, due to historical infilling along shorelines. Further evaluations would be needed prior to construction. Any contaminated soils or hazardous materials would be handled and disposed of in accordance with applicable state and federal regulations.
Transportation and Navigation	Local roadways, I-895 and I-95 tunnels would be vulnerable to disruption from flooding events.	Direct and indirect, short-term, minor, adverse impacts and direct and indirect, long-term, beneficial impacts.	Direct and indirect, short-term, minor, adverse impacts and direct and indirect, long-term, beneficial impacts.	Direct and indirect, short-term, minor, adverse impacts and direct and indirect, long-term, beneficial impacts.	Direct and indirect, short-term, minor, adverse impacts and direct and indirect, long-term, beneficial impacts.	Direct and indirect, short-term, minor, adverse impacts and direct and indirect, long-term, beneficial impacts.
Noise	No effect.	Direct short-term, minor, adverse impacts.	Direct, short-term, minor, adverse impacts.	Direct, short-term, minor, adverse impacts.	Direct, short-term, minor, adverse impacts.	Direct, short-term, minor, adverse impacts.
Air Quality/ Greenhouse Gas Emissions	No effect.	Direct and/or indirect, short-term, minor, adverse impacts.	Direct and/or indirect, short-term, minor, adverse impacts.	Direct and/or indirect, short-term, minor, adverse impacts.	Direct and/or indirect, short-term, minor, adverse impacts.	Direct and/or indirect, short-term, minor, adverse impacts.
Coastal Zone Management Program	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.

Resource	No Action	4- Critical Infrastructure	5- Critical Infrastructure and Nonstructural Focus Areas	5A- Critical Infrastructure with Select Nonstructural Plan	6-Critical Balanced	7-Mid-Tier Balanced
Chesapeake Bay Critical Area	No effect.	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.
Climate Change and SLC	The Baltimore City Metropolitan area is vulnerable to SLC.	Direct, long-term, beneficial impacts.	Direct, long-term, beneficial impacts.	Direct, long-term, beneficial impacts.	Direct, long-term, beneficial impacts.	Direct, long-term, beneficial impacts.
Cultural Resources	Cultural resources could be vulnerable to SLC and coastal flooding.	Potential impacts to I-895 if aspects of historical significance are impacted. Potential impacts to historical properties from floodproofing measures.	Potential impacts to I-895 if aspects of historical significance are impacted. Potential impacts to historical properties from floodproofing measures.	Potential impacts to I-895 if aspects of historical significance are impacted. Potential impacts to historical properties from floodproofing measures.	Potential impacts to I-895 if aspects of historical significance are impacted. Potential impacts to historical properties from floodproofing measures.	Potential impacts to I-895 if aspects of historical significance are impacted. Potential impacts to historical properties from floodproofing measures. Potential impacts from elevated walkways and floodwalls on historic districts in Inner Harbor areas.
Socioeconomics	Coastal flooding events could lead to displacement of residents and communities.	Direct and indirect, long-term, beneficial impacts.	Direct and indirect, long-term, beneficial impacts.	Direct and indirect, long-term, beneficial impacts.	Direct and indirect, long-term, beneficial impacts.	Direct and indirect, long-term, minor, adverse impacts.
Environmental Justice (EJ)	No effect.	Direct and indirect, long-term, beneficial impacts. No disproportionate, direct impacts to vulnerable communities. Long-term, beneficial impacts.	Direct and indirect, long-term, beneficial impacts. No disproportionate impacts to vulnerable communities.	Direct and indirect, long-term, beneficial impacts. No disproportionate impacts to vulnerable communities.	Direct and indirect, long-term, beneficial impacts. No disproportionate impacts to vulnerable communities.	Direct and indirect, long-term, beneficial impacts. No disproportionate impacts to vulnerable communities.
Recreational Resources	Recreational resources may be at	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.	Direct, long-term, minor, adverse impacts.

Resource	No Action	4- Critical Infrastructure	5- Critical Infrastructure and Nonstructural Focus Areas	5A- Critical Infrastructure with Select Nonstructural Plan	6-Critical Balanced	7-Mid-Tier Balanced
	risk due to flooding events.					
Visual Aesthetics	No effect.	No effect.	No effect.	No effect.	No effect.	Direct, long term, moderate, adverse impacts.
Utilities	Utilities could be at risk from flooding events.	Direct, short-term, minor, adverse impacts.	Direct, short-term, minor, adverse impacts.	Direct, short-term, minor, adverse impacts.	Direct, short-term, minor, adverse impacts	Direct, short-term, minor, adverse impacts

5 PLAN COMPARISON AND SELECTION

The following section outlines the FWP condition and benefits evaluation methodology for the final array of alternatives, the four accounts evaluation, and the plan comparison leading to the Recommended Plan decision. The FWP condition is the most likely condition expected to exist in the future if a specific project is undertaken. A full discussion on the FWP condition and benefits can be found in Appendix E: Economic Analysis.

5.1 Future With-Project Condition

The PDT evaluated the No Action Alternative, as well as Alternatives 4, 5, 5A, 6, and 7 and compared them each with an emphasis on outputs and effects that would influence the decision-making process for identifying the Recommended Plan. Alternatives 4, 5, 5A, 6, and 7 were each evaluated at 1 percent AEP, 2 percent AEP, and 5 percent AEP. Structural components for each alternative remained the same under the different AEPs. The structures that were vulnerable under each AEP differed because the flood extent with lower frequency storms increased and more structures may be vulnerable. The SLC rate used in the G2CRM computations was 0.00994 feet per year. G2CRM was used to estimate PV damages and average annual damages in the FWOP and FWP for each alternative. Details on the damages expected to occur under the FWOP condition and the damages reduced in the FWP condition are included in Appendix E: Economic Analysis.

5.2 Future With-Project Benefits

The difference in expected mean PV flood damages in the Baltimore Coastal Study area between the FWOP condition and FWP condition represents the CSRM benefits to the project. Therefore, these benefits represent damages reduced from coastal storm surge inundation with the combination of SLR for each alternative. However, ER 1105-2-100, the PGN[6], dictates that the calculation of net NED benefits for a plan is calculated in average annual equivalent terms. Therefore, the PV damages were converted to average annual damages and the costs were annualized using the fiscal year 2024 discount rate of 2.75 percent and a 50-year period of analysis for the purpose of the comparison. FWP benefits for the final array of alternatives can be found in Appendix E: Economic Analysis.

Relevant data for each of the alternatives described above were entered into G2CRM as alternative plans and the potential for flood damage reduction was calculated. These benefits were compared to costs developed for each alternative and non-structural MA. The equivalent annual benefits were compared to the average annual cost to develop net benefits and a benefit-to-cost ratio (BCR) for each alternative. The net benefits for each alternative were computed by subtracting the average annual costs from the equivalent average annual benefits. BCR was calculated by dividing average benefits by average

[6] The Planning Guidance Notebook was updated on 7 December 2023 as ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The PDT is aware of this new guidance and consulted the draft guidance while completing the study.

annual costs. Net benefits were used for identification of the NED plan in accordance with the Federal objective. Tables 31 and 32 in the Economics Appendix contain a detailed summary of the benefits, costs, net annual benefits, and benefit to cost ratio for each alternative by AEP, with line items for each separate model component.

5.3 Four Accounts Evaluation

5.3.1 National Economic Development

In accordance with the Federal objective, the NED plan is defined as the cost-effective plan that reasonably maximizes net benefits. The equivalent annual benefits were compared to the average annual cost to develop net benefits and a BCR for each alternative. The net benefits for each alternative were computed by subtracting the average annual costs from the equivalent average annual benefits. The BCR was calculated by dividing average benefits by average annual costs. Net benefits were used for identification of the NED plan in accordance with the Federal objective. Economic evaluation for the final array of alternatives and detailed project component and alternatives are found in Table 31 of Appendix E: Economic Analysis. The NED Plan is Alternative 5A – Critical Infrastructure with Select Nonstructural Measures Plan. This plan contained four MAs of non-structural measures which resulted in negative net benefits. After the Agency Decision Milestone, the non-structural components of the plan were optimized and reanalyzed as summarized in Section 5.5. Table 5-1 provides a summary of the costs and benefits for each of the AEPs under each alternative evaluated in the final array of alternatives and the optimized Alternative 5A.

Table 5-1. Costs and Benefits Results for Final Array of Alternatives*

Alternative Description	First Cost	Total Cost	Average Annualized Net Benefits	BCR
No Action		-	-	
Alt 4 -100YR Summary	$ 63,986,000	$ 65,160,000	$4,155,000	2.8
Alt 4 - 50YR Summary	$ 58,758,000	$ 59,869,000	$4,341,000	3.0
Alt 4 - 20YR Summary	$ 57,155,000	$ 58,247,000	$4,398,000	3.1
Alt 5 - 100YR Summary	$ 454,717,000	$ 460,590,000	($5,772,000)	0.6
Alt 5 - 50YR Summary	$ 269,495,000	$ 273,148,000	$7,000	1.0
Alt 5 - 20YR Summary	$ 174,735,000	$ 177,245,000	$2,380,000	1.4
Alt-5A - Optimized Plan**	$ 77,489,000	$ 83,490,000	$ 3,092,000	20.9
Alt 6 - 100YR Summary	$ 487,860,000	$ 494,875,000	($6,803,000)	0.6

Alternative Description	First Cost	Total Cost	Average Annualized Net Benefits	BCR
Alt 6 - 50YR Summary	$ 302,638,000	$ 307,419,000	($1,046,000)	0.9
Alt 6 - 20YR Summary	$ 207,878,000	$ 211,516,000	$1,326,000	1.2
Alt 7 - 100YR Summary	$ 559,403,000	$ 575,451,000	($8,762,000)	0.6
Alt 7 - 50YR Summary	$ 554,286,000	$ 570,273,000	($8,621,000)	0.6
Alt 7 - 20YR Summary	$ 552,673,000	$ 568,639,000	($8,581,000)	0.6

*Fiscal year 2022 discount rate of 2.25 percent (October 2021 price level)
**Alt. 5A Costs updated and at Fiscal Year 2024 discount rate of 2.75 percent (October 2023 price level)

5.3.2 Regional Economic Development (RED)

The current certified Regional Economic System (RECONS) 2.0 model was used to estimate the RED benefits in the Baltimore Coastal Study. The RED evaluation estimates changes in the distribution of regional economic activity for each alternative plan. The RED evaluation focuses on the creation of jobs and regional contributions to income and economic output associated with investments from the proposed action. Since RECONS uses the expenditures in the study area to forecast future jobs and value added to the economy, the higher the cost of the project the higher are jobs and value added to the economy. The direct expenditures generate additional economic activity, often called secondary or multiplier effects. Alternatives 4, 5, 5A, 6, and 7 generated positive RED outputs, with Alternative 7 (the highest costing alternative) generating the highest RED outputs. A summary of RED impacts for the final array of alternatives is included in Table 5.3. The direct and secondary RED impacts are measured in output, jobs, labor income, and gross regional product and are summarized in Appendix E: Economic Analysis.

5.3.3 Environmental Quality (EQ)

Wetland information and GIS data were collected from various sources for identification of wetland areas within the study areas. U.S Geological Survey (USGS) topographic quadrangles, U.S. Department of Agriculture (USDA) web soil surveys, FEMA floodplain mapping, and USFWS National Wetland Inventory (NWI) were used to access SAV, and soil types. Historical resources, archeological sites, EJ community, and aesthetics were examined in the classification of alternatives. The environmental quality (EQ) account used qualitative assessment consistent with ecosystem environmental compliance guidance to assesses the impact of floodwall and nonstructural measures in the study area. The EQ impacts were similar for Alternatives 4-7, with no significant environmental impacts identified. Primary environmental concerns area related to minor impacts resulting from minor and temporary increases in air quality emissions and noise during construction. Potential direct, long-term, minor, and adverse impacts to the Chesapeake Bay Critical Area were identified under Alternatives 4-7. More information on the EQ analysis is included in Section 4 and impacts are summarized in Table 4-1 of this IFR/EA.

5.3.4 Other Social Effects (OSE)

5.3.4.1 Life Loss

To identify risk to life safety, each alterative was evaluated for potential life loss calculations. G2CRM is capable of modeling life loss using a simplified life loss methodology (Appendix E: Economics Analysis). Since there is uncertainty in modeling life loss, the FWOP project condition was modeled to serve as a baseline. Therefore, when compared to the FWP condition, any addition or reduction of life loss from the baseline would serve as a proxy in identifying impacts to life safety the alternatives might have.

As part of the OSE analysis, it was important to learn the risk to the individuals impacted during a flood event. In addition, vulnerable populations such as the elderly were considered. Therefore, during the G2CRM modeling the vertical evacuation (i.e., ability to reach higher ground via stairs, ladder, etc.) of vulnerable groups was considered. Life loss calculations are separated out by two ages. One category is people under 65 years and the second category is people over 65. As discussed in Section 2.6.2, there are three possible lethality functions for structure residents: safe, compromised, and chance. Safe would have the lowest expected life loss, although safe does not imply that there is no potential life loss. Chance would have the highest expected life loss.

Each type of structure has an associated storm surge lethality. The surge over the foundation height is the minimum for a lethality zone (safe, compromised, chance). Surge lethality is also dependent on the population age distribution as described above. Different surge heights are modeled for people over 65 years of age than for those under 65 years of age.

The model cycles through every active structure during each storm. For each structure, the model defaults the lethality function to safe and checks for the maximum lethality function such that the modeled area stage is greater than the sum of the first flood elevation of the structure and the lethality function's surge above the foundation. This is checked separately for under and over 65, as these two age groups can have different lethality functions depending on the age-specific surge above foundation for that occupancy type.

Uncertainty is factored in the life loss modeling. The results of the modeling should be viewed as more qualitative as opposed to a quantitative assessment of life loss even though the results are stated in numerical values. This result should be used in terms of order of magnitude compared to the baseline, No Action, or the FWOP, and when comparing between alternatives.

A population of 89,066 was modeled in the structure inventory. An annualized percent life loss of 0.0034% would occur under the future without project condition. Comparative analysis of the future with project condition resulted in a reduction of 0.001% loss of life when compared to the future without project condition. Loss of life was identified in the Inner Harbor and Alternative 7 provides life safety benefits by reducing incremental life loss.

Life loss was not found at the I-95 and I-895 tunnels or associated facilities for FWP or FWOP conditions. For the optimized nonstructural measures of Alternative 5A, life loss of 8 was identified in FWP and FWOP conditions, indicating no impact on life loss by Alternative 5A (see Appendix E).

5.3.4.2 Health and Safety

One of the measures of social well-being is the health and safety of individuals and the community. Conditions that are seen as unsafe or unhealthy create personal stress and dissatisfaction among those affected. Structural and nonstructural measures would protect the health and safety of residents from the direct impact of coastal storms by keeping flood waters away from property (structural) and by reducing future damages (nonstructural). The I-95 and I-895 tunnels are vital for transportation of goods and people in the Baltimore metropolitan area. These transportation corridors are also important for access to emergency services, recovery operations, and economic goods in the area, which improve health and safety.

Alternatives 6-7 would improve the resiliency of the MSA, which provides emergency services to communities in the area.

5.3.4.3 Social Vulnerability and Resilience

The final array of alternatives improves community resiliency by proposing measures to reduce coastal flood risk. Alternatives 4-7 would improve the resiliency of the I-95 and I-895 tunnels. As discussed in Section 2.4.6 of this IFR/EA, the I-95 and I-895 tunnels are vital transportation corridors for the Baltimore metropolitan area and the East coast of the US. The Baltimore Harbor Tunnel receives approximately 27.6 million vehicles per year, while the Fort McHenry Tunnel receives about 45.4 million vehicles per year (commuting both directions) (MDTA, 2021).

5.3.4.4 Economic Vitality

The proposed structural component at I-95 and I-895 tunnels entrances and associated critical infrastructure buildings included in Alternatives 4-7, would maintain economic vitality by ensuring connectivity between communities, access to jobs, and overall transportation network. Beneficial impacts to EJ communities are anticipated under Alternatives 4-7 from maintenance of transportation corridors under I-95 and I-895. Nonstructural measures proposed under Alternative 5A would improve the economic resiliency of businesses in the Inner Harbor, Canton, and Locust Point areas by allowing business to reopen with minimal disruption.

5.3.4.5 Community Identity

Community identity is the sense of self of the community, distinguished from other groups by values, beliefs, norms, and culture. Visual and physical access to the Baltimore Harbor is part of the identity of many communities along the water, particularly the Fells Point and Canton neighborhoods.

Alternatives 4, 5 and 5A would maintain historical character and cultural identity by maintaining physical and visual access to the water. Nonstructural floodproofing measures proposed would maintain historical characteristic/façade of structures and would maintain the neighborhood character by maintaining aesthetics and access to the Baltimore Harbor. Nonstructural measures proposed would not include displacement of communities or people.

Alternative 7 would negatively impact the neighborhood historical character and aesthetics through proposed floodwalls along the shoreline, which would block views and physical access to the Baltimore Harbor.

5.3.5 Summary of the Four Accounts Evaluation

Table 5-2 shows the four accounts evaluation. Since the alternative plans add on to each other, some of the benefits and impacts are the same for each. Those highlighted in green have the highest benefit under that account. For EQ, the impacts are similar across all alternatives. The NED Plan is identified as Alternative 5A – Critical Infrastructure Plan with Select Nonstructural Measures, which reasonably maximizes net benefits across all categories, while maintaining historic neighborhood character, access to water, and improving community resiliency. While Alternative 7 – Mid Tier Plan has higher RED benefits resulting from the higher total investment associated with that Plan, it has a BCR below parity and negative net benefits. Although Alternative 7 provides life safety benefits, it yields negative net NED benefits and would negatively impact neighborhood character, recreation and aesthetics through proposed floodwalls along the shoreline.

Under the FWOP conditions, social vulnerability, health and safety, community resilience and economic vitality would be negatively impacted from due to coastal flood impacts. The EQ benefits/impacts from the No Action/FWOP condition are presented in Table 4-1.

There are EJ communities present in the study area but that are not impacted by flooding. These are the Fairfield/Curtis, Brooklyn, Cherry Hill, and Westport neighborhoods. These are elevated or are not directly impacted by coastal flooding; however, transportation could be impacted due to coastal flooding. The Recommended Plan would maintain access to critical transportation corridors through the tunnels for these EJ communities.

Table 5-2. Four Accounts Evaluation Summary

PLAN SUMMARY		FWOP	Alt 4*	Alt 5*	Alt 5A**	Alt 6*	Alt 7*
Description		No Action	Critical Infrastructure	Critical Infrastructure with NS Plan	Critical Infrastructure with Select NS Plan	Critical Balanced	Mid-Tier
Total Project Costs*		0	$58.2M-$65.2M	$117.2M-$460.6M	$191.5M	$211.5M-$494.9M	$568.9M-$575.9M
Net Benefits		Negative net benefits	High net benefits, low community resilience.	High net benefits at 5% AEP while maintaining historic neighborhood character, access to water, and community resilience.	Maximizes net benefits while maintaining historic neighborhood character, access to water, and community resilience.	Lower net benefits with negative benefits at Seagirt Marine Terminal. Similar EQ and OSE benefits to Alt 5.	Negative net benefits. Detrimental community and visual impacts.
National Economic Development (NED)*	**Net Benefits**	0	$124.0M-$129.5M	$-171.5M-$71.0M	$2.4B	$-203.0M-$39.6M	$-261.4M-$-256.0M
	BCR	0	2.8-3.1	0.6-1.4	12.5	0.6-1.2	0.6
Regional Economic Development (RED)*	**Local-US Jobs**	0	900-997	2,354-5,943	1,678	3,813-7,402	9,729-9,641
	Local-US Outputs	0	$159.1M-$185.7M	$438.1M-$1,106.2M	$250.9M	$709.8M-$1,377.9M	$1,811.2M-$1,794.7M
	Employment Income	0	$81.9M-$95.6M	$292.5M-$738.5M	$135.6M	$365.5M-$709.6M	$932.8-$924.3M
Environmental Quality (EQ)		▲No significant impacts	▲ No significant impacts. Minor critical area buffer impacts (Does not vary across alternatives).				
Social Vulnerability and Resilience		▲Social vulnerability ▼Economic and community resilience	▲Improves community resiliency	▲Maintains historical character and cultural identity through visual and physical access to Baltimore Harbor. ▲Improves community resiliency			▲Improves resiliency ▼Long term negative impacts to aesthetics and visual and physical access to Baltimore Harbor.
Economic Vitality		▼economic vitality from vulnerable critical infrastructure and commercial and industrial properties	▲ Ensures connectivity between communities and access to jobs.				▼May have a long-term negative impacts to waterfront businesses from reduced physical and visual access to Baltimore Harbor from floodwalls.

*Range in costs and outputs under Alternatives 4, 5, 6, and 7 represent values for the different AEPs evaluated under each alternative. Alternative 5A costs and outputs do not include a range in values because the alternative includes only the MA MAs/AEPs that yielded the highest net benefits. Fiscal year 2022 discount rate of 2.25 percent (October 2021 price level). **Only Alt. 5A economic numbers and costs updated at Fiscal Year 2024 discount rate of 2.75 percent (October 2023 price level).

5.4 Plan Selection

As detailed in Section 3.7.1, the final array of alternatives addresses the study objectives to reduce coastal storm risk and reduce damages and impacts from coastal inundation to people and critical infrastructure assets. All five action plans meet the P&G screening criteria and are complete, efficient, cost effective, and acceptable.

All six alternatives in the final array of alternatives, including the no action plan, were compared using the four accounts criteria. The no action plan provided a basis for comparing the final array of alternative and represents that no federal CSRM action would be taken as part of this feasibility study effort. The NED Plan was identified as Alternative 5A – Critical Infrastructure Plan with Select Nonstructural Measures, which is also the maximum total net benefits plan, maximizing benefits across three of the four accounts (NED, EQ, OSE). It is noted that Alternative 7 has higher RED benefits, but also has a BCR below parity and negative net benefits and, therefore, is not selected for further evaluation. Additionally, the road elevation proposed at MSA was found to not be feasible and may induce flooding in nearby residential areas. Alternative 5A – Critical Infrastructure Plan with Select Nonstructural Measures was selected as the Recommended Plan at the ADM.

5.5 Nonstructural Plan Optimization

The G2CRM modeling and analysis of the non-structural measures leading to the TSP milestone relied on MAs developed for structural alternatives. The benefits presented at the TSP Milestone showed that only two MAs yielded positive net benefits. Following the selection of the Alternative 5A as the Recommended Plan at the ADM, the PDT re-defined the MAs and limited the study area with a refined clustering approach to optimize the nonstructural plan. This analysis was focused on the Recommended Plan (Alternative 5A) with the goal of re-defining the MAs used in the final array of alternatives evaluations that focused on structural solutions. The re-defining of the MAs allowed for a more targeted analysis of the nonstructural measures in the Recommended Plan. Figure 5-1 shows the limited study area map used in the Recommended Plan re-analysis. This reanalysis also evaluated the MAs for the I-95 and I-895 tunnel areas. Figure 5-2 shows the study area map MAs for the final array of alternatives analysis (top map).

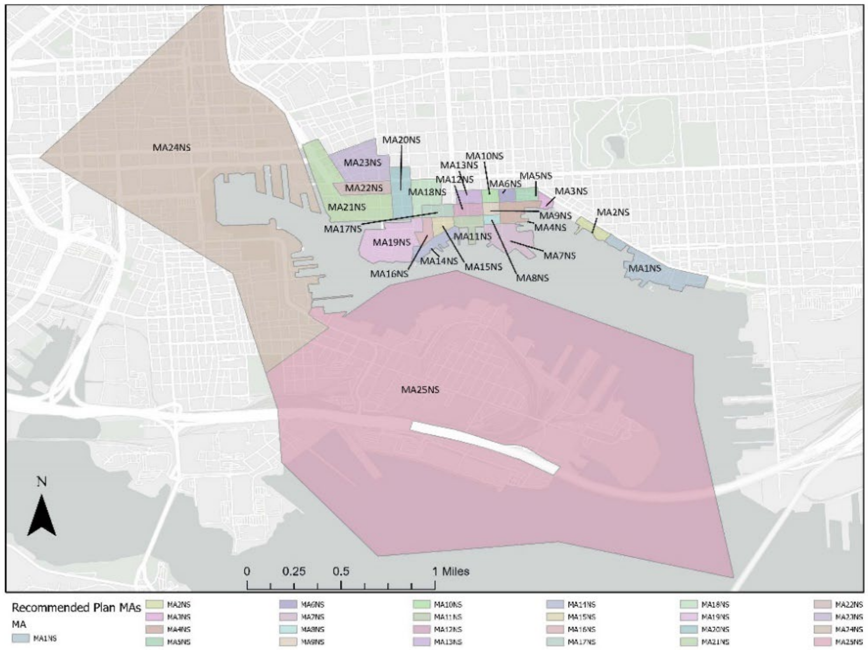

Figure 5-1. Limited Study Area Map Used in the Recommended Plan Re-analysis

As part of the re-defining of the MAs for the Recommended Plan analysis, neighborhoods in which there are a large number of potentially vulnerable structures were further subdivided to cluster similar structure types within contiguous blocks. These neighborhoods included Harbor East, Little Italy, Harbor Point, Fells Point, and Canton. Fells Point has the densest concentration of structures at risk and the neighborhood was subdivided so that, generally, structures associated with industrial properties are clustered together, rowhouses that house commercial businesses are clustered together, and residential rowhouses in contiguous blocks are clustered together. Several model areas were also combined because there were few potentially vulnerable structures within each model area. Properties were categorized into three structure types: commercial, industrial and residential.

The structural inventory used was refined throughout the study process as additional information was gathered and evaluated. After the ADM, the structural inventory was further refined to remove residential structures from analysis for floodproofing applications due to safety and structural concerns, following emerging recommendations from the USACE Nonstructural Summit held in July 2023. Therefore, only commercial and industrial properties were analyzed for inclusion in the Recommended Plan.

Each optimized MA was analyzed within the 1 percent AEP (100YR), 2 percent AEP (50YR), and 5 percent AEP (20YR) flood frequencies. The G2CRM model was re-run with the updated MAs using the refined clustering approach.

The PDT identified typical floodproofing measures that would be applied to structures identified within the study area (commercial and industrial structures). Costs were developed based on estimates of these typical floodproofing measures.

Typical floodproofing measures used for costs estimating and analysis included:

- Commercial:
    - Dry floodproofing:
        - Floodproof doors
        - Stoplog closures
        - Interior skimmer pumps
        - Relocation of electrical systems
        - Backflow preventers
- Industrial:
    - Dry floodproofing of interior office area
        - Floodproof doors
        - Interior skimmer pumps
        - Backflow preventers
    - Wet floodproofing open area
        - Flood louvers
    - Elevate exterior mechanical and electrical systems

The PDT used these updated floodproofing costs and the result of the economic modeling analysis of the Recommended Plan, to identify the MAs/clusters that yielded positive net benefits. The updated economic evaluation identified 109 commercial and industrial structures that have a positive BCR and yielded the highest net benefits. Additional information on methodology can be found in Appendix E: Economic Analysis. Figure 5-2 provides an overview of the nonstructural plan optimization process.

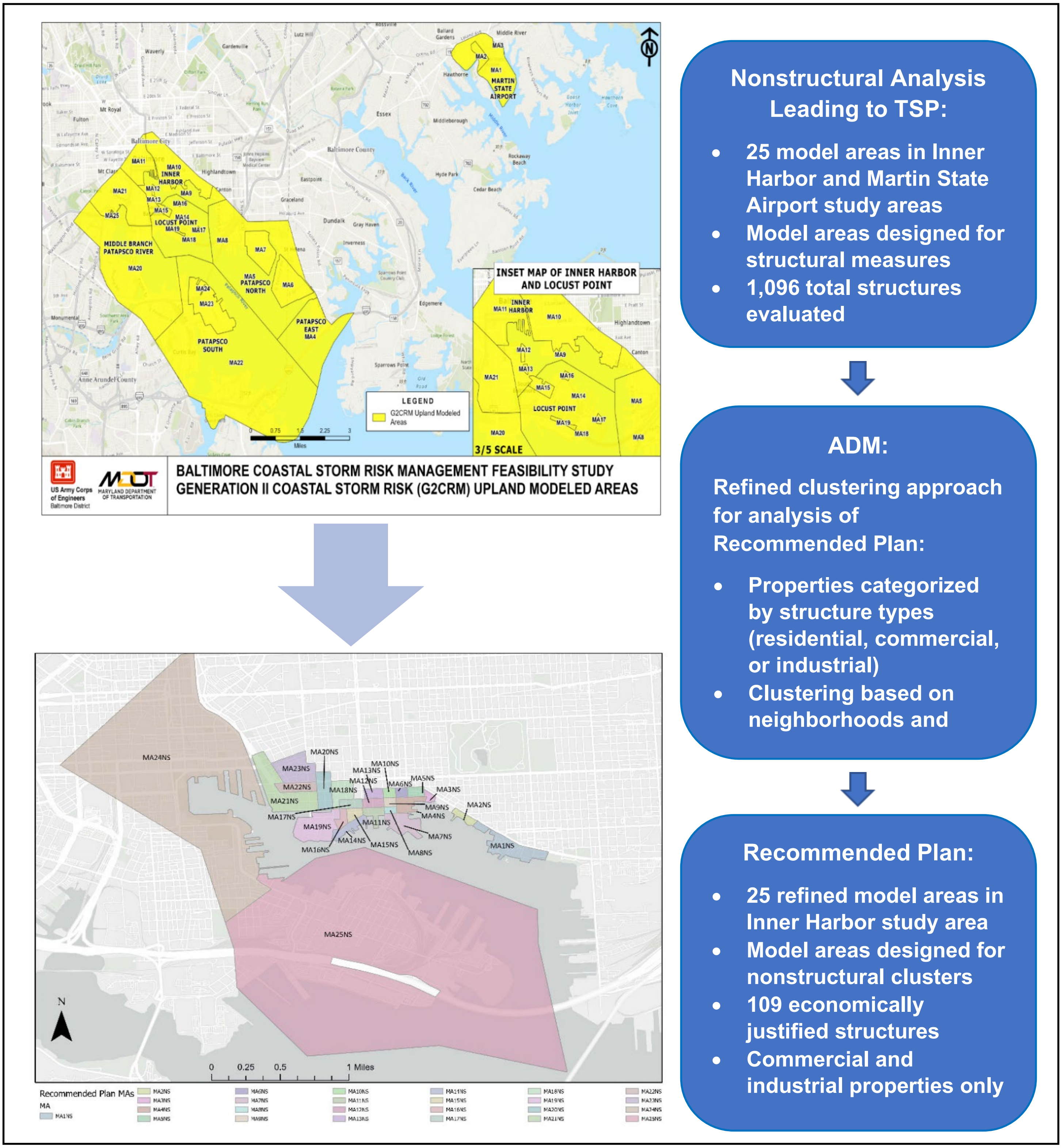

Figure 5-2. Overview of the Nonstructural Plan Optimization.

5.6 G2CRM Modeling Input Errors

During the internal agency reviews of this final IFR/EA, a discrepancy in the computed frequency curves between Coastal Hazards System (CHS) data and G2CRM output was discovered. The discrepancy in the frequency curve was partially due to extra-tropical storm inputs missing in the G2CRM modeling efforts. There are differences in methodology on how G2CRM computes frequency curves and how CHS computes frequency curves for the NACCS data, which also contributed toward the discrepancies. The frequency curve discrepancies resulted in modeling outputs with lower projected storm surge elevations than that of CHS data and underestimated damages computations. The discrepancy was addressed by adding the extra-tropical storms data to the modeling inputs and by adjusting the vertical conversion from Mean Lower Low Water (MLLW) to Mean Sea Level (MSL) from –0.81 to 0.37 in file metadata to account for the differences in methodology.

This correction to modeling inputs did not require changes in the re-defined MA mapping or the structural inventory evaluated in G2CRM in the Recommended Plan analysis discussed in Section 5.5. The change in the input water levels in G2CRM impacted the evaluation in G2CRM and the extent of damages provided by the model output, but there were no impacts to the inundation mapping.

Following correction of the model inputs, G2CRM was re-run. However, due to time and funding limitations, the model was re-run only on the limited study area re-defined for the Recommended Plan analysis. Therefore, only the Recommended Plan was re-analyzed and not the entire study area or other measures in the final array of alternatives. As a result of these errors, our Recommended Plan was compared to FWOP economic conditions only within this limited study area (Figure 5-1).

This feasibility study is an interim response to the study authority. Since only the Recommended Plan was re-analyzed following discovery of the modeling input issues, it should be noted that there is an opportunity for general reanalysis within the greater study area. Since re-analysis was not able to be completed on other measures of the final array of alternatives, these were not adequately evaluated and should be re-analyzed within the greater study area. Any re-analysis of the greater study area within the scope of this feasibility study would have required additional time and funding and would have delayed the implementation of the actionable items that are part of the Recommended Plan.

5.7 Update to the Recommended Plan

For the Alternative 5A nonstructural features, the project cost was developed at a Class 5 level of technical information and design reflecting approximately a 10 percent level of project definition. The cost estimates for the nonstructural features were completed at a parametric level and to obtain Class 3 level designs for the nonstructural features, site specific assessments would need to be conducted for each of the structures. However, site specific assessments were not able to be completed during the feasibility phase. Due to these factors which result in high-cost contingencies and uncertainty, the nonstructural measures have been removed from the Recommended Plan. Therefore, the final Recommended Plan only includes the structural features of Alternative 5A, which proposes floodwalls and closure structures at the I-95 and I-895 Tunnels and supporting infrastructure (Fort McHenry and Harbor Tunnels). The nonstructural plan may be further analyzed and implemented locally, through separate agencies or grant programs, or through future USACE studies.

This Recommended Plan (Alternative 5A-structure features only) reasonably maximizes net benefits while improving community and critical infrastructure resilience. The Recommended Plan has net annual benefits of $61.4 million and a benefit-to-cost ratio (BCR) of 20.9, based on fiscal year 2024 discount rate of 2.75 percent (October 2023 price level). The estimated total project first cost for the Recommended Plan is $77.5 million at a Class 3 level of technical information and design reflecting approximately a 10 percent level of project definition. The total project first cost includes a contingency value of $21.8 million, which is approximately 39 percent of the estimated base project cost of $55.7 million. The cost contingencies reflect an 80 percent confidence level in estimated total project first cost and are intended to cover cost and schedule increase due to the identified project risks and their probability of occurrence. The total cost for the Recommended Plan is approximately $83.5 million. The total cost includes project first cost, interest during construction (IDC), and O&M costs.

6 RECOMMENDED PLAN

The Recommended Plan is the structural features only plan of Alternative 5A, which incorporates floodwalls and closure structures at the I-95 and I-895 Tunnels and supporting infrastructure (Fort McHenry and Harbor Tunnels). Figure 6-1 shows the location of the proposed structural measures. Table 6-1 shows the economic summary of the Recommended Plan.

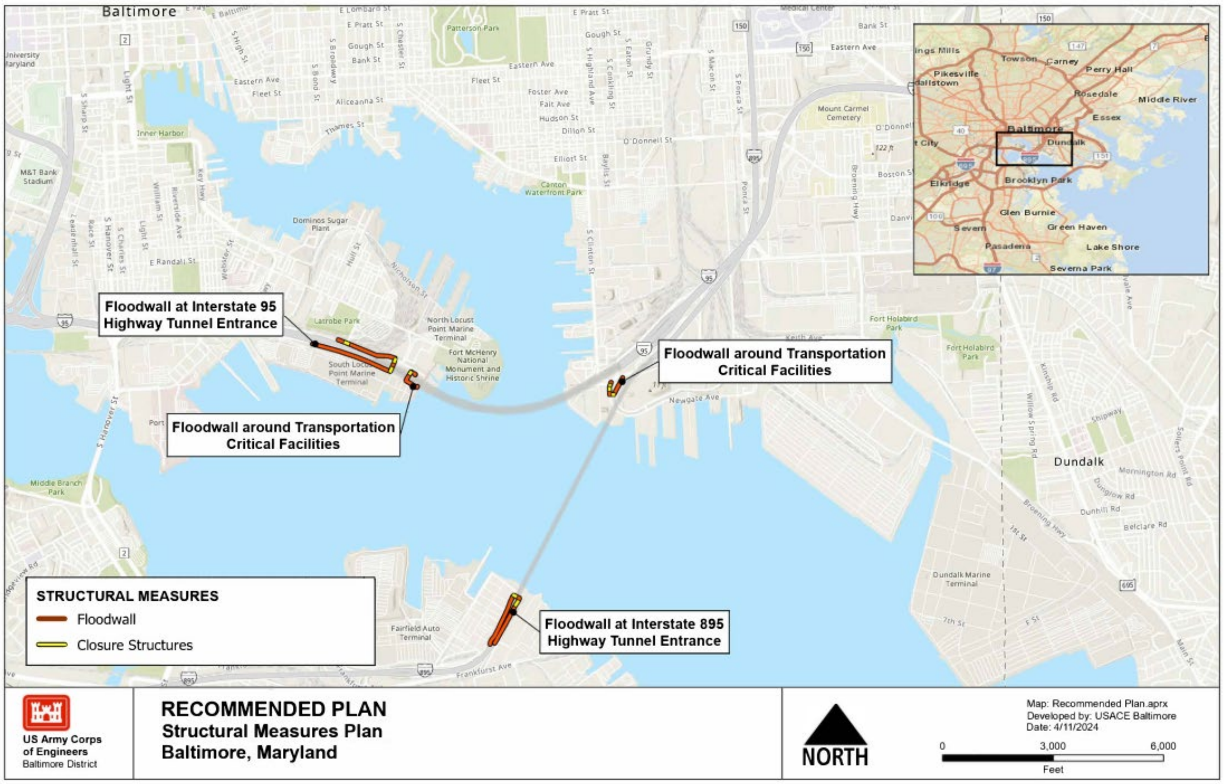

Figure 6-1. Recommended Plan – Alternative 5A Structural Features Only

Table 6-1. Economic Summary of the Recommended Plan

Economic Summary*	
First Cost	$77.5 M
IDC	$871,000
O&M	$5.1M
Total Cost**	$83.5 M
Total Net Annual Benefits	$61.4 M
BCR	20.9

* Based on fiscal year 2024 discount rate of 2.75 percent (October 2023 price level)
***Total cost includes first cost, IDC and O&M.*

6.1 Plan Accomplishments*

The coastal storm events in the past century that have impacted the Baltimore area left many images and memories of flooded streets, houses, and damage to infrastructure. Baltimore has been resilient, clearing debris and repairing damaged structures. However, the efforts taken to prepare and recover from storms, and the disruption on peoples' lives and livelihoods have been significant. Those impacts are forecast to continue and increase in the future with SLC and changing climate conditions.

The Recommended Plan has been formulated to reduce economic damages, reduce disruption to critical infrastructure, improve the resilience of critical infrastructure, and reduce risk to human health and safety. In turn, these objectives contribute to community resilience and health in the face of changing conditions.

I-95 and I-895 are heavily utilized travel corridors in the Baltimore Metropolitan area and serve a critical role in the efficient transportation of goods, people, and services along the eastern seaboard of the United States. I-95 is a direct link between the communities of South Baltimore and eastern Baltimore City and County, as well as an important route for people to reach job centers further afield. Similarly, I-895 provides a direct link to eastern Baltimore City and County with communities in South Baltimore separated from the rest of the city by the Middle Branch of the Patapsco River, as well as communities in northern Anne Arundel County. It also provides relief for congestion on I-95. If these transportation assets were damaged by a coastal storm, recovery is expected to be costly and time consuming. Loss of these transportation corridors could lead to disruption in emergency services, recovery operations, and nearby community recovery and resilience, in addition to the massive impact to the transportation of people and goods along the east coast of the USA.

The Recommended Plan proposes reducing the coastal flood risk to the assets of the I-95 and I-895 tunnels that are vulnerable to damage from coastal storm flooding. Modification of the tunnels' infrastructure through T-walls and closure structures would result in a rapid return to operation if the tunnels were closed during a high-water event. Transportation at these critical nodes would resume and resources that would otherwise be directed to recovery at the tunnels could be used in other critical areas. Other transportation corridors, such as I-695, the Baltimore Beltway, would receive less traffic than if the tunnels were forced to close for an extended period of time. People would continue to use the tunnels to access jobs, family, and services.

6.2 Plan Components*

Floodwalls

The floodwalls considered for the protection of the I-95 and I-895 tunnels are cast-in-place concrete T-walls. In all, the Recommended Plan includes the construction of approximately 9,559 linear feet of fixed floodwalls with 6 closure structures. Two different types of floodwalls were selected and referenced as Type 1 and Type 2. Floodwall Type 1 would be constructed around tunnel entrances while Type 2 would be constructed to protect the two tunnel ventilation buildings. Type 1 floodwall height ranges from 5.5 ft to 6.5 ft while Type 2 varies between 2.5 ft and 3.5 ft. The preliminary design results for T-wall types 1 and 2 are provided in Table 6-2 below. A typical cross section of a T-wall is shown in Figure 6-3. Closure structures in the form of roller gates would be incorporated where needed.

The design elevation is 12.5 feet NAVD88, based on the NACCS 100-year WSEL with approximately 90% confidence level and intermediate SLC curve through year 2080. The floodwall limits were based on tying into high ground at elevation 12.5 feet NAVD88.

Table 6-2. Floodwall dimensions at Transportation Facilities and Tunnel Entrances

Wall Type	Footing		Stem			Key	
	Width (ft)	Thickness (in)	Height (ft)*	Thickness at Crest (in)	Thickness at Base (in)	Depth (ft)	Thickness (in)
1	11.5	24	8.5	18	18	2	12
2	6.67	18	5.5	14	14	1.5	12

*From top of footing

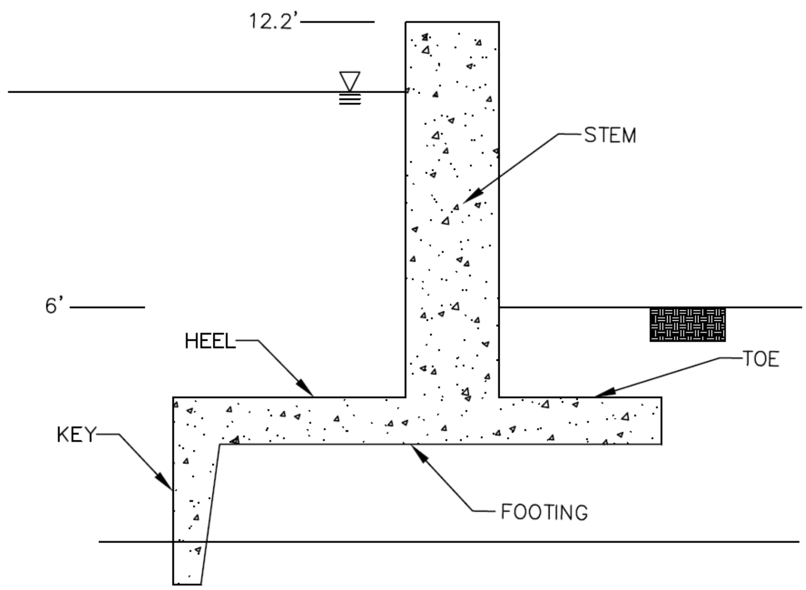

Figure 6-2. Typical Cross Section of a T-wall

The concrete T-walls were analyzed for global stability and structural strength based on the requirements established on EM 1110-2-2100 “Stability Analysis of Concrete Structures”, EM 1110-2-2502 “Retaining and Floodwalls”, ECB No. 2017-2 “Revision and

Clarification of EM 2100 and EM 2502", and EM 1110-2-2104 "Strength Design for Reinforced Concrete Hydraulic Structures".

Five different loading conditions are typically evaluated during the stability analysis in accordance with Table B-5 of EM 1110-2-2100. An additional loading condition, Design Resiliency Check, is also evaluated and includes water to the top of the wall. This case is adapted from the USACE New Orleans District Design Guidelines and applies to structures whose primary function is hurricane flood protection. The case was developed to verify the survivability of a structure during major storm events.

The controlling case for the design of the floodwalls was assumed to be the Design Resiliency Check case, water to top of wall. Additional information on the analysis can be found in Appendix A: Civil Engineering.

6.3 Cost Estimate and Cost Sharing

During project implementation (PED and construction phases), the project would be cost shared 65 percent federal and 35 percent non-federal. LERRs required for project construction must be provided by the non-federal sponsor for the non-federal construction cost share amount as described in Section 6.4. The value of the LERRs is credited toward the non-federal sponsor's 35 percent cost share. If the value of the LERRs is very large, the sponsor will only receive credit up to their 35 percent share, but they must provide a minimum of 5 percent in cash.

The non-federal sponsor for the Recommended Plan is the MDTA, which is an authority under MDOT. For construction authorization, this report will assume all costs are cost-shared with a non-federal sponsor.

The apportionment of the costs based on project first costs, including associated costs, between the federal government and the non-federal sponsor is shown on Table 6-3. Table 6-4 shows the costs based on Total Project Costs, which include fully funded Project Cost escalated to approximate midpoints for construction.

Table 6-3. Baltimore Coastal Cost Sharing- Structural Plan
(October 2023 Price Level)[1]

Item	Federal Share	Non-federal Share	Project First Cost
Structural			
Levees and Floodwalls	$32,739,000	$17,629,000	$50,368,000
Cultural Resource Survey and Preservation	$335,000	$180,000	$515,000
Preconstruction, Engineering & Design (PED)[2]	$9,522,000	$5,127,000	$14,649,000
Construction Management (S&I)[2]	$3,380,000	$1,820,000	$5,200,000
Lands, Easements, Right-of-Ways, Relocations (LERR) - Structural	$4,392,000	$2,365,000	$6,757,000
Project First Cost including LERR (65% FED/35% NFED)	$50,368,000	$27,121,000	$77,489,000
Credit to NFS for LERR – Structural		($6,757,000)	

[1]Cost is based on Project First Cost.
[2]PED and construction cost sharing totals are reflected as 65% federal/35% non-federal.

Table 6-4. Baltimore Coastal Cost Sharing Fully Funded- Structural Plan
(At Midpoint Price Levels)[1]

Item	Approximate Midpoints	Federal Share	Non-federal Share	Total Project Cost
Levees, Floodwalls, and Floodway Control	2029Q2	$37,397,000	$20,137,000	$57,534,000
Cultural Resource Survey and Preservation	2029Q2	$382,000	$206,000	$588,000
Preconstruction, Engineering & Design (PED)[2]	2026Q1	$10,332,000	$5,564,000	$15,896,000
Construction Management (S&I)[2]	2029Q2	$3,972,000	$2,139,000	$6,111,000
Lands, Easements, Right-of-Ways, Relocations (LERR) - Structural	2026Q1	$4,685,000	$2,523,000	$7,208,000
Total Project Cost[1]		$56,768,000	$30,569,000	$87,337,000
Credit to NFS for LERR – Structural			($6,757,000)	

[1]Total Project Cost is based on Fully Funded Project Cost escalated to approximate midpoints.
[2]PED and construction cost sharing totals are reflected as 65% federal/35% non-federal.

6.4 Lands, Easements, Rights-of-Way, Relocations, and Disposal

At this preliminary stage, the lands and damages real estate cost estimate is approximately $6.8 million for the structural measures. These costs include acquisition administration costs, contingency, and estimated damages for structural measures of the Recommended Plan.

The above costs include funds for the LERRs, if applicable. Incidental acquisition costs are also included and include costs for title work, appraisals, appraisal review, coordination meetings, review of documents, legal support (including but not limited to approval of the nonstandard estate and easement drafting), crediting, project close out, and other costs incidental to the acquisitions and the project.

6.5 Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

This section discusses the O&M for components of the Recommended Plan. The annualized O&M for the I-895 tunnel floodwall and associated transportation critical facility is estimated to be $130,000. The annualized O&M for the I-95 tunnel floodwall and the associated transportation critical facility floodwall is estimated to be $60,000. The concrete floodwalls bordering the tunnels and transportation critical facilities would require moderate maintenance over the 50-year period of analysis. O&M on the floodwalls, closure structures and other appurtenant features is a non-federal responsibility and would likely be managed by the MDTA.

6.5.1 General

(1) The structures and facilities constructed by the United States for local flood risk management shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

(2) The Sponsor (likely the MDTA), or other responsible local agency, which furnished assurance that it will maintain and operate flood control works in accordance with regulations prescribed by the Secretary of the Army, as required by law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the "Superintendent," who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and maintenance of all of the structures and facilities during flood periods without cost to the United States.

(3) A reserve supply of materials needed during a flood emergency shall be kept on hand at all times.

(4) No encroachment or trespass which will adversely affect the efficient operation or maintenance of the project works shall be permitted upon the rights-of-way for the protective facilities.

(5) No improvement shall be passed over, under, or through the walls, levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the works without prior determination by the District Engineer of the Department of the Army or his authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as may be found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the District Engineer or, if otherwise obtained, shall be submitted for his approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished the District Engineer after completion of the work.

(6) It shall be the duty of the superintendent to submit a semiannual report to the District Engineer covering inspection, maintenance, and operation of the protective works.

(7) The District Engineer or his authorized representatives shall have access at all times to all portions of the protective works.

(8) Maintenance measures or repairs which the District Engineer deems necessary shall be promptly taken or made.

(9) Appropriate measures shall be taken by local authorities to ensure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the Superintendent's organization during flood periods.

(10) The Department of the Army will furnish local interests with an Operation and Maintenance Manual for each completed project, or separate useful part thereof, to assist them in carrying out their obligations under this part.

6.5.2 Flood Walls

This section discusses the O&M for floodwalls.

(1) Maintenance. Periodic inspections shall be made by the Superintendent to be certain that:

> (i) No seepage, saturated areas, or sand boils are occurring;
>
> (ii) No undue settlement has occurred which affects the stability of the wall or its water tightness;
>
> (iii) No trees exist, the roots of which might extend under the wall and offer accelerated seepage paths;
>
> (iv) The concrete has not undergone cracking, chipping, or breaking to an extent which might affect the stability of the wall or its water tightness;
>
> (v) There are no encroachments upon the right-of-way which might endanger the structure or hinder its functioning in time of flood;
>
> (vi) Care is being exercised to prevent accumulation of trash and debris adjacent to walls, and to ensure that no fires are being built near them;

(vii) No bank caving conditions exist riverward of the wall which might endanger its stability;

(viii) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged.

Such inspections shall be made immediately prior to the beginning of the flood season, immediately following each major high-water period, vehicular collision, and otherwise at intervals not exceeding 90 days. Measures to eliminate encroachments and effect repairs found necessary by such inspections shall be undertaken immediately. All repairs shall be accomplished by methods acceptable in standard engineering practice.

(2) Operation. Floating plant or boats will not be allowed to lie against or tie up to the walls. Should it become necessary during a flood emergency to pass anchor cables over the wall, adequate measures shall be taken to protect the concrete and construction joints. Immediate steps shall be taken to correct any condition which endangers the stability of the wall.

6.5.3 Drainage structures

(1) Maintenance. Adequate measures shall be taken to ensure that inlet and outlet channels are kept open, and that trash, drift, or debris is not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on drainage structures shall be examined, oiled, and trial operated at least once every 90 days. Where drainage structures are provided with stop log or other emergency closures, the condition of the equipment and its housing shall be inspected regularly, and a trial installation of the emergency closure shall be made at least once each year. Periodic inspections shall be made by the Superintendent to be certain that:

(i) Pipes, gates, operating mechanism, riprap, and headwalls are in good condition;

(ii) Inlet and outlet channels are open;

(iii) Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes;

(iv) Erosion is not occurring adjacent to the structure which might endanger its water tightness or stability.

Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspections.

(2) Operation. Whenever high-water conditions impend, all gates will be inspected a short time before water reaches the invert of the pipe and any object which might prevent closure of the gate shall be removed. Automatic gates shall be closely observed until it has been ascertained that they are securely closed. Manually operated gates and valves shall be closed as necessary to prevent inflow of flood water.

6.5.4 Closure structures

(1) Maintenance. Closure structures for traffic openings shall be inspected by the Superintendent every 90 days to be certain that:

(i) No parts are missing;

(ii) Metal parts are adequately covered with paint;

(iii) All movable parts are in satisfactory working order;

(iv) Proper closure can be made promptly when necessary;

(v) Sufficient materials are on hand for the erection of sandbag closures and that the location of such materials will be readily accessible in times of emergency.

Tools and parts shall not be removed for other use. Trial erections of one or more closure structures shall be made once each year, alternating the structures chosen so that each gate will be erected at least once in each 3-year period. Trial erection of all closure structures shall be made whenever a change is made in key operating personnel. Where railroad operation makes trial erection of a closure structure infeasible, rigorous inspection and drill of operating personnel may be substituted therefor. Trial erection of sandbag closures is not required. Closure materials will be carefully checked prior to and following flood periods, and damaged or missing parts shall be repaired or replaced immediately.

(2) Operation. Erection of each movable closure shall be started in sufficient time to permit completion before flood waters reach the top of the structure sill. Information regarding the proper method of erecting each individual closure structure, together with an estimate of the time required by an experienced crew to complete its erection will be given in the Operation and Maintenance Manual which will be furnished local interests upon completion of the project. Boats or floating plant shall not be allowed to tie up to closure structures or to discharge passengers or cargo over them.

Tools and parts shall not be removed for other use. Closure structure test installations of one or more closure structures shall be made once each year, alternating the structures chosen so that each gate will be erected at least once in a 3-year period. Trial erection of all closure structures shall be made whenever a change is made in key operating personnel. Where railroad operation makes trial erection of a closure structure infeasible, rigorous inspection and drill of operating personnel may be substituted therefor. Trial erection of sandbag closures is not required. Closure materials will be carefully checked prior to and following flood periods, and damaged or missing parts shall be repaired or replaced immediately.

6.6 Project Risks and Uncertainty

Risk and uncertainty are inherent in water resources planning and design. These factors arise due to errors in measurement and from the innate variability of complex physical, social, and economic situations. The measured or estimated values of key planning and design variables are rarely known with certainty and can take on a range of possible values. Risks identified during the planning process are documented and managed through a risk register that the project team uses throughout the project life. Risk analysis in CSRM projects is a technical task of balancing risk of design exceedance with reducing the risk from flooding; trading off uncertainty of flood levels with design accommodations; and providing for reasonably predictable project performance. Risk-based analysis is therefore a methodology that enables issues of risk and uncertainty to be included in project formulation.

The USACE has a mission to manage flood risks:

"The USACE Flood Risk Management Program (FRMP) works across the agency to focus the policies, programs and expertise of USACE toward reducing overall flood risk. This includes the appropriate use and resiliency of structures such as levees and floodwalls, as well as promoting alternatives when other approaches (e.g., land acquisition, flood proofing, etc.) reduce the risk of loss of life, reduce long-term economic damages to the public and private sector, and improve the natural environment."

The PDT identified the Recommended Plan risks discussed below.

- Contaminated soils may be present in construction areas for the I-95 and I-895 tunnels. Further investigations during PED would be necessary to determine if contaminated soils are present. Per ER 1105-2-100[7], 2-13 (p) and ER 1165-2-132, investigations during PED would be cost-shared and any associated clean-up of HTRW would be the responsibility of the NFS.
- Drilling and testing will occur during the PED phase, at which time site specific data regarding soils, foundations, and contamination will be updated. This information may require modification to the design of project elements, which could increase cost, or it may necessitate changes to the alignment and location of project

[7] The Planning Guidance Notebook was updated on 7 December 2023 as ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The PDT is aware of this new guidance and consulted the draft guidance while completing the study.

elements. Different construction techniques may be required. Changes to the real estate requirements for the project may be necessitated.

- Geotechnical modeling has been deferred to the PED phase. It's likely that some areas near water will require deep foundations, which in turn require a high volume of steel to construct. Steel is a very expensive commodity with a very long delay in acquiring the material. The project schedule will likely be marginally impacted, as contractors may not be able to obtain enough steel materials prior to construction.
- Market/Bidding conditions – Typically, the range of bids is due to local market and bidding conditions, which could impact the project cost. Low bid competition can be from prequalification of bidders, the saturation of market, and labor shortages.
- Scope change – The project scope may change once design is developed with more data and analysis. Changes may include the height of walls, pump flow rates, closure gate types and/or sizes during the PED phase. The baseline cost estimate was prepared in detail to meet Class 3 estimate. Any risks above and beyond the Class 3 design maturity are captured as contingency at 80% confidence level in the Cost and Schedule Risk Analysis. See Appendix: Cost Engineering and Risk Analysis for additional details.
- Cost Escalation of key materials - If the project is pushed further and market conditions change unfavorably, real price escalation of materials may exceed the current escalation included in the estimate. If a deep foundation is required, more steel material will be needed. Currently steel is the material with the highest cost and longest lead time. Other construction materials may have similar effects with some variations.
- Hydrologic and Hydraulic (H&H) NACCS model – This is performed for existing conditions and FWOP conditions, but not for "With Project Conditions". H&H project conditions and effects on surrounding areas have not been fully analyzed or considered.
- Funding Schedule – Large studies such as this CSRM study tend to have funding delays and other external factors that can prolong the project schedule and lead to higher costs.
- Acquisitions and Easements – Easements largely follow existing rights of way, but it may still be difficult to avoid private property. Easements for private properties can be complex. For structural measures, if the property owner is not cooperative, condemnations are necessary. Condemnations are very time consuming. Railroad properties may also be impacted. Acquisition of easements on railroad properties may involve a lengthy process.
- Trails and sidewalks – Coordination and decisions on how to replace trails and sidewalks can be time consuming.
- High SLC scenarios projections could negatively impact the performance of the structural plan. Resiliency and adaptability of the Recommended Plan is discussed in Section 6.7.1 of this IFR/EA.

- Cultural Resources – surveys, determinations of NRHP eligibility, and effects assessments will be conducted during PED. If adverse effects to historic properties are identified, this could cause changes to project design if those effects cannot be mitigated through consultation. The implementation of any Historic Property Treatment Plans and associated mitigation could prolong the project schedule and lead to higher costs.

G2CRM was used to evaluate life loss and the results can be found in Section 5.2.1 above. The areas being evaluated under this study did not present substantial life threats from flooding and therefore, LifeSim was not used to compute life loss. A Life Safety Risk Assessment was completed by the Levee Safety Center and is included in Appendix A of this final IFR/EA. The purpose of the Life Safety Risk Assessment is to make sure that the feasibility level designs follow the four tolerable risk guidelines: understanding the risk, building risk awareness, fulfilling daily responsibilities, and actions to reduce risk. The life safety risk consideration was accomplished by performing a feasibility screening level potential failure mode analysis of the current Recommended Plan to identify potential failure modes that would need to be addressed as the design matures, to ensure minimal risk to the public and identify cost risks that may affect the total project cost. For more information on Geotechnical and Civil engineering considerations for design, reference Appendix A: Civil Engineering and Appendix D: Geotechnical Analysis.

6.6.1 Residual Risk

The risk that remains in the study area after the proposed coastal storm risk management project is implemented is residual risk. It includes the consequence of capacity exceedance as well as consideration of the project flood risk reduction. Hence, given the hydrological, environmental, and economic constraints, the residual risk cannot be mitigated. Three metrics; Average Annual Damages (AAD), Life Loss, and Number of Structures at risk were used to assess the residual risk as shown in below Table 6-4.

As discussed in Section 5.5, following the selection of Recommended Plan, the study area was refined to conduct a re-analysis of this plan. The total FWOP damage in the limited study area is $3.3 billion with the AAD of $123.2 million, and the life loss is 8 (Table 6-5). The total damage reduced by the intervention is $1.7 billion with the AAD of $64.5 million.

Table 6-5. Residual Risk

Average Annual Damages *Based on fiscal year 2024 discount rate of 2.75 percent (October 2023 price level). 50-year analysis*	
Future without Project	123,205,000
Less: Risk Reduction	64,481,000
Residual Risk	**58,724,000**
RR as % of FWOP	*48%*
Life Loss	
Future without Project	8
Less: Risk Reduction	0
Residual Risk	
RR as % of FWOP	*100%*
Number of Structures at Risk[1]	
Future without Project	191
Less: Risk Reduction	8
Residual Risk	**183**
RR as % of FWOP	*96%*

[1] A structure is at risk if expected inundation damage is greater than 5% of its value

The residual risk of the project is represented by the AAD remaining in the study area with the implementation of the Recommended Plan. This residual risk is $58.7 million, which represents a 48 percent of the FWOP condition or potential flood damages remaining.

The life loss statistics with high level of uncertainty at inundated structures were assessed using G2CRM. The results should be viewed as more qualitative as opposed to a quantitative assessment of life loss even though the results are stated in numerical values. Since there are not life loss benefits with respect to the Recommended Plan, the life loss residual risk remains at 100-percent for the Recommended Plan.

The last metric used to assess residual risk is the number of structures at risk of inundation damages. A structure is at risk if its expected damages are greater than 5% of its structure and contents value. The number of structures that continue to be at risk after the implementation of the Recommended Plan is 183, an equivalent of 96-percent of the total number of structures.

Since this residual risk analysis included only the limited study area of the Recommended Plan, the residual risk for the larger study area is not analyzed and may be much higher. Residual risk in the larger study area may be understated. Residual risk for the larger study area should be analyzed in any future re-analysis of the final array of alternatives.

6.7 Design and Construction

The Recommended Plan has three project areas: I-95 Fort McHenry Tunnel in the Locust Point planning unit, the I-895 Tunnel and supporting infrastructure in the Patapsco South planning unit, and the supporting infrastructure for the I-95 Tunnel in the Patapsco North planning unit. It is estimated that the construction duration at the I-95 Fort McHenry Tunnel in Locust Point, including the associated transportation critical facilities would be 42 months. Duration of construction at the I-895 Tunnel in Fairfield, including the associated transportation critical facilities would be approximately 42 months. The cost estimate assumes 8-hour days for all areas, except for the Harbor Tunnel entrance, which may require 12-hour days to avoid heavy daytime traffic. Materials would be brought in by land by flatbed trucks, trailers, and dump trucks.

The design phase assumes two years to start in October 2024 and end in September 2026. The construction window for all areas would likely start in 2027 and end in 2029. Construction would occur nearly concurrently.

6.7.1 Recommended Plan Resiliency & Adaptability

ER 1110-2-8162 titled "Incorporating Sea Level Change in Civil Works Programs," provides guidance for incorporating the direct and indirect physical effects of projected future SLC across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects. Per ER 1110-2-8162, this section evaluates the Recommended Plan for resiliency and adaptability to SLC.

The measures of the Recommended Plan (floodwalls along the southern approach of I-95 and I-895 and their associated critical infrastructure), were evaluated for performance against SLC over the 50-year period of analysis (year 2080) and beyond to the planning adaptation horizon of 100 years (years 2031-2130). The Recommended Plan design elevation of 12.5 feet NAVD88, equivalent to the 100-year or 1 percent AEP storm event, is anticipated to reduce coastal storm risk under the intermediate SLC scenario up to the year 2080 and under the low SLC scenario up to year 2130. USACE guidance requires that the PDT assess the sensitivity of the project area and recommended plan to the 3 USACE SLC curves. Although the original plan formulation has been done using the Intermediate SLC curve, the recommended plan was evaluated under the high SLC curve and both risk and future adaptation are documented in this IFR/EA and Appendix B. The recommended plan design accounts for 1.55ft of relative sea level rise. If actual SLC trend follows High curve, then the Recommended Plan is not expected to perform to year 2080. If the trend follows "High SLC" scenario then the Recommended Plan would perform to year 2062, and the project may start failing to function as designed past the year 2062. Additional information on sensitivity analysis of the Recommended Plan to SLC can be found in Appendix B: Hydrology and Hydraulic Analysis.

The floodwall measures at the I-95 and I-895 tunnel entrances can be adapted to increase coastal resiliency over the planning adaptation horizon of 100 years by designing to the 0.5 percent AEP or 200-year storm event level of performance, which could also yield maximum net benefits (Figure 6-3 & 6-4). However, designing to the 200-year storm event level of performance would likely result in significant real estate challenges. Accommodating a wider floodwall foundation and tying into a higher elevation may not be feasible without extensive changes to adjacent roadways (such as McComas Road) and railroads around the tunnel entrances. McComas Street is a roadway surrounding the I-95 tunnel entrance providing access to the adjacent Port of Baltimore-Cruise Maryland, Locust Point Marine Terminal, and MDTA facilities. A wider floodwall foundation would likely require realignment of McComas Street, which would result in impacts to adjacent railways and properties and disruption of this thoroughfare. If the costs increased significantly due to acquiring additional LERRs or a deeper and/or wider floodwall foundation, the plan may no longer be justified by positive net-benefits. There would also likely be a high risk of impact to the schedule from the additional time needed to acquire easements for railroad and private lands affected. It is estimated that any acquisition involving a railroad would take two years and this does not include the condemnation process, should that be necessary.

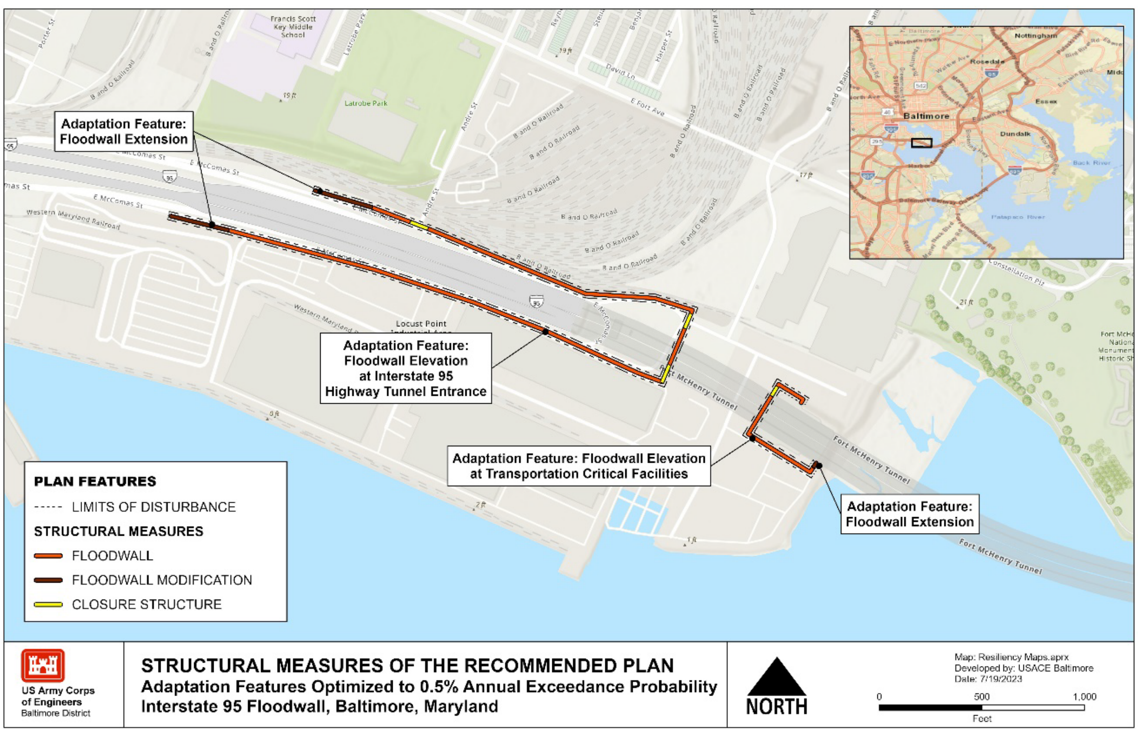

Figure 6-3. Structural Measures of the Recommended Plan at the I-95 Tunnel Optimized to 0.5% AEP

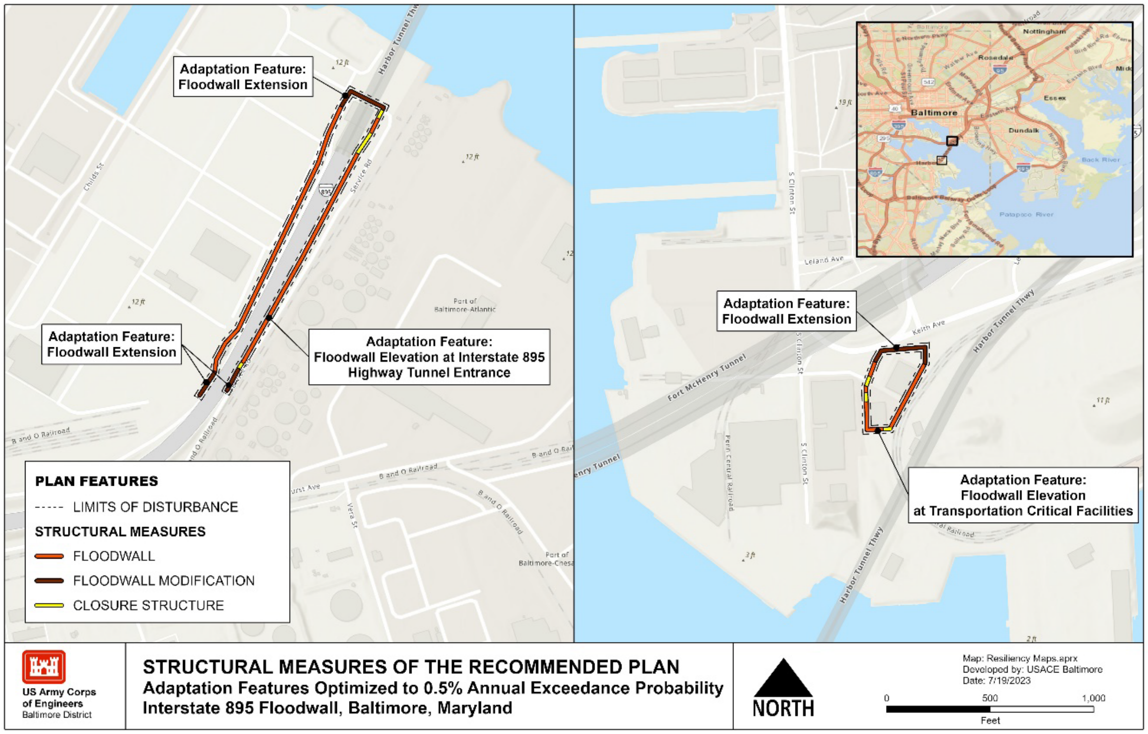

Figure 6-4. Structural Measures of the Recommended Plan at the I-895 Tunnel Optimized to 0.5% AEP

6.8 Environmental Commitments*

- Sediment and erosion controls would be used to minimize impacts to wetlands and waterways.
- Noise reduction techniques would include installing sound-muffling devices available from the equipment manufacturer and limiting engine idling time. To ensure operational maintenance noises do not become a nuisance, equipment would be maintained in good working order and would only be operated during daylight working hours.
- Contaminated soils may be present construction areas for the I-95 and I-895 tunnels. Numerous sites were identified for HTRW concern within the search radius used to identify such sites in the study area. Further investigations will be necessary to determine if contaminated soils are present. These investigations would be conducted during PED phase.
- As of February 2024, CENAB has resubmitted information for the Northern Long-Eared Bat required in the USFWS Northeast Endangered Species Determination Key. USACE has received concurrence from the USFWS IPaC that no adverse impacts will occur to Northern Long-Eared Bat. USACE will continue to address potential impacts to the Northern Long-Eared Bat or Federal Actions that May Affect Northern Long-Eared Bats into the USFWS IPaC prior to construction.

- A Critical Area Buffer Management Plan/Landscape plan would be completed during the PED phase and submitted to the Critical Area Commission for potential impacts to the Critical Area 100-foot Buffer.
- Due to the timing of the Project, CENAB is unable to fully identify and evaluate cultural resources and determine effects of the Recommended Plan on historic properties prior to completion of the environmental assessment. Therefore, pursuant to 54 U.S.C. 306108 and 36 CFR 800.14(b)(1)(ii), CENAB is deferring final identification and evaluation of historic properties until PED when additional funds become available, and prior to construction by executing a PA. The PA stipulates cultural resource investigations to be conducted during the PED phase and is developed with the MD SHPO and other consulting parties. The PA includes nonstructural measures from the previously evaluated Recommended Plan; however, the updated Recommended Plan only includes structural measures. The PA is included in Appendix G.

6.9 Cumulative Effects*

The Recommended Plan is not expected to result in significant direct, indirect, or cumulative effects. Conversely, the Recommended Plan would provide coastal resiliency and reduce risk to critical infrastructure. The Plan would be in-line with other coastal resilience measures taking place near the study area, including projects such as Reimagine Middle Branch and the climate resiliency roadmap for Turner Station. Construction of the Recommended Plan along with other construction activities in the area may cumulatively result in a temporary increase in noise and local fuel usage due to an increased activity of construction vehicles. Table 6-6 below describes the cumulative effects on each resource topic.

Table 6-6. Summary of Cumulative Effects on Resource Topics

Resource Topic	Cumulative Effect
Wetlands	No cumulative impacts are anticipated.
Wildlife (Threatened and Endangered Species, at risk species, migratory birds)	No cumulative impacts are anticipated.
Land Use	No cumulative impacts are anticipated.
Geology, Physiography, and Soils	No cumulative impacts are anticipated.
Water Quality	No cumulative impacts are anticipated.
Floodplains	No cumulative impacts are anticipated.

Resource Topic	Cumulative Effect
Hazard, Toxic and Radioactive Waste (HTRW)	Contamination may be present in the proposed construction areas. However, the Recommended Plan would not introduce new HTRW during construction.
Transportation and Navigation	Temporary cumulative impacts may result in increased, local fuel usage due to an increase in construction vehicles. Long-term cumulative impacts are expected to be positive as the Recommended Plan will allow for sustained access through the Ft. McHenry and Baltimore Harbor Tunnels in the event of increased flooding.
Noise	Construction noise along with other industrialized noises (road traffic, freight trucks, heavy equipment usage) in these areas would result in a temporary cumulative effect during construction.
Air Quality/Greenhouse Gas Emissions	Air emissions will be below de minimis air quality standards and would not have a cumulative effect on air quality in the region.
Coastal Zone Management Program	No cumulative impacts are anticipated.
Chesapeake Bay Critical Area	Mitigation in the form of tree/vegetation replanting will occur in areas impacting the Chesapeake Bay Critical Area. The goal of the replanting is to ensure any new impervious development within the Critical Area is mitigated for appropriately and to be consistent with water quality standards. Mitigation may take form of replanting in the specific area of disturbance if applicable or paying a fee into a mitigation bank within the affected watershed. Mitigation and development will be consistent with IDA's within the Critical Area.
Climate Change and Sea Level Rise	Long-term cumulative impacts are expected to be positive as the Recommended Plan is anticipated to protect human health and safety in anticipation of climate change and sea level rise through the life of the project.

Resource Topic	Cumulative Effect
Cultural Resources	Cumulative impacts to cultural resources are not anticipated. A PA to conduct archaeological and architectural investigations during the PED has been developed with consulting parties. The final, signed PA is included in Appendix G.
Socioeconomics	Positive, indirect benefits are anticipated to socioeconomics as the implementation of the Recommended Plan will keep I-95 and I-895 accessible during potential flooding events.
Environmental Justice	No cumulative impacts are anticipated.
Recreation	No cumulative impacts are anticipated.
Visual Aesthetics	No cumulative impacts are anticipated.
Utilities	No cumulative impacts are anticipated.

6.10 Environmental Operating Principles (EOP)*

The USACE Environmental Operating Principles (EOP) were developed to ensure that USACE missions integrate sustainable environmental practices. The EOP relates to the human environment and applies to all aspects of business and operations. The principles were designed to provide direction on how to better achieve stewardship of air, water, and land resources, and to demonstrate a positive relationship between management of these resources and the protection and improvement of a sustainable environment. The EOP informed the plan formulation process and are integrated into the proposed solution for CSRM.

The EOP:

- Foster sustainability as a way of life throughout the organization,
- Proactively consider environmental consequences of all USACE activities and act accordingly,
- Create mutually supporting economic and environmentally sustainable solutions,
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the USACE, which may impact human and natural environments,
- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs,
- Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE's actions in a collaborative manner,

- Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

Plan selection considered these principles to ensure the sustainability and resiliency of the NED plan while considering the environmental consequences of implementation. In addition to construction BMPs to maintain water quality standards, other opportunities to implement sustainable measures that are cost effective and comply with USACE construction standards will be further evaluated during the PED phase. The study team considered avoiding and minimizing adverse impacts to existing environmental resources and cultural resources within the project area to the extent practicable during the plan formulation process.

6.11 Views of the Non-Federal Sponsor

The non-federal sponsor for the Baltimore Coastal Study is MDOT. CENAB has been in continuous coordination with MDOT while carrying out the feasibility study and MDOT supports the Recommended Plan.

The non-federal sponsor during the PED and construction phases would be MDTA. A Letter of Intent to participate and in support of the Recommended Plan has been received from MDTA.

6.12 Implementation Schedule

This IFR/EA will culminate in a proposed Chief's Report in 2024. A Chief's Report, the Report of the USACE Chief of Engineers, is developed when a water resources project would require Congressional authorization or a change to existing project authorization. After the final feasibility report is submitted to Headquarters USACE, a Chief's Report is developed.

After the Chief's Report is signed, the project could enter the PED phase, pending funding and execution of a Design Agreement. The PED phase is anticipated to take two years and is assumed to start in October 2024 and last through September 2026. If Congressional authorization for the project and budget appropriations are made, construction of the structural measures along the I-895 and I-95 tunnel entrances and their support facilities would likely begin October 2027 and end in 2029.

7 ENVIRONMENTAL COMPLIANCE*

7.1 Environmental Compliance Table

Compliance with environmental laws and EOs is required for the project alternatives under consideration. Tables 7-1 and 7-2 lists the current compliance status for each environmental and cultural requirement that was identified and considered for the study.

Table 7-1. Status of Compliance with Applicable Environmental and Cultural Resource Laws

LAWS	COMPLIANCE STATUS
Archeological and Historic Preservation Act of 1974	Full
Bald and Golden Eagle Protection Act of 1962, as amended	Full
Chesapeake Bay Critical Area Act (1984) and its Criteria (1986)	Full
Clean Air Act of 1970, as amended 1977 and 1990	Full
Clean Water Act of 1972, as amended	N/A
Coastal Barrier Resources Act of 1982	N/A
Coastal Zone Management Act of 1972, as amended	Full
Comprehensive Environmental Response, Compensation and Liability Act of 1980	In Progress
Endangered Species Act of 1973	Full
Farmland Protection Policy Act	N/A
Fish and Wildlife Coordination Act of 1958, as amended	Full
Magnuson-Stevens Fishery Conservation and Management Act	Full
Marine Mammal Protection Act of 1972, as amended	N/A
National Environmental Policy Act of 1969, as amended	In Progress
National Historic Preservation Act of 1966	Full
Noise Control Act of 1972, as amended	Full
Resource Conservation and Recovery Act of 1976	In Progress
Rivers and Harbors Act of 1899	N/A
Wild and Scenic Rivers Act of 1968	N/A

Table 7-2. Status of Compliance with Applicable Executive Orders

EXECUTIVE ORDERS	COMPLIANCE STATUS
Protection and Enhancement of Environmental Quality (E.O. 11514/11991)	Full
Protection and Enhancement of Cultural Environment (E.O. 11593)	Full
Floodplain Management (E.O. 11988)	Full
Protection of Wetlands (E.O. 11990)	Full
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)	Full
Protection of Children from Health Risks and Safety Risks (E.O. 13045)	Full
Chesapeake Bay Protection and Restoration (E.O. 13508)	Full
Invasive Species (E.O. 13112)	Any disturbed lawn or other landscaped pervious areas will be re-seeded or be planted closely following disturbance with native or non-invasive plants to avoid infill with invasive plants.
Consultation and Coordination with Indian Tribal Governments (E.O. 13175)	Full
Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)	Full

7.2 National Environmental Policy Act

This document follows the 1978 NEPA implementing regulations (40 CFR Parts 1500-1508). NEPA regulations provide for a scoping process to identify the scope and significance of environmental issues associated with a project. The process identifies and eliminates from further detailed study issues that are not significant. CENAB used this process to comply with NEPA, and it was determined that an EA was the appropriate NEPA document to prepare for this project.

The draft IFR/EA was available for public and agency review July 01, 2022, to August 19, 2022. Public meetings were held following release of draft IFR/EA in person on August 01, 2022, and virtually on August 02, 2022.

Upon completion of the final IFR/EA and the signing of the Finding of No Significant Impact (FONSI), the project will be in full compliance with NEPA. The FONSI is provided in Appendix G. Agency, Tribal and Public coordination can be found in Appendix H.

7.3 Chesapeake Bay Critical Area Act

Construction of a proposed floodwall around the perimeter of the Fort McHenry West Ventilation Building is expected to have minor impacts to the Chesapeake Bay Critical Area 100-foot Buffer. A Critical Area Buffer Management Plan and/or Landscape Plan will be developed to mitigate the impacts during the PED phase.

7.4 Clean Water Act & Wetlands

A Section 401 Water Quality Certification (WQC) is not required from MDE as no in-water work will take place during the life of the project and no waters of the U.S. exist within the extents of the Recommended Plan. Section 404 of the Clean Water Act (CWA) and the 404(b)(1) Guidelines at 40 CFR Part 230 require that USACE avoid, minimize, and mitigate impacts to wetlands. Please see Appendix G for correspondence from MDE. Construction of a proposed floodwall around the Fort McHenry West Ventilation Building would be located adjacent to a tidal wetland but would have no direct or indirect impacts to the wetland; therefore, a CWA permit is not required for this undertaking. Please see Appendix H for correspondence from MDE.

7.5 Federal Coastal Zone Management Act

A federal consistency determination in accordance with 15 CFR Part 930 Subpart C was approved by MDE in March 2023, stating that the Recommended Plan is consistent with the enforceable policies of the State of Maryland's federally approved coastal management program (Appendix G).

7.6 Clean Air Act

An Air Conformity Assessment was prepared and can be found in Appendix G. The actions associated with the Recommended Plan are exempt from the General Conformity Rules in Section 176c of the Clean Air Act. Ozone precursors, VOCs and oxides of nitrogen (NOx) are below the USEPA threshold of 100 tons per year for all maintenance areas. All other annual emission totals and aggregated study emission totals for criteria pollutants are not anticipated to exceed all other USEPA *de minimis* thresholds; therefore, no mitigation measures are required.

7.7 Magnuson-Stevens Fishery Conservation and Management Act

This Act requires federal action agencies to consult with the NMFS if a proposed action may affect EFH. No in-water work is proposed for the Recommended Plan. Therefore, there will be no effect to EFH as a result of the Recommended Plan. Please see Appendix H for correspondence from NOAA NMFS.

7.8 U.S. Fish and Wildlife Coordination Act

The FWCA requires Federal agencies to consult with the USFWS, NMFS, and the state fish and wildlife agencies where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted or otherwise controlled or modified" by any agency under a federal permit or license. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources." The intent is to give fish and wildlife conservation equal consideration with other purposes of water resources development projects. A USFWS Coordination Act Letter (Appendix H) was completed and submitted to CENAB on April 6, 2022, indicating that species and habitats identified within the project area are not likely to be impacted by this project.

7.9 Endangered Species Act

The Recommended Plan is compliant with the Endangered Species Act of 1973 (ESA). CENAB determined that the Recommended Plan would have no effect on federal and state-listed threatened and endangered species due to the lack of suitable habitat conditions and/or the lack of documented observances where the effects are likely to occur. The Recommended Plan would have no effect on threatened and endangered species under the purview of NMFS or USFWS.

7.10 Marine Mammal Protection Act

Coordination with the USFWS, NOAA NMFS Habitat Conservation Division and Protected Resources Division has been completed and concurrence has been reached that the Recommended Plan would have no effect on marine mammals or marine habitats.

7.11 Section 106 and 110(f) of the National Historic Preservation Act

The NHPA applies to properties listed in or eligible for listing in the NRHP; these are referred to as “historic properties.” Historic properties eligible for listing in the NRHP include prehistoric and historic sites, structures, buildings, objects, and collections of these in districts. Under Section 106 of the NHPA of 1966, as amended and its implementing regulations at 36 CFR Part 800, the CENAB assessed potential effects on historic properties that are located within the APE. Pursuant to 54 U.S.C. 306108 and 36 CFR Part 800.14(b)(1)(ii), CENAB is deferring final identification and evaluation of historic properties until PED when additional funding becomes available and prior to construction by executing a PA with the Maryland SHPO and other consulting parties. The signed PA is included in Appendix G.

Consultation and coordination efforts to date, and the executed PA, are included in Appendix G. Coordination with the Maryland SHPO and other consulting parties will continue through the remainder of the study.

Section 110(f) of the NHPA requires that Federal agencies, to the maximum extent possible, minimize harm to any NHL that may be directly or adversely affected by an undertaking. The Recommended Plan does not include any alternatives that would have an impact on NHLs.

7.12 Resource Conservation and Recovery Act (RCRA)

An HTRW Investigation Report was drafted for this study. Further investigations and field testing are needed to determine the presence of contamination at the proposed construction sites. Compliance is expected to be achieved through coordination and reporting with MDE, EPA, and private property owners during the PED phase and Phase II Environmental Site Assessment.

7.13 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund)

No Superfund sites listed on the National Priorities List (NPL) are located in or nearby the proposed construction sites.

7.14 Executive Order 11988, Floodplain Management

This EO states that federal agencies shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibilities. The Recommended Plan would reduce the risk of flood loss, and minimize the impacts of floods on human safety, health, and welfare. CENAB has utilized the 8-step decision making process for EO 11988. Through the 8-step process, CENAB has determined that the proposed action is not within the base floodplain, except for the previously evaluated nonstructural portion of the action (Step 1). A public review meeting was held in-person on 01 August 2022 and virtually on 02 August 2022 (Step 2). CENAB identified and evaluated a no action alternative (or FWOP), and non-floodplain alternatives such as floodproofing, building elevation, acquisition and relocation, and enhanced warning systems, as well as alternatives within the floodplain (Step 3). CENAB calculated minimal impacts to the 100-year and 500-year floodplain through the proposed action (Step 4). The purpose of the Baltimore CSRM study is to reduce flood risks and protect human health and safety (Step 5), CENAB has also optimized the proposed alternative by eliminating one proposed floodwall adjacent to the Ft. McHenry west ventilation building due to an already existing base elevation that acts as a natural flood barrier (Step 6). CENAB conducted modeling to assess the effects of induced flooding and recommends the proposed action for implementation in compliance with minimization plans and flood insurance requirements (Steps 7 and 8).

7.15 Executive Order 11990, Protection of Wetlands

This EO directs all federal agencies to minimize the destruction, loss, or degradation of wetlands and preserve and enhance the natural beneficial values of wetlands in the conduct of the agency's responsibilities. The Recommended Plan would have no direct or indirect effects to wetlands.

7.16 Executive Order 12898, Federal Actions to Address Environmental Justice

No group of people would bear a disproportionately high share of adverse environmental consequences resulting from the Recommended Plan.

7.17 Executive Order 13045, Protection of Children from Environmental and Safety Risks

No children would bear a disproportionately high share of adverse environmental consequences resulting from the proposed work and there should be no effect on children.

7.18 Executive Order 13186 Responsibilities of Federal Agencies to Protect Migratory Birds

No migratory birds or their associated habitat will be impacted.

7.19 Rivers and Harbors Act, 33 U.S.C. 401, et seq.

The Recommended Plan does not propose construction of any structure in or over navigable waters of the United States.

8 DISTRICT ENGINEER RECOMMENDATIONS

The CENAB recommends structural measures of floodwalls and closure structures at the Interstate I-95 and I-895 Tunnels and supporting transportation critical facilities (the Fort McHenry and Harbor Tunnels ventilation buildings). The CENAB recommends the CSRM measures in Baltimore City, Maryland, be constructed generally in accordance with the selected plan herein, and with such modifications thereof, as per the discretion of the Director of Civil Works, may be advisable at an estimated project first cost of approximately $77.5 million (October 2023 price level). The interest during construction is approximately $871,000 and O&M costs are $5.1 million, for a total cost of $83.5 million.

Recommendations for provision of Federal participation in the plan described in this report would require the non-federal sponsor(s) to enter into a written Project Partnership Agreement (PPA), as required by Section 221 of Public Law 91-611, as amended, to provide local cooperation satisfactory to the Secretary of the Army. Such local cooperation shall provide, in part, the following draft items of local cooperation:

a. Provide 35 percent of construction costs, as further specified below:

1. Provide, during design, 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide all lands, easements, rights-of-way, and placement areas and perform all relocations determined by the Federal government to be required for the project;

3. Provide, during construction, any additional contribution necessary to make its total contribution equal to at least 35 percent of construction costs;

b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might reduce the level of coastal storm risk reduction the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

c. Inform affected interests, at least yearly, of the extent of risk reduction afforded by the project; participate in and comply with applicable Federal floodplain management and flood insurance programs; prepare a floodplain management plan for the project to be implemented not later than one year after completion of construction of the project; and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with the project;

d. Operate, maintain, repair, rehabilitate, and replace the project or functional portion thereof at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal laws and regulations and any specific directions prescribed by the Federal government;

e. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project to inspect the project, and, if necessary, to undertake work necessary to the proper functioning of the project for its authorized purpose;

f. Hold and save the Federal government free from all damages arising from design, construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the Federal government or its contractors;

g. Perform, or ensure performance of, any investigations for hazardous, toxic, and radioactive wastes (HTRW) that are determined necessary to identify the existence and extent of any HTRW regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, and any other applicable law, that may exist in, on, or under real property interests that the Federal government determines to be necessary for construction, operation and maintenance of the project;

h. Agree, as between the Federal government and the non-Federal sponsor, to be solely responsible for the performance and costs of cleanup and response of any HTRW regulated under applicable law that are located in, on, or under real property interests required for construction, operation, and maintenance of the project, including the costs of any studies and investigations necessary to determine an appropriate response to the contamination, without reimbursement or credit by the Federal government;

i. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the owner and operator of the project for the purpose of CERCLA liability or other applicable law, and to the maximum extent practicable shall carry out its responsibilities in a manner that will not cause HTRW liability to arise under applicable law; and

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4630 and 4655) and the Uniform Regulations contained in 49 C.F.R Part 24, in acquiring real property interests necessary for construction, operation, and maintenance of the project including those necessary for relocations, and placement area improvements; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to higher authority as proposals for authorization and implementation funding. However, prior to transmittal to higher authority, the sponsor, the states, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

ESTHER S. PINCHASIN
COL, EN
Commanding

22 May 2024
DATE

9 LIST OF PREPARERS

9.1 List of Preparers

The PDT for the study included team members from the CENAB (Table 9-1). The team members listed below provided substantial text to the Final IFR/EA.

Table 9-1. List of Preparers

NAME	AFFILIATION
Joe Bieberich	Project Manager, CENAB-PPC
Vanessa Campbell	Study Manager, CENAB-PL-P
Andrew Roach	Plan Formulation, CENAB-PL-P
Damian Lebron Gonzalez	Civil Engineer, CENAB-ENC-E
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Heather Sachs	Realty Specialist, CENAB-REC
Cynthia Mitchell	Public Affairs Specialist, CENAB-CC
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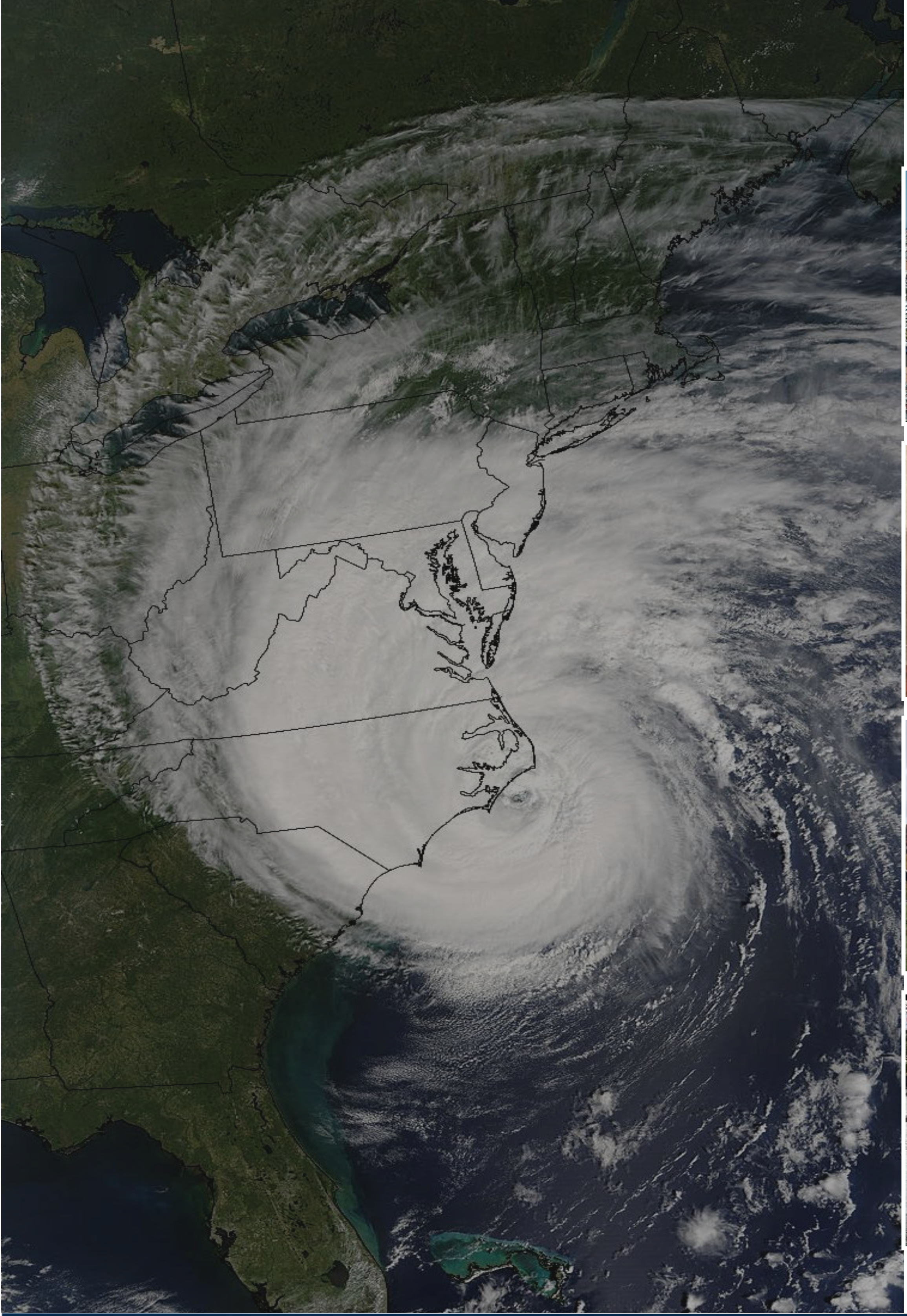

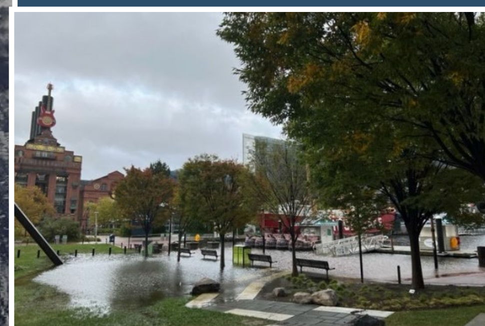

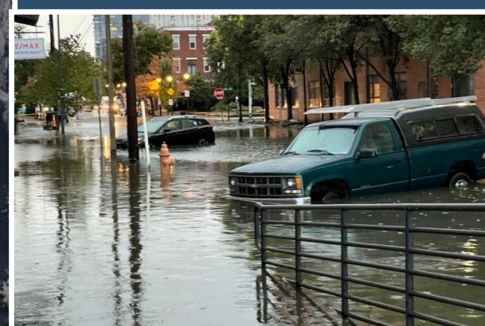

This Report was developed through a partnership of the United States Army Corps of Engineers and the Maryland Department of Transportation.

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