

Final Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study / Environmental Impact Statement



Feasibility Study
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US Army Corps
of Engineers®
Norfolk District



COVER SHEET

Final City of Norfolk Coastal Storm Risk Management Feasibility Study Report/Environmental Impact Statement Norfolk, Virginia

LEAD AGENCY: Department of the Army
U.S. Army Corps of Engineers, Norfolk District

COOPERATING AGENCIES: U.S. Environmental Protection Agency, Region 3

ABSTRACT:

The U.S. Army Corps of Engineering (USACE), Norfolk District and the City of Norfolk proposes to construct structural, non-structural, and Natural and Nature-Based Features to manage coastal storm risk in the City of Norfolk, Virginia. Without a plan to promote resiliency and reduce the risks of coastal storm damage, the City will continue to be vulnerable to coastal storm damage caused by coastal storms like nor'easters, tropical storms and hurricanes, as well as climate change and rising sea levels. The USACE has prepared an Environmental Impact Statement (EIS) to evaluate potential impacts of the proposed action in accordance with the requirements of the National Environmental Policy Act of 1969, as amended, implementing regulations of the NEPA, 40 Code of Federal Regulations 1500-1508, and other applicable state and federal laws, and USACE policies. Four alternatives, including the No Action/Future Without Project Alternative, were evaluated to determine the potential environmental, cultural, and socioeconomic impacts resulting from the proposed action. Resource areas evaluated in the EIS include land use and land cover, water resources, ecological resources, floodplains, geology and soils, air quality, noise, recreation, transportation, utilities, socioeconomics, aesthetics and visual resources, and cultural resources. Potential impacts to floodplains and wetlands are described in the EIS.

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EXECUTIVE SUMMARY

This Integrated Feasibility Report and Environmental Impact Statement is for the Norfolk Coastal Storm Risk Management Study.

Norfolk, Virginia is an international city and the urban core of the Hampton Roads region. Its location at the mouth of the Chesapeake Bay, one of the richest tidal estuaries in the world, places it at the gateway to the Nation's capital. Established in August 1682, Norfolk has a long and proud history as a national maritime trading, shipbuilding and military center. Today, a city of approximately 250,000, Norfolk is the commercial center of Hampton Roads, a region of 1.7M residents, producing over \$93B worth of product annually.

The city is a global security hub, home to the largest naval base in the world, Naval Station Norfolk (NSN), and the only NATO command on U.S. soil. Many of the 65,000 active duty and civilian base personnel employed at NSN commute to work from off the base, making the housing and road infrastructure in Norfolk critical to mission readiness for the US Navy. Norfolk is home to the Port of Virginia's Norfolk International Terminals (NIT), one of Virginia's most significant economic assets with an impact of \$60 billion in economic activity annually and port-related industries generating 374,000 jobs. The city is also home to multiple universities and key medical services supporting the region including Old Dominion University, Norfolk State University, Eastern Virginia Medical School, Sentara Norfolk General Hospital, and The Children's Hospital of the King's Daughters.

Norfolk is increasingly at risk from flooding and damage from coastal storms. The city is a highly urbanized, relatively flat, community with nearly all areas below elevation 15 feet (North American Vertical Datum of 1988). The low elevations and tidal connections to the Elizabeth River and Chesapeake Bay place a significant percentage of the city at risk of flooding from high tides, nor'easters, hurricanes and other storms. Exacerbating the flooding is the phenomenon of relative sea level rise (RSLR), which is the combination of water level rise and land subsidence. Norfolk is documented as having one of the highest rates of RSLR among Atlantic coastal communities.

This U.S. Army Corps of Engineers (USACE) study is a response to identified flood risks. The study develops and evaluates coastal storm risk management alternatives for Norfolk. These measures are formulated to reduce risk to residents, industries, businesses and infrastructures which are critical to the nation's economy. The long-term strategy for resilience in Norfolk is a layered solution that includes elements executed by the non-Federal sponsor, other Federal agencies, the Commonwealth of Virginia or one of its agencies, and/or non-governmental organizations in addition to the recommendations for implementation by the USACE study. The study seeks to not only reduce coastal storm risk, but also to build on resilience by implementing strategic approaches that address identified stresses and potential shocks such as nuisance flooding risk, major storms, and the impact on residents and economic activity.

The following Recommended Plan (RP) includes a combination of the following types of measures to reduce flood risk across large segments of the city:

Structural flood risk management 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 that are implemented to protect people and property.

Nonstructural flood risk management measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. 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. Nonstructural measures recommended in the RP include property elevation, floodproofing, buyouts, and basement fills.

Natural or nature-based (NNBF) flood management measures work with or restore natural processes with the aim of wave attenuation and storm surge reduction. NNBF measures recommended in the RP include tidal wetlands that may include a sill or flanking reef structure and stand-alone reef structures.

The study follows policies and guidelines for consideration of economic, environmental, cultural, and social impacts. The RP presented herein is formulated and designed for a coastal storm flood elevation calculated by the USACE as the 1.4% (70 yr.) annual chance exceedance (ACE) event. To assist with better understanding of the components of the plan it has been broken down into four construction areas. The following paragraphs give a brief description of the measures by these areas.

Area 1 - Pretty Lake Barrier System Plus Willoughby Spit Nonstructural

This system of measures would provide flood risk reduction for the Pretty Lake area that includes residential neighborhoods, emergency evacuation routes for northern Norfolk, and routes that provide access to Little Creek Amphibious Base. In particular, Route 60 (Shore Drive), used by military personnel, has average annual daily traffic volume of 26,000. A system of floodwalls and a storm surge barrier are recommended for keeping storm surge from entering Pretty Lake at Shore Drive. On Willoughby Spit, the neighborhoods south of Ocean View Avenue include property elevation, basement fills, and buyouts for nonstructural measures. Living shoreline mitigation and oyster reef NNBF are proposed for the Pretty Lake area.

Area 2: Lafayette River Watershed Storm Surge Barrier Plus Nonstructural

A storm surge barrier extending approximately 7,000 ft from Norfolk International Terminal (NIT) to the Lamberts Point golf course is proposed for providing flood risk management to the Lafayette River watershed. The Lafayette watershed represents approximately 26% of the study land area. The barrier would protect portions of Hampton Boulevard, which is used by military personnel to access Naval Station Norfolk, as well as providing trucking access to port facilities. Nonstructural floodproofing measures are proposed for industrial areas west of the storm surge barrier. Living shoreline and wetland mitigation is proposed in the Lafayette River watershed. Oyster reef NNBF is proposed adjacent to the surge barrier.

Area 3: Ghent, Hague, Downtown Barrier System

This system would provide flood risk reduction in the economic core of the city. The structural measure would form an alignment extending from West Ghent to the Harbor Park area. Floodwalls would tie into both sides of the existing downtown floodwall. A storm surge barrier is proposed at the entrance to The Hague. Behind the system alignment lies important infrastructure such as the region’s only Tier 1 trauma hospital, the region’s children’s hospital, emergency services, the region’s only medical school, critical transportation corridors used for evacuation, city hall, the city institutional network, cultural assets, and adjacent historic districts as well as public housing. No nonstructural measures are proposed for this area. Two locations for living shorelines are proposed in this area, one for environmental mitigation and the other as a project NNBF. This system extends into the western part of Area 4 in the vicinity of Harbor Park and the Tidewater neighborhood.

Area 4 - Broad Creek, Berkley, and Campostella Nonstructural

A storm surge barrier and associated floodwalls are proposed for preventing floodwaters from the Elizabeth River from entering the Broad Creek watershed. The barrier system will be aligned parallel with the southern side of I-264 and the light rail tracks. Nonstructural measures including basement fills, elevation, buyouts, and floodproofing are proposed for the Elizabeth Park neighborhood and areas south of the floodwalls. Basement fills, elevation, buyouts, and floodproofing nonstructural measures are also proposed south of the Elizabeth River in the Berkley and Campostella neighborhoods. Oyster reef NNBF is proposed for the shoreline adjacent to the Broad Creek surge barrier.

Project benefits are anticipated to exceed the project costs. The relationship between benefits and costs is expressed in the benefit cost ratio (BCR) shown in Table 1. Project First Cost and Total Project Cost are estimated to be \$1.37 billion and \$1.57 billion respectively. Project First Cost is the constant dollar cost of the RP at current price levels and is the cost used in the authorizing document for a project. Total Project Cost is the constant dollar fully funded with escalation to the estimated midpoint of construction. Total Project Cost is the cost estimate used in Project Partnership Agreements for implementation of design and construction of a project. Total Project Cost is the cost estimate provided to the non-Federal sponsor for their use in financial planning as it provides information regarding the overall non-Federal cost sharing obligation. The non-Federal costs include the value of lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRDs). Total LERRDs are estimated to be \$47,159,784. The Project First Cost and Total Project Cost are shown below in Table 2 and Table 3 respectively.

Table 1. Project Benefits and Costs

Annual Benefits (\$1000's)	Project First Costs (\$1000's)	Annual O&M Costs (\$1000's)	Total Average Annual Costs (\$1,000)	Annual Net Benefits (\$1,000)	BCR
\$174,740	\$1,368,897	\$ 1,759	\$54,514	\$120,226	3.2

Table 2. First Cost Apportionment Table

	Federal (65%)	Non-Federal (35%)	Total
Initial Project Cost	\$ 889,783,000	\$ 479,114,000	\$ 1,368,897,000
LERRD Credit		\$ 36,276,757	
Cash Contribution		\$ 442,837,243	

Table 3. Total Project Cost Apportionment Table

	Federal (65%)	Non-Federal (35%)	Total
Initial Project Cost	\$ 1,020,942,000	\$ 549,738,000	\$ 1,570,680,000
LERRD Credit		\$ 47,159,784	
Cash Contribution		\$ 502,578,216	

Figure 1 below shows the areas of the city impacted by the RP color coded in order to provide a high level overview of the geographic extent of the measures that make up the RP. Solid colored areas are those parts of the city that are behind the proposed structural measure. The colored, hatched areas are those parts of the city that are recommended to receive nonstructural flood risk management measures. Areas of the city that are not hatched or colored were not recommended for flood risk management. The hatched naval base area is not part of the authorized study area. While project economics cannot rely on benefits to the navy base the study does acknowledge that proposed project measures that improve the operational capabilities of Naval Station Norfolk will provide benefits in the form of military readiness for the nation.

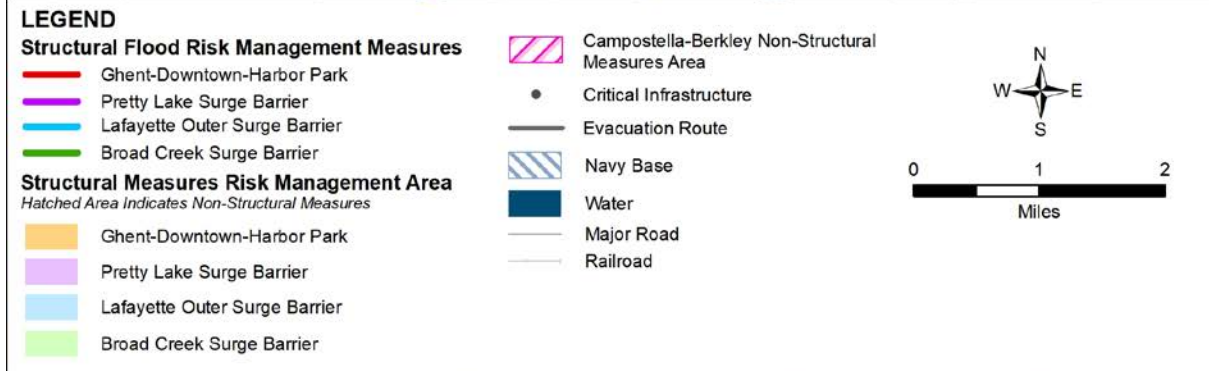
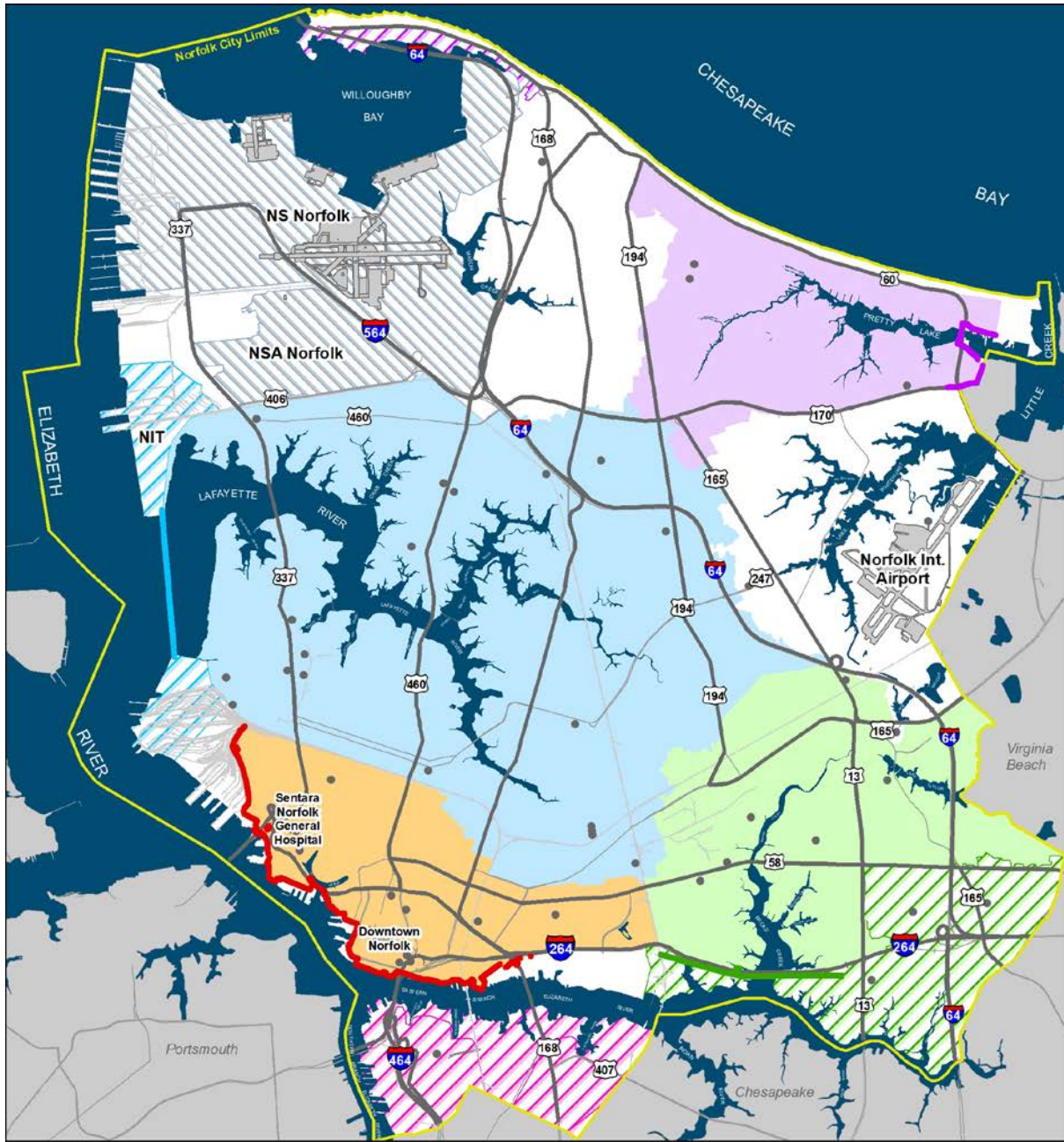


Figure 1. Map Supporting the Description of the Recommended Plan

Environmental Impacts and Mitigation

A public scoping meeting and several follow up public meetings were held throughout the study process. Cooperating agencies were invited to participate in the development of this Environmental Impact Statement (EIS); and consulting parties were invited to participate in the development of a Programmatic Agreement to address historic resources. Interagency coordination of the EIS occurred throughout the study process.

The project will have both temporary and permanent adverse impacts on essential fish habitat, marine mammals, transportation, navigation, recreation, wetlands, mudflats, open water, hydrology, bathymetry, water quality, cultural resources, and visual resources. Impacts to federally listed species under the jurisdiction of the National Marine Fisheries Service (NMFS) (Atlantic Sturgeon, fin whale, sei whale, green sea turtle, Kemp's ridley sea turtle, and loggerhead sea turtle) would be may affect, not likely to adversely affect. Impacts to the northern long-eared bat under the jurisdiction of the U.S. Fish and Wildlife Service would be may affect, likely to adversely affect because of the anticipated tree removal actions. However, this impact would be excepted from the incidental take prohibitions as addressed in the USFWS Programmatic Biological Opinion on Final 4(d) Rule for the Northern Long-Eared Bat and Activities Excepted from Take Prohibitions. All other impacts to federally listed species under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) (piping plover, red knot, west Indian manatee) would be may affect, not likely to adversely affect. There would be no impact to critical habitat as none exists in the Action Area.

Minor to moderate, temporary and permanent adverse effects to fish and other aquatic organisms may occur as a result of construction of the storm surge barriers and gate openings. During construction, noise and temporary minimal sedimentation due to disturbance of the bottom is expected, which could disrupt foraging, reproduction, and passage. Once constructed, the storm surge barrier gates will remain open except during major storm events requiring closure. The gates will allow passage of aquatic organisms; however, passage and availability of prey species may be more restricted than currently. Closures would temporarily cut off passage of all aquatic organisms. Adverse effects on Essential Fish Habitat (EFH) and marine mammals are being addressed through coordination with the National Marine Fisheries Service, pursuant to the Magnuson-Stevens Act, and the Marine Mammal Protection Act (MMPA), respectively.

There will be minor impacts to navigation; particularly at the Lafayette River storm surge barrier. The storm surge barrier at the mouth of the Lafayette River will have ten openings. The USACE-maintained federal navigation channel near the center of the Lafayette River will remain in operation; a sector gate will be constructed at that location. There are no Federal navigation channels in Pretty Lake, The Hague, or Broad Creek; however, those areas are used for local and recreational boat traffic. Overall, impacts to navigation due to the storm surge barriers will be minor; the proposed navigational openings would be sufficient for navigable use and access.

With respect to floodplains, structural flood risk management projects, such as the storm surge barrier systems, are typically large scale projects that reduce flood risk for a large number of structures, which is a beneficial and significant impact. The USACE required Floodplain Management Plan should address the City's outreach and education plan for communicating residual flood risks to its citizens, which is a beneficial and significant component of the flood management system, and the City's ability to be resilient and sustainable from a storm event.

Impacts to the environment and floodplain areas, including wetlands, upland areas, natural drainage features, utilities, existing structures, etc. will generally be within the footprint of the project alignment. The associated impacts are not considered adverse and will be temporary and negligible/minor in severity. The project will adhere to Executive Order 11988.

The footprint of the storm surge barriers and the floodwalls will permanently impact less than 2 acres of emergent intertidal wetlands, and less than 2 acres of scrub/shrub intertidal wetlands. In addition, approximately 22 acres of subaqueous bottom and mudflat will be directly impacted by structures. All wetland, oyster, and mudflat impacts will be mitigated, such that this impact would not be significant. All required permits will be obtained for these impacts.

Hydrodynamic and water quality modelling was conducted to determine effects on flushing, salinity, dissolved oxygen, and nutrients. It was found that minor, but permanent changes to water quality would occur. Significant changes to the salinity of upper reach waters of Pretty Lake are expected during a storm-event driven closure; however, water quality will return to normal within a month post-storm. Minor, permanent changes to bathymetry would occur, except where surge barriers are placed, where impacts are significant. Plankton mortality due to changes in salinity in upper reach waters of Pretty Lake are expected, but only during closure due to a storm event. Permanent and adverse effects to benthics will occur for construction of surge barriers, which will be compensated by mitigation.

Cultural resource impacts will include visual impacts to some historic districts and properties that are eligible for listing in the National Register of Historic Places. There is also potential to affect sunken historical vessel sites. Further study will be needed, and these potential impacts are addressed through a Programmatic Agreement (PA) with the Virginia Department of Historic Resources (VDHR) and consulting parties, pursuant to Section 106 of the National Historic Preservation Act.

There will be both temporary and permanent visual adverse effects. Construction equipment will be visible at almost all locations, during construction. The floodwalls and storm surge barriers will be permanent and visible on land and/or water at their locations.

The project will have temporary, minor to moderate, adverse to beneficial effects on land use, socioeconomics, recreation, transportation, safety, and utilities. Construction may result in temporary noise, temporary diversion or restriction of traffic or land uses in locations where structures are installed; potentially restricted use during construction of the recreational facilities such as the Elizabeth River Trail, Harbor Park, and Town Point Park. There may also be permanent impacts on the Lamberts Point Golf Course at the location of the storm surge barrier. There will also be temporary but potentially significant adverse effects to transportation at street gate locations; when closures occur, traffic will need to reroute. However, overall, the permanent effects on land use, recreation, transportation, safety, noise, and utilities are expected to be minimally adverse to mostly beneficial, because these resources would be enhanced through flood risk management. Noise impacts would be temporary and minor, during construction.

Impacts to hazardous materials and wastes would be negligible to temporary and minor during construction. Care would be taken at the storm surge barrier connection to upland at Lamberts

Point Golf Course, formerly a landfill. Overall, there would be minor benefits post-construction due to increased protection against coastal erosion.

There will be minimal to negligible temporary or permanent impacts on wildlife and terrestrial vegetation. Some mechanized land clearing will be necessary for installation of structures and construction access. Wildlife in the area is accustomed to an urban/suburban environment and would likely avoid the areas during construction. There will be minor to negligible impacts on geology and soils. All erosion and sediment control regulations will be followed and all disturbed areas will be stabilized.

This project would have negligible temporary effects on air quality during construction due to emissions, and negligible permanent effects are anticipated.

There will be no effect to submerged aquatic vegetation (SAV); there are no SAV beds near the project footprints of any of the structures.

PERTINENT DATA

MAJOR FEATURES OF THE NORFOLK CSRM MEASURES

<u>Pretty Lake Structural System (PL-2S)</u>	
Design Elevation (NAVD88)	15 ft
Surge Barrier	
Surge Barrier Length	114 ft
Miter Gate Number	1
Miter Gate Opening	65 ft
Floodwall	
Length	5,642 ft
Type	T-wall
Road Closures	1
Interior Drainage	
Pump / Power Station	1
NNBF and Mitigation	
NNBF Oyster Reef	560 lf
Mitigation Living Shoreline	2,375 lf
Real Estate Requirements	
Permanent Easements	1.98 ac
Temporary Easements	1.35 ac
<u>Willoughby Nonstructural (WB-1N)</u>	
	<u>Number of Structures</u>
Basement Fill	3
Basement Fill + Elevation	38
Acquisition	15
Elevation	243

<u>Lafayette River Structural System (LR-1aS)</u>	
Design Elevation (NAVD88)	15.5 ft
Surge Barrier	
Surge Barrier Length	6,634 ft
Miter Gate Number	9
Miter Gate Opening	70 ft
Sector Gate Number	1
Sector Gate Opening	150 ft
Power Station	1
Levee	
Crest Width	10 ft
Side Slope	3H:1V
NIT Segment 1 Length	1,030 ft
Commonwealth Ave. Segment 1 Length	70 ft
Commonwealth Ave. Segment 2 Length	230 ft
WWTP North Length	95 ft
WWTP South Length	110 ft
NNBF and Mitigation	
NNBF Living Shoreline	6,200 lf
NNBF Oyster Reef	3,290 lf
Mitigation Living Shoreline	5,150 lf
Mitigation Wetland	1,100 lf
Interior Drainage	
Tide (Sluice) Gates	3
Real Estate Requirements	
Permanent Easements	40.78 ac
Temporary Easements	15.72 ac
<u>Main Stem 2 Nonstructural (MS-2N)</u>	
	<u>Number of Structures</u>
Floodproofing	11

Final Integrated City of Norfolk CSRM Feasibility Study / Environmental Impact Statement

<u>Ghent, Hague, Downtown Structural System (EBS)</u>	
Design Elevation (NAVD88)	16.5 ft
Surge Barrier	
Surge Barrier Length	600 ft
Miter Gate Number	2
Miter Gate Opening	50 ft
Power Station	1
Floodwall	
Length	27,236 ft
Type	T-wall
Road Closures	26
Levee	
Crest Width	10
Side Slope	3H:1V
Length	2,582 ft
Interior Drainage	
Pump Stations	4
Tide (Sluice) Gates	4
NNBF and Mitigation	
NNBF Living Shoreline	7,200 lf
NNBF Oyster Reef	5,250 lf
Mitigation Living Shoreline	3,800 lf
Real Estate Requirements	
Permanent Easements	43.21 ac
Temporary Easements	20.42 ac

<u>Broad Creek Structural System (BC-1S)</u>	
Design Elevation (NAVD88)	16.5 ft
Surge Barrier	
Surge Barrier Length	1,291 ft
Miter Gate Number	6
Miter Gate Opening	65 ft
Power Station	1
Floodwall	
Length	8,787
Type	T-wall
Road Closures	2
Interior Drainage	
Pump Stations	1
Tide (Sluice) Gates	4
NNBF and Mitigation	
NNBF Oyster Reef	620 lf
Mitigation Living Shoreline	2,174 lf
Real Estate Requirements	
Permanent Easements	5.33 ac
Temporary Easements	2.64 ac
<u>Ingleside Nonstructural (EB-7N)</u>	
	<u>Number of Structures</u>
Basement Fill	11
Basement Fill + Elevation	7
Floodproofing	10
Elevation	38
<u>Elizabeth Park Nonstructural (EB-8N)</u>	
	<u>Number of Structures</u>
Basement Fill	5
Basement Fill + Elevation	12
Acquisition	6
Floodproofing	19
Elevation	265

<u>Campostella and Berkley Nonstructural (EB-4N, EB-4aN, EB- 4bN)</u>	<u>Number of Structures</u>
Basement Fill	157
Basement Fill + Floodproofing	1
Basement Fill + Elevation	32
Acquisition	55
Floodproofing	14
Elevation	78

TABLE OF CONTENTS

Chapter 1	INTRODUCTION.....	1
1.1	BACKGROUND.....	1
1.1.1	North Atlantic Coast Comprehensive Study	1
1.1.2	Non-Federal Sponsor.....	1
1.1.3	Additional Study Guidelines	1
1.1.4	Federal Interest.....	1
1.2	STUDY AREA	1
1.2.1	Area 1 - Mason Creek, Pretty Lake, and Willoughby	4
1.2.2	Area 2 – Lafayette River Watershed	4
1.2.3	Area 3 – The Elizabeth River.....	5
1.2.4	Area 4 – Elizabeth River Eastern Branch	5
1.2.5	Purpose and Need for the Proposed Action	6
1.3	STUDY AUTHORITY.....	6
1.4	RISK INFORMED DECISION FRAMEWORK.....	6
1.4.1	Stakeholder Involvement	6
1.4.2	Alternatives Development	7
1.4.3	Climate Change and Sea Level Rise	9
1.4.4	Future Storm Frequency and Intensity	11
1.4.5	Risk Based Storm Frequency Simulation	11
1.4.6	Socio-Economic Evaluation	12
1.4.7	Scenario Planning.....	12
1.4.8	Evaluation Criteria for Ranking and Comparing Plans.....	12
1.5	CITY OF NORFOLK HISTORIC STORM DAMAGE RECORD	12
1.6	PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS	15
1.7	PUBLIC AND AGENCY COORDINATION.....	16
1.7.1	Interagency Coordination	16
1.7.2	Public Involvement.....	17
Chapter 2	PLANNING CONSIDERATIONS	18
2.1	PROBLEMS AND OPPORTUNITIES	18
2.2	OBJECTIVES	18
2.3	CONSTRAINTS.....	18
2.4	MULTIPLE LAYERS OF RESILIENCY	19

2.5	PERIOD OF ANALYSIS	20
2.6	DEVELOPMENT / REDEVELOPMENT PROJECTIONS.....	20
2.7	CRITICAL ASSUMPTIONS	20
2.7.1	Storm Intensity and Water Surface Elevations	21
2.7.2	Relative Sea Level Rise Projections	22
2.7.3	Future Scenarios and Design Water Levels for Formulation	23
2.8	PLANNING REACHES.....	27
2.9	AREAS OUTSIDE THE STUDY ALIGNMENT	30
2.9.1	Naval Station Norfolk	30
2.9.2	Chesterfield Heights.....	30
Chapter 3	HYDROMODELING ANALYSIS	32
3.1	NACCS HYDROMODELING ANALYSIS	32
3.1.1	Modeling of Surge Levels and Wave Characteristics	32
3.1.2	Determination of Stage Frequencies.....	32
3.1.3	Determination of Structure Heights and Overtopping Volumes	34
3.2	Determination of Interior Flooding.....	34
3.3	RELATIVE SEA LEVEL RISE EFFECTS ON STRUCTURE HEIGHTS	34
3.3.1	Adjusting NACCS Data for the Study	34
3.3.2	Incorporating Future RSLR	35
3.4	VERTICAL CONTROLS AND DATUMS.....	35
Chapter 4	ECONOMIC APPLICATION	36
4.1	GEOGRAPHIC DATA.....	36
4.2	DEVELOPMENT AND LAND USE PROJECTIONS	36
4.3	STRUCTURE INVENTORY AND VALUATION	37
4.4	VEHICLE DATA.....	37
4.5	EMERGENCY COST ESTIMATES.....	38
4.6	TRANSPORTATION.....	39
4.7	STAGE-DAMAGE FUNCTIONS	40
4.8	STAGE-PROBABILITY DATA	40
4.9	ADDITIONAL ECONOMIC CONSIDERATIONS.....	41
4.9.1	Residual Damages	41
4.9.2	Gross Regional Output, Employment, and Earned Income Impacted.....	41
Chapter 5	FORMULATING MANAGEMENT MEASURES AND ALTERNATIVES	42
5.1	PLAN FORMULATION PROCESS	42

5.2	MEASURES FOR COASTAL STORM RISK MANAGEMENT	43
5.3	INVENTORYING AND SCREENING MEASURES	44
5.4	FORMULATION OF ALTERNATIVES	47
5.5	NATURAL AND NATURE-BASED FEATURES.....	47
5.6	NATURAL AND NATURE-BASED FEATURES AND PLAN FORMULATION	48
Chapter 6	REFINING MEASURES AND EVALUATION	50
6.1	STRUCTURAL MEASURES.....	50
6.1.1	Beach and Dune	50
6.1.2	Floodwall	50
6.1.3	Ringwall	50
6.1.4	Levee.....	51
6.1.5	Gate Closures.....	51
6.1.6	Storm Surge Barriers and Tide Gates	51
6.2	NONSTRUCTURAL MEASURES.....	52
6.2.1	Elevation.....	52
6.2.2	Basement Fill/Removal	52
6.2.3	Relocation.....	52
6.2.4	Acquisition	52
6.2.5	Floodproofing.....	52
6.2.6	Flood Warning System.....	53
6.2.7	Flood Emergency Preparedness, Response, Recovery, and Mitigation Planning	53
6.2.8	Land Use Regulations.....	53
6.3	NATURAL AND NATURE-BASED FEATURES.....	54
6.4	INTERIOR FLOODING ANALYSIS.....	57
6.5	SEPARABLE AND COMPLEMENTARY MEASURES.....	57
6.6	REFINED MEASURES.....	58
6.6.1	Refined Structural Measures.....	58
6.6.2	Refined Nonstructural Measures.....	60
6.7	EVALUATION AND COMPARISON	60
6.7.1	Other Social Effects Analysis	60
6.7.2	Benefit Cost Analysis	61
6.7.3	Cost and Construction Time Metrics	61
6.7.4	Risk and Uncertainty Analysis.....	63
6.7.5	Engineering Risk and Uncertainty Analysis.....	63

6.7.6	Cost Risk and Uncertainty Analysis	64
6.7.7	Economic Risk and Uncertainty Analysis	64
6.8	ECONOMIC RESULTS FOR SEPARABLE MEASURES	66
Chapter 7	FOCUSED ARRAY OF ALTERNATIVES	70
7.1	FOCUSED ARRAY OF ALTERNATIVES	70
7.2	REFORMULATION OF THE FOCUSED ARRAY	72
7.3	COMPLETE, EFFICIENT, EFFECTIVE AND ACCEPTABLE	73
7.4	NO ACTION/FUTURE WITHOUT PROJECT ALTERNATIVE	73
7.5	FOCUSED ARRAY ALTERNATIVE 2a, 2b, and 2c	74
7.6	FOCUSED ARRAY ALTERNATIVE 3.....	74
7.7	FOCUSED ARRAY OF ALTERNATIVEs 4a, 4b, 4c, 4d, 4e, 4f.....	74
7.8	SCREENING OF THE FOCUSED ARRAY OF ALTERNATIVES	75
7.8.1	Other Social Effects Matrix.....	75
7.8.2	Alternative 2b, 4b, and 4e Screening	78
7.8.3	Alternative 2c, 4c, and 4f Screening.....	79
7.8.4	Reformulating Pretty Lake and Campostella / Berkley for Neighborhood Cohesiveness.....	79
Chapter 8	FINAL ARRAY OF ALTERNATIVES	81
8.1	FINAL ARRAY COST ESTIMATES	81
8.1.1	Final Array Cost Updates.....	81
8.2	DESCRIPTION OF THE FINAL ARRAY	85
8.2.1	Alternative 1/No Action/Future Without Project Alternative.....	85
8.2.2	Alternative 2a/Structural Only	85
8.2.3	Alternative 3/Nonstructural.....	87
8.2.4	Alternative 4d/ Structural and Nonstructural.....	89
8.3	NNBFS IN THE FINAL ARRAY	91
8.4	CRITICAL INFRASTRUCTURE IN THE FINAL ARRAY	91
8.5	EVALUATION AND COMPARISON USING THE FOUR ACCOUNTS	92
Chapter 9	RECOMMENDED PLAN	93
9.1	OPTIMIZATION OF THE TSP	93
9.1.1	Incorporating Updated Costs, Benefits, and Planning Decisions.....	93
9.1.2	Analyzing Three Water Levels	93
9.2	CSRA OF THE RECOMMENDED PLAN.....	94
9.3	NNBF IN THE RECOMMENDED PLAN	95

9.4	CRITICAL INFRASTRUCTURE IN THE RECOMMENDED PLAN.....	97
9.5	ECONOMIC RESULTS OF THE RECOMMENDED PLAN.....	99
9.6	DESCRIPTION OF THE RECOMMENDED PLAN	100
9.7	EXECUTIVE ORDER (EO) 11988 AND PUBLIC LAW 113-2 CONSIDERATIONS...106	
9.7.1	EO 11988	106
9.8	OPERATION OF THE RECOMMENDED PLAN.....	107
9.9	RESILIENCY, SUSTAINABILITY, AND CONSISTENCY WITH THE NACCS.....	109
9.9.1	Resiliency	109
9.9.2	Sustainability.....	110
9.9.3	Adaptability	110
9.10	CONSISTENCY WITH THE NACCS	112
Chapter 10	AFFECTED ENVIRONMENT	113
10.1	LAND USE	113
10.1.1	Definition of Resource.....	113
10.1.2	Methodology	113
10.1.3	Framework.....	113
10.1.4	Existing Conditions	114
10.2	GEOLOGY AND SOILS.....	121
10.2.1	Definition of Resource.....	121
10.2.2	Methodology	122
10.2.3	Framework.....	122
10.2.4	Existing Conditions	122
10.3	COASTAL HYDRAULICS.....	130
10.3.1	Definition of Resource.....	130
10.3.2	Methodology	131
10.3.3	Existing Conditions	131
10.4	WATER QUALITY	134
10.4.1	Definition of Resource.....	134
10.4.2	Methodology	134
10.4.3	Framework.....	134
10.4.4	Existing Conditions	136
10.5	FLOODPLAINS	139
10.5.1	Definition of Resource.....	139
10.5.2	Methodology	139

10.5.3	Framework.....	139
10.5.4	Existing Conditions	140
10.6	WETLANDS AND MUDFLATS	148
10.6.1	Definition of Resource.....	148
10.6.2	Methodology	148
10.6.3	Framework.....	150
10.6.4	Existing Conditions	151
10.7	SUBMERGED AQUATIC VEGETATION.....	161
10.7.1	Definition of Resource.....	161
10.7.2	Methodology	162
10.7.3	Framework.....	162
10.7.4	Existing Conditions	163
10.8	TERRESTRIAL WILDLIFE AND UPLAND VEGETATION.....	164
10.8.1	Definition of Resource.....	164
10.8.2	Methodology	164
10.8.3	Framework.....	164
10.8.4	Existing Conditions	165
10.9	PLANKTON.....	166
10.9.1	Definition of resource	166
10.9.2	Existing Conditions	167
10.10	FISH AND FISHERY RESOURCES	167
10.10.1	Definition of Resource	167
10.10.2	Methodology.....	167
10.10.3	Framework	168
10.10.4	Existing Conditions.....	168
10.11	BENTHIC RESOURCES	170
10.11.1	Definition of Resource	170
10.11.2	Methodology.....	170
10.11.3	Existing Conditions.....	170
10.12	SPECIAL STATUS SPECIES	174
10.12.1	Definition of Resource	174
10.12.2	Methodology.....	175
10.12.3	Framework	176
10.12.4	Federally Listed Threatened and Endangered Species and Critical Habitat ...	177

10.12.5	Species Protected under the American Bald and Golden Eagle Act of 1972 ..	192
10.12.6	Species Protected under the Migratory Bird Treaty Act of 1918 and Executive Order 13186.....	193
10.13	CULTURAL RESOURCES	195
10.13.1	Definition of Resource	195
10.13.2	Methodology.....	196
10.13.3	Framework	197
10.13.4	Existing Conditions.....	197
10.14	RECREATIONAL RESOURCES	214
10.14.1	Definition of Resource	214
10.14.2	Methodology.....	215
10.14.3	Framework	215
10.14.4	Existing Conditions.....	216
10.15	VISUAL RESOURCES	221
10.15.1	Definition of Resource	221
10.15.2	Methodology.....	221
10.15.3	Framework	224
10.15.4	Existing Conditions.....	224
10.16	SOCIOECONOMICS.....	227
10.16.1	Definition of Resource	227
10.16.2	Methodology.....	227
10.16.3	Framework	227
10.16.4	Existing Conditions.....	228
10.17	HAZARDOUS MATERIALS AND WASTES.....	237
10.17.1	Definition of Resource	237
10.17.2	Methodology.....	237
10.17.3	Framework	238
10.17.4	Existing Conditions.....	238
10.18	SAFETY	243
10.18.1	Definition of Resource	243
10.18.2	Methodology.....	243
10.18.3	Framework	243
10.18.4	Existing Conditions.....	244
10.19	TRANSPORTATION AND NAVIGATION	249

10.19.1	Definition of Resource	249
10.19.2	Methodology.....	250
10.19.3	Framework	250
10.19.4	Existing Conditions.....	251
10.20	UTILITIES.....	266
10.20.1	Definition of Resource	266
10.20.2	Methodology.....	266
10.20.3	Framework	267
10.20.4	Existing Conditions.....	267
10.21	AIR QUALITY	270
10.21.1	Definition of Resource	270
10.21.2	Methodology.....	271
10.21.3	Framework	271
10.21.4	Existing Conditions.....	273
10.22	NOISE	274
10.22.1	Definition of Resource	274
10.22.2	Methodology.....	276
10.22.3	Regulatory Framework	276
10.22.4	Existing Conditions.....	277
10.23	CLIMATE CHANGE.....	277
10.23.1	Definition of Resource	277
10.23.2	Methodology.....	277
10.23.3	Framework	277
10.23.4	Existing Conditions.....	278
Chapter 11	ENVIRONMENTAL CONSEQUENCES	279
11.1	SUMMARY OF IMPACTS	279
11.2	LAND USE	283
11.2.1	No Action Alternative/Future Without Project	283
11.2.2	Alternative 2a: Structural Only Alternative.....	285
11.2.3	Alternative 3: Nonstructural Alternative	290
11.2.4	Alternative 4d: Recommended Plan.....	291
11.2.5	Cumulative Effects.....	291
11.3	GEOLOGY AND SOILS.....	292
11.3.1	No Action Alternative/Future Without Project	292

11.3.2	Alternative 2A: Structural Only Alternative	294
11.3.3	Alternative 3: Nonstructural Alternative	294
11.3.4	Alternative 4d: Recommended Plan	294
11.3.5	Cumulative Effects	295
11.4	COASTAL HYDRAULICS	296
11.4.1	No Action Alternative/Future Without Project	296
11.4.2	Alternative 2a: Structural Only Alternative	296
11.4.3	Alternative 3: Nonstructural Alternative	300
11.4.4	Alternative 4d: Recommended Plan	300
11.4.5	Cumulative Effects	300
11.5	WATER QUALITY	302
11.5.1	No Action Alternative/Future Without Project	302
11.5.2	Alternative 2a: Structural Only Alternative	304
11.5.3	Alternative 3: Nonstructural Alternative	307
11.5.4	Alternative 4d: Recommended Plan	307
11.5.5	Summary	307
11.5.6	Cumulative Effects	308
11.6	FLOODPLAINS	308
11.6.1	No Action Alternative/Future Without Project	308
11.6.2	Alternatives 2a, 3, and 4d	310
11.6.3	Structural Measures	311
11.6.4	Nonstructural Measures	312
11.6.5	Natural and Nature Based Features	314
11.7	WETLANDS AND MUDFLATS	315
11.7.1	No Action Alternative/Future Without Project	315
11.7.2	Alternative 2a: Structural Only Alternative	316
11.7.3	Alternative 3: Nonstructural Alternative	323
11.7.4	Alternative 4d: Recommended Plan	324
11.7.5	Cumulative Effects	325
11.8	SUBMERGED AQUATIC VEGETATION (SAV)	327
11.8.1	All Alternatives	327
11.8.2	Cumulative Impacts	328
11.9	TERRESTRIAL WILDLIFE AND UPLAND VEGETATION	329
11.9.1	No Action Alternative/Future Without Project	329

11.9.2	Alternative 2a: Structural Only Alternative.....	330
11.9.3	Alternative 3: Nonstructural Alternative	331
11.9.4	Alternative 4d: Recommended Plan.....	332
11.9.5	Cumulative Effects.....	332
11.10	BENTHIC RESOURCES	332
11.10.1	No Action Alternative/Future Without Project.....	332
11.10.2	Alternative 2a: Structural Only Alternative	333
11.10.3	Alternative 3: Nonstructural Alternative.....	337
11.10.4	Alternative 4d: Recommended Plan	337
11.10.5	Cumulative Effects	337
11.11	PLANKTON.....	338
11.11.1	No Action Alternative/Future Without Project.....	338
11.11.2	Alternative 2a: Structural Only Alternative	339
11.11.3	Alternative 3: Nonstructural Alternative.....	339
11.11.4	Alternative 4d: Recommended Plan	340
11.11.5	Cumulative Effects	340
11.12	FISH AND FISHERY RESOURCES	340
11.12.1	No Action Alternative/Future Without Project.....	340
11.12.2	Alternative 2a: Structural Only Alternative	341
11.12.3	Alternative 3: Nonstructural Alternative.....	343
11.12.4	Alternative 4d: Recommended Plan	343
11.12.5	Cumulative Effects	343
11.13	SPECIAL STATUS SPECIES.....	344
11.13.1	No Action Alternative/Future Without Project.....	344
11.13.2	Alternative 2a: Structural Only Alternative	345
11.13.3	Alternative 3: Nonstructural Alternative.....	345
11.13.4	Alternative 4d: Recommended Plan	346
11.14	PASSAGE/TRAPPING EFFECTS	351
11.15	TURBIDITY	352
11.16	VESSEL INTERACTIONS.....	353
11.17	CUMULATIVE EFFECTS	355
11.17.1	Piping Plover and Red Knot	357
11.17.2	Northern Long-eared Bat.....	357
11.17.3	West Indian Manatee	358

11.17.4	Bald Eagle Determination.....	358
11.18	CULTURAL RESOURCES	362
11.18.1	Approach to Analysis.....	362
11.18.2	No Action Alternative/Future Without Project.....	362
11.18.3	Alternative 2a: Structural Only Alternative	363
11.18.4	Alternative 3: Nonstructural Alternative.....	365
11.18.5	Alternative 4d: Recommended Plan	367
11.18.6	Cumulative Effects	370
11.19	RECREATIONAL RESOURCES	370
11.19.1	No Action Alternative/Future Without Project.....	370
11.19.2	Alternative 2a: Structural Only Alternative	371
11.19.3	Alternative 3: Nonstructural Alternative.....	376
11.19.4	Alternative 4d: Recommended Plan	377
11.19.5	Cumulative Effects	377
11.20	VISUAL RESOURCES	378
11.20.1	No Action Alternative/Future Without Project.....	378
11.20.2	Alternative 2a: Structural Only Alternative	379
11.20.3	Alternative 3: Nonstructural Alternative.....	380
11.20.4	Alternative 4d: Recommended Plan	381
11.20.5	Cumulative Effects	383
11.21	SOCIOECONOMICS	383
11.21.1	Approach to Analysis.....	383
11.21.2	No Action Alternative/Future Without Project.....	383
11.21.3	Alternative 2a: Structural Only Alternative	385
11.21.4	Alternative 3: Nonstructural Alternative.....	385
11.21.5	Alternative 4d: Recommended Plan	385
11.21.6	Cumulative Effects	387
11.22	HAZARDOUS MATERIALS AND WASTES.....	387
11.22.1	Approach to Analysis.....	387
11.22.2	No Action Alternative/Future Without Project.....	387
11.22.3	Alternative 2a: Structural Only Alternative	389
11.22.4	Alternative 3: Nonstructural Alternative.....	389
11.22.5	Alternative 4d: Recommended Plan	390
11.22.6	Cumulative Effects	391

11.23 SAFETY	391
11.23.1 No Action Alternative/Future Without Project.....	391
11.23.2 Alternative 2a: Structural Only Alternative	393
11.23.3 Alternative 3: Nonstructural Alternative.....	393
11.23.4 Alternative 4d: Recommended Plan	393
11.23.5 Cumulative Effects	394
11.24 TRANSPORTATION AND NAVIGATION	395
11.24.1 No Action Alternative/Future Without Project.....	395
11.24.2 Alternative 2a: Structural Only Alternative	401
11.24.3 Alternative 3: Nonstructural Alternative.....	415
11.24.4 Alternative 4d: Recommended Plan	416
11.24.5 Cumulative Effects	416
11.25 UTILITIES.....	417
11.25.1 No Action Alternative/Future Without Project.....	417
11.25.2 Alternative 2a: Structural Only Alternative	418
11.25.3 Alternative 3: Nonstructural Alternative.....	418
11.25.4 Alternative 4d: Recommended Plan	419
11.25.5 Cumulative Effects	419
11.26 NOISE	419
11.26.1 No Action Alternative/Future Without Project.....	419
11.26.2 Alternative 2a: Structural Only Alternative	420
11.26.3 Alternative 3: Nonstructural Alternative.....	421
11.26.4 Alternative 4d: Recommended Plan	421
11.26.5 Cumulative Effects	422
11.27 CLIMATE CHANGE.....	422
11.27.1 No Action Alternative/Future Without Project.....	422
11.27.2 Alternative 2a: Structural Only Alternative	423
11.27.3 Alternative 3: Nonstructural Alternative.....	423
11.27.4 Alternative 4d: Recommended Plan	423
11.28 AVOIDANCE, MINIMIZATION, AND MITIGATION MEASURES	423
11.28.1 Project Implementation.....	423
11.28.2 Public Outreach and Environmental Justice	424
11.28.3 Wetlands, Mudflat, and Open Water.....	424
11.28.4 Natural and Nature Based Features	424

11.28.5	Chesapeake Bay Preservation Act	424
11.28.6	Water Quality	425
11.28.7	Cultural Resources and Historic Properties	425
11.28.8	Special Status Species and Essential Fish Habitat.....	425
11.28.9	Hazardous Materials	427
11.28.10	Noise and Worker Safety	427
11.28.11	Erosion and Sediment Control	427
11.28.12	Other Standard Best Management Practices	428
Chapter 12	ENVIRONMENTAL COMPLIANCE	431
12.1	NATIONAL ENVIRONMENTAL POLICY ACT OF 1969, AS AMENDED, 42	434
12.2	CLEAN WATER ACT.....	435
12.3	WETLANDS	435
12.4	RIVERS AND HARBORS ACT, 33 U.S.C. 401 ET AL.	435
12.5	FEDERAL COASTAL ZONE MANAGEMENT ACT, 16 U.S.C. 1451 ET SEQ.	436
12.6	CLEAN AIR ACT, AS AMENDED, 42 U.S.C. 7401 <i>ET SEQ.</i>	436
12.7	U.S. FISH AND WILDLIFE COORDINATION ACT, 16 U.S.C.661-666(C).....	437
12.8	ENDANGERED SPECIES ACT.....	437
12.9	MAGNUSON-STEVENSON FISHERY CONSERVATION AND MANAGEMENT ACT (MSA), 16 U.S.C.1801 <i>ET SEQ.</i>	438
12.10	ANADROMOUS FISH CONSERVATION ACT, 16 U.S.C. 757, <i>ET SEQ.</i>	438
12.11	MARINE MAMMAL PROTECTION ACT, 16 U.S.C. 1631, <i>ET SEQ.</i>	438
12.12	SECTION 106 and 110(F) OF THE NATIONAL HISTORIC PRESERVATION ACT, 16 U.S.C. 470 <i>ET SEQ.</i>	439
12.13	RESOURCE CONSERVATION AND RECOVERY ACT, AS AMENDED, 42	439
12.14	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT, 42 U.S.C. 9601 <i>ET SEQ.</i>	440
12.15	MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT	440
12.16	EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT	440
12.17	EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS	440
12.18	EXECUTIVE ORDER 13112, INVASIVE SPECIES	441
12.19	EXECUTIVE ORDER 12898, FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE IN MINORITY POPULATIONS AND LOW INCOME POPULATIONS.....	441
12.20	EXECUTIVE ORDER 13045, PROTECTION OF CHILDREN FROM ENVIRONMENTAL HEALTH RISKS AND SAFETY RISKS	441
12.21	MIGRATORY BIRD TREATY ACT, 16 U.S.C. 703 <i>ET SEQ.</i> ; EXECUTIVE ORDER	

13186, FEDERAL RESPONSIBILITY TO PROTECT MIGRATORY BIRDS.....	441
Chapter 13 CONCLUSIONS AND RECOMMENDATIONS.....	442
13.1 CONSTRUCTION SEQUENCING STRATEGY FOR THE RECOMMENDED PLAN	442
13.1.1 Critical Infrastructure Floodproofing	444
13.1.2 Area 3 - Ghent, The Hague, and Downtown Areas	444
13.1.3 Area 1 - Pretty Lake Area and Willoughby Spit Nonstructural	444
13.1.4 Area 2 - Lafayette River Area.....	444
13.1.5 Area 4 - Broad Creek, Berkley, and Campostella Areas.....	444
13.2 PLAN IMPLEMENTATION	444
13.2.1 Consistency with Laws and Policy	445
13.2.2 Cost Sharing and Real Estate Costs.....	445
13.2.3 Project Partnership – Local Sponsor Responsibilities	446
13.2.4 Design and Construction Considerations and Schedule.....	448
13.2.5 Real Estate Requirements	449
13.2.6 Views of the Non-Federal Sponsor and Other Agencies	449
13.3 PATH FORWARD	449
13.4 RECOMMENDED ACTIONS FOR OTHERS.....	449
13.4.1 Nonstructural Recommendations.....	450
13.4.2 Natural and Nature Based Features.....	450
13.5 LIST OF AGENCIES CONTACTED.....	451
13.6 LIST OF REPORT PREPARERS	452
13.7 STATEMENT FROM THE DISTRICT ENGINEER.....	452
LITERATURE REFERENCED	454

Appendices

The following appendices are available in a separate document:

Appendix A – Plan Formulation Appendix

Appendix B – Engineering Appendix

Appendix C – Economics Appendix

Appendix D – Environmental Appendix

Appendix E – Real Estate Plan

Appendix F – Coordination with the Non-Federal Sponsor

Appendix G – Review Certifications

LIST OF FIGURES

Figure 1-1. City of Norfolk Vicinity Map	2
Figure 1-2. City of Norfolk Area Map	3
Figure 1-3. Quadratic Fit of Global Mean SLR (mm)	10
Figure 1-4. Sewells Point Tide Gauge RSLR (mm) Record	11
Figure 1-5. Water Levels at Sewells Point for Various Historic Storms	13
Figure 2-1. Relative Sea Level Rise at Sewell’s Point, VA	22
Figure 2-2. Topography of Norfolk.....	25
Figure 2-3. Planning Reaches and 2075 NACCS 3% (35-yr) Inundation Map	29
Figure 2-4. Conceptual Design of the Ohio Creek Watershed Project at Chesterfield Heights ..	31
Figure 4-1. Household debris as a result of flood from Hurricane Katrina.....	38
Figure 4-2. Hurricane Joaquin, October 2015. Firefighters rescue a stranded motorist	40
Figure 4-3. Sample graph of Study Water Surface Elevations	41
Figure 5-1. Norfolk CSRM Plan Formulation Process.....	43
Figure 6-1. Tidal Wetland Flanked by a Stone Sill.....	54
Figure 6-2. Conventional and Ecosystem-Based Coastal Defenses Compared	55
Figure 6-3. Subtidal Oyster Reef	57
Figure 6-4. Citywide View of Refined Structural Measures	59
Figure 6-5. Risk Analysis Diagram	63
Figure 8-1. Alternative 2a Structural Only Map.....	87
Figure 8-2. Alternative 3 Nonstructural Only Map.....	88
Figure 8-3. Alternative 4d Structural and Nonstructural Combination Map	90
Figure 9-1. Overview Map of NNBF in the Recommended Plan.....	96
Figure 9-2. Critical Infrastructure with the Recommended Plan.....	99
Figure 9-3. Recommended Plan Citywide View.....	101
Figure 9-4. Recommended Plan Area 1 Measures.....	102
Figure 9-5. Alternative 4d Area 2 Measures.	103
Figure 9-6. Alternative 4d Area 3 Measures.	104
Figure 9-7. Alternative 4d Area 4 Measures.	105
Figure 9-8. Norfolk Elevations.....	111
Figure 9-9. Area 4 Proposed Design Elevation in Relation to USACE RSLR Estimates	112
Figure 10-1. Land Use- Area 1	116
Figure 10-2. Land Use - Area 2.....	117
Figure 10-3. Land Use – Area 3	119
Figure 10-4. Land Use – Area 4	121
Figure 10-5. Physiographic Map of Virginia	123
Figure 10-6. Soils Map of Norfolk, Virginia	130
Figure 10-7. FEMA 1% (red) and 0.2% (white) Annual Chance Floodplains.....	142
Figure 10-8. NACCS 3% Annual Chance Flood with 2075 Sea Level Rise Floodplain	143
Figure 10-9. Norfolk FEMA Repetitive Loss Areas	144
Figure 10-10. Zonation of Tidal Marshes.....	151
Figure 10-11. Area 1, Wetlands, mudflats, and open water habitats within the ROI.	153
Figure 10-12. Area 1 - Location of Storm Surge Barrier at Pretty Lake.....	154
Figure 10-13. Area 2, Wetlands, mudflats, and open water habitats within the ROI.	155

Figure 10-14. Area 2, The location of the Storm Surge Barrier across the Lafayette River.....	156
Figure 10-15. Area 3, Wetlands, mudflats, and open water habitats within the ROI	157
Figure 10-16. Area 3 - Wetland inlet at Lamberts Creek.....	157
Figure 10-17. Area 4, Wetland, mudflats, and open water habitats within the ROI.	159
Figure 10-18. Area 4 - Narrow marsh and saltbush community west of Harbor Park.....	160
Figure 10-19. Area 4 -Saltbush community adjacent to Harbor Park.	160
Figure 10-20. Area 4 - Narrow fringe of a mixed community along the south side of the Tide rail line and I-264	161
Figure 10-21. Area 4 - Narrow marsh fringe along the south side of the Tide rail line, near the mouth of Broad Creek.	161
Figure 10-22. Map of the Lafayette River, showing existing oyster reef restoration projects (orange), relict reefs (green), prime restoration bottom (yellow).	173
Figure 10-23. Critical habitat for the Atlantic Sturgeon in the James River, Virginia (area within the limits of the heavy, bold line)	182
Figure 10-24. Marine Mammal Strandings Reported in the Region of Influence/Action Area, 2009-2016.....	189
Figure 10-25. Displays the extent of anticipated water quality impacts to aquatic Special Status Species.	190
Figure 10-26. Stranded Marine Mammals Reported in the Region of influence/Action Area from 2009-2016.....	191
Figure 10-27. Stranded sea turtles reported in the Region of Influence/Action Area from 2009-2016.....	192
Figure 10-28. 1861 Map of Norfolk.....	200
Figure 10-29 1891 Bird's Eye View Map of Norfolk, Portsmouth, and Berkley	201
Figure 10-30. Boundaries of NRHP listed, eligible, or potentially eligible properties in Norfolk from DHR data.	213
Figure 10-31. Phase I Archaeological Surveys in Norfolk.....	214
Figure 10-32. Recreation for Area 1	217
Figure 10-33. Recreation for Area 2	218
Figure 10-34. Recreation for Area 3.....	220
Figure 10-35. Recreation for Area 4.....	221
Figure 10-36. Development along the Main Stem, Eastern Branch and Southern Branch of the Elizabeth River.....	225
Figure 10-37. City of Norfolk Shoreline Classification and Local Aesthetics	226
Figure 10-38. Metropolitan Statistical Area.....	231
Figure 10-39. Population by Census Tract, 2010 Census	232
Figure 10-40. Income by Census Tract	233
Figure 10-41. Predominately Minority Low Income Census Tracts	234
Figure 10-42. Minority Population by Census Tract.....	235
Figure 10-43. Population Under 15 by Census Tract, 2010 Census.....	236
Figure 10-44. Population Over 65, 2010 Census.....	237
Figure 10-45. EPA Cleanup Sites in the Vicinity of Norfolk.....	239
Figure 10-46. Virginia Department of Environmental Quality Solid Waste Site Inventory.....	241
Figure 10-47. Virginia Department of Environmental Quality Registered Tanks	243
Figure 10-48. Projected FEMA 100 Year Floodplain Map	245

Figure 10-49. UDF Analysis	247
Figure 10-50. Interstate and other Principal Arterial Roadways within the City of Norfolk.....	253
Figure 10-51. Minor Arterial and Collector Roadways within the City of Norfolk	254
Figure 10-52. Hurricane Evacuation Routes for Eastern Virginia.....	255
Figure 10-53. Transportation Area 1	257
Figure 10-54. Google Earth Image of Pretty Lake, Route 60 bridge, and Fishermans Cove....	259
Figure 10-55. Transportation Area 2	260
Figure 10-56. Transportation Area 3	262
Figure 10-57. The Tide Light Rail Line route, in Areas 3 and 4.....	263
Figure 10-58. Route Map of the HRT Elizabeth River Ferry.	264
Figure 10-59. Transportation Area 4	265
Figure 10-60. Flood Mapping with Transmission Level Electric Power Assets	269
Figure 11-1. Land Use - Area 1	286
Figure 11-2. Land Use - Area 2.....	287
Figure 11-3. Land Use – Area 3.....	288
Figure 11-4. Land Use - Area 4.....	290
Figure 11-5. Monitoring Stations on the Lafayette River.....	305
Figure 11-6. Wetlands -- Area 1	318
Figure 11-7. Wetlands -- Area 2.....	320
Figure 11-8. Wetlands -- Area 3.....	321
Figure 11-9. Wetlands -- Area 4.....	323
Figure 11-10. SAV - Area 1	328
Figure 11-11. Bald Eagle Nesting Sites.....	359
Figure 11-12. Alternative 2a, Structural Only, Measures and NRHP Boundaries.....	364
Figure 11-13. Alternative 3 Nonstructural and Ringwall Treatments on NRHP and Potentially Significant Sites	366
Figure 11-14. Alternative 4d Measures	369
Figure 11-15. Recreational Resources – Area 1.....	372
Figure 11-16. Recreational Resources – Area 2.....	373
Figure 11-17. Recreational Resources – Area 3.....	374
Figure 11-18. Recreational Resources – Area 4.....	376
Figure 11-19. Proposed Lafayette River SSB miter gate design (10%)	380
Figure 11-20. Petroleum Release Sites in Norfolk and Project Measures.....	390
Figure 11-21. Proposed Miter Gate Across Pretty Lake	403
Figure 11-22. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 1	404
Figure 11-23. Transportation and Navigation – Area 1	405
Figure 11-24. Proposed Sector Gate at the Lafayette Navigation Channel.....	406
Figure 11-25. Proposed Storm Surge Barrier Wall and Miter Gate	407
Figure 11-26. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 2	407
Figure 11-27. Transportation and Navigation – Area 2.....	408
Figure 11-28. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 3, and part of Area 4.....	410
Figure 11-29. Transportation and Navigation – Area 3.....	411
Figure 11-30. Proposed Storm Surge Barrier Wall and Miter Gate at Broad Creek	412
Figure 11-31. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 4	413

Figure 11-32. Transportation and Navigation – Area 4.....414
 Figure 13-1. Norfolk CSRM Project Sequencing Map.....443

LIST OF TABLES

Table 1-1. Stakeholder Involvement History..... 7
 Table 1-2. Historic FEMA Flood Claims in Norfolk..... 15
 Table 2-1. 2017 FEMA and 2016 NACCS Water Surface Elevations (feet NAVD88)21
 Table 2-2. Estimated RSLR (feet) at Sewells Point, VA.....23
 Table 2-3. NACCS Water Levels (ft, NAVD88) at 2016.....26
 Table 2-4. NACCS Water Levels (ft, NAVD88) by 207526
 Table 4-1. 2017 Land Use in the Study Area.....36
 Table 5-1. Management Measures Screening.....45
 Table 6-1. Focused Array of Structural Management Measures.....60
 Table 6-2. Economic Results for Structural and Nonstructural Measures67
 Table 7-1. Focused Array of Alternatives70
 Table 7-2. Other Social Effects Matrix.....76
 Table 8-1. Economic Results for Final Array Measures82
 Table 8-2. Final Array of Alternatives84
 Table 8-3. Measures in Each Alternative Plan.....84
 Table 8-4. Nonstructural Measures Included in Alternative 389
 Table 8-5. Nonstructural and Ringwall Measures Portion of Alternative 4d91
 Table 9-1. TSP Optimization Results94
 Table 9-2. NNBF Quantities Associated with RP Structural Measures97
 Table 9-3. NNBF Costs Per Structural Measure.....97
 Table 9-4. Critical Infrastructure Sites by Sector98
 Table 9-5. Cost Estimate by Measure within the Recommended Plan.100
 Table 9-6. Nonstructural Measures within the Recommended Plan.....105
 Table 9-7. WSEL Duration Above 4 ft at Sewell's Point Gauge108
 Table 9-8. Approximately Gate Closure Time (days).....108
 Table 10-1. Study Area Soils Information for Geological Resources124
 Table 10-2. Water Quality Data.....138
 Table 10-3. FEMA Flood Claims in Norfolk145
 Table 10-4. Federally listed species known or with the potential to occur in the Study Area...177
 Table 10-5. Marine Mammal Species in Stranding Records from Virginia, 1988-2013187
 Table 10-6. Marine Mammal Strandings Reported in the Region of Influence/Action Area, 2009-2016.....189
 Table 10-7. Migratory Birds in the ROI.....193
 Table 10-8. State Listed Species with the potential to occur in the Region of Influence.....195
 Table 10-9. Laws, Regulations, Executive Orders, and Guidelines197
 Table 10-10. Current Status of Historic Resources in Norfolk (VDHR 2017)202
 Table 10-11. City of Norfolk, Public and Private Sector Employment (Bureau of Labor Statistics 2017)229
 Table 10-12. City of Norfolk Employment and Wages by Industry Sector.....230

Table 10-13. Population and Population Change in the MSA by Municipality	231
Table 10-14. Ethnic Make-Up of Norfolk.....	235
Table 10-15. EPA Cleanup Sites.....	240
Table 10-16. Common Sounds and Their Levels	275
Table 10-17. Maximum Permitted Sound Levels with the City of Norfolk.....	276
Table 11-1. Summary of impacts for the final array of project alternatives.....	279
Table 11-2. Estimated Direct Permanent Tidal Wetland Impacts (Wetland Delineation to be completed in PED phase)	325
Table 11-3. Proxy Projects for Estimating Underwater Noise	347
Table 11-4. Proxy-Based Estimates for Underwater Noise.....	348
Table 11-5. Estimated Distances to Sturgeon/Salmon Injury and Behavioral Threshold.....	349
Table 11-6. Estimated Distances to Sea Turtle Injury and Behavioral Threshold.....	350
Table 11-7. Estimated Distances to Cetacean Behavioral Thresholds.	351
Table 11-8. Conclusion Table: Threatened and Endangered Species Under the Jurisdiction of the National Marine Fisheries Service.....	355
Table 11-9. Conclusion Table: Threatened and Endangered Species.....	360
Table 11-10. Hearing Range of Marine Mammals in the Region of Influence	361
Table 11-11 Number of Buildings Where Nonstructural Measures Would Cause Adverse Effects in Alternative 3	366
Table 11-12 Number of Buildings with Nonstructural Measures in Alternative 4d	368
Table 12-1. Table of Environmental Compliance.....	431
Table 12-2. Federally listed species known or with the potential to occur in the Action Area...	437
Table 12-3. Anadromous fish known or with the potential to occur in the Region of Influence.	438
Table 13-1. First Cost Apportionment Table.....	445
Table 13-2. Total Project Cost Apportionment Table	445
Table 13-3. Implementation Schedule.....	448
Table 13-4. Agencies Contacted.	451
Table 13-5. Report Preparers.....	452

ACRONYMS

ADCIRC – Advanced Circulation Model

BCE – Before the Common Era (replaces B.C.)

BCR – Benefit-to-cost ratio

BFE – Base Flood Elevation

CAA – Clean Air Act

CE – Common Era (replaces A.D.)

CERCLA – Comprehensive Environmental Response, Compensation and Liability Information System

CIEE – Craney Island Eastward Expansion

CSRM – Coastal Storm Risk Management

CWA - Clean Water Act

CZMA - Coastal Zone Management Act

DO - Dissolved Oxygen

EA - Environmental Assessment

EFH - Essential Fish Habitat

EO – Executive Order

ESA - Endangered Species Act

ESI - Environmental Sensitivity Index

FA – Focus Area

FEMA – Federal Emergency Management Agency

FIRM – Flood Insurance Rate Map

FONSI - Finding of No Significant Impact

FCSA –Feasibility Cost Sharing Agreement

FWCAR – Fish and Wildlife Coordination Act Report

GIS – Geographic Information System

H & H – Hydrology and Hydraulics

HEC-FDA - Hydrologic Engineering Center-Flood Damage Risk Reduction Analysis

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

MSFCMA - Magnuson-Stevens Fishery Conservation and Management Act

MSL – Mean Sea Level

NAAQS - National Ambient Air Quality Standards

NACCS – North Atlantic Coast Comprehensive Study

NAD – North Atlantic Division

NAVD88 - North American Vertical Datum of 1988

NED – National Economic Development

NEPA - National Environmental Policy Act

NHPA - National Historic Preservation Act

NMFS - National Marine Fisheries Service

NOAA – National Oceanographic and Atmospheric Administration

NNBF – Natural and Nature Based Features

NRHP - National Register of Historic Places

NWI - National Wetlands Inventory Project

PCB - Polychlorinated Biphenyls

PED – Preconstruction Engineering and Design

PDT – Project Delivery Team

ROI – Region of Influence

RSLR – Relative Sea Level Rise

SAV – Submerged Aquatic Vegetation

SLR – Sea Level Rise

TMDL – Total Maximum Daily Load

TSP – Tentatively Selected Plan

TSS - Total Suspended Solids

USACE – United States Army Corps of Engineers

USEPA – United States Environmental Protection Agency

USFWS – United States Fish and Wildlife service

USGS - United States Geological Survey

VCRIS - Virginia Cultural Resource Information System

VDEQ - Virginia Department of Environmental Quality

VDCR – Virginia Department of Conservation and Recreation

VDHR - Virginia Department of Historic Resources

VDGIF - Virginia Department of Game and Inland Fisheries

VDH - Virginia Department of Health

VIMS - Virginia Institute of Marine Science

VMRC – Virginia Marine Resources Commission

WRDA - Water Resources Development Act

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The Norfolk Coastal Storm Risk Management (CSRM) Study has investigated potential structural and nonstructural solution sets in terms of coastal storm risk management. Coastal storm risk management seeks to address coastal storm and flood risk to vulnerable populations, property, ecosystems, and infrastructure along the coast. Norfolk, Virginia has high levels of risk and vulnerability to coastal storms which will be exacerbated by a combination of sea level rise and climate change over the study period.

1.1.1 North Atlantic Coast Comprehensive Study

Norfolk was evaluated within the North Atlantic Coast Comprehensive Study (NACCS). The NACCS provided a broad initial analysis (Tier 1) spanning 10 states and was completed using regional data sets to include a broad evaluation of exposure and risk. A Tier 2 analysis of Norfolk was completed in January 2015 using more detailed data sets such as hurricane evacuation shelters and light rail stations. The Tier 2 analysis represents a desktop analysis. This focus area study represents a finer, more detailed evaluation and is considered to be a Tier 3 analysis according to the NACCS Framework.

1.1.2 Non-Federal Sponsor

The City of Norfolk, Virginia is the non-Federal sponsor for this study.

1.1.3 Additional Study Guidelines

Norfolk was identified as a focus area (FA) within the NACCS and received federal funding in fiscal year 2016. The Feasibility Cost Sharing Agreement (FCSA) was signed in February 2016. Oversight and coordination for the implementation of the focus area studies is headquartered at the NACCS Command Center which is housed at Baltimore District, United States Army Corps of Engineers (USACE). The Command Center assists in ensuring that all of the focus areas are coordinated and facilitates the coordination with the CSRM Planning Center of Expertise (PCX) which is located within the North Atlantic Division (NAD).

1.1.4 Federal Interest

The Norfolk area is extremely vulnerable to coastal storm events. Coastal storm risk management is an identified primary mission area of USACE. This feasibility study identifies a variety of solutions that have the potential to be economically justified, environmentally acceptable, addressable through engineering solutions, and consistent with USACE policies and the Infrastructure System Rebuilding Principles. Norfolk is home to the largest naval base in the world and the area supports the sixth largest containerized cargo complex (Port of Virginia) in the country. USACE authorization, as described in Section 1.3 STUDY AUTHORITY, and the previous NACCS study have identified the need for coastal storm risk management in Norfolk.

1.2 STUDY AREA

The study area is defined as Norfolk's jurisdictional boundary (Figure 1-1). Norfolk is a city located in the Chesapeake Bay watershed approximately 200 miles southeast of Washington DC and approximately 90 miles southeast of Richmond, Virginia. The city is bordered mostly by

water with the Chesapeake Bay to the north, Hampton Roads Harbor to the west and the Elizabeth River to the south. The cities of Chesapeake and Virginia Beach bound Norfolk to the south and east, respectively. The assessment area lies within the jurisdiction of the following Congressional Delegations: U.S. Senators Mark Warner and Timothy Kaine (VA), U.S. Representative Scott Taylor (VA-2), and U.S. Representative Robert Scott (VA-3).

It is recognized that many other localities in the Hampton Roads area also have high levels of risk and vulnerability to coastal storm events. Norfolk was studied first by USACE because it had an existing study authority, it had a local sponsor with available funding, and an internal momentum to move this study forward. This study is considered an “interim” response as an acknowledgement that other areas in the region may need similar studies.

Naval Station Norfolk (NSN), the largest naval station in the world, is located in the northwestern portion of the city and is within the study area. NSN is shown by the hatching in Figure 1-1. The project has the potential to provide significant benefits to the nation by reducing coastal storm risk on Norfolk infrastructure, including primary roadways into the Naval Station used in the city by Department of Defense (DoD) personnel.

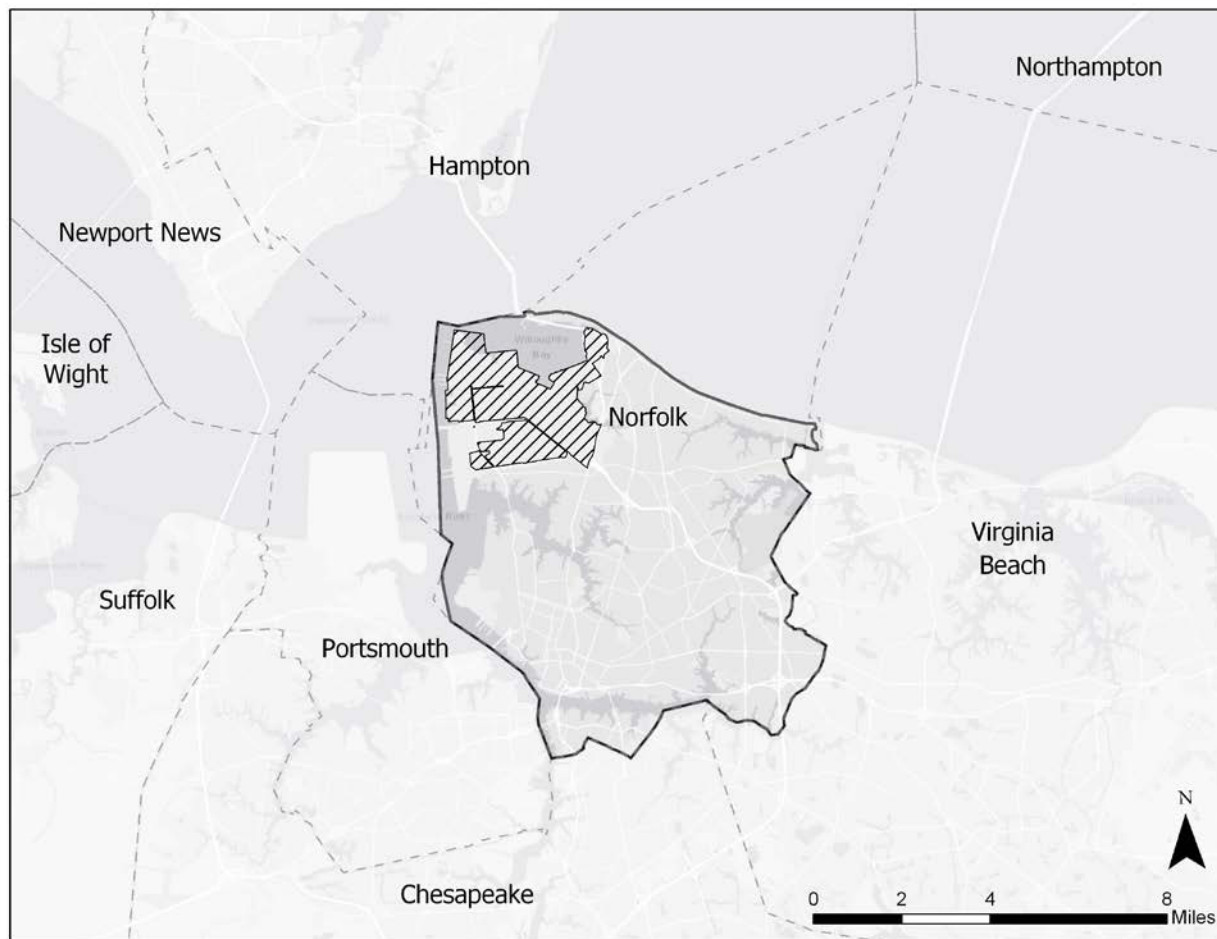


Figure 1-1. City of Norfolk Vicinity Map

For the purpose of this study, Norfolk has been broken into four areas (Figure 1-2) based on watersheds within the city. In addition to addressing coastal flooding within the city as a whole,

area specific planning problems and opportunities were identified and used to develop potential measures for these four sub-areas. The following paragraphs review and characterize the current conditions of the entire project area (Norfolk jurisdictional boundaries) and for each of the four areas. Figure 1-2 below shows the major neighborhoods and water features of the Norfolk area.

City of Norfolk Coastal Storm Risk Management Study Areas



Figure 1-2. City of Norfolk Area Map

1.2.1 Area 1 - Mason Creek, Pretty Lake, and Willoughby

Area 1 is located on the northern boundary of Norfolk on the Chesapeake Bay. It covers the Willoughby Bay and Little Creek watersheds, as defined by the 12-digit hydrologic-unit codes (HUC). Area 1 includes four environs of interest: the bayside shoreline (including Willoughby Spit), Pretty Lake, Mason Creek, and Lake Whitehurst. The bayside shoreline includes the areas from the Norfolk jurisdictional boundaries to the east, which is marked by the jetties at Little Creek Inlet, to the western tip of Willoughby Spit. The location and orientation of the study area at the southern boundary of the Chesapeake Bay and immediately within the mouth of the bay have made this area readily susceptible to damage associated with storm activity. Extreme high tides combined with wave attack, resulting primarily from coastal storms, cause severe losses of sand and structural damage to buildings and infrastructure located landward of the beach (USACE, Willoughby Spit and Vicinity Limited Reevaluation Report). These areas are mixed urban and suburban residential, with commercial development along Ocean View Avenue and Shore Drive. There are no historic districts within Area 1.

The Pretty Lake watershed is located in the northeastern corner of Norfolk. Pretty Lake is a tributary of the Little Creek Inlet from the Chesapeake Bay. The Pretty Lake watershed contains mainly residential development with some commercial development along Shore Drive. Much of the development is older, and therefore built before the standards of the National Flood Insurance Program (NFIP) required elevating first floors above the 1% annual chance exceedance (ACE) base flood elevation (BFE).

The Mason Creek watershed is located adjacent to Naval Station Norfolk, and consists of residential development. Mason Creek is connected to the Willoughby Bay through an underground culvert, which is controlled by a manual tide gate on the Navy's property.

Lake Whitehurst is a reservoir located on the eastern side of Norfolk that serves as a backup reservoir for the city. Although the reservoir has not historically been flooded from coastal processes, it is at risk to storm surge causing saltwater intrusion during a significant coastal event, especially when relative sea level rise is considered.

1.2.2 Area 2 – Lafayette River Watershed

Area 2 is composed of the entire Lafayette River Watershed. This watershed makes up the northern portion of the Elizabeth River HUC, which covers the southwestern parts of Norfolk. The Lafayette River flows into the Elizabeth River, near its mouth to the Chesapeake Bay. This area is characterized by residential and commercial development, Old Dominion University, and industry. The main roadways in Area 2 flow north-to-south and provide a large amount of transportation service between downtown Norfolk, where several major interstates converge, and Naval Station Norfolk. The major industry in this area is Norfolk International Terminal, which requires a coastal location, but also utilizes the major transportation corridors in the area to carry shipments to and from the port by both truck and rail. The Lafayette River Watershed is subject to storm surge flooding during coastal storms, but several neighborhoods in this watershed also experience nuisance flooding from high tides and large rainfall events. The Larchmont Neighborhood on the southern coast near the mouth of the Lafayette River is particularly susceptible to these events. There are five historic districts located within flood zones in Area 2: Park Place, Colonial Place, Riverview, Winona, and Lafayette Residence Park.

1.2.3 Area 3 – The Elizabeth River

Area 3 covers the areas on the southern coast of Norfolk, along the main stem of the Elizabeth River. This is the southern portion of the Elizabeth River HUC. This area includes the neighborhoods of West Ghent, Fort Norfolk, The Hague/Ghent, Freemason, and Downtown Norfolk. The residential developments in these areas often date back to the 1800s, but there are several neighborhoods that have been redeveloped since the early 1980s. There are four historic districts located within flood zones in Area 3: Ghent, North Ghent, Auto Row, and West Freemason.

The West Ghent area is located to the west of Hampton Boulevard and consists of dense residential development, a few commercial businesses, and an industrial shipyard (MHI Shipyard). The area is subject to flooding from heavy rainfall events and storm surge events.

The Fort Norfolk area is located to the South of Brambleton Avenue, along the Elizabeth River. The area consists of condominiums and office buildings, and is particularly subject to storm surge flooding due to low land elevations and water from the Elizabeth River to its south and The Hague to its north and east. The Fort Norfolk area is also where the Norfolk District Headquarters building is located.

The Hague and Ghent area is bounded by Hampton Boulevard to the west, Brambleton Avenue and The Hague to the south, 23rd Street to the north, and Monticello Avenue to the east. The area consists of urban residential development, including the Ghent Historic District; commercial businesses along Colley Avenue, 21st Street and Monticello Avenue; and Sentara Norfolk General Hospital, a level one trauma center, a medical complex which also includes Eastern Virginia Medical School (EVMS) and the Children's Hospital of the Kings Daughters (CHKD). The area is susceptible to flooding from The Hague, a u-shape inlet from the Elizabeth River, during high tides and storm surge events. Due to limited drainage gradients, precipitation events also cause flooding of roadways. Much of the area is built on fill, including The Hague, which was once a tidal creek known as Smith Creek.

The Freemason area is located to the east of Brambleton Avenue and the South of Boush Street, along the Elizabeth River. The area consists primarily of dense, historic residential development, but some commercial businesses are also located in this area. The development in this area and some parts of downtown Norfolk includes structures located on the water-side of the existing downtown floodwall project. For example, several condominium buildings were built on fill into the Elizabeth River. Downtown Norfolk is the area located to the east of The Hague/Ghent neighborhood and Freemason, and to the west of Interstate 264 and St. Paul's Boulevard. The area consists of urban development and commercial businesses. There is an existing floodwall and pump station along the Elizabeth River to protect the downtown area from storm surge.

1.2.4 Area 4 – Elizabeth River Eastern Branch

Area 4 covers the areas of Norfolk east of Interstate 264 and St. Paul's Boulevard, and is bounded by the Norfolk jurisdictional boundaries. This area covers the only land area within the Norfolk jurisdictional boundaries situated to the south of the Elizabeth River, the Berkley and Campostella neighborhoods. The Berkley and Campostella area includes residential neighborhoods and industry, mainly several shipyards. Area 4 includes the Military Highway

major corridor, which consists of a large amount of large commercial and industrial businesses. Area 4 also includes low-lying areas along Tidewater Drive, Ohio Creek, and Broad Creek, tributaries of the Elizabeth River, which are subject to tidal and storm surge flooding. The Tidewater Drive area includes residential and non-residential buildings and Harbor Park Baseball stadium along the Elizabeth River. The Broad Creek watershed, which also includes several smaller tributaries, is mainly residential including multiple public housing developments with some commercial and industrial use along the main corridors. There are two historic districts located within flood zones in Area 4: Chesterfield Heights and Berkley North.

1.2.5 Purpose and Need for the Proposed Action

Norfolk is a highly urbanized, relatively flat, community with nearly all areas below elevation 15 feet North American Vertical Datum of 1988 (NAVD88). The low elevations and tidal connections to the Elizabeth River and Chesapeake Bay place a significant percentage of the city at risk of flooding from high tides, nor'easters, tropical storms, hurricanes and other storms. Exacerbating the flooding is the phenomenon of relative sea level rise (RSLR), which is the combination of water level rise and land subsidence. Norfolk is documented as having one of the highest rates of RSLR among Atlantic coastal communities. Without a plan to promote resiliency and reduce the risks of coastal storm damage, the area will continue to be at risk from coastal storms.

This study will develop and evaluate coastal storm risk management measures for Norfolk residents, industries, and businesses, some of which are critical to the nation's economy and global security due to the presence of NSN and other military assets. The Recommended Plan will be a layered solution that may include elements that could be executed by the non-Federal sponsor, other federal agencies, the Commonwealth of Virginia or one of its agencies, and/or non-governmental organizations in addition to recommendations for implementation by USACE.

The study seeks to not only reduce coastal storm risk, but to also build resilience by implementing strategic approaches that address identified stresses and potential shocks such as nuisance flooding risk, major storms, and the impact on residents and economic activity.

1.3 STUDY AUTHORITY

This study was authorized by Resolution of the Senate Committee on Environment and Public Works dated July 25, 2012.

“Resolved by the Committee on Environment and Public Works of the United States Senate, That the Secretary of the Army is requested to review the report of the Chief of Engineers on beach erosion and hurricane protection for Norfolk, VA, dated April 17, 1984, and other pertinent reports, to include existing coastal storm risk management studies and engineering reports to determine whether any modifications of the recommendations contained therein are advisable in the interest of flood damage reduction in the vicinity of Norfolk, VA.”

1.4 RISK INFORMED DECISION FRAMEWORK

1.4.1 Stakeholder Involvement

Stakeholder involvement has been a critical component of the Norfolk CSRM Study and the development of a citywide vision for managing coastal storm risk throughout Norfolk. Table 1-1

below documents the meetings, workshops, and charrettes that have taken place in order to add value to the planning effort. The table also shows which stakeholders were involved in those sessions. Stakeholders, as identified for this study, include but are not limited to, the City of Norfolk elected officials, staff, and citizens, federal agencies, military interests, state agencies, non-profit environmental organizations, local and regional planning commissions, commercial interests such as shipping and navigation, as well as recreational interests. Throughout the study the USACE has received comments from stakeholders, including the general public. These comments can be found in Appendix D.

Table 1-1. Stakeholder Involvement History

Session	Date	Description	Stakeholders
Kickoff Stakeholder Meeting	March 24, 2016	Gather Initial Input on Objectives, Strategies, and Solutions	Interested Agencies and Organizations
NEPA Public Scoping Meeting	May 25, 2016	Open House Public Meeting to Collect Scoping Comments	Local Citizens, Interested Agencies
Planning Charrette	March 20-23, 2017	Engineering and Environmental Measures Review	City of Norfolk Staff
City Council Presentation	May 23, 2017	Study Update Presented to Norfolk City Council	Norfolk City Council, Local Media
Cooperating Agency and State Regulatory Agency Meeting	March 29, 2017	Review of Measures and Alternatives	EPA, Coast Guard, Navy, VMRC, VADEQ
Public Meeting	June 8, 2017	Open House Public Meeting	Local Citizens, Interested Agencies, and Media
Meeting with Elizabeth River Project	July 5, 2017	Project Review with Elizabeth River Project	Elizabeth River Project
Meeting with Chesapeake Bay Foundation	July 24, 2017	Project Review with Chesapeake Bay Foundation	Chesapeake Bay Foundation
Draft Reprt NEPA Public Meeting	November 16, 2017	Open House Public Meeting	Local Citizens, Interested Agencies, and Media
NEPA Public Comment Period	November – December 2017	Public Comment Submission Period on the Draft Report	Local Citizens, Interested Agencies, Stakeholders

1.4.2 Alternatives Development

Structural and nonstructural measures, along with natural and nature-based features (NNBF), are the building blocks of alternative plans for Norfolk CSRM. An alternative plan is a set of one or more measures functioning together to address one or more planning objectives. In order to ensure that the PDT was developing a comprehensive coastal storm risk management plan for the entire City of Norfolk, the team developed a comprehensive list of CSRM measures that could reasonably address the problems and opportunities identified.

The first step in the formulation of measures involved extensive public involvement in partnership with the City of Norfolk. The USACE partnered with Norfolk to identify and evaluate coastal storm risk management strategies. Once these measures were considered for their applicability to the shoreline types in each of the four areas in the city, they were screened based on their ability to meet the study objectives and avoid planning constraints. The four types of alternatives are the 1) No Action, 2) Structural Only, 3) Nonstructural Plus Ringwalls, and 4) a Combination of Structural and Nonstructural.

The next step in the formulation of measures involved screening structural, nonstructural, and NNBF measures based on cost, environmental impacts, and social impacts. Certain measures, once analyzed with existing data, could easily be screened out due to high costs, unacceptable environmental disturbance, or high levels of objection from stakeholders. These measures were deemed “not feasible” and were eliminated from further consideration.

The final step in the plan formulation process, combining measures into alternative plans, entailed the consideration of reasonable and efficient integration of structural measures with nonstructural and NNBF into viable alternative plans. This report and the appendices present the performance of various alternative plans and illustrate tradeoffs between and among plans on specific objectives and overall program goals. Stakeholder input was incorporated into the plan comparison through public meetings, regular meetings with the sponsor, and meetings with the cooperating agencies.

Alternative plans seek to identify a solution that provides comprehensive CSRM benefits to Norfolk. Therefore, while this study seeks alternatives and separable elements of alternatives that can be implemented through USACE authorities, it also discusses elements that could be implemented under the authorities of other federal agencies, State and local entities, and non-government interests.

The No Action Alternative would involve no action from the USACE to mitigate against coastal storm risk. Although the No Action Alternative would not accomplish the purpose of this study, it must always be included in the analysis and can serve several purposes. First, it is warranted for situations where the impacts are great and the need is relatively minor. Second, it will be used as a benchmark, enabling decision makers to compare the magnitude of economic, environmental, and social effects of the actionable alternatives.

The Structural Only Alternative assumes solutions for coastal risk management can be implemented with structural measures. The structural measures carried forward after measures screening were primarily surge barriers, floodwalls, tide gates, and beach/dune restoration where there is sandy beach along the Chesapeake Bay Shoreline. Note that beach/dune restoration is treated as a structural measure, however, they can also be considered natural and nature based features. Along with the structural barriers, drainage improvements and flap gates on outfalls were also carried forward for all of the areas to manage interior and precipitation flooding. The measures carried forward after screening for each sub-area were combined into an interim array of structural alternatives and those plans were screened based on their completeness, effectiveness, efficiency, and acceptability.

The Nonstructural Plus Ringwalls Alternative assumes solutions can be implemented by

incorporating flood mitigation features at the individual property level. This alternative does not significantly change the overall floodplain but prevents structures from getting inundated. Nonstructural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. 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. Nonstructural measures can be divided into physical and nonphysical measure categories. Physical nonstructural measures would include elevation, relocation, buyout, or wet/dry floodproofing of structures. Nonphysical measures would include flood warning systems, flood preparedness and evacuation plans, zoning and flood insurance regulations, etc. Some nonphysical measures, such as zoning, are not implemented by the USACE, but instead are the responsibility of the local municipality. All nonstructural measures are assumed to be applicable across all four city areas. USACE guidance on ringwalls was changed with Planning Bulletin (PB) 2016-01, published in December 2015. Whereas ringwalls were previously treated as a nonstructural measure, the new guidance mandates they be considered as a structural measure. For the purposes of this study ringwalls are combined with the nonstructural measures due to the fact that the anticipated implementation of ringwalls and their impact on the overall floodplain, is similar to nonstructural measures.

NNBF refers to those features that define natural coastal landscapes and are either naturally occurring or engineered to mimic natural conditions. Some examples of NNBF are beaches and dunes, salt marshes, oyster reefs and barrier islands. For this study NNBF measures are supporting actors that are justified based on their ability to reduce operation and maintenance costs for structural measures and or provide ecosystem goods and services. Because resilience is a key theme for this study, all NNBF measures were carried forward and considered in all of the alternatives that include structural measures. NNBF measures will be removed from the alternatives if there is not a reasonable and justifiable way to incorporate them.

1.4.3 Climate Change and Sea Level Rise

The most recent assessments of the Intergovernmental Panel on Climate change (IPCC (Fifth Assessment Report (AR5)) have noted that global mean sea level has risen significantly since the Industrial Revolution (ending in the mid-1800s) when accurate records regarding sea level were first kept (circa 1870s). This rate has been accelerating (1.7 mm yr/1 between 1901-2010, 2.0 mm yr/1 between 1971-2010, and 3.2 mm yr/1 between 1993-2010) (IPCC 2013: http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf). AR5 projects that global sea level will rise at least 60 cm by 2100, though it may rise by significantly more than 1 m by 2100 according to some projections as sea level rise (SLR) has been accelerating in recent years. The best-fit of this data and resultant rate can be seen in Figure 1-3 with SLR reported in millimeters.

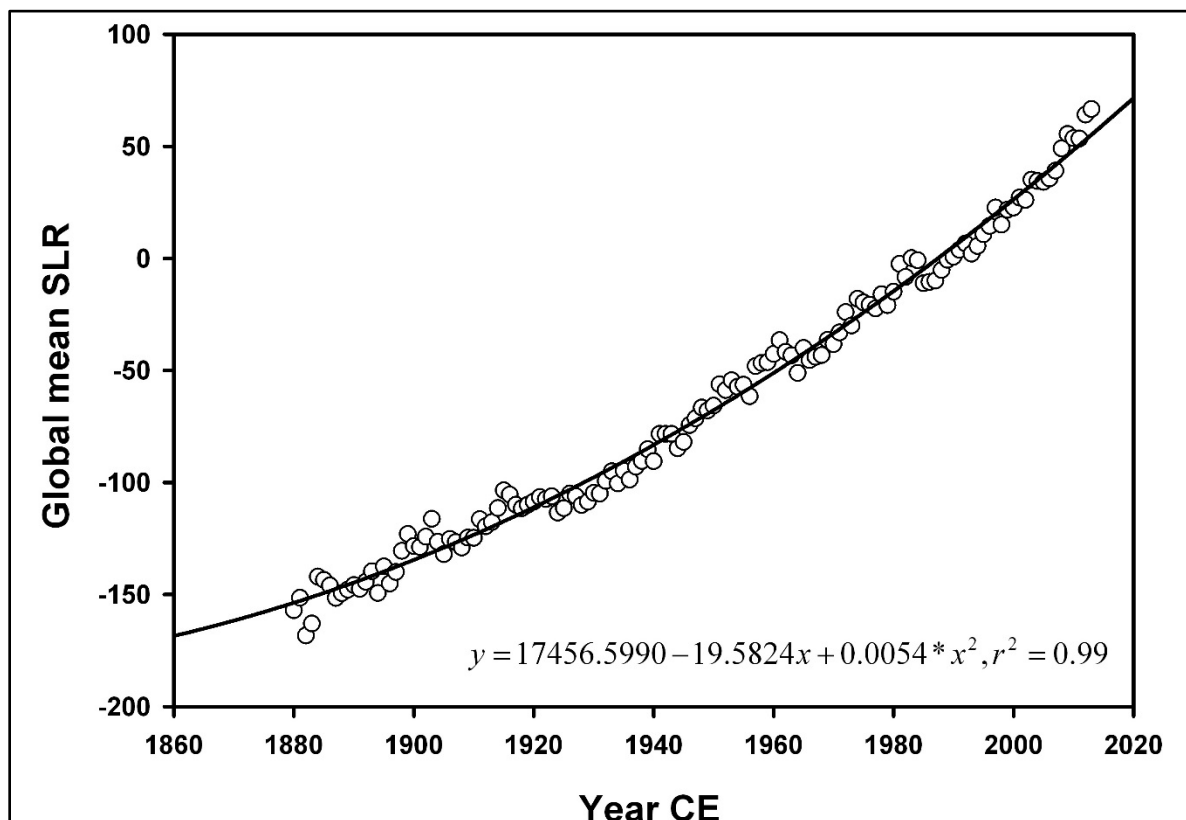


Figure 1-3. Quadratic Fit of Global Mean SLR (mm)

Locally, the rate of relative sea level rise (RSLR), which is a combination of SLR and local land subsidence, has been significantly higher than the global mean, due to the presence of a SLR “hot spot” along the Atlantic Coast of North America (Sallenger et al. 2012) that is part of a larger region in the North Atlantic that is experiencing sea level rise higher than the global mean (Yin et al. 2009). This “hot spot” region extends from Cape Hatteras, NC to Boston, MA and from 1970-2009 has experienced a mean SLR of 3.80 ± 1.06 mm yr⁻¹. The Southern Chesapeake Bay region, which lies in the southern region of this “hot spot,” experienced an even higher mean rate of SLR ($> 4.64 \pm 0.0.85$ mm yr/1) from 1955-2007, due to ongoing land subsidence in the local region caused partly by glacial rebound induced by the melting of the Laurentide ice sheet (Barbosa and Silva 2009, Kleinoksy et al. 2007) which is still causing local land subsidence today (Boon et al. 2010) estimated at 2.101 mm yr/1 for Chesapeake Bay. Local (relative) sea level rise in the southern Chesapeake Bay continues to accelerate, with a quadratic fit similar to the global mean rate. The recent mean rate at Sewells Point (2000-2017) is 4.61 ± 0.23 mm/yr. It is expected that this rate will continue to accelerate. Figure 1-4 below shows the RSLR record in millimeters at the Sewell’s Point gauge.

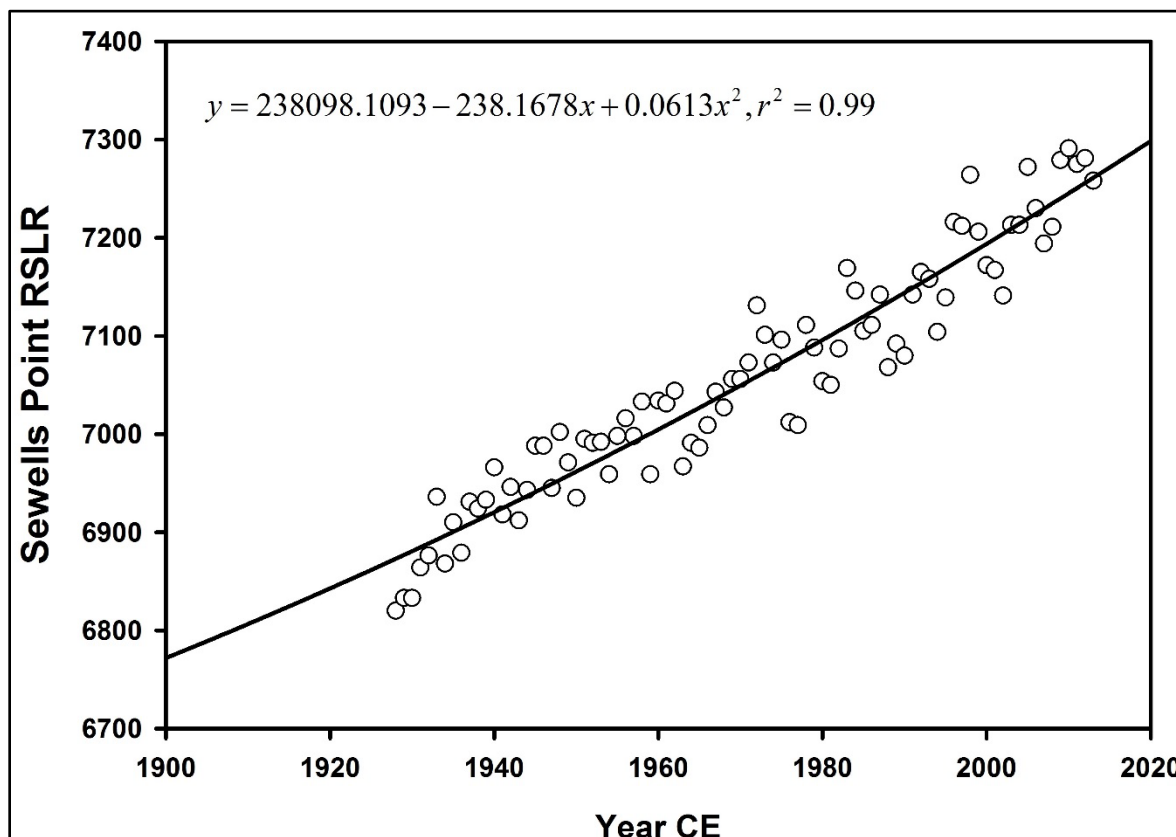


Figure 1-4. Sewells Point Tide Gauge RSLR (mm) Record

Information describing the study assumptions related to RSLR can be found in Section 2.7.2.

1.4.4 Future Storm Frequency and Intensity

This study is currently using existing historical data and information for estimating storm frequency and intensity. This study does not incorporate estimates for changes in future storm frequency and intensity due to a lack of quantifiable data. Future sea level rise estimates are incorporated into the study based on scientific estimates.

Please reference Appendix B for further information regarding future climate change.

1.4.5 Risk Based Storm Frequency Simulation

One of the most significant accomplishments in the last few years is the development and application of numerical models to replicate coastal storm surges and to statistically determine the potential frequency of events at individual locations around Norfolk. There are two sources of storm surge water surface elevations (WSEL) available for analysis and comparison. The Federal Emergency Management Agency (FEMA) has published WSELs for Norfolk in a February 2017 report. The USACE, as part of the North Atlantic Coast Comprehensive Study (NACCS), published the "North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Main Report" in January 2015. As part of the NACCS study USACE developed coastal storm surge WSELs for areas around Norfolk. The WSELs developed by NACCS are adopted and used in the CSRM study for Norfolk.

1.4.6 Socio-Economic Evaluation

As a means to process data for a city of approximately 250,000 people under multiple future scenarios, the PDT utilized a geographic information system (GIS) and census data to assess the damages to residential and non-residential structures, their contents, and vehicles in Norfolk. The application was also used to study census information containing the number of structures, vulnerable populations, employment, income, and critical infrastructure affected by the stages associated with various frequency flood events. Impacts to cultural resources were also studied with a GIS database. These inventories allow the PDT to evaluate alternatives and interact with stakeholders using a flexible and meaningful level of outputs.

1.4.7 Scenario Planning

It is not possible to predict with absolute certainty the various societal and environmental conditions of the future. In order to reduce the risk and uncertainty in the planning phase, various scenarios are evaluated for plan performance. Scenario planning is an approach for dealing with key uncertainties. Scenarios represent futures that can plausibly occur given a set of plausible combinations of future conditions. These conditions represent uncertain values of key drivers that will result in different futures. The key drivers that are anticipated to influence future coastal flood risk in Norfolk are 1) the rates of RSLR (subsidence and sea level rise), 2) storm intensities, and 3) changes in development and population within the City.

1.4.8 Evaluation Criteria for Ranking and Comparing Plans

Plan formulation has been 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, and other federal planning requirements. Plan formulation also considers all effects, beneficial or adverse, to each of the four evaluation accounts identified in the 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* (Principles and Guidelines) which are National Economic Development, Environmental Quality, Regional Economic Development, and Other Social Effects.

1.5 CITY OF NORFOLK HISTORIC STORM DAMAGE RECORD

During the past 84 years, the City has been impacted by six tropical and three extratropical major events: August 1933 Hurricane, Nor'easter (1956), Ash Wednesday Storm (1962), Hurricane Floyd (1999), Hurricane Isabel (2003), Nor'Ida (2009), Hurricane Irene (2011), Hurricane Sandy (2012) and Hurricane Matthew (2016). The tidal surges associated with these storm events inundated structures and caused coastal erosion. Figure 1-5 below shows the water levels in Norfolk from historic storms.

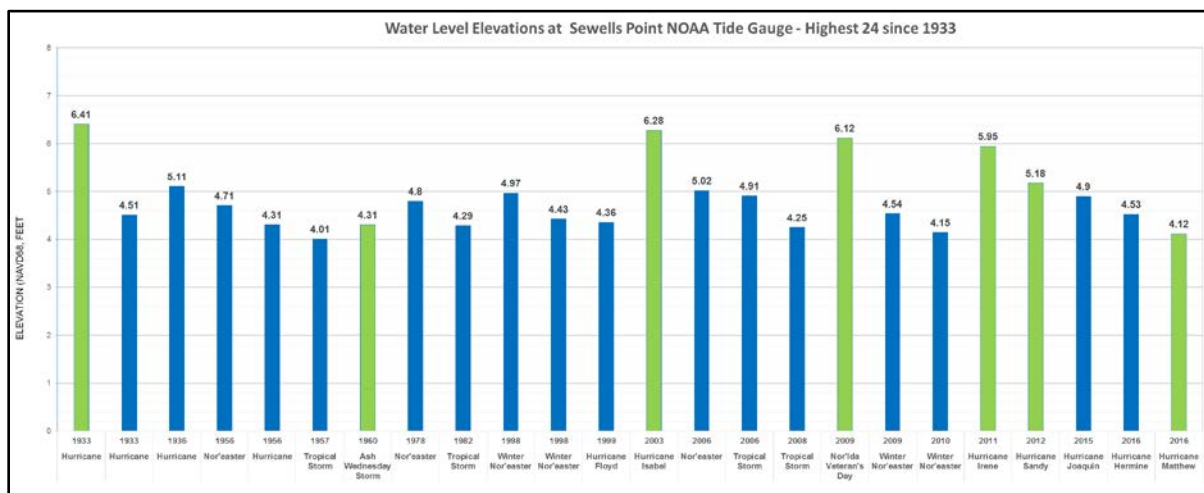


Figure 1-5. Water Levels at Sewells Point for Various Historic Storms

August 1933 Hurricane

The August 1933 Hurricane was and continues to serve as the flood of record for Hampton Roads. The eye passed over Hampton Roads and caused a maximum water level of 6.41 ft NAVD88 at Sewells Point, VA. The storm caused extensive damage to harbor and shipping, waterfront property and low-lying buildings. According to The Norfolk Ledger, dated August 23, 1933, “The entire spit from Nansemond Hotel to the point was under water and at some sections high waves rushed across from Chesapeake Bay to Little Bay.”

According to a pictorial Record of Tidewater’s Worst Storm, August 22 and 23, 1933:

“Untold property damage and an almost complete paralysis of transportation, communication and business was the toll of the tropical hurricane that swept Tidewater, Virginia...”

March 6 - 8, 1962 Nor’easter – “Ash Wednesday Storm”

This nor’easter caused disaster flooding and high waves along the entire Eastern Seaboard. This unusual storm passed Hampton Roads and reversed its motion and drifted south, bringing large volumes of water and waves. The maximum water surface elevation was 5.6 ft NAVD88. The hardest hit sections of the city were the residential and resort communities of East Ocean View, Willoughby Spit and the Central Business District in downtown Norfolk. The waves battered the shoreline for several days resulting in approximately \$4.6 million in damages in 1962 dollars.

The Norfolk Ledger and Portsmouth Star report that “...households all along West Ocean View Avenue from Granby Street to the Hampton Roads Bridge Tunnel indicate waist-high waters cover almost the entire area from Little Bay to the Chesapeake Bay side of the spit.”

Hurricane Isabel (2003)

Isabel made landfall on September 18, 2003, along the Outer Banks of North Carolina and tracking northward through Virginia and up to Pennsylvania. At landfall, maximum sustained winds were estimated at 104 mph. Isabel weakened to a tropical storm by the time it moved into Virginia and lost tropical characteristics as it moved into Pennsylvania. The storm caused high winds, storm surge flooding, and extensive property damage throughout the Chesapeake Bay region. Within Virginia, ninety-nine communities, including Norfolk, were directly affected by Isabel. There were thirty-three deaths, over a billion dollars in property damage, and over a

million electrical customers without power for many days. Historical maximum water level records were exceeded at several locations within the Chesapeake Bay area. In general, maximum water levels in the lower Chesapeake Bay resembled those of the August 1933 hurricane, with storm surge occurring around the time of the predicted high tide. Some communities along the Chesapeake Bay and its tributaries also experienced severe damage from wave action.

Nor'Ida (2009)

Nor'Ida" or the "Veteran's Day Storm" (formed the combination of the remnants of Hurricane Ida and a nor'easter) affected the U.S. east coast for several days in early November of 2009. The interaction between this extratropical low and a strong high pressure system over eastern Canada brought strong winds, coastal flooding, and heavy rains to the mid-Atlantic region. The situation produced large wave heights, strong wave action at the shore, and moderate to severe flooding. Flooding on some barrier islands was worse on the bay side than on the ocean side because of the build-up of water between tide cycles during this lengthy event. The high water mark at Sewells Point in Norfolk, VA, was 6.1 ft NAVD88, just inches under the 1933 Hurricane.

According to the National Weather Service, 7.4 in of rain fell in Norfolk between November 11 and 13, nearly three times the monthly average for November; in those three days alone, the total rainfall surpassed the monthly record of 7.01 in set in 1951. Hurricane-force winds also affected the state, with a peak gust of 74 mph occurring in Norfolk.

Hurricane Irene (2011)

Hurricane Irene was a large and powerful Atlantic hurricane that left extensive flood and wind damage along its path through the Caribbean, the United States East Coast and as far north as Canada. Irene made landfall near Cape Lookout, North Carolina, at around 7:30 a.m. on Aug. 27 as a strong Category 1 storm. On the evening of Aug. 26, well ahead of landfall, Hurricane Irene also spawned several tornadoes. The water surface elevation for Hurricane Irene, reported at Sewells Point, was 5.93 ft NAVD88.

Hurricane Sandy (2012)

Hurricane Sandy impacted 24 states, including the East Coast from Florida to Maine. On October 26, 2012, Virginia Governor Bob McDonnell declared a state of emergency. The U. S. Navy sent ships and forces to sea from the Norfolk Naval Base for their protection and the National Guard was authorized to activate 630 personnel ahead of the storm. In preparation for the storm, authorities closed the Midtown Tunnel and evacuated low-lying areas.

Hurricane Matthew (2016)

On November 2, 2016, President Barack Obama declared a major disaster existed in Virginia due to damage sustained during October 7 – 15, 2016 for the independent cities of Chesapeake, Newport News, Norfolk and Virginia Beach.

Table 1-2 provides a summary of the total Federal Emergency Management Agency (FEMA) flood claims paid to Norfolk policyholders as a result of these tropical events. The table includes the number of paid losses, the total amount paid, and the average amount paid on each loss. The table excludes losses that were not covered by flood insurance.

Table 1-2. Historic FEMA Flood Claims in Norfolk

Event	Year	Number of Paid Claims	Total Amount Paid (1,000s)	Average Amount Paid (1,000s)
Hurricane Floyd (1999)	Aug 99	11	\$83	\$7.7
Hurricane Isabel (2003)	Sep 03	1,281	\$27,071	\$21.1
Nor'Ida (2009)	Nov 09	247	\$25,491	\$103.2
Hurricane Irene (2011)	Aug 11	737	\$12,725	\$17.3
Hurricane Sandy (2012)	Oct 12	202	\$2,557	\$12.7
Hurricane Matthew (2016)	Oct 16	295	\$4,774	\$16.2

Source: Federal Emergency Management Agency (FEMA) as of 3/31/2017

Note: Total amount paid was updated to 2017 price level using RS Means historical cost index for Norfolk, VA.

1.6 PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

Numerous studies and reports have been conducted for Norfolk and the Hampton Roads region. A detailed listing of these reports, from USACE, federal, state, and local entities, can be found in Appendix A.

The NACCS study provides the basis for design water surface elevations for storm surge. Past USACE Continuing Authorities Program (CAP) studies and City of Norfolk engineering studies have provided concepts for coastal storm risk management measures in various areas throughout Norfolk. Studies by other agencies such as FEMA, DoD, and local transportation authorities have identified flood vulnerabilities to military, transportation, and other critical infrastructure in the city.

The existing federal projects of Willoughby Spit and the downtown Norfolk floodwall are considered as part of the existing and future without project conditions for this study. Additional information on the Willoughby Spit Hurricane Protection Project can be read in the Hydraulics, Hydrology, and Coastal Sub-Appendix, attached to the Engineering Appendix.

The floodwall is located at the southwestern corner of downtown Norfolk, on the right bank of the Elizabeth River, near its confluence with the Elizabeth River east branch. The floodwall is 2,674 feet long. From its western end it begins near the corner of Tazewell and Duke Streets and runs along Tazewell, Boush Street, and Waterside Streets to high ground behind the United States Customs House building on Main Street. The top of floodwall elevation is 11.0 to 12.5 feet MSL (10.74 to 12.26 feet NAVD 88), or about 3 feet above the water level during the 1933 hurricane. The floodwall was designed for a still water elevation of 10.0 feet MSL (9.74 feet NAVD 88). The floodwall is 0.5 to 8.5 feet tall with an average height of about 6.5 feet.

The majority of the floodwall is a cantilevered steel sheetpile I-wall with concrete cap. There are five gate closure structures at Brooke Avenue, Plume Avenue, Main Street, Ramp G (entrance to Town Point Park), and North Service Road (service road to the World Trade Center building). The project also includes a pump station incorporated into the floodwall at the foot of City Hall

Avenue at the location of an old slough for interior drainage.

The floodwall system was built by USACE between 1966 and 1971 and turned over to Norfolk for operation and maintenance. Additional information on the floodwall, including an alignment map, is included in the Geotechnical Sub-Appendix, attached to the Engineering Appendix.

An existing flood risk management project is currently under design that will provide coastal flood risk reduction for the Chesterfield Heights neighborhood of the city. This neighborhood is in Area 4 and the project is locally referred to as the Ohio Creek Watershed Project. Construction of the project is anticipated to run from 2019 to 2022 and will include a combination of levees, road raising, stormwater improvements and nonstructural measures. Project design is intended to meet the current FEMA base flood elevation plus three feet. This puts the design elevation for measures in this area at approximately 11 ft NAVD88. This project is assumed to be in place in the future without project conditions.

1.7 PUBLIC AND AGENCY COORDINATION

1.7.1 Interagency Coordination

Interagency coordination began with a kick-off stakeholder meeting on March 24, 2016. Approximately 130 federal, state, and local government officials, resource agencies, academics, and nonprofit organization members were invited to the workshop, with the goal of focusing the Norfolk CSRM study objectives and identifying solutions that would address flood risk in Norfolk. During the workshop, workgroups were formed and conferred on these topics.

In addition, the following were invited to be cooperating agencies: U.S. Environmental Protection Agency (USEPA), U.S. Coast Guard, U.S. Navy, Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA), and the U.S. Fish and Wildlife Service (USFWS). Only the EPA accepted the invitation; however coordination with both the Navy and the Coast Guard has also occurred at various points during this study. Both the Navy and Coast Guard are members of the PDT. A cooperating agency meeting, to which state regulatory agencies Virginia Marine Resources Commission (VMRC) and the Virginia Department of Environmental Quality (VDEQ) were also invited, was held on March 29, 2017; a follow-up meeting with the Navy occurred on March 30, 2017.

Coordination under the U.S. Fish and Wildlife Coordination Act (FWCA) with the U.S. Fish and Wildlife Service (USFWS) is ongoing. Coordination under Section 7 of the Endangered Species Act is ongoing and a Biological Assessment has been prepared and is provided in Appendix D.

Coordination with the NMFS under the Magnuson-Stevens Fishery Conservation and Management Act is ongoing and an Essential Fish Habitat (EFH) Assessment has been prepared and is provided in the Environmental Appendix as well. Coordination as required per Section 106 the National Historic Preservation Act is ongoing and a draft Programmatic Agreement has been prepared and is also provided in the Environmental Appendix. Further coordination will occur between the release of this draft and final report.

Coordination for compliance with Section 106 of the National Historic Preservation Act began

shortly after the planning charrette in March 2017 with a letter on March 30 to the Virginia Department of Historic Resources (VDHR) detailing project measures under consideration and a map showing their locations in relation to known historic resources. The letter proposed using a programmatic agreement (PA) to defer identification surveys to the Preconstruction Engineering and Design stage of the project, and to set forth streamlined reviews of effects and mitigation measures. VDHR responded on June 7 with their willingness to participate in a PA. On June 23, 2017 letters went out to the Norfolk Historical Society, Delaware Nation, Delaware Tribe of Indians, the Nansemond Indian Tribe, and the Pamunkey Indian Tribe describing the project and inviting them to participate in consultation on Section 106 and the PA. The Norfolk Historical Society and Delaware Nation accepted, the Delaware Tribe of Indians declined, and the Pamunkey Indian Tribe has not responded. The Advisory Council on Historic Preservation was invited to participate in the PA on June 23. They requested additional information on July 19, 2017, provided to them on July 20, 2017, and they wrote back declining to participate August 2, 2017. On August 9, 2017 the Naval History and Heritage Command was invited to participate, they have not responded.

1.7.2 Public Involvement

On May 25, 2016, the USACE held a National Environmental Policy Act (NEPA) Open-House-Style Public Scoping meeting, at a local library. USACE staff were on-hand with storyboards to show the areas of the city to be addressed, to describe the potential measures, to answer questions, and to obtain public comments. Approximately 70 people attended, and approximately 30 comments were submitted during and after the meeting.

On June 8, 2017, the USACE held an Open House Public Meeting to update the public on the measures and the alternatives. It was also an open-house style forum, including updated storyboards. Approximately 80 people and the media attended, and 25 more public comments were received.

On November 16, 2017, the USACE held an Open House Public Meeting to allow the public to review and provide comment on the findings of the draft feasibility report released to the public. The meeting was an open-house style forum including updated storyboards, copies of the report for review, and handouts summarizing the findings of the draft report. Approximately 56 people attended and the media was present. Eleven public comments were recorded.

The public comments from all of these meetings are included in Appendix D. Key non-profit organizations Chesapeake Bay Foundation (CBF) and the Elizabeth River Project (ERP) attended the meetings and submitted comment letters. Public comments were also submitted via email during the draft report public comment period.

CHAPTER 2 PLANNING CONSIDERATIONS

2.1 PROBLEMS AND OPPORTUNITIES

There are three primary problems occurring in Norfolk with relation to coastal flooding:

1. Rising sea level, land subsidence and oceanographic changes are increasing the frequency of flooding in the city.
2. Norfolk experiences recurrent flooding that is exacerbated by an inadequate and aging storm water management system and a highly developed urban environment.
3. Access to critical infrastructure, emergency services, and evacuation routes is limited or sometimes cut off entirely during flood events due to roadway (including tunnels, underpasses, and interstate ramps) flooding.

Opportunities are the desirable future outcomes which address the water resource problems and improve conditions in the study area. Opportunities identified for this analysis include:

1. Reduce flood risk and damages to residential, commercial, historic and critical infrastructure within the project area
2. Improve community outreach by educating public/stakeholders about flood risk
3. Improve economic sustainability by reducing flood impacts to areas at risk
4. Reduce transportation impacts due to high water events that make roads impassable
5. Utilize existing open space as areas for water retention and/or storage and use green infrastructure/open space to address flooding issues and also create co-benefits supporting recreation, human health, public access to water, and tourism
6. Create and maintain recreational opportunities when planning for coastal storm risk management.
7. Locate coastal storm risk management project features on publicly owned land and co-locate infrastructure where possible
8. Use a coastal storm risk management project to promote/improve neighborhood connectivity across the city. (ex. greenways, roadway improvements)
9. Leverage and combine all available resources (federal, state, and local) to maximize funding for coastal storm risk management studies and projects
10. Improve wildlife habitat and reduce shoreline erosion through creation of Natural and Nature-Based Features (NNBF)

2.2 OBJECTIVES

The goal of this study is to recommend a holistic suite of coastal storm risk management measures for Norfolk to address flooding damages due to coastal storm events.

The following objectives will help to achieve the study goal:

1. Reduce economic damages from coastal storm risk to business, residents and infrastructure in Norfolk
2. Reduce risk to human health and safety from storm impacts in Norfolk
3. Improve the resiliency of the local economy to impacts from coastal storms

2.3 CONSTRAINTS

Constraints are conditions to be avoided or things that cannot be changed, which limit the development and selection of alternative plans. Specific constraints for this analysis include:

1. Maintain access to military installations during flooding events and avoid impacts on military infrastructure and operations
2. Avoid and minimize the impacts of a project on historic assets and preserve the character of the historic districts and structures

Other planning **considerations** include:

1. Avoid creating or exacerbating existing social justice issues
2. Minimize project impacts to the city's tax base
3. Avoid and/or minimize impacts to existing environmental resources
4. Maintain cultural and socio-economic cohesiveness across different neighborhoods and areas of the city and avoid isolating neighborhoods as a result of the recommended project
5. Leverage and combine all available resources (federal, state, and local) to maximize funding for coastal storm risk management studies and projects
6. Integrate structural, nonstructural and Natural and Nature-Based Features (NNBF)
7. Avoid creating or exacerbating flooding within the project area, to other municipalities, and to local military installations
8. Avoid or mitigate impacts on neighboring cities (Virginia Beach, Chesapeake, and Portsmouth)

2.4 MULTIPLE LAYERS OF RESILIENCY

Resiliency increases when there are multiple layers incorporated in any risk management project and this is especially true in coastal storm risk management planning. By incorporating multiple layers, residual risk is reduced and there is a certain level of redundancy that improves the overall level of resiliency for Norfolk. In this study, a combination of three key coastal storm risk reduction components—structural measures, nonstructural measures, and natural and nature based features are being investigated by USACE.

The coastal storm risk management measures that will eventually be proposed in the USACE Recommended Plan (RP) will be augmented by recent and ongoing planning and resiliency efforts by Norfolk. The following actions are considered additional layers of resiliency that will complement future coastal storm risk management efforts proposed by the USACE.

Increased Freeboard Requirements

Effective in January 2014, an additional three feet of required elevation, above the effective FEMA Base Flood Elevation (BFE), for structures located within the 1% annual chance floodplain (100 year) was added to the city's floodplain ordinance as the standard for new construction and any substantial repair or improvement. An 18 inch freeboard above grade is also required in the 0.2% annual chance floodplain (500 year) floodplain to reduce risk of property damage and improve resilience during flood events.

Norfolk Zoning Code

Norfolk's new zoning ordinance was unanimously adopted by City Council on January 23, 2018. The new zoning code encourages and supports development that makes Norfolk more resilient, both physically and economically. The code contains a number of pioneering approaches in response to the long-term challenges posed by sea level rise. The new code requires all development within the city to meet a resilient quotient. The requirement is measured on a points system covering three separate resilience elements: risk reduction, stormwater

management, and energy resilience. Additionally, new or expanding development must meet minimum requirements for first floor elevations as described above with Norfolk's increased freeboard requirements.

2.5 PERIOD OF ANALYSIS

The period of analysis for all the alternatives is the 50-year period from 2026 to 2075. Project implementation is expected to begin in the year 2021, depending on the alternative. The implementation period is the time period that construction is expected, which would run from 2021 to 2026. The base year is considered the year the alternatives have been implemented and benefits begin accruing. The base year is assumed to be 2026. In order to evaluate plan performance out over a minimum of 50 years which is standard USACE policy, future damages were calculated out to year 2075.

The alternative that is selected as the RP will be assessed for engineering and environmental performance out to 100 years from project implementation, which is estimated to be the year 2125. This 100 year period for consideration of coastal sustainability is in compliance with USACE Principle and Guidelines.

2.6 DEVELOPMENT / REDEVELOPMENT PROJECTIONS

Norfolk is estimated to be 95% built out. Because of this there is not expected to be any significant development of land that is not already developed in some form. Any significant future developments are expected to be redevelopments. Any redevelopment is expected to be constructed to established higher standards including freeboard above the FEMA BFE.

Recognizing the Federal government's commitment to ensure no inducement of development in the floodplain pursuant to Executive Order (EO) 11988, this project will identify in the Project Partnership Agreement (PPA) the need for the non-Federal sponsor to develop a floodplain management plan and a requirement for the sponsor to certify that measures are in place to ensure that the project does not induce development within the floodplain. The Policy Guidance Letter (PGL) No. 52, Flood Plain Management Plans, stipulates the requirement for the project sponsor to prepare a floodplain management plan within one year of the PPA execution. The floodplain management plan must also be implemented not more than a year after completion of project construction. Norfolk, as the non-Federal sponsor, is expected to comply with the requirements of the EO 11988 and the PGL No. 52.

2.7 CRITICAL ASSUMPTIONS

In order to move forward in the decision making process, the Norfolk CSRM PDT made certain assumptions and simplifications while performing this study. Critical assumptions from various disciplines were deliberated within the USACE and communicated with decision makers in the form of a risk register. A few of the most significant assumptions for each discipline are listed below:

Economics: HAZUS user defined facility points and repetitive loss polygons, developed for the 2017 Hampton Roads Mitigation Plan, were used to highlight areas of need and focus. HEC-FDA and Beach-fx are USACE approved economic models that were employed in in this study. Beach-fx covered the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project

area where beach erosion occurs. HEC-FDA was used for the remainder of the city where wave action is less significant, shoreline types differ from the beach/dune environment, and flood inundation is the dominant risk factor. HEC-FDA is typically applied in riverine, flood prone areas, however it has been employed in other coastal projects such as the Coastal Texas Protection and Restoration Study.

Engineering: Existing information was used for geo-environmental and utilities. Additional surveys will occur in Preconstruction Engineering and Design (PED).

Environmental: Interim impacts analysis was used to inform the RP selection with more thorough analysis conducted post-RP. Section 106 surveys will be completed during PED. Hydraulic and water quality modeling is limited to maximum impact areas and no sediment transport modeling will be conducted.

Scenario planning is a purposeful examination of a range of potential futures that addresses the uncertainty inherent in long-term planning. Unlike forecasts, scenarios do not indicate what the future will look like so much as what the future could look like. Scenario construction helps planners, decision makers, and stakeholders better adapt to a rapidly changing and complex future. Scenario planning acknowledges the critical influence of a few uncertainty drivers on the future condition that provides the base condition for evaluation. For the Norfolk CSRM analysis, RSLR and storm intensity were identified as the most important drivers that affect the performance of coastal storm risk management plans.

A table that provides a more comprehensive list of some of the important decisions, along with a qualitative assessment of the risks and consequences associated with those decisions, is included in Appendix A.

2.7.1 Storm Intensity and Water Surface Elevations

There are multiple storm variables that affect the intensity of storm surge. The wind magnitude, storm size, and exposure time are some of these variables. The NACCS developed coastal WSELs based on a suite of storms in order to estimate the probability of various storm surge WSELs. Lower probability events represent more extreme storms that produce higher WSELs. There are 11 locations off the coast of the city where the NACCS calculated water surface elevations. Modeled WSELs as reported by NACCS were compared to currently published FEMA WSELs throughout the Norfolk coastline. A comparison of the NACCS and FEMA estimated WSELs for existing conditions is presented in Table 2-1. The comparison is at The Hague, a neighborhood near downtown Norfolk. There are other locations around the city with FEMA and NACCS calculated values and they follow a similar relationship to that shown below.

Table 2-1. 2017 FEMA and 2016 NACCS Water Surface Elevations (feet NAVD88)

Study	Annual Chance Exceedance			
	10%	2%	1%	0.2%
FEMA	5.7	7.2	7.8	9.8
NACCS	7.3	10.0	11.1	13.7

USACE guidance directed the study to use NACCS water surface elevations for project design. A discussion comparing the FEMA and NACCS modeling can be found in Appendix B.

2.7.2 Relative Sea Level Rise Projections

This study is formulated to consider the impacts that RSLR will have on future conditions both with and without project alternatives in place and is consistent with ER 1100-2-8162, "Incorporating Sea Level Change in Civil Works Programs". Research by climate science experts predict continued or accelerated climate change for the 21st century and possibly beyond, which would cause a continued or accelerated rise in the sea level in the Norfolk area. The resulting RSLR will impact future USACE coastal projects and system performances. As a result, coastal studies must consider how sensitive and adaptable both environmental and engineered systems are to the effects of RSLR and climate change.

The forecast for Norfolk includes a relative sea level change for the 50-year period of analysis of 2026 – 2075. According to the USACE Sea Level Rise Calculator, water levels will rise 0.74, 1.25 and 2.87 feet for the USACE low, intermediate and high curve estimates. Other entities have made RSLR predictions for the area. The National Oceanic and Atmospheric Administration predicts higher rates of RSLR than USACE. Sea level rise estimates are provided in Figure 2-1 and Table 2-2.

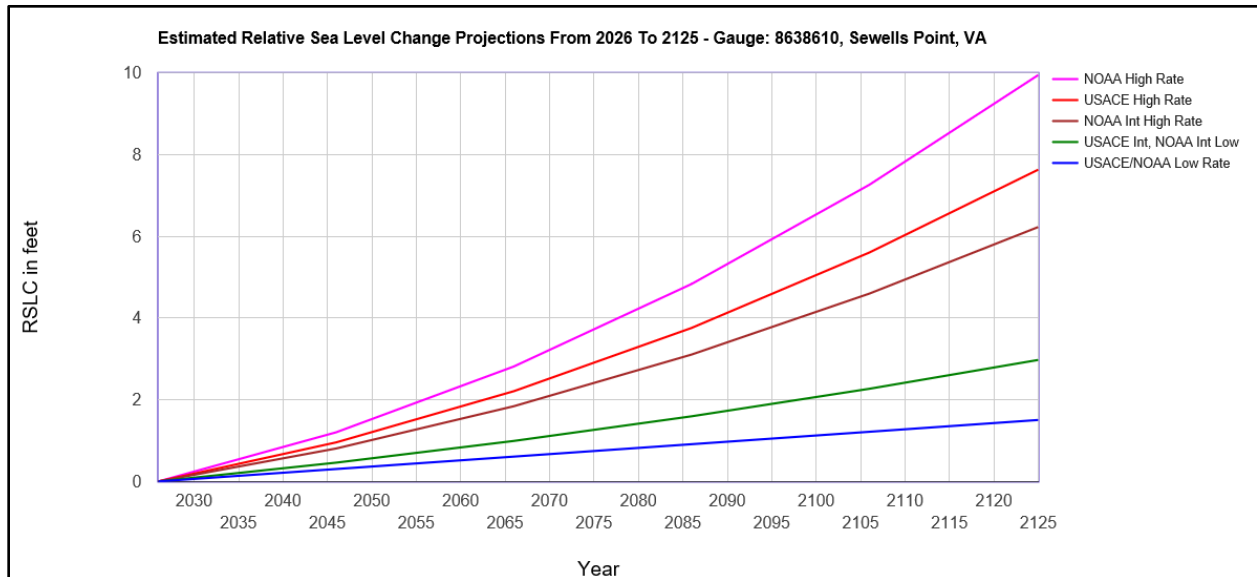


Figure 2-1. Relative Sea Level Rise at Sewell’s Point, VA

Table 2-2. Estimated RSLR (feet) at Sewells Point, VA

Estimated Relative Sea Level Change from 2026 To 2125							
8638610, Sewells Point, VA							
User Defined Rate: 0.01520 feet/yr							
All values are expressed in feet							
Year	NOAA Low	USACE Low	NOAA Int Low	USACE Int	NOAA Int High	USACE High	NOAA High
2026	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2030	0.06	0.06	0.09	0.09	0.14	0.17	0.21
2035	0.14	0.14	0.20	0.20	0.34	0.39	0.49
2040	0.21	0.21	0.32	0.32	0.54	0.64	0.80
2045	0.29	0.29	0.44	0.44	0.76	0.90	1.13
2050	0.37	0.37	0.56	0.56	1.00	1.18	1.49
2055	0.44	0.44	0.69	0.69	1.25	1.48	1.88
2060	0.52	0.52	0.83	0.83	1.51	1.80	2.29
2065	0.59	0.59	0.96	0.96	1.79	2.14	2.72
2070	0.67	0.67	1.11	1.11	2.08	2.50	3.19
2075	0.75	0.75	1.25	1.25	2.38	2.87	3.67
2080	0.82	0.82	1.41	1.41	2.70	3.26	4.19
2085	0.90	0.90	1.56	1.56	3.04	3.68	4.72
2090	0.97	0.97	1.72	1.72	3.39	4.11	5.29
2095	1.05	1.05	1.89	1.89	3.75	4.55	5.88
2100	1.13	1.13	2.06	2.06	4.13	5.02	6.49
2105	1.20	1.20	2.23	2.23	4.52	5.51	7.13
2110	1.28	1.28	2.41	2.41	4.93	6.01	7.80
2115	1.35	1.35	2.60	2.60	5.35	6.53	8.49
2120	1.43	1.43	2.78	2.78	5.78	7.07	9.21
2125	1.51	1.51	2.98	2.98	6.23	7.63	9.95

The USACE intermediate curve was selected for use in estimating future design water surface elevations and formulation of the RP. The intermediate curve is believed to represent a reasonable estimate of RSLR with the information available today and is recommended for use by USACE guidance. The USACE high curve will be used to analyze how sensitive the RP is to a lower probability, but scientifically feasible, extreme RSLR.

2.7.3 Future Scenarios and Design Water Levels for Formulation

Future with-project and without project scenarios were compared to aid decision making. The primary variables that were believed to have most impact on choosing the best RP for the future were the storm intensity and the rate of sea level rise. The formulation for this project was to compare the performance of various alternatives from a time period of 2026 to 2075 using the

NACCS WSEL estimates and the USACE intermediate sea level rise to 2075. Future without-project and with-project scenarios included assumptions about other future projects and conditions that are reasonably likely to occur in Norfolk. The Ohio Creek Watershed Project discussed earlier is an example of a project assumed to be in place in the future condition scenarios.

A wide variety of potential solutions were preliminarily considered for reducing flood risk to Norfolk, but were screened out from further consideration. Many of these solutions (e.g. surge barrier across the Chesapeake Bay or the Elizabeth River) would require regional coordination and cost sharing to not only expand the project authorization but to align with the fiscal realities of a project sponsor's financial capabilities. Other solutions, such as floodwalls surrounding the entire city or ringing large portions of the city were screened out based on high cost and the feasibility of constructing such a large project at once. Other concerns associated with ringing the city with floodwalls include the social impacts of large barriers dividing up the city along with impacts to traffic, and potential impacts to adjacent municipalities.

The authority of the Norfolk CSRM Study identified Norfolk as the sole study sponsor. This means that Norfolk is not only responsible for assuming the sponsor study cost share but it is also the sole cost share partner for construction of the Recommended Plan. Therefore, fiscal limitations of the city were considered when identifying feasible solutions to coastal flooding. Based on the study authority economic benefits of the study plan were limited to those that accrue in the City of Norfolk. Flood risk management solutions were justified primarily on their benefits to the economy, with the benefits being weighed against costs for economic justification. Any plan that would provide a regional solution would require an expanded authorization that commits other municipalities in the region. For these reasons, the PDT felt that the most feasible path would be to investigate solutions within Norfolk that would be constructed independently and would function independently from one another. These are known as separable measures. The start of this process was to divide the city into various areas for investigation.

The four areas of the city that are described in Chapter 1 were used to investigate separable flood risk management measures. These separable measures would meet study authority requirements and would also be at a scale that would be fiscally feasible for the City of Norfolk to cost share. The low lying topography of Norfolk, along with interconnected waterways that run through the city, limit the options for providing flood risk management to the entire city with one large project (e.g. large floodwall or levees surrounding the city). This means that topography would be required to keep floodwaters from overflowing one area and into another and potentially flanking a proposed measure. Figure 2-2 below shows the four areas of the city along with a perspective of the local topography. Note the limited availability of high ground between the areas. Generally speaking there is a limit in the 11-13 ft range between the various areas. The PDT used this 11-13 ft range as a general benchmark for the highest design level to consider for this study.

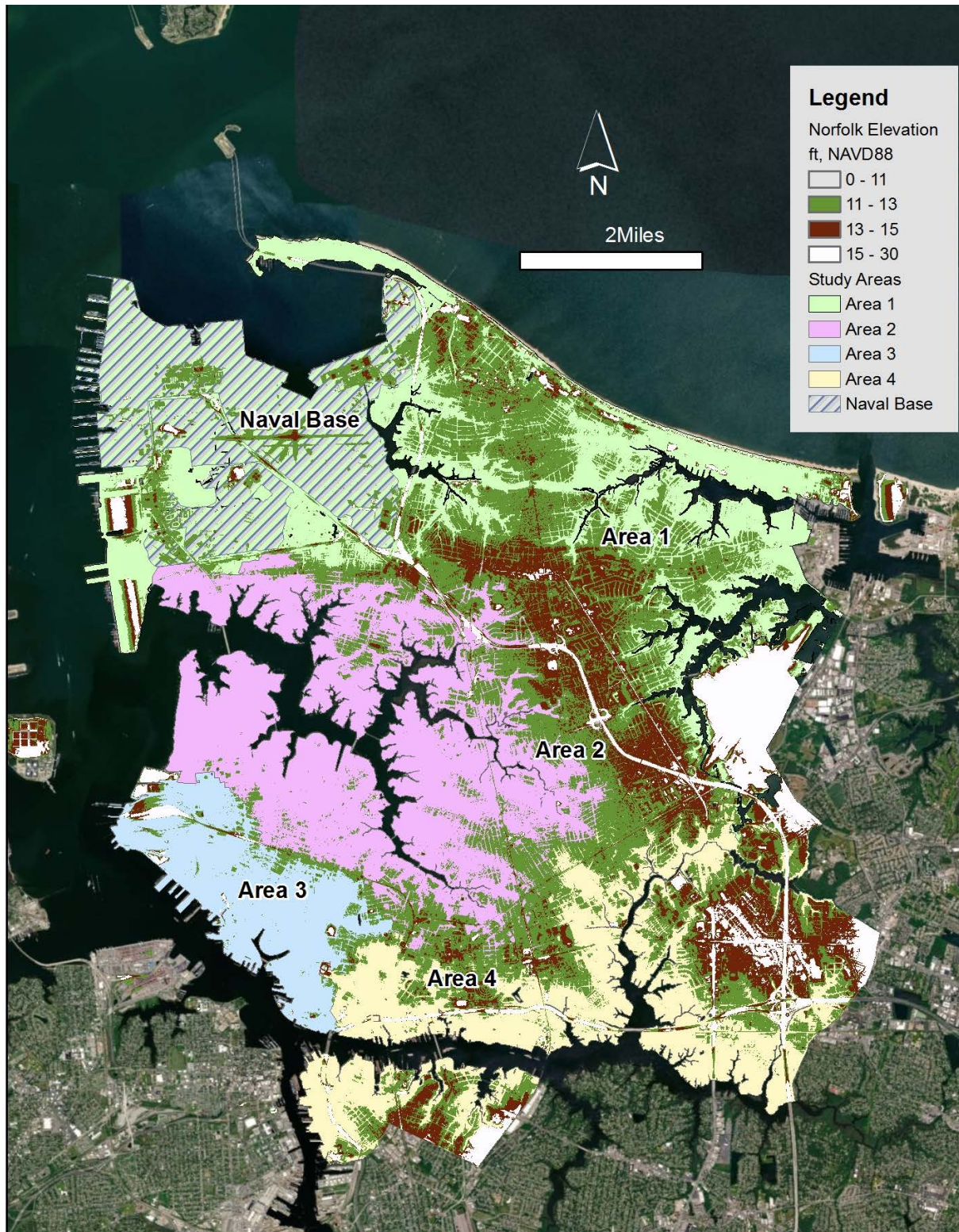


Figure 2-2. Topography of Norfolk

Water surface elevation estimates for storm surge vary in different areas of the city. Generally the storm surge elevations increase from Area 1 to Area 4. The following paragraph and Table 2-3 and Table 2-4 describe and show the WSEL frequencies used in the study and how they are estimated to vary across Norfolk.

The PDT estimated the elevations where Areas 1, 2, 3 and 4 were separable from one another. The elevation of separation generally corresponds with a predicted year 2075 NACCS 1.4% ACE (70-yr) storm event. This assumes sea level rise to 2075 based on the USACE intermediate curve. It is at this elevation where the limits of separability between areas of Norfolk begin to be observed. Based on this limit of separability the PDT decided that the NACCS 1.4% ACE (70-yr) WSEL should be the maximum in the range of elevations used for formulating separable measures throughout Norfolk. The 2075 10% ACE (10-yr) event was decided to be the minimum WSEL that would create substantial enough flood damages to justify a large flood reduction construction project. The WSEL associated with the 10% NACCS ACE is the lower limit of the analysis. A middle value of the 3% ACE (35-yr) event was determined to be an appropriate midpoint for the formulation. The water levels at the NACCS 10%, 3%, and 1.4% probabilities are higher than FEMA 10%, 2%, and 1% ACE events respectively and therefore are believed to cover an acceptable range of water levels.

Table 2-3. NACCS Water Levels (ft, NAVD88) at 2016

NACCS Stillwater Level w/o RSLR					
% Flood	Annual Recurrence Interval (Years)	Area 1	Area 2	Area 3	Area 4
10	10	6.67	6.67	7.14	7.47
3	35	8.04	8.04	8.72	9.15
1.4	70	9.15	9.15	9.92	10.35

Table 2-4. NACCS Water Levels (ft, NAVD88) by 2075

NACCS Stillwater Level w/ RSLR (+1.45 +/- 0.1')					
% Flood	Annual Recurrence Interval (Years)	Area 1	Area 2	Area 3	Area 4
10	10	8.12	8.12	8.59	8.92
3	35	9.49	9.49	10.17	10.60
1.4	70	10.60	10.60	11.37	11.80

Formulation for the Final Array of alternatives is based on the 3% ACE storm surge event. The Final Array are those alternatives that are compared against each other for economic, environmental, and social impacts. The 3% ACE storm level is selected as the initial design water level because it supersedes the published FEMA 1% ACE water levels in the area. The Final Array plan that most reasonably maximizes net annual benefits is then selected as the TSP. The TSP is then optimized for performance assessment at the 10%, 3%, and 1.4% NACCS ACE water surface elevations. Optimization assumes that the measures that make up the TSP will remain the same but the design parameters, such as wall height, may change. The final selected plan and design level is called the RP.

The RP will be assessed for performance against two other scenarios in order to identify further risks and options for adaptability. The plan will be compared to a scenario in which the USACE high RSLR curve is assumed in order to identify the risks associated with an unlikely and

extreme event. The RP will also be assessed for risk and adaptability 100 years out to 2125 in order to see how the plan performs further out into the future.

In order to formulate for an alternative that reasonably maximized net economic benefits, several project levels of design were compared to find the most economically efficient variation. Three design WSELs that provide a low-medium-high range of flood risk management were selected for analyzing a range of costs and benefits.

2.8 PLANNING REACHES

All areas of the city were evaluated for flood risk and then various measures were considered for reducing that risk. The city was segmented into planning reaches that follow hydrologic boundaries much like a drainage catchment. The planning reaches provide natural, hydrologic boundaries for delineating structural measures and create sensible boundaries for analysis of nonstructural measures. The planning reaches are also the geographic boundaries for assessing economic damages with the models HEC-FDA and Beach-fx (reaches Ra, Rb, and Rc only). The economic benefits from nonstructural and structural measures will be compared in future without-project (FWOP) and future with-project (FWP) scenarios by comparing the costs associated with each measure against the benefits they provide. Figure 2-3 below shows the planning reaches used in the study.

The inundation layer drawn with the planning reaches in Figure 2-3 shows which reaches are hydraulically separable and which ones may need to be grouped together. The inundation layer shown is the predicted water level in 2075 from an estimated USACE intermediate level of RSLR and a 3% (35-yr) NACCS storm event. Based on the inundation mapping, the study area can be grouped into several areas with hydraulic connections. The following is a brief description of the areas and the nature of their hydraulic connections. Generally, the areas of the city become connected when surge elevations reach elevations approximating the 1% ACE NACCS WSEL.

Lake Whitehurst Area

The Lake Whitehurst (LW-1, LW-2) area is considered hydraulically separable from other reaches up to approximately 11-12 ft NAVD88 except for reach BC-1 where a drainage channel connects the reaches at the southern side of the Norfolk airport. This connection is not considered to be a source of significant flood risk between Areas due to the limitation on the channel size and the culvert connections under roadways between Areas 1 and 4.

Pretty Lake Area

The Pretty Lake area constitutes planning reaches PL-1, PL-1a, and PL-2. This area is considered separable from the surrounding reaches of the Mason Creek (WB-2), Lake Whitehurst (LW-1, LW-2), Lafayette River (LR-2) and beach (Rb and Rc) reaches. An elevation of approximately 10 ft is estimated to be an approximate limit where high ground on the landside of Willoughby Beach would prevent significant storm surge from entering the Pretty Lake area.

Willoughby Beach

Reaches along the beach (Rb and Rc) can become inundated from back flooding in Pretty Lake, therefore, reaches Rb and Rc, would rely upon structural measures to prevent back flooding in Pretty Lake in order to reduce flood risk to some areas of those reaches. Flooding from the

beach, however, does not impact the Pretty Lake area from surge elevations of approximately 10 ft or below. The beach reaches are separable from the Mason Creek (WB-2) area at the analyzed water surface elevations. Reach Ra and reach WB-1 are connected hydraulically by back flooding from the southern side of the spit.

Mason Creek, Glenwood Park, and Norfolk Naval Station Surrounding Areas

The Mason Creek (WB-2) area is considered separable from flooding from surrounding reaches up to approximately the 1.4% ACE NACCS WSEL. This event is associated with WSEL of approximately 11 ft. At this point inundation appears possible from reach WB-2 into naval station areas in WB-2a. The city neighborhood of Glenwood Park lies in the middle of WB-2a. This neighborhood is believed to be hydraulically separable from surrounding reaches. Above elevation 11 ft the risk of flooding between the Lafayette River watershed, the naval base area, and the Mason Creek area becomes more likely.

Lafayette River

The watershed of the Lafayette River (LR-1, LR-2) has hydraulic connections to reach MS-2. Up to approximate WSEL 11.5 ft these connections are through storm drainage systems and are not considered significant. The Lafayette River watershed is considered hydraulically separable from all other reaches at WSELs below approximately 11.5 ft. Train tracks on high ground separate LR-1 and LR-2 from the EB-1, EB-1a, and H-1 reaches, however, above elevation 11.5 ft there is increasing risk of flooding between these areas due to limitations in the elevation of high ground.

Ghent, Downtown, and Harbor Park Areas

Hydraulic connections exist between the EB-1, EB-1a, H-1, EB-2, EB-3, EB-3a, EB-5, and EB-5a reaches. EB-6 is currently undergoing coastal storm risk reduction project and therefore this area is considered separable from the other reaches. There is a small area to the east of reach EB-5 where flooding from a creek in EB-7 could occur. At approximate elevations of 11.5 ft and above this area can hydraulically connect to the Lafayette River watershed.

Broad Creek Area

The Broad Creek watershed (BC-1) is hydraulically connected to the Lake Whitehurst reach LW-2 through a drainage channel. This channel is not considered a significant threat to flooding between the reaches due to the size of the channel and hydraulic constrictions at culverts. Reach BC-1 is connected by a creek to reach EB-7. Most of the boundary between BC-1 and EB-7 and EB-8 is separated by a highway embankment. At water surface elevations of 12 ft and above overland flow between the Broad Creek watershed and the Lafayette River watershed appear to be possible.

Campostella / Berkley Area

Reaches EB-4, EB-4a, and EB-4b constitute the Campostella and Berkley neighborhoods. These areas are considered hydraulically separable from other areas of the city due to their separation by the Elizabeth River.

Neighborhood Cohesiveness

Norfolk has a diverse range of neighborhoods that vary by socioeconomic status. Several planning considerations relate to maintaining neighborhood cohesiveness and avoiding negative

impacts to social justice issues. There are two areas where modeling for HEC-FDA required a planning reach to be subdivided in order to model structural features. These two cases are 1) PL-1a partitioned out from PL-1 and 2) EB-4a and EB-4b partitioned out from EB-4. From a community cohesiveness standpoint PL-1 and PL-1a are considered one community and EB-4a, EB-4b, and EB-4 are considered one community.

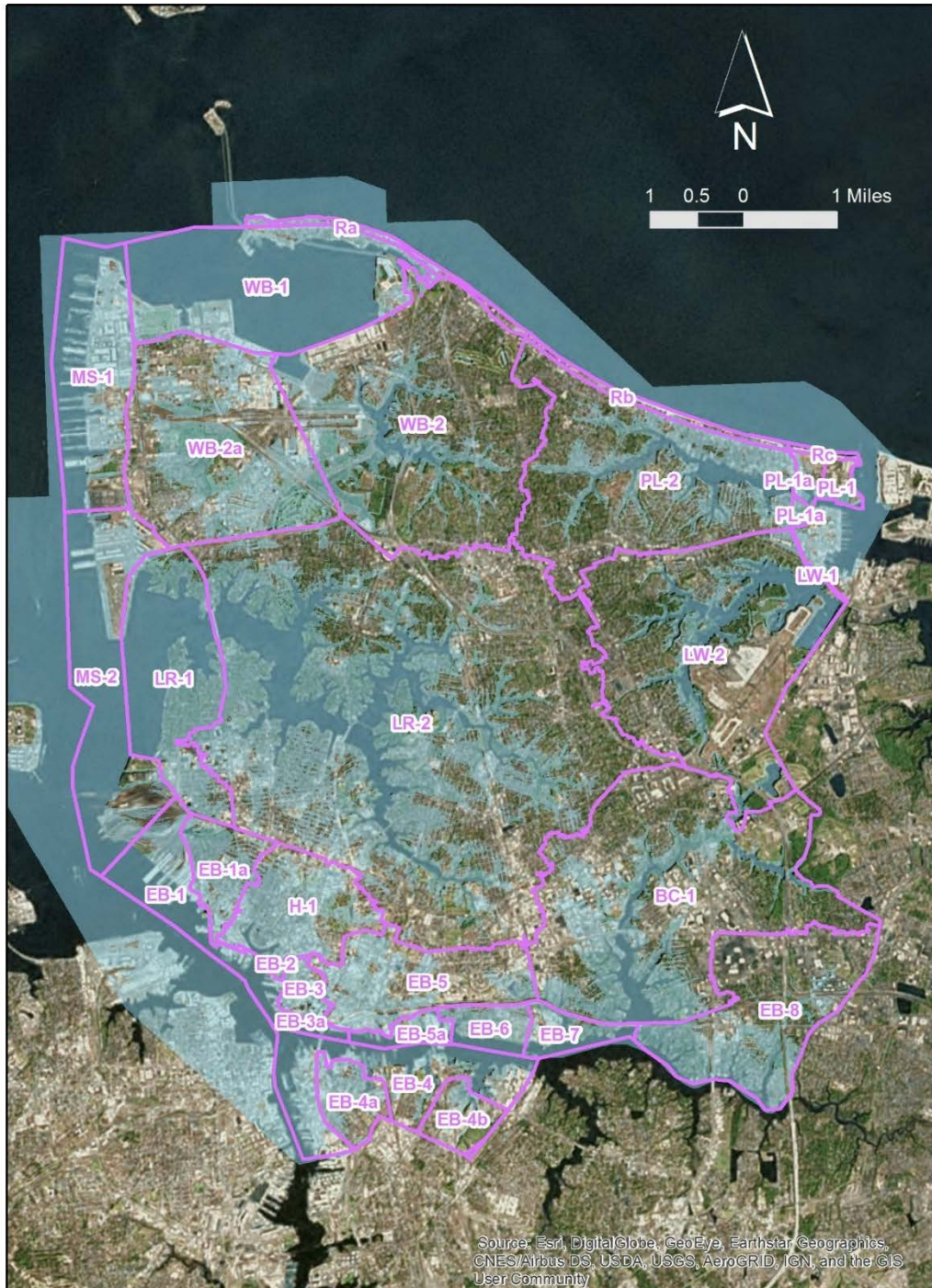


Figure 2-3. Planning Reaches and 2075 NACCS 3% (35-yr) Inundation Map

2.9 AREAS OUTSIDE THE STUDY ALIGNMENT

There are two areas that are considered to be outside the project alignment at the study start. The first of these areas is Naval Station Norfolk, located within portions of reaches MS-1, WB-1, WB-2, and WB-2a. The second area is the Chesterfield Heights neighborhood which is the reach EB-6. A further description of considerations for both these areas is provided below.

2.9.1 Naval Station Norfolk

The NSN is a federally owned property and therefore cannot be used to justify benefits for USACE Civil Works projects. This does not mean that USACE is prohibited from recommending project features be constructed on NSN property; however, benefits from features constructed on NSN property cannot be counted toward overall project benefits. The study does the following to ensure the NSN facility area is considered for impacts to other areas:

- 1) The study considers the flow paths over the NSN area and how those flow paths will impact portions of the city.
- 2) The NSN area is considered for projects that may prevent flooding on City of Norfolk property.
- 3) The study considers secondary benefits to the NSN operations through risk reduction measures that will improve transportation to the facility and reduction in risk to sailor housing located in the city.
- 4) The NSN is a stakeholder in the study and has been appraised of the study results throughout the process.

2.9.2 Chesterfield Heights

Chesterfield Heights is a neighborhood that lies between I-264 and the Elizabeth River east of downtown Norfolk. The area is shown as reach EB-6 in Figure 2-3. Norfolk is currently undergoing design for coastal storm risk management of this area through a Housing and Urban Development grant. The project is called the Ohio Creek Watershed Project. The design is expected to include a mix of structural, nonstructural, and NNBF measures that will reduce flood risk to this area. Due to the efforts of Norfolk in this area, the fact that design and construction funding is on hand, and the level of design, the study team feels that this area does not need to be studied by the USACE at this point. The USACE study does the following to ensure the Chesterfield Heights area is considered for impacts to other areas.

- 1) USACE study will consider flow paths in the Chesterfield Heights area to appropriately assess any measures that need to tie-in to the Ohio Creek Watershed Project.
- 2) USACE team receives updates on the Ohio Creek Watershed Project design changes to ensure appropriate alignment

However, the final design of the project in Chesterfield Heights is not complete and so there is always risk that there will not be perfect alignment with the USACE study. At this point the risk is not considered significant based on what the team has observed from conceptual designs. Figure 2-4 below shows the latest conceptual design received in April of 2018.

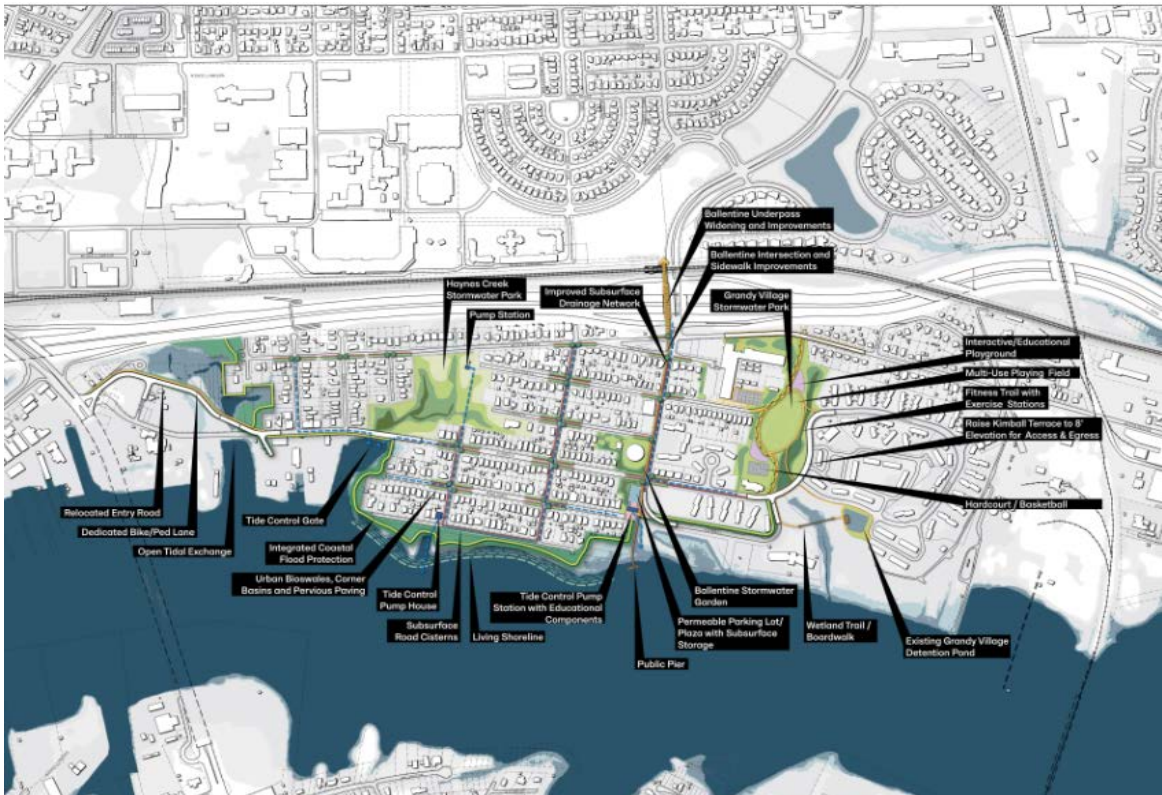


Figure 2-4. Conceptual Design of the Ohio Creek Watershed Project at Chesterfield Heights

CHAPTER 3 HYDROMODELING ANALYSIS

3.1 NACCS HYDROMODELING ANALYSIS

Water surface elevations for the study area were determined using estimated storm surge water levels from the NACCS study in combination with estimated levels of RSLR from the USACE sea level rise calculator. Hydrodynamic modeling was completed for water quality analysis and environmental impacts. The water quality modeling effort is discussed in Section 10.4 WATER QUALITY. The sections below will discuss the NACCS modeling efforts for the determination of water levels.

3.1.1 Modeling of Surge Levels and Wave Characteristics

A suite of high-fidelity numerical models were used for the NACCS Study. The model effort provided information for computing the joint probability of coastal storm forcing parameters. The numerical modeling study was performed using the high-fidelity models within the Coastal Storm Modeling System (CSTORM-MS). The NACCS numerical modeling study produced nearshore wind, wave and water level estimates and the associated marginal and joint probabilities. Data (storms, waves, tides, etc.) was collected from many resources. Once storms were selected and the necessary data was inputted into the models ADCIRC was used to simulate the surge and circulation response to the storms; and STWAVE was used to provide the nearshore wave conditions including local wind generated waves.

ADCIRC is a system of computer programs for solving time dependent, free surface circulation and transport problems in two and three dimensions. This model utilizes the finite element method in space allowing the use of highly flexible, unstructured grids. Typical ADCIRC applications have included:

- prediction of storm surge and flooding
- modeling tides and wind driven circulation
- larval transport studies
- near shore marine operations
- dredging feasibility and material disposal studies

STWAVE uses a finite-difference representation of a simplified form of the spectral balance equation to simulate near-coast, time-independent spectral wave energy propagation.

Once the models were calibrated and validated, NACCS production began on the suite of 1150 storms for three conditions (historical extratropical storms, historical tropical storms, and synthetic tropical storms and were executed for all production simulations). The products of this detailed, large-domain modeling study are intended to close gaps in data required for coastal storm risk management analyses by providing statistical wave and water level information for the entire North Atlantic coast, while providing cost savings compared to developing coastal storm hazard data for individual local projects.

3.1.2 Determination of Stage Frequencies

Floods are generally explained according to their likelihood of occurring in any given year at a specific location. The most commonly used definition is the “100-year flood”, which is also referred to as “1 percent flood” or having a “recurrence interval” or “return period” of 100 years.

The NACCS study incorporated existing and future forcing and potential future climate change to perform statistical analyses and numerical hydrodynamic modeling for the region. The statistical analyses resulted in Stillwater level elevations for a 1 year, 2 year, 5 year, 10 year, 20 year, 50 year, 100 year, 200 year, 500 year, 1,000 year, 2,000 year, 5,000 year, 10,000 year storm event frequencies and for different confidence limits.

The NACCS study report goes on to read that, “a common misinterpretation is that a 100-year flood is likely to occur only once in a 100-year period. In fact, a second 100-year flood could occur a year or even a week after the first one. The term only means that that the average interval between floods greater than the 100-year flood over a very long period (say 1,000 years) will be 100 years. However, the actual interval between floods greater than this magnitude will vary considerably. In addition, the probability of a certain flood occurring will increase for a longer period of time. For example, over the life of an average 30-year mortgage, a home located within the 100-year flood zone has a 26 percent chance of being flooded at least once. Even more significantly, a house in a 10-year flood zone is almost certain to be flooded at least once (96 percent chance) in the same 30-year mortgage cycle. The probability (P) that one or more of a certain-size flood occurring during any period will exceed a given flood threshold can be estimated as

$$P = 1 - \left[1 - \frac{1}{T}\right]^n$$

where T is the return period of a given flood (e.g., 100 years, 50 years, 25 years) and n is the number of years in the period”. Due to the potential confusion, the NACCS report states, recent USACE guidance documents and policy letters recommend use of the annual exceedance probability terminology instead of the recurrence interval or return period terminology. For example, one would discuss the “1-percent-annual-exceedance-probability flood” or “1-percent-chance-exceedance flood,” which may be shortened to “1 percent flood” as opposed to the “100-year flood.” This report will use “percent flood” instead of “year flood”. Therefore for the stillwater elevations for storm frequencies mentioned above, this report will use the percent flood shown in the table below:

Table 3-1. Recurrence Interval and Percent Chance of Occurrence

Recurrence Interval in Years	Percent Chance of Occurrence
1	100%
2	50%
5	20%
10	10%
20	5%
50	2%
100	1%
200	0.50%
500	0.20%
1,000	0.10%
2,000	0.05%
5,000	0.02%

10,000	0.01%
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3.1.3 Determination of Structure Heights and Overtopping Volumes

The risk-reducing capability of the Norfolk CSRM project during hurricanes, tropical storms and nor'easters is dependent upon the levee's and floodwall's ability to resist against wave overtopping flow rates. Wave overtopping was analyzed using NACCS stillwater levels and wave heights. The analysis included the development of peak overtopping rates for NACCS return periods (10% flood, 3% flood, and 1.4% flood) at stillwater levels calculated for the year 2025 (start of the project analysis period), at year 2050 (middle of the project analysis period), and for the year 2075 (end of the project analysis period). The stillwater levels vary amongst the Areas 1-4 within the city. These wave flow rates have the potential of causing scour and possible failure of the protective ability of the feature. Structures heights were adjusted and determined based on the overtopping rates. Please refer to the Engineering Appendix for more information on the overtopping Analysis.

3.2 DETERMINATION OF INTERIOR FLOODING

The levee or wall associated with an interior area is generally referred to as the line of protection. The line of protection excludes flood water originating from the exterior, but normally does not directly alleviate flooding that may subsequently occur from interior runoff. In fact, the line of protection can often aggravate the problem of interior flooding by blocking drainage outlets. In these cases drainage system enhancements such as flap gates, tide gates, and possibly pumps, will be needed. For the Norfolk CSRM study, a preliminary interior flooding/drainage analysis using existing information and data was performed. The PDT utilized information from analyses performed through past City of Norfolk studies as well as performing new modeling analysis where needed. Please refer to Appendix B for more information on the interior flooding/drainage analysis.

3.3 RELATIVE SEA LEVEL RISE EFFECTS ON STRUCTURE HEIGHTS

Many coastal storm risk management design projects in the past typically took into consideration the effects of coastal forces from waves, tides, currents, and storm surges. However, many in the past have not taken into consideration the effects of sea level rise on a coastal structure. In recent years, as sea level rise and climate change become apparent, the impacts of existing structures now show the repercussions of not including the sea level. The rise in the sea level could potentially change the effects of coastal forces, due to the change in the water depths. Knowing the future coastal conditions of an area, engineers should design to include future potential impacts on coastal structures. Incorporating the effects of sea level rise in the initial design could also reduce the risk of failure in the future and reduce changing or making major adjustments for the structure in the future.

3.3.1 Adjusting NACCS Data for the Study

Published NACCS water levels are referenced to the year 1992, the midpoint of the current National Tidal Datum Epoch (NTDE) (1983-2001). Therefore an adjustment was made to incorporate RSLR from 1992 to 2016, which is when the study began. Based on the USACE low scenario at the Sewells Point NOAA gage from 1992 to 2016, the RSLR increase during this time period was estimated to be 0.36 feet. This value was added to the NACCS published results.

To make sure that the extreme total water level (TWL) (storm surge occurring at a MHHW (mean higher high water)) was considered, the difference between the NACCS Base Conditions + 96 random tides and MHHW (approximately 0.20 feet) at Sewell's Point was added the NACCS stillwater elevation. The tidal range measured at Sewell's Point is approximately 1.2 feet. The Base Conditions + 96 random tides only captures approximately 1.0 feet and not the full 1.2 feet of the tidal range, therefore, 0.20 feet was added to ensure that the total water level was included to match MHHW. This is important because storm events could occur when the tide is at MLLW (mean lower low water), at MHHW, or anywhere in between. The MHHW elevation was selected in order to ensure that the uncertainty of when a storm event could occur (at MLLW or MHHW) was considered and captured. Therefore, for the Norfolk CSRM study, an overall value of 0.56 feet was added to published NACCS stillwater elevations after data was converted to NAVD 88 (in feet).

3.3.2 Incorporating Future RSLR

For the Norfolk CSRM study, the anticipated increase of RSLR of 1.45 feet from 2016 to the end of the year 2075 (end of period of analysis) was added to the NACCS water levels. With the adjusted water levels, including sea level rise, a top of wall height was determined and overtopping analysis performed to include the effects on the proposed structures for the project. Wave forces were also calculated from wave heights. It should also be noted that when including the calculated sea level rise that changes in the bathymetry (or ground elevation) are included. It is anticipated that Norfolk will be affected not only by sea level rise, but from land subsidence as well. For the Norfolk CSRM, the 1.45 feet from the year 2016 to the year 2075 added to the NACCS water levels also account for the land subsidence rate. Please refer to Appendix B for more information of sea level rise and land subsidence.

3.4 VERTICAL CONTROLS AND DATUMS

The horizontal datum for this study and design is tied to the State Plane Coordinate System using North American Datum of 1983 (NAD83, Virginia South, 4502). Distances are in feet by horizontal measurement. Coordinates are Virginia South Zone. The vertical datum for this study is tied to the North American Vertical Datum of 1988 (NAVD88), a requirement of ER 1110-2-8160. Elevations stated in this report are in feet, NAVD88 unless otherwise noted.

CHAPTER 4 ECONOMIC APPLICATION

4.1 GEOGRAPHIC DATA

The study area is defined as Norfolk's jurisdictional boundaries. The City is located in the Chesapeake Bay watershed approximately 200 miles southeast of Washington DC and approximately 90 miles southeast of Richmond, Virginia. The City is bordered mostly by water with the Chesapeake Bay to the north and the Hampton Roads Harbor to the west. The cities of Chesapeake, Portsmouth and Virginia Beach bound Norfolk to the south, west and east, respectively.

Additional major water bodies that traverse the City include Broad Creek, Eastern Branch of the Elizabeth River, The Hague, Lafayette River, Lake Whitehurst, Mason Creek and Pretty Lake. Due to the number of water bodies, approximately 144 miles of shoreline, and varied land use, the city was divided into 27 unique hydrologic reaches to facilitate economic analysis of the project alternatives through the use of the HEC-FDA certified model. In addition, 13 reaches were identified along the Willoughby Spit & Vicinity Coastal Storm Damage Reduction Project for evaluation within Beach-fx.

4.2 DEVELOPMENT AND LAND USE PROJECTIONS

The U.S. Census totals the number of developed and undeveloped land within Norfolk as 54.12 square miles. Established as a town in 1682, the historic city is nearly fully developed with only 3% remaining as undeveloped land. As a result of limited vacant space, the majority of new development is expected to be accomplished through redevelopment and intensification. Residential buildings make up the majority of the city with an aggregate total of 41.4%. It is important to note that a large portion of the city, approximately 16%, is composed of military installations. This can be viewed in Table 4-1.

Due to the density of the structures in Norfolk and the very limited vacant land, a future development structure inventory was not included in the damage calculations. It is anticipated that the majority of future development will be the infill of structures on the limited vacant land, or redevelopment.

Table 4-1. 2017 Land Use in the Study Area

Land Class Name	Acres	Percentage of Total
Residential	11,574	41.4%
Commercial/Office	2,239	8.0%
Industrial	1,681	6.0%
Mixed use	36	0.1%
Institutional	1,941	6.9%

Land Class Name	Acres	Percentage of Total
Open Space/Recreation	2,986	10.7%
Utility/Transportation	2,259	8.1%
Military	4,367	15.6%
Vacant	863	3.1%
Total	27,946	100%*

Source: City of Norfolk

*Total rounded to the nearest percentage

4.3 STRUCTURE INVENTORY AND VALUATION

Parcel boundaries and 2017 real estate assessment table were provided by Norfolk to assist with characterizing residential and nonresidential structures for the economic analysis. Data included addresses, property class description, property use, dwelling year built, dwelling condition/grade, crawl code, number units, etc. With the building footprints provided by Norfolk, property class descriptions and Google Maps were used to classify buildings into damage categories and occupancy types.

4.4 VEHICLE DATA

Based on the 2017 city of Norfolk Bill of Export Summary, there were a total of 168,655 vehicles in Norfolk. The count value includes 153,485 residential, 13,060 nonresidential, and 1,836 public vehicles. The vehicle count was divided by the total number of structures in the study area and the quotient was the following per structure; 1.62 vehicles per residential, 2.86 vehicles per commercial, and 2.37 vehicles per public. The average number of vehicles per apartment buildings was derived in a similar fashion and held a value of 15 vehicles per structure. According to the Southeast Louisiana Evacuation Behavioral Report published in 2006 following Hurricanes Katrina and Rita, approximately 70 percent of privately owned vehicles are used for evacuation during storm events. The remaining 30 percent of the privately owned vehicles remain parked at the residences and are subject to flood damages. For nonresidential structures, an assumption was made that 50% of the vehicles are evacuated and 50% remain. For public vehicles, after consultation with City employees, an assumption was made that 100% of the public vehicles do not evacuate the City during a storm event. Vehicle monetary values were obtained from Norfolk. The City institutes a personal property tax based on National Automobile Dealers Association (NADA) depreciated values to determine the fair value of vehicles. The Norfolk District team determined that the obtained values from the City reflect the most accurate estimated values of the depreciated vehicle inventory. The average value of vehicles in Norfolk was determined to be the following; \$5,862 per residential vehicle, \$10,875 per nonresidential or commercial vehicle, and \$11,842 per public vehicle. For public vehicle value estimate, city fleet summary was obtained from the City and the Sum of Years

Digits (SYD) depreciation method was applied. The SYD seemed to be a more appropriate method to depreciate vehicle values because, unlike straight line depreciation, the SYD is an accelerated method of depreciation that parallels actual vehicle loss of value. After observing the City's inventory data, the average public vehicle age was determined to be 10.04 years. An assumption was made that regular cars have a 15 year life span, and trucks have a 20 year life span. A weighted average of the two depreciated values was taken in order to derive the final average public vehicle estimate.

4.5 EMERGENCY COST ESTIMATES

In addition to structural damages, a flooded community typically incurs a variety of other flood related costs including debris removal. The cost of the debris removal can vary according to the residential or nonresidential occupancy type of the structure. The content-related debris includes white goods (refrigerators, stoves, dishwashers, etc.), electronics, and hazardous waste (paints, oil, household chemicals, poisons, etc.).

Interviews were conducted with experts in the fields of debris collection, processing, and disposal following Hurricanes Katrina and Rita. The experts were asked to provide a minimum, most likely, and maximum estimate for the cleanup costs associated with the 2 feet, 5 feet, and 12 feet depths of flooding. A prototypical structure size in square feet was used for the residential occupancy categories and for the nonresidential occupancy categories. The experts were asked to estimate the percentage of the total cleanup caused by floodwater and to exclude any cleanup that was required by high winds.



Figure 4-1. Household debris as a result of flood from Hurricane Katrina

Source: Image.nola.com

In order to account for the cost/damage surrounding debris cleanup, values for debris removal were incorporated into the structure inventory for each record according to its occupancy type. These values were then assigned a corresponding depth-damage function with uncertainty in the HEC-FDA model. For all structure occupancy types, 100% damage was reached at 12 feet of flooding. All values and depth-damage functions were selected according to the short-duration flooding data specified in a report titled “Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes.” The debris clean-up values provided in the report were expressed in 2010 price levels for the New Orleans area. These values were converted to 2017 price levels for the Norfolk area using the indexes provided by Gordian’s 38th edition of “Square Foot Costs with RSMeans Data.” The debris removal costs were included in the HEC-FDA structure records for the individual residential and nonresidential structures and used to calculate the expected annual without-project and with-project debris removal and cleanup costs.

4.6 TRANSPORTATION

Roadway flooding is a common occurrence within the City. See Figure 4-2. Flooding causes residents and travelers to move their vehicles to higher ground or parking garages, travel alternate routes or risk losing their vehicle. While vehicles were included in the HEC-FDA model, additional travel time incurred by using alternate routes to avoid flooded roads was not included in this analysis. In 2016, Sandia National Laboratories investigated the economic impacts of flooding for transportation dependent industries in Norfolk. The 2016 report titled “Development of an Urban Resilience Analysis Framework with Application to Norfolk, VA” estimated totals of \$27-55 million in losses from a 4 day storm related shutdown. Future analyses may want to consider this additional benefit, however, it is not expected to significantly contribute to project benefits.



Figure 4-2. Hurricane Joaquin, October 2015. Firefighters rescue a stranded motorist
Source: Hamptonroads.com

4.7 STAGE-DAMAGE FUNCTIONS

As a NACCS Focus Area, the depth damage functions (DDFs) established within the NACCS Physical Depth Damage Function Summary Report were used for residential and nonresidential structures. Functions developed as part of the Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation Report in 2013 (2013) were included to provide a wider range of DDFs to more closely match the structure inventory. Vehicle depth-damage relationships were taken from Economic Guidance Memorandum (EGM), 09-04., Generic Depth-Damage Relationships for Vehicles. The DDFs developed for sedan automobiles was applied to vehicles associated with residential structures and DDFs developed for small trucks was applied to vehicles associated with nonresidential structures. Both reports are available upon request.

4.8 STAGE-PROBABILITY DATA

Stage-probability relationships were provided for the existing (2025) without-project condition and future without project conditions (2075). Water surface profiles were provided for eight annual chance exceedance (ACE) events: 50% (2-year), 20% (5-year), 10% (10-year), 5% (20-year), 2% (50-year), 1% (100-year), 0.5% (200-year), and 0.2% (500-year). The without-project water surface profiles were based on NACCS ADCIRC Save Points published on the Coastal Hazards System. Figure 4-3 depicts water surface elevations used for the Broad Creek Economic Reach. Water surface elevations trended higher than the effective Flood Insurance Rate Map, dated February 17, 2017.

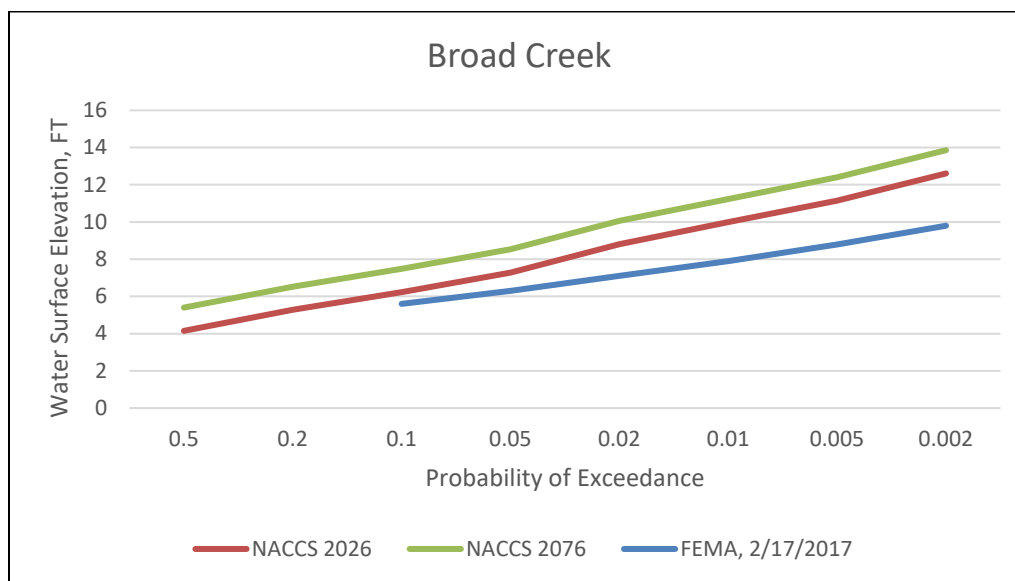


Figure 4-3. Sample graph of Study Water Surface Elevations

For each of these ACE events, the water surface profiles for the years 2025 and 2075 were determined by adding relative sea level rise, as determined by the USACE Sea Level Rise Calculator for Sewells Point, Virginia using the USACE Intermediate Curve to the Save Point elevations. The mean sea level trend of 4.61 mm/year or 0.01512 feet/year, as published for Sewells Point, VA as of 2016, was used as the sea level change rate.

4.9 ADDITIONAL ECONOMIC CONSIDERATIONS

4.9.1 Residual Damages

Nonstructural and structural measures reduce flood risk and damage. Unfortunately, beyond acquiring and demolishing a structure, there is no perfect mitigation measure and some level of damage can occur. Experience obtained at USACE's Hydrologic Engineering Center has shown that 5% applied to the 1% event or the 100 year is a good target stage and has been established as a default in the HEC-FDA module.

4.9.2 Gross Regional Output, Employment, and Earned Income Impacted

Regional Economic Development (RED) was evaluated on the RP. The RED measures the dependence between industries and workers in an economy. In other words, if a government agency invests in a certain area, how will the regional economy respond? The calculation is performed by a model developed by IWR, Michigan State University and the Louis Berger Group. Further detail on the RED development can be found in Appendix C.

CHAPTER 5 FORMULATING MANAGEMENT MEASURES AND ALTERNATIVES

5.1 PLAN FORMULATION PROCESS

Plan formulation has been 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, and other federal planning requirements. Plan formulation also considers all effects, beneficial or adverse, to each of the four evaluation accounts identified in the Principles and Guidelines which are National Economic Development, Environmental Quality, Regional Economic Development, and Other Social Effects. The following diagram in Figure 5-1 displays the formulation strategy for selecting the Recommended Plan.

The plan formulation process shown in Figure 5-1 focuses on establishing alternatives with structural and nonstructural measures initially and then adds natural and nature based features (NNBF) to the final array of alternatives as design considerations that will enhance the performance and durability of structural measures included in those alternatives. NNBF were formulated and will be analyzed as design features of the structural components of the recommended plan. NNBFs are considered separable elements which are incrementally justified. These features will complement the project features in ways that provide both flood risk and/or storm attenuation benefits as well as environmental benefits. The NNBFs are justified in that they meet the project objectives while reducing the operation and maintenance of the structural features of the alternatives. In addition, these features will provide redundancy and increase resiliency as part of a holistic strategy for coastal storm risk management. As an example, a living shoreline might be used where a rip-rap revetment would otherwise have been needed.

On 16 August, 2017 the USACE TSP milestone meeting was held and approval of the TSP was granted by the vertical team. This approval allowed the project team to move forward with the draft feasibility report and further analysis of the TSP. The TSP underwent USACE technical reviews, public reviews, agency reviews, and an independent expert peer review (IEPR). The technical and public review comments were then responded to and the report was edited per the comment-response process. After the review period the TSP was assessed for economic performance at the three water levels: 10%, 3%, and 1.4% ACE. The best performing plan was selected as the NED Recommended Plan (RP) and that plan underwent final feasibility level design with engineering, cost, economics, environmental, and real estate evaluations. On 12 March, 2018 the Agency Decision Milestone (ADM) meeting was held. The ADM highlighted the comments and responses from the various reviews and the RP was presented to USACE Headquarters. Approval from USACE Headquarters was received for moving forward with the RP.

When referring to Figure 5-1 the study concludes with a final feasibility level design. The final design and study report receive a final review by the USACE vertical chain as well as by environmental and state agencies, and the general public. The review process concludes with a recommendation for construction by the USACE in a signed Chief's Report. The Chief's Report

goes to Congress to await funding authorization for the PED and construction phases.

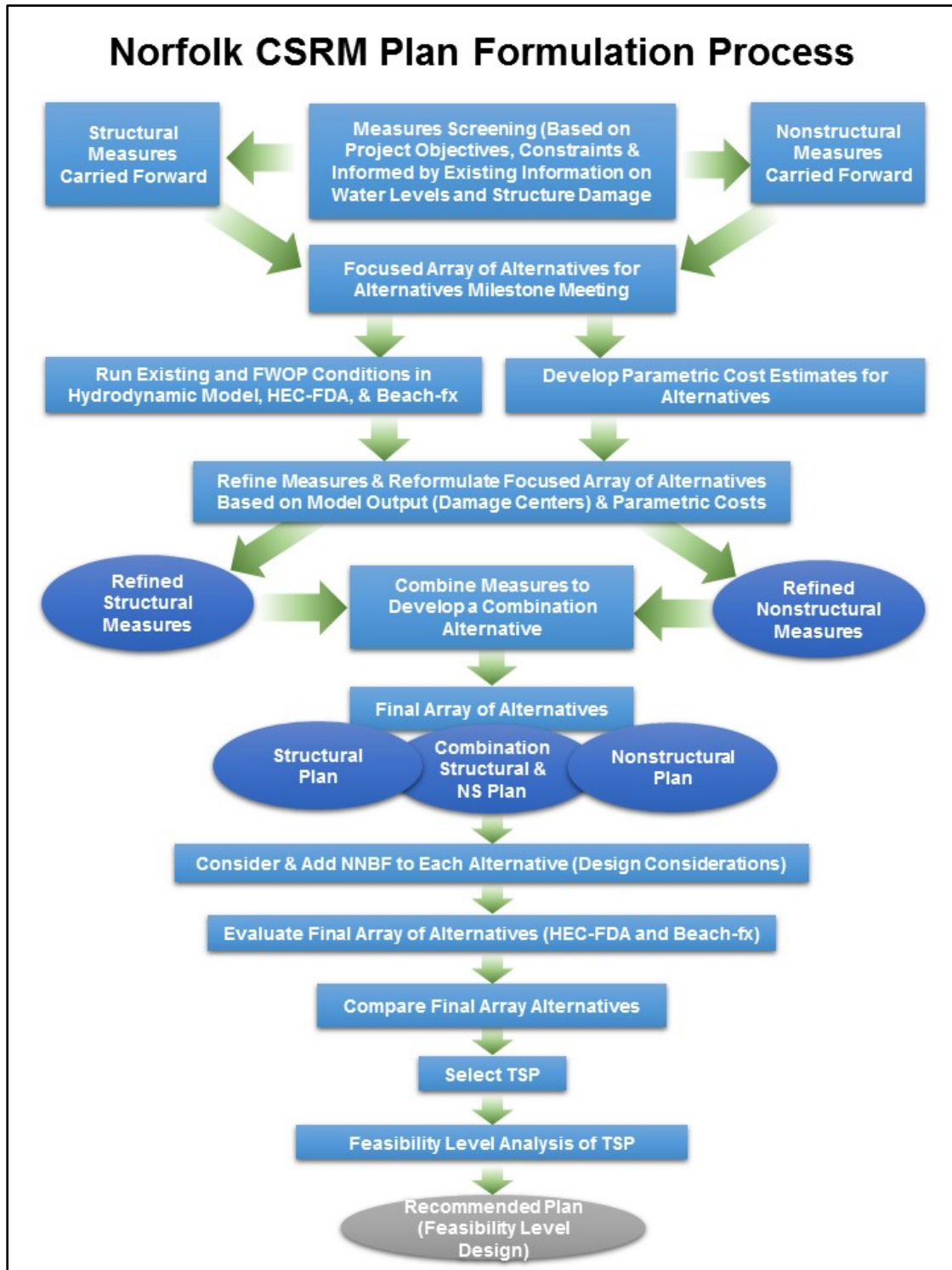


Figure 5-1. Norfolk CSRM Plan Formulation Process

5.2 MEASURES FOR COASTAL STORM RISK MANAGEMENT

Coastal storm risk management measures consist of three basic types: structural, nonstructural, and natural or nature-based features. This study will yield a series of feasible coastal storm risk

management alternatives that may consist of a variety of natural, structural, and nonstructural measures. Following the USACE planning methodology, this approach would consider the engineering attributes of features and the dependencies and interactions among these features over both the short-and long-term. Structural measures have historically been the technique most desired by the general public, as these modify flood patterns and “remove floods away from people” through measures such as floodwalls and levees. Nonstructural coastal storm risk management measures basically “remove people from floods” leaving stormwater to pass unmodified.

Structural coastal storm risk management 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 that are implemented to protect people and property.

Nonstructural coastal storm risk management measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. 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, floodproofing, home elevation, and flood warning systems are examples of nonstructural measures.

Natural or nature-based coastal storm risk management measures work with or restore natural processes with the aim of wave attenuation and storm surge reduction. For this study, construction of wetlands, living shorelines, and greenways was considered.

5.3 INVENTORYING AND SCREENING MEASURES

All areas of the city were evaluated for flood risk and then various measures were considered for reducing that risk. Norfolk has a diverse range of neighborhoods that vary by socioeconomic status. Formulation of the measures considered maintaining neighborhood cohesiveness and avoiding negative impacts to minority and low-income populations.

Table 5-1 shows the full variety of measure types that were considered for this study and the screening results. The measure types were screened in the Alternatives Milestone phase with some types of measures found to be unsuitable in the Norfolk area. The measure types that were carried through (highlighted in green) were then developed into more detailed measures with more location and engineering detail added to develop costs. A charrette was held with the City of Norfolk in March of 2017 to fully develop the possible measures that could be considered for citywide coastal storm risk management alternatives. The team developed nonstructural and structural measures throughout the city. After developing the possible measures a public meeting was held to explain the measures to Norfolk citizens and other stakeholders and allow them to provide feedback.

Screening criteria included:

1. Four Principles and Guidelines Accounts – Complete, effective, efficient, acceptable
2. Meets Objectives
 - a. Reduce economic damages from coastal storm risk

- b. Reduce risk to health and human safety from storm impacts
- 3. Avoids Constraints
 - a. Military
 - b. Cultural Resources
- 4. Minimize Residual Risk
- 5. Constructability – Likelihood that the measure can be feasibly constructed

Table 5-1. Management Measures Screening

Measure	Measure Carried Forward (Y/N)	Discussion
Nonstructural		
Nonstructural in Mason Creek	N	Consultation with the U.S. Navy screened out any measures that would create or elevate any structures in the flight path at the air station.
Acquisition, Relocation, Retrofit, Land Use / Flood Insurance Management, Flood Warning / Preparedness and Evacuation Planning	Y	Important to not negatively affect city's tax base when considering buyouts, options are feasible and can be implemented citywide.
Structural		
Ringwall around Moores Bridges WTP	Y	Critical infrastructure
Storm Surge Barrier across the Chesapeake Bay or Elizabeth River	N	Screened out based on analysis and coordination completed by the Norfolk District and City of Norfolk. Significant national security concern. Extremely high cost.
Storm Surge Barrier (barrier under Interstate 64 to protect back bay surge flooding from Willoughby Bay)	N	Determined to not be feasible due to cost and environmental considerations.
Deployable Floodwalls	Y	Only appropriate in areas with infrequent, low level flooding (less than 24"), and over relatively short spans such as railroad tracks or minor roadways.
Add pump station and berm in Mason Creek (Outside Naval Station)	N	Consultation with the U.S. Navy screened out any measures that would create or elevate any structures in the flight path/clear zone for the adjacent runway.
Elevate existing dam/improve spillway at Lake Whitehurst	N	City of Norfolk report no significant damages if backup drinking water supply is contaminated with salt water, not enough economic benefit to justify.

Measure	Measure Carried Forward (Y/N)	Discussion
Modify (elevate) Existing Hague Floodwall	N	Screened out in study by others as less cost effective than surge barrier measure.
Structural Shoreline stabilization (including bulkhead, armoring)	N	Not effective in reducing inundation from coastal storm surge/tidal flooding. Most of the shoreline in the study area is already hardened.
Breakwaters and groins	N	These measures already exist at the present Willoughby beach project. Negligible benefits from new breakwaters and groins are not anticipated to justify costs.
Floodwall on U.S. Navy property for Mason Creek	Y	This measure is carried forward after consultation with the U.S. Navy.
Storm Surge Barriers at Pretty Lake, Broad Creek, The Hague, Lafayette River	Y	Determined to be feasible by previous studies and/or PDT analysis.
Flap gates/backflow preventers on stormwater outfalls	Y	Effective when combined with barrier measures such as floodwalls.
Drainage Improvements	Y	Interior drainage/rain event flooding is a significant problem in Norfolk and usually occurs along with a coastal storm event. Unless accompanying a floodwall or surge barrier, this is a non-Federal responsibility.
Floodwalls and Levees	Y	Highly urbanized shoreline leads to floodwalls. Levees feasible where space allows.
Tide Gates	Y	Will be effective where significant drainage (e.g. creeks, inlets) cross through proposed floodwalls and levees or in existing culverts.
Daylight historic creeks	N	Opening creeks that have been forced into culverts. Daylighting creeks would improve stormwater function, however, the authorization for this project is for coastal flooding.
Modify (elevate) Existing Downtown Floodwall	Y	Floodwall may need to be modified to reduce damage in the city. Also needs to be elevated to maintain FEMA certification.
Beach Nourishment and dune creation	Y	Adding a dune and/or increasing the berm to existing USACE Willoughby Beach project determined to be feasible.

Measure	Measure Carried Forward (Y/N)	Discussion
Retrofit existing stormwater outfalls with backflow preventors	Y	Existing stormwater pipes would be retrofitted to prevent tidal backflow into the City stormwater infrastructure.
Natural and Nature-Based		
Living Shorelines (stone toe with native tidal wetlands)	Y	Provides shoreline stabilization, bio-diversity, wave energy dissipation, and limited flood reduction benefits. Would augment structural features.
Greenways along Tidewater Dr. and Stockley Gardens	Y	Function as additional storage/retention during coastal storm and/or heavy rain events. Would augment structural measures.
Subtidal Reef Structures	Y	Provides shoreline stabilization, bio-diversity and wave energy dissipation but will not alleviate flooding on their own. Would augment structural features.
Standalone Wetlands	N	Provides shoreline stabilization, bio-diversity and wave energy dissipation, and limited flood reduction benefits but would not achieve project objectives as well as a living shoreline.

5.4 FORMULATION OF ALTERNATIVES

Measures were combined into alternative plans that will provide coastal storm risk reduction for large portions of Norfolk. In order to develop a comprehensive project and meet the objectives of the study the formulation strategy is such that all areas of the city were analyzed for some level of coastal storm risk management. A comprehensive project will allow Norfolk to maintain critical infrastructure, evacuation routes, and cohesive neighborhoods. Also, by formulating a very inclusive citywide alternative, socially vulnerable neighborhoods will receive the same, or similar, levels of risk reduction as wealthy or more valuable property areas.

Four types of alternatives were formulated: the No Action, the Structural Only, the Nonstructural Plus Ringwalls, and the Structural and Nonstructural Combination Alternatives. The PDT, in coordination with the City of Norfolk, used the plan formulation strategy (Figure 5-1) to combine measures into Alternative Plans based on the four plan options listed above. In all, ten alternative plans were developed, plus the No Action Alternative. Each alternative plan has its own economic valuations based on its component measures. More detailed descriptions of the final array of measures and Alternative Plans can be found in the following chapters.

5.5 NATURAL AND NATURE-BASED FEATURES

Section 1184 of the Water Resources Development Act of 2016 requires the Secretary of the

Army, with the consent of the non-federal sponsor, to consider Natural and Nature-Based Features (NNBFs) when studying the feasibility of projects for coastal storm risk management. Other policy drivers for incorporating NNBF, as outlined below:

- Executive Order 11988, Section 1, which directs Federal agencies to take action to restore and preserve the natural and beneficial values served by floodplains; and
- Consistent with Federal Government Policy Priorities and best practices which promote integration of green infrastructure for coastal storm risk management following Hurricane Sandy (e.g. Hurricane Sandy rebuilding Strategy Recommendations 19-22).

Natural features are those that are created through physical, geological, and chemical processes over time. Nature-based features are features that are created by human design, engineering, and construction that work in association with natural processes to mimic, as closely as possible, conditions that would occur in the absence of human influence to the environment in order to achieve the study objectives. NNBFs that were considered as part of the plan formulation process consisted of the following features:

- Wetlands;
- Living Shorelines;
- Subtidal Reefs; and
- Greenways.

Identifying and locating these features was determined through a planning charrette held by the USACE and the City of Norfolk. Site visits were performed and input from stakeholders was considered. For example, one of the proposed living shoreline locations was recommended by the Elizabeth River Project, a nongovernmental organization, and is incorporated as a NNBF feature for the project.

For the purposes of this project, the NNBFs were considered for two purposes: 1) to help meet the project objectives and provide coastal storm risk management measures and 2) to provide onsite, compensatory mitigation for impacts to tidal wetlands and uplands.

5.6 NATURAL AND NATURE-BASED FEATURES AND PLAN FORMULATION

During plan formulation the application of NNBFs as a stand-alone measure was considered as well as placement of the NNBFs in combination with structural measures. It was determined that the application of the NNBFs would best meet the project objectives when placed in combination with the structural measures. In addition, to provide the greatest level of benefits, the living shorelines would be placed in combination with the subtidal reefs to provide a superior level of storm surge and wave attenuation benefits. Wave energy dissipation from the marsh component of a living shoreline or a stand-alone marsh can reach 20% even in water depths during major storm conditions (water depths at +2m above normal, with an additional 0.9 m wave) with a 40 m wide marsh wetland (Moller et al. 2014). With wider living shorelines or marshes in front of man-made dikes, the wave energy can be reduced by 55% (a 1.8 meter reduction in storm surge wave height) (Vuik et al. 2016). Considering the reef frontal edge of a living shoreline, or as stand-alone, reefs proposed for NNBFs in the present study consist of shaped concrete structures (interlocking rings, reef balls, pyramids, or rectangular interlocking structures, for example) rising from the bottom into the intertidal zone. These will function

similarly to coral reefs, not low profile shell beds more typical of the modern-day Bay which provide less protection against storm surge (Piazza et al. 2005, Stone et al. 2005, Spalding et al. 2013, Sutton-Grier et al. 2015). Historically many reefs in the southern part of Chesapeake Bay rose several meters off the bottom into the intertidal zone, some which paralleled the shore for many kilometers in length (Woods et al. 2005) similar to a fringing coral reef. Fringing coral reefs reduce incoming storm wave energy by at least 25%, with wider fringing reefs reducing it up to 50% (Guannel et al. 2016). Fringing oyster reefs that reach the low intertidal zone in height function similarly to coral reefs (Stone et al. 2005) and can effectively reduce wave energy during both typical conditions and under storm conditions. Of importance is that it has been observed that the reef crest, the shallowest part of the reef, dissipates the most energy (Ferrario et al. 2014) so if reef NNBF as stand-alone or as the front part of a living shoreline are considered, they should crest into the low-intertidal zone for maximum coastal storm protection benefits.

Costs of the NNBFs have been developed. Those costs are compared to the benefits provided by the NNBF. NNBFs are considered separable elements that are incrementally justified, meaning the costs and benefits of each NNBF must be considered in order to determine the most effective features. Formulation of NNBFs is in accordance with Implementation Guidance for Section 1184 of the Water Resources Development Act of 2016 (WRDA 2016), Consideration of Measures, dated September 28, 2017. That guidance states that "Study teams should account for and present the benefits, costs (including Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) costs), and impacts relevant to decision-making during the study, even though not all benefits, costs, and impacts align with USACE authorities and missions and the degree to which they can be quantified or monetized may vary." Therefore, the study considers cost and benefits of the NNBFs, but also considers feature justification through ecosystem goods and services as well as other social benefits. NNBF benefits are also quantified using a reduction in Operation and Maintenance (O&M) costs to adjacent structural measures. The O&M cost reduction is determined using literature sources such as Reguero et al. (2014) that describe benefits of wetlands and oyster reefs in terms of reductions to storm surge and wave attenuation. The existing literature does not directly address quantification of benefits for NNBFs, so the references are used to apply best professional judgment to extrapolate from the risk reduction provided by each NNBF into the indirect (O&M reduction) benefit.

Each type of NNBF may have a slightly different analysis. For example, per Reguero et al. (2014), oyster reefs can provide a hazard reduction factor for wind waves of 20-50%. The calculated reduction in O&M costs is compared to the cost of the NNBF to determine the approximate cost effectiveness of the features. Those features found to be reasonably cost effective are then included as the project moves forward – those that are not are removed. For those features that remain, the NNBF is combined with the larger structural features and an overall BCR for each separable element is re-calculated.

CHAPTER 6 REFINING MEASURES AND EVALUATION

Feasible management measures that were carried through the initial screening were analyzed further for suitability of implementation. The project team estimated costs for construction, real estate, environmental and cultural resources mitigation. The refined measures were also subjected to public and stakeholder review. Refined measures could be an individual feature, such as a levee, or a larger system of features that reduce flood damages in an area. The sections below describe those measures that were considered for implementation throughout Norfolk. Also discussed in this chapter are the methods of evaluation and comparison including preliminary economics for measures throughout the city and how some of these measures are combined into coastal storm risk management systems for Norfolk.

6.1 STRUCTURAL MEASURES

6.1.1 Beach and Dune

Beaches and dunes are structural measures that can also be considered natural and nature-based features. Beach and dune measures provide coastal storm risk reduction and resilience by forming a physical barrier against waves and storm surges. Additionally, beach nourishment can be used to reduce coastal storm damage by introducing additional sand into the system to reinforce the natural protection to the upland afforded by the beach, and therefore reduces risk due to wave damage and inundation.

6.1.2 Floodwall

Based on the anticipated flood water levels it was determined that I-walls, T-walls, and berms would be appropriate to use in the alignment as existing conditions permitted. Wall heights vary from approximately 0.5 feet to 11.5 feet. From EC-1110-2-6066, it was determined that any wall that is six feet or less in height could be I-walls and any wall that was six feet or more would be pile supported T-walls. I-walls were preliminarily designed using CI-WALL and CWALSHT software programs. For adaptation purposes for RSLR it is assumed that T-walls will be used in areas where the design water surface elevation requires a four foot or higher wall.

T-Walls will be traditional concrete stem walls with pile supported bases. I-walls will be concrete-capped cantilevered sheet pile walls. Piles for T-Walls and sheet piles for I-Walls are anticipated to be 60 feet in length. T-Walls will be designed in accordance with EM 1110-2-2502.

6.1.3 Ringwall

Ringwalls are constructed with the same engineering requirements as floodwalls. The primary difference between a ringwall and a floodwall is scale. Whereas a floodwall protects a large area (e.g. neighborhood) a ringwall is considered for individual structures or a small grouping of structures. A ringwall could adversely impact the effective floodplain, but generally, the wall is located in close proximity to the building(s) it is protecting, so that floodplain characteristics such as depth and velocity are not impacted. A concern regarding ringwalls is that they may entice people to seek shelter in a structure instead of evacuating, if a ringwall is present. This presents a life safety concern in the event a ringwall is overtopped or fails.

6.1.4 Levee

A standard berm/levee geometry of a 10-foot wide crest covered with 6 inches of aggregate base, 3H: 1V side slopes, and 2 feet of riprap on the waterside slope was adopted. An inspection or key trench is excavated into existing ground along the berm/levee alignment. The inspection trench is 10 feet wide at the bottom with 1H: 1V sides slopes. For a berm/levee height less than 6 feet, the depth of the inspection trench is equal to the height of the levee. For a berm/levee height of 6 feet or greater, the depth of the inspection trench is 6 feet. The inspection trench is backfilled with compacted embankment fill material, which is also used to construct the levee.

6.1.5 Gate Closures

Gate closures are designed into a floodwall system where passage through the floodwall is needed during non-flooding periods. Typically gate closures are designed to accommodate automobile traffic where a floodwall is designed across a roadway. Gate closures can also be designed for pedestrian traffic. The gates are closed during flooding periods and so disruptions to traffic should be considered. The existing Norfolk floodwall utilizes gate closures and the closures envisioned for this study are likely to be similar in design and function.

6.1.6 Storm Surge Barriers and Tide Gates

Two types of gates were considered for storm surge barriers. They were sector gates (large openings) and miter gates (smaller openings). Sluice gates were also consider for smaller tidal creeks.

Sector Gates

Sector gates were considered for crossing the channel in the Lafayette River Basin. Based upon the federal channel width of 200 feet (at the toe), it was decided that a 150 foot wide sector gate would be used to cross the channel. The top of gate was preliminarily estimated to range in elevation from 10.5 ft 15.5 ft with a bottom of gate elevation at -20.0 ft. These elevations were selected in consideration of equipment systems requirements and potential scour or accretion. The “go-by” for estimating purposes was “New Bedford – Fairhaven Barrier” located in the New England District. This gate was selected as its geometry and opening width are similar to the one anticipated for this project.

Miter Gates

All other major storm surge barriers that crossed river inlets include miter gates. The miter gate system was selected as it is heavily employed in the Norfolk District area of responsibility. Miter gates spanning across openings of 40 to 75 feet are used at the Richmond Filtration Plant flood mitigation project and the Atlantic Intercostal Waterway. The miter gate barriers for this project would be constructed adjacent to bridge structures in between the bridge pier spans. The bridge pier spans are commonly 60 to 70 feet in length and the depths range between 10 to 25 feet. All of these dimensions work well with the miter gate designs we currently use. We based our cost estimates on existing gate constructions and operations making adjustments to suit the Norfolk CSRM study.

Tide Gates (Sluice Gates)

Barriers that cross small tidal creeks are proposed to be sluice gates. The sluice gates

considered for this study are vertical rising sluice gates. Norfolk District has extensive experience using vertical rising sluice gates on several existing flood mitigation projects.

6.2 NONSTRUCTURAL MEASURES

The following nonstructural measures represent techniques commonly utilized in reducing flood risk and the damages associated with flooding and storm surge. These measures vary from removing an entire structure from the floodplain to insuring a structure that is permanently located within the floodplain. The costs associated with implementing a measure are variable, where reduction of flood damages is proportional to the cost of the measure (i.e., removal of a structure from the floodplain will eliminate all future damages associated with flooding; purchasing flood insurance for a structure will assist in making the structure whole after a flood event, but it does not eliminate future flood damages to that structure).

6.2.1 Elevation

This nonstructural technique lifts an existing structure to an elevation that is at least equal to or greater than the design flood elevation. In many elevation scenarios, the cost of elevating a structure an extra foot or two is less expensive than the first foot, due to the cost incurred for mobilizing equipment. Elevation can be performed using fill material, on extended foundation walls, on piers, post, piles, and columns. Elevation is also a very successful technique for reinforced concrete slab-on-grade structures.

6.2.2 Basement Fill/Removal

This nonstructural technique consists of the entire removal of the basement/crawlspace by drilling holes into the floor for floodwater entry and filling the area with a clean run material. Utilities, such as furnace, water heater, and other electrical or mechanical equipment should be relocated to a higher elevation or utility addition.

6.2.3 Relocation

This nonstructural technique requires physically moving the at-risk structure and purchasing the land upon which the structure is located. This technique is most effective when structures can be relocated from a high flood risk area to an area that is located completely out of the floodplain.

6.2.4 Acquisition

This nonstructural technique consists of purchasing the structure and the land. The structure is either demolished or sold and relocated to a site external to the floodplain. Development sites, if needed, can be part of a proposed project in order to provide locations where displaced residents can build new homes within an established community.

6.2.5 Floodproofing

This nonstructural technique is applicable as either a stand-alone measure or as a measure combined with other measures such as elevation. There are two types of floodproofing, wet floodproofing and dry floodproofing.

Wet Floodproofing

This nonstructural technique allows floodwaters to enter a structure without resulting in damage.

As a stand-alone measure, all construction materials and finishing materials need to be water resistant and all utilities must be elevated above the flood elevation. Wet floodproofing is quite applicable to commercial and industrial structures when combined with a flood warning and flood preparedness plan. This measure is generally not applicable to large flood depths and high velocity flows.

Dry Floodproofing

This nonstructural technique consists of waterproofing the structure. This can be done to residential homes as well as commercial and industrial structures. This measure achieves flood risk reduction but it is not recognized by the NFIP for any flood insurance premium rate reduction if applied to a residential structure. Based on laboratory tests, a “conventional” built structure can generally only be dry flood proofed up to 3-feet in elevation. A structural analysis of the wall strength would be required if it was desired to achieve higher protection. A sump pump and perhaps French drain system should be installed as part of the measure. Closure panels are used at openings. This concept does not work with basements nor does it work with crawl spaces. For buildings with basements and/or crawlspaces, the only way that dry floodproofing could be considered to work is for the first floor to be made impermeable to the passage of floodwater

6.2.6 Flood Warning System

This nonstructural technique relies upon coastal gauges, rain gauges, and hydrologic computer modeling to determine the impacts of flooding for areas of potential flood risk. A flood warning system, when properly installed and calibrated, is able to identify the amount of time available for residents to implement emergency measures to protect valuables or to evacuate the area during serious flood events.

6.2.7 Flood Emergency Preparedness, Response, Recovery, and Mitigation Planning

The City of Norfolk, through collaboration with USACE, FEMA, and other interested federal partners, is encouraged to develop and maintain a Flood Emergency Preparedness Plan (FEPP) that identifies flood hazards, risks, and vulnerabilities; identifies and prioritizes evacuation and mitigation actions; and encourages the development of local mitigation. The FEPP should incorporate the community’s response to flooding, location of evacuation centers, primary evacuation routes, and post-flood recovery processes.

6.2.8 Land Use Regulations

Land use regulations within a designated floodplain are effective tools in reducing flood risk and flood damage. The basic principles of these tools are based nationally in the National Flood Insurance Program (NFIP), which requires minimum standards of floodplain regulation for those communities that participate in the NFIP. The City of Norfolk participates in the NFIP. Effective in January 2014, an additional three feet of required elevation, above the effective FEMA BFE, for structures located within the 1% annual chance floodplain (100 year) was added to the city’s floodplain ordinance as the standard for new construction and any substantial repair or improvement. An 18 inch freeboard above grade is also required in the 0.2% annual chance floodplain (500 year) floodplain to reduce risk of property damage and improve resilience during flood events.

The Norfolk zoning codes were updated in 2018 to support physical and economic resiliency. This is described further in Section 2.4.

6.3 NATURAL AND NATURE-BASED FEATURES

As described in Chapter 4, the following NNBFs were retained following the plan formulation screening process: living shorelines (tidal wetland that may be flanked by a stone sill or reef structure), stand-alone reef structures, and greenways (water storage features with native vegetation plantings).

Tidal Wetland and Living Shoreline

This feature that was considered during the planning process consisted of the construction of saltmarsh cordgrass (*Spartina alterniflora*) dominated tidal wetlands that would be constructed along shorelines in areas currently devoid of wetlands or in areas where wetlands could be enhanced. If needed, the tidal wetland would be flanked by a sill or reef structure to create a living shoreline. Wetlands are areas that are inundated by surface or ground water at a frequency and duration that can support vegetation typically adapted for life in saturated soil conditions. A picture of an example wetland flanked with a stone sill is provided in Figure 6-1.



Figure 6-1. Tidal Wetland Flanked by a Stone Sill

The value of wetlands to wildlife and water quality is well understood. For the purposes of meeting the project objectives, wetlands also provide storm surge protection and wave attenuation benefits. Wetlands provide valuable shoreline protection in that they serve to protect shorelines from erosion.

Studies have shown that wetlands provide valuable protection against coastal storms. One study (Costanza et al., 2008) estimated that a loss of 1 hectare of wetlands increased average storm damages by \$33,000 for coastal cities, while in coastal Louisiana, it has been estimated (Barbier et al. 2013) that a 0.1 increase in the ratio of wetlands to open water resulted in saving 3-5 properties estimated at \$590,000-\$792,000. They function to reduce incoming wave energy by absorbing it with both the growing vegetation as well as the elevation change as the shoreline is approached.

For example, *Spartina alterniflora*, our locally most common estuarine marsh grass, was examined in North Carolina and it was found that healthy *Spartina* marsh was able to reduce typical wave height by 90 percent within 20 m of the marsh edge (Knutson 1982). Though higher wave heights due to storm events will not experience such a high rate of attenuation (Moller 2006), they will also be reduced in height by the marsh. For example, marsh cordgrass was able to reduce typical (non-storm) wave height by 90 percent within 20 meters of the marsh edge (Knutson 1982). Wave energy dissipation can still reach 20% even in water depths during major storm conditions (water depths at +2m above normal, with an additional 0.9 m wave) with a 40 m wide marsh wetland (Moller et al. 2014), with wider marshes in front of man-made dikes able to reduce such wave energy by 55% (a 1.8 meter reduction in storm surge wave height) (Vuik et al. 2016).

Figure 6-2 below illustrates how reefs and wetlands could be used to stabilize and protect shorelines – natural defense - in an estuarine riverine environment and reduce impacts related to rising sea levels and storm activity.

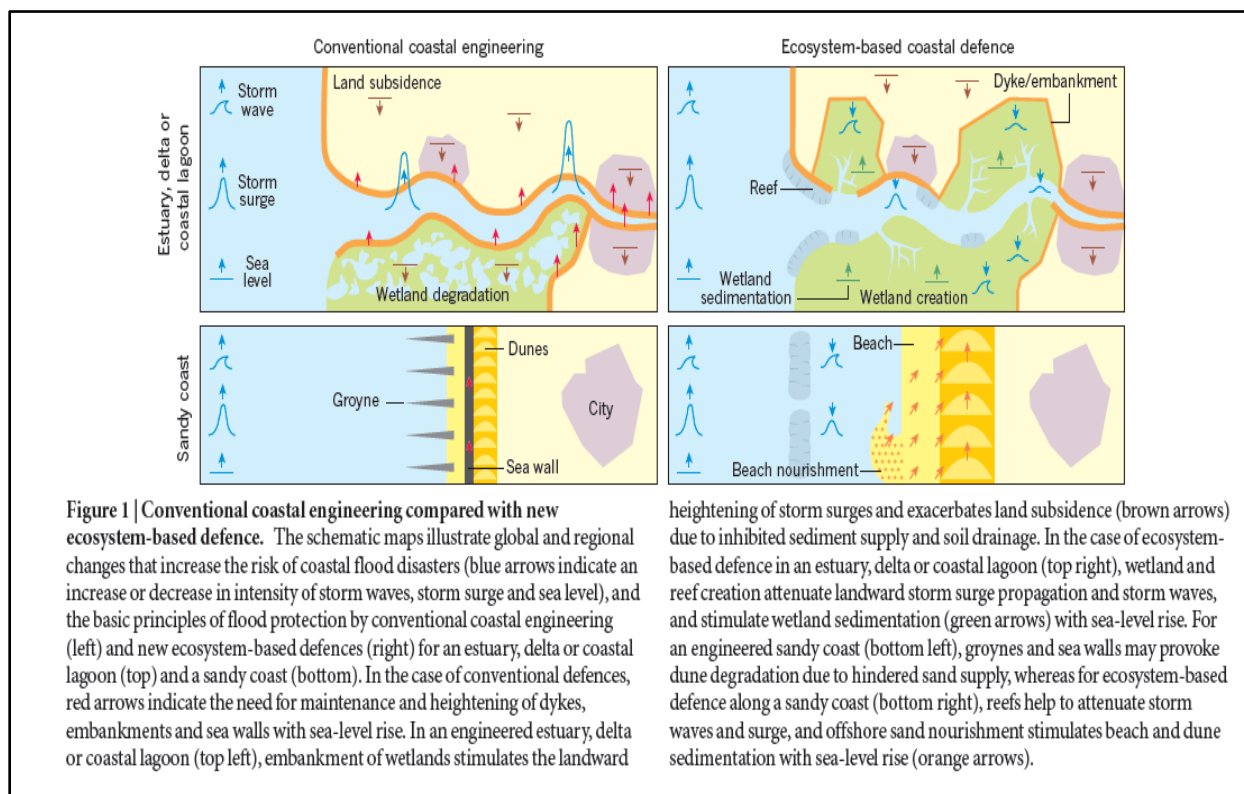


Figure 6-2. Conventional and Ecosystem-Based Coastal Defenses Compared
Source: Temmerman et al. (2013)

This feature would entail conducting a topographic survey with reference elevation points to determine the amount of grading and/or elevation needed to construct the wetland and constructing a wetland of a width of approximately 20 feet extending from the existing riverbank. The site would then be planted with a mix of native, tidal wetland vegetation. Species within the tidal wetland planting portion of the site would include black needlerush (*Juncus roemerianus*) and saltmarsh cordgrass. A salt-tolerant native plant community would be planted on the upslope to the upland vegetation areas as well. At the upland areas, an upland mixed tree

community of salt-tolerant trees would be planted as well if necessary to ensure stabilization of the site. For a listing of additional native species that would be planted, please refer to the Environmental Mitigation Plan provided in Appendix D. The site would be adaptively managed to adjust the grading as necessary and replant vegetation if necessary.

Oyster Structures / Reefs

This NNBF consists of the construction of a subtidal (submerged under most conditions) oyster reef that would be composed of a stone granite material. An example of a subtidal reef is displayed in Figure 6-3.

The value of oyster reefs to enhancing water quality and providing habitat to fish species is well understood. Subtidal oyster reefs improve water quality by removing excess nutrients. The restoration of oyster reefs is a key priority of the Chesapeake Bay Program, a partnership of state and federal agencies that partners with nongovernmental organizations and public stakeholders. This is the key organization for restoration of the Chesapeake Bay. Oysters are also part of the rich cultural heritage of coastal communities, whose economies and populations grew in part because of the bountiful oyster reefs in the region. In terms of meeting the project objectives, the value of oyster reefs in reducing wave energy is well known. For example, a study conducted in Staten Island indicated that coastal areas experience approximately 30% and 200% higher wave energy today as compared to the past prior to the loss of their natural oyster beds (Brandon et al. 2016). The oyster reefs proposed for NNBFs in the present study consist of shaped concrete structures rising from the bottom into the intertidal zone. These will function similarly to coral reefs, not low profile shell beds more typical of the modern-day Bay which provide less protection against storm surge (Piazza et al. 2005, Stone et al. 2005, Spalding et al. 2013, Sutton-Grier et al. 2015). Historically many reefs in the southern part of Chesapeake Bay rose several meters off the bottom into the intertidal zone, some which paralleled the shore for many kilometers in length (Woods et al. 2005) similar to a fringing coral reef. Fringing coral reefs reduce incoming storm wave energy by at least 25%, with wider fringing reefs reducing it up to 50% (Guannel et al. 2016). Fringing oyster reefs that reach the low intertidal zone in height function similarly to coral reefs (Stone et al. 2005) and can effectively reduce wave energy during both typical conditions and under storm conditions. Of importance is that it has been observed that the reef crest, the shallowest part of the reef, dissipates the most energy (Ferrario et al. 2014), so if reef NNBF are considered, they should crest into the low-intertidal zone for maximum coastal storm protection benefits.



Figure 6-3. Subtidal Oyster Reef

Greenways

Greenways provide innovative water management solutions that increase water storage capacity, increase infiltration capacity with natural elements, and provide native plantings that enhance wildlife habitat. The greenways will contain water storage features that can be used to store water and will also be incorporated with native vegetation plantings to provide for increased infiltration capacity. The PDT analyzed proposed greenway locations identified by the City of Norfolk.

6.4 INTERIOR FLOODING ANALYSIS

According to Engineering Manual 1110-2-1413, an interior area is defined as the area protected from direct riverine, lake, or tidal flooding by levees, floodwalls or seawalls and low depression or natural sinks. Management measures, such as a levee or wall, associated with an interior area is generally referred to as the project alignment. The project alignment excludes flood water originating from the exterior but normally does not directly alleviate flooding that may subsequently occur from interior rainfall runoff. In fact, the project alignment can often aggravate the problem of interior flooding by blocking drainage outlets. Interior flooding / drainage analysis using the software SWMM (Storm Water Management Model) of the storm water drainage system was done by Moffatt & Nichol for the City of Norfolk. This existing analysis is utilized in the Norfolk CSRM study to assess the need for interior drainage features such as tidal sluice gates and pumps. Further information on the interior flooding analysis can be found in Appendix B.

6.5 SEPARABLE AND COMPLEMENTARY MEASURES

Separable measures are those measures that can provide a level of risk reduction to an area without relying on other measures. A separable measure will compete against other measures in the same planning reach. For example, a nonstructural measure would compete against a structural measure in a particular reach in order to compare the advantage of one measure versus another in a particular area. Separable measures are individually justified and can be combined to form alternative plans.

Complementary measures are those measures that provide risk reduction in the residual floodplains of structural measures in order to provide a uniform level of risk reduction throughout the city. For example, engineering constraints may limit the location of a structural measure such that a portion of a neighborhood is left unprotected. Providing a complementary measure, typically nonstructural, that will provide a similar level of risk reduction, allows for a more holistic approach to citywide flood risk reduction.

6.6 REFINED MEASURES

The measure types that were carried through from an initial screening were developed into more detailed measures with more location and engineering detail added to develop costs. A charrette was held with the City of Norfolk in March of 2017 to fully develop the possible measures that could be considered for citywide coastal storm risk management alternatives. The team developed nonstructural, structural, and NNBF measures throughout the city. After developing the possible measures a public meeting was held to explain the measures to Norfolk citizens and other stakeholders and allow them to provide feedback. The public meeting was held in June of 2017.

6.6.1 Refined Structural Measures

A coastal storm risk management structural measure is considered a standalone system that protects a hydraulically distinct area. The structural measures tend to align with the planning reaches shown in Figure 6-4 below since they follow hydraulic boundaries, however, depending on the water surface elevation being studied, structural measures may have to cross reach boundaries. Note that ringwalls, while considered structural measures, were analyzed and grouped with nonstructural measures due to the requirements of defining their suitability on an individual property basis. A detailed description of each of the measures and further explanation on structure location, type, and configuration is provided in Appendix A. A graphic showing the locations of the structures can be found in Figure 6-4.

All the structural measures shown in the figure below are considered separable measures in that performance of any one structural measure does not depend on any other structural measure. The measures LR-1aS, LR-1bS, and LR-1cS are various alignments for a single proposed surge barrier across the Lafayette River. These three alignments are competing against each other for inclusion in an alternative plan.

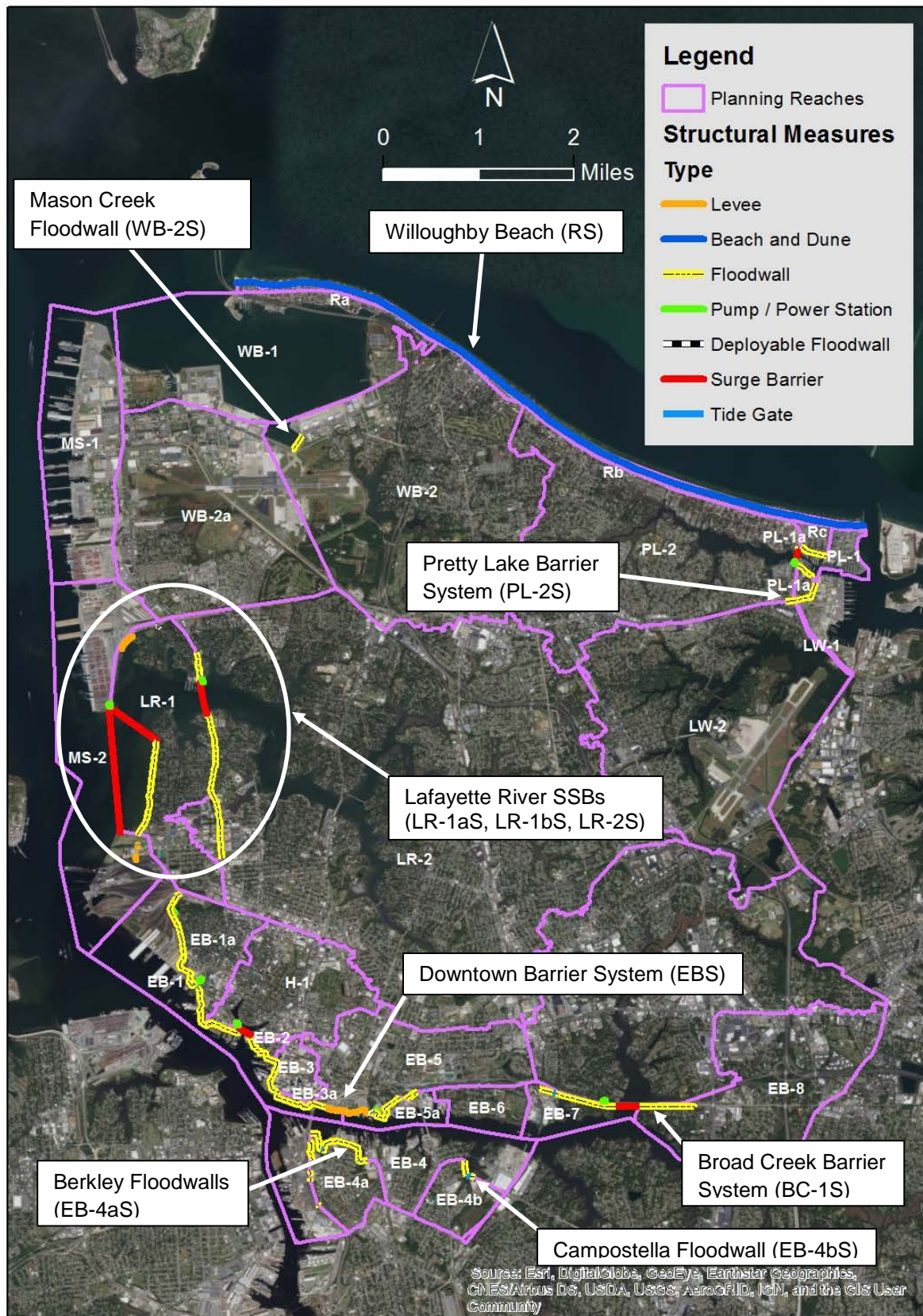


Figure 6-4. Citywide View of Refined Structural Measures

Table 6-1 shows the structural measures along with their locations and descriptions.

Table 6-1. Focused Array of Structural Management Measures

Measure Name	Location	Features
BC-1S	Broad Creek at I-264	Surge Barrier, Pump Station, and Floodwall
EBS	West Ghent, The Hague, Ghent, Downtown, Harbor Park	Surge Barrier, Pump Stations, Tide Gates, Levee, and Floodwall
EB-4aS	Berkeley	Floodwall, Tide Gate, Pump Station
EB-4bS	Campostella	Floodwall, Tide Gate, Pump Station
LR-1aS	Lafayette Outer Barrier	Surge Barrier, Floodwall, Levee, Power Station
LR-1bS	Lafayette Middle Barrier	Surge Barrier, Floodwall, Levee, Power Station
LR-2S	Lafayette Inner Barrier	Surge Barrier, Floodwall, Power Station
PL-2S	Pretty Lake	Surge Barrier, Floodwall, Pump Station
WB-2S	Mason Creek	Floodwall
RaS	Willoughby Beach West	Varying Beach Dune and Berm Dimensions
RbS	Willoughby Beach Middle	Varying Beach Dune and Berm Dimensions
RcS	Willoughby Beach East	Varying Beach Dune and Berm Dimensions

6.6.2 Refined Nonstructural Measures

Each planning reach shown in Figure 2-3 was analyzed as an independent reach for nonstructural measures. So for example, the nonstructural measures for reach LW-2 are grouped into a measure area called LW-2N. Possible nonstructural actions that were considered for each reach include elevating structures, filling in basements, flood proofing, and acquisition. Ringwalls, while considered structural measures, were grouped and analyzed along with the nonstructural measures. So a nonstructural reach such as LW-2N could include ringwalls. Within every reach the nonstructural measures and ringwalls competed against each other based on 1) whether they were feasible for the type of property and 2) which was most cost efficient. Note that economic reaches EB-4, EB-4a, and EB-4b are considered to be one cohesive neighborhood when combined. The area was divided into three reaches for the sole purpose of investigating the EB-4aS and EB-4bS floodwalls. For nonstructural analysis the intent is to combine the costs and benefits of all three reaches in order to assess justification. Further detail about the types and costs of nonstructural measures in each reach can be found in Appendix A.

6.7 EVALUATION AND COMPARISON

The focused array of alternatives was screened by the PDT and City of Norfolk in a charrette based on study constraints, economics, and other social effects (OSE).

6.7.1 Other Social Effects Analysis

The City of Norfolk and the PDT reviewed the focused array of alternative plans based on OSE metrics. The rating scheme used to rank the plans was based on the Institute for Water Resources' handbook for Applying Other Social Effects in Alternatives Analysis (2013). This scheme uses a -3 to 3 scale with -3 representing significant negative effects and 3 representing significant beneficial effects. Zero is negligible effects or no impact. The one and two rankings are for minor and moderate effects in either the negative or positive direction. Results are

shown in Section 7.8.1. OSE were also used to evaluate NNBFs and this analysis is described in Appendix D.

6.7.2 Benefit Cost Analysis

Benefit-cost analysis is a technique to evaluate in monetary terms what is achieved (benefits) in comparison to what is invested (costs). It is used to ensure that the value of the benefits exceeds the value of the costs, or, in other words, resources are allocated in the most efficient manner possible. When both benefits and costs can be measured in monetary terms, then benefit-cost analysis can help decision makers select the best solution. Benefit-cost analysis involves two mathematical comparisons:

- **Net benefits** are calculated by subtracting total economic costs from total economic benefits. Net benefits represent the amount of total benefits less the total costs. This analysis is used to select and scale a recommended course of action from an array of alternatives
- A **benefit-cost ratio** is calculated by dividing total economic benefits by total economic costs. A benefit-cost ratio tells us which alternative produces the most benefits for every dollar of cost (total benefits/total costs). The benefit-cost ratio is useful for comparing or ranking different projects.

The benefits and costs are annualized and averaged over the 50 year period of analysis to create average annual benefits, average annual net benefits, and average annual costs. The economic tables shown throughout this report will typically present the average annual form of the benefits, net benefits, and costs for comparison of study measures and alternatives.

Once the optimal scale of the alternative is identified by measuring the average annual net benefits, the benefit-cost ratio can be used to rank among competing investments.

6.7.3 Cost and Construction Time Metrics

Life Cycle Costs

The life cycle cost metric represents the total cost of implementing an alternative plan, which includes first costs plus operation and maintenance, repair, replacement and rehabilitation costs. All costs for selecting the TSP, up to and including the Final Array of Alternatives, are reported in Fiscal Year (FY) 2017 (October 2016) price levels to be consistent with price levels used for calculating economic benefits. The FY17 interest rate used to annualize the project costs is 2.875 percent. All costs for selecting the RP, including the costs for comparing the optimization levels, are reported in FY 2018 price levels in order to be consistent with price levels for calculating economic benefits.

The base year is 2026 for all the alternatives. First costs include engineering and design, facility relocations, real estate, mitigation, and construction costs. Construction costs include the cost of materials and construction of physical structures as well as construction management costs. Construction costs also include costs associated with constructing a system that will be adaptable so future enhancements for maintaining the risk reduction levels of structural measures into the future associated with relative sea level rise and/or degradation of the coast, i.e. future levee lifts. The life cycle cost metric does not include adaptive management or

monitoring costs.

Life cycle costs are presented both as annual equivalents and present values at year 2026 in thousands of dollars. The cost estimates were developed for labor, equipment, materials, and supplies. The estimated costs were based upon an analysis of each line item evaluating quantity, production rate, and time, together with the appropriate equipment, labor, and material costs. All cost estimates used to evaluate and compare alternatives include a contingency percentage. Cost contingencies for comparing the final array of alternatives are based on an abbreviated cost risk assessment. Cost estimates for the final array of alternatives are first costs only. Further details on the development of project costs can be found in Appendix B.

Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

Operations and maintenance costs for determining the TSP were based on parametric costs developed in the North Atlantic Coast Comprehensive Study (NACCS). Parametric costs were then adjusted based on the length and type of measure. The following assumptions were applied to operation and maintenance estimates:

- \$2 per linear foot plus \$10,000 per drain for floodwalls and levees.
- 0.5% of total costs for wetlands and living shorelines.
- 1% of total costs for groins, breakwaters, and revetments.
- 0.5% of total costs for storm surge barriers.
- 1% of total costs for beach restoration with renourishment interval of 4 years.

After computation of the total costs, they were annualized using the FY2017 (October 2016) discount rate of 2.875% for a 50 year life cycle of the project. Repair, replacement, and rehabilitation cost will be completed during optimization phase and are not expected to impact plan selection.

The engineering team developed more detailed OMRR&R estimates for determining costs associated with the RP. Further detail on the OMRR&R costs associated with the RP can be found in Appendix B.

Non-Federal Share of Life Cycle Costs

The non-Federal share of the life cycle costs (i.e. City of Norfolk costs) would be 35% for all project costs except for OMRR&R which are a 100% non-Federal responsibility. The non-Federal share of life cycle costs are present values at year 2026 in thousands of dollars.

Construction Time

The construction time metric represents the length of time required to design and construct an alternative plan so that most of its intended benefits are realized. The following assumptions were applied to the construction time metrics for the various measures:

- 1-5 years for structural measures, with larger systems such as the downtown flood barrier system (EBS) taking longer than smaller systems such as the barrier system at Pretty Lake (PL-2S)
- 1 year for nonstructural measures in an economic reach
- 1-5 years for NNBF measures that complement a structural measure

6.7.4 Risk and Uncertainty Analysis

The USACE is transforming to a risk-based management organization. Risk is a measure of the probability of undesirable consequences. Risk analysis is a decision-making framework that explicitly evaluates the level of risk if no action is taken and recognizes the monetary and non-monetary costs and benefits of reducing risks when making decisions. Risk analysis comprises three tasks: risk assessment, risk management, and risk communication. Figure 6-5 below shows the interrelatedness of the three parts of risk analysis and the notion that risk communication is a vital and joining activity that must take place for the analysis to be an effective decision framework.

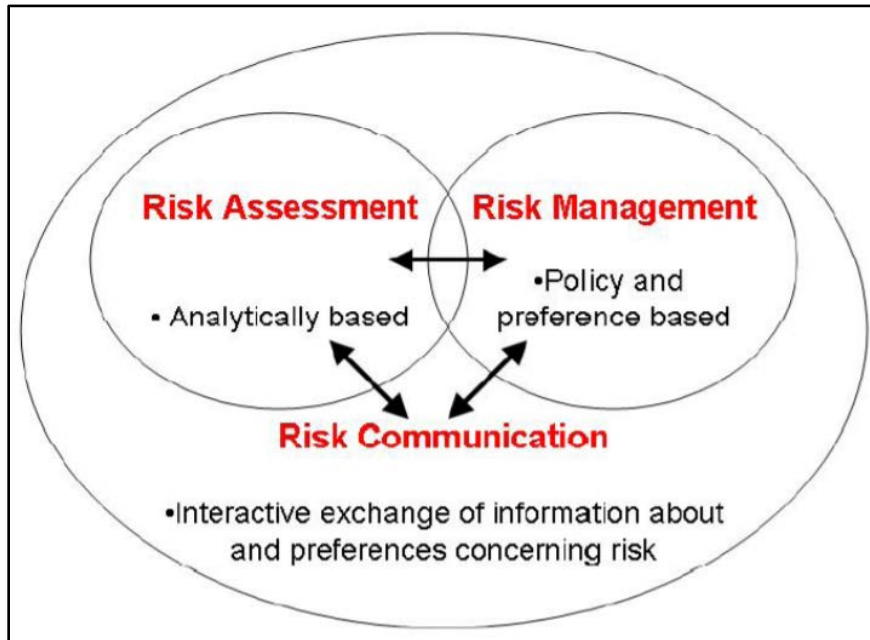


Figure 6-5. Risk Analysis Diagram

6.7.5 Engineering Risk and Uncertainty Analysis

As stated in the previous paragraph, risk is a measure of the probability (or likelihood) and consequences of uncertain future events. Risk analysis is a decision-making framework that explicitly evaluates the level of risk if no action is taken and recognizes the monetary and non-monetary costs and benefits of reducing risks when making decisions. A variety of variables and their associated uncertainties may be incorporated into the risk assessment of a coastal storm risk management study. Design conditions for major coastal and flood protection projects are often vague and design parameters contain large uncertainties. One factor of uncertainty is the confidence of the NACCS water levels, which are higher than the FEMA water levels. For a more robust discussion of the uncertainty of the NACCS still water levels, refer to the NACCS technical reports mentioned in the beginning of this appendix. For calculating wave overtopping, the EurOtop method used both a deterministic and probabilistic approach to analyze the wave overtopping for the design of the vertical wall and levee. To analyze risk of wave overtopping, different heights of walls were analyzed and adjusted based on findings and results to meet protection for the 50 year life of the project. The approach to address this issue can be read in the Hydraulics, Hydrology and Coastal Engineering Sub-Appendix within the Engineering Appendix which is Appendix B of this Norfolk CSRM Report. When assessing a floodwall for risk

analysis, the geotechnical engineer assumed two generalized, "worst-case" soil profiles to ensure safe wall performance. The structural engineer considered additional scour protection around the floodwall and if this will affect loads acting on the wall and realistic uplift loads. For more information on how risk was incorporated into the structural design of the floodwall, refer to the Geotechnical Engineering Sub-Appendix and the Structural Engineering Sub-Appendix for evaluations and hand calculations.

6.7.6 Cost Risk and Uncertainty Analysis

In accordance with ECB No. 2007-17, dated 10 September 2007, "Cost risk analysis methods will be used for the development of contingency for the Civil Works Total Project Cost estimate. It is the process of identifying and measuring the cost and schedule impact of project uncertainties on the estimated total project cost. When considerable uncertainties are identified, cost risk analysis can establish the areas of high cost uncertainty and the probability that the estimated project cost will or will not be exceeded. This gives the management team an effective additional tool to assist in the decision making process associated with project planning and design."

An Abbreviated Risk Analysis (ARA) was completed on the Final Array of Alternatives described in Chapter 8. A full Cost and Schedule Risk Analysis (CSRA) was performed on the Recommended Plan. Further information regarding the CSRA can be found in Appendix B.

6.7.7 Economic Risk and Uncertainty Analysis

Economic Uncertainty

The uncertainty surrounding the four key economic variables (structure values, contents-to-structure value ratios, first floor elevations, and depth-damage relationships) was quantified and entered into the HEC-FDA model. The HEC-FDA model used the uncertainty surrounding these variables to estimate the uncertainty surrounding the stage-damage relationships developed for each study area reach.

Structure and Vehicle Values. A triangular probability distribution based on the depreciated replacement costs derived for the three construction classes (economy, average, and luxury) was used to represent the uncertainty surrounding the residential structure values in each occupancy category. The most-likely depreciated value was based on the average construction class, the minimum value was based on the economy construction class, and the maximum value was based on the luxury construction class. These values were then converted to a percentage of the most-likely value with the most-likely value equal to 100 percent of the average value for each occupancy category and the economy and luxury class values equal to a percentage of these values. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values in each residential occupancy category.

A triangular probability distribution based on the depreciation percentage associated with the three exterior wall types (wood frame, masonry on wood frame, and masonry on masonry or steel) for a 30-year old structure was used to represent the uncertainty surrounding the non-residential structure values in each occupancy category. The most-likely depreciated value was based on the depreciation percentage (30 percent) assigned to a masonry exterior wall

construction, the minimum value was based on the depreciation percentage (35 percent) assigned to a wood frame exterior wall construction, and the maximum value was based on the on the depreciation percentage (25 percent) assigned to a masonry on masonry/steel exterior wall construction. These values were then converted to a percentage of the most-likely value with the most-likely value being equal to 100 percent and the minimum and maximum values equal to percentages of the most-likely value. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values for each non-residential occupancy category.

The uncertainty surrounding the values assigned to the vehicles in the inventory was determined using a triangular probability distribution function. The most-likely value was based on the assessed values provided by the City of Norfolk. These values were adjusted to reflect the number of vehicles per household and the percentage of these vehicles that would not be used for evacuation prior to a storm event. The average value of a new vehicle before taxes, license, and shipping charges was used as the maximum value, while the average salvage value of a vehicle was used as the minimum value. The percentages were developed for the most-likely, minimum and maximum values with the most-likely equal to 100 percent, and the minimum and the maximum values as percentages of the most-likely value. These percentages were entered into the HEC-FDA model as a triangular probability distribution to represent the uncertainty surrounding the vehicle value for both residential and non-residential vehicles.

Content-to-Structure Value Ratios. A triangular probability distribution was used to represent the uncertainty surrounding the contents-to-structure value ratios (CSVRs) for residential structures. The minimum CSVR value, 25 percent, was taken from the Willoughby GRR, an evaluation completed in the northern part of the city, while the maximum CSVR value, 70 percent, was based on a survey of homes in coastal Louisiana. The most-likely value, 50 percent, was taken from an economic analysis completed in support of a Continuing Authorities Program, Section 205 study on Newmarket Creek, Hampton, VA. A triangular probability distribution was also used to represent the uncertainty surrounding the CSVRs for the non-residential occupancies. The minimum, maximum and most-likely values were based on data obtained from either the Physical Depth Damage Function Summary Report published as a part of NACCS study or the 2013 Draft Non-residential Flood Depth-Damage Functions Derived from Expert Elicitation, depending on the type of non-residential occupancy.

First Floor Elevations. There are two sources of uncertainty surrounding the first floor elevations: the use of the 2013 Light Detection and Ranging (LIDAR) data to estimate the ground elevation, and the use of parcel data to determine the foundation heights above ground elevation. The error implicit in using LIDAR data is normally distributed with a mean of zero and a standard deviation of 0.377 feet. The error implicit in the use of parcel data is also normally distributed with a mean of zero and a standard deviation of 0.51 feet for residential structures and 0.31 feet for non-residential structures at the 95 percent level of confidence. There was less uncertainty surrounding the commercial structures relative to the residential structures because there was less variation in foundation types. The combination of the two uncertainties yielded a standard deviation of 0.63 for residential structures and 0.49 for non-residential structures.

Depth-Damage Relationships. A triangular probability density function was used to determine the uncertainty surrounding the damage percentages associated with each depth of flooding for the various residential and non-residential occupancy categories. A minimum, maximum, and most-likely damage estimate for each depth of flooding was obtained from the Physical Depth Damage Function Summary Report published as a part of NACCS study and the 2013 Draft Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation. A national panel of building, construction, insurance, and restoration experts was used to develop the data contained in these reports.

Engineering Uncertainty

The uncertainty surrounding three key engineering parameters was quantified and entered into the HEC-FDA model. These engineering variables include ground elevations and the stage-probability curves. The HEC-FDA model used the uncertainty surrounding these variables to estimate the uncertainty surrounding the elevation of the storm surges for each study area reach.

Ground Elevations. According to USGS Norfolk, VA LiDAR, Report Produced for U.S. Geological Survey, USGS Contract: G10PC00013, Task Order: G13PD00279, Report Date: 5/30/2014, for the Norfolk, VA LiDAR project, the majority LiDAR elevations were +/- 0.15 meters or 0.49 feet, with some elevations at +/- 0.23m or 0.75 ft. The only area where elevations were a concern was near shoreline. This was, particularly, a challenge for structures located on a piers for dock access. For these structures, the ground stage was extracted from the landward edge of the pier if no additional information was available.

Stage-Probability Relationships. Stage-probability relationships were provided for the existing (2026) without-project condition and future without project conditions (2076). Water surface profiles were provided for eight annual chance exceedance (ACE) events: 99% (1-year), 25% (4-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.4% (250-year), and 0.2% (500-year). The without-project water surface profiles were based on NACCS ADCIRC Save Points published on the Coastal Hazards System. Based on the years of record included in the NACCS numerical modeling, a 74-year equivalent record length was used to quantify the uncertainty surrounding the stage-probability relationships for each study area reach. Based on this equivalent record length, the HEC-FDA model calculated the confidence limits surrounding the stage-probability functions. No additional elevation, to account for near shore effects, was added to the water surface elevations.

Sea Level Change. For each of these ACE events, the water surface profiles for the years 2026 and 2076 were determined by adding relative sea level rise, as determined by the USACE Sea Level Rise Calculator for Sewells Point, Virginia using the USACE Intermediate Curve to the Save Point elevations. The mean sea level trend of 4.61 mm/year, or 0.01512 feet/year, with 95% confidence rating +/- 0.23 mm/year, as published for Sewells Point, VA, was used as the sea level change rate.

6.8 ECONOMIC RESULTS FOR SEPARABLE MEASURES

The various nonstructural and structural management measures were analyzed for their costs and benefits. The results are shown below in Table 6-2. The cost analysis includes screening

level estimates for the cost of construction, operations and maintenance, environmental mitigation, and real estate for water surface elevations associated with the NACCS 3% (35yr) annual chance exceedance (ACE) water surface elevation. For initial comparison purposes, the project team analyzed a 3% ACE water level; however, the project team analyzed 1.4% and 10% ACE water levels in order to optimize the TSP. The three analyses at the 1.4%, 3%, and 10% water levels will not result in substantially different plans. The NACCS 3% ACE also roughly corresponds to the FEMA 1% ACE, which is a priority for the city to consider in the analysis.

Economic damages and benefits were calculated using HEC-FDA for all reaches except the Willoughby Beach reaches Ra, Rb, and Rc. The Willoughby Beach reaches were analyzed with Beach-fx due to the model's ability to evaluate shoreline protection projects such as a beach and dune system. Note that in Table 6-2 the Willoughby Beach reaches were split into Ra, Rb, and Rc due to engineering feasibility concerns about minimum lengths of beach construction. It was eventually determined through Beach-fx modeling runs that the entire Willoughby Beach area should be analyzed as one structural measure along the entire beach to include RaS, RbS, and RcS. The structural measure for this entire beach is called RS. No other planning reaches are dependent on measure RS.

The Pretty Lake watershed area includes reaches PL-1, PL-1a, and PL-2. Structural measure PL-2S would provide flood risk reduction for planning reaches PL-1a and PL-2. PL-2S would also provide protection to planning reach Rb as storm surge can backflood the beach neighborhood in this reach.

In the downtown Norfolk area, Measure EBS incorporates several economic reaches that were determined to need one structural measure to protect reaches that are not separable at the 3% 2075 water surface elevation. Measure EBS provides risk reduction for EB-1a, EB-2, EB-3, EB-3a, EB-5, and H-1. This covers the neighborhoods of West Ghent, Ghent, The Hague, Downtown, and Harbor Park.

The Broad Creek watershed area includes reaches BC-1, EB-7 and EB-8. Structural measure BC-1S would provide flood risk reduction for planning reach BC-1 and a small portion of reach EB-5.

The Berkley neighborhood and the Campostella neighborhood each have proposed floodwalls protecting portions of the respective neighborhoods. EB-4aS and EB-4bS provide flood risk reduction for areas of Berkley and Campostella respectively.

All structural measures provided in the table below are considered separable measures in that no structural measure depends on any other measure to provide the benefits calculated.

Table 6-2. Economic Results for Structural and Nonstructural Measures

Segment	Segment	Average Annual Costs (\$1000's)	Annual Benefits (\$1000's)	Annual Net Benefits (\$1000's)	BCR	Total Project Cost (\$1000's)
Broad Creek Surge Barrier	BC-1S	\$ 4,869	\$ 8,319	\$ 3,450	1.7	\$ 128,317
Broad Creek	BC-1N	\$ 7,798	\$ 9,841	\$ 2,043	1.3	\$ 205,493

Segment	Segment	Average Annual Costs (\$1000's)	Annual Benefits (\$1000's)	Annual Net Benefits (\$1000's)	BCR	Total Project Cost (\$1000's)
Nonstructural						
Ghent-Downtown-Harbor Park Barrier System	EB S	\$ 9,212	\$ 50,379	\$ 41,167	5.5	\$ 242,747
Elizabeth River Eastern Branch Nonstructural	EB-1N	\$ 1,900	\$ 6,351	\$ 4,451	3.3	\$ 50,072
West Ghent Nonstructural	EB-1aN	\$ 2,930	\$ 7,444	\$ 4,514	2.5	\$ 77,216
Freemason Nonstructural	EB-2N	\$ 1,245	\$ 1,529	\$ 284	1.2	\$ 32,805
Waterside Nonstructural	EB-3aN	\$ 2,084	\$ 2,498	\$ 414	1.2	\$ 54,907
Downtown Nonstructural	EB-3N	\$ 163	\$ 1,926	\$ 1,764	11.9	\$ 4,283
Campostella / Berkley Nonstructural	EB-4N	\$ 2,645	\$ 8,120	\$ 5,476	3.1	\$ 69,694
Berkley Floodwall	EB-4aS	\$ 1,806	\$ 647	\$ (1,159)	0.36	\$ 47,585
Berkley Nonstructural	EB-4aN	\$ 1,408	\$ 850	\$ (558)	0.60	\$ 37,103
Campostella Floodwall	Eb-4bS	\$ 261	\$ 68	\$ (193)	0.26	\$ 6,876
Campostella Nonstructural	EB-4bN	\$ 202	\$ 96	\$ (105)	0.48	\$ 5,311
Downtown / Norfolk State Nonstructural	EB-5N	\$ 4,867	\$ 15,254	\$ 10,387	3.1	\$ 128,249
Lyon Shipyard Nonstructural	EB-5aN	\$ 663	\$ 2,655	\$ 1,992	4.0	\$ 17,473
Ingleside Rd. Nonstructural	EB-7N	\$ 622	\$ 877	\$ 255	1.4	\$ 16,391
Elizabeth Park Nonstructural	EB-8N	\$ 3,087	\$ 3,288	\$ 200	1.1	\$ 81,354
The Hague Nonstructural	H-1N	\$ 6,451	\$ 22,335	\$ 15,884	3.5	\$ 169,996
Lafayette River Outer Surge Barrier	LR-1aS	\$ 28,796	\$ 40,179	\$ 11,383	1.4	\$ 758,834
Lafayette River Middle Surge Barrier	LR-1bS	\$ 25,313	\$ 40,179	\$ 14,866	1.6	\$ 667,034
Lafayette River Outer Nonstructural	LR-1N	\$ 6,720	\$ 11,824	\$ 5,105	1.8	\$ 177,082
Lafayette River Inner Surge Barrier	LR-2S	\$ 13,945	\$ 29,546	\$ 15,601	2.1	\$ 367,474
Lafayette River Inner Nonstructural	LR-2N	\$ 26,893	\$ 32,213	\$ 5,320	1.2	\$ 708,677
Lake Whitehurst Lower Nonstructural*	LW-1N	\$ 0	\$ 0	\$ 0	-	\$ 0
Lake Whitehurst Upper Nonstructural*	LW-2N	\$ 570	\$ 117	\$ (454)	0.20	\$ 15,025
Elizabeth River Main Stem Nonstructural	MS-1N	\$ 86	\$ 1,672	\$ 1,586	19.5	\$ 2,256
Norfolk International Terminal Nonstructural	MS-2N	\$ 1,705	\$ 6,430	\$ 4,725	3.8	\$ 44,929
Pretty Lake Lower Nonstructural	PL-1N	\$ 132	\$ 612	\$ 481	4.6	\$ 3,475
Pretty Lake Lower Nonstructural	PL-1aN	\$ 555	\$ 382	\$ (173)	0.7	\$ 14,622
Pretty Lake Upper Surge	PL-2S	\$ 2,680	\$ 8,172	\$ 5,492	3.1	\$ 70,612

Segment	Segment	Average Annual Costs (\$1000's)	Annual Benefits (\$1000's)	Annual Net Benefits (\$1000's)	BCR	Total Project Cost (\$1000's)
Barrier						
Pretty Lake Upper Nonstructural	PL-2N	\$ 7,107	\$ 8,133	\$ 1,026	1.1	\$ 187,279
Willoughby Bay Nonstructural	WB-1N	\$ 3,214	\$ 8,059	\$ 4,845	2.5	\$ 84,705
Mason Creek Navy Floodwall*	WB-2S	\$ 301	\$ 22	\$ (280)	0.07	\$ 7,939
Mason Creek Nonstructural*	WB-2N	\$ 1,451	\$ 11	\$ (1,439)	0.01	\$ 38,230
Glenwood Nonstructural*	WB-2aN	\$ 1,491	\$ 1,391	\$ (100)	0.93	\$ 39,302
Willoughby Beach Fill*	RS (RaS+RbS +RcS)	\$ 2,366	\$ 3,309	\$ 942	1.4	\$ 106,470
Willoughby Beach Western Nonstructural*	RaN	\$ 7,290	\$ 797	\$ (6,493)	0.11	\$ 192,109
Willoughby Beach Middle Nonstructural*	RbN	\$ 0	\$ 0	\$ 0	-	\$ 0
Willoughby Beach Eastern Nonstructural*	RcN	\$ 2,070	\$ 1,245	\$ (824)	0.60	\$ 54,547

*These measures are eventually screened out from the Final Array as is described in Section 7.2

The Campostella and Berkley neighborhoods are located in the portion of the city that is south of the Elizabeth River. This part of the city geographically separate from the rest of the city due to the river. The measures that denote efforts in this area are labeled with an EB-4. The PDT has always considered this portion of the city to be a cohesive neighborhood with similar socioeconomic conditions, land use, and needs stemming from its history and the location separate from the rest of the city. In order to investigate the possibility for structural measures in the area the modeling software required the area be divided based on the alignment of those structural measures. This is why there are multiple EB-4 areas reported. However, structural measures do not show economic justification and are not considered reasonable based on the geography of the shoreline. For nonstructural justification the area has been considered as one cohesive neighborhood with the costs and benefits of EB-4N, EB-4aN, and EB-4bN combined for economic assessment.

CHAPTER 7 FOCUSED ARRAY OF ALTERNATIVES

7.1 FOCUSED ARRAY OF ALTERNATIVES

The measures listed in Table 6-1 and Table 6-2 were combined into alternative plans that would provide coastal storm risk management for large portions of Norfolk. In order to meet the objectives of the study all areas of the city were investigated for coastal storm risk management solutions. The formulation strategy sought a comprehensive project that would allow Norfolk to maintain critical infrastructure, evacuation routes, and cohesive neighborhoods. Also, by formulating a comprehensive, citywide alternative, socially vulnerable neighborhoods will receive the same, or similar, levels of risk reduction as wealthy or more valuable property areas.

Four types of alternatives were formulated: the No Action, the Structural Only, the Nonstructural Only, and the Structural / Nonstructural Combination Alternatives. The PDT, in coordination with the City of Norfolk, used the plan formulation process (Figure 5-1) to combine the measures listed in Table 6-1 and Table 6-2 into alternative plans based on the four types listed above. There are limited feasible structural elements for coastal storm risk management within Norfolk. These are primarily perimeter plans and the main variable is the location of the Lafayette storm surge barrier. So the comparison in other locations was primarily structural versus nonstructural. Some other structural measures were screened out earlier in the process. In all, ten alternative plans were developed, plus the No Action Alternative. Each alternative plan has its own economic valuations based on its component measures (Table 6-2). The alternative plans are shown in Table 7-1. These alternative plans include some measures that were later found to be not cost-justified, at which point re-formulation of the focused array was necessary.

Table 7-1. Focused Array of Alternatives

Alternative Plan	Measures	Total Avg. Annual Costs (\$1000's)	Annual Benefits (\$1000's)	Annual Net Benefits (\$1000's)	BCR	Total Project Cost (\$1000's)
Alternative 1	No Action	0	0	0	0	0
Alternative 2a - Structural Only (LR-1a)	BC-1S, EBS, EB-4aS, EB-4bS, LR-1aS, PL-2s, WB-2S, RS.	\$ 52,000	\$ 123,000	\$ 71,000	2.4	\$ 1,369,000
Alternative 2b - Structural Only (LR-1b)	BC-1S, EBS, EB-4AS, EB-4BS, LR-1BS, PL-2S, WB-2S, RS.	\$ 49,000	\$ 123,000	\$ 75,000	2.5	\$ 1,278,000
Alternative 2c - Structural Only (LR-2 S)	BC-1S, EBS, EB-4aS, EB-4bS, LR-2S, PL-2S, WB-2S, RS.	\$ 37,000	\$ 83,000	\$ 46,000	2.3	\$ 978,000
Alternative 3- Nonstructural Only (All reaches)	All Nonstructural segments	\$ 88,000	\$ 152,000	\$ 64,000	1.7	\$ 2,319,000

Alternative Plan	Measures	Total Avg. Annual Costs (\$1000's)	Annual Benefits (\$1000's)	Annual Net Benefits (\$1000's)	BCR	Total Project Cost (\$1000's)
Alternative 4a - Combination Structural and Nonstructural (LR-1a)	BC-1S, EBS, EB-4AS, EB-4bS, LR-1aS, PL-2S, WB-2S, RS, EB-1N, EB-4N, EB-5AN, EB-7N, EB-8 N, LW-1N,LW-2N, MS-1N,MS-2N, PL-1N,WB-1N,WB-2AN	\$ 72,000	\$ 162,000	\$ 90,000	2.2	\$ 1,903,000
Alternative 4b - Combination Structural and Nonstructural (LR-1b)	BC-1S, EBS, EB-4AS, EB-4BS, LR-1bS, PL-2S, WB-2S, RS, EB-1N, EB-4N, EB-5AN, EB-7N, EB-8N, LW-1N,LW-2N, MS-1N,MS-2N, PL-1N,WB-1N,WB-2AN.	\$ 69,000	\$ 162,000	\$ 93,000	2.7	\$ 1,811,000
Alternative 4c - Combination Structural and Nonstructural (LR-2 S)	BC-1 S, EBs, EB-4A S, EB-4B S, LR-1N, LR-2 S, PL-2 S, WB-2 S, RS, EB-1 N, EB-4 N, EB-5AN, EB-7 N, EB-8 N, LW-1 N,LW-2 N, MS-1 N,MS-2 N, PL-1 N,WB-1 N,WB-2A N	\$ 64,000	\$ 163,000	\$ 99,000	2.6	\$ 1,688,000
Alternative 4d - Combination Structural and Nonstructural (LR-1a), Berkley and Campostella Nonstructural	BC-1 S, EBs, LR-1a S, PL-2 S, WB-2 S, RS, EB-1 N, EB-4 N, EB-4A N, EB-4B N, EB-5AN, EB-7 N, EB-8 N, LW-1 N,LW-2 N, MS-1 N,MS-2 N, PL-1 N,WB-1 N,WB-2A N	\$ 72,000	\$ 162,000	\$ 90,000	2.3	\$ 1,891,000
Alternative 4e - Combination Structural and Nonstructural (LR-1b), Berkley and Campostella Nonstructural	BC-1 S, EBs, LR-1b S, PL-2 S, WB-2 S, RS, EB-1 N, EB-4 N, EB-4A N, EB-4B N, EB-5AN, EB-7 N, EB-8 N, LW-1 N,LW-2 N, MS-1 N,MS-2 N, PL-1 N,WB-1 N,WB-2A N	\$ 68,000	\$ 162,000	\$ 94,000	2.4	\$ 1,799,000
Alternative 4f - Combination Structural and Nonstructural (LR-2 S), Berkley and Campostella Nonstructural	BC-1 S, EBs, LR-1N, LR-2 S, PL-2 S, WB-2 S, RS, EB-1 N, EB-4 N, EB-4A N, EB-4B N, EB-5AN, EB-7 N, EB-8 N, LW-1 N,LW-2 N, MS-1 N,MS-2 N, PL-1 N,WB-1 N,WB-2A N	\$ 64,000	\$ 163,000	\$ 100,000	2.6	\$ 1,676,000

7.2 REFORMULATION OF THE FOCUSED ARRAY

Where possible, the focused array of alternatives included risk reduction measures for all reaches of the city that showed flood damages, regardless of the measures' BCR. During the June charrette the team reviewed reaches that contained risk reduction measures that were not justified based on their net annual benefits. The team considered impacts to critical infrastructure, major transportation routes, and vulnerable populations. If there was no justification based on these criteria then the measure was screened out of the alternative and the alternative was reformulated without that particular measure. The section below describe the reformulation process. Chapter 8 FINAL ARRAY OF ALTERNATIVES includes the results of the reformulation process, including which measures and alternatives are included in the Final Array and their economic results.

Willoughby Beach (RS)

Measure RS was eliminated as it did not show significant benefits beyond the existing Willoughby project. There is already a Federal beach project at this location, which was constructed in the spring of 2017 (beach berm width of 60 feet). Beach-fx was used to analyze if additional dune or beach berm widening would reduce flood risk in this area. However, the analysis showed that the current federal project shows adequate coastal storm risk management and no additional beach construction is recommended. More detail on the Beach-fx modeling can be found in Appendix C

Willoughby Beach Nonstructural Reaches (RaN, RbN, RcN)

The nonstructural measures RaN, RbN, and RcN were eliminated as they did not show economic justification. The area is not considered a low income or socially vulnerable area and therefore the team did not find adequate justification in this area beyond the economic analysis.

Mason Creek (WB-2S)

The Mason Creek area borders the Naval Air Station. The floodwall measure WB-2S is not justified economically based on damages to City of Norfolk jurisdictional areas. The floodwall also does not appear to protect critical infrastructure. The wall may be of interest to the Naval Station Norfolk as the floodwall would prevent flooding of access roads adjacent to the Naval Air Station runways. Measure WB-2S was removed from the alternatives formulation.

Berkley (EB-4aS) and Campostella (EB-4bS)

Floodwalls EB-4aS and EB-4bS did not show BCR values above 1.0. The Campostella and Berkley neighborhoods do include socially vulnerable, low income populations. The team determined that critical infrastructure and roadway concerns would not justify recommending this measure with a low BCR. The team decided that nonstructural measures would be a preferable method of flood risk reduction in this area.

Lake Whitehurst Nonstructural (LW-2N)

The nonstructural measure for Lake Whitehurst (LW-2N) is not economically justified. The team determined that there was no justification beyond economics for recommending this measure. LW-2N was removed from consideration in the alternatives.

Glenwood Nonstructural (WB-2aN)

The Glenwood neighborhood nonstructural measure, WB-2aN, was not economically justified. The team determined that this measure could not be justified for recommendation for other reasons. WB-2aN was removed from consideration in the alternatives.

7.3 COMPLETE, EFFICIENT, EFFECTIVE AND ACCEPTABLE

Reference ER 1105-2-100, Section 2-3, c (2), states, "As a general rule projects must be formulated to reasonably maximize benefits to the national economy, to the environment or to the sum of both. Each alternative plan shall be formulated in consideration of four criteria described in the Principles and Guidelines: completeness, efficiency, effectiveness, and acceptability." A discussion is included below of each of those criteria and how these alternatives were developed to meet these criteria. As is discussed later in this chapter, several of these alternatives were screened later in the process when additional engineering detail became available which resulted in the determination that alternatives no longer met this criteria.

Complete: All plans in the focused array are not reliant on any other activity for benefits. The measures were formulated as separable elements that could be fit together into functioning complete alternatives.

Efficient: The focused array and each separable element have been incrementally justified. Those separable elements that were found to be not justified were later removed from consideration.

Effective: All of the plans generally meet the study objectives, though some better than others. The fully nonstructural plan would leave the evacuation routes as well as the main transit routes to the military installations unprotected, resulting in higher residual risk. The fully structural plans leaves some areas of the city unprotected as some structural separable elements are not justified.

Acceptable: The plan meets all applicable laws, regulations and policy. The EIS analyzes the final array of alternatives against this criteria. The nonstructural only plan would have many additional obstacles with environmental justice, socioeconomics, aesthetics, and cultural resource concerns. These impacts may be mitigable and therefore eventually acceptable, but the impact would be very significant.

7.4 NO ACTION/FUTURE WITHOUT PROJECT ALTERNATIVE

The No Action Alternative is a plan that proposes the USACE will not implement any of the proposed actions identified in this study. The No Action Alternative also assumes current floodplain management conditions continue into the future. Estimated future changes such as changes in sea level, local environment, land use, and population are incorporated into the No Action Alternative.

This plan is considered the projected baseline, or without project, condition which is used to compare all other proposed alternatives. Future economic, environmental, and social impacts of all proposed alternatives are assessed against the No Action Alternative.

We present the no action as an alternative and discuss the impacts associated with no action in order define the environmental baseline for comparison to the action alternatives. Although this report discusses impacts associated with the no action alternative (e.g., the potential

consequences of sea level rise and coastal flooding if no coastal storm risk management measures are implemented), selection of this alternative would not "cause" impacts--it merely represents the anticipated condition with no action by the USACE.

7.5 FOCUSED ARRAY ALTERNATIVE 2A, 2B, AND 2C

Alternative 2a, 2b, and 2c are structural only alternatives. The only difference between the alternatives is the alignment of the Lafayette River storm surge barrier. Alternative 2a includes measure LR-1aS which is the outer Lafayette storm surge barrier. Alternative 2b includes measure LR-1bS which is the middle barrier. Alternative 2c includes measure LR-2S which is the inner barrier. These plans would reduce flood risk only to areas that are behind the structures. Nonstructural measures were not considered in any of these alternatives.

7.6 FOCUSED ARRAY ALTERNATIVE 3

Alternative 3 is a "nonstructural plus ringwall" plan. All economic reaches of the City were analyzed for the feasibility and economic results of implementing nonstructural and ringwall features. Ringwalls, while considered structural measures per USACE Planning Bulletin PB 2016-01, are included with the nonstructural plan due to 1) the nature of ringwalls impacting flood hazard on the scale of an individual property and 2) the number and spread-out locations of ringwalls proposed in the study.

Nonstructural measures considered for this alternative include elevating properties, basement fills, floodproofing, and acquisition. Ringwalls are a structural measure that are included along with all the nonstructural measures. All of the costs for the nonstructural measures and ringwalls were compared against the least cost option for any particular property. The floodproofing measure was assumed to be an option for areas with flooding of 3 feet or less. Flooding above three feet ruled out floodproofing in which case ringwalls were then assumed as an option. If necessary, basement fills were combined with other measures, such as elevating a home.

Note that there are several measures that have a BCR lower than 1.0 (See Table 6-2). The reasons these were included:

1. Upon compilation of the initial focused array, the BCR data was not yet available
2. It was important to the team to formulate a comprehensive risk reduction plan for Norfolk

At this phase of the study the individual measures have not been reviewed for OSE and critical infrastructure. Two of the measures, LW-1N and RbN, did not show damages, because these areas are not calculated to have flood damages at the design 3% ACE WSEL.

7.7 FOCUSED ARRAY OF ALTERNATIVES 4A, 4B, 4C, 4D, 4E, 4F

There are six variations of Alternative 4 that were combined and included in the Focused Array. These alternatives are combinations of structural and nonstructural measures that provide flood risk reduction in every studied economic reach of Norfolk. Alternatives 4a, 4b, and 4c include all the structural measures as proposed in Alternatives 2a, 2b, and 2c, with the associated Lafayette River SSB alignments. Alternatives 4a, 4b, and 4c include all nonstructural reaches that constituted residual flood risk exposure. The list of measures for each alternative is shown in Table 7-1.

Alternatives 4d, 4e, and 4f are the same as Alternatives 4a, 4b, and 4c except for the fact that

4d, 4e, and 4f provide nonstructural coastal storm risk management for the entire Campostella / Berkley neighborhoods versus the proposed structural measures used in Alternatives 4a, 4b, and 4c.

7.8 SCREENING OF THE FOCUSED ARRAY OF ALTERNATIVES

In order to arrive at a final array of alternative plans the focused array of alternatives was screened by the PDT and the City of Norfolk in a June 2017 charrette. Screening criteria established by the PDT included information based on study constraints, economics, and other social effects (OSE). First, the team reviewed the economic analysis and engineering information available to determine the viability of each alternative. Then, an OSE ranking was performed to ensure that any decisions based on economics and engineering would not negatively impact life/safety, critical infrastructure, and/or cause disproportionate negative impacts to socially vulnerable populations. The OSE matrix shown in Table 7-2 was completed by the PDT and City of Norfolk staff in order for the team to better comprehend the impact each alternative would have on city, regional, and national interests.

7.8.1 Other Social Effects Matrix

The City of Norfolk and the PDT reviewed the focused array of ten alternative plans based on OSE metrics. The rating scheme used to rank the plans was based on the Institute for Water Resources' handbook for Applying Other Social Effects in Alternatives Analysis (2013). This method uses a -3 to 3 scale with -3 representing significant negative effects and 3 representing significant beneficial effects. Zero is negligible effects or no impact. The one and two scores are for minor and moderate effects in either the negative or positive direction. All metrics were scored for each alternative with consideration as to how that particular alternative would impact the metric in the future. Alternative plans can then be compared against each other based on the scoring results.

Table 7-2. Other Social Effects Matrix

Factor	Metric	No Action	Alternative 2a	Alternative 2b	Alternative 2c	Alternative 3
1. Health and Safety		-3	2	2	1	-2
2. Economic Vitality	Port of Virginia	-3	1	1	-2	-2
	Tax Revenue	-3	1	0	-2	-2
3. Regional/National/Global Impact	Security	-3	2	2	-1	-2
	Commerce	-3	2	2	-1	-3
4. Community Cohesion		-3	0	0	-1	-1
5. Historic Structures/Districts	Historic Structures	-3	2	2	1	-2
	Archeological Sites	-3	-1	-1	-1	0
6. Socially Vulnerable Populations		-3	2	2	2	-3
7. Recreation		-3	1	-1	1	-1
8. Military Readiness	Installations / Facilities	0	0	0	0	0
	Access to Installations	-3	2	2	-1	-3
9. Critical Infrastructure	Evacuation Routes	-3	2	2	-1	-3
	Emergency Services	-3	2	2	-1	-3
	Port of Virginia	-3	1	1	-1	-3
	Total	-42	19	16	-7	-30

Table 7-2 (continued) Other Social Effects Matrix

Factor	Metric	Alt 4a	Alt 4b	Alt 4c	Alt 4d	Alt 4e	Alt 4f
1. Health and Safety		3	3	1	3	3	1
2. Economic Vitality	Port of Virginia	1	1	-2	1	1	-2
	Tax Revenue	1	1	-2	1	1	-1
3. Regional/National/Global Impact	Security	2	2	-1	2	2	-1
	Commerce	2	2	-1	2	2	-1
4. Community Cohesion		1	1	0	1	1	-1
5. Historic Structures/Districts	Historic Structures	2	2	1	2	2	1
	Archeological Sites	-1	-1	-1	-1	-1	-1
6. Socially Vulnerable Populations		2	2	2	2	2	2
7. Recreation		1	-1	1	1	-1	1
8. Military Readiness	Installations / Facilities	0	0	0	0	0	0
	Access to Installations	2	2	-1	2	2	-1
9. Critical Infrastructure	Evacuation Routes	2	2	-1	2	2	-1
	Emergency Services	2	2	-1	2	2	-1
	Port of Virginia	1	1	-1	1	1	-1
	Total	21	19	-6	21	19	-6

The OSE matrix shows that based on broad social impacts the alternatives that include structural measures score significantly higher than the No Action and nonstructural alternatives. This is primarily because the structural measures protect transportation interests by reducing road flooding throughout the city. Transportation is important for the readiness of Naval Station Norfolk and the economic viability of the Virginia Port Authority facilities and other economic interests. Transportation interests are also important for access to hospitals and emergency response. Alternative 3 is a nonstructural only plan and therefore leaves the transportation network more highly exposed to flooding and flood related damages. The nonstructural only plan rated poorly and the lack of positive effects as displayed in the OSE table results demonstrates the relative unacceptability for such a plan.

Alternatives 2a, 2b, 4a, 4b, 4d and 4e all score positively. Alternative 4a-4e provide a comprehensive plan with nonstructural and structural measures combined. Nonstructural measures are recommended in several low income neighborhoods where structural measures could not be economically justified or were not feasible to construct. The combination of

nonstructural and structural measures allows for a more comprehensive plan for the city than those plans that include just one or the other. A more comprehensive plan will allow for the sustainability of more neighborhoods throughout Norfolk. Alternatives 2a, 2b, and 2c do not provide nonstructural measures, they are structural only plans. Because they do not provide as comprehensive a plan as those in Alternative 4, the economic vitality and health and safety scores were slightly lower.

Alternatives 2a, 2b, 4b, and 4e have similar scores that were judged to be positive. Alternatives 2c, 4c and 4f are rated negatively primarily due to the impact that the inner Lafayette River SSB, measure LR-1cS, would have on Hampton Boulevard transportation. The process of conducting the OSE matrix spurred further discussion between the PDT and City of Norfolk staff on the pros and cons of various measures included in the focused array plans. Further screening based on engineering, economics and critical infrastructure took place. The results of these screening are described in the following sections.

7.8.2 Alternative 2b, 4b, and 4e Screening

Alternatives 2b, 4b, and 4e include the measure LR-1bS, the Lafayette River middle SSB. Figure 6-4 and Appendix A show where this SSB is located. During the June charrette the City of Norfolk and the PDT reviewed engineering detail that had not been available earlier in the planning process and recognized that the middle Lafayette Barrier was not feasible for implementation based on established screening criteria. The concerns are primarily based on the proposed floodwall that would run along approximately 5,500 ft. of the Larchmont neighborhood shoreline. The shoreline consists predominately of privately owned, waterfront homes. The following bullets describe the concerns that led to the screenings of measure LR-1bS, and hence Alternatives 2b, 4b, and 4e.

The screening criteria applicable to this alternative include the cultural resource constraint and potential implementation issues that are difficult to currently estimate due to high level of uncertainty.

- **Cultural Resource Constraint:** The aesthetic impact would be a significant adverse impact to the viewshed and therefore would violate the cultural resource constraint.
- **Potential implementation/constructability:** The floodwall requires extensive acquisition of residential waterfront property within the Larchmont neighborhood. The acquisition of private property in this area is considered highly uncertain due to the fact that a floodwall would cutoff property owners from their boat docks and it would likely significantly reduce property values.
- **Potential implementation:** There is no city right of way on any of those properties so all easements would be new acquisitions. If all of the property owners, approximately 50 privately owned properties, did not agree to a voluntary easement, the city would need to take the necessary property extents by condemnation in order to construct and maintain the floodwall. This acquisition likely would have to go through condemnation proceedings, creating a high degree of uncertainty regarding both cost and schedule.
- **Potential Opposition:** During the June 2017 public meeting the USACE received strong feedback against the Lafayette River middle SSB (LR-1bS). In large part, this feedback focused on concerns that this alternative would run along 5,500 feet of the Larchmont neighborhood shoreline and sever properties from direct waterfront access.

- **Potential implementation/constructability:** There are rights to access to the water granted to those properties under state law. The City of Norfolk would be required to acquire those rights as well, if the floodwall restricted access to the water. There are currently 41 docks on properties that would be impacted by the flood wall.

7.8.3 Alternative 2c, 4c, and 4f Screening

Alternatives 2c, 4c, and 4f include the measure LR-2S, the Lafayette River inner SSB. Figure 6-4 and Appendix A show where this SSB is located. During the June charrette the City of Norfolk and the PDT reviewed engineering detail that had not been available earlier in the planning process and recognized that the inner Lafayette Barrier was not feasible for implementation based on established screening criteria. The concerns are all based on the proposed floodwall that would run along approximately 10,000 ft of Hampton Boulevard. The following bullets describe the concerns that led to the screenings of measure LR-2S, and hence Alternative 2c, 4c, and 4f, based on a floodwall along Hampton Boulevard. These concerns are also reflected in the OSE matrix scoring for these alternatives.

The screening criteria used to screen this alternative include the acceptability, constructability, meeting objectives, minimize residual risk, and military readiness constraint.

- **Impacts to military readiness:** The route is the primary north-south travel route for Norfolk International Terminal and Naval Station Norfolk. Traffic congestion due to a flood project could negatively impact commerce to NIT and access for those working at the NSN.
- **Life Safety Objective:** A wall along Hampton Blvd would cause significant impacts to this primary evacuation route. Emergency evacuation and emergency vehicles could be negatively impacted, creating a life safety hazard.
- **Potential implementation:** Hampton Boulevard is the most traveled roadway in Norfolk. Increased traffic congestion due to intersection impacts could be significant. The floodwall would impact over 20 traffic intersections and place an approximately 6-8 ft wall along the roadway. These impacts have not been quantified but would definitely be an adverse impact.
- **Life Safety Objective:** Potential floodwall would negatively impact visibility which could increase traffic accidents.
- **Minimize Residual Risk:** This alternative would leave a large area of the city, along with the critical infrastructure in that area, at risk to coastal storm damage. Although nonstructural elements would be considered for the area west of the inner barrier and floodwall, the roadways would be flooded and public facilities unprotected.

7.8.4 Reformulating Pretty Lake and Campostella / Berkley for Neighborhood Cohesiveness

Due to the requirements of HEC-FDA, economic reaches PL-1a, EB-4a, and EB-4b were created in order to account for the damages and benefits of a structural measure. Economic reach PL-1a was created because the proposed structural measure PL-2S cuts through what was originally a larger PL-1 reach. From a neighborhood and community perspective PL-1a and PL-1 should be treated with similar risk reduction. For Alternative 3, nonstructural and ringwall, the team proposes PL-1 and PL-1a be justified based on their combined BCR due to maintaining neighborhood cohesiveness. This combined BCR is 1.4.

Economic reaches for EB-4a and EB-4b were created in HEC-FDA to account for floodwall measures EB-4aS and EB-4bs. The Campostella / Berkley neighborhoods are considered connected and the team believes that whole area including measures EB-4, EB-4a, and EB-4b should be combined for nonstructural justification. The structural measures EB-4aS and EB-4bS are not justified based on BCR. A combined nonstructural measure including EB-4N, EB-4aN, and EB-4bN would have a BCR of 2.1. The team feels that the three measures should be justified based on their combined BCR in order to maintain neighborhood cohesiveness.

The final array of measures is described in Chapter 8. The alternatives in the final array were reformulated from the focused array of alternatives based on the reasons described above.

CHAPTER 8 FINAL ARRAY OF ALTERNATIVES

An alternative plan is a set of one or more management measures functioning together to address one or more planning objectives. Those measures in the Focused Array of Alternatives that were not screened out for further consideration were developed into the Final Array of Alternatives. Based on the measures carried forward, both structural and nonstructural alternative plans were developed with more detailed analysis.

The final array was evaluated considering the following factors:

- HEC-FDA – economic damages prevented
- Health Human and Safety – Other Social Effects analysis such as evacuation, traffic, environmental justice, and national defense
- Environmental – impact analysis such as water quality modeling and ESA considerations
- Construction – construction costs and feasibility
- Real Estate – acquisition costs and considerations
- Public Meetings – citizen input on focused array of alternatives

These categories were critical and considered the integral components of the four Principle and Guidelines criteria for evaluation of each alternative plan. The four criteria are completeness, efficiency, effectiveness, and acceptability. In addition, benefits were calculated using HEC-FDA.

8.1 FINAL ARRAY COST ESTIMATES

8.1.1 Final Array Cost Updates

The measures in the Final Array of Alternatives underwent more detailed cost estimating than was performed on the Focused Array of Alternatives. The following describe where cost estimates were refined:

Abbreviated Risk Assessment

The costs analysis on the measures in the Final Array included an Abbreviated Risk Assessment (ARA). The ARA is a PDT effort, led by the cost engineer, to properly weight uncertainties associated with each major construction cost item or feature. The weighting of these uncertainties ties directly into an estimated cost contingency for construction items that make up the measures.

Real Estate Estimates

A more detailed real estate plan was developed for the measures in the Final Array. Land and home values were updated to more accurately reflect current fair market prices and trends. Certain easement locations were reexamined and optimized.

Engineering Updates

The design of some structural measures was updated by the engineering department. Floodwall dimensions were adjusted to account for wave action. Adjustments included elevation or realignment of floodwall dimensions in certain locations. Results from a water quality analysis of the impacts of a SSB on the Lafayette River informed a change in the number of miter gates necessary for the outer Lafayette SSB. The number of miter gates was reduced from 18 miter

gates to nine miter gates to be included with the one sector gate at the navigation channel.

Discount Rate

The discount rate used to discount benefits and costs was updated to the new Fiscal Year (FY) 2018 (October 2017) level of 2.75%. The slight drop in the discount rate from 2.875% caused a marginal increase to the benefits and a marginal decrease to the costs due to inverse correlation. Refer to table 9-2 for the cost estimates by measure within the TSP Alternative 4d.

Table 8-1. Economic Results for Final Array Measures

Description	Economic Reach	Average Annual Costs (\$1,000)	Annual Benefits (\$1,000)	Annual Net Benefits (\$1,000)	BCR	Total Project Cost (\$1,000)
Broad Creek Surge Barrier	BC-1 S	\$8,205	\$13,469	\$5,264	1.64	\$221,517
Broad Creek Nonstructural	BC-1 N	\$10,559	\$9,944	-\$614	0.94	\$285,054
Ghent-Downtown-Harbor Park Barrier System	EB S	\$15,275	\$55,977	\$40,702	3.66	\$412,387
Elizabeth River Eastern Branch Nonstructural	EB-1 N	\$2,144	\$5,913	\$3,769	2.76	\$57,893
West Ghent Nonstructural	EB-1a N	\$3,774	\$8,262	\$4,489	2.19	\$101,885
Freemason Nonstructural	EB-2 N	\$1,220	\$1,506	\$286	1.23	\$32,944
Waterside Nonstructural	EB-3a N	\$2,740	\$2,498	-\$243	0.91	\$73,983
Downtown Nonstructural	EB-3 N	\$220	\$1,826	\$1,605	8.28	\$5,950
Campostella / Berkley Nonstructural	EB-4 N	\$3,560	\$4,643	\$1,083	1.30	\$96,107
Berkley Nonstructural	EB-4a N	\$1,812	\$857	-\$956	0.47	\$48,931
Campostella Nonstructural	EB-4b N	\$271	\$97	-\$174	0.36	\$7,328
Downtown / Norfolk State Nonstructural	EB-5 N	\$5,196	\$12,946	\$7,750	2.49	\$140,285
Lyon Shipyard Nonstructural	EB-5a N	\$896	\$2,682	\$1,786	2.99	\$24,198

Description	Economic Reach	Average Annual Costs (\$1,000)	Annual Benefits (\$1,000)	Annual Net Benefits (\$1,000)	BCR	Total Project Cost (\$1,000)
Ingleside Rd. Nonstructural	EB-7 N	\$839	\$889	\$50	1.06	\$22,640
Elizabeth Park Nonstructural	EB-8 N	\$4,168	\$3,196	-\$972	0.77	\$112,523
The Hague Nonstructural	H-1 N	\$8,568	\$19,572	\$11,004	2.28	\$231,308
Lafayette River Outer Surge Barrier	LR-1a S	\$18,907	\$56,343	\$37,436	2.98	\$510,439
Lafayette River Outer Nonstructural	LR-1 N	\$8,944	\$12,363	\$3,419	1.38	\$241,463
Lafayette River Inner Nonstructural	LR-2 N	\$36,319	\$34,482	-\$1,837	0.95	\$980,516
Elizabeth River Main Stem Nonstructural*	MS-1 N	\$397	\$44	-\$352	0.11	\$10,705
Norfolk International Terminal Nonstructural	MS-2 N	\$2,193	\$4,822	\$2,629	2.20	\$59,199
Pretty Lake Lower Nonstructural	PL-1 N	\$145	\$269	\$123	1.85	\$3,919
Pretty Lake Lower Nonstructural	PL-1a N	\$757	\$382	-\$375	0.50	\$20,432
Pretty Lake Upper Surge Barrier	PL-2 S	\$3,219	\$10,690	\$7,471	3.32	\$86,905
Pretty Lake Upper Nonstructural	PL-2 N	\$9,730	\$8,143	-\$1,587	0.84	\$262,676
Willoughby Bay Nonstructural	WB-1 N	\$4,176	\$7,922	\$3,746	1.90	\$112,750

*Removed from the Final Array of Alternatives Plan Calculations in Table 8-2

One measure was removed from consideration in the Final Array of Alternatives. The economic estimate for measure MS-1N was improved based on more detailed data for warehouses in this area. The reach is not justified economically or for other reasons for inclusion in a recommended plan. All the other nonstructural measures were carried forward based on justification for community cohesiveness (EB-4aN, EB-4bN) and based on the fact that nonstructural cost estimates were not finalized at this point in the study. The decision was made

to keep as many feasible, nonstructural reaches in consideration until the costs were at a more detailed level. The final array are shown in Table 8-2. Alternatives are not listed in any particular rank or order. Costs and benefits are rounded to the nearest million dollar value.

Table 8-2. Final Array of Alternatives

Alternative Plan	Description	Total Avg. Annual Costs (\$1000's)	Annual Benefits (\$1000's)	Annual Net Benefits (\$1000's)	BCR	Total Project Cost (\$1000's)
Alternative 1	No Action	0	0	0	0	0
Alternative 2a	Structural Only in All Reaches with the Outer Lafayette SSB, NNBF	\$46,000	\$136,000	\$91,000	3.0	\$1,231,000
Alternative 3	Nonstructural and Ringwalls Only in All Reaches	\$108,000	\$143,000	\$35,000	1.3	\$2,933,000
Alternative 4d	Structural and Nonstructural Combination, Outer Lafayette SSB, Campostella/Berkeley Nonstructural, NNBF	\$66,000	\$168,000	\$102,000	2.5	\$1,787,000

The following table shows the measures that make up each alternative plan.

Table 8-3. Measures in Each Alternative Plan

Alternative Plan	Description
Alternative 1	No Action
Alternative 2a	PL-2S, LR-1aS, EBS, BC-1S
Alternative 3	BC-1N, EB-1N, EB-1aN, EB-2N, EB-3N, EB-3aN, EB-4N, EB-4aN, EB-4bN, EB-5N, EB-5aN, EB-7N, EB-8N, H-1N, LR-1N, LR-2N, MS-2N, PL-1N, PL-1aN, PL-2N, WB-1N
Alternative 4d	PL-2S, LR-1aS, EBS, BC-1S, EB-1N, EB-4N, EB-4aN, EB-4bN, EB-5aN, EB-7N, EB-8N, MS-2N, PL-1N, WB-1N

The first alternative is the No Action alternative. The second and third are single focus alternatives that include a Structural Only alternative, Alternative 2a, and a Nonstructural Plus Ringwalls alternative, Alternative 3. The fourth alternative is Alternative 4d. This alternative represents a hybrid alternative that is a combination of both structure and nonstructural measures. Each alternative was evaluated utilizing the intermediate rate for NAACS sea-level rise. Alternatives were examined for water surface elevations associated with the NACCS 3% (35-yr) annual chance exceedance (ACE) storm event. The project will also consider the 1.4% (70-yr) and 10% (10-yr) ACE storm events moving forward during optimization, but started with the 3% for initial comparison purposes. The NACCS 3% ACE also roughly corresponds to the FEMA 1% ACE, which is a priority for the city to consider in the analysis.

Cost estimates and justification for proposed NBNF measures are presented in Appendix D.

8.2 DESCRIPTION OF THE FINAL ARRAY

The following summarizes and briefly describes the final array of alternatives. Detailed descriptions can be found in the previous chapter on the focused array of alternatives where individual measures are discussed. More detailed information on the component measures that make up the alternatives can also be found in Appendix A.

8.2.1 Alternative 1/No Action/Future Without Project Alternative.

The No Action alternative will serve as the future without project condition, which serves as the base condition to use as a comparison for all the other alternatives. The future without project condition within the period of analysis is identified. Relevant resources of the area and the No Action alternative are succinctly described as required by NEPA. The No Action alternative and the plan formulation “Future Without-Project” setting are equivalent. The future without project condition within the period of analysis (2026-2075) are identified as continued damages to structures, content, vehicles, infrastructure, life safety and quick access to emergency services from future storm events. This will result in continued maintenance and reconstruction of houses and roads following storm events. The No Action alternative would see no additional federal involvement in storm damage reduction as outlined within this study. Current projects and programs that the USACE conducts in conjunction with Norfolk would continue. For example, the USACE Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project would continue to be maintain and benefits associated with the project would continue. The No Action alternative would also see the City of Norfolk continue to move forward with its own resiliency program as discussed in Chapter 1.

8.2.2 Alternative 2a/Structural Only

Alternative 2a demonstrates the project costs and benefit analysis of a plan with structural elements only. Not considered as part of this alternative are ring walls for the protection of individual structures. As part of the discussion with the USACE National Nonstructural Committee (NNC), such measures were recently determined to be structural elements. However, for the purpose of this study, they are included in the nonstructural alternative as the implementation costs and actions associated with this measure would be grouped with other nonstructural measures.

Structural measures are features/measures that are designed to modify the elements

associated with flooding. They are items that can be used manage peak flows, reduce volumes, or direct waters away or through designed systems. Descriptions of the various structural features are described in Section 6.1 and in Appendix A. Structural features included within this study are floodwalls, levees, storm surge barriers, various types of gates and pump stations as well as NNBF. The project will also include protective features associated with the existing conditions Willoughby Spit and Vicinity Coastal Storm Damage Reduction Damage Reduction Project.

This alternative will provide flood risk reduction to an estimated 9,037 properties. This alternative does not provide complete coverage of the project area and only portions of the city behind the measure would see benefits from reduced flood risk. Portions of the project area will see continued damages to structures, contents, vehicles, infrastructure, life safety and quick access to emergency services from future storm events. This will result in continued maintenance and reconstruction of houses and roads following storm events. Figure 8-1 shows the areas in which structural measures will be placed and areas that are without risk management measures. Areas that will not have coastal storm risk management measures will continue to see elevated risks to structures, contents, vehicles, infrastructure, life safety and emergency services access from future storm events.

This project alternative considers the following possible NNBFs: greenways, living shorelines, and oyster reefs. The final siting of NNBFs will be contingent on the final engineering design and the ability to attain required real estate protections.

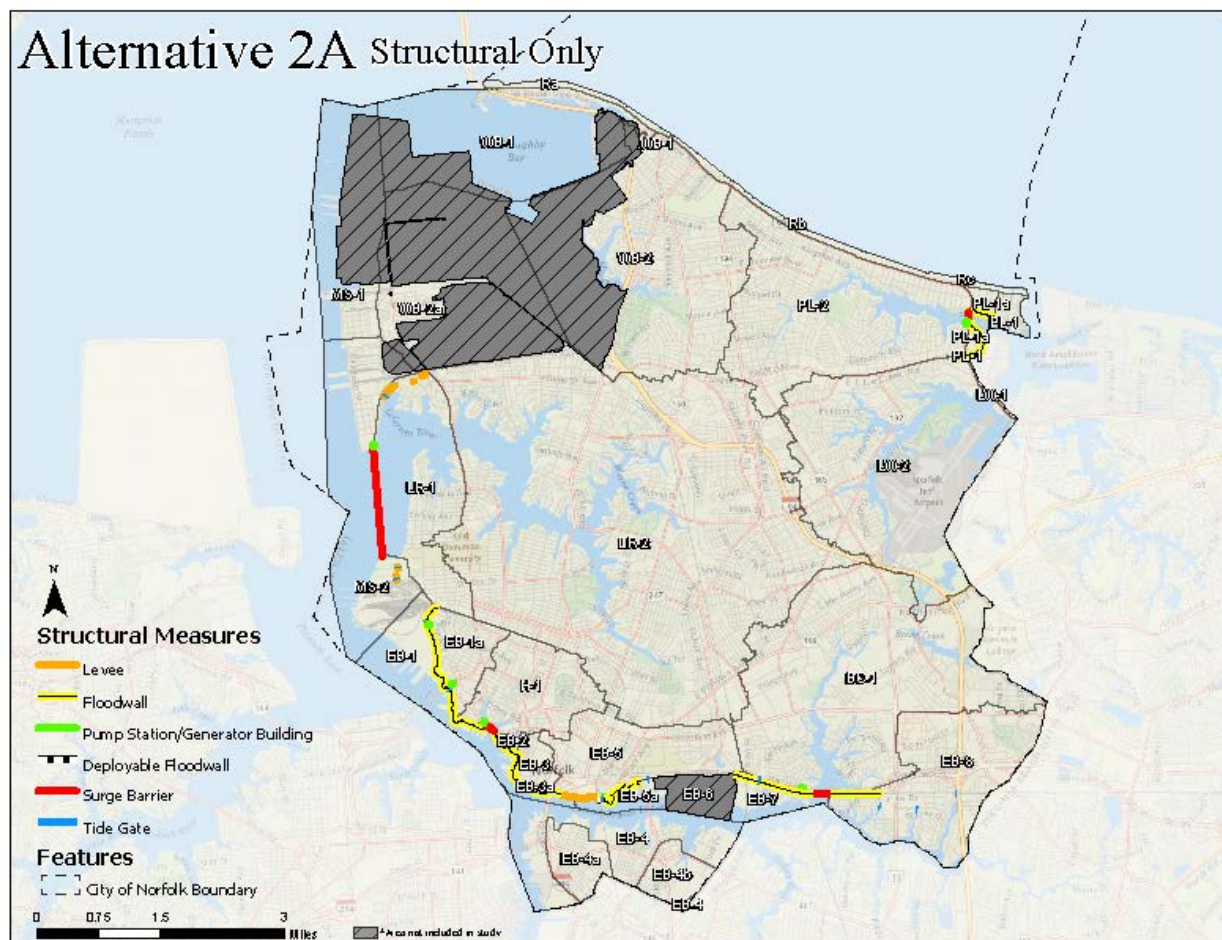


Figure 8-1. Alternative 2a Structural Only Map

8.2.3 Alternative 3/Nonstructural

Nonstructural coastal storm risk management measures are techniques for reducing accountable flood damages within floodplains. These techniques consist of measures such as acquisition, flood proofing (wet/dry), elevating, flood warning systems, flood emergency preparedness plans, and public education. In addition, ringwalls as discussed previously are included within this alternative. While such items are structural in nature, their implementation will be designed to work in conjunction with other nonstructural features. Areas where no large scale structural features will be implemented may still contain ring walls, and as such, this technique will be considered within areas defined by nonstructural management measures.

This alternative does not provide complete coverage of the project area and only structures and features that are subjected to flood proofing will see direct benefits and reduction of storm related damages. Portions of the project area will see continued damages to structures, content, vehicles, infrastructure, life safety and quick access to emergency services from future storm events. This will result in continued maintenance and reconstruction of houses and roads following storm events. Current estimates for this study indicate that there are over 11,000 structures that will be eligible for nonstructural floodproofing. An assumption was made that 100% participation would occur for the nonstructural program. Figure 8-2 shows a map of the areas of the city that are included in Alternative 3.

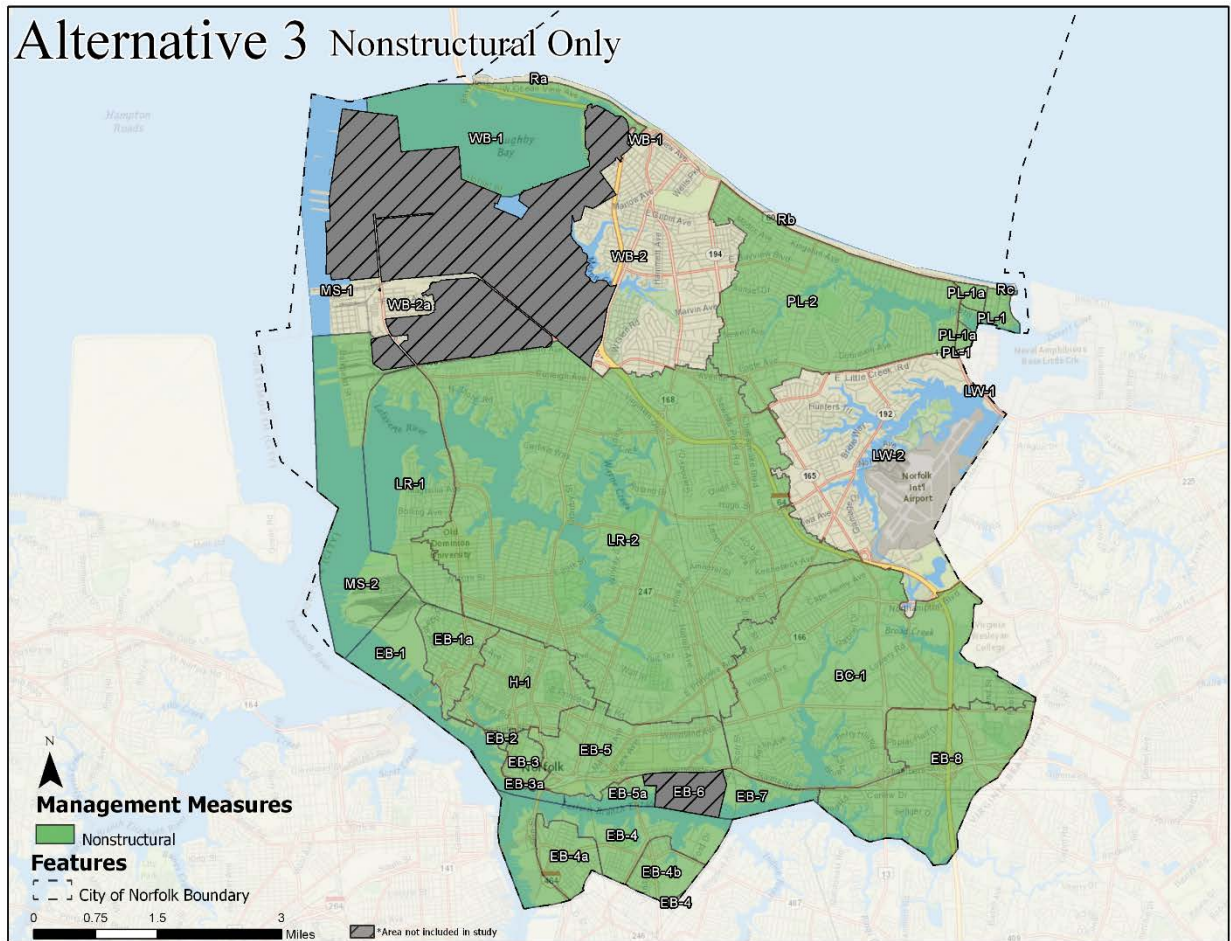


Figure 8-2. Alternative 3 Nonstructural Only Map

Table 8-4 shows a breakdown of the structures and types of measures that can be applied across the study area. The table shows the total number of properties that are proposed for nonstructural measures. The total number of properties is then broken down into residential and nonresidential properties. There are different measure assumptions made between residential and nonresidential properties. Residential properties are limited to the basement fill, elevation, and buyout measures. Nonresidential properties are limited to the basement fill, floodproofing, ringwall and buyout measures. Historic property numbers are provided separately and are a subset of the overall total, so the historic properties are a mix of residential and nonresidential properties. The costs to implement some nonstructural measures can be more expensive for historic properties.

Table 8-4. Nonstructural Measures Included in Alternative 3

Alternative 3 - Nonstructural Only (All reaches)				
Measure	Total Structures	Residential	Nonresidential	Historic
Basement Fill	2,183	2,130	53	912
Basement Fill + Floodproofing	9	0	9	1
Basement Fill + Elevate	1,352	1,352	0	412
Basement Fill + Ring Wall	61	0	61	11
Buyout	646	606	40	71
Floodproofing	432	0	432	40
Elevate	4,915	4,915	0	279
Ring Wall	1,946	0	1,946	165
Total	11,544	9,003	2,541	1,891

8.2.4 Alternative 4d/ Structural and Nonstructural

This alternative maximizes both structural and nonstructural elements of the project as shown in Figure 8-3. Where possible, structural features were sought to modify elements associated with flooding first. Then reaches outside of structural alignments were examined to see if elements of nonstructural flood damage reduction could be achieved. Thus, a priority is given to structural measures, as it has the ability to capture the most benefits. Infrastructure behind such structural measures benefit from the modification of flooding within the area served by the measure. In areas covered by nonstructural measures, flooding will continue to occur, and only those properties or portions of infrastructure that participate in the nonstructural measure will achieve benefits.

Structural features included within this alternative include floodwalls, berms, storm surge barriers, various types of gates and pump stations as well as NNBF. While areas of the city with nonstructural measures will see benefits for those properties that are improved, these same areas will see continued negative impacts to non-participating properties, property contents, vehicles, infrastructure, life safety and quick access to emergency services from future storm events. The current estimate for this study indicates that there are 1,856 properties that will be eligible for nonstructural measures, while an estimated 9,037 properties will benefit from flood risk reduction from structural measures. The sum of properties benefiting is estimated at 10,893.

This project alternative incorporates the following NNBFs: greenways, living shorelines, and

subtidal reefs. The subtidal reefs would be constructed adjacent to the living shorelines. The final siting of NNBFs will be contingent on the final engineering design and the ability to attain required real estate protections. NNBF costs were included in the final alternatives. The benefits were not calculated at this point in the study, but are developed for the determination of the Recommended Plan. Further detail on the NNBF in the Recommended Plan can be found in Section 9.3. Because costs are already quantified but NNBF benefits are not yet quantified, the efficiency of the alternatives are likely to increase once NNBF benefits are considered. A broad description of NNBF features are included in Chapter 4 and a more detailed description including feature types with locations are included in Appendix A. Appendix D includes a white paper that details the methodology for assessing and justifying NNBF.

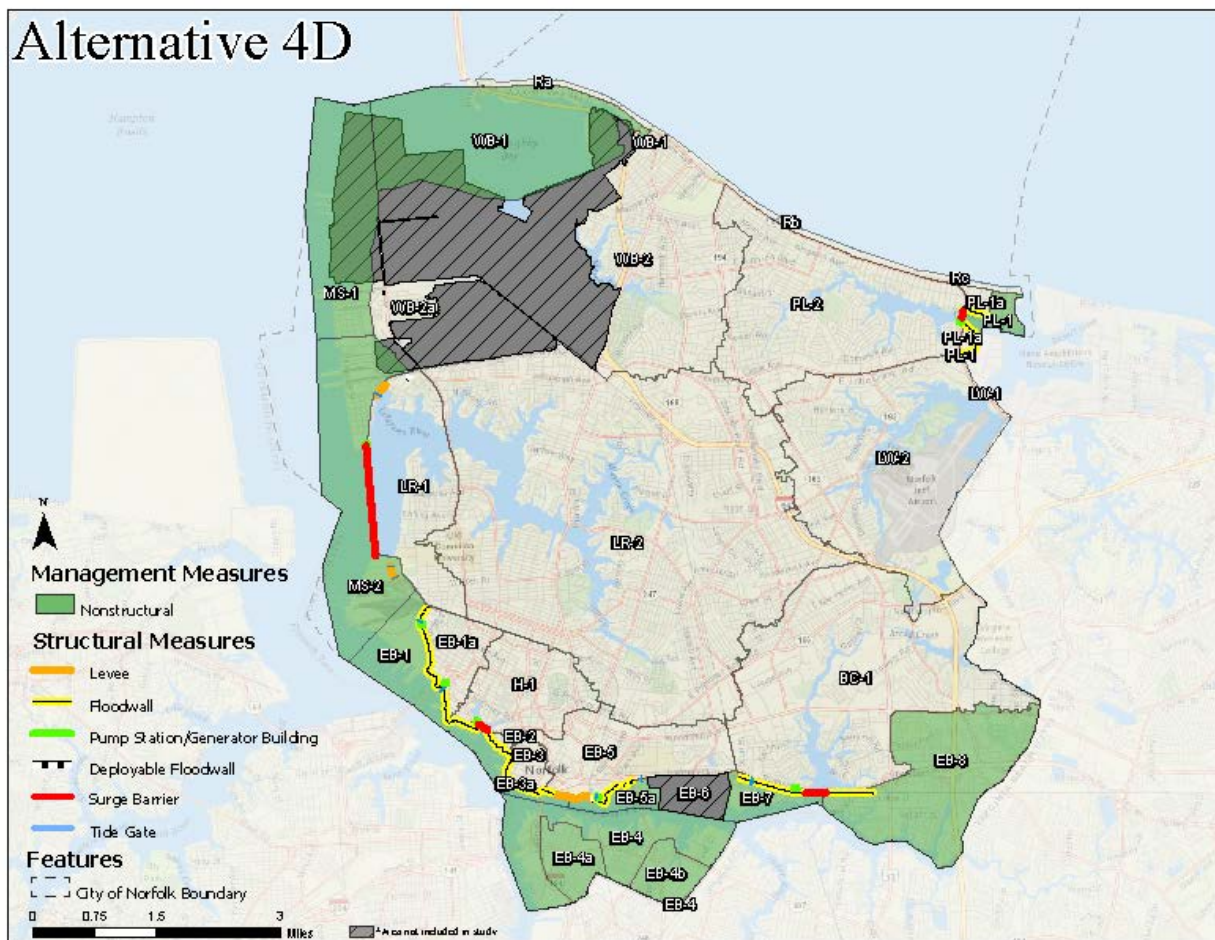


Figure 8-3. Alternative 4d Structural and Nonstructural Combination Map

Table 8-5 shows the breakdown of nonstructural measure types for residential, nonresidential, and historic properties.

Table 8-5. Nonstructural and Ringwall Measures Portion of Alternative 4d

Alternative 4d – Combination Plan with Outer SSB				
Measure	Total Structures	Residential	Nonresidential	Historic
Basement Fill	180	178	2	33
Basement Fill + Floodproofing	1	0	1	0
Basement Fill + Elevate	93	93	0	4
Basement Fill + Ring Wall	2	0	2	0
Buyout	104	95	9	27
Floodproofing	77	0	77	2
Elevate	730	730	0	13
Ring Wall	669	0	669	35
Total	1,856	1,096	760	114

8.3 NNBFS IN THE FINAL ARRAY

Based on information provided by stakeholders, the non-federal sponsor, limited site visits, and a geospatial analysis conducted in ArcMap 10.4.1, potential sites for application of NNBFs were investigated throughout the study area. Maps depicting the preliminary locations of NNBF sites with further description can be found in Appendix D. The final recommendations for NNBF can be found in Chapter 9.

8.4 CRITICAL INFRASTRUCTURE IN THE FINAL ARRAY

The Final Array of Alternatives included costs and benefits for providing flood risk management measures for critical infrastructure. A list of facilities, initially provided by the City of Norfolk Department of Emergency Management, were preliminarily identified as critical infrastructure. There were a total of 238 facilities preliminarily identified as critical. The PDT and the City refined the list down to 51 structures to be considered for flood risk management measures. The formulation strategy is to provide flood risk management measures for critical infrastructure regardless of the Alternative Plan that is selected for recommendation or whether or not a planning reach has been identified as economically justifiable. In this case critical infrastructure such as fire and police stations may be recommended for measures in areas where no other action is taking place and in areas where a structural measure is proposed.

A more detailed review and analysis of the critical infrastructure list and measure

recommendations occurs on the optimized, Recommended Plan. Further description can be found in Chapter 9.

8.5 EVALUATION AND COMPARISON USING THE FOUR ACCOUNTS

National Economic Development: The benefits for each plan were evaluated based on damages avoided using HEC-FDA. These benefits were used to compare across the final array of alternatives and select the NED plan. The results of this analysis are shown earlier in this chapter.

Regional Economic Development (RED): The final Recommended Plan, as described in Chapter 9, is evaluated for RED. Discussion on the RED results can be found in Appendix C. The RED does not influence plan selection, however, the results can be useful for the sponsor and local stakeholders.

Environmental Quality (EQ): A separate EQ analysis was not conducted, as the EQ account did not drive the plan selection for this project. However, the environmental benefits and impacts are discussed in great detail as part of the NEPA evaluation in this report.

Other Social Effects (OSE): An OSE evaluation was completed on the focused array in order to help the team compare alternatives and ensure that social effects were considered as the alternatives were narrowed to a final array. This evaluation was conducted using the Institute for Water Resources' handbook for Applying Other Social Effects in Alternatives Analysis (2013).

Based on the economic comparison of the final array of alternatives, Alternative 4d maximizes annual net benefits and is therefore the NED plan. Economic results are shown earlier in this chapter in Table 8-2. The EQ analysis was performed on all of the final array alternatives. Of the alternatives, the nonstructural plus ringwalls plan, Alternative 3, showed the lowest environmental impact. The structural only plan, Alternative 2a, and the structural plus nonstructural plan, Alternative 4d, show similar levels of environmental impact with Alternative 4d overall having the greatest negative environmental impacts. The environmental impacts of each alternative are described in Chapter 10. OSE analyses show the greatest benefits accruing in Alternative 2a and 4d. Alternative 3 leaves much of the roadway, utility, and other infrastructure exposed to inundation which would have significant negative impact in the future. Based on all the account assessments the NED plan, Alternative 4d, is the Tentatively Selected Plan for Norfolk. The next chapter discusses the optimization of the TSP and the final selection for the Recommended Plan.

CHAPTER 9 RECOMMENDED PLAN

This study considered a range of nonstructural and structural measures to reduce the risk of storm damage in the study area. Through an iterative planning process, potential coastal storm risk management measures were identified, evaluated, and screened. Those remaining were developed into defined coastal storm risk management alternatives that composed a focused array of alternatives. The alternatives and measures of the focused array then underwent further screening and comparison to reduce the list of alternatives to final array of alternatives. Based on an evaluation of the costs and benefits of the final array of alternatives, including potential environmental impacts, Alternative 4d, as described in Chapter 8, was identified as the Tentatively Selected Plan (TSP). The TSP is the identified plan at the 3% ACE water level. After identification of the TSP, the plan was evaluated at the 10% and the 1.4% ACE water levels in order to better optimize the plan for costs and benefits. The outcome of these final analyses is a Recommended Plan (RP). The RP then underwent a cost and schedule risk analysis (CSRA) to improve project cost estimates. The optimization and CSRA analyses are discussed in this chapter, as is the description of the RP.

Study goals and objectives were developed to comply with the study authority and to respond to study area problems. Planning objectives were identified based on the problems, needs, and opportunities, as well as existing physical and environmental conditions present in the study area. The main goal is to contribute to National Economic Development (NED) by reducing the risk of flood damages caused by coastal storm surge within the study area, consistent with the nation's environment, pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements. The RP is also the NED plan.

9.1 OPTIMIZATION OF THE TSP

9.1.1 Incorporating Updated Costs, Benefits, and Planning Decisions

Cost and planning refinements were implemented after the TSP was selected and had undergone technical and public reviews. These refinements were incorporated for the optimization of the TSP and selection of a Recommend Plan. One of the more significant decisions between the TSP selection and the optimization was the decision to eliminate ringwalls as a potential measure for properties identified in the nonstructural reaches. This measure was previously included in the Alternative 3 and TSP (Alternative 4d) plans in the Final Array. The measure was removed due to life safety concerns associated with implementing ringwalls for structures frequented by the general public.

9.1.2 Analyzing Three Water Levels

The TSP was reanalyzed at all three water levels in order to further maximize annual net benefits. The plan at the 10%, 3%, and 1.4% ACE design levels have similar project alignments. The primary differences are in the height of the structures and the locations for tying into high ground. The three plan levels each had their own quantities calculated for costs and they were each analyzed for economic benefits in HEC-FDA. The annual without project damages are shown to describe the estimated annual damages that are expected to occur over the 50 year period if no project is constructed. This value assumes the total probability of hypothetical, future coastal flood events and relative sea level rise. The damage reduction percentage shows

the ability for each of the proposed, project design levels to reduce damages during the 50 year period of analysis. The economic results of the optimized plan analysis are provided below in Table 9-1.

Table 9-1. TSP Optimization Results

Water Level ACE	Equiv Annual Without Project Damages (\$1,000s)	Equiv Annual With-Project Damages (\$1,000s)	Equiv Annual Benefits (\$1,000s)	Total Average Annual Costs (\$1,000s)	BCR	Annual Net Benefits (\$1,000s)
1.4% (70yr)	\$283,615	\$108,874	\$174,741	\$66,822	2.6	\$107,919
3% (35yr)	\$283,615	\$125,019	\$158,596	\$64,080	2.5	\$94,516
10% (10yr)	\$283,615	\$155,296	\$128,319	\$60,458	2.1	\$67,861

Based on the results, the preferred plan is the 1.4% ACE design level. The plan at this design level maximizes annual net benefits and has a superior economic efficiency with the best BCR. The Recommended Plan was then subjected to a CSRA in order to improve cost estimates and assign a final cost contingency value to various project cost accounts.

During the process four nonstructural reaches were found to be below a 1.0 BCR. The reaches are EB-1N, EB-5aN, PL-1N, and WB-1N. The reaches could not be justified based on other social effects and are not considered socially vulnerable, therefore, these reaches were removed from the plans. These nonstructural reaches are stand-alone and do not impact the performance of any other measures in the Recommended Plan. The final cost and economic valuations of the Recommended Plan, including valuations for individual measures is provided in Section 9.5.

9.2 CSRA OF THE RECOMMENDED PLAN

Accurately estimating the cost and schedule for projects is complicated by the significant uncertainties inherent to known and unknown risks when planning a project from design through completion of construction. Attempting to address these uncertainties by applying a pre-determined contingency percentage can either underestimate project specific risks or inflate project estimates to a point where defensibility is compromised. The CSRA process allows the PDT to identify, analyze, and account for project specific risks in project cost and schedule estimates.

The CSRA process assesses the likelihood and impact of a wide range of potential project risks and uses statistical analysis to model and apply risk-based contingencies to project cost and schedule estimates. The result is a range of project costs representing different confidence levels. When considerable uncertainties are identified, cost risk analysis can establish the areas of high cost uncertainty and the probability that the estimated project cost will or will not be exceeded. This gives the PDT an effective additional tool to assist in the decision making process associated with project planning and design.

For the USACE the CSRA has proven a valuable tool in estimating cost and schedule for projects. It has been adopted as a primary tool to support planning and budgeting. By quantifying the potential impacts from project risks, the CSRA provides a defensible process to inform development of cost and schedule contingency. Proactive use of the CSRA process allows the project team to identify and effectively manage those risks with the greatest potential to impact project cost and schedule. A representative from the USACE Walla Walla District facilitated the CSRA on the Recommended Plan for this study. The Walla Walla District is the center of expertise for project cost analysis.

The level of design achieved for the Recommended Plan is one element that impacts contingency estimates for project costs and schedules. Lower levels of design carry more uncertainty into the PED phase of a project. With greater uncertainty in the design comes greater uncertainty in the costs for construction. The Recommended Plan for this project is at an estimated 10% level of design. This level of design is considered sufficient for selecting the best plan for Norfolk and the low design level is reflected in the cost and schedule contingencies determined in the CSRA. The project cost and schedule contingencies are determined to be 30% overall. Further detail on the CSRA can be found in Appendix B.

9.3 NNBF IN THE RECOMMENDED PLAN

An analysis of NNBF measures was completed for justifying incorporation of these measures into the RP. Appendix D includes a detailed description of the methodology for assessing NNBF measures for the project. The Norfolk CSRM study is authorized for coastal storm risk management and therefore the project and its constituent measures are justified by their ability to reduce economic damages from coastal storms. NNBF measures are economically justified by their ability to reduce maintenance costs associated with structural features of the RP. For example, oyster reefs and living shorelines can be placed adjacent to floodwalls or surge barriers to reduce the wave damage on these structures. As described in the Environmental Appendix, studies suggest NNBF such as oyster reefs can reduce wind generated wave hazards by approximately 20% - 50%. This reduction in wave attack can be used to estimate reductions in O&M to adjacent structures. If the cost of the NNBF is less than the costs saved through reduced O&M then NNBF could be justified economically. Greenways can be used to reduce interior drainage and the need for pump capacity. If the pumping costs can be lowered to offset the cost of the greenways then the greenways can be determined to be economically justifiable. Other social effects (OSE) rationale can also be used to justify NNBF measures. OSE benefits can include recreation and education. Both economic and OSE benefits were used to justify NNBF measures in the RP.

A couple of primary constraints limited the ability to justify NNBF in the Norfolk area. These constraints are:

- Limited available land area due to highly urbanized land use
- Limited available area in the water due to navigation requirements of the port and military

The NNBF measures that were carried through TSP are living shorelines, oyster reefs, and greenways. Of these three measures living shorelines and oyster reefs were determined to be justifiable for inclusion in the RP. Greenways were removed from consideration based on a lack

of water retention benefits and their high costs in relation to benefits. Storage volumes for retaining interior drainage is limited by the water table and available space. The analysis of the storage capacity possibilities in relation to pump station requirements did not show a justifiable benefit. Due to costs for greenway construction in an urban area OSE benefits were determined to not be justifiable.

Living shorelines and the oyster reef structures are estimated to reduce operation and maintenance costs for the structural measures in the RP. Living shorelines are estimated to provide a 10% reduction and the oyster reef structures are estimated to provide a 5% reduction to the overall annual operation and maintenance for the portions of the proposed floodwalls and storm surge barriers that they are adjacent to. The annual O&M costs for the length of wall behind an adjacent NNBF is calculated with the appropriate reduction factor and compared to the costs to construct and maintain the NNBF. If the costs are lower than the benefits (reduced O&M value) then the NNBF is assumed to be economically justified. Figure 9-1 below shows an overview of the NNBF locations that are recommended in the RP.

Table 9-2 and Table 9-3 display the quantities and costs associated with each NNBF measure respectively.

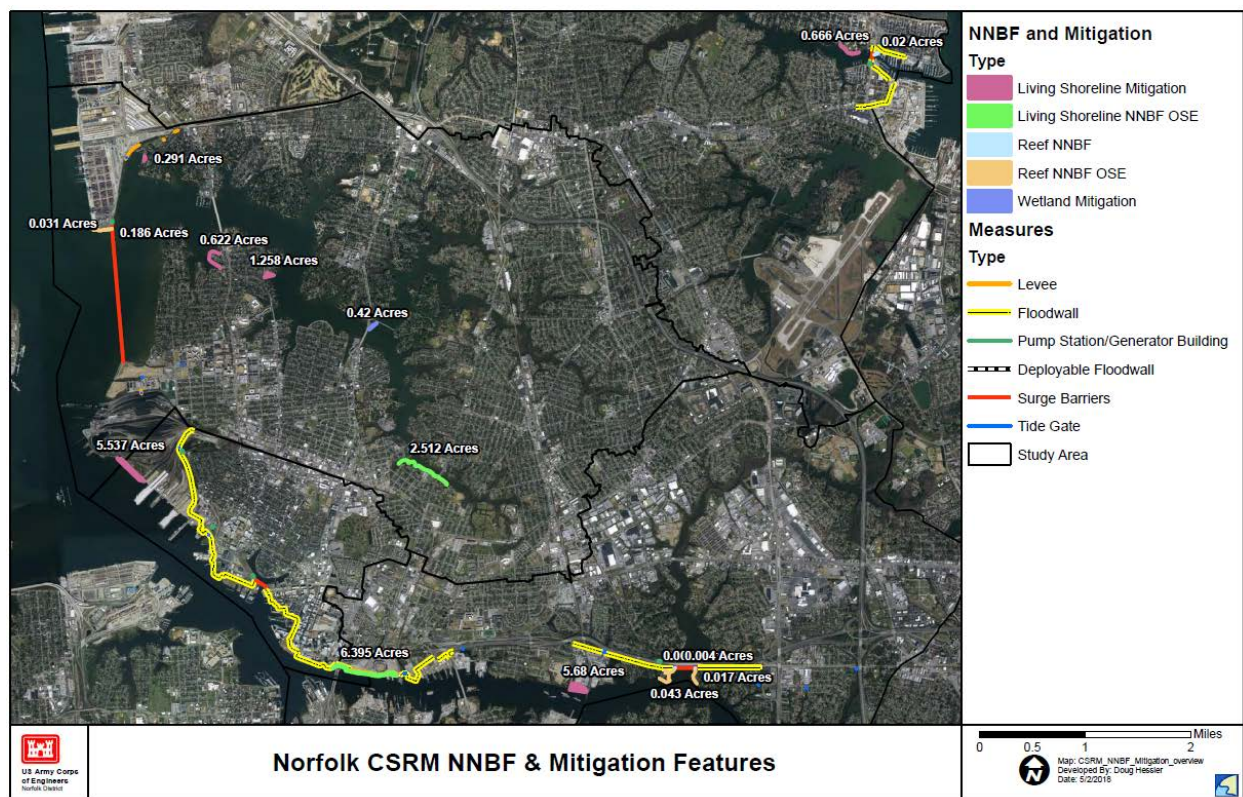


Figure 9-1. Overview Map of NNBF in the Recommended Plan

Table 9-2. NNBF Quantities Associated with RP Structural Measures

Measure Type	Quantity per Project Structural Measure (LF)			
	PL-2S	LR-1aS	EBS	BC-1S
Living Shoreline Mitigation	2,375	5,150	3,800	2,174
Wetland Mitigation		1,100		
Living Shoreline NNBF OSE		6,200	7,200	
Reef NNBF	560	1,370		620
Reef NNBF OSE		1,920	5,250	
Total	2,935	15,740	16,250	2,794

Table 9-3. NNBF Costs Per Structural Measure

Measure Type	Cost per Project Structural Measure			
	PL-2S	LR-1aS	EBS	BC-1S
Living Shoreline Mitigation	\$3,360,625	\$ 7,287,250	\$ 5,377,000	\$ 3,076,210
Wetland Mitigation				
Living Shoreline NNBF OSE	\$ -	\$ 8,773,000	\$ 10,188,000	\$ -
Reef NNBF	\$ 56,000	\$ 137,000	\$ -	\$ 62,000
Reef NNBF OSE	\$ -	\$ 192,000	\$ 525,000	\$ -
Total	\$3,416,625	\$ 16,389,250	\$ 6,090,000	\$ 3,138,210

9.4 CRITICAL INFRASTRUCTURE IN THE RECOMMENDED PLAN

Fifty-one critical infrastructure sites are identified in the study for consideration in the RP. Appendix A shows a list of all the locations with descriptions. The list includes City of Norfolk police, fire, and critical administration facilities, hospitals, water treatment and wastewater plants as well as structures critical for transportation and emergency communication. Critical infrastructure are recommended for dry floodproofing up to three feet above ground elevation. The proposed floodproofing will provide flood risk management for those facilities outside the structural project alignment. Ringwalls were initially considered as potential measures for critical infrastructure but were screened out based on a lack of detail for determining specific site needs and concern about life safety should the measure fail or be overtopped.

A teleconference with several critical infrastructure facilities including the majority of the hospital systems within the City, Norfolk International airport, and the local public radio station provided a summary of risk management practices considered and implemented. The hospital systems are generally prepared for flooding by either having elevated first floor elevations, elevated

emergency power generation, deployable floodproofing onsite, or a combination of these measures. The primary concern identified by the hospital systems was flooded roads impeding ambulance, employee, and patient access to the hospitals. The Norfolk International Airport is located on the highest ground in Norfolk with a finished floor of approximately 23 feet NAVD88. The airport identified concerns of power transmission to the airport and access via flooded roadways to the airport during flooding. The airport has an agreement with the City of Norfolk to allow city equipment, such as police and fire trucks, to be staged at the airport during a flood event. WHRO Public Media identified critical cabling at ground level that would be flooded at the design water level of the Recommended Plan. If the cables are flooded, WHRO would not be able to broadcast emergency management messaging to citizens. Table 9-4 below displays the number of critical infrastructure sites by sector. A critical infrastructure site may include more than one building.

Table 9-4. Critical Infrastructure Sites by Sector

Sector	Number of Sites
Emergency Services	22
Government Facilities and Shelters	16
Water and Wastewater Systems	3
Transportation	3
Healthcare and Public Health	5
Communications	1
Commercial Facilities	1

Of the 51 critical infrastructure locations, 40 are behind a structural alignment. Of the 11 that are outside a structural alignment, eight are located outside the design flood, and were not recommended for additional floodproofing. The other four sites will receive floodproofing measures as they are located at locations that will be impacted by the design flood. These four sites include a facility at the Moores Bridges water treatment plant located in the Lake Whitehurst area (LW-2), an area headquarters facility for the Virginia Department of Transportation in the Elizabeth Park neighborhood (EB-8) and the Berkley Recreation Center (emergency shelter) and a fire station in the Berkley neighborhood (EB-4).

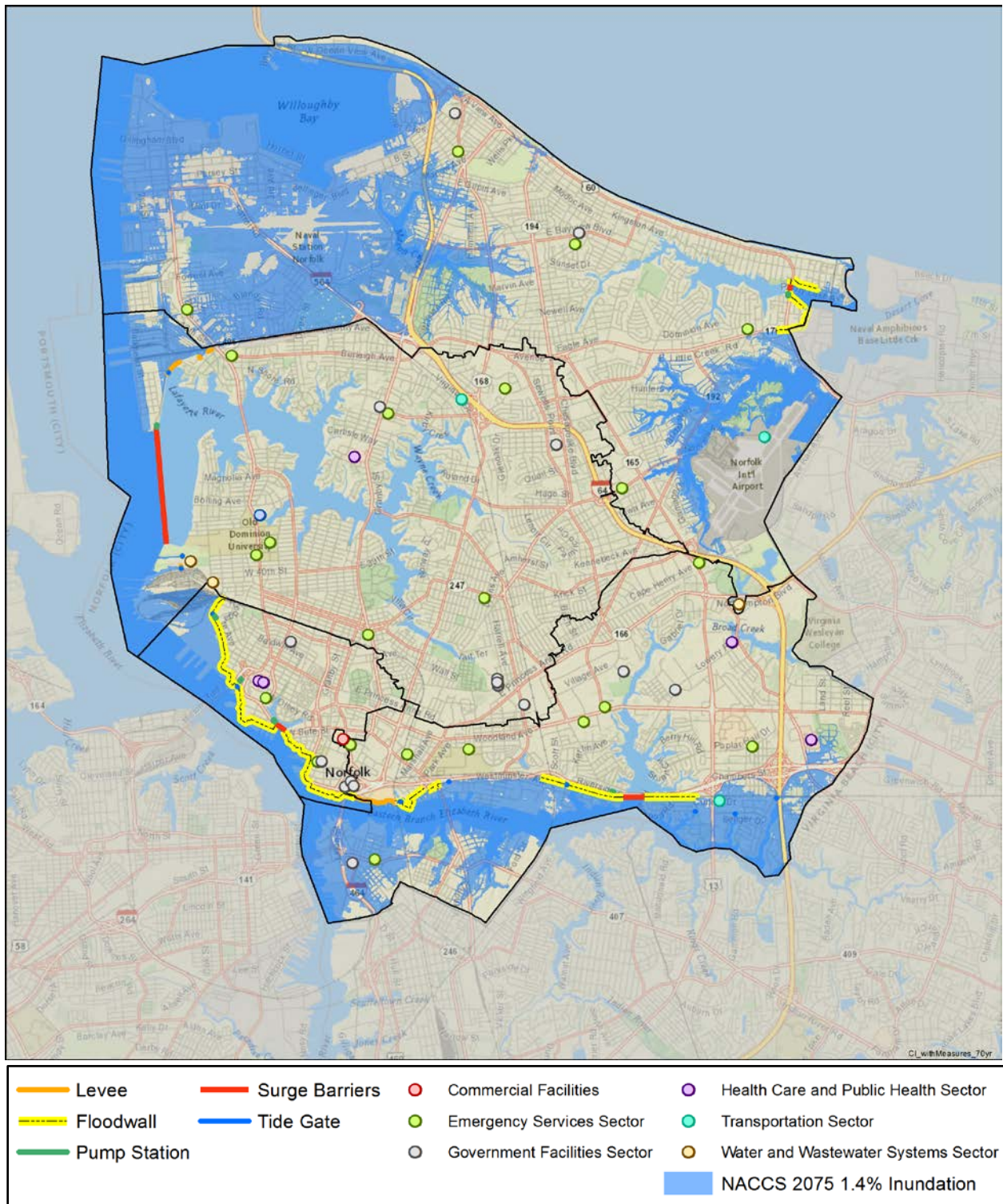


Figure 9-2. Critical Infrastructure with the Recommended Plan

9.5 ECONOMIC RESULTS OF THE RECOMMENDED PLAN

Table 9-5 below shows the results of the cost and benefits analysis for each measure and the overall project. Note that critical infrastructure costs are provided, however, the benefits for critical infrastructure are embedded in their respective economic reach. Critical infrastructure

are justified and included in the RP based on OSE benefits and not on economic benefits. As discussed in Section 6.6.2 the BCR for measures EB-4N, EB-4aN, and EB-4bN represent a cohesive part of the city and their BCR is combined to reflect this consideration. Measure MS-2N shows a BCR of 149. Measure MS-2N is predominately floodproofing of industrial facilities and a wastewater treatment plant. On-site inspections of the facilities by a team of engineers in the PED phase will provide a more accurate cost estimate for floodproofing these facilities.

Table 9-5. Cost Estimate by Measure within the Recommended Plan.

Description	Economic Reach	Annual Benefits (\$1000's)	Project First Costs	Annual O&M Costs (\$1000's)	Total Average Annual Costs (\$1,000)	Annual Net Benefits (\$1,000)	BCR
Broad Creek Surge Barrier	BC-1 S	\$15,451	\$174,578	\$375	\$6,930	\$8,520	2.2
Ghent-Downtown-Harbor Park Barrier System	EB S	\$63,776	\$477,183	\$585	\$19,260	\$44,516	3.3
Campostella & Berkley Nonstructural	EB-4 All*	\$1,926	\$43,753	\$0	\$1,621	\$305	1.2
Ingleside Rd. Nonstructural	EB-7 N	\$1,056	\$12,512	\$0	\$463	\$593	2.3
Elizabeth Park Nonstructural	EB-8 N	\$3,887	\$80,960	\$0	\$2,999	\$888	1.3
Lafayette River Outer Surge Barrier	LR-1a S	\$65,632	\$414,354	\$613	\$16,829	\$48,803	3.9
Norfolk International Terminal Nonstructural	MS-2 N	\$1,147	\$208	\$0	\$8	\$1,139	149
Pretty Lake Upper Surge Barrier	PL-2 S	\$17,212	\$91,009	\$186	\$3,651	\$13,562	4.7
Willoughby Bay Nonstructural	WB-1 N	\$7,649	\$71,706	\$0	\$2,656	\$4,992	2.9
Critical Infrastructure**	Various	-	\$2,635	-	\$98	-	106
Recommended Plan	All of the above	\$174,740	\$1,368,897	\$ 1,759	\$54,514	\$120,226	3.2

*EB-4 All is the combination of EB-4N, EB-4aN, and EB-4bN for neighborhood cohesiveness

**Critical infrastructure benefits are included in each CI facility's respective economic reach

9.6 DESCRIPTION OF THE RECOMMENDED PLAN

This RP alternative is the NED plan and includes both structural and nonstructural measures to reduce flood damages to Norfolk. The RP is an outcome of analyses that looked at a variety of competing measures and competing alternative plans. Three design water levels were investigated to determine the recommended project alignment. This alternative is a hybrid plan that maximizes structural measures and fills in areas not protected by such measures with nonstructural measures to provide greater coverage and reduce damages within the project

area.

For the purpose of this report, the RP has been broken down within the original four defined sub-areas that were used within the initial formulation of the study. Detailed information and preliminary designs can be found in Appendix A as well as Appendix B.

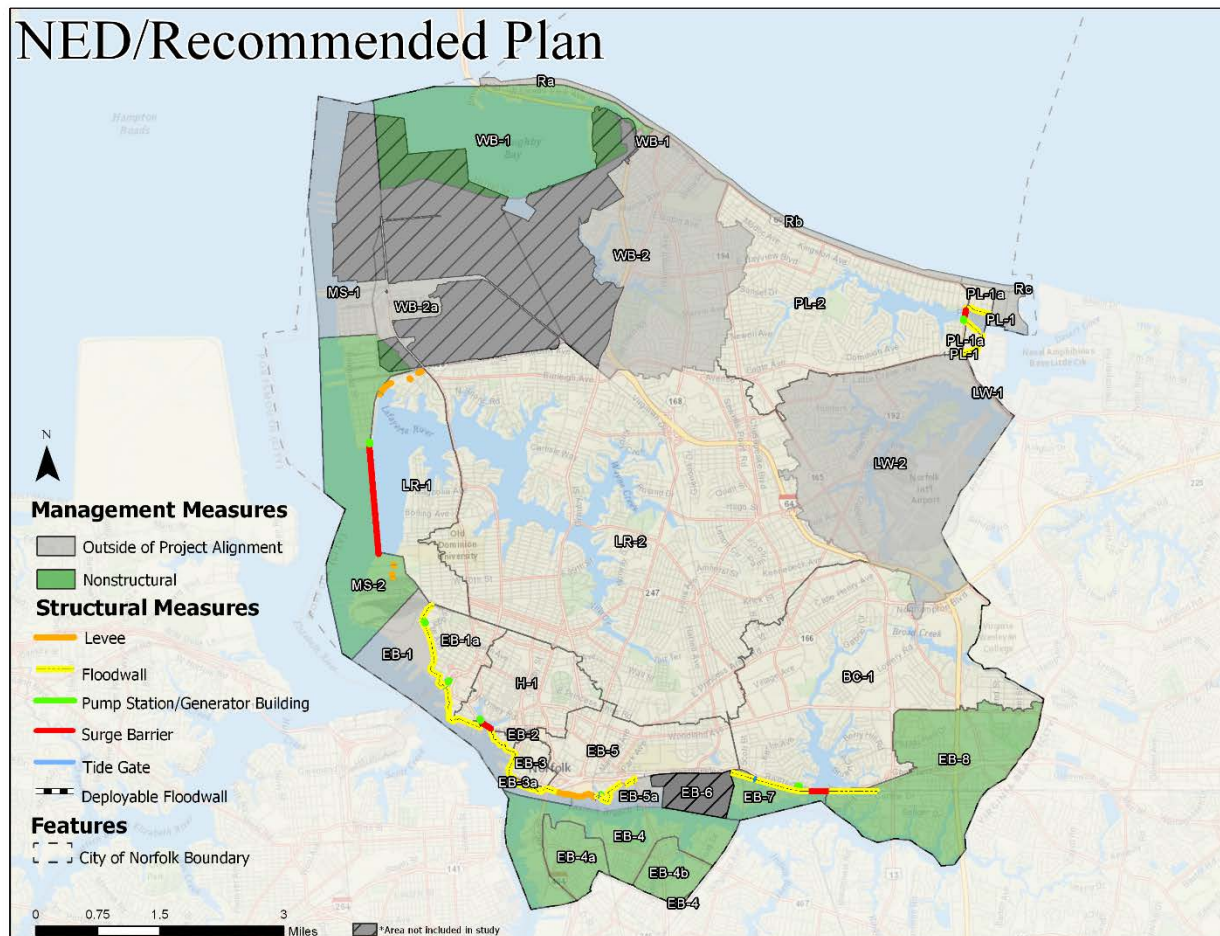


Figure 9-3. Recommended Plan Citywide View

The RP incorporates recommendations in each of the four planning areas. Area 1 would include a SSB, a pump station, and flood walls to isolate Pretty Lake from damaging storm surge. Along the northern coastline, the project will continue to use the Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project, which is part of the Future without Project condition. In addition to the structural measures, nonstructural measures are also recommended for portions of Area 1 on the southern side of Willoughby Spit. Within Area 1 is Norfolk Naval Station. While there are no measures planned that augment the base’s resilience, elements of the alternative will accordingly create benefits to the base’s military and civilian personnel who live in the immediate areas and/or commute onto the naval base.

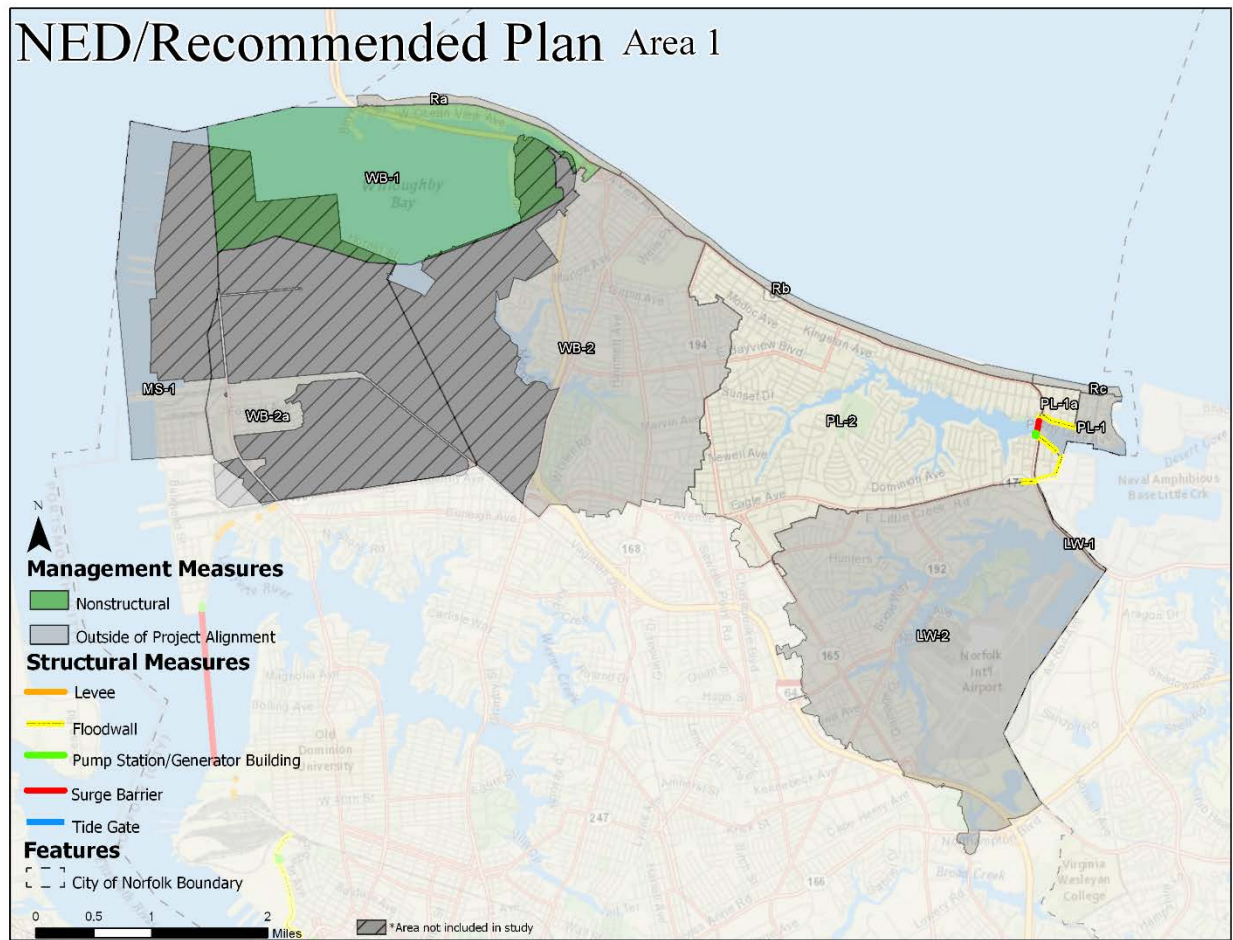


Figure 9-4. Recommended Plan Area 1 Measures.

Area 2 is largely comprised of the Lafayette storm surge barrier (Figure 9-5). It will cross the Lafayette River connecting high ground from the Norfolk International Terminal (NIT) to the Lamberts Point Golf Course. The storm surge barrier will be comprised of a barrier wall, nine miter gates, and one large sector gate for the navigation channel. In addition, to prevent flanking, a system of levees will be needed on both Lamberts Point and the NIT property. Nonstructural measures are recommended for the protection of infrastructure that will fall outside (west of) the SSB.

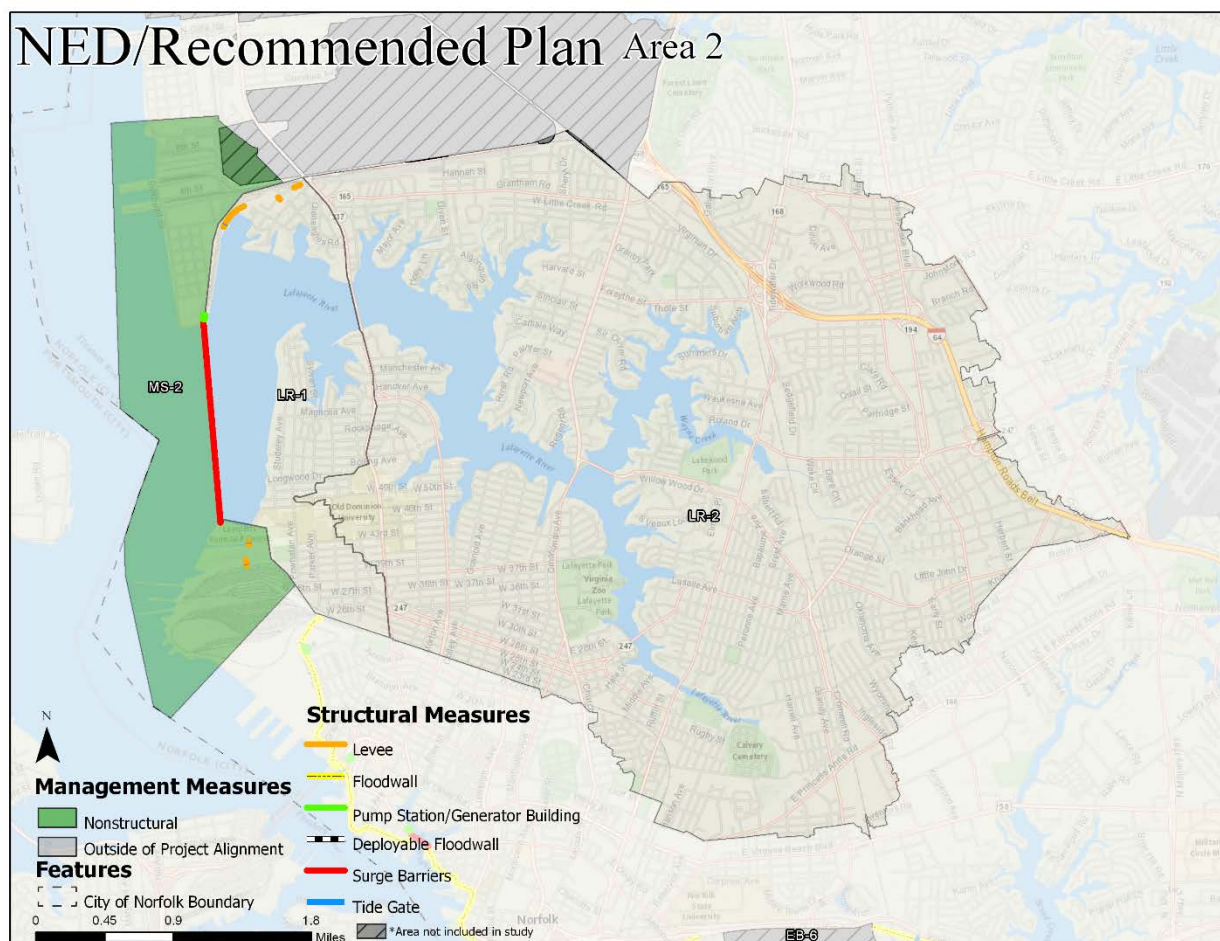


Figure 9-5. Alternative 4d Area 2 Measures.

Area 3 covers most what is considered downtown Norfolk (Figure 9-6). The area is characterized by a protective floodwall measure that runs from the West Ghent neighborhood to just past the Harbor Park area. In places where floodwalls currently exist in the downtown area, they will be modified to meet current standards and the design level identified within this study. In addition, a small storm surge barrier will be placed at the opening of The Hague. The barrier will include miter gates to allow access for small recreation boats. The gates will close during high water level events in order to prevent storm surge from entering The Hague neighborhood. Pump stations will be placed in various locations to control interior drainage and stormwater that may accumulate behind the floodwalls and The Hague SSB. Within the Harbor Park area, a levee will be constructed that ties in the eastern extent of Area 3 and the western extent of Area 4. There is sufficient right-of-way to allow the construction of this feature where in other parts walls are used because of limited space. Nonstructural measures were eliminated from the downtown area due to a lack of economic justification.



Figure 9-6. Alternative 4d Area 3 Measures.

Area 4 covers the eastern portion of the city and the neighborhoods of Berkley and Campostella along the southern side of the eastern Branch of the Elizabeth River. The measures in Area 4 include the connection of the levee within Harbor Park with additional floodwall systems along the north bank of the eastern Branch of the Elizabeth River. The floodwall continues to, and terminates at, the eastern side of Chesterfield Heights (EB-6). The Broad Creek barrier system (BC-1S) begins on the western edge of Chesterfield heights with a floodwall running parallel to I-264. The floodwall extends to Broad Creek where a SSB is proposed at the I-264 crossing with Broad Creek. The SSB would be constructed on the downstream (south) side of the I-264 Bridge. Flood walls will tie-in the SSB to the surrounding high ground. The proposed barrier wall would consist of a system of miter gates and floodwalls. Construction will be similar to that of the proposed SSB at Pretty Lake with tide gates and pumps. Nonstructural measures are proposed for the neighborhoods of Ingleside Rd. (EB-7N), Elizabeth Park (EB-8N), as well as Berkley and Campostella (EB-4N, EB-4aN, EB-4bN).

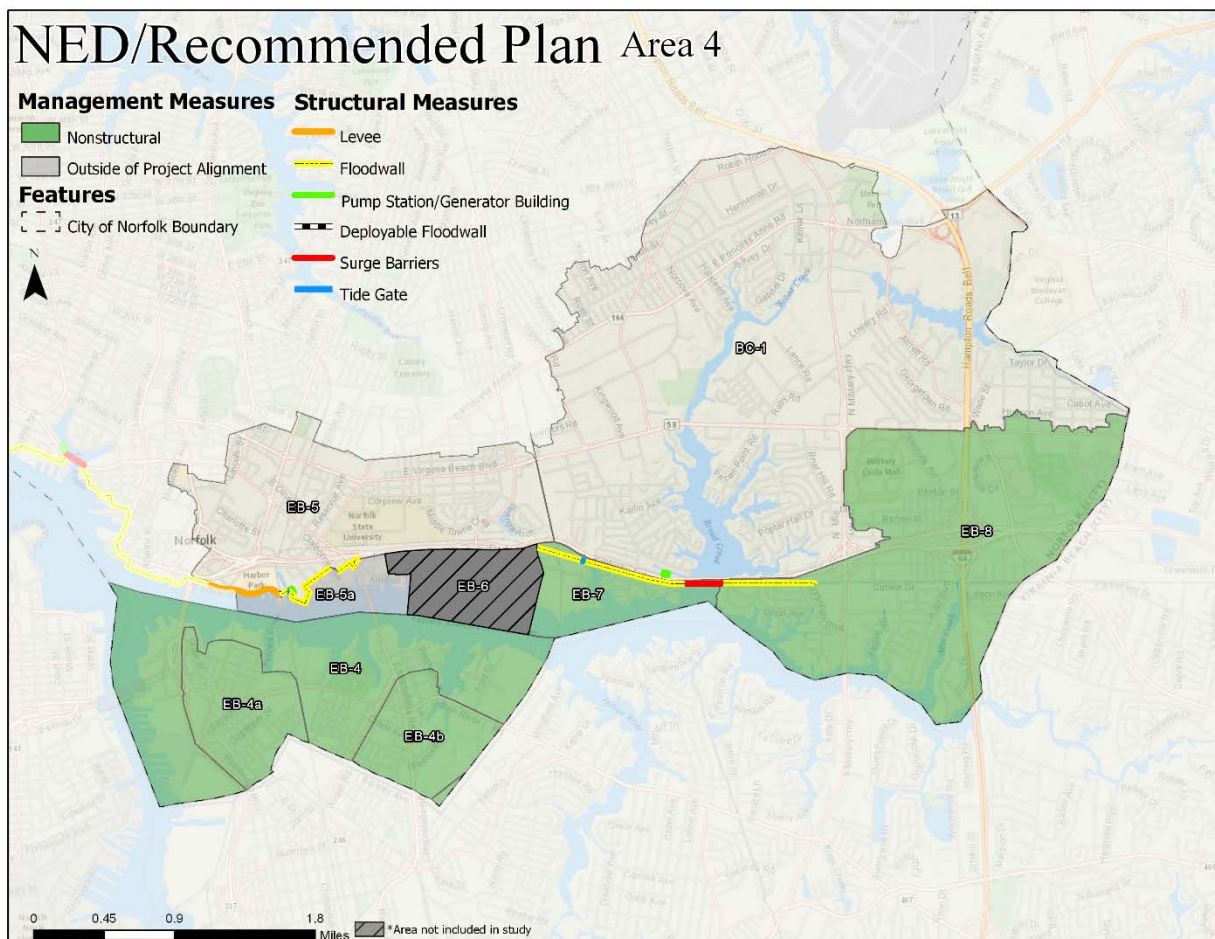


Figure 9-7. Alternative 4d Area 4 Measures.

Table 9-6 shows the breakdown in nonstructural measure types that are recommended in the RP. The table breaks down the total structures into residential and nonresidential categories. Residential signifies single family homes and similar structures such as duplexes. Elevation is a typical solutions for residential structures and there is already a precedent for elevating residential structures in the Norfolk area. Nonresidential buildings are commercial and industrial in nature but also include multifamily structures such as apartment and condominium buildings. Nonresidential structures are not likely to be elevated due to their construction type and size. Floodproofing is a common solution for nonresidential buildings. The table below also breaks out the historic structures from the total. Historic structures are noted because they may have higher costs to mitigate and they provide cultural value to an area.

Table 9-6. Nonstructural Measures within the Recommended Plan

Nonstructural Measure	Total Structures	Nonresidential	Residential	Historic
Basement Fill	176	1	175	33
Basement Fill + Floodproofing	1	1	0	0
Basement Fill + Elevation	89	0	89	4

Nonstructural Measure	Total Structures	Nonresidential	Residential	Historic
Buyout	76	6	70	27
Floodproofing	54	54	0	5
Elevation	624	0	624	12
Total	1020	62	958	81

9.7 EXECUTIVE ORDER (EO) 11988 AND PUBLIC LAW 113-2 CONSIDERATIONS

This study has considered the requirements of EO 11988, Flood Plain Management and PL 113-2, the Disaster Relief Appropriations Act of 2013. Specifically, this section of the report addresses:

- The Water Resources Council Floodplain Management implementing guidelines for EO 11988;
- The specific requirements necessary to demonstrate that the project is economically justified, technically feasible, and environmentally acceptable, per PL 113-2;
- The specific requirements necessary to demonstrate resiliency, sustainability, and consistency with the North Atlantic Coast Comprehensive Study (NACCS), per PL 113-2.

9.7.1 EO 11988

Executive Order 11988 requires federal agencies avoid, to the extent possible, the long and short term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency 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 flood plains in carrying out its responsibilities."

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight step process that agencies should carry out as part of their decision making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below.

- 1. Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).** The proposed action is within the base floodplain. However, the project is designed to reduce damages to existing infrastructure located landward of the proposed project.
- 2. If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.** Chapters 5 through 8 discuss the process of screening and analyzing both measures and alternatives. Nonstructural, structural, and NNBF measures were all considered in the process.
- 3. If the action must be in the floodplain, advise the general public in the affected area**

and obtain their views and comments. An Environmental Impact Statement (EIS) and the National Environmental Protection Act (NEPA) procedures are being developed concurrently with the study. During this process the local stakeholders and the general public have been afforded the opportunity to review and comment on the study recommendations.

- 4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.** The anticipated impacts and environmental compliance associated with the Recommended Plan are summarized in Chapters 11 and 12. The project is not expected to alter or impact the natural or beneficial flood plain values.
- 5. If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.** The project provides benefits primarily for existing and previously approved development, and is not likely to induce significant development. Nonstructural components of the project, and real estate requirements required for construction of the project will reduce the level of development that is at risk.
- 6. As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the “no action” alternative.** The project is not expected to induce development in the flood plain. In areas where the project will impact the natural or beneficial flood plain values, environmental mitigation is planned. Due to the built-out level of the city the impact to natural floodplains is considered minimal. Chapters 5 through 8 of this report summarizes the alternative identification, screening and selection process. The “no action” alternative was included in the plan formulation phase.
- 7. If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.** The Draft Interim Feasibility Report and Environmental Impact Statement were provided for public review. Public meetings were scheduled during the public review period. Each comment received will be addressed and, if appropriate, incorporated into the Final Report. A record of all comments received will also be included in Appendix D.
- 8. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.** The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

9.8 OPERATION OF THE RECOMMENDED PLAN

This section discusses the operational aspects of the RP. In particular it will focus on the recommended operation of the storm surge barriers (SSB) due to the significant interest from the public in strategy for closing and opening the gates on the SSBs. Note that the Recommended Plan as described in this study is estimated to be at a 10% design level. Therefore modifications to design and operations are possible during later stages of project design and construction. Any modifications may require new investigation into environmental and social impacts. A more detailed description of the operations of the RP can be found in

Appendix B.

The authority of the Norfolk CSRM study is for coastal storm risk management. As such, it is not intended for mitigating against nuisance flooding such as king tides. The expectation is that SSB gates will close during significant storms such as nor'easters and hurricanes. Norfolk begins to see significant flooding related damages when coastal water surface elevations reach 4 ft NAVD88. The water surface elevations recorded by the Sewell's Point gauge were studied for the duration of time that a storm event would keep water surface elevations above 4 ft. The longest duration of record is from Hurricane Sandy with a duration of 16 hours above 4 ft. See Table 9-7. The closing of a storm surge barrier is expected to occur during a preceding low tide in order to maximize interior storage for rainfall runoff. The WSELs associated with Hurricane Sandy were then analyzed to calculate the expected time duration from the preceding low tide, through the storm event, and until the WSELs dropped below 4 ft. The results show that gate closure durations should be anticipated from four days in the beginning of the project life to 5.5 days by 2075. The duration is expect to increase over this time period due to RSLR. Table 9-8 shows the estimated closure times for surge barrier gates.

Table 9-7. WSEL Duration Above 4 ft at Sewell's Point Gauge

Storm Name	Month/Year	Duration above 4.0 ft NAVD88 (hrs)	Duration above 4.0 feet NAVD88 (days)
Unnamed Storm	8 / 1933	8	0.33
Unnamed Storm	9 / 1933	5	0.21
Unnamed Storm	9 / 1936	5	0.21
Unnamed Storm	4 / 1956	5	0.21
Isabel	9 / 2003	10	0.42
Irene	8 / 2011	7	0.29
Sandy	10 / 2012	16	0.67
Matthew	10 / 2016	3	0.13

Table 9-8. Approximately Gate Closure Time (days)

Year	Closure Time in days (approx.)
2026	4 days
2050	5 days
2075	5.5 days

The frequency of surge barrier gate closures is another consideration, in particular for environmental and operational cost concerns. For this study it is assumed that the trigger elevation to close the SSB gates will occur for WSELs reaching 4 ft to 5 ft, NAVD88. Flood damages are estimated to begin occurring in Norfolk at elevation 4ft, NAVD88. Based on analysis of the Sewells Point gauge historical records, and accounting for RSLR, it is estimated that the number of mobilizations to close the RP SSB gates could range from 0 – 10 times per year. This depends on the determined trigger elevation, with fewer closures necessary if a higher trigger elevation is chosen. It is possible the trigger elevation could be adjusted upwards

further along in the project life in order to adapt for changing sea levels. Further detail on the operation of the system will be created during the design and construction phase of the project.

9.9 RESILIENCY, SUSTAINABILITY, AND CONSISTENCY WITH THE NACCS

This section has been prepared to address how the NED Plan contributes to the resiliency of Norfolk; how it affects the sustainability of the affected area; and how it will be consistent with the findings and recommendations of the NACCS.

Resiliency is defined in the February 2013 USACE-NOAA Infrastructures Systems Rebuilding Principles white paper as the ability to adapt to changing conditions and withstand, and rapidly recover from disruption due to emergencies. Sustainability is defined as the ability to continue (in existence or a certain state, or in force or intensity), without interruption or diminution.

9.9.1 Resiliency

The USACE Climate Change Adaptation Goal is to minimize impacts from climate change and maximize resiliency in the coastal landscape. The USACE describes resilience as “the ability to anticipate, prepare for, respond to, and adapt to changing conditions and to withstand and recover rapidly from disruptions with minimal damage.

Anticipate

The recommended design and plan for the Norfolk CSRM project anticipates the effects of sea level rise and land subsidence on possible flood elevations. Future land use and development have been anticipated through use of the City of Norfolk long range planning strategies such as Vision 2100.

Prepare

The City of Norfolk, through implementation of floodplain management, zoning, and city planning strategies that consider relative sea level rise has become more prepared for changing future conditions. The implementation of a project such as the Norfolk CSRM will enhance that preparedness.

Respond

The Norfolk CSRM study considers critical infrastructure in order to improve the ability for Norfolk to respond to flood risks. Police and fire stations are considered, as are the major hospital systems in the area. Major roadways behind the project alignments will see lower risk of future flooding, thus allowing emergency responders to travel throughout the city.

Adapt

The updated zoning codes implemented by the City of Norfolk codifies adaptation of new and substantially updated development throughout the city. Norfolk also has an established vision for adapting the land use and development of the city. Further description on the adaptability of the Recommended Plan can be found in Section 9.9.3 Adaptability.

One of the planning objectives of the Norfolk CSRM is to improve the resiliency of the local economy to impacts from coastal storms. All of the Recommended Plan features will improve the resiliency of the Norfolk economy, particularly with future sea level rise taken into account.

Generally speaking, the project will reduce the average annual damages to infrastructure from coastal storms. The project will also reduce flood risk to roadways that are behind structural

project features. Nonstructural measures for critical infrastructure will enable the city to maintain and more quickly recover services deemed critical to the functioning of the city. The project is complemented by projects and efforts incorporated by the City. These efforts include improved floodplain management plans and zoning codes that strengthen infrastructure resiliency.

Every project has its limitations and the Recommended Plan is no different, however, the local economy will see improvements to economic resiliency through the reduction in damages and disruptions from coastal storms.

9.9.2 Sustainability

The project meets economic and community sustainability goals for the fifty year length of the project. Economic principals are used in benefit calculations, plan formulation ranking, and project justification by their contributions to the National Economic Development account. Environmental concerns are evaluated in the EIS and through coordination and review by the resource agencies including the Environmental Protection Agency, the US Department of Interior, and the Virginia Department of Environmental Quality as part of the feasibility process. Other Social Effects (OSE) accounts were used to differentiate several alternatives from one another. OSE was also used in the justification for some of the natural and nature based features that are proposed for the project. The nexus of economic, environmental, and social accounts indicates that the recommended project is sustainable.

9.9.3 Adaptability

The ability of the project to adapt into the future was assessed through the analysis of varying rates of sea level rise as well as an assessment of project performance out to 2125. Adaptability is defined as the quality of being able to adjust to new conditions or the capacity to be modified for a new use or purpose. The USACE Climate Change Adaptation Goal is to minimize impacts from climate change and maximize resiliency in the coastal landscape. The current 10% structural design of the Norfolk CSRM project takes into consideration the effects of sea level rise, land subsidence, and climate change as part of the design (i.e., heights of walls). For the analysis on SLR and when the heights of walls will need to be adjusted, please see the Hydraulics, Hydrology, and Coastal Engineering Sub-Appendix, which further discussion on SLR, design water levels, confidence limits, and risk.

Although USACE designs Civil Works projects to have a 50 year design life, the designs should take into consideration how and if the design can adapt to the effects of sea level rise and climate change 100 years after the project is constructed and what adjustments can be made to the design to assure that the project can adapt. For the Norfolk CSRM, walls that are recommended to be 4 feet or higher, will be built as T-walls, because these walls can be constructed higher at a later date if needed.

Figure 9-8 below shows elevation ranges in Norfolk. The Recommended Plan is designed for design water surface elevations in the 11-12 foot range. The project structural measures are considered separable up to those elevations. However, going beyond 12 feet increases the likelihood that a measures will be flanked by floodwaters. For example, flooding over Naval Station Norfolk would likely begin to enter the Lafayette River basin above 12 feet. The brown and white colors represent elevations over 13 feet. The majority of Norfolk sits below 13 ft NAVD88 with very little area above 15 ft.

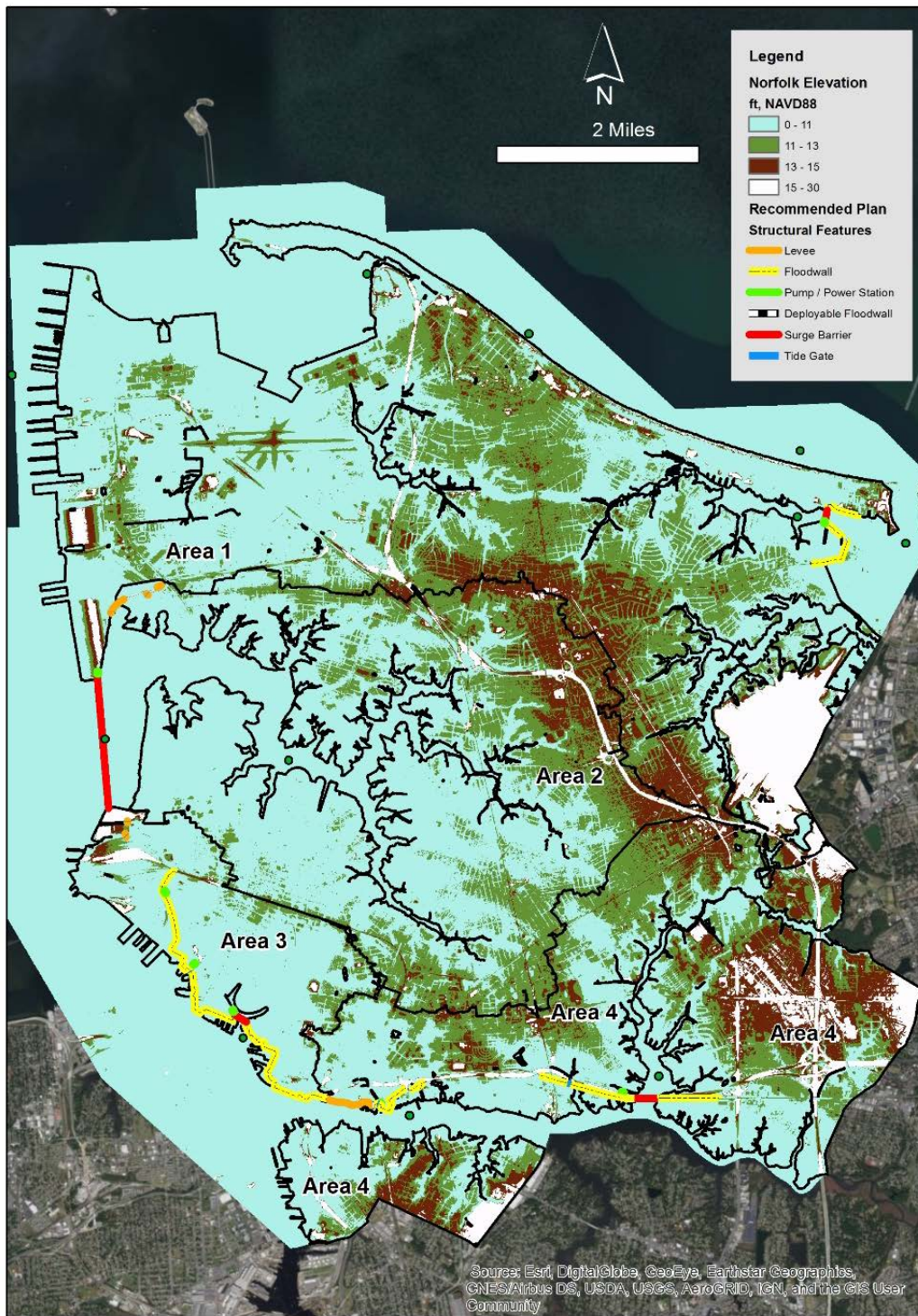


Figure 9-8. Norfolk Elevations

Figure 9-9 below graphically displays the service level of the project against the low, intermediate, and high rates of RSLR as estimated by the USACE. The figure is for Area 4 of Norfolk. The blue, dashed line indicates the design water level in Area 4 of Norfolk. The elevation of the wall in this area is shown as the yellow bar and is at elevation 16.5 ft NAVD88. The wall elevation is higher than the design water level in order to account for wave runup. As

can be seen in the figure the design water level will be reached by approximately 2050, 2075, and 2120 for the high, intermediate, and low rates of RSLR. As has been mentioned the majority of Norfolk sits below elevation 13 ft NAVD88. Options for adaptive flood risk management beyond 2075, at the design level of the RP, are limited due to the low topography of Norfolk. A structural project alignment would essentially need to extend around the city to keep up with sea level rise. This situation will arrive more quickly with a high rate of RSLR. Because RSLR rates are the same around the various areas of Norfolk, this timeline should be considered similar to all areas of Norfolk.

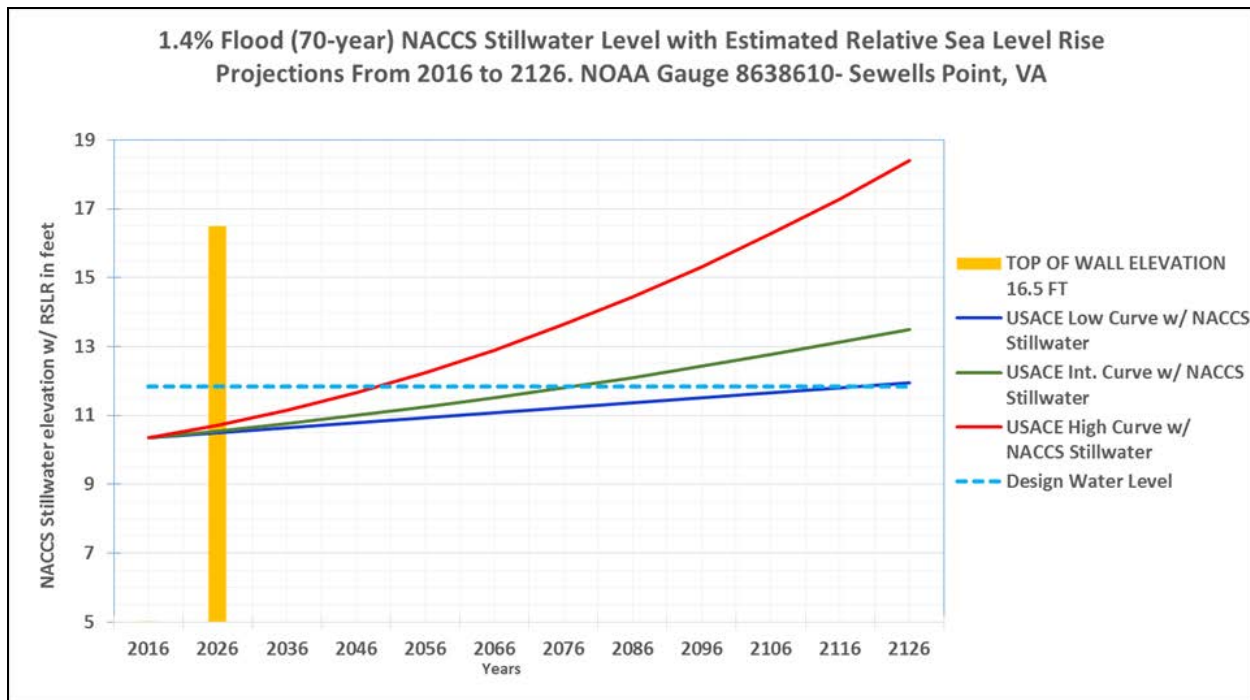


Figure 9-9. Area 4 Proposed Design Elevation in Relation to USACE RSLR Estimates

9.10 CONSISTENCY WITH THE NACCS

The North Atlantic Coast Comprehensive Study was released in January 2015 and provides a risk management framework 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. In particular, it encourages planning for resilient coastal communities that incorporates wherever possible sustainable coastal landscape systems that takes into account future sea level and climate change scenarios. The process used to identify the Recommended Plan utilized the NACCS Risk Management framework that included evaluating alternative solutions and also considering future sea level change and climate change. The Norfolk CSRM echoes many of the principles of the NACCS, in that it considers the entire area as a system, the formulation considered multiple plan components to address the multiple risks, the plan incorporates non-structural and NNBF components, and has been developed in recognition of balancing the needs for coastal storm risk management with the requirements of the partner agencies.

CHAPTER 10 AFFECTED ENVIRONMENT

10.1 LAND USE

10.1.1 Definition of Resource

Land use comprises the natural conditions and/or human-modified activities occurring at a particular location. Human-modified land use categories include residential, commercial, industrial, transportation, communications and utilities, agricultural, institutional, recreational, and other developed use areas. State laws, management plans, and zoning regulations determine the type and extent of land use allowable in specific areas and often intend to protect specially designed or environmentally sensitive areas. Zoning requirements are regulations developed by the locality to control potential future development. Comprehensive plans evaluate long-term demographic trends to identify how the region of analysis should be developed. Where zoning focuses on immediate trends in development, comprehensive plans are generally less regulatory in nature and often serve as guidance when current planning department is evaluating applications for development.

10.1.2 Methodology

In describing land use, all existing and proposed future land uses within the Study Area are considered. This includes consideration of the zoning as well as comprehensive plans for the entire city of Norfolk.

The Region of Influence (ROI) for land use is all land throughout the Study Area, or the entire city of Norfolk. While the Study Area does not include the Naval Station Norfolk; direct and indirect effects to it are still considered.

10.1.3 Framework

Federal Coastal Zone Management Act (CZMA), 16 U.S.C. 1451 et seq. This Act requires each federal agency activity performed within or outside the coastal zone (including development projects) that affects land or water use, or natural resources of the coastal zone to be carried out in a manner which is consistent with the Coastal Zone Management Program to the maximum extent practicable. It also holds that the federal agency shall complete and provide a federal consistency determination to the state.

Chesapeake Bay Protection Act (CBPA). State-local cooperative program administered by the Virginia Department of Environmental Quality's (DEQ's) Water Division and 84 localities in Tidewater, Virginia established pursuant to the Chesapeake Bay Preservation Act (Virginia Code §§ 62.1-44.15:67 through 62.1-44.15:79) and Chesapeake Bay Preservation Area Designation and Management Regulations (Virginia Administrative Code 9 VAC 25-830-10 *et seq.*). Under the CBPA, the 100-foot width of riparian buffer from mean low water landward is known as the Resource Protection Area (RPA), and there are land use restrictions on tree-clearing and most types of disturbance or development within this area.

Local Zoning Ordinance. Norfolk's new zoning ordinance was unanimously adopted by City Council on January 23, 2018. The new zoning code encourages and supports development that makes Norfolk more resilient, both physically and economically. The code contains a number of

pioneering approaches in response to the long-term challenges posed by sea level rise. The new code requires all development within the city to meet a resilient quotient. The requirement is measured on a points system covering three separate resilience elements: risk reduction, stormwater management, and energy resilience. Additionally, new or expanding development must meet minimum requirements for first floor elevations 1.5 – 3 feet above the FEMA base flood elevation.

plaNorfolk 2030. The General Plan of the city of Norfolk (adopted by the City Council March 26, 2013, Revised January 2017). Adopted by Norfolk City Council on March 26, 2013, plaNorfolk 2030 is used to guide decision making about physical development and public infrastructure. It is intended to be sufficiently flexible to respond to changes in development patterns and contains the broad outlines neighborhoods will use to guide and plot their path to the future.

Vision 2100. Adopted by Council on November 22, 2016, it provides a long-term strategy to address the challenges of sea level rise, infrastructure needs, and population growth. Its overall goal is to design the coastal community of the future, ensuring that Norfolk will be a dynamic, water-based city well into the future. Vision 2100 guides the City's decisions about public infrastructure investments or its response to development proposals. Vision 2100 aims to ensure that resources are used efficiently, with an eye towards the future.

Rockefeller Foundation's 100 Resilience Cities Initiative. As one of the first cities selected to participate in the Rockefeller Foundation's 100 Resilience Cities initiative, in October 2015 the city of Norfolk released the world's third comprehensive Resilience Strategy that identifies numerous short and long term actions to build resilience. Norfolk's Resilience Strategy, will guide the city in its shift to a successful coastal community of the future. The Resilience Strategy includes an updated risk and vulnerability assessment across coastal, economic and social systems.

Norfolk Citywide Drainage Master Plan 2012. Norfolk contracted with the Timmons Group consulting firm to develop a drainage master plan that identified areas throughout the city, requiring improvements based on readily available complaint information, and capacity and condition of existing stormwater infrastructure.

10.1.4 Existing Conditions

City of Norfolk Land Use Overview

The city of Norfolk is a mature, developed city that consists of approximately 53 square miles of land and 13 square miles of water. The City's predominant land use is residential, at 41.4%, followed by military (15.6%), open space and recreational (10.7%), utility and transportation (8.1%), commercial and office space (8.0%), institutional (7%), and industrial (6.0%). Only approximately 3.1% of the City consists of vacant land (City of Norfolk, 2017). Commercial businesses line many of the arterial roadways. Approximately 48 public schools, 14 private schools, and 102 public recreational parks and facilities of varying sizes are scattered throughout the city. As of July 1, 2015, the Census reported that Norfolk's population is 246,393, up 1.5% from its population of 242,831 in April 2010. (U.S. Department of Commerce, 2017).

There are approximately 62,000 residential, commercial, and public structures within the City. The total also accounts for about 240 structures considered critical infrastructure, including emergency services, Government facilities and shelters, water and wastewater systems, transportation, communications, healthcare and public health, and commercial facilities. Approximately 7,500 structures are located within the FEMA 1% annual chance floodplain. Out of that number, there are about 760 designated historical structures. At the higher NACCS 1% annual chance water level, there are approximately 25,000 and 3,400, respectively.

Area 1–Willoughby, Ocean View, Mason Creek, Little Creek, Pretty Lake, and Lake Whitehurst Watershed.

As can be seen in Figure 10-1, Area 1 largely consists of residential and military (Naval Station Norfolk) property. In addition, Norfolk International Airport, Southside Hampton Roads' only commercial airport, is located in the southeastern corner of Area 1, adjacent to Lake Whitehurst.

The Willoughby and Ocean View watershed is in the northern section of the City. It is fully developed with older and newer residential and commercial structures that are located to take advantage of the benefits inherent with a beach environment. Over the past several years, the older and storm damaged buildings have been periodically demolished and replaced with new structures constructed with the first floor of the living area above the 100-year flood level in accordance with federal state and city building code regulations. (USACE, 2013). There are approximately seven miles of public beachfront with numerous access points stretching from Willoughby Spit to East Ocean View.

Naval Station Norfolk is located just south of Willoughby Bay, and is shown in navy blue in the figure below. Although the base itself is not included in the ROI, at least half of its employees commute to work daily, many of them residents of Norfolk. In Fiscal Year 2015, Naval Station Norfolk alone employed: 42,997 active duty, 1,462 reserves, 13,438 civilians and 7,037 contractors (USDOT, 2016). It is by far the City's largest employer.

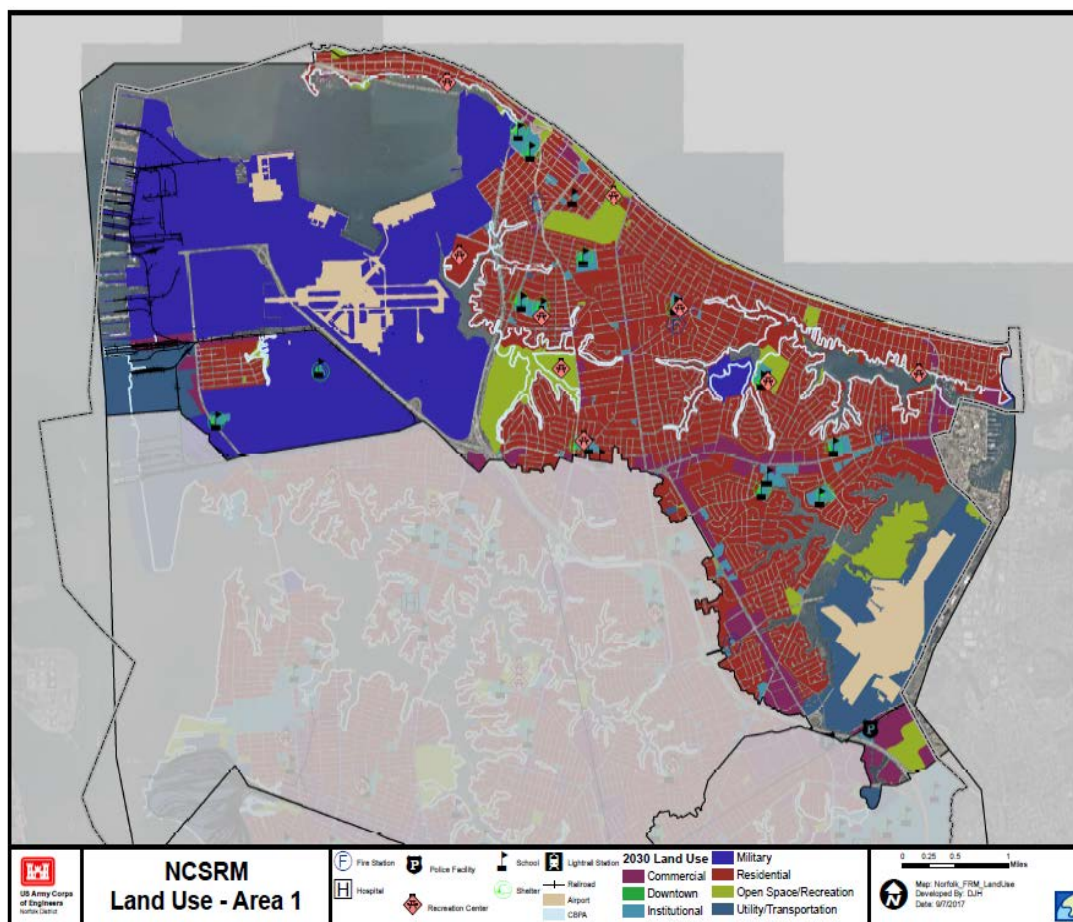


Figure 10-1. Land Use- Area 1

The Little Creek/Fishermans Cove/Pretty Lake watershed is in the northeast portion of the city. It includes the East Ocean View residential/commercial community, and the Bayview and Carmellisa neighborhoods. Land use surrounding Pretty Lake is almost entirely residential and recreational; however there are three commercial marinas within Fisherman Cove, which adjoins Pretty Lake to Little Creek. The southern portion of this watershed is bordered by Lake Whitehurst. Not including Naval Station Norfolk, the watershed is primarily residential, with low-density residential making up by far the largest land use, at 60.4%. Medium density residential, high density residential, commercial, open space/recreational, mixed use, institutional, and vacant land uses, ranging from 5.9-8.7% of the watershed (Fugro Atlantic, 2012a).

The locations and orientation of these watersheds make them vulnerable to damage associated with storm activity. Extreme high tides have caused structural damage to buildings and infrastructure landward of the beach in the past. This area is subject to tidal and storm surge flooding from Pretty Lake as well. Also, much of the development is older, and therefore built before the standards of the National Flood Insurance Program (NFIP), which requires first floors to be elevated above the 1% base flood elevation (BFE) (USACE, 2015).

Lake Whitehurst is a drinking water reservoir located on the eastern border of the city of Norfolk.

Under the Chesapeake Bay Preservation Act (CBPA), the 100-foot width of riparian buffer from mean low water landward (tidal areas only) is known as the Resource Protection Area (RPA),

and there are land use restrictions on tree-clearing and most types of disturbance or development within this area. However most existing land use types are grandfathered.

Area 2 – Lafayette River Watershed.

The Lafayette River watershed is located in the west-central portion of the city of Norfolk. It is one of Norfolk’s largest watersheds, and includes Old Dominion University (ODU), and the Colonial Place, Larchmont, Lochhaven, Riverfront, Talbot Park, and Algonquin Park neighborhoods. The watershed also contains local landmarks located along the shoreline like the Virginia Zoological Park and the Hermitage Museum. It also contains DePaul Hospital. As can be seen in Figure 10-2, dominant land use in the watershed is primarily low density residential development, with total residential development comprising approximately 49% of the land area; however, the riverfront is largely residential (Fugro Atlantic, Consultants, 2016). According to the City, this area contains approximately 25% of its tax base.

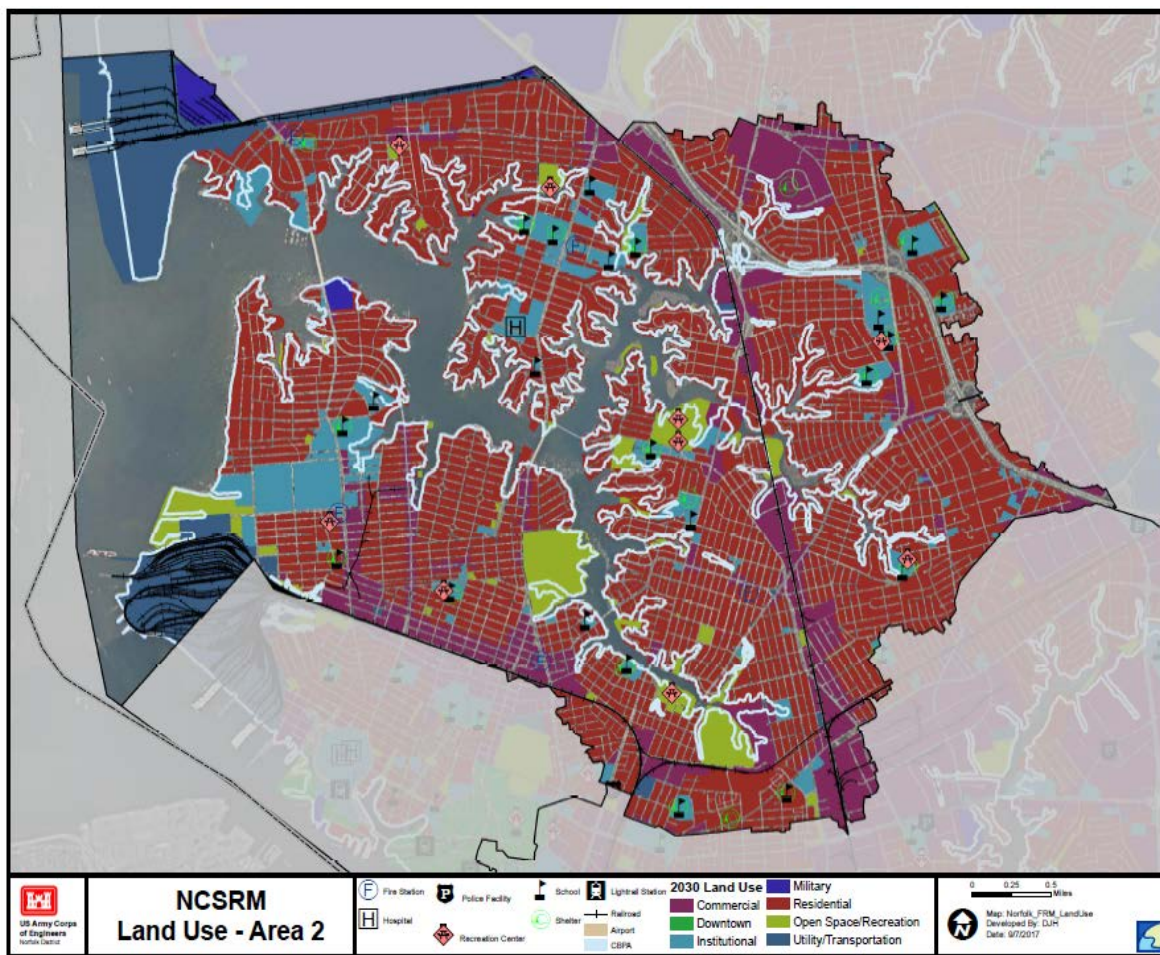


Figure 10-2. Land Use - Area 2

Commercial development exists along the main roadway corridors and urban residential development surrounds ODU, while more suburban development covers much of the remaining areas in the Lafayette River watershed. The major industries in this area are Norfolk

International Terminal (NIT) and Lamberts Point Terminal. Both require a coastal location and are located along the main stem of the Elizabeth River. NIT utilizes the major transportation corridors in the area for truck shipments, along with the railroad system; whereas Lamberts Point is a coal terminal and is largely dependent the Norfolk Southern railroad system. NIT, at 567 acres, is the Virginia Port Authority's largest terminal, and is capable of handling 12,000-14,000 TEU's a day (VPA, 2017). The Lamberts Point Terminal is operated as a transshipment terminal. Lamberts Point operates 24 hours a day, seven days a week (www.nscorp.com).

An additional area that needs special consideration in this study area is the Lamberts Point Landfill. Located directly north of Lamberts Point Terminal, the landfill was closed in the 1980s and subsequently, the Lamberts Point Golf Club was built on top of it. Grass plantings and rocks have been placed along the shoreline in the early 1990s; however the area has continued to experience erosion and exposed landfill contents. A large boulder riprap revetment at least 25 feet wide has been constructed around a portion of the northern shore of the golf course (USACE, 2013). Since the riprap revetment has been constructed, no additional erosion or spillage has occurred.

The Lafayette River Watershed is subject to storm surge flooding during coastal storms, but several neighborhoods in this watershed also experience nuisance flooding from high tides and large rainfall events. The Larchmont Neighborhood on the southern coast near the mouth of the Lafayette River is particularly susceptible to these events. (USACE, 2013).

Under the Chesapeake Bay Preservation Act (CBPA), the 100-foot width of riparian buffer from mean low water landward (tidal areas only) is known as the Resource Protection Area (RPA), and there are land use restrictions on tree-clearing and most types of disturbance or development within this area. However most existing land use types are grandfathered.

Area 3 – The Elizabeth River Mainstem, Ghent/West Ghent, The Hague, Freemason, Downtown Watershed.

Area 3 covers the areas on the southwestern shoreline of the city of Norfolk, along the main stem of the Elizabeth River as seen in Figure 10-3. This area includes the neighborhoods and/or Districts of West Ghent, Fort Norfolk, The Hague (Ghent), and Freemason; and Downtown Norfolk. The residential development in these areas often dates back to the 1800s, but there are several neighborhoods that have been redeveloped since the early 1980s. The West Ghent area is located to the west of Hampton Boulevard and consists of dense suburban development, a few commercial businesses, and an industrial shipyard (MHI Shipyard). Little or no natural floodplain areas remain; and the area is subject to flooding from heavy rainfall events and storm surge events (USACE 2013).

The Fort Norfolk area is located south of Brambleton Avenue, along the Elizabeth River. The area consists of condominiums and office buildings, including Eastern Virginia Medical School (EVMS), and is particularly subject to storm surge flooding due to low land elevations and water from the Elizabeth River to its south and the Hague to its north and east. The Fort Norfolk area is also where the Norfolk District USACE is located (USACE, 2013).

The Hague watershed includes urban and dense suburban residential development, including

the Ghent Historic District; commercial businesses along Colley Avenue, 21st Street, and Monticello Avenue. The Children’s Hospital of the Kings Daughters and Sentara Norfolk General Hospital, regionally important facilities, are also located there. Portions of the Hague watershed area are susceptible to flooding from The Hague water body, a u-shape inlet from the Elizabeth River, during high tides and storm surge events. The design of the storm sewer system in this area is responsible for tidal flooding and often high tide events will cause the storm sewer inlets to overflow, allowing storm water to flood roadways. Much of the area is built on fill, including The Hague, which was once a tidal creek known as Smith Creek (Moffat & Nichol, 2014).

The Freemason area is located to the south of Brambleton Avenue and the west of Boush Street, along the Elizabeth River. The area, which contains some of the City’s oldest buildings, consists primarily of dense residential development, but some commercial businesses are also located in this area. The development in this area and some parts of Downtown Norfolk includes structures located on the water-side of the Downtown Floodwall and several condominiums are built on fill into the Elizabeth River (Moffat Nichol, 2014).

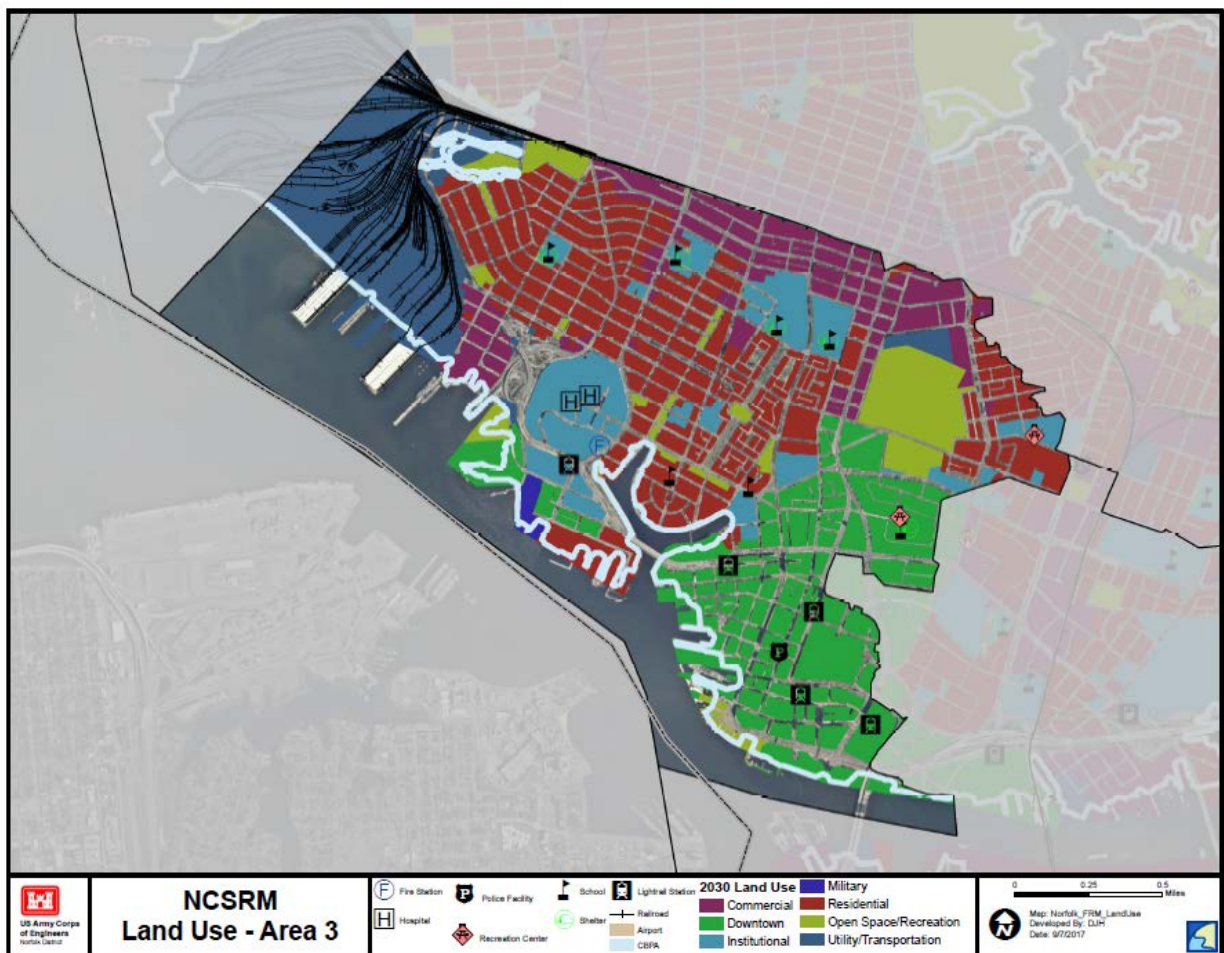


Figure 10-3. Land Use – Area 3

Downtown Norfolk is the area located to the east of The Hague/Ghent neighborhood and Freemason, and to the west of Interstate 264 and St. Paul’s Boulevard. It is a regionally significant urban commercial center that includes office buildings, shopping, dining, and

entertainment. This area includes Scope and Chrysler Hall, two regionally important venues for concerts, professional sports, conventions, and similar large events. It also contains Macarthur Mall, Waterside, Town Point Park, Nauticus Museum, several historic churches, and numerous dining and smaller shopping venues, along with some mixed development high rises and condominiums. There is an existing floodwall and pump station along the Elizabeth River near Nauticus and Town Point Park, to protect the Downtown area from storm surge.

Under the Chesapeake Bay Preservation Act (CBPA), the 100-foot width of riparian buffer from mean low water landward (tidal areas only) is known as the Resource Protection Area (RPA), and there are land use restrictions on tree-clearing and most types of disturbance or development within this area. However most existing land use types are grandfathered.

Area 4 - Elizabeth River Eastern Branch Watershed. As seen in Figure 10-4, Area 4 covers the southeastern section of the city of Norfolk, east of Interstate 264 and St. Paul's Boulevard, and bounded by the Norfolk/Virginia Beach jurisdictional boundaries to the east. The area includes residential and non-residential buildings and Harbor Park baseball stadium along the Elizabeth River. Along the waterfront of the Eastern Branch of the Elizabeth River, east of Harbor Park, there is a residential neighborhood bordered by commercial/industrial water-dependent land uses along waterfront (Lyons Shipyard and Morans Environmental Recovery).

Further east is the Ohio Creek watershed, which is mainly residential, but includes Norfolk State University and a large city high school. It is labelled "E-6" earlier in this document, and is not part of the ROI because its needs are being addressed through a separate grant and project.

East of Ohio Creek watershed, the Broad Creek watershed, which also includes several smaller tributaries, is mainly residential with some commercial and industrial use along the main corridors. At the headwaters of Broad Creek are Sentara Leigh Hospital, Lake Taylor Transitional Care Hospital, Virginia Wesleyan College, and Norfolk Academy. There is a major commercial and industrial business corridor along Military Highway that includes shopping and dining at Military Circle and Janaf Shopping Center. The city's Moore's Bridges Water Treatment plant is also located in this watershed. Interstate 264 and the Hampton Roads Transit Light Rail, known as the Tide, parallel each other and roughly parallel the Eastern Branch of the Elizabeth River, and cross Broad Creek.

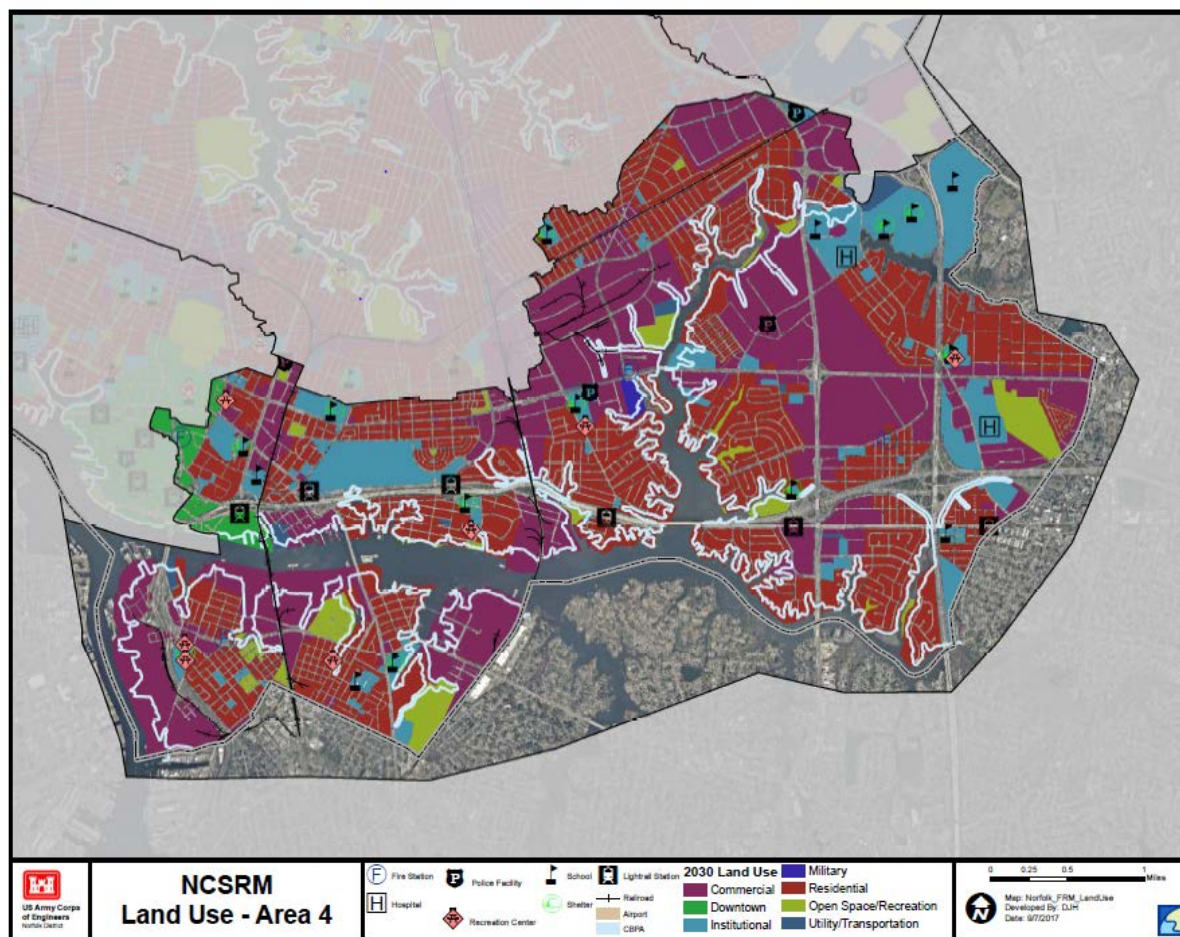


Figure 10-4. Land Use – Area 4

Area 4 includes the only land area within the Norfolk jurisdictional boundaries situated to the south of the Elizabeth River, the Berkley and Campostella neighborhoods. The Berkley and Campostella area includes residential neighborhoods and industry, mainly several shipyards.

Under the Chesapeake Bay Preservation Act (CBPA), the 100-foot width of riparian buffer from mean low water landward (tidal areas only) is known as the Resource Protection Area (RPA), and there are land use restrictions on tree-clearing and most types of disturbance or development within this area. However most existing land use types are grandfathered.

10.2 GEOLOGY AND SOILS

10.2.1 Definition of Resource

Geological resources are defined as the topography, geology, mining, and soils of a given area. Topography describes the physical characteristics of the land such as slope, elevation, and general surface features. The geology of an area includes bedrock materials and mineral deposits. Mining refers to the extraction of resources (e.g., gravel). The principal geologic factors influencing the stability of structures are soil stability, depth to bedrock, and seismic properties. Soil refers to unconsolidated earthen materials overlaying bedrock or other parent material.

This resource section includes a discussion of geotechnical conditions. Geotechnical engineering is defined as the behavior of earthen materials, both natural and man-made.

10.2.2 Methodology

The methodology for identifying, evaluating, and mitigating impacts to geology and soils was established through review of geological and soil studies and reports, and federal and state laws and regulations.

The ROI is located within the lowland subprovince of the Virginia Coastal Plain Physiographic Province. The topography of the Coastal Plain is a terraced landscape that stair-steps down to the coast and to the major rivers. The Coastal lowland subprovince is a low-relief region along the major rivers and surrounding the Chesapeake Bay, at topographic elevations between zero and 60 feet above mean sea level. The lowland subprovince is depicted in yellow (“CL” for coastal lowland) in Figure 10-5. (College of William and Mary, 2006).

10.2.3 Framework

The regulatory framework for geology and soils mainly consists of its potential to affect other resources including air quality and water.

Virginia’s Erosion and Sediment Control Law requires soil-disturbing projects to be designed to reduce soil erosion and to decrease inputs of chemical nutrients and sediments to the Chesapeake Bay, its tributaries, and other rivers and waters of the Commonwealth. This program is administered by the DEQ (Virginia Code §62.1-44.15:51 *et seq.*). Clearing, grubbing, and grading activities during construction will adhere to the Virginia Department of Conservation and Recreation (VDCR) Erosion and Sediment Control Program. The program requires erosion and sedimentation control plans to minimize erosion and siltation that could impact local streams.

Soil erosion and sedimentation control measures to control off-site runoff would be implemented during construction. An erosion and sediment control plan detailing construction Best Management Practices (BMPs) would be prepared in accordance with the Virginia Erosion and Sediment Control Laws and Regulations and Virginia Storm Water Management Law and Regulations. Construction would be monitored to ensure erosion and stormwater management practices are adequate in preventing sediment and pollution migration into nearby surface waters. Therefore, the proposed alternatives would be consistent to the maximum extent practicable.

Because the city of Norfolk does not lie within a seismically active area, regulations and policies that relate to geologic hazards and seismic safety do not apply.

10.2.4 Existing Conditions

Topography

The entire project area is underlain by the Virginia Coastal Plain. The Coastal Plain extends from the Fall Zone eastward to the Atlantic Ocean (College of William and Mary, 2006). The “Fall Line” or “Fall Zone” marks the transitional zone where the softer, less consolidated sedimentary rock of the Atlantic Coastal Plain to the east intersects the harder, more resilient

metamorphic rock to the west, forming an area of ridges, waterfalls and rapids (Frye, 1986). Through the Fall Zone, the larger streams cascade off the resistant igneous and metamorphic rocks of the Piedmont to sea level. Large tidal rivers such as the Elizabeth River flow across the Coastal Plain to the Chesapeake Bay. The bay, in turn, empties into the Atlantic Ocean (College of William and Mary, 2006).

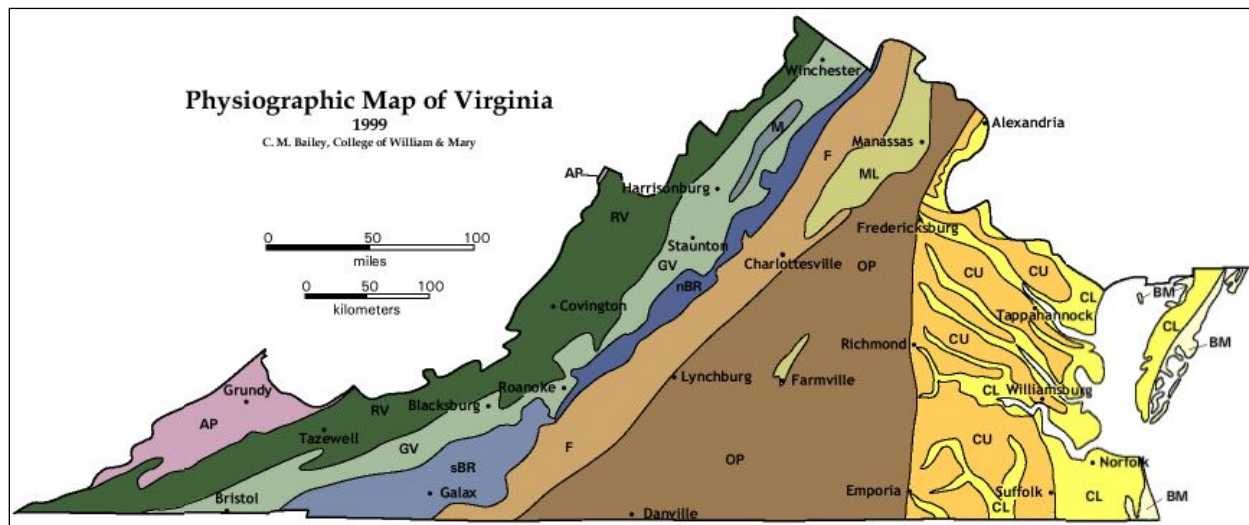


Figure 10-5. Physiographic Map of Virginia

CL= Coastal Lowland, CU= Coastal Upland, OP=Outer Piedmont, ML= Mesozoic lowlands, OP= Outer Piedmont, F= Foothills Subprovince, nBR= northern Blue Ridge, sBR= southern Blue Ridge, RV= Ridge & Valley, GV= Great Valley, M=Massanutten Mountain, AP= Appalachian Plateau
Source: (College of William and Mary 2006)

The topography of the Coastal Plain is a terraced landscape that stair-steps down to the coast and to major rivers. The risers (scarps) are former shorelines and the treads are emergent bay and river bottoms. The higher, older plains in the western part of the Coastal Plain are more dissected by stream erosion than the lower, younger terrace treads. This landscape was formed over the last few million years as sea level rose and fell in response to the repeated melting and growth of large continental glaciers and as the Coastal Plain slowly uplifted.

During the glacial maxima, much of the continental shelf was emergent and the Susquehanna River flowed through the Chesapeake lowland and across the exposed shelf to the sea 50 miles or more to the east. The Chesapeake Bay was created about 5,000 to 6,000 years ago when the lower course of Susquehanna River through the Chesapeake lowland was flooded as meltwater from the large Pleistocene continental glaciers raised sea level. Continuing sea level rise and shoreline erosion caused the bay to expand its aerial extent (College of William and Mary, 2006).

The Virginia Coastal Plain is underlain by a thick wedge of sediments that increases in thickness from a featheredge near the fall zone to more than 2.5 miles under the continental shelf. These sediments rest on an eroded surface of Precambrian to early Mesozoic rock. Two-thirds of this wedge is composed of late Jurassic and Cretaceous clay, sand, and gravel; they were stripped from the Appalachian Mountains, carried eastward by rivers and deposited in deltas in the newly formed Atlantic Ocean basin. A sequence of thin, fossiliferous marine sands

of Tertiary age overlies the older strata. This pattern of deposition was interrupted about 35 million years ago by a larger meteorite that plummeted into a shallow sea, and created a crater more than 55 miles in diameter, termed the Chesapeake Bay Impact Structure. It was subsequently buried under about 4,000 feet of younger sediment (College of William and Mary, 2006).

Latest Tertiary and Quaternary sand, silt, and clay, which cover much of the Coastal Plain, were deposited during interglacial high stands of the sea under conditions similar to those that exist in the modern Chesapeake Bay and its tidal tributaries (College of William and Mary, 2006).

According to the Physiographic Map of Virginia, the project area lies entirely within Lowland Sub province of the Atlantic Coastal Plain (College of William and Mary, 2006). The City has land elevations that are generally less than 15 feet, NAVD88. Approximately 10% of the land area is at elevation six feet or less, 40% at 10 feet or less, 80% at 13 feet or less, and 90% at 15 feet or less. One of the highest places in the City is the Norfolk International Airport, with land elevations generally greater than 17 feet, NAVD88.

Geologic Hazards

The city of Norfolk is located in an area of historically low seismic activity. Earthquakes of significant magnitude are unlikely occurrences for the Hampton Roads region (Hampton Roads Planning District Commission, 2011). The Virginia Department of Emergency Management has identified no significant earthquakes within in the most recent 200 years in eastern Virginia (Commonwealth of Virginia, 2013). However, the soils within the City have shrink-swell potential (USDA, 1980).

The extent of shrinking and swelling is influenced by moisture and the amount and kind of clay in the soil. Shrinking and swelling of soils can cause damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, or with material having this rating (USDA 1995).

Soils

Although the Study Area consists of numerous soil types, twenty-seven distinct types of soil have been recognized and mapped in the Norfolk area. Table 10-1 presents the properties of the soil types found within the Study Area (USDA, 2017).

Table 10-1. Study Area Soils Information for Geological Resources

Soil Type	Soil Characteristics
Altavista fine sandy loam	Depth Class: Very deep Drainage Class: Moderately well drained Permeability: Moderate Surface Runoff: Slow Parent Material: Loamy fluvial sediments Slope: 0 to 10 percent

Soil Type	Soil Characteristics
Dragston fine sandy loam	Depth Class: Very deep Drainage Class: Somewhat poorly drained Permeability: Moderately rapid Surface Runoff: slow Parent Material: loamy marine and fluvial sediments Slope: 0 to 2 percent
Duckston fine sand	Consists of poorly drained sands near the coast. These soils are in shallow depressions between coastal dunes and on nearly level flats between the dunes and the marshes. Slopes are 0 to 2 percent.
Johnston silt loam	Drainage Class (Agricultural): Very poorly drained Flooding Frequency and Duration: Frequent or occasional for very brief to long periods Ponding Frequency and Duration: None Internal Free Water Occurrence: Shallow, common Permeability: Moderately rapid Landscape: Lower to upper coastal plain Landform: Flood plain, swamp Geomorphic Component: Tread Parent Material: Alluvium Slope: 0 to 2 percent
Lawnes loam	Consists of very deep, very poorly drained, moderately permeable soils on tidal marshes. The soils formed in alluvial sediments. Slopes range from 0 to 2 percent.
Munden loamy fine sand	Depth Class: Very deep Class: Moderately well drained Permeability: Moderate to moderately rapid in the A and B horizon and moderately rapid in the C horizons Surface Runoff: Slow Parent Material: Loamy and sandy marine and fluvial sediments Slope: 0 to 8 percent
Nimmo fine sandy loam	Depth Class: Very deep Drainage Class: Poorly drained Permeability: Moderate in the A and B horizons and moderately rapid to rapid in the C horizons Surface Runoff: Slow Parent Material: Loamy and sandy marine and fluvial sediments Slope: 0 to 2 percent
Munden fine sandy loam	Depth Class: Very deep Class: Moderately well drained Permeability: Moderate to moderately rapid in the A and B horizon and moderately rapid in the C horizons Surface Runoff: Slow Parent Material: Loamy and sandy marine and fluvial sediments. Slope: 0 to 8 percent

Soil Type	Soil Characteristics
Augusta fine sandy loam	Depth Class: Very deep Drainage Class: Somewhat poorly drained Permeability: Moderate Surface Runoff: Slow Parent Material: Loamy alluvial sediments Slope: 0 to 2 percent
Seabrook loamy fine sand	Depth Class: Very deep Drainage Class: Moderately well drained Permeability: Rapid Surface Runoff: Slow Parent Material: Sandy marine and fluvial sediments Slope: 0 to 2 percent
Nawney silt loam	Depth Class: Very Deep Drainage Class: Poorly drained Permeability: Moderate Surface Runoff: Slow Parent Material: Formed in loamy marine and fluvial sediments Slope: 0 to 2 percent
State fine sandy loam	Depth Class: Very deep Drainage Class (Agricultural): Well drained Internal Free Water Occurrence: Deep, persistent, thick Flooding Frequency and Duration: Occasional, rare, very rare, or none for very brief or brief periods, December to June Ponding Frequency and Duration: None Index Surface Runoff: Negligible to medium Permeability: Moderate (Saturated Hydraulic Conductivity: Moderately high) Shrink-swell Potential: Low Landscape: Piedmont and coastal river valleys Landform: Stream terraces Geomorphic Component: Riser, treads Hillslope Profile Position: Summit, shoulder Parent Material: Alluvium Slope: 0 to 10 percent
Tomotley fine sandy loam	Depth Class: Very Deep Drainage Class: Poorly drained Permeability: Moderate to moderately slow Surface Runoff: Slow Parent Material: Formed in loamy marine and fluvial sediments Slope: 0 to 2 percent
Udorthents-Dumps complex	Udorthents are deep or very deep, well drained or somewhat excessively drained, nearly level to very steep, loamy and clayey soils. These soils are mainly on summits and side slopes in the uplands. They mostly consist of overburden and waste rock that have been stockpiled during quarrying.
Urban land	Typically 85 percent, ranging from about 10 to 95 percent. Consists of areas such as roads, commercial buildings, industries, schools, churches, parking lots, streets, and shopping centers. Not prime farmland and not hydric.

Soil Type	Soil Characteristics
Augusta loam	Depth Class: Very deep Drainage Class: Somewhat poorly drained Permeability: Moderate Surface Runoff: Slow Parent Material: Loamy alluvial sediments Slope: 0 to 2 percent
Psamments	Depth Class: Drainage Class: Well drained Permeability: High Surface Runoff: Parent Material: Consists basically of unconsolidated sand deposits, often found in shifting sand dunes. Slope: 0 to 10 percent
Psamments-Urban land complex	Depth Class: Drainage Class: Moderately Well drained Permeability: Moderate Surface Runoff: Parent Material: Consists basically of unconsolidated sand deposits, often found in shifting sand dunes. Slope: 2 to 5 percent
Tetotum loam	Depth Class: Very deep Drainage Class: Moderately well drained Permeability: Moderate in the B horizon and moderate to rapid in the C horizons Surface Runoff: Slow on nearly level areas and medium to rapid on steeper areas Parent Material: Moderately fine textured fluvial or marine sediments underlain by stratified coarse to medium textured sediments Slope: 0 to 15 percent
Tomotley loam	Depth Class: Very Deep Drainage Class: Poorly drained Permeability: Moderate to moderately slow Surface Runoff: Slow Parent Material: Formed in loamy marine and fluvial sediments Slope: 0 to 2 percent
Beaches	Comprises very shallow and shallow, well drained, moderately permeable soils that formed in residuum from hard, very fine grained, metamorphic sandstone. These sloping to steep soils are on sandstone hills and in valleys. Slopes range from 1 to about 70 percent.
Udorthents , loamy	Depth Class: vary greatly with depth Drainage Class: Well drained Permeability: Moderate to slow Surface Runoff: Low Parent Material: Consists of nearly level and gently sloping areas where the original soils have been cut away or covered with a loamy fill material. Slope: 0 to 6 percent

Soil Type	Soil Characteristics
Udorthents-Urban land complex	Depth Class: Drainage Class: Somewhat poorly drained Permeability: Moderate Surface Runoff: Low Parent Material: Consists primarily of moderately coarse textured soil material and a few small areas of medium textured material Slope: 2 to 15 percent
Bohicket muck	Consists of very poorly drained, very slowly permeable soils that formed in marine sediments in tidal marshes. These soils are flooded twice daily by sea water. Slopes are less than 2 percent. Bohicket silty clay loam--saltwater marsh wildlife habitat. (Colors are for moist soil.)
Bojac sandy loam	Depth Class: Very deep Drainage Class: Well drained Permeability: Moderately rapid Surface Runoff: Slow to medium Parent Material: Loamy and sandy fluvial and marine sediments Slope: 0 to 10 percent
Bojac fine sandy loam	Depth Class: Very deep Drainage Class: Well drained Permeability: Moderately rapid Surface Runoff: Slow to medium Parent Material: Loamy and sandy fluvial and marine sediments Slope: 0 to 10 percent
Chapanoke-urban land complex	Depth Class: Very deep Drainage Class: Somewhat poorly drained Permeability: Moderately slow Surface Runoff: slow Parent Material: loamy marine sediments Slope: 0 to 3 percent

Source: USDA 2017.

Norfolk contains twenty-seven soils (Figure 10-6) (USDA, 2017). All twenty-seven soils are found in numerous locations throughout the study area which are located in residential neighborhoods, recreational areas, and industrial areas. The Study Area is mostly made up of Udorthents-Dumps complex at 19.56%, Altavista fine sandy loam at 18.83%, Urban Land at 18.61%, Tomotly fine sandy loam at 11.17%, Augusta fine sandy loam at 9.98%, Munden loamy fine sand at 9.56%, State fine sandy loam at 8.56%, Nimmo fine sandy loam at 8.09%, Augusta loam at 7.04%, Bojac fine sandy loam at 5.00%, Nawney silt loam at 4.89%, Tomotley loam at 3.99%, Lawnes loam at 3.03%, Bohicket muck at 2.50%, Tetotum loam at 1.79%, Duckston fine sand at 1.52%, Munden fine sandy loam at 1.47%, Beaches at 1.36%, Psamments-Urban land complex at 1.34%, and Chapanoke-Urban land complex at 1.22%. Dragston fine sandy loam, Johnston silt loam, Dragston fine sandy loam, Seabrook loamy fine sand, Psamments, Beaches, Udorthents loamy, Udorthents-Urban land complex, Urban land, Udorthents-Urban land complex, Urban land, and Bojac sandy loam make up less than 1.00% within the Study Area.

Elizabeth River and Lafayette River

The sediments that comprise the Elizabeth River and the Lafayette River consist mostly of clays

and silts. Sand can be present, typically mixed with finer sediments, in local areas, typically near river bends or confluences with tributaries and, historically, often formed the base layer of oyster reefs, as oysters favored such firmer sediments and hydro-dynamically complex areas for settlement and growth.

Willoughby Spit and Ocean View Beach

Willoughby Spit and Ocean View beach consists primarily of sandy material, which originated from the site and has been placed there during beach re-nourishment projects or deposited by wave action. The mean diameter for all sediment found in the project area is 0.13 phi (0.9 millimeters). Broken shell hash make up 50% of the largest particles and approximately 10% to 15% of the beach consists of clays and finer size material. In May and September 1988, sediment samples were taken along the survey lines, at the top of the berm, high-tide mark, mid-tide mark, low-tide mark, -3.0, -6.0, -12.0, -15.0 (NGVD) and at the crest of the submarine bar. The mean sediment size for the study area was found to be 0.5 millimeters. In June 1994, VIMS collected 53 samples along the entire beach profile at six locations along the western portion of project site. Mean grain sizes ranged from 0.5 to 2.2 (phi) with an average of approximately 1 (phi) or 0.5 millimeters. Moffatt and Nichol (2004) analyzed samples from the Ocean View area and reports a median grain size at mid-dune of 0.31 millimeters, mid-beach 0.39 millimeters and between high and low water of .45 millimeters. For the purposes of sand compatibility and overfill calculations, the mean sand grain size of the existing beach would be conservatively set at 0.5 millimeters.

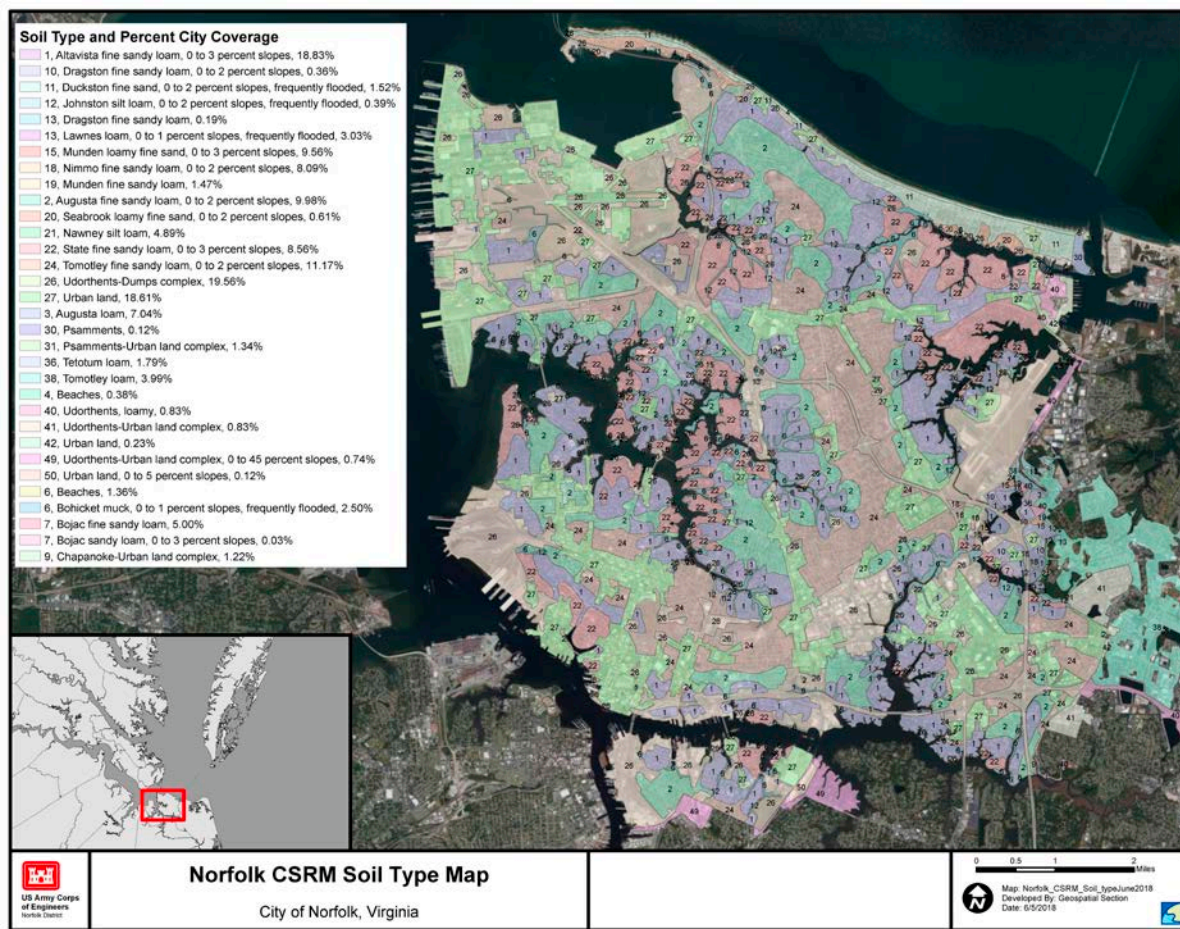


Figure 10-6. Soils Map of Norfolk, Virginia

Source: (USACE 2017)

10.3 COASTAL HYDRAULICS

10.3.1 Definition of Resource

Hydrology is the science that deals with the properties, circulation and distribution of water on and under the surface of the earth and in the atmosphere from the moment of precipitation until it returns to the atmosphere through evapotranspiration or is discharged into the ocean.

Hydraulics is the science that deals with practical applications of runoff flowing through a channel. Collectively, hydrology and hydraulics are referred to as “H&H.” Fluvial geomorphology is the study of river forms and the processes that shape them, and involves consideration of the geological setting, channel morphology, hydrology, hydraulics, sediment transport, and riparian and floodplain vegetation. Bathymetry, which is the configuration of the waterway bottom, influences H&H and where applicable, it will be discussed.

This H&H section provides a summary of the key findings of this draft Integrated Feasibility Report (IFR), but for full details please see APPENDIX B. This affected environment section analyzes the existing and potential future H&H and fluvial geomorphology conditions associated with the waters surrounding and within the City of Norfolk (all are included in the ROI), focusing on the Standard Project Flood (SPF) event and the mid-range sea level rise scenario. All areas

proposed for project construction are tidal with the exception of Lake Whitehurst, a freshwater reservoir. Mean tidal range of local waters is 2.43 feet.

10.3.2 Methodology

The following H&H analysis describes existing conditions within the Study Area, outlines the approach to analysis, and evaluates potential impacts and mitigation measures related to implementation of the Proposed Action. The ROI for H&H includes the city of Norfolk, estuarine waters including Willoughby Bay and Ocean View, tidal tributaries including Pretty Lake, much of the Elizabeth River, including the Lafayette River, a tributary of the Elizabeth, The Hague, and Broad Creek, and Lake Whitehurst within the Study Area. The extent of the regional H&H models extend beyond the Study Area sufficiently both upstream and downstream to characterize any potential impacts due to actions within the Study Area. Primarily, the ROI for H&H as presented in this analysis extends throughout the Elizabeth River system, Willoughby Bay, nearshore waters off of Ocean View, Pretty Lake, and Lake Whitehurst. There are not specific regulations regarding H&H, though these will impact water quality, which does have significant regulations on the state and federal level. These are described in the Regulatory Framework in the following section on water quality.

10.3.3 Existing Conditions

Area 1

Willoughby Spit and Ocean View

The Willoughby Spit-Ocean View area is open to wave attack from the north clockwise to the east. As storm waves approach the shoreline, their characteristics are altered by bottom friction, change in water depth, and local meteorological conditions such as wind or rain. Water depths in Willoughby Bay are fairly uniform, with the majority of the Bay ranging from 9-11 feet deep. Shallower water can be found close to shore, especially along the inside (south side) of Willoughby Spit. Nearshore waters along Ocean View and the north side of Willoughby Spit are in general shallower further offshore, ranging from the low intertidal to 4 feet deep approximately 60-160 feet offshore. Normally the waves are moderate in height because the average velocity of the winds is only about 13 miles per hour; however, during storms northerly to easterly winds with large fetches produce waves which impinge heavily on the shores, especially the Chesapeake Bay side shore. The Chesapeake Bay is a very complicated area for estimating wave data because of characteristics such as refraction, shoaling, currents, and non-uniform topography. The study area is no exception and any gauge or historical observations are considered critical to the formulation of plans. In this regard, three years of wave data are available in "Wave Climate at Selected Locations along U.S. Coasts" (CERC TR 77-1). Although the fetch distribution is somewhat different because the gauge was not specifically located in the study area, it is representative of the wave distribution that can be experienced at Willoughby Spit-Ocean View. Historically, the study area was among the hardest hit sections of the city during coastal storms. Wave heights on the order of 7 to 10 feet can occur during major storm events, causing extensive damage and flooding.

Tides in the Chesapeake Bay at Willoughby Spit-Ocean View are uniformly semi-diurnal with the principal variations following the changes in the moon's distance and phase. The mean range of tide is 2.6 feet and the spring range is 3.1 feet. The Sewells Point mean range of tide

is 2.43 feet and the diurnal range is 2.76 feet. Maximum tidal currents average about 1.0 knot flood and 0.8 knots ebb at 0.7 nautical miles north of Willoughby Spit. Variations in water surface elevations of more than 9 feet have resulted from storms and studies indicate that tides in excess of 10 feet above normal are possible. Littoral transport is the movement of sedimentary material (littoral drift) caused by waves and currents in the littoral zone. As wave trains approach a shore at an angle, they generate a current which moves sediment that has been placed in suspension by wave action along the shore. This shore-parallel movement of sediment is called "longshore transport". The direction of longshore transport is mostly dependent on the angle of wave approach with shoreline orientation and nearshore bottom geometry affecting it to a lesser degree. The Willoughby Spit area has a definite east to west net longshore transport as is evidenced by the buildup of sand on the east side of the numerous groins along the study area and a large accumulation of sand at the western tip of Willoughby Spit. Transport of material perpendicular to a shoreline (onshore-offshore transport) is also influenced by the above factors. A three-dimensional hydrodynamic-sedimentation model, HYSED-3D (Boon et al. 1999), was developed in the late 1990s by the Virginia Institute of Marine Science (VIMS). This model was developed to model tides, currents, circulation, salinity, and sedimentation within Hampton Roads and nearby tributaries. Simulations produced by the model were verified by VIMS through field observations of tides and currents. Given that no significant changes have occurred along the Hampton Roads shoreline since the model results were published, the existing conditions provided in the model are assumed to remain valid and are discussed as follows. Hampton Roads' tide ranges from approximately -1.5 feet to 1.5 feet above mean water level. Simulated currents south of the northern entrance/exit to the I-64 tunnel were - 2 to 2 ft/s near the surface and - 0.6 to 0.6 ft/s near the bottom. There are two eddies, or current loops, within the Hampton Roads area. A clockwise surface eddy appears at the entrance of the Elizabeth River near the northeast corner of Craney Island. The eddy only exists during apogean-neap tides (during the smallest tidal range). A large counter-clockwise eddy appears in non-tidal surface currents at the southwest end of Hampton Flats, which is located in Hampton Roads at the mouth of the Hampton River. According to the VIMS model, salinity ranges from 23 to 30 parts per thousand (ppt) during low river inflow, from 13 to 23 ppt during mean river flow, and from 6 to 22 ppt during high river inflow. An average salinity of 14 to 22 ppt during apogean-neap tides and perigeon spring tides exists near I-64. Sedimentation patterns in the James River show that coarser sandy bottom sediments occur in the channel and northern flank near Hampton Flats and finer muddy bottom sediments occur in the southern flank near Craney Island. Areas of high sedimentation potential are located along the south shore of Hampton Roads, with relatively little along the north shore.

Pretty Lake

Pretty Lake is an estuarine creek, a branch of Little Creek, located in northwest Norfolk. Little Creek flows directly into lower Chesapeake Bay. Along the shoreline and its tidal arms, waters average 3-4 feet deep. The main body of Pretty Lake ranges up to 6 feet deep in the main channel. While deeper channel areas consist of more mud, clays and fine silts, the majority of the bottom consists of fine-grained silty sand. The mean tidal range is 2.6 feet. Tidal currents in Little Creek average 0.9 knots. Salinity typically ranges in the low to mid 20s PSU, and DO typically meets the standard for aquatic faunal health, 5.0 mg/l. There has not been any significant hydrodynamic modeling in Pretty Lake to date. However, due to the shallowness of

the waters, it is likely that the tides control flushing in Pretty Lake, not density driven gravitational circulation as it is unlikely that waters are deep enough to allow for density stratification, where higher salinity deeper waters from the Bay would lie below less saline surface waters. Due to the tidal restriction, with Pretty Lake having a small opening to Little Creek, which in turn has a restricted opening to lower Chesapeake Bay, flushing rates are likely to be low and retention times in the order of days over a week.

Lake Whitehurst

Lake Whitehurst is a freshwater reservoir with simple wind-driven hydrodynamics and is not tidal or influenced by any Chesapeake Bay processes. It was once part of the Little Creek estuarine waterway, but was dammed off of it, along with Little Creek Reservoir, Lake Lawson, and Lake Smith in the 1920s in order to provide additional water sources for the city of Norfolk.

Area 2: Lafayette River

The Lafayette River is a tributary of the Elizabeth River, as such water conditions are similar, with salinity typically ranging from 16-18 PSU. It has a main channel, much of which is natural and unmodified, indicating a low sediment deposition rate is occurring in this river. It has a significant watershed, mostly urban, meaning much of the freshwater input is in the form of urban runoff and highly dependent on precipitation. Hydrodynamically, it is a retentive system, with a low flushing rate. It has been modeled hydrodynamically (Sisson and Shen 2012, Shen et al. 2017), a HEM-3D model (a 3D hydrodynamic model, with the hydrodynamic portion being the Environmental Fluid Dynamics Code (EFDC)) with a lateral resolution of 50-100m. This model indicated there is a circular gyre near the mouth of the Lafayette River that is largely responsible for its reputation as a retentive system, known for high oyster larval settlement compared to many other waterbodies in the region. Used to model oyster larval behavior, it predicted the majority of the larvae would be retained in the Lafayette River until they settled, confirming the Lafayette is a retentive system.

Area 3: West Ghent, Hague, Ft. Norfolk, Downtown, Freemason

The main waterbody of interest is the Hague, an urban creek in downtown Norfolk that flows into the Elizabeth River. The Hague is a heavily modified estuarine creek, its original waterway now mostly filled. It covers 18.83 acres in size. Near the Brambleton street bridge, water depths are 15 feet deep, quickly becoming shallower (~ 10 feet deep), and the majority of the Hague ranges from 8 to 10 feet deep. Near the retaining walls, it becomes shallower, typical depths at the toe of the wall are 4 to 6 feet deep. Its confluence with the Eastern Branch is approximately 300 feet in length. The specific hydrodynamics of the Hague are relatively unknown, though limited modeling on the tidal exchange rate within the Hague (Fugro, 2012) has been done.

Area 4: Elizabeth River Eastern Branch (Newton's Creek/Tidewater Dr., Broad Creek, Berkley, and Campostella)

The Eastern Branch of the Elizabeth River is approximately 9.0 miles long, with its headwaters in Virginia Beach, flowing west through Norfolk and joining with the main stem of the Elizabeth River there. It has a navigation channel that covers the bulk of the main channel, and is maintained at approximately 30-35 feet in depth near the mouth where it joins the Southern Branch, shallowing rapidly to 20 feet or less above the Campostella Bridge. Outside the channel, waters are much shallower, typically less than 10 feet deep. General circulation in the

Eastern Branch is linear, no significant gyres are present. As this branch of the river is mostly straight, this is an expected condition. The hydrodynamics of Broad Creek are unknown, a modeling effort is underway to examine this.

10.4 WATER QUALITY

10.4.1 Definition of Resource

Water Quality can be defined as the ability of the water to support life, as well as human activities such as recreation. Water quality describes the chemical and physical composition of water as affected by natural conditions and human activities. Impacts on water resources can also influence other issues such as land use, biological resources, socioeconomics, public safety, and environmental justice.

10.4.2 Methodology

The following analysis of water resources identifies associated regulatory requirements, describes existing conditions within the ROI and vicinity, outlines the approach to analysis, and evaluates potential impacts and mitigation measures related to implementation of the Proposed Action. The ROI for water resources is the subwatersheds in the Study Area (Figure 1-2), which encompasses the city of Norfolk and its surrounding waters to include the Elizabeth River and its tributaries, Willoughby Bay, Chesapeake Bay waters along Ocean View and Willoughby Spit, Pretty Lake, and the freshwater reservoir of Lake Whitehurst. A number of water quality and hydrodynamic models were used to assess potential impacts to water quality in various areas of the ROI where project features are considered. For details on these models, including the type, duration run, and other factors considered, please see the Environmental Appendix as only the results of the models will be discussed in this section of the EIS.

10.4.3 Framework

This water quality analysis has been prepared considering the following federal and state regulations:

Federal

Clean Water Act

The Clean Water Act (CWA) of 1972, as amended (33 USC §§ 1251 et seq.), is the primary federal law that protects the nation's waters, including lakes, rivers, and coastal areas. The CWA prohibits all unpermitted discharge of any pollutant into any jurisdictional waters of the U.S. The U.S. Environmental Protection Agency (USEPA) is responsible for administering the water quality requirements of the CWA. Section 303(d) of the CWA requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. States must develop a total maximum daily load (TMDL) for each pollutant that contributes to the impairment of a listed water body. The Virginia Department of Environmental Quality (VDEQ) is responsible for ensuring that TMDLs are developed for impaired surface waters in Virginia. In addition to the discharge restrictions, the CWA Section 404 requires a USACE issued permit for the dredging and/or filling of jurisdictional waters of the U.S. Areas meeting the "waters of the U.S." definition are under the jurisdiction of the USACE. Anyone proposing to conduct a project that requires a federal permit or involves dredge or fill activities that may result in a discharge to U.S. surface waters and/or waters of the U.S. is required to obtain a CWA Section 401 Water

Quality Certification from the VDEQ, verifying that project activities will comply with water quality standards. Two standards of importance for Chesapeake Bay are total nitrogen (N) and total phosphorus (P), which are 3.0 mg/l and 0.3 mg/l, respectively. Chlorophyll A (ChlA) for high water quality should be no more than 15 ug/l, and dissolved oxygen (DO) should exceed 5 mg/l for surface waters and 1 mg/l for deep channel waters. Total suspended sediments should not exceed 15 mg/l for SAV (seagrass) growth and survival. For bacteria, the upper limit for swimming is 104 cfu/100 ml.

Rivers and Harbors Act

Section 10 of the **Rivers and Harbors Act of 1899** (as amended; 33 USC § 403) regulates structures or work that would affect navigable waters of the U.S. Structures include any tidal gate, storm surge wall, pump intakes or outlets that might be built as a result of recommendations of this study as well as piers, wharfs, bulkheads, etc. Work includes dredging, filling, excavation, or other modifications to navigable waters of the U.S. The USACE issues permits for work or structures in navigable waters of the U.S.

State

The State Water Control Law mandates the protection of existing high-quality state waters and provides for the restoration of all other state waters so they will permit reasonable public uses and will support the growth of aquatic life. The adoption of water quality standards under Section 62.1-44.15(3a) of the law is one of the State Water Control Board's methods of accomplishing the law's purpose. Water quality standards consist of statements that describe water quality requirements. They also contain numeric limits for specific physical, chemical, biological or radiological characteristics of water. These statements and numeric limits describe water quality necessary to meet and maintain uses such as swimming and other water-based recreation, public water supply, and the propagation and growth of aquatic life. Virginia manages water quality of its streams, lakes, reservoirs and tidal waters through a continuing planning process modeled after Section 303 of the Clean Water Act. An annual Virginia Water Quality Assessment 305(b)/303(d) Integrated Report summarizes findings and makes recommendations for a list of impaired waters by DEQ. Every two years, a List of Impaired Waters is developed to describe segments of streams, lakes, and estuaries within the state that exhibit violations of water quality standards. In order to maintain the water quality standard, VDEQ creates TMDLs (Total Maximum Daily Loads) on a tributary level that indicate the total pollutants that a water body can assimilate and still meet water quality standards.

The determination whether the Commonwealth's waters support their applicable designated uses as mandated by Section 305(b) of the Clean Water Act is made by DEQ and reported annually to EPA based on monitoring data. Virginia's water quality standards define the water quality needed to support each of these uses by establishing the numeric criteria for comparison of physical and chemical data. If a waterbody contains more of a pollutant than is allowed by the water quality standards, it will not support one or more of its designated uses. Such waters are considered to have an "impaired" quality. An "impairment" refers to an individual parameter or characteristic that violates a water quality standard. A water fails to support a designated use when it has one or more impairments. Water quality standards designate uses for waters. There are six designated uses for surface waters in Virginia: aquatic life, fish consumption, public water supplies (reservoirs only), recreation (swimming), shellfish harvest, and wildlife use.

Additionally, several subcategories of aquatic life use have been adopted for the Chesapeake Bay and its tidal tributaries. The standards define the water quality needed to support each of these uses. If a water body contains more contamination than allowed by water quality standards, it will not support one or more of its designated uses. Such waters have "impaired" water quality. In most cases, a cleanup plan (called a "total maximum daily load") must be developed and implemented to restore impaired waters. In Virginia, the most common cause of impaired waters is due to bacterial contamination, followed by contaminated sediments, low DO (dissolved oxygen), and PCBs (polychlorinated biphenols, once commonly used in industry but proven to be highly toxic and long-lived once accidentally released into the environment).

10.4.4 Existing Conditions

Area 1

Willoughby Spit and Ocean View Beach

The state waters immediately seaward of Willoughby Spit and Ocean View extending offshore towards the 3-mile limit of the borrow site are considered Class I Special Standard Open Ocean waters (9 VAC 25-260-520). This classification pertains to waters generally used for public or municipal water supplies, primary contact recreations, fishing, or other beneficial uses (MMS, 1997). Under this classification, the requirements for minimum dissolved oxygen are 5.0 mg/l, pH range of 6.0 to 9.0, and any rise above natural temperature shall not exceed 3 degrees Celsius. The special standard sets fecal coliform standards for shellfishing waters (9 VAC 25-260-310). Waters off Ocean View are considered healthy by VDEQ (2014) being one of the few such waters in Chesapeake Bay. However, the beach area of Willoughby Bay, which includes the intertidal and nearshore waters and covers 0.14 square miles, exceeds acceptable limits for bacteria. Waters of Willoughby Bay, covering 2.48 square miles, also have a fish consumption advisory due to PCB in fish tissue.

Pretty Lake

Pretty Lake is the western branch of Little Creek, which is an estuarine sub-embayment of the southern shore of the Chesapeake Bay mainstem with limited freshwater input and a restricted opening into Chesapeake Bay. The salinity typically ranges from 18-21 PSU. According to VADEQ (2012) these waters are not impaired for aquatic life and no impairment of the 30-day DO standard throughout the year for open water aquatic life has been noted, indicating water quality for marine life is generally good. However, shellfish harvest and consumption is prohibited due to bacterial contamination. Commercial fishing is also prohibited, although sport fishing is not and is a common activity in Little Creek harbor with limited fishing in Pretty Lake, due to more limited boat access and shallower waters. However, there is a fish consumption advisory for the Little Creek region, due to dioxin contamination but this is limited to two-eight ounce meals/month for gizzard shad, spot or croaker only.

Lake Whitehurst

Lake Whitehurst is a freshwater reservoir for drinking water for the city of Norfolk and surrounding communities. It is 0.654 square miles in size and its watershed is approximately 4.5 square miles. This lake has a fish consumption advisory due to elevated levels of mercury and PCBs and recommends that no more than two eight-ounce meals/month of carp or gizzard shad should be eaten. It is also listed as impaired due to high levels of ChlA, indicating there

are likely high levels of N and P (which is listed as an impairment for the Lake) in the lake, as these nutrients increase ChlA levels by encouraging phytoplankton blooms. It also is impaired due to low levels of DO, with approximately 10% of monitoring results showing low DO levels (> 4 mg/l).

Area 2: Lafayette River

Due to its long history of military operations, industrial pollution, and urbanization, the Elizabeth River, which the Lafayette River is a tributary and part of, is considered one of the most impacted regions in the Chesapeake Bay watershed in terms of water quality and bottom sediment composition. It is on EPA's list of impaired waters. The Lafayette River is a small sub-estuary of the Elizabeth River, ranging in depth from 1 to 23 feet, with a volume of 0.228 cubic miles, a surface area (not counting smaller tributary creeks) of 2.386 square miles, and a watershed of approximately 20.997 square miles, encompassing most of the city of Norfolk. Salinities within the project area range between 15 and 26 PSU) depending on water depth, tidal phase and time of year (USACE-ND, 2005a). In the uppermost reaches of the river, salinity decreases below 15 PSU, declining with distance upstream until salinity approaches zero PSU. The Lafayette River is one of the healthiest areas in the Elizabeth River system, having almost no instances (less than five percent) where DO was less than four milligrams/liter. There is currently a fish consumption advisory not only for the Lafayette but also for the Elizabeth River waters, due to dioxin contamination. Although water quality can be described as, generally fair to poor, overall trends are improving due to a variety of clean-up efforts at several of the most contaminated sites, along with restoration of wetlands and oyster reefs. Many contaminants are declining as clean up progresses, and while bacteria levels and nitrogen are also declining, phosphorus has been noted to be on the increase recently.

Area 3: West Ghent, Hague, Ft. Norfolk, Downtown, Freemason

The waterbody of concern in Area 3 is The Hague, formally known as Smith Creek, an estuarine tidal creek that was mostly filled during the urbanization of the City. The Hague comprises 0.029 square miles of open water and is the region near the former creek mouth and confluence with the Eastern Branch of the Elizabeth River. It mainly serves to drain stormwater from the 894 acres of land in its watershed, and has 40 stormwater outfalls leading into it. Moffat and Nichol conducted an extensive study on The Hague (2014) for the City to assess it and recommend potential improvements. Table 10-2 is the water quality data from the report:

Table 10-2. Water Quality Data

Parameter	Range Sampled within the Hague	Range Sampled Between NOAA and PETA	Range from CBP Elizabeth River Station ELE01
Temperature (°F)	50 – 81	50 – 80	41 – 79
Salinity (ppt)	4.3 – 22.1	14.9 – 22.0	14.3 – 22.5
Dissolved Oxygen (mg/L)	2.5 – 12.5	3.8 – 10.5	3.7 – 10.6
Dissolved Oxygen Saturation ¹ (%)	36 – 125	54 – 110	77 – 102
pH	6.3 – 8.2	7.5 – 8.1	7.4 – 8.0
Total Nitrogen (mg/L)	0.7 – 6.9	0.9 – 3.5	0.44 – 0.94
Total Phosphorus (mg/L)	0.03 – 0.14	0.04 – 0.10	0.04 – 0.13
Total Organic Carbon (mg/L)	BQL – 31.6	4.7 – 18.9	5.11
Suspended Sediments (mg/L)	2.9 – 26.2	3.4 – 15.5	9.5 – 36.0
Bacterial pathogen indicators (CFU/100 mL) ²	1 – 4200	2 – 1000	25 – 125

Source: (Moffatt and Nichol 2014)

From the report, it can be seen that the Hague has widely swinging salinity fluctuations, almost certainly due to its role in draining the stormwater from its urban watershed during rain events, which provide for a massive and rapid volume of freshwater input during a storm event. Bacterial levels are quite high compared to the Eastern Branch of the River, again, likely due to the urban stormwater from its watershed and such levels prohibit most recreational activities in the water, such as swimming. As can be seen from the water quality data, the Hague at times exceeds the limit for total nitrogen, which is 3.0 mg/l. Bacterial limits for recreation use also exceed the upper limit for recreational use of 104 cfu/100 ml (Moffat and Nichol, 2014).

Area 4: Elizabeth River Eastern Branch (Newton's Creek/Tidewater Dr., Broad Creek, Berkley, and Campostella

This area includes the Eastern Branch of the Elizabeth River, as both Ohio and Broad Creeks are tributary to it. These waterbodies are all tidal and estuarine in nature. The salinity regime here is similar to that in the Lafayette River. The lower Eastern Branch (not counting the low salinity upper reaches) has a surface area of approximately 1.419 square miles, and Broad Creek, a major tributary creek being considered for a tidal/storm surge gate, has a surface area of approximately 2.64 square miles. The watershed for the Eastern Branch and its tributaries is 47.05 square miles. There is currently a TMDL for these areas as bacterial limits exceed acceptable levels, especially in Broad Creek, which has a mean CFU/100 ml of 544, while the Eastern Branch Mainstem has a mean count of 96 CFU/100 ml ranging up to 1800 CFU/100 ml, well in exceedance of acceptable limits for shellfish harvest or swimming. In addition to this, waters in the Eastern Branch and Broad Creek are considered impaired for aquatic life. The Eastern Branch of the Elizabeth River has one of the highest DO violations for aquatic life in Virginia waters, with a summertime exceedance rate of 43.2%. There is also a fish consumption advisory based on levels of contaminants in their tissues, mainly dioxin.

10.5 FLOODPLAINS

10.5.1 Definition of Resource

For the purpose of the following discussion, floodplains is defined as any land area susceptible to being inundated by floodwaters from any source.

10.5.2 Methodology

The ROI is all floodplain areas within the City where flooding has occurred in the past or there is a potential for flooding, including tidal and/or rainfall events.

10.5.3 Framework

Executive Order 11988 – Floodplain Management. Through Executive Order (EO) 11988, Federal agencies are required to evaluate all proposed actions within the 1% annual chance (100-year) floodplain. Actions include any Federal activity involving 1) acquiring, managing, and disposing of Federal land and facilities, 2) providing Federally undertaken, financed, or assisted construction and improvements, and 3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, and licensing activities. In addition, the 0.2% annual chance (500-year) floodplain should be evaluated for critical actions or facilities, such as storage of hazardous materials or construction of a hospital. The EO provides an eight-step process to evaluate activities in the floodplain that generally includes 1) determine if the proposed action is in the floodplain, 2) provide public review, 3) identify and evaluate practicable alternatives to locating in the 1% annual chance floodplain, 4) identify the impacts of the proposed action, 5) minimize threats to life and property and to natural and beneficial floodplain values and restore and preserve natural and beneficial floodplain values, 6) reevaluate alternatives, 7) issue findings and a public explanation, and 8) implement the action. Proposed actions may have limited impacts such that the eight-step process may vary or be reduced in application, which is the case for this project.

USACE Engineering Regulation 1165-2-26 – Implementation of Executive Order 11988 on Floodplain Management. This regulation sets forth general policy and guidance for USACE implementation of Executive Order 11988 as it pertains to the planning, design, and construction of Civil Works projects and activities under the Operation and Maintenance and Real Estate Programs.

Section 202 (c) of Water Resources Development Act of 1996. Section 202(c) provides that before the construction of any project for local flood damage reduction or hurricane or storm damage reduction that involves assistance from the Secretary of the Army, the non-Federal interest must agree to participate in and comply with applicable Federal floodplain management and flood insurance programs. It also requires non-Federal interests to prepare a Floodplain Management Plan designed to reduce the impacts of future flood events in the project area within one year of signing a Project Cooperation Agreement and to implement the Plan not later than one year after completion of construction of the project.

More specifically, Section 202 (c) requires that the non-Federal interest shall prepare a Plan designed to reduce the impacts of future flooding in the project area. It should be based on post-project floodplain conditions. The primary focus of the Plan should be to address potential

measures, practices and policies which will reduce the impacts of future residual flooding, help preserve levels of protection provided by the USACE project and preserve and enhance natural floodplain values. In addition, the Plan should address the risk of future flood damages to structures within the post-project floodplain and internal drainage issues related to USACE levee/floodwall projects. Since actions within the floodplain upstream and downstream from the project area can affect the performance of a USACE project, the Plan developed by the non-Federal sponsor should not be limited to addressing measures solely within the immediate project boundaries.

10.5.4 Existing Conditions

As with any coastal community, Norfolk has its challenges with flooding. By having exposed waterfront areas, flat topography, land areas with low elevations, and being a populated and urbanized city, the concerns and issues are continuous and becoming more frequent. Most of the City's land area is developed at 95%, such that new development will be infill or redevelopment.

Along some land areas that are low in elevation, the City experiences nuisance type or minor flooding during a normal astronomical high tide, even on a sunny day when there is no storm or heavy rainfall. Water levels can be higher when the tide is highest during a Spring tide cycle. The NACCS identifies where local sea level rise and land subsidence have caused an increase in nuisance type flooding and will only get worse over time. While the flooding may not be life threatening, it can disrupt transportation, damage infrastructure, and impact a community's maintenance budget. A nuisance flood can become more severe if a tidal storm and/or rainfall event coincides with high tide.

Severe or major flooding usually occurs during tidal storm events and/or from heavy rainfall, usually associated with tropical systems, nor'easters, or just a heavy rainfall weather event. Flooding can be short term in duration or long term duration. For tropical events, peak tidal flooding will typically last during one astronomical tide cycle. When tropical events reach the mid-Atlantic latitude, they start to move faster in forward speed. On the other hand, nor'easters are usually slow moving and large in size, produce large amounts of rainfall, and high water levels caused by storm surge can stay elevated above normal astronomical tide cycles for long periods of time. These types of storms can cause inland flooding from rainfall and significant beach and shoreline erosion from persistent wave action and onshore winds. For any coastal community with flat topography, low land elevations, and developed areas, flooding can be significantly worse when there is combined tidal and rainfall flooding, especially with respect to storm water drainage systems. Aside from tropical storms and nor'easters, rainfall events by themselves can cause flooding. With sudden and brief heavy downpours, drainage systems that are not designed to discharge the large amount of rainfall runoff can easily be overwhelmed. With the amount of impervious surface area, urban areas are most prone to flash flooding. Steady rainfall that occurs over a multi-day/week period or from back-to-back weather events can cause the ground to become over saturated and unable to absorb water, thus increasing the amount of rainfall runoff that may enter the drainage system and cause flooding.

The National Weather Service began official weather records for the City in 1871. The Sewells Point tide gage went into service in 1927. Since 1927, historical high water tidal flood events for

the City have mainly been from tropical storms, weak Category 1 hurricanes, or nor'easters; the City has not experienced a major hurricane on official record. At the Sewells Point gauge, before Hurricane Isabel in 2003, the 1933 August Hurricane and 1962 Ash Wednesday Nor'easter were the highest tidal flood events on record, 6.4 and 5.6 feet (stillwater), respectively, referenced to the North American Vertical Datum of 1988 (NAVD88). While the 1933 Hurricane is still the flood of record at Sewells Point, Hurricane Isabel produced a near equal storm tide at 6.3 feet, NAVD88. Note, considering sea level rise, if the 1933 Hurricane would have occurred today, the maximum water level would be about a foot higher. Other more recent notable tidal events and their maximum stillwater levels, from highest to lowest, recorded at Sewells Point include Nor'Ida in November 2009 at 6.1 feet, Hurricane Irene in August 2011 at 5.9 feet, Hurricane Sandy in October 2012 at 5.2 feet, and a nor'easter in November 2006 at 5.2 feet, all referenced to NAVD88. Similarly, for all the events mentioned above, the following also had rainfall amounts at approximately 10 inches: Nor'Ida, Hurricane Irene, and Hurricane Sandy. The last major coastal event was in October 2016, Hurricane Mathew, where the maximum storm tide elevation at Sewells Point was 4.3 feet, NAVD88 and rainfall at approximately 10 inches, with some locations in nearby communities receiving up to 15 inches or more of rainfall. Many residential and commercial structures that experienced flooding were located beyond the designated Federal Emergency Management Agency's (FEMA) 1% annual chance floodplain and not required to, nor carried Federal flood insurance.

Historical accounts do show that Norfolk was impacted by major storm events. For examples, a 1667 hurricane raised the Chesapeake Bay 12 feet. Hurricanes in 1749 and 1806 helped create Willoughby Spit, where the Chesapeake Bay was raised 15 feet with the 1749 storm. The 1879 Hurricane raised the normal tide nearly eight feet. Hurricanes in 1897, 1899, 1903, and 1926 were approximately equal to the 1933 Hurricane or about one foot higher. Even though it has been a very long time since the City has been impacted by a major hurricane, history can repeat itself.

The City has land elevations that are generally less than 15 feet, NAVD88. Approximately 10% of the land area is at elevation six feet or less, 40% at 10 feet or less, 80% at 13 feet or less, and 90% at 15 feet or less. One of the highest places in the City is the Norfolk International Airport, with land elevations generally greater than 17 feet, NAVD88. The historical stillwater elevations mentioned above at Sewells Point are around 5.2 to 6.4 feet, NAVD88, or generally at a 10% (10-year) to 4% (25-year) annual chance flood based on FEMA's city of Norfolk Flood Insurance Study and Flood Insurance Rate Maps, dated February 2017. Using the NACCS stillwater levels, the historical water levels are approximately equal to a 20% to 10% annual chance flood. At Sewells Point, the FEMA and NACCS 1% annual chance stillwater elevations are 7.2 and 9.6 feet, NAVD88, respectively. The FEMA 0.2% (500-year) annual chance stillwater flood elevation is 8.9 feet, NAVD88, between the NACCS 2% and 1% annual chance flood elevations of 8.5 feet and 9.6 feet, respectively. Figure 10-7 shows the inland extent of FEMA's 1% (red color) and 0.2% (white color) annual chance floodplains with respect to the four study areas. The Norfolk Naval Base in Area 1 and Chesterfield Heights in Area 4 (both orange color) are not included in the Norfolk study.

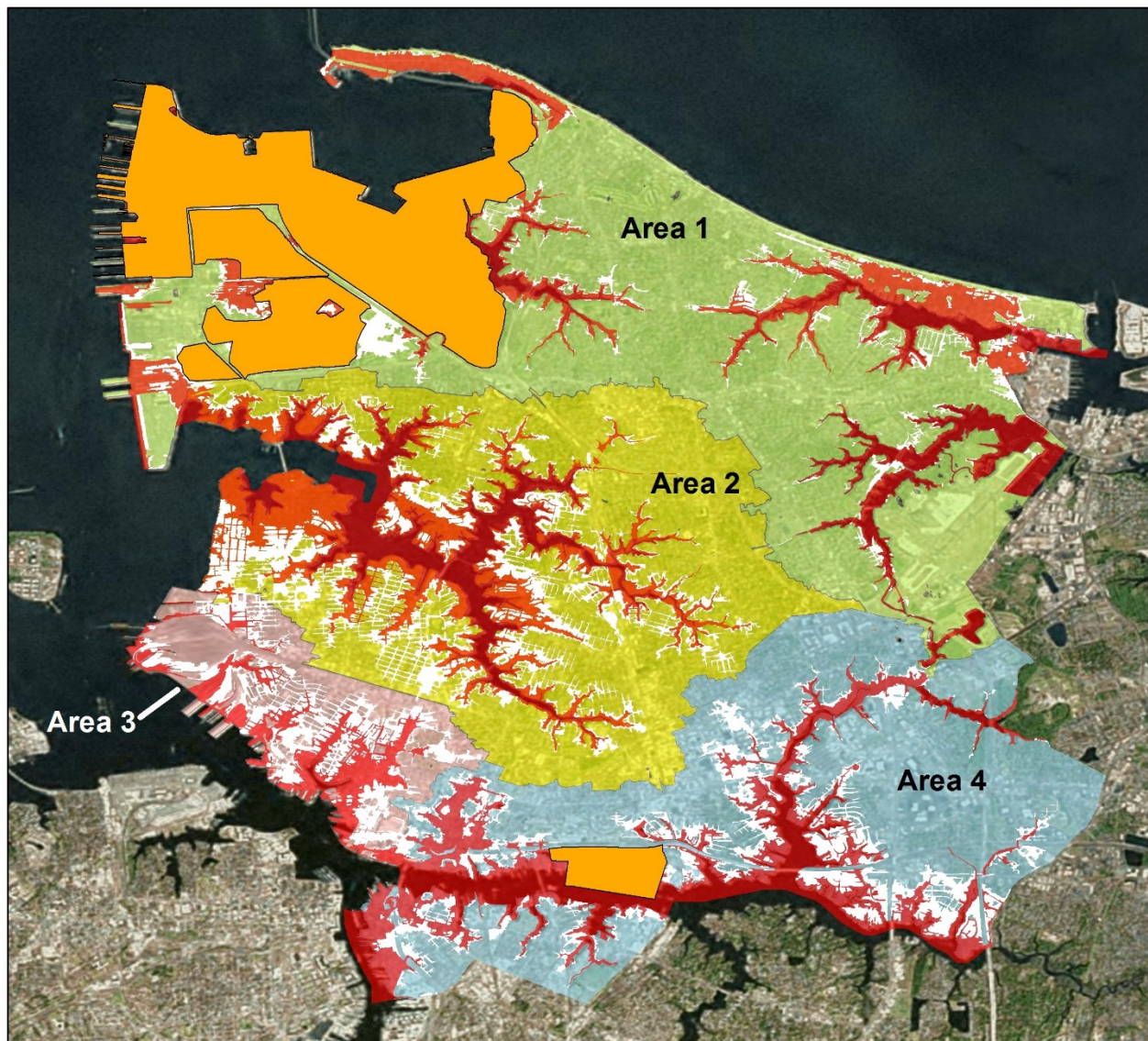


Figure 10-7. FEMA 1% (red) and 0.2% (white) Annual Chance Floodplains

There are approximately 62,000 residential, commercial, and public structures within the City. The total also accounts for about 240 structures considered critical infrastructure, including emergency services, Government facilities and shelters, water and wastewater systems, transportation, communications, healthcare and public health, and commercial facilities. Approximately 7,500 structures are located within the FEMA 1% annual chance floodplain. Out of that number, there are about 760 designated historical structures. At the higher NACCS 1% annual chance water level, there are approximately 25,000 and 3,400, respectively.

The design stillwater flood level for the Norfolk study is the NACCS 3% (35-year) annual chance flood elevation plus sea level rise to the year 2075, ranging from 9.5 feet to 10.5 feet, NAVD88 for the four study areas. The design flood level is generally equal to the FEMA 1% annual chance flood BFE plus three feet of freeboard, which will help to account for uncertainty and future conditions and achieve certification and accreditation of flood protection systems. At the design stillwater flood level, approximately 26,000 structures and 3,400 designated historical structures are located within the floodplain. Figure 10-8 shows the inland extent of the NACCS

3% annual chance floodplain including sea level rise in white color.



Figure 10-8. NACCS 3% Annual Chance Flood with 2075 Sea Level Rise Floodplain

The City became a participant in FEMA's National Flood Insurance Program (NFIP) in 1979. There are approximately 12,000 flood insurance policies in force within the City. As of February 2017 and going back to 1978, the City has had 5,839 paid claims totaling approximately \$67 million. Using FEMA's past historical flood claims data, Figure 10-9 shows a general representation of Repetitive Loss areas in Norfolk.

As of 2016, the City had 944 recognized Repetitive Loss structures. As defined by FEMA, a Repetitive Loss property is any insurable building for which two or more claims of more than \$1,000 were paid by the NFIP within any rolling ten-year period, since 1978. A Repetitive Loss property may or may not be currently insured by the NFIP. In addition, the City had 180 recognized Severe Repetitive Loss structures. Severe Repetitive Loss is defined as a residential property that is covered under an NFIP flood insurance policy and:

- (a) That has at least four NFIP claim payments (including building and contents) over \$5,000 each, and the cumulative amount of such claims payments exceeds \$20,000; or
- (b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

Considering FEMA's Flood Insurance Rate Maps mainly depict tidal flooding, some Repetitive Loss areas may include damage associated only with rainfall flooding and/or combined tidal and rainfall flooding. Thus, some Repetitive/Severe Repetitive Loss properties may be located beyond or outside the designated FEMA 1% annual chance floodplain.

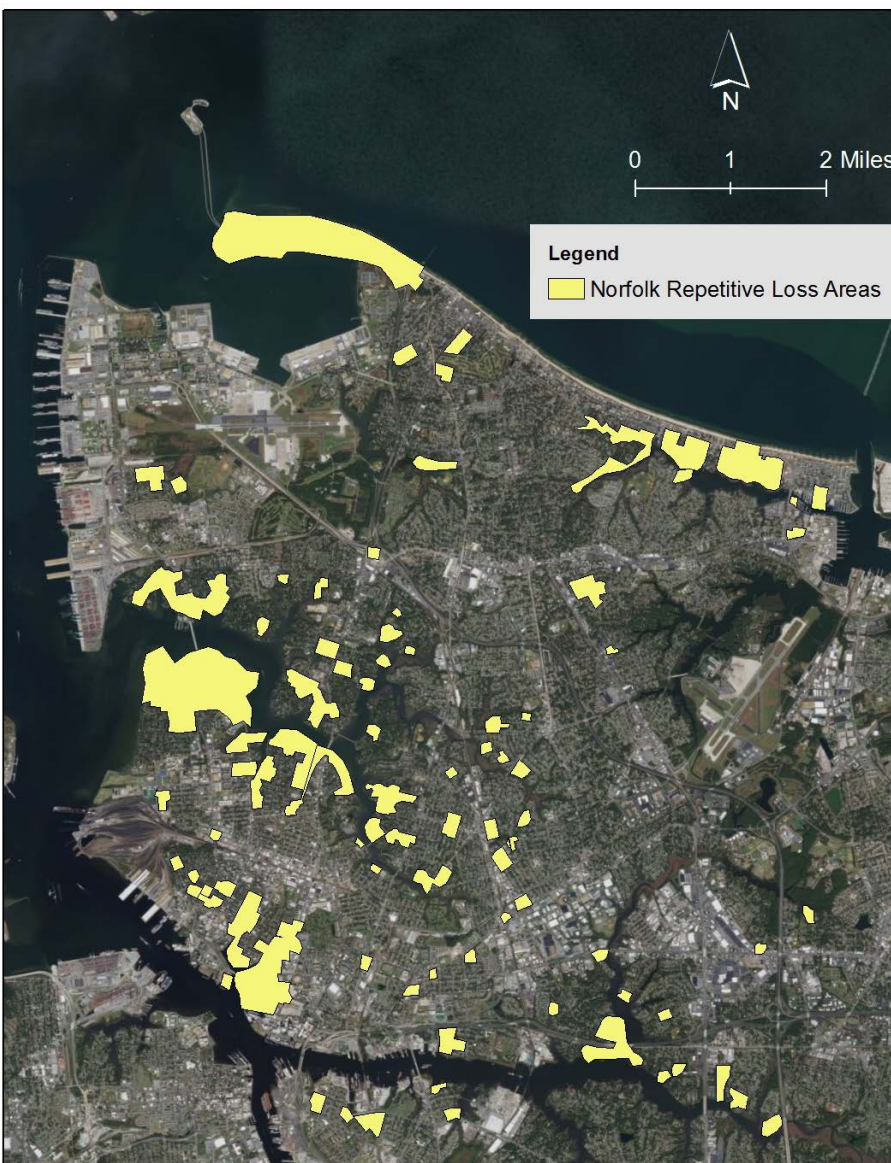


Figure 10-9. Norfolk FEMA Repetitive Loss Areas

Table 10-3 outlines past flood events, the number of FEMA paid claims, total amount paid, and average amount paid. It is interesting to note the possible relationship between stillwater elevation and rainfall, with respect to the number of paid claims. Hurricane Isabel (6.3 feet, NAVD88) and Nor'Ida (6.1 feet, NAVD88) had about the same stillwater elevation, but Nor'Ida had about 10 inches of rainfall, whereas Isabel had a lower amount of about four inches. The higher amount of rainfall may explain why Nor'Ida (1,400) had slightly more paid claims than Isabel (1,281). At 737 claims, Hurricane Irene had a stillwater elevation (5.9 feet, NAVD88) just under Isabel and Nor'Ida and rainfall at approximately 8 inches. With only 11 claims for Hurricane Floyd, the stillwater elevation (4.4 feet, NAVD88) was about two feet lower than Isabel and Nor'Ida, but had approximately 10 inches of rainfall.

Table 10-3. FEMA Flood Claims in Norfolk

Event	Year	Number of Paid Claims	Total Amount Paid (1,000s)	Average Amount Paid (1,000s)
Hurricane Floyd (1999)	Aug 99	11	\$45	\$4.1
Hurricane Isabel (2003)	Sep 03	1,281	\$16,115	\$12.6
Nor'Ida (2009)	Nov 09	1,400	\$23,133	\$16.5
Hurricane Irene (2011)	Aug 11	737	\$11,491	\$15.6
Hurricane Sandy (2012)	Oct 12	202	\$ 2,432	\$12.0
Hurricane Matthew (2016)	Oct 16	295	\$4,769	\$16.2

Source: Federal Emergency Management Agency (FEMA) as of 3/31/2017

The City participates in FEMA's Community Rating System (CRS), joining the program in 1992. By being proactive in flood mitigation activities, such as public information, mapping and regulation, flood damage reduction, and flood preparedness, flood insurance policy holders are able to receive insurance premium discounts. FEMA encourages communities to participate and help prevent loss of life and reduce flood damage. The City is currently rated a Class 7 and citizens located in the Special Flood Hazard Area (1% annual chance floodplain) receive a 15% discount on premium rates. Here are activities the City has completed or involved with, possibly receiving credit under the CRS Program:

- a. Completed in 1971, USACE built a floodwall in the Downtown area, which previously provided protection from the 1% annual chance flood. FEMA updated the City's Flood Insurance Study in 2017, with new and updated 1% annual chance BFEs (stillwater and wave runup). The floodwall project is currently certified and accredited by FEMA. Facing RSLR, the City is currently analyzing the floodwall and any future improvements to assure the floodwall will maintain the required certificate and accreditation by FEMA. As the local Sponsor for a Federal project, the City is responsible for operations and maintenance of the floodwall, in coordination with the USACE.

- b. The City partnered with USACE to place sand along the Willoughby Beach area to help protect and strengthen the existing beach and dune system. The \$34.5 million Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project was completed in May 2017, consisting of placing sand over a seven mile distance, widening the beach on average at 60 feet, creating a berm to an elevation of 3.5 feet, NAVD88. The beach is expected to be nourished about every seven to nine years. As part of the project, the City will maintain the existing dune system.
- c. Mason Creek flows into Willoughby Bay and is located adjacent to the east side of the Norfolk Naval Air Station. Approximately 3,250 acres drain into Mason Creek from surrounding residential developments and the Norfolk Naval Air Station. Mason Creek's hydraulics are characterized by storm water infrastructure which drains the surrounding area into Mason Creek, and empties through an 1,800 foot long combination box culvert/semi-circular culvert which runs under the Norfolk Naval Air Station. The culvert was installed during World War II when the area was filled for expansion of Naval Station Norfolk. The outlet is approximately 20 feet in width, 11 feet in height. In addition, a tide gate exists at the culvert inlet to reduce tidal flooding during storms and is controlled by the Naval Station. The gate is operated by closing the gate at low tide in advance of predicted significant tidal events.
- d. In 2014, the City created a Chief Resilience Officer position and the City Manager's Office of Resilience. The City coordinates resilience initiatives across all levels of government and with the private sector, locally as well as nationally. A Recurrent Flooding Fund was also established for the purpose of storm water project design, hydrologic and hydraulic studies, local grant match, and other costs related to flood risk reduction.
- e. The City Council in 2016 adopted Vision 2100, a new chapter in the City's Comprehensive Plan, which addresses long term land use strategy and public investment prioritization to adapt to sea level rise.
- f. Through the Department of Housing and Urban Development (HUD), the City is implementing the \$112 million Ohio Creek Watershed Project, a resilience grant in two low-moderate income neighborhoods vulnerable to flooding, which allows for the construction of coastal flood protection, stormwater management, and improved public space.
- g. For structures within the effective FEMA 1% annual chance floodplain, the City established one foot of freeboard, above FEMA BFE, in 1992 and then increased it to three feet in 2014.
- h. For structures within the effective FEMA 0.2% annual chance floodplain, the City requires that all development must have a finished floor or flood proofed 18 inches above grade in 2014.
- i. Regulations require twenty foot setback from the landward edge of mean high water for principle structures.
- j. Regulations prohibit the construction of subgrade crawl spaces within the 1% annual chance floodplain.

- k. Regulations prohibit the use of breakaway walls in coastal VE and AE zones.
- l. Regulations require coastal VE construction requirement in coastal AE zones.
- m. Regulations require existing buildings come into compliance with current regulations if flood damage from two events, on average, each equals or exceeds 25% the market value of the structure and the building is structurally damaged or altered.
- n. From 2014 to 2017, 13 structures have been elevated as hazard mitigation projects. Currently, 16 projects (15 elevation, 1 acquisition) have funding in place where they are waiting for design, in design, out for bid, or under construction/acquisition.
- o. The City is currently finalizing a citywide green infrastructure master plan that identifies areas that are most suitable for implementation.
- p. During 2014 to 2016, the City installed six tide gauges to better monitor real time water levels at these locations: the Ocean View Recreation Center at Pretty Lake; the Colonial Place, Haven Creek Boat Ramp; the Tidewater Drive bridge at Lafayette River; the downtown pump station on the Elizabeth River; and the Grandy Village Learning Center pier on the eastern branch of the Elizabeth River.
- q. Since 2011 alone, the Storm Water Department has completed over 35 drainage related Capital Improvement Projects and city-wide vulnerability assessments valued at over \$17 million.
- r. During 2014 to 2015, Brambleton Avenue, a major route leading to the Mid-Town Tunnel and Sentara Norfolk General Hospital, was elevated due to flooding.
- s. Public outreach and education, such as online flood awareness and mitigation activities through the City's Emergency Management and Public Works offices. Web mapping applications such as, the Tidal Inundation Tracking Application for Norfolk (TITAN) and STORM MAP, a live and historic record of storm related events.
- t. Between 2011 and 2015, the City has tripled its linear footage of constructed wetland areas, from approximately 61,000 feet to 217,000 feet.
- u. Since 2014, the City completed several major shoreline restoration projects valued at over \$10 million.
- v. The City will be working with the USACE in developing a Floodplain Management Plan as required by Section 202 (c) of Water Resources Development Act of 19
- w. In May 2018 the City increased real estate tax reserving \$0.01 of that increase to fund resilience projects (approximately \$1.8 million per year).

Environmentally, flooding can increase the amount of pollutants that enter the various water bodies, on a short and/or long term basis, which could be unsafe for people, animals, and

plants. As flood levels increase, more surface area is impacted and pollutants are carried away, such as oil and gas from road pavement, sediment, pesticides, fertilizer, etc. Long duration events, such as nor'easters where tidal and rainfall flooding may occur, can aggravate the situation. In addition, many sanitary sewer pipelines can be taxed from floodwaters entering from manholes, underground seepage, or pump failure, where the floodwaters can be contaminated. From past flood events, especially in the urban, downtown, and high density areas of the City, although the City allows free parking in elevated city-owned parking garages, many cars routinely get flooded, adding to the amount of pollutants to enter the floodwater. It does not appear from historical flood events, that the City has had to deal with the any industrial type facilities getting flooded, where the environment has been significantly impacted. The City does have to contend with continued maintenance with storm sewers and channels, to address sediment build-up, which can reduce the flow carrying capacity during rainfall events.

The City has completed several natural and nature based projects, which may provide some protection or lessen the intensity or severity of a storm event. As noted above, the City has tripled its wetland areas and completed several major shoreline restoration projects. The NACCS identifies where coastal ecosystems reduce wave energy and can also reduce inland flooding depths during storm surge events by providing resistance to the flow of water. Living shorelines and wetlands also help stabilize the shoreline, prevent erosion, create effective buffers, provide valuable habitat, and improve water quality.

Socially and economically, the City is working to address flooding concerns for all of its citizens, in the near term and the future. As noted above, the City created a Chief Resilience Officer position and the City Manager's Office of Resilience, a Recurrent Flooding Fund, evaluating sea level rise in its Comprehensive Plan, are using a HUD grant to help low-moderate income neighborhoods in the Ohio Creek Watershed, working with FEMA's grant programs to elevate structures, incorporating green infrastructure and natural and nature based features, public outreach and education, etc. With most of the land area built out at 95%, the City is proactive with more restrictive floodplain regulations that will apply to new development or structures that are substantially improved. These actions will help the City and its citizens be socially and economically resilient and sustainable now and into the future.

10.6 WETLANDS AND MUDFLATS

10.6.1 Definition of Resource

Wetlands are defined by the Clean Water Act regulations as, "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (USEPA 2016). The two major categories of wetlands are tidal (subject to the ebb and flow of tide), and nontidal (freshwater). Wetlands may be forested, scrub/shrub, or emergent. Mudflats are nonvegetated flats between the elevations of mean low water (MLW) and mean high water (MHW).

10.6.2 Methodology

The ROI for wetlands includes all wetland areas within the Study Area to be directly filled,

dredged, excavated, or otherwise converted to another use as a result of the construction of the measures, as well as all wetlands indirectly adversely affected by the project, by means such as alteration in tidal flushing, sedimentation, currents, erosion, changes in salinity, and community type. It should be noted that all wetlands within the ROI are tidal and brackish. Lake Whitehurst, which is not within the ROI, contains freshwater wetlands along its banks.

The wetland data provided in this report was obtained through the following sources:

GIS mapping of Cowardin Classification wetland system. For purposes of this report, we will describe the community types and amounts of all wetlands in Areas 1-4, which make up the Study Area, using a data set provided by the U.S. Fish and Wildlife Service that represents the extent, approximate location and type of wetlands and deepwater habitats in the United States and its Territories. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979). It is acknowledged that due to the map scale, the primary intended use is for regional and watershed data display and analysis, rather than for specific project data analysis. The map products were neither designed nor intended to represent legal or regulatory products. These data were developed in conjunction with the Cowardin classification system publication (1979), and were obtained from GIS mapping provided to USACE.

The Cowardin system classifies wetlands based on cover type and hydrologic regime. For example, “palustrine” signifies a freshwater wetland, and “estuarine” signifies an intertidal (brackish) water wetland. A forested wetland is signified by “FO”; a scrub-shrub wetland is signified by an “SS”, and an emergent wetland is signified by an “EM.” Numeric values signify permanence and/or type of vegetation. Therefore, an intertidal marsh with persistent emergent vegetation is given the classification “E2EM1” and an intertidal, broad-leafed, deciduous scrub/shrub wetland is given the classification “E2SS1.”

Shoreline Situation Report, Shoreline Situation Report City of Norfolk, Prepared by: Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science (VIMS) College of William and Mary, Gloucester Point, Virginia 23062 (2014). This shoreline inventory was developed as a tool for assessing conditions along tidal shorelines in the city of Norfolk. Data were collected using image processing and photo interpretation techniques. This shoreline situation report states that it “represents the first in the statewide series to utilize high resolution imagery for the vast majority of data collection.” The report indicates that field work was conducted to ground-truth the photo-analyzed data. Conditions are reported for three zones within the immediate riparian shoreline area: riparian land use, bank and buffers, and the shoreline. The report indicated that it used state of the art GPS, GIS, and remote sensing to collect, analyze, and display shoreline conditions. The shoreline situation report included data collection, data processing and analysis, and map generation.

Current Google Earth aerial photography and spot-checking in the field. For purposes of this NEPA document, wetlands were in many cases, spot-checked in the field if publically accessible; as we do not have real estate access or entry agreements for all of the parcels at this time. In all cases, current aeriels were closely examined. A full wetland delineation will be completed in the Preconstruction, Engineering, and Design (PED) Phase, once the project is in the final design.

USACE Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0). Once the project is in the PED phase, a full wetland delineation will be conducted in accordance with this methodology. This is the official delineation manual and appropriate supplement for the ROI, and is the manual the USACE uses pursuant to Section 404 of the Clean Water Act.

10.6.3 Framework

Section 10 of the Rivers and Harbors Act of 1899, as amended (33 USC Section 403) regulates structures and work that would affect navigable waters of the U.S. Structures include piers, wharves, jetties, bulkheads, groins, breakwaters, etc. Work includes dredging, filling, excavation, or other modifications to navigable waters of the U.S. All wetlands subject to the ebb and flow of tide are by definition navigable waters (33 CFR 328).

The Clean Water Act (CWA) of 1972, as amended (33 USC Section 1251 et seq) is the primary federal law that regulates the nation's waters, including lakes, rivers, and coastal areas. The CWA prohibits all unpermitted discharge of any pollutant into any jurisdictional waters of the U.S. The CWA Section 404 requires a permit for the discharge of dredged or fill material into jurisdictional waters of the U.S, including wetlands. Wetlands regulated under the Clean Water Act are delineated pursuant to the 1987 USACE Wetland Delineation Manual, along with the appropriate regional supplement manual. The Study Area falls under the Atlantic and Gulf Coast Plain Region Regional Supplement to the Corps of Engineers Wetland Delineation Manual: (Version 2.0).

The CWA Section 401 requires a state water quality certification for discharges into waters of the U.S., including wetlands. In addition, the Virginia Department of Environmental (VDEQ) regulates activities in waters of the U.S., including wetlands, under State Water Control Law (Code of Virginia Title 62.1), and Virginia Administrative Code Regulations.

Section 307(c)(1) of the Coastal Zone Management Act (CZMA) requires that any federal agency that undertakes any development project in the coastal zone of a state shall insure that the project is, to the maximum extent practicable, consistent with the enforceable policies of the approved state management programs. It also holds that the federal agency shall complete and provide a federal consistency determination to the state.

Chesapeake Bay Protection Act (CBPA). State-local cooperative program administered by the Virginia Department of Environmental Quality's (DEQ's) Water Division and 84 localities in Tidewater, Virginia established pursuant to the Chesapeake Bay Preservation Act (Virginia Code §§ 62.1-44.15:67 through 62.1-44.15:79) and Chesapeake Bay Preservation Area Designation and Management Regulations (Virginia Administrative Code 9 VAC 25-830-10 *et seq.*). Under the CBPA, a vegetated buffer no less than 100 feet wide be located adjacent to and landward of all tidal shores, tidal wetlands, non-tidal wetlands, and contiguous to tidal wetlands connected by surface flow and contiguous to tidal wetlands along water bodies with perennial flow. These features, including the riparian area, comprise the Resource Protection Area (RPA). Generally, vegetation in the 100-foot buffer must be preserved on lots that include an RPA; authorization is required for removal. The RPA includes all tidal wetlands in the city of Norfolk.

10.6.4 Existing Conditions

Tidal Wetlands

The major waterways that make up the four areas of the Study Area--Pretty Lake, Little Creek, Willoughby Bay, the Elizabeth River, the Lafayette River, the Hague, and Broad Creek—are all estuaries subject to daily tides. Estuary environments change constantly with the combined stress of inundation, desiccation, and changes in salinity. These conditions limit the types of vegetation that can survive within the ROI and the plant communities within this dynamic ecosystem have evolved the capacity to thrive in the ever-changing environment (Perry et al., 2001).

Tidal marshes are typically wide, topographically flat, habitats where subtle changes in elevation, inundation frequency, and salinity dictate the species mix of the associated plant communities. Figure 10-10 depicts the typical associations of species and tidal hydrology found in the salt marshes of the Chesapeake Bay (Perry et al., 2001).

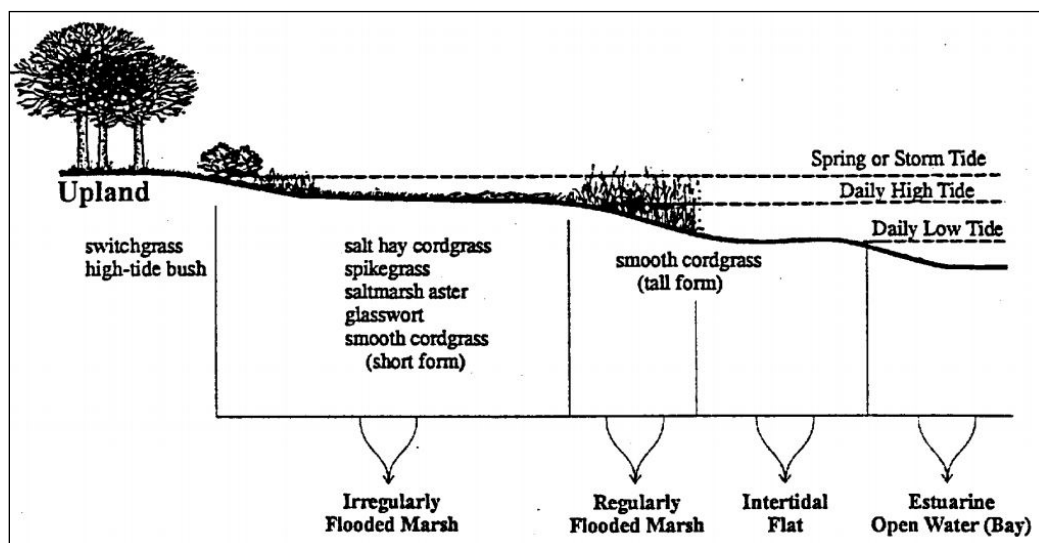


Figure 10-10. Zonation of Tidal Marshes

Source: Perry et al., 2001.

Over the course of many years in Norfolk, shorelines and wetlands have been hardened and filled to facilitate development; and residential communities, commercial businesses, marinas, and large industrial and military deep water access piers and marine terminals have been constructed. The Elizabeth River Project (ERP) reports that the Elizabeth River Watershed, in its entirety, has lost roughly 50% of its wetlands since World War II (ERP and DEQ 2008).

The major wetland community types within the ROI are described below.

Saltmarsh Cordgrass Community. The saltmarsh cordgrass community dominates physiological distribution ranges from mean low water to mean high water. The community is comprised of dense, often mono-specific stands of *Spartina alterniflora* (smooth cordgrass), the most salt-tolerant of the marsh species.

Saltmeadow community. Slightly upslope of *Spartina alterniflora*, *Spartina patens* (saltmeadow cordgrass) and *Distichlis spicata* (saltgrass) are often co-dominants. Less common are stands of *Juncus roemerianus* (black needle rush), which may occur as monotypic communities but at slightly higher elevations. All of these species are salt-tolerant.

Saltbush Community. Landward of the saltmeadow community is the saltbush community. The two main species are *Iva frutescens* (saltbush), which occurs roughly at the mean high water (MHW) line, and *Baccharis hamifolia* (groundsel tree), which is generally found upslope of MHW, in the spring high tide range.

Reed Grass Community. The reed grass community is dominated by the invasive common reed grass *Phragmites australis*. The community is usually located near or above mean high water (MHW) and is often associated with topographic or other disturbances such as the placement of fill material, plant die-back, or surface erosion. While the reed grass is salt tolerant up to salinities of 10 ppt for germination and up to 18 ppt vegetatively, it is not as salt-tolerant as *Spartina alterniflora*. It propagates through not only seeds but also a network of underground rhizomes.

With the exception of the upper headwaters of these waterways, most of the wetlands in these rivers are narrow fringe cordgrass marshes; disturbed, common reed-dominated areas; or narrow sections of scrub/shrub wetlands. The Virginia Institute of Marine Science (VIMS), which issued shoreline inventory reports, found that there are very few untouched stretches of shoreline in the City (VIMS, 2002).

Area 1: Willoughby Bay, Chesapeake Bay, Little Creek, Fishermans Cove, and Pretty Lake.

In Area 1, the largest expanse of tidal wetland is in the upper tributary reaches of Pretty Lake. The VIMS shoreline report, conducted by Berman et. al. (2014) found that there were approximately 71 acres of saltmarsh cordgrass community, and 14 acres of “brackish mix”, and found that common reed was present in 28% of marsh areas surveyed. At the mouth of Pretty Lake at the Shore Drive (Route 60) bridge, there is a narrow band of saltmarsh cordgrass fringe community, saltgrass community, and saltbush community (Figure 10-12). Figure 10-11 depicts vegetation types, mudflats, open water found within the Area 1, Region of Influence and adjacent areas based on a depiction of the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (2017).

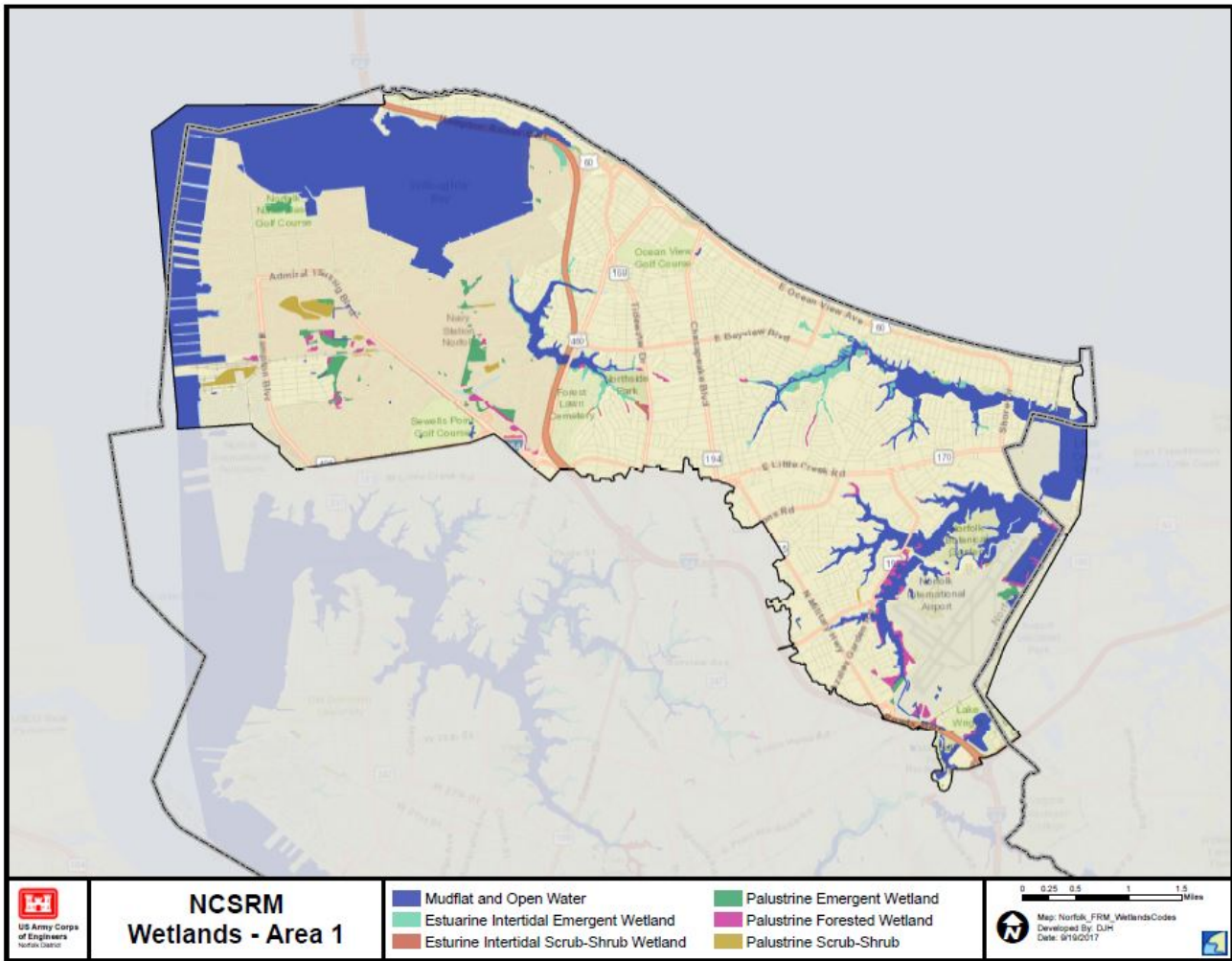


Figure 10-11. Area 1, Wetlands, mudflats, and open water habitats within the ROI.



Figure 10-12. Area 1 - Location of Storm Surge Barrier at Pretty Lake

Lake Whitehurst, one of the City's reservoirs, is entirely nontidal, freshwater. The shorelines of the lake include an unquantified acreage of freshwater emergent, scrub/shrub, and forested wetlands.

Chesapeake Bay in Area 1 is beachfront, with no vegetated wetlands. Willoughby Bay contains approximately 14 acres of fringe marsh, with a blend of smooth cordgrass and brackish mix (VIMS, 2014).

Area 2: Lafayette River Watershed

The Lafayette River watershed is Norfolk's largest watershed and tributary system to the Elizabeth River. Similar to Pretty Lake in Area 1, its largest expanses of tidal marshes are in its upper reaches. Berman et. al. (2014) surveyed approximately half of the wetlands in its watershed, and estimated that there are approximately 385 acres. Of this acreage, approximately 288 acres is estimated to be intertidal emergent marsh, with 186 acres of this taking the form of embayments and marsh islands, and 102 acres existing as fringe marsh. Berman et. al. field-check surveyed approximately half of these areas, and found about 85% of them to be saltmarsh cordgrass, 5% saltbush, 8% brackish mix, and 3% to be common reed grass-dominated, with common reed present in 32% of all of the marshes.

At the mouth of the Lafayette, there is a large riprap revetment at the south bank, along the Lamberts Point Golf Course, and the Norfolk International Terminal (NIT) marine terminal on the north bank. There are no wetlands at these locations. Figure 10-13 depicts vegetation types, mudflats, open water found within the Area 2, Region of Influence and adjacent areas based on a depiction of the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (2017).

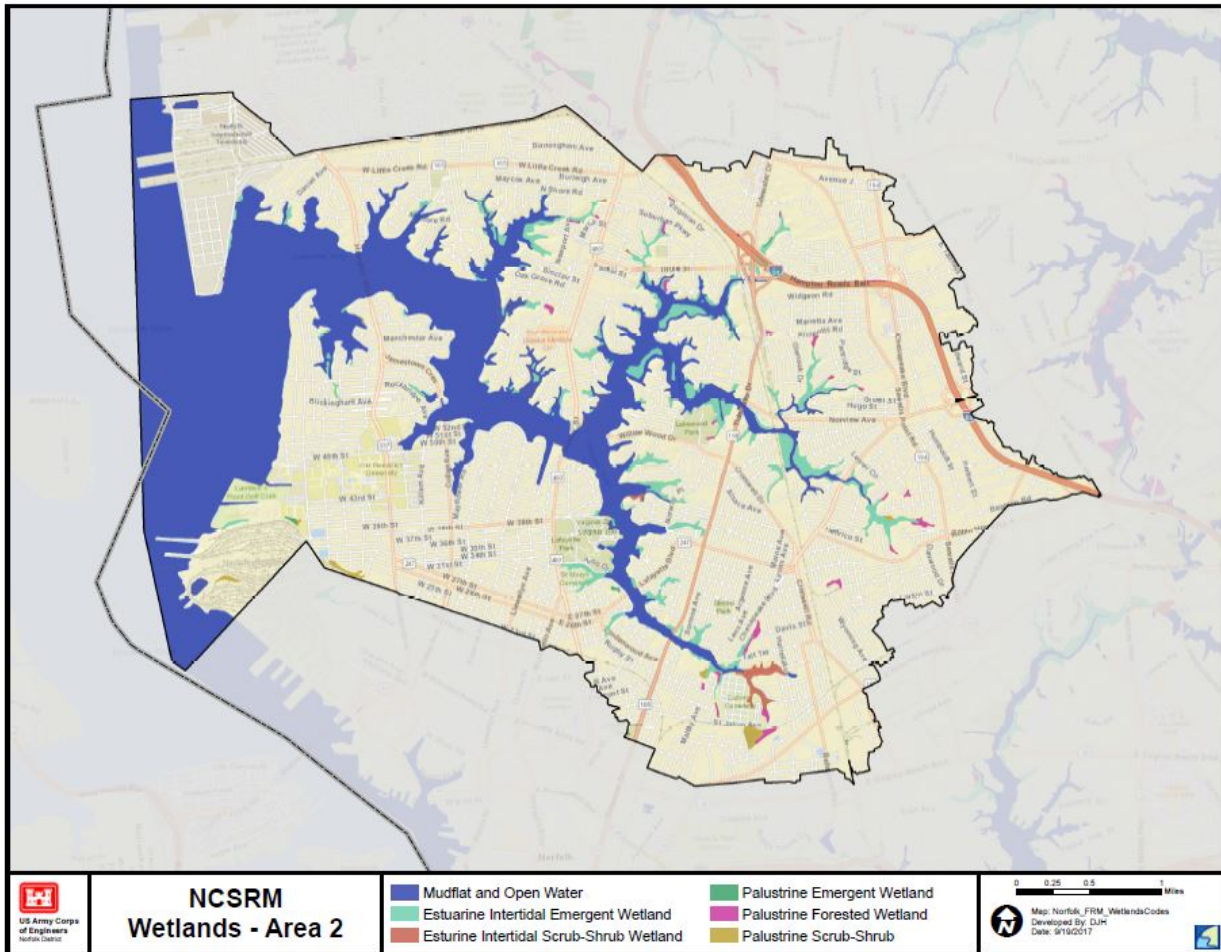


Figure 10-13. Area 2, Wetlands, mudflats, and open water habitats within the ROI.



Figure 10-14. Area 2, The location of the Storm Surge Barrier across the Lafayette River

Area 3: The Mainstem Elizabeth River, The Hague, Freemason, and Downtown Norfolk

Area 3 is almost entirely characterized by heavily disturbed and developed shorelines. The only wetlands present are a large intertidal marsh and scrub/shrub community adjacent to Lamberts Point along the Elizabeth River, and an inlet of Lamberts Creek. The Lamberts Creek inlet wetland system, near the northwest section of Area 3, is physically fragmented from the Elizabeth River by the many railroad lines at Lamberts Point; however, the wetland system still receives regular daily tides through pipes underneath the rail lines. This tidal area is likely a remnant of what was a much larger marsh system historically. The inlet contains shallow water, intertidal mudflat, smooth cordgrass fringe marsh, and saltbush community, but its largest wetland community type is common reed-dominated.

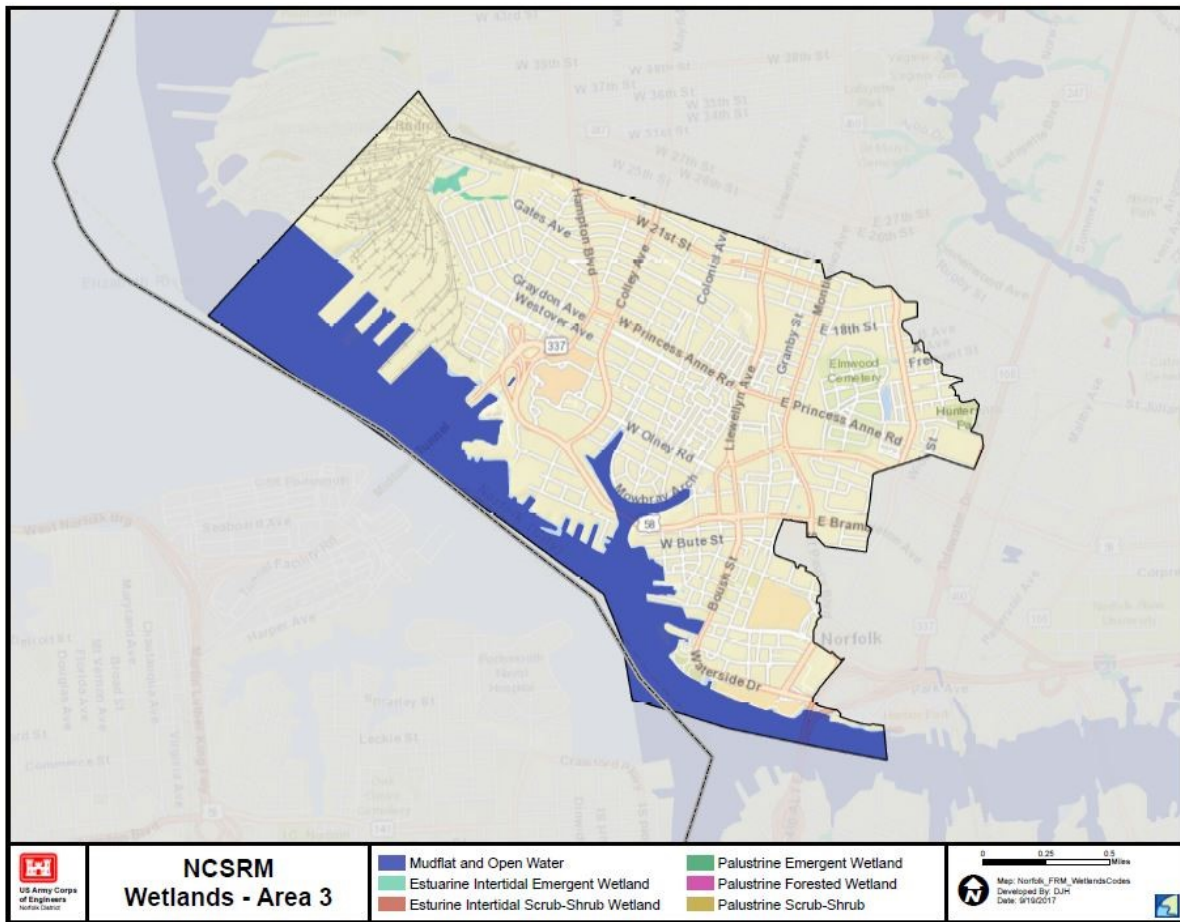


Figure 10-15. Area 3, Wetlands, mudflats, and open water habitats within the ROI



Figure 10-16. Area 3 - Wetland inlet at Lamberts Creek.

Area 4: Elizabeth River Eastern Branch, Newton’s Creek/Tidewater Dr., Ohio Creek, Broad Creek

These watersheds extend roughly from the Harbor Park baseball stadium, eastward, through

Broad Creek, near the eastern jurisdictional City boundary, and include both sides of the Eastern Branch within Norfolk. According to the Berman et. al VIMS study (2014), there are approximately 201 acres of tidal wetlands within the Norfolk portion of the watershed. Berman et. al. found that approximately 78% of this acreage was fringe smooth cordgrass marsh, 21.5% of it was embayed marshes and marsh islands in the upper reaches of Broad Creek and the upper reaches of the Eastern Branch; and approximately 14% was other wetland community types, including scrub/shrub. Berman et. al. found that roughly 27% of the marshes they surveyed contained some common reed.

Around Harbor Park, there is a narrow *smooth cordgrass* marsh, with a narrow band of saltbush community landward of it. These areas and immediately south of the baseball diamond, are heavily disturbed with rock, and old concrete block and pavement, and other debris (See 6 and 7). Figure 10-17 depicts vegetation types, mudflats, open water found within the Area 4, Region of Influence and adjacent areas based on a depiction of the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (2017).

Immediately east of Harbor Park, there is a small tidal wetland inlet dominated by *smooth cordgrass*. Further east, along the northern bank of the main stem of Eastern Branch, immediately south of the Tide rail line, there is a narrow but relatively undisturbed tidal marsh and saltbush community. This area contains smooth cordgrass, common reed, and saltbush.

At the mouth of Broad Creek, south of the Tide rail line, there are narrow fringes of smooth cordgrass, with smaller pockets of *Juncus roemerianus* (black needle rush) mixed in.

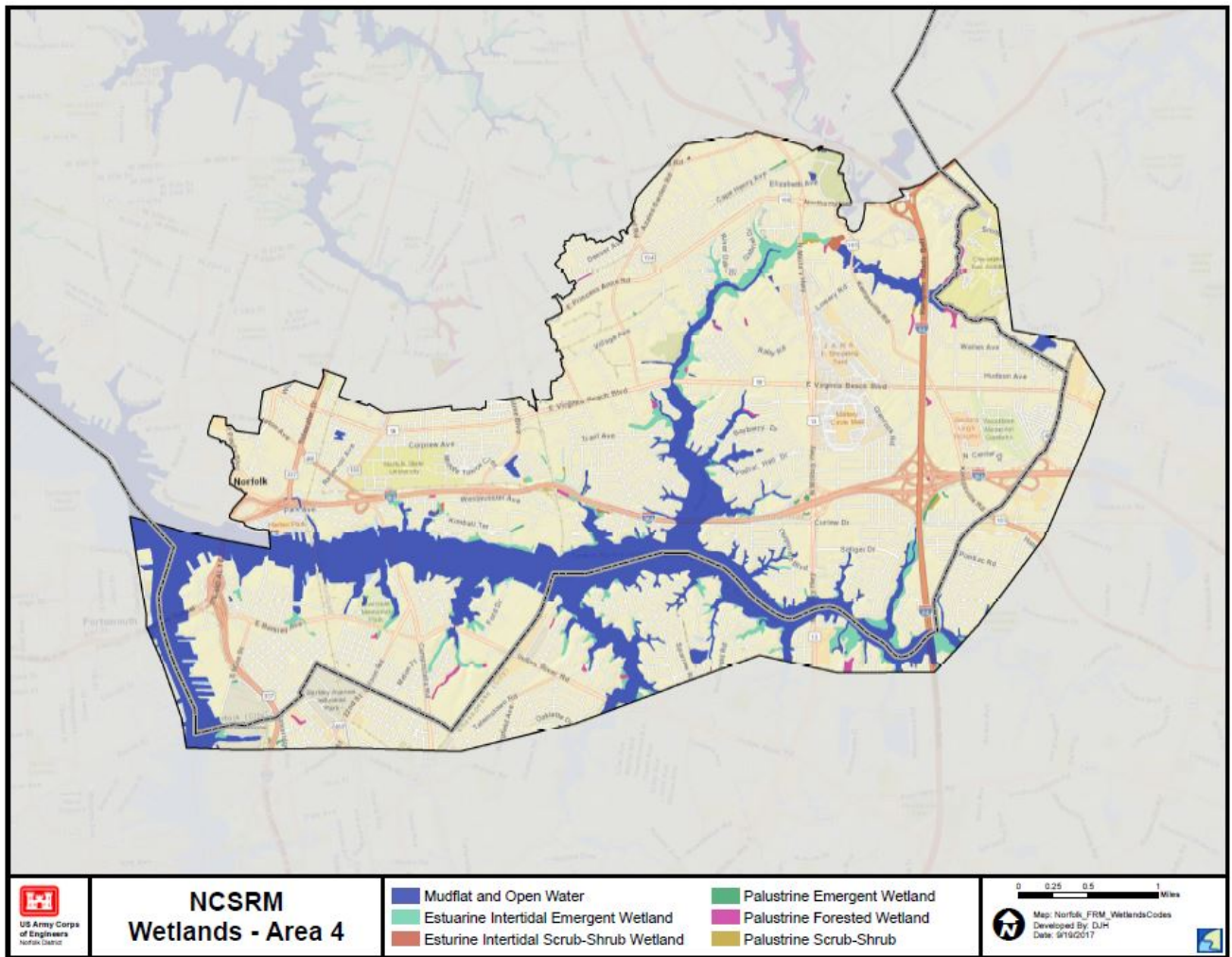


Figure 10-17. Area 4, Wetland, mudflats, and open water habitats within the ROI.



Figure 10-18. Area 4 - Narrow marsh and saltbush community west of Harbor Park.



Figure 10-19. Area 4 -Saltbush community adjacent to Harbor Park.



Figure 10-20. Area 4 - Narrow fringe of a mixed community along the south side of the Tide rail line and I-264



Figure 10-21. Area 4 - Narrow marsh fringe along the south side of the Tide rail line, near the mouth of Broad Creek.

10.7 SUBMERGED AQUATIC VEGETATION

10.7.1 Definition of Resource

SAV are non-flowering or flowering plants that grow completely underwater. In the Chesapeake Bay region, SAVs generally grow in shallow areas ranging from high salinity regions to freshwater tidal environments (VIMS 2017b).

More than a dozen species of SAV are native to the Chesapeake Bay and its tributaries, but the most notable ones in the Norfolk area are eelgrass (*Zostera marina*) and widgeon grass (*Ruppia*

maritima). Salinity, light penetration, water depth, and bottom sediment are factors which determine where each species can grow. SAV survival depends on water clarity and the amount of sunlight available; thus, they only occur within the shallow waters within the photic zone. SAV provides food and shelter for diverse populations of waterfowl, fish, shellfish, and invertebrates. As a producer of oxygen, it serves a very important function in the Chesapeake Bay, where dissolved oxygen can be depleted during the warm months of the year. SAV provides other ecological benefits such as the ability to filter and trap sediment, and to absorb nutrients like nitrogen and phosphorus (US Fish and Wildlife Service, Chesapeake Bay Field Office, 2016). The varied life stages of numerous fish species in Virginia depend on SAV (Terceiro 2006; Love and May 2007; Phillips et al. 1989). As a critical food, refuge, and nursery and juvenile habitat, a wide variety of waterfowl, shellfish, and fish species, also depend on SAV for the ecological functions it provides. In addition, SAV beds are often utilized as an indicator of a river's health, because of its sensitivity to water clarity, total suspended solids, and nutrient loadings. (Fisher and Willis 2000).

10.7.2 Methodology

The ROI for SAV is all aquatic areas where structure or fill is being placed or dredging is being conducted, for storm surge barriers, floodwalls, pump stations, natural and nature-based features, or other activities associated with the project. The ROI also includes any areas that may be indirectly affected due to alterations in currents, velocities, salinity, tidal flushing, sedimentation, total suspended solids, or other alterations in hydrodynamics. As stated earlier in this report, the City is divided into Areas 1-4.

The Virginia Institute of Marine Science (VIMS) has been compiling reports and aerial photography of SAV coverage within the Chesapeake Bay watershed since the 1980s. According to VIMS, black-and-white aerial photography at a scale of 1:24,000 and digital imagery was originally the primary source of information that it used to assess distribution and abundance of SAV in Chesapeake Bay, and its tributaries. Typically, over 100 flight lines are flown each year to yield aerial photography negatives. These negatives are scanned and orthorectified to create orthophoto mosaics. These mosaics are carefully examined on-screen and outlines are drawn to identify all SAV beds visible on the photography. This information contributes to a geographic information system (GIS) digital database of bed areas and locations. Ground survey information is collected in these years and is tabulated and entered into the VIMS SAV GIS digital database. Outlines of SAV beds are then interpreted on-screen, providing a cross reference for the digital database (VIMS 2017a).

VIMS mapped the annual distribution of SAV in Chesapeake Bay and its tributaries using multispectral digital imagery and supplemented with black and white aerial photographs. These images were acquired between May and November 2016, encompassing 187 flight lines. (VIMS 2017a).

10.7.3 Framework

The following laws and regulations address the protection of SAV:

Section 10 of the Rivers and Harbors Act of 1899, as amended (33 USC Section 403)

regulates structures and work that would affect navigable waters of the U.S. Structures include

piers, wharves, jetties, bulkheads, groins, breakwaters, etc. Work includes dredging, filling, excavation, or other modifications to navigable waters of the U.S. All waters to the ebb and flow of tide are by definition navigable waters (33 CFR 328).

The Clean Water Act of 1972, as amended (33 USC Section 1251 et seq) is the primary federal law that protects the nation's waters, including lakes, rivers, and coastal areas. The CWA prohibits all unpermitted discharge of any pollutant into any jurisdictional waters of the U.S. The CWA, Section 404 requires a permit for the dredging and/or filling of jurisdictional waters of the U.S, including wetlands. Under CWA implementing regulations, SAVs (or vegetated shallows) are defined as a special aquatic site. The CWA Section 401 requires a State Water Protection Permit for impacts to waters of the U.S., including wetlands and other special aquatic sites.

Section 28.2-03 and 28.2-1230 of the Code of Virginia states that any removal of naturally-occurring SAV from State bottom, or planting of nursery stock SAV, for any purpose, except as part of a prior-approved research or scientific investigation, shall require prior approval by the Virginia Marine Resources Commission (VMRC). In determining whether or not to grant approval for SAV removal or planting, VMRC shall be guided by §28.2-1205 of the Code of Virginia and the SAV Transplantation Guidelines, or any new and improved methodologies as approved by the VMRC. These same state regulations also require a permit from the VMRC to build, dump, or otherwise trespass upon or over or encroach upon or take or use any materials from the beds of the bays and ocean, rivers, streams, creeks, which are the property of the Commonwealth. Unless specifically exempted by regulation, those regulated activities include dredging, filling, structures, overhead and submarine crossings, etc. As per the Submerged Lands Act of 1953 (43 USC Section 1301-1315), Virginia's jurisdiction over its coastal waters and bottomlands extends from mean low water shoreline three nautical miles seaward.

Chesapeake Bay Preservation Act. This Act was enacted as part of Virginia's non-point source management program, and regulates riparian lands up to 100 feet landward of all tidal wetlands and waterways.

Section 307(c)(1) of the Coastal Zone Management Act (CZMA) requires that any federal agency that undertakes any development project in the coastal zone of a state shall insure that the project is, to the maximum extent practicable, consistent with the enforceable policies of the approved state management programs. It also holds that the federal agency shall complete and provide a federal consistency determination to the state.

10.7.4 Existing Conditions

After a review of VIMS data from the years 2000 through 2017, the latest survey and mapping and reporting efforts by VIMS, two SAV beds are documented within the city of Norfolk (The 2017 data is preliminary). Both are within Area 1; however, neither are within the ROI. The two species documented there are *Zostera marina* (eelgrass), and *Ruppia maritima* (widgeon grass) (VIMS 2017c).

The larger SAV bed is approximately 10.4 acres, and is located on the southern bank of Little Creek Cove, south of Little Creek Amphibious Base, approximately 1.6 miles from the ROI. The smaller of the two is approximately 0.35 acres, and is located along the western bank of Little

Creek near its confluence with Fishermans Cove, approximately 220 feet west of the Little Creek federal navigation channel, and 0.3 miles outside of the ROI. (USACE 2017).

Areas 2, 3, and 4 have no documented SAV, currently or historically, since VIMS' records dating to the 1990s (VIMS 2017a). In addition, reviews of the records from 17 years of data throughout the Study Area reveal that SAV coverage within the city of Norfolk has changed only very slightly in size or location during that date range (VIMS 2017).

These findings represent the recent available information. It is recognized that SAV coverage may change from year to year. Therefore, once this project enters the PED phase, the most current VIMS mapping of SAVs will be re-checked, and impact determinations will be modified as appropriate.

10.8 TERRESTRIAL WILDLIFE AND UPLAND VEGETATION

10.8.1 Definition of Resource

For the purpose of the following discussion, wildlife is limited to terrestrial species of invertebrates, amphibians, reptiles, birds, and mammals. Protected species and more information on migratory bird species are discussed in the Special Status Species Section; and aquatic species are discussed in the fisheries and benthics sections.

10.8.2 Methodology

The ROI is all areas within the City where structure or fill is being placed for storm surge barriers, floodwalls, pump stations, natural and nature-based features, or other activities associated with the project, including all noise and disturbance effects to species in and adjacent to areas that are filled, graded, cleared, excavated, or otherwise converted to another use as a result of the construction of the measures. It also includes areas indirectly adversely affected by the project, by means such as erosion, alteration of wildlife passage corridors, or changes in community type.

10.8.3 Framework

Fish and Wildlife Coordination Act. The Fish and Wildlife Coordination Act requires the USACE to coordinate with the USFWS and VDGIF on water resources related projects to obtain their views toward preservation of fish and wildlife resources and migration of unavoidable impacts.

Chesapeake Bay Preservation Act. This Act was enacted as part of Virginia's non-point source management program, and regulates riparian lands up to 100 feet landward of all tidal wetlands and waterways.

Section 307(c)(1) of the Coastal Zone Management Act (CZMA) requires that any federal agency that undertakes any development project in the coastal zone of a state shall insure that the project is, to the maximum extent practicable, consistent with the enforceable policies of the approved state management programs. It also holds that the federal agency shall complete and provide a federal consistency determination to the state.

10.8.4 Existing Conditions

Area 1 –Willoughby Spit and Oceanview Beach Area

Willoughby Spit and Ocean View consist of a beach environment that is approximately 7.3 miles long and an average of 60 feet wide. The City partnered with USACE to place sand along the Willoughby Beach area to help protect and strengthen the existing beach and dune system. The \$34.5 million Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project was completed in May 2017, consisting of placing sand over a seven mile distance, widening the beach on average at 60 feet, creating a berm to an elevation of 3.5 feet, NAVD88. The beach is expected to be nourished about every seven to nine years. As part of the project, the City will maintain the existing dune system.

The beach is the zone of unconsolidated material that extends landward from the low water line to the fore-dune line. Beach surfaces are a harsh environment as the temperature of the sand on a hot, sunny day can be extremely high, and also subject to conditions such as salinity fluctuations, winds and rain, blowing sand, and wave action that causes erosion and accretion. The upper beach, above mean high water, is generally dry, except during storms. Due to these surface environmental conditions, most of the permanent residents of the upper beach are burrowers, and come out primarily at night. Typical species in these areas are ghost crabs (*Ocypode spp*), hermit crabs (*Pagurus spp*), and sand fiddler crabs (*Uca pugilator*) (USACE, 2014).

Many birds also use the beach for breeding, nesting, and feeding. Gulls (*Larus spp*), sandpipers (*Calidris spp*), sanderlings (*Crocethia alba*), and terns (*Sterna spp.*) are among the most common species found in this area. Residents of the lower beach, below mean low water, are discussed in the benthics section of this document (USACE, 2014).

The most common plant species within the primary and secondary dunes are sea oats (*Uniola paniculata*), seaside goldenrod (*Solidago sempervirens*), sea rocket (*Cakile edentula*), sandspur (*Centrus tribuloidesa*), beach elder (*Iva imbricate*), and American beach grass (*Ammophila breviligulata*). Landward of secondary dune line, tree species that thrive in sandy soils, such as live oak (*Quercus virginiana*) and loblolly pine (*Pinus taeda*), are most common.

Area 1 (continued), Area 2, Area 3, and Area 4

In the remainder of the City, the terrestrial environment found in the vicinity of Pretty Lake, Little Creek, Mason Creek, and Lake Whitehurst of Area 1, and Areas 2, 3, 4, are similar. Over the course of the City's history, habitats and wildlife corridors have been eliminated and/or fragmented; and as a result, very few unaltered habitats remain. According to the City's 2030 Comprehensive Plan, approximately 86% of the City is currently developed; with approximately 10.7% of the land area consisting of recreational and open space; and 3.1% consisting of vacant land (City of Norfolk 2017). As such, many of the terrestrial plant species within the ROI consist of maintained lawns and roadway corridors, and ornamental and nonnative trees. Common native tree species within the City are loblolly pine (*Pinus taeda*), red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), and various oaks (*Quercus spp*).

In general, the City is home to species that are tolerant of human activity and well-adapted to conditions ranging from highly urbanized to suburban (residential). Common amphibians

include various species of toads, frogs, salamanders; and reptiles include various species of snakes, lizards, and terrapins. Non-migratory bird species include species of wading birds, raptors, and songbirds. Common mammals known to occur include rodents (voles, mice, rats, squirrels, groundhogs), eastern cottontail (*Sylvilagus floranus*), raccoons (*Procyon lotor*), opossum (*Didelphis virginiana*), and whitetail deer (*Odocoileus virginianus*). For a more detailed list of wildlife species with the potential to occur within the City, please see the listing from the Virginia Department of Game and Inland Fisheries (VDGIF) database, found in Appendix D.

10.9 PLANKTON

10.9.1 Definition of resource

Plankton are free-floating organisms found in freshwater and marine ecosystems that are largely transported by wind and currents.

Zooplankton form a crucial link in the food chain between the primary producers and higher levels of the food chain. Zooplankton consists of primary consumers (those that eat phytoplankton) and secondary consumers (larger zooplankton that consume the secondary consumers). Zooplankton are then consumed by fishes which are subsequently prey for larger fishes and wildlife (Reshetiloff 1997).

Copepods are tiny crustaceans that are approximately one millimeter long and are the most abundant zooplankton in the Chesapeake Bay and its surrounding tributaries (Chesapeake Bay Foundation 2015). Larval fish and shellfish, which include commercial and recreational fisheries species and species of restoration and management concern, comprise an important component of the zooplankton community. For example, oyster, blue crab, and finfish larvae such as red drum compose the zooplankton community seasonally.

Protozoa are single-celled zooplankton that consume bacteria and decaying plant and animal matter. Bacteria also play a crucial role in the bay and surrounding tributaries because they break down decaying plant and animal matter and provide nutrients in the food chain for higher level organisms. Comb-jellies and jellyfish are larger zooplankton that are visible to the naked eye and have some swimming capability, however, their location is largely driven by tides and currents and therefore, they are still considered zooplankton.

All fish within the Chesapeake Bay and its surrounding tributaries depend, whether directly or indirectly, on zooplankton because of its critical role in the food chain. Some fish such as anchovies, herring, and shad solely feed on zooplankton throughout their entire life cycle (Chesapeake Bay Foundation 2015). Other fish species depend on plankton for a portion of their lifecycle either directly or indirectly through the food chain.

Phytoplankton are able to use the sunlight's energy to produce food via a green pigment called Chlorophyll *a*. The amount of Chlorophyll *a* in the water column is a function of phytoplankton biomass in the water column (Egerton and Marshall 2014). Phytoplankton require Nitrogen and Phosphorous to grow. However, in ecosystems out of balance, elevated phytoplankton biomass can lead to poor water quality and reduced dissolved oxygen levels as excess biomass is not consumed, sinks to the bottom, dies and decomposes, entering the detrital food chain.

10.9.2 Existing Conditions

Refer to Figure 1-2 to see a detailed map of the project areas. The abundance of phytoplankton in the bay and its tributaries is seasonal with the highest abundance occurring during the spring when the highest concentration of nutrients flow into the Bay from melting snow and rain events. Nutrient pollution can cause algal blooms that can reduce oxygen levels in the Chesapeake Bay and its surrounding tributaries (Chesapeake Bay Foundation 2015). During a bloom, phytoplankton may accrue so densely in the water column that sunlight availability for other photosynthetic organisms is diminished. After a bloom, phytoplankton sink to the benthos where it decomposes; this can produce anoxic conditions, which can cause mortality of fish and other benthic organisms.

Zooplankton are the mostly microscopic, free-floating animal life and they are the most abundant animals found in the Chesapeake Bay and its surrounding tributaries (Chesapeake Bay Foundation 2015). Zooplankton abundance is considerably lower in the Elizabeth River as compared to other southern Chesapeake Bay sampling stations and is linked with salinity gradients that occur in this region (Sharp 1995; Birdsong 1993; Buchanan 1991 in USFWS 2002). Elevated levels of copper and zinc in the Elizabeth River are reported to reduce the survival of a zooplankton copepod species and are thought to be linked to the lower abundances of zooplankton within the Elizabeth River (Sunda et al. 1990).

Phytoplankton (microalgae) are tiny, single-celled organisms. Phytoplankton are primary producers because they generate food and oxygen in the Chesapeake Bay and its surrounding tributaries by a process called photosynthesis. To perform photosynthesis, phytoplankton need the energy of sunlight and they are typically found in the upper reaches of the water column. There are hundreds of species of phytoplankton in the Chesapeake Bay but typically, the most abundant phytoplankton in the Chesapeake Bay and its surrounding tributaries are the diatoms and dinoflagellates (Chesapeake Bay Foundation 2015).

Organisms are more tolerant of stressful environments when changes in physical conditions are gradual, occurring over a period of several hours, rather than abrupt (Richmond & Woodin 1996).

10.10 FISH AND FISHERY RESOURCES

10.10.1 Definition of Resource

For the purpose of the Norfolk Coastal Storm Risk Management Project (NCSRM), the ROI is defined as those fish and fishery resources that are present with and adjacent to the project footprint. The bodies of water which may contain affected fish and fishery resources include the Chesapeake Bay, Pretty Lake, Little Creek, the Mainstem and Eastern Branch of the Elizabeth River, and the Lafayette River.

10.10.2 Methodology

The ROI includes all marine and estuarine areas where a structure or fill is being placed for storm surge barriers, tidal gates, floodwalls, pump stations, natural and nature-based features, or other activities associated with the project, including all areas that are filled, dredged, or otherwise converted to another use as a result of implementation of project construction or has

been impacted by previous construction and operation of coastal storm management structures. With implementation of the NCRSM, direct effects to fish and fishery resources would include noise disturbances, turbidity plumes, potential entrainment, and restriction of marine and/or estuarine fish passage. Also included within the ROI are marine/estuarine areas that are either temporarily or permanently altered by implementation of an action alternative. Alterations that would affect fish and fishery resources include shifts in circulation patterns, salinity, turbidity, temperature, nutrient fluctuations, and passage restrictions.

10.10.3 Framework

The Magnuson-Stevens Fishery Conservation and Management Act of 1994 (MSA) applies to federally managed species, and requires federal agencies to identify and describe Essential Fish Habitat (EFH) for fisheries that may be impacted by a potential project. Essential Fish Habitat is defined as “those waters and substrates necessary to fish for spawning, breeding, feeding, or growing to maturity.” The MSA applies to federally managed species under the management of regional fishery management councils. Under the MSA, fishery management plans must identify and describe EFH for the fishery, minimize adverse effects from fishing on the fishery and sustainably manage the resource. “Adverse effect” includes “any impact which reduces quality and/or quantity of EFH, through direct impacts (e.g. contamination or disruption), indirect impacts (e.g. loss of prey, reduction in fecundity), or individual, cumulative, or synergistic impacts.

The Anadromous Fish Conservation Act of 1965 authorizes the Secretaries of the Interior and Commerce to enter into cooperative agreements with the States and other non-Federal interests for conservation, development, and enhancement of anadromous fish. In Virginia, anadromous fish regulations and requirements also fall under the authority of Virginia Department of Game and Inland Fisheries (VDGIF) and the Virginia Marine Resources Commission (VMRC).

The Fish and Wildlife Coordination Act of 1958 requires the USACE to coordinate with the USFWS on water resources related projects to obtain their views toward presentation of fish and wildlife resources and mitigation of unavoidable impacts.

10.10.4 Existing Conditions

The Chesapeake Bay is ranked third in the nation for fisheries; only the Atlantic and Pacific Ocean exceed Bay catch (U.S. Fish and Wildlife Service 2013). The Chesapeake Bay and its tributaries have provided fishing grounds for both commercial and recreational purposes for centuries. Approximately 350 species of fish are known to inhabit the Chesapeake Bay Region. Of these fish species, only 32 species are year-round residents (Chesapeake Bay Program 2016a; National Wildlife Foundation 2016). The remaining species enter the Bay either from freshwater tributaries or the Atlantic Ocean to reproduce, feed, or find shelter.

The fish species in the Chesapeake Bay Region fall into two categories: resident and migratory. Resident fishes tend to be smaller than migratory species and are often found in shallow water, where they feed on a variety of invertebrates. Common resident species include the bay anchovy (*Anchoa mitchilli*), Atlantic silverside (*Menidia menidia*) killifish (Cyprinodontidae), blennies (Bleniidae), skillettfish (*Gobiesox stumosus*), gobies (Gobiidae), pipefish (*Syngnathus*

spp.), lined seahorse (*Hippocampus erectus*), oyster toadfish (*Opsanus tau*), blackcheek tonguefish (*Symphurus plagiusa*), hogchoker (*Trinectes maculatus*), windowpane flounder (*Scophthalmus aquosus*), white perch (*Morone americana*), yellow perch (*Perca flavescens*), and silver perch (*Bidyanus bidyanus*). Although these species are permanent Bay residents, some are considered semi-anadromous, meaning they often move around the Bay and its tributaries due to changes in temperature, water quality, food availability, and for spawning.

Migratory fishes fall into two categories: catadromous or anadromous. Catadromous fishes live in freshwater and travel to high-salinity oceanic water to spawn, while anadromous fishes travel from oceanic, or high salinity areas, to spawn in freshwater streams and rivers. Anadromous fish species in the lower Chesapeake Bay include the Atlantic sturgeon (*Acipenser oxyrinchus*), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), hickory shad (*S. mediocris*), blueback herring (*A. aestivalis*), alewife (*A. pseudoharengus*), Atlantic herring (*Clupea harengus*), and white perch (*Morone Americana*). Catadromous fish species in the Chesapeake Bay ecosystem include the American eel (*Anguilla rostrata*), Atlantic menhaden (*Brevoortia tyrannus*), black drum (*Pogonias cromis*), bluefish (*Pomatomus saltatrix*), and silver perch (*Baridiella chrysura*). The alewife, blueback herring, and shad species have spawning and nursery areas upstream in the James River and other coastal tributaries and use Hampton Roads for passage between upstream and coastal habitats (Klauda et al. 1991a, 1991b). Striped bass and white perch also move through Hampton Roads to spawning and nursery areas upstream in the James River and other coastal tributaries (Setzler-Hamilton 1991a, 1991b). Other anadromous fish travel shorter distances to spawn and occupy a narrower range of salinities (Klauda et al. 1991a, 1991b).

Commercial Fisheries

A significant recreational and commercial fishery exists within the ROI. The most common species in this portion of the lower Bay include spot (*Leiostomus xanthurus*), croaker (*Micropogon undulates*), weakfish (*Cynoscion regalis*), spotted sea trout (*C. nebulosus*), tautog (*Tautoga onitis*), striped bass, Atlantic menhaden, and bluefish (Sherfy 1994; Hoskin 2003 in USACE 2003). Major commercial species found as migrants in the lower Bay and vicinity include: menhaden, summer flounder (*Paralichthys dentatus*), croaker, weakfish, southern kingfish (*Menticirrhus americanus*), bluefish, alewife, blueback herring (*A. aestivalis*), American shad (*Alosa sapidissima*), and scup (*Stenotomus chrysops*). The mouth of the Chesapeake Bay and adjacent Atlantic Ocean also serve as spawning grounds for the croaker, weakfish, red drum (*Sciaenops ocellata*), black drum (*Pogonius cromis*), flounder, menhaden, spot, and black sea bass (*Centropristis straita*) (USACE 2003).

Due to hundreds of years of industry and commerce in the area, rivers and water bodies surrounding and adjacent to the city of Norfolk have become degraded over time. Reduced water quality and increased levels of toxins limit the capacity for fishes and their prey species to survive. For example, a site visit to The Hague on 20 April 2017 by Norfolk District staff revealed that the majority of the bottom was silt, at least two feet thick. There is evidence of small, long-buried oyster reefs in several locations, but these were under at least two feet of silt and no longer living structures. Additionally, there are a number of storm water outfalls that flow into The Hague that carry pollutants and trash from surrounding streets and neighborhoods. There is very little to no shade or cover for fish and no wetlands present at The Hague, making it poor

habitat for fish and their prey.

In the recent past, the Lafayette River was listed as a bacteria-impaired waterway due to high levels of bacteria (fecal coliforms and enterococcus). However, due to diligent work conducted by local, state, and government organizations to improve sewer systems and restore wetlands and oyster reefs, the water quality in the Lafayette River has dramatically improved. In 2016, the river was removed from Virginia's list of bacteria-impaired waterways (CBP 2016). Additionally, as of the summer of 2017, the Lafayette River achieved 93% of its oyster restoration goal, which is the closest to 'fully restored,' for oyster metrics, of any of Virginia's estuarine rivers (ERP 2017).

Over the past 20 years the Elizabeth River Project has aimed to restore and cleanup the impaired waters of the Elizabeth River, although waters throughout the Elizabeth River are currently under fish consumption advisories, and remain degraded. Only limited wetlands in the 20-mile reach remain to support wildlife and filter pollution. This sub-estuary of the Chesapeake Bay provides spawning grounds for fish, habitat for rare terns, peregrine falcons and great egrets, and mud flats for shellfish.

An Essential Fish Habitat Assessment that contains further information about the species and habitat within the ROI is located in the Environmental Appendix (Appendix D) of this document.

10.11 BENTHIC RESOURCES

10.11.1 Definition of Resource

Benthos include organisms living near, in or on the bottom sediments of the various waterbodies included in the present study. They include highly motile forms such as flounder, blue crabs, semi-motile forms capable of relocating short distances in response to changes in their environment, such as hard clams and polychaetes, to sessile invertebrates that remain in place all their adult lives, such as oysters. For purposes of this study, most of these communities are estuarine, however, Lake Whitehurst is a freshwater reservoir so the associated benthos will be freshwater-adapted.

10.11.2 Methodology

The ROI is the bottom under the waters surrounding the city of Norfolk, has been sub-divided into four areas as described in previous sections of this EIS. The regulatory framework for these fauna are described under the Fish and Fishery Resources. There is currently no commercial fishing of benthic mollusks due to environmental contamination and/or bacterial contamination in the project ROI, with none being found immediately off of Willoughby Spit though these could be fished if they were present.

10.11.3 Existing Conditions

Area 1: Willoughby Spit and Ocean View

These are open Bay waters near the confluence of the Bay and the Atlantic Ocean, salinity is typically polyhaline (18-30 PPT (Parts per Thousand)). Bottom conditions in this region are coarse sand to silty sand, of, on average, 0.5 mm in diameter. The only hard bottom habitat is stone breakwaters located intermittently along the shoreline, which is mostly open beach.

Residents of the lower beach, nearshore below mean high water, include annelid worms, such as the lugworm, (*Arenicola marina*), clams (*Donax spp.*) and *Gemma gemma*, the predatory moon snail, (*Euspira heros*), and crustaceans such as the mole crab (*Emerita spp.*). These species provide important ecological functions in coastal environments including cycling of organic matter and nutrition and transfer of both primary and secondary production to surf zone fishes and shore birds. As in most harsh environments, the fauna and flora are limited in number of species, often in number of individuals, and the inhabitants include many examples of extreme adaptation to a specialized way of life. Animals that live in shifting sands on marine beaches are well adapted and tolerate environmental extremes in order to feed, burrow, and reproduce. Subtidal benthos are more extensive, and include commercially important species such as the hard clam, (*Mercenaria mercenaria*), which have been found at low densities in this area (0.26 clams/m²) (Mann et al. 2005). Important predators in this region, besides the moon snail, include The blue crab (*Callinectes sapidus*) and two species of bottom-feeding fishes, spot (*Leiostomus xanthurus*) and hogchoker (*Trinectes maculatus*), all of which feed on the suite of benthic burrowing organisms present, which include those found in the intertidal zone, but with more species of polychaetes, including *Scolelepis squamata*, and additional gastropod snails such as *Acteon punctostriatus*. Many benthic species are prey for economically important species such as the blue crab (*Callinectes sapidus*), striped bass (*Morone saxatilis*), spot (*Leiostomus xanthurus*), and croaker (*Micropogonias undulatus*) (CBP 2016).

The City partnered with USACE to place sand along the Willoughby Beach area to help protect and strengthen the existing beach and dune system. The \$34.5 million Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project was completed in May 2017, consisting of placing sand over a seven mile distance, widening the beach on average at 60 feet, creating a berm to an elevation of 3.5 feet, NAVD88. The beach is expected to be nourished about every seven to nine years. As part of the project, the City will maintain the existing dune system.

Pretty Lake

This is a small, polyhaline embayment that is part of the Little Creek sub-estuarine complex. It is lined with mostly residential development, and while the watershed and shoreline are heavily developed, some salt marsh (*Spartina spp.*) wetlands remain along the shore. It has a narrow opening linking it to the rest of Little Creek. Pretty Lake is being considered for placement of a tidal/storm surge barrier/gate and within its waters impacts from placing a gate could occur. Bottom conditions in this embayment consist of silty sand along with some mud flats and softer bottom. There are also small mitigation oyster reefs in Pretty Lake, they were constructed by others and the status of these reefs is unknown. These reefs are not mitigation for any USACE project. The presence of large numbers of oysters in the low intertidal zone of Pretty Lake indicates it can support a shellfish community, consisting primarily of three species, oysters (*Crassostrea virginica*), ribbed mussels (*Geukensia demissa*) and hard clams (*Mercenaria mercenaria*), though there is no commercial fishing for shellfish in Pretty Lake. Blue crabs (*Callinectes sapidus*) can also be found. Other, non-commercial benthos include common worm species such as *Pelosclex gabriellae*, *Leaeonereis culveri*, *Heteromastus filiformis*, *Streblospio benedicti*, *Capitella capitata*, and *Nereis succinea* as well as suspension feeding spionid polychaetes (*Polydora ligni*, and *Paraprionospio pinnata*), deposit-feeding oligochaetes, subsurface deposit-feeding capitellid polychaetes (*Heteromastus filiformis*, *Capitella spp.*, and *Mediomastus ambiseta*). Non-commercial bivalves likely to be found in Pretty Lake include the

stout razor clam (*Tagelus plebeius*), soft shell clam (*Mya arenaria*), and Baltic clam (*Macoma balthica*).

Lake Whitehurst

This Lake is a freshwater body that serves as a reservoir, one of 11 in the region, for drinking water for the city of Norfolk. It covers 673 acres and drains a watershed of approximately 4.5 square miles. Lake Whitehurst has significant freshwater wetlands along its shoreline, and the watershed is largely urbanized. The Lake provided excellent scenic views, fishing, and recreational boating until 2009 when it was closed to the public due to security reasons as it borders Norfolk International Airport. A wide variety of benthic invertebrates can be found in the reservoir, mostly smaller organisms such as polychaetes. Due to the freshwater nature of the Lake, no oysters or estuarine clams or mussels can be found in the Lake.

Area 2: Lafayette River

This area includes the Lafayette River, the upper-most Eastern Branch of the Elizabeth River, as well as a portion of the Elizabeth River mainstem bordering the western edge of the City. The Lafayette River is being considered for placement of a tidal/storm surge barrier/gate at or near the mouth of the river and within the Lafayette River is the main region in Area 2 where impacts to the benthos could occur. The Lafayette River is a small sub-estuary of the Elizabeth River, ranging in depth from 0.3 to 7.0 meters, with a volume of $9.50 \times 10^6 \text{ m}^3$, a surface area (not counting smaller tributary creeks) of $6.18 \times 10^6 \text{ m}^2$ (1527 acres), and a watershed of approximately 5,438 HA (13,438 acres) encompassing most of the city of Norfolk. The watershed is heavily urbanized and has been for decades, with most of the wetlands within the watershed lost prior to 1950. A navigation channel is maintained for much of the river's mainstem length (up to the Granby Street Bridge). This maintained channel follows the natural channel of the river, with the lower portion, which extends from the mouth of the River to Hampton Blvd, becoming a Federal project and first dredged in the late 1930s and the upper portion, which extends from Hampton Blvd to Granby St, being dredged in the 1970s. The channel has never been dredged in its entirety, only those areas requiring it, so a considerable portion of the channel remains in its natural state. Bottom conditions vary from fine silts and mud in the deep part of the navigation channel as well as portions of the mainstem, especially the upper reaches, except closer to the shoreline where a harder, sandier bottom can be found. The mainstem of the Elizabeth River near its mouth is a region of low diversity and biomass and is generally dominated by small polychaetes. Hard clams (*Mercenaria mercenaria*) can be found in the area, at varying densities, typically 0-3/m² (Mann et al. 2005). Hard clams typically prefer firmer sediments with shell substrate, followed by sand, with mud and anoxic mud being the least preferred habitat (< 0.05 clams/m²) (Mann et al. 2005). Common bivalve species known to occur in the Elizabeth River include the thin-shelled clams (*Macoma balthica*) (the most numerous clam in terms of individuals found), *M. mitchelli* and *M. tenta*, the stout razor clam (*Tagelus plebeius*), as well as the dwarf surfclam (*Mulinia lateralis*), the eastern aligena (*Aligena elevate*), *Anadara* sp., the amethyst gemclam (*Gemma gemma*), and the angel wing clam (*Cyrtopleura costata*). All of these species can also be found in the Lafayette River. The benthic suite of species also includes those found and listed at Pretty Lake. Of special interest in Area 2 is the presence of a large network of ten relict oyster reefs in the Lafayette River, which have not been exploited in decades due to pollution and bacterial contamination. These reefs extend from near the mouth of the River east to the Granby Street Bridge, mostly found on

the upper edges of the main channel of the River. They cover close to 60 acres and a recent (Burke 2014) survey noted almost 17 million oysters on these reefs. They were found at a density of 69 oysters/m², which is considered a thriving reef by the CBP (Chesapeake Bay Program). There is also a large (> 6 acres) mitigation reef near NIT (Norfolk International Terminal), built to compensate for the Craney Island Eastward Expansion (CIEE). Recent (2016) monitoring (Burke and Lipcius 2016) indicates it is also successful based on CBP criteria, which are 50 adults/m² and 50 g/Dry Mass/m². The NGOs the Elizabeth River Project and the Chesapeake Bay Foundation have also restored a number of small reefs in the Lafayette River, these collectively cover several acres including sites near Tanner's Point (1.02 acres), Lafayette NIT (3.5 acres), and near the Hermitage Museum (1.5 acres) (Figure 10-22). If proposed reefs by NGOs in the local region, which have been funded, are constructed, the Lafayette River will be the first "preliminarily restored" River in Virginia waters of Chesapeake Bay according to standards determined under Executive order 13508 on Chesapeake Bay protection and restoration.

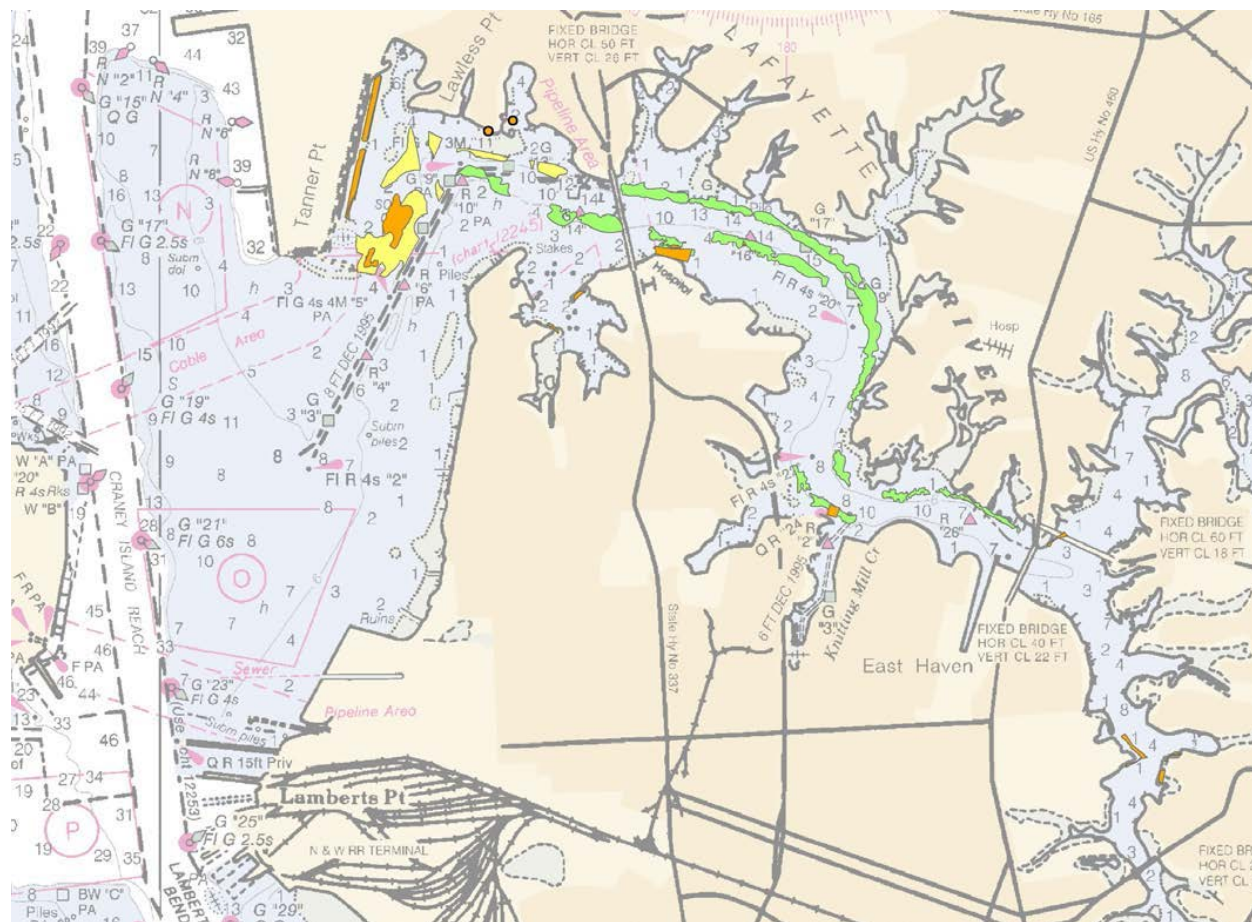


Figure 10-22. Map of the Lafayette River, showing existing oyster reef restoration projects (orange), relict reefs (green), prime restoration bottom (yellow).

Area 3: West Ghent, The Hague, Ft. Norfolk, Downtown, Freemason

This area is dominated by the Hague, a former tidal creek, now mostly filled in except for the confluence area, which covers 18.83 acres. It lies on the Eastern Branch of the Elizabeth River, and its watershed is completely urbanized. The Hague is being considered for placement of a

tidal/storm surge barrier/gate. The shoreline of the Hague consists of a stone wall and is the main area where impacts to the benthos could occur. A survey by the USACE (2017) revealed that the bottom within the Hague consists of over 90% soft silts and fines, to a depth of at least 2 feet. Along the edge of the stone wall bordering the Hague, there is a toe of concrete rubble from 1-2 meters away from the base of the wall. Small, sub-market (< 76 mm) oysters were found on these rocks at low density (< 10/m²). Small numbers of oysters were observed on the stone wall itself, at approximately 2 oysters/m². Ribbed mussels were also found in low densities intermixed with the oysters on the rubble. No live oyster reef habitat was located, though a small buried one lying against the wall directly behind the bridge was located. It likely died and was buried in recent decades, based on what USACE observed it was likely Hurricane Agnes that killed this reef off. It extended approximately 2 meters away from the wall toe at this location. An occasional small hard clam was found living at this location, a common occurrence at buried shell reefs as clams survive at higher rates when burrowed in with mixed shell bottom. The silt/mud community consists of low biomass and diversity and is typically dominated by small worms as described for Pretty Lake. The organisms that colonize this type of benthic habitat are typically a limited suite of small, opportunistic species with a short life cycle, that are adapted to soft bottom environments with frequent disturbance.

Area 4 (Elizabeth River Eastern Branch (Newton's Creek/Tidewater Dr., Broad Creek, Berkley, and Campostella)

The Eastern Branch of the Elizabeth River mainstem has been surveyed using hydroacoustics and bottom grabs by NOAA (2015). The data revealed most of the bottom is silts and mud, though once out of the deeper channel, sand, gravel, and a mix of oyster shell with sand/mud/gravel (including live oysters) can be found in many areas. Broad Creek, which lies on the northern shore of the Eastern Branch, is being considered for a tidal/storm surge barrier/gate and is the main area where significant impacts to the benthos could occur. A floodwall/levee system is being considered along a significant portion of the Eastern Branch of the Elizabeth River. The NOAA survey considered the mouth region of Broad Creek. Based on the bottom conditions, significant oyster reef habitat is not found in or near the mouth of the Creek. Due to the salinity within the creek (mesohaline (at least 5 PSU) to polyhaline (18-30 PSU), the suite of benthic organisms would be similar to those listed for Pretty Lake and the Lafayette River. There are inactive public oyster grounds in the Southern Branch and Eastern Branch of the Elizabeth River, none are close (< 100 m) to any of the proposed construction. None of these public oyster grounds have ever been maintained, and they have been inactive since the 1920s due to bacterial contamination closing the River to oyster harvest.

10.12 SPECIAL STATUS SPECIES

10.12.1 Definition of Resource

In reference to the Endangered Species Act of 1973, as amended, "endangered species" is defined as any plant or animal species in danger of extinction throughout all or a substantial portion of its range. A "threatened species" is any species likely to become an endangered species in the foreseeable future throughout all or a substantial part of its range. "Proposed Species" are animal or plant species proposed in the Federal Register to be listed under Section 4 of the ESA. "Candidate species" are species for which the USFWS and NMFS have sufficient information on their biological status and threats to propose them as endangered or threatened

under the ESA. “Critical habitat” is designated per 50 CFR parts 17 or 226 and defines those habitats that are essential for the conservation of a federally threatened or endangered species and that may require special management and protection.

In reference to the Marine Mammal Protection Act of 1972, as amended, a marine mammal refers to a species found in the U.S. that is classified into one of the following four distinct groups: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walrus), sirenians (manatees and dugongs), and marine fissipeds (polar bears and sea otters). In the ROI for this project, only cetaceans, pinnipeds, and sirenians have the potential to occur in the Action Area.

Migratory birds are defined as those described by the USFWS in the 50 CFR 10.13 and consists of species that belongs to a family or group of species in the United States as well as Canada, Japan, Mexico, or Russia. Most birds native (naturally occurring in the U.S.) to the U.S. belong to a protect family and are protected by the Migratory Bird Treaty Act.

A species qualifies for protection under the Migratory Bird Treaty Act if it meets one or more of the following four criteria:

(1) It (a) Belongs to a family or group of species named in the Canadian convention of 1916, as amended in 1996; (b) specimens, photographs, videotape recordings, or audiotape recordings provide convincing evidence of natural occurrence in the United States or its territories; and (c) the documentation of such records has been recognized by the American Ornithologists Union or other competent scientific authorities.

(2) It (a) Belongs to a family of group of species named in the Mexican convention of 1936, as amended in 1972; (b) specimens, photographs, videotape recordings, or audiotape recordings provide convincing evidence of natural occurrence in the United States or its territories; and (c) the documentation of such records has been recognized by the AOU or other competent scientific authorities.

(3) It is a species listed in the annex to the Japanese convention of 1972.

(4) It is a species listed in the appendix to the Russian convention of 1976.

10.12.2 Methodology

The ROI (or Action Area per 50 Code of Federal Regulation (CFR) 402.02 with respect to federally listed threatened and endangered species), is defined as those areas that have the potential to be directly or indirectly impacted by an alternative as it pertains to Special Status Species. (The terms ROI and Action Area will be used interchangeably in this section).

The ROI/Action Area includes the limits of physical disturbance of the habitat caused by construction and maintenance of the potential structural and nonstructural project features as well as the extent of hydraulic and water quality impacts that have the potential to impact threatened and endangered species. For the extent of the physical, hydraulic, and water quality impacts all areas upstream of the storm surge barriers and tidal gates will be included as well as an area extending 300 feet from these structures and an area extending approximately 100 feet from the remaining structural and nonstructural features. The Action Area is also defined by the

extent of noise impacts as they pertain to threatened and endangered species. For the extent of noise impacts as it pertains to special status species, a maximum size distance from the storm surge barriers of five miles was used.

We compiled lists of the state and federally listed species, marine mammals, and migratory birds that have the potential to occur in the ROI based on the following technical reports and Commonwealth of Virginia and federal databases:

- Information, Planning, and Conservation Database (U.S. Fish and Wildlife Service 2018);
- Virginia Fish and Wildlife Information Service (VaFWIS) Database (Virginia Department of Game and Inland Fisheries 2017);
- Virginia Natural Heritage Database (Virginia Department of Conservation and Recreation 2017);
- Virginia Sea Turtle and Marine Mammal Stranding Network Reports (Swingle et al. 2017-2010; Barco and Swingle 2014); and the
- Virginia Aquarium Stranding Response Program's Vessel Interaction datasets for sea turtles and marine mammals (Virginia Aquarium Foundation/Virginia Aquarium Stranding Response Program 2017a-2017b).

The Biological Assessments submitted to the NMFS and the USFWS provided in Appendix D provides the search results from the federal and state databases.

Nesting Buffers to estimate potential impacts to nesting bald eagles were calculated in accordance with the USFWS National Bald Eagle Management Guidelines (2007). To avoid disturbing bald eagles, a nest buffer is recommended between the human activity and the nest where applicable. Human impacts are considered detrimental to nesting success within the primary buffer and within the secondary buffer human impacts are thought to impact the quality of the primary buffer. The primary buffer is a distance of 330 feet from the nest and the secondary buffer is a distance of 660 feet from the nest. Human activities that are considered detrimental to breeding activities (e.g. development, logging, use of toxic chemicals, etc.) are to be limited within the primary buffer and those that could impact the integrity of the primary buffer are restricted within a secondary buffer (e.g. developments, roadways, etc.). Per the Management Guidelines, a nest buffer of 2,640 feet is recommended from the nest for loud, disturbing noises such as those caused by blasting and other loud, intermittent noises.

10.12.3 Framework

Animals and plants listed as endangered or threatened are protected under the **Endangered Species Act of 1973**, as amended (ESA). The ESA provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range and the conservation of habitats upon which they depend. The law also prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife unless otherwise authorized by the USFWS.

The **Marine Mammal Protection Act of 1972**, as amended (MMPA) prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S. (NOAA, 2016m). All marine mammals in the U.S. are afforded protection under the MMPA.

The term “take” per the Marine Mammal Protection Act is defined as harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal. For most activities “harassment” refers to the act of pursuit, torment, or annoyance which:

- Can injure a marine mammal or a marine mammal stock in the wild which is referred to as Level A Harassment; or
- Has the potential to disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns that include but are not limited to the following: migration, breathing, nursing, breeding, feeding or sheltering which is referred to as Level B Harassment.

The **Migratory Bird Treaty Act (MBTA) and Executive Order 13186 (EO)** requires agencies to protect and conserve migratory birds and their habitats. Any activity that results in the take of migratory birds or eagles is prohibited unless otherwise authorized by the USFWS. (USFWS IPaC, August 2017).

The **American Bald and Golden Eagle Act** requires consideration of impacts on these species. The USFWS National Bald Eagle Management Guidelines (2007) provide general recommendations for land management practices that will benefit bald eagles, describe the potential for various human activities that disturb bald eagles, and encourage land management practices that benefit bald eagles.

10.12.4 Federally Listed Threatened and Endangered Species and Critical Habitat

This section provides a summary of the state and federally listed species that have the potential to occur in the Action Area. The following references were consulted for inclusion of applicable information into this section: Virginia Fish and Wildlife Information Service (VaFWIS) database search within a three mile radius of the Study Area (Virginia Department of Game and Inland Fisheries 2017), Information, Planning, and Consultation System (IPaC) database search (USFWS 2018), the Virginia Natural Heritage Database Search (Virginia Department of Conservation and Recreation 2017), the Virginia Aquarium’s Virginia Sea Turtle and Marine Mammal Stranding Network Reports (Swingle et al. 2017-2010), and the Virginia Aquarium Stranding Response Program’s Vessel Interaction datasets for sea turtles and marine mammals (Virginia Aquarium Foundation/Virginia Aquarium Stranding Response Program 2017a-2017b). A copy of the reports generated from the federal and state databases is provided in Appendix D. While some of the federally listed species in Table 10-4 have critical habitat, there is no designated critical habitat located in the Action Area of this project. We also included the West Indian manatee as it has previously been reported to occur in coastal waters of Virginia (Barco and Swingle 2014).

Table 10-4. Federally listed species known or with the potential to occur in the Study Area.

Taxonomic Category/Common Name	Scientific Name	Status	Critical Habitat
Birds			
Piping plover	<i>Charadrius melodus</i>	T	Y*
Red knot	<i>Calidris canatus rufa</i>	T	Y*

Taxonomic Category/Common Name	Scientific Name	Status	Critical Habitat
Fish			
Atlantic sturgeon (all DPS)	<i>Acipenser oxyrinchus</i>	T, E	Y*
Mammals			
Fin whale	<i>Balaenoptera physalus</i>	E	N
Northern long-eared bat	<i>Myotis septentrionalis</i>	T	N
Sei whale	<i>Balaenoptera borealis</i>	E	N
West Indian manatee	<i>Trichechus manatus</i>	T	Y*
Reptiles			
Green sea turtle (North Atlantic DPS)	<i>Chelonia mydas</i>	T	Y*
Kemp's Ridley sea turtle	<i>Lepidochelys kempii</i>	E	N
Loggerhead sea turtle (Northwest Atlantic DPS)	<i>Caretta caretta</i>	T	Y*

DPS = Distinct Population Segment; T = Threatened; E = Endangered; Y = Yes; N = No; P = Proposed; ^Species status is reported as it pertains to the DPS/Action Area; *Critical Habitat not located in Action Area

Source: (U.S. Fish and Wildlife Service 2018; Virginia Aquarium Foundation/Virginia Aquarium Stranding Response Program 2017a-2017b; Virginia Department of Conservation and Recreation 2017; Virginia Department of Game and Inland Fisheries 2017; Swingle et al. 2017-2010; Barco and Swingle 2014).

Birds

Piping Plover. The piping plover was listed as threatened in January 1986. The piping plover is a small shorebird that nests in the three separate geographic populations in the U.S.: the Great Plains states, the shores of the Great Lakes, and the shores of the Atlantic coast. Birds from all populations winter on the southern Atlantic and Gulf coasts in the U.S. The Atlantic coast population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally South Carolina) and winters along the Atlantic coast from North Carolina south, along the Gulf Coast, and in the Caribbean. (USFWS 1996).

The piping plover is approximately seven inches in length, with a wingspan of about 15 inches. It has a pale brown back and crown, white underparts and rump, and a black upper tail with a white edge. It has an orange bill with black tip, a single breast black breastband, and a black bar across its forehead, and yellow to orange legs. The piping plover forages for invertebrates along the waterline of beaches, and nests in sandy/gravelly depressions away from the water, often within tern colonies. Nest sites are shallow scraped depressions in substrates ranging from fine grained sand to mixtures of sand and pebbles, shells or cobble, usually where there is little or no vegetation. (USFWS 1996). Breeding and wintering plovers forage on exposed wet sand in wash zones. They feed by probing for invertebrates that are found at or below the surface.

Piping plovers can be found in Virginia from spring through fall. In Virginia breeding and nesting

is currently restricted to the Eastern Shore barrier islands (VDGIF 2016a). Plovers nest on ocean-facing beaches with little vegetation. Extensive beaches with wash-over habitat that have access to mudflats, sandflats, and tidal lagoons provide optimal nesting habitat for this species (VDGIF 2016a). According to VDGIF and USACE, they have been documented within the Action Area, in the northern portion of, and within 0.75 mile of, the southern portion of the Craney Island Dredged Material Management Area (CIDMMA). This species previously nested at CIDMMA, however, nesting has not occurred since 1997. Since 1998, USACE staff have observed migrating piping plovers foraging at CIDMMA in the early spring and again in the late summer during migration. Therefore, this species may occur and forage within the Action Area but it does not currently nest in the Action Area.

Since its listing in 1986, the overall species population has increased 234%, from 790 pairs to an estimated 1,849 pairs; and the U.S. population has almost tripled from approximately 550 pairs to an estimated 1,596 pairs. However, its population growth pattern remains unstable. For example, in the Southern recovery unit, there had been a 68% decline between 1995 and 2001, prior to an overall increase between 1989 and 2008 of 66%, with almost three-quarters of this increase occurring in two years: 2003-2005. The main threats to the species are habitat loss and degradation, predation (particularly by dogs and cats), human disturbance, and more recently, wind turbines and climate change. Oil spills also are a potential threat to this species.

Critical habitat has been designated for this species in Illinois, Indiana, Michigan, Minnesota, New York, Ohio, and Pennsylvania, but there is no designated critical habitat in Virginia.

Red Knot. The red knot was listed as threatened in 2014. Red knots are characterized by their large, bulky sandpiper body form and a short, straight bill that tapers at the tip. Their head and breast are reddish in color during the breeding season but gray in color during the rest of the year. Red knots are known for their extensive migrations that can occur more than 9,300 miles from the Tierra del Fuego to the Canadian Arctic (USFWS 2016b). The decline of the red knot population in the 2000s is thought to be attributed to degrading foraging habitats. Delaware Bay is a key stopover for migrating red knots before they reach their breeding grounds in the Canadian Arctic. Horseshoe crab harvests in Delaware Bay are now under management to help recover the red knot population. There is no nesting habitat within the Action Area, however, foraging may occur in the Action Area. Red knots are thought to be vulnerable to the increasing threats of climate change that may impact the arctic tundra ecosystem in their breeding areas, coastal foraging habitats and other foraging habitats, and storm and weather changes (USFWS 2016b). Within the past few years, the population is thought to have stabilized but still remains at low population levels (USFWS 2016b).

Fish

Atlantic Sturgeon. Atlantic Sturgeon that are spawned in U.S. rivers, or are captive progeny of Atlantic sturgeon that were spawned in U.S. rivers, are listed under the ESA as five Distinct Population Segments (DPSs). They are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs. The range of the five overlaps and extends from Canada through Cape Canaveral, Florida. They can be found in major rivers, estuaries, bays and coastal waters along the eastern seaboard of the United States. The Chesapeake Bay is known to be used by all five DPSs. The Gulf of Maine DPS was federally listed as threatened and the

rest were listed as endangered on February 6, 2012 (NOAA 2016a).

Atlantic sturgeon are an anadromous bony fish that are distinguishable from other fish by five rows of bony scutes along the length of their body, a protrusible mouth, and heterocercal tail. They are slow growing and late maturing, and have been recorded to reach up to 16 feet in length and 60 years of age. They are bottom feeders that suck food into a ventrally-located protruding mouth. The diet of adult and subadult includes mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish. (NMFS 2012).

Spawning for the Chesapeake Bay DPS is only known to occur in the James River outside of the Action Area. It may be occurring in other tributaries to the Chesapeake Bay, but this has not been confirmed. Spawning migrations generally occur during April-May in Mid-Atlantic systems; water temperature plays a primary role in triggering the timing. Male sturgeon begin upstream spawning migrations when waters reach approximately 6°C (43°F), and remain on spawning grounds through the spawning season. Females begin spawning migrations when temperatures are closer to 12°C to 13°C (54-55°F), make rapid spawning migrations upstream, and quickly depart following spawning. Spawning is believed to occur in flowing water between the salt front of the estuaries and the fall line of large rivers, when and where optimal flows are 46-76 cm/s and depths are three to 27 meters. Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock. At temperatures of 20°C and 18°C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition. Larval Atlantic sturgeon are assumed to inhabit the same riverine or estuarine areas where they were spawned. Studies show that egg and larvae through age two sturgeon occur in low salinity waters; as such, no eggs, larvae, or young of the year are likely to occur in the Action Area. However, older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters. Atlantic sturgeon may remain in the natal estuary for months to years before migrating to open ocean as subadults (NMFS 2012).

Adults will pass through the northern limits of the Action Area as they move to the James River to spawn in the spring, and then again as they return to the ocean. Subadults could be present in or near the Action Area year-round, but are less likely to be present in the winter months when individuals would be at overwintering areas, which are not known to occur in the Action Area. (NMFS 2012).

The USACE, Norfolk District has documented the presence of the Atlantic Sturgeon within the lower Chesapeake Bay. During sea turtle relocation trawling conducted in fall of 2003 in conjunction with the 50-foot deepening of the inbound element of the Thimble Shoal Channel, 14 Atlantic sturgeon were captured by the trawler and released live in and around the channel; no incidental takes of Atlantic sturgeon by hopper dredge were observed during this period. Additionally, the incidental take of two Atlantic sturgeon were documented in York Spit Channel during April of 2011 while conducting maintenance dredging operations with a hopper dredge. The York Spit Channel is not within the Action Area for this project. The noted incidental takes and relocations of the Atlantic sturgeon in the lower Chesapeake Bay are associated with hopper dredging operations that are known to pose a risk of entrainment.

Historically, this species had range-wide declines due to overfishing and the caviar market. Currently, the most significant threat for all five DPSs is by-catch in fisheries. Other significant

threats are vessel strikes, poor water quality, water availability, dams, and dredging. Records show that 11 Atlantic sturgeon were struck by vessels between 2005 and 2007 in the James River, which is northwest of the Action Area (NMFS 2012).

In 2017 NMFS designated Critical Habitat for the Gulf of Maine, New York Bight, and Chesapeake Bay DPSs of Atlantic sturgeon in the Federal Register. These locations are in Maine, New York, New Jersey, Pennsylvania, Maryland, and Virginia. The locations in Virginia include the Potomac, Rappahannock, York, and James Rivers, out to their confluence with the Chesapeake Bay. In Virginia, the designated critical habitat is not located in the Action Area (Figure 10-23).

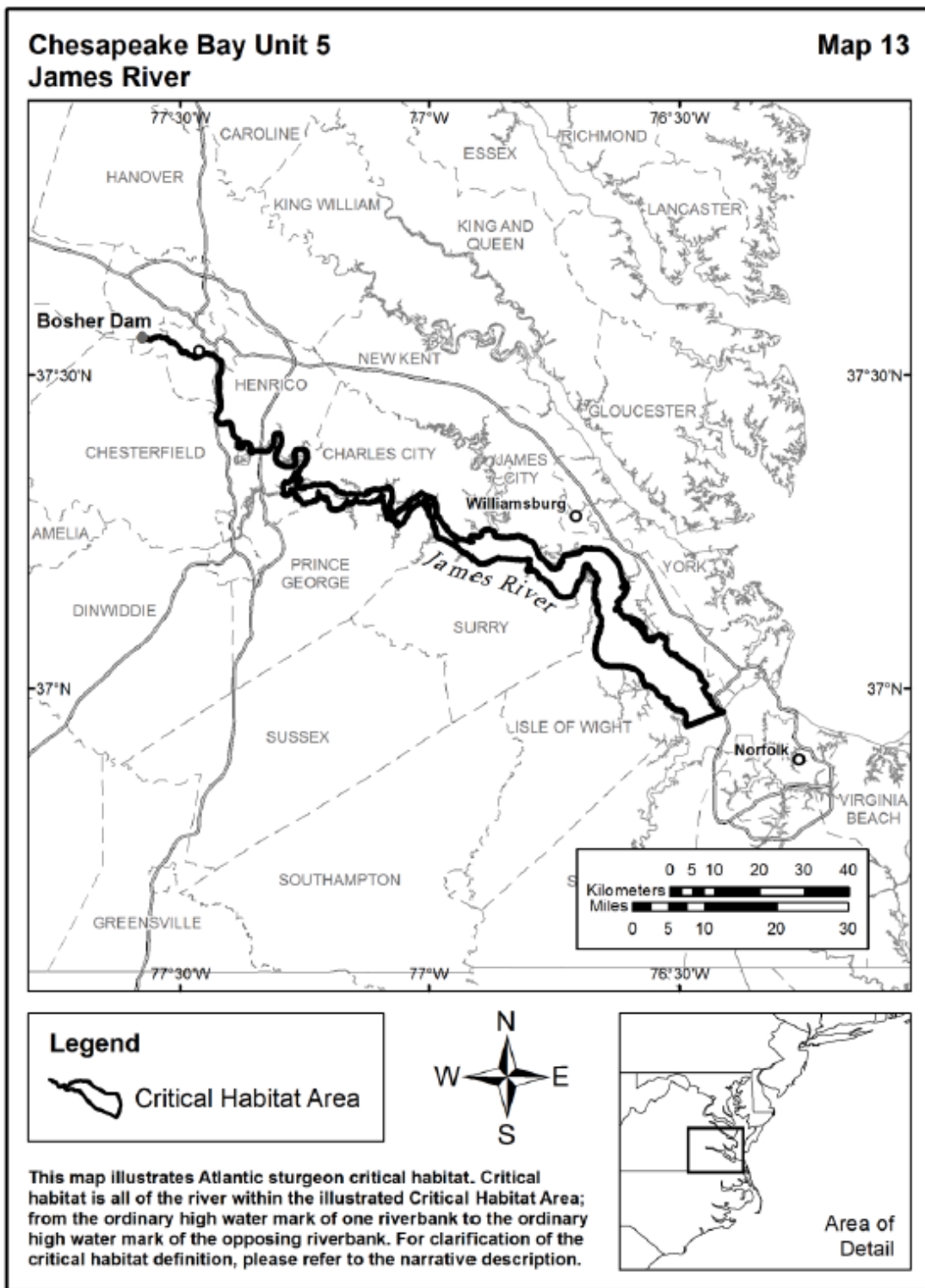


Figure 10-23. Critical habitat for the Atlantic Sturgeon in the James River, Virginia (area within the limits of the heavy, bold line)

Mammals

Fin Whale. The fin whale was listed in endangered in 1970. Fin whales are characterized by their sleek, streamlined body with black or dark brownish-gray coloration on the top and sides

with a white underbelly. Fin whales are second in size only to the blue whale and can reach a maximum length of 85 feet and can weigh up to 160,000 pounds (NOAA 2013). Females are typically longer than males and can be as much as 10% longer. Fin whales occasionally hybridize with blue whales (NOAA 2013). Fin whales typically occur in social groupings that consist of 2-7 fin whales (NOAA 2013). In the North Atlantic, fin whales sometimes congregate to feed with other whales and dolphins (Jefferson et al. 2008 in NOAA 2013). They forage on krill, small schooling fish, and squid except in the winter when they are fasting. The only reported predator of the fin whale is the killer whale.

Fin whales are distributed in a wide range of latitudes and longitudes typically in deep, offshore waters worldwide (NOAA 2013). There are two subspecies of fin whale (*B. physalus* that occurs in the North Atlantic and *B. physalus quoyi* that occurs in the Southern Atlantic Ocean) (NOAA 2013). The Western North Atlantic Stock is estimated at 1,678 whales (NOAA 2013).

Commercial whaling greatly depleted the fin whale but was ended in most locations by 1987. Fin whales are still hunted in Greenland subject to the catch limits of the IWC. Poaching and also resumed commercial whaling are potential threats to this species (NOAA 2013). Other threats include ship strikes, entanglement in fishing gear, low prey abundance from overfishing, habitat degradation, and noise disturbance (NOAA 2013). Based on a database that consisted of all reported whale ship strikes from 1975 through 2002, fin whales were struck more than any other whale species with 75 out of 292 strikes (Jensen and Silber 2003).

Northern Long-Eared Bat. The USFWS listed the northern long-eared bat threatened in 2015, with no designated critical habitat. The most severe threat attributed to the substantial population decline of the northern long-eared bat has been the widespread spread of the White-Nosed Syndrome that is caused by the fungal infection *Pd* (*Pseudogymnoascus destructans*).

The Action Area is located within the managed White-Nose Syndrome Buffer Zone as defined by the USFWS (2015b). Populations in Virginia are thought to have declined by 96% and are anticipated to decline with the continued spread of the White-Nose Syndrome (VDGIF 2014, unpublished data in USFWS 2015a). The northern long-eared bat is dark brown on its back with lighter coloration underneath with a wingspan of approximately nine to 10 inches and is approximately three to four inches in body length (USFWS 2015a). This bat is distinguished from other similar bat species in its genus by the length of its ears that extend past its nose when folded. During the winter, northern long-eared bats hibernate in caves and mines called hibernacula. During the summer, this species roosts beneath bark and in cavities of both live and dead trees (snags). They will also roost in human-made structures such as culverts, barns, and sheds. Females give birth to one young during the summer. There are no known surveys of this species in the Action Area so it unknown if they forage in the Action Area. No reported natural hibernacula are located in the Action Area. It is unknown if northern long-eared bats migrate through the Action Area.

Sei Whale. The sei whale was listed as Endangered in 1970. Sei whales are characterized by a dark bluish-gray body that is pale underneath with a dorsal fin that is located approximately two-thirds of the way down the back. They have a single ridge on their rostrum which distinguishes them from other whale species. Sei whales can reach up to 60 feet and weigh 100,000 pounds. The whale is listed as endangered throughout its range and has a worldwide

cosmopolitan distribution throughout subtropical, temperate, and subpolar waters although they prefer temperate waters in mid-latitudes; they are found in the Atlantic, Indian, and Pacific Oceans. Sei whales in the U.S. are divided into the Hawaiian Stock, Eastern North Pacific Stock, Nova Scotia Stock, and Western North Atlantic Stock. The estimated worldwide population is approximately 80,000 whales with the Hawaiian Stock containing approximately 40 – 80 whales and the eastern north Pacific stock containing approximately 35 – 55 whales (NOAA 2016h). There are no other stock assessments available in the U.S. The full distribution and migratory patterns of this species are largely unknown. Populations are thought to migrate to the lower latitudes in the winter and the higher latitudes during the summer. They are typically found in oceanic areas far from coastlines.

Sei whales were largely depleted during the 19th and 20th century from commercial hunting and whaling with a loss of an estimated 300,000 whales (NOAA 2016h). Other contributing threats to the sei whale population include potential impacts from ship strikes and entanglement in fishing gear (NOAA 2016h). Jensen and Silber (2003) reported three ship strikes worldwide to the sei whales in a database compiled that consisted of all reported ship strikes through 2002. The sei whale population in the Southern Atlantic Ocean is still largely depleted while the whales are more abundant in the North Atlantic and North Pacific (NOAA 2016h).

The sei whale forages on plankton, small fish, and cephalopods. Sei whales are often spotted in small groups of approximately two to five whales. They are the fastest swimming cetaceans, reaching speeds of 34.5 miles per hour (NOAA 2016h).

West Indian Manatee. The West Indian manatee is listed as a federally listed species throughout its range. It can be found along the coast of Florida and in the Caribbean. Adult manatees are about 10 feet long and weigh from 800 to 1,200 pounds. These docile animals feed on aquatic vegetation and move slowly through the water, often resting just below the water's surface with only its snout above water. They prefer large slow-moving rivers, river mouths, and shallow coastal areas. According to U.S. Fish and Wildlife Service, "The animals may travel great distances as they migrate between winter and summer grounds. During the winter, manatees congregate around warm springs and around power plants that discharge warm water. During summer months, they have occasionally been seen as far north as Virginia and Maryland." (USFWS 2008). Barco and Swingle (2014) documented the occurrence of the West Indian manatee in coastal waters of Virginia. There is no resident manatee population in the Action Area and the presence of a manatee in the Action Area would be considered a rare occurrence.

Sea Turtles

Five sea turtle species are found in the U.S. Atlantic Ocean: green, hawksbill, Kemp's Ridley, leatherback, and loggerhead sea turtles. Sea turtles often migrate long distances from nesting beaches to their foraging grounds. The Atlantic and Gulf waters serve as important foraging and developmental areas for sea turtles when water temperatures are warm enough. As water temperatures warm in the spring, sea turtles begin to migrate northward, typically arriving in Virginia waters as early as April/May and on the more northern foraging grounds in New England in June. This trend is reversed in the fall as water temperatures cool with most sea turtles leaving New England by fall (NOAA 2016g). Sea turtles may be in Virginia waters from

April through mid-November with the greatest number of sea turtles present from June through October (NMFS 2012). Based on the sea turtle nesting database compiled by the USACE of the long-term monitoring records from the Virginia Marine Aquarium and the VIMS, no sea turtle nesting occurs in the Action Area.

Green Sea Turtle. The green sea turtle was listed as endangered in Florida, and threatened elsewhere in the US, in July 1978. However, on April 6, 2016, NMFS superseded this with a Federal Register announcement of 11 worldwide DPSs for this species, the North Atlantic DPS being inclusive of this region. The range of this DPS extends from the boundary of South and Central America, north along the coast to include Panama, Costa Rica, Nicaragua, Honduras, Belize, Mexico, and the United States East Coast. The range extends due east across the Atlantic Ocean to include a portion of the west coast of Africa. It was re-listed as a threatened species (Federal Register, 81 FR 20057).

Green turtles are the largest of all the hard-shelled sea turtles, but have a comparatively small head. Its carapace is smooth with shades of black, gray, green, brown, and yellow. Adults can grow to three feet in length and weigh up to 300 pounds. Juveniles are omnivorous feeding on both benthic invertebrates as well as algae and sea grasses. Adults are largely herbivorous, feeding on algae and sea grasses. They occur seasonally in mid-Atlantic waters such as the Chesapeake Bay and the Long Island Sound, which serve as foraging and developmental habitat. The principal feeding areas for the species are the west coast of Florida, the Florida Keys, and the Yucatan Peninsula (NMFS 2012). Although not likely, juveniles have the potential to forage in the Action Area.

According to NMFS, nesting has increased considerably since the 1970s. By far the most important nesting grounds for the Western Atlantic population remains in Costa Rica. In the U.S., nesting mostly occurs in Florida, although it has recently been recorded in North Carolina, at Bald Head Island and the Cape Hatteras National Seashore (NMFS 2012). Its critical habitat in the U.S. is confined to Puerto Rico (NMFS 2012).

Kemp's Ridley Sea Turtle. The Kemp's Ridley sea turtle was listed endangered in 1970. According to NMFS, Kemp's Ridley is one of the least abundant of the world's sea turtles; it is mostly found in the Gulf of Mexico and the northwestern Atlantic Ocean. The majority of nesting occurs along a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico. In the U.S., nesting is limited to South Texas, where a record 195 nests were found in 2008. Nesting occurs from April through July each year, with hatchlings emerging after 45-48 days. Once they leave the nesting beach, hatchlings are distributed in both Gulf of Mexico and Atlantic Ocean (NMFS 2012).

Adult Kemp's Ridelies are the smallest marine turtle in the world. Their carapaces are often grayish-green, and nearly circular. Each of the front flippers has one claw while the back flippers may have one or two. Adults can reach 24-28 inches in length, and can weigh up to 100 pounds. Developmental habitats are defined by several characteristics, including coastal areas sheltered from high winds and waves such as embayments and estuaries, and nearshore temperate waters shallower than 50 m. Kemp's Ridelies eat a variety of crab species, with mollusks, shrimp, and fish consumed less frequently. (NMFS 2012).

The threats to the species are similar to those of other sea turtle species. Interactions with fisheries may be particularly high for Kemp's Ridleys. In addition, they may be more susceptible to oceanographic-related events such as cold-stunning. From 2006-2010, an average annual rate of 115 Kemp's Ridleys were found cold-stunned on Cape Cod. Populations reached their lowest recorded point in 1985, when fewer than 300 nesting females were identified. Populations began to recover in the 1990s; and by 2006, there were an estimated 7,000-8,000 Kemp's Ridley turtles (NMFS 2012). In 2014, there were a total of 10,986 nests recorded in Mexico, so there is cautious optimism; but not high enough numbers to declassify the species as of yet (NMFS and USFWS 2015).

NMFS documents that the Chesapeake Bay is among the foraging areas documented for this species. In the Bay, Kemp's Ridleys frequently forage in submerged aquatic grass beds for crabs.

Loggerhead Sea Turtle. The loggerhead sea turtle was listed as threatened in July 1978. The NMFS indicates that the loggerhead is the most abundant species of sea turtle in U.S. waters. The Northwest Atlantic DPS loggerhead is found in temperate and subtropical waters, from Florida to Cape Cod. Aerial surveys of continental shelf waters north of Cape Hatteras showed that loggerheads were most commonly sighted in waters with bottom depths ranging from 22 to 49 meters. However, in more recent survey data and satellite tracking data support that they occur in waters from beach to beyond continental shelf, in a range of habitats including offshore waters, continental shelves, bays, estuaries, and lagoons. They have been observed in waters with surface temperatures of 7°C to 30°C, but water temps of greater than 11°C are most favorable. They occur year-round in the ocean waters of North Carolina, South Carolina, Georgia, and Florida (NMFS 2012).

Loggerheads were named for their relatively large heads. They have powerful jaws that enable them to feed on hard-shelled prey, such as whelks and conch. Their carapaces are slightly heart-shaped and reddish-brown in adults and subadults, while the undersides are generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom. Adults can reach lengths of three feet and weigh up to 250 pounds. (NOAA 2016g).

As coastal water temperatures warm in the spring, loggerheads begin to migrate to inshore waters of the Southeastern U.S., and also move up the U.S. Atlantic coast. They arrive in Virginia foraging areas as early as April and May. The majority of the nesting occurs on beaches of the southeastern U.S. Within its range, nesting season occurs late April to early September and hatching season late June through early November. Juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface. Subadults and adults are primarily coastal dwelling and typically prey on benthic invertebrates such as mollusks and decapods crustaceans in hard bottom habitats. The loggerhead is a long-lived species with an average life span of 57 years (NMFS 2012).

Threats to species include by-catch in fisheries, interactions with vessels and dredges, oil spills, and other marine pollution in the water; and habitat loss, nesting predation or disturbance that affects eggs, hatchlings, and nesting females on land. Based on a five-year status review of the species, which discussed a variety of threats to loggerheads including climate change, NMFS

and USFWS determined that they should not be delisted or reclassified. A NMFS model in 2009 had suggested that the populations are most likely declining, although overall nesting population remains widespread, and the trend for nesting population appears to be stabilizing (NMFS 2012).

Critical habitat designated for this species includes the coastlines of Texas, Louisiana, Florida, and North Carolina, and areas well offshore of Mississippi, Alabama in the Gulf of Mexico, and well offshore of Georgia, South Carolina, and Virginia, in the Atlantic Ocean. Therefore, no critical habitat exists within the Action Area (NOAA 2016d).

Bald Eagle

Although the bald eagle is no longer federally listed, the USFWS National Bald Eagle Management Guidelines (2007) provide general recommendations for land management practices that will benefit bald eagles, describe the potential for various human activities that disturb bald eagles, and encourage land management practices that benefit bald eagles.

To avoid disturbing bald eagles, a nest buffer is recommended between the human activity and the nest where applicable. Human impacts are considered detrimental to nesting success within the primary buffer and within the secondary buffer human impacts are thought to impact the quality of the primary buffer. The primary buffer is a distance of 330 feet from the nest and the secondary buffer is a distance of 660 feet from the nest. Human activities that are considered detrimental to breeding activities (e.g. development, logging, use of toxic chemicals, etc.) are to be limited within the primary buffer and those that could impact the integrity of the primary buffer are restricted within a secondary buffer (e.g. developments, roadways, etc.). Per the Management Guidelines, a nest buffer of 2,640 feet is recommended from the nest for loud, disturbing noises such as those caused by blasting and other loud, intermittent noises.

Marine Mammals

Table 10-5 provides a comprehensive listing of marine species documented to occur throughout the coastal waters of Virginia as documented in the marine mammal stranding record from 1988-2013 (Barco and Swingle 2014). 'Historic' refers to published accounts for the species. For these species, no animals were in the Virginia stranding record from 1988-2013.

Table 10-5. Marine Mammal Species in Stranding Records from Virginia, 1988-2013

Taxonomic Category/Common Name	Scientific Names	Strandings
Baleen Whales		
Bryde's whale	<i>Balaenoptera brydei</i>	historic
fin whale*	<i>Balanoptera physalus</i>	11
humpback whale	<i>Megaptera novaeangliae</i>	33
minke whale	<i>Balaenoptera acutorostrata</i>	9
northern right whale*	<i>Eubalena glacialis</i>	4
sei whale*	<i>Balaenoptera borealis</i>	2
Delphinids		
Atlantic spotted dolphin	<i>Stenella frontalis</i>	4
Atlantic white-sided dolphin	<i>Lagenorhynchus acutus</i>	14

Taxonomic Category/Common Name	Scientific Names	Strandings
bottlenose dolphin	<i>Tursiops truncatus</i>	1,593
Clymene dolphin	<i>Stenella clymene</i>	C. Potter, pers. Comm
common dolphin	<i>Delphinus delphis</i>	98
long-finned pilot whale	<i>Globicephala melas</i>	14
melon headed whale	<i>Peponocephala electra</i>	2
panropical spotted dolphin	<i>Stenella attenuata</i>	historic
pygmy killer whale	<i>Feresa attenuata</i>	3
Risso's dolphin	<i>Grampus griseus</i>	22
rough toothed dolphin	<i>Steno bredanensis</i>	14
	<i>Globicephala</i>	
short-finned pilot whale	<i>macrorhynchus</i>	7
striped dolphin	<i>Stenella coeruleoalba</i>	16
Other toothed whales		
Cuvier's beaked whale	<i>Ziphius cavirostris</i>	historic
dwarf sperm whale	<i>Kogia sima</i>	10
Gervais' beaked whale	<i>Mesoplodon europaeus</i>	6
harbor porpoise	<i>Phocoena phocoena</i>	318
pygmy sperm whale	<i>Kogia breviceps</i>	24
Sowerby's beaked whale	<i>Mesoplodon bidens</i>	2
sperm whale*	<i>Physeter macrocephalus</i>	1
True's beaked whale	<i>Mesoplodon mirus</i>	1
Pinnipeds		
grey seal	<i>Halichoerus grypus</i>	15
harbor seal	<i>Phoca vitulina</i>	82
harp seal	<i>Pagophilus groenlandica</i>	38
hooded seal	<i>Cystophora cristata</i>	12
Sirenians		
West Indian manatee*	<i>Trichechus manatus</i>	annual sightings

*Species is federally listed in Virginia under the protection of the Endangered Species Act.

Source: Table reproduced courtesy of Barco and Swingle 2014.

We also added starred in this table those species that are federally listed in Virginia as of the date of this report. The humpback whale, West Indies Distinct Population Segment, the only humpback population segment that occurs in Virginia, is no longer federally listed but is still afforded protection under the Marine Mammal Protection Act.

Table 10-6 provides the reported marine mammal strandings in the Region of Influence/Action Area from 2009-2016 (Swingle et al. 2017-2010). The location of these marine mammal strandings is provided in Figure 10-24.

Table 10-6. Marine Mammal Strandings Reported in the Region of Influence/Action Area, 2009-2016

bottlenose dolphin	common dolphin	fin whale	gray seal	harbor seal	harbor porpoise	pilot whale	sei whale	unidentifiable delphinid	unidentifiable <i>Kogia sp.</i>
109	4	1	1	4	1	1	1	1	1

Source: (Swingle et al. 2017-2010)

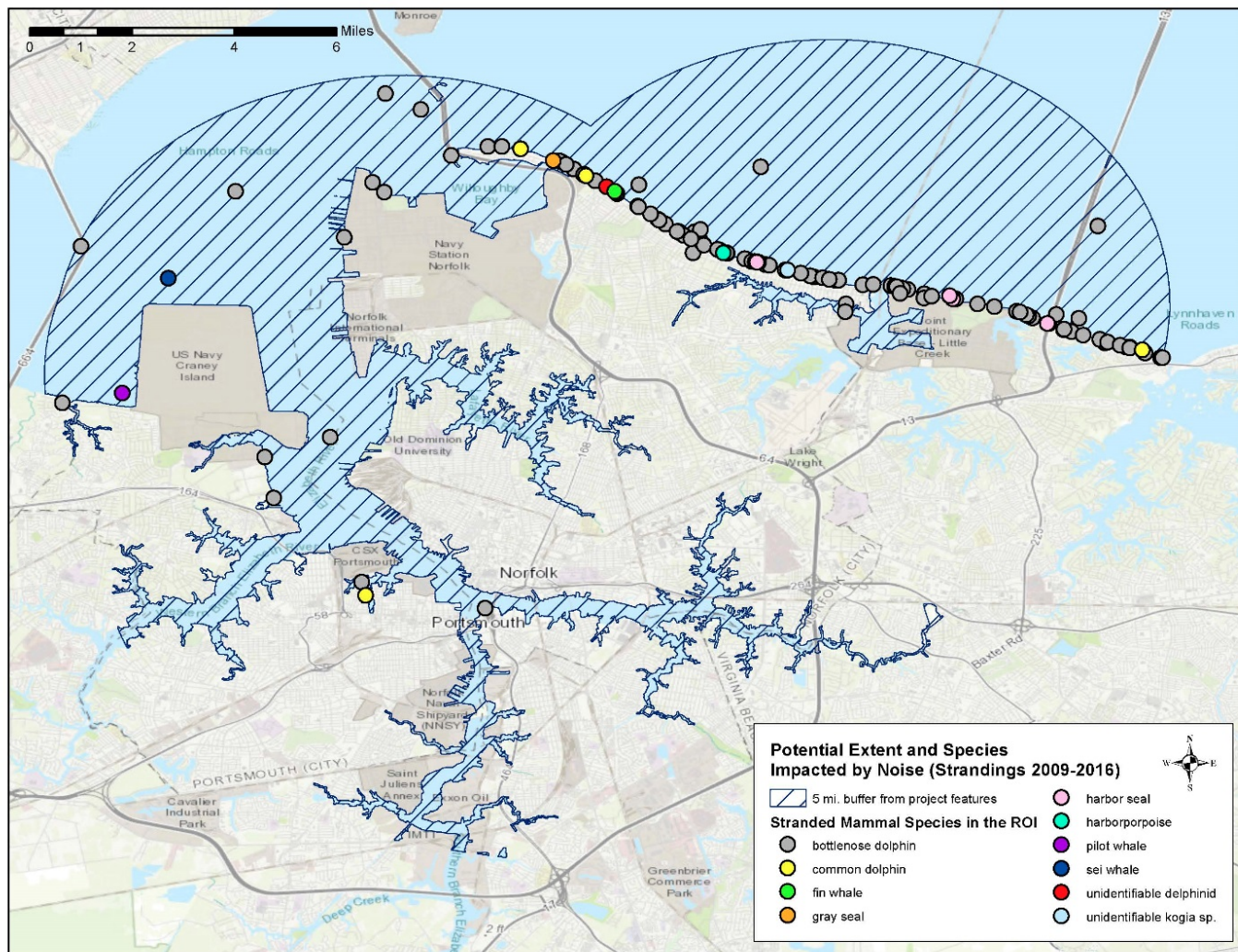


Figure 10-24. Marine Mammal Strandings Reported in the Region of Influence/Action Area, 2009-2016

Source: (Swingle et al. 2017-2010).

Figure 10-25 and Figure 10-26 display the extent of the buffers for noise and water quality impacts with regard to marine mammals and sea turtles that have stranded in the area from 2009-2016 (Swingle et al. 2017-2010). The maps presented below have been used to help determine the marine mammal and sea turtle species that have the potential to occur and/or be affected by potential project impacts in the Action Area.



Figure 10-25. Displays the extent of anticipated water quality impacts to aquatic Special Status Species.

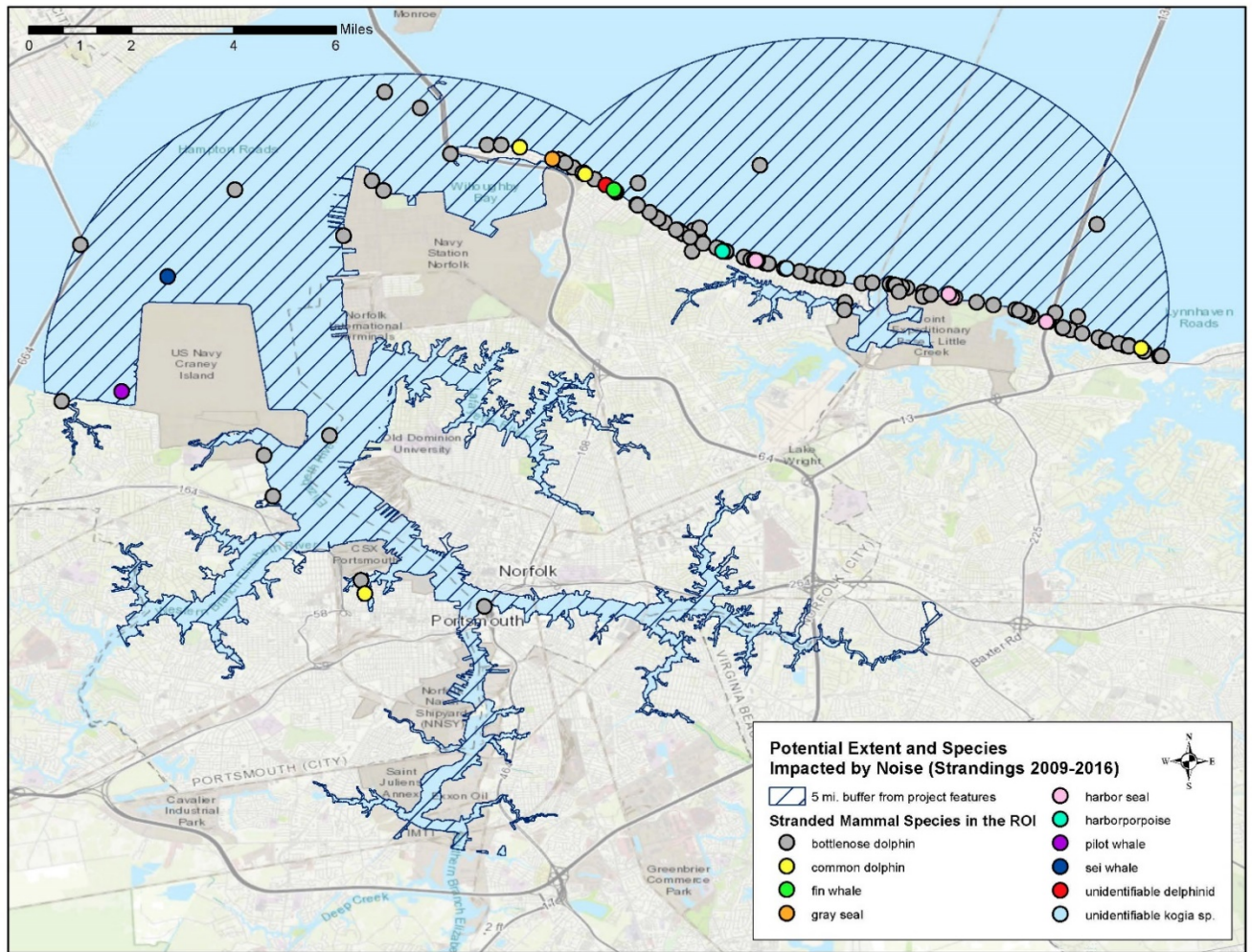


Figure 10-26. Stranded Marine Mammals Reported in the Region of Influence/Action Area from 2009-2016
 Source: (Swingle et al. 2017-2010).

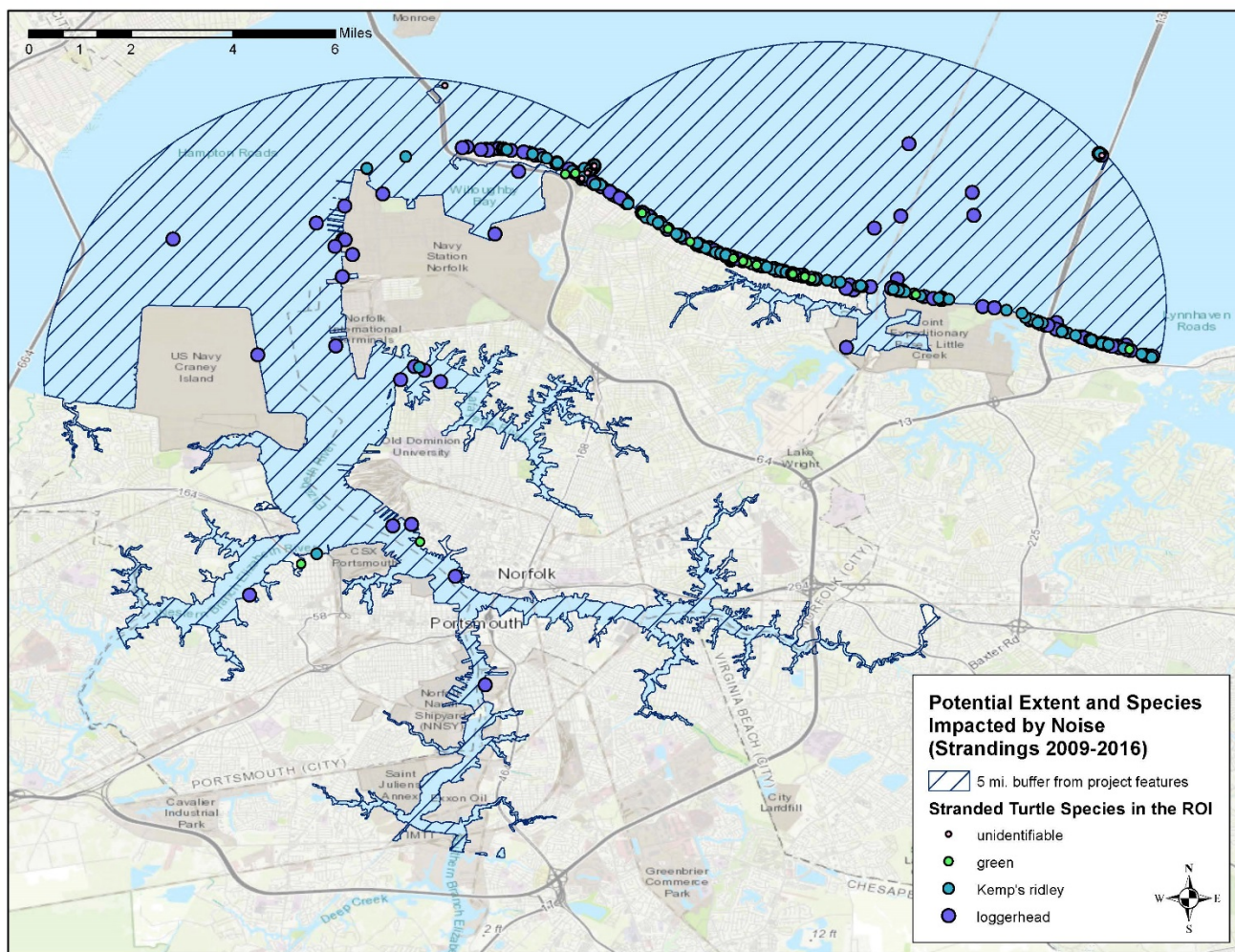


Figure 10-27. Stranded sea turtles reported in the Region of Influence/Action Area from 2009- 2016

Source: Swingle et al. 2017-2010

10.12.5 Species Protected under the American Bald and Golden Eagle Act of 1972

Bald eagle. Once federally-listed as endangered, the bald eagle (*Haliaeetus leucocephalus*) has made a remarkable comeback. It is currently protected under the American Bald and Golden Eagle Act, and the Migratory Bird Treaty Act; and also remains a state-listed threatened species. Bald Eagles breed throughout much of Canada and Alaska, in addition to scattered sites across the lower 48 states, from California to the southeastern U.S. coast and Florida. Wintering covers most of the contiguous U.S., with some year-round distribution in the northwest.

A large raptor, the bald eagle has a wingspread of about seven feet. Adults have a dark brown body and wings, white head and tail, and a yellow beak. Juveniles are mostly brown with white mottling on the body, tail, and undersides of wings.

Bald Eagles typically breed and winter in forested areas adjacent to large bodies of water. However, such areas must have an adequate food base, perching areas, and nesting sites.

Throughout its range, it selects large, super-canopy roost trees that are open and accessible. Nests are constructed from an array of sticks placed in an interwoven pattern. Other materials added as fillers may include grasses, mosses, even corn stalks.

10.12.6 Species Protected under the Migratory Bird Treaty Act of 1918 and Executive Order 13186

Migratory birds nest throughout North America, some as far north as the Arctic. In late summer and fall, they migrate south for the winter. Some winter in the southern United States, Mexico, the Caribbean or Central America while others go as far as South America. Then, each spring they return north to their breeding grounds. Many migratory songbirds, shorebirds, and raptors rest and refuel here during their spring and fall migrations. Others winter south and return to the Chesapeake Bay watershed each spring to breed.

Migratory bird species that may be in or pass through the ROI (USFWS 2017) are provided in Table 10-7.

Table 10-7. Migratory Birds in the ROI

Common Name	Scientific Name
American Bittern	<i>Botaurus lentiginosus</i>
American Kestrel	<i>Falco sparverius paulus</i>
American Oystercatcher	<i>Haematopus palliatus</i>
Bald Eagle	<i>Haliaeetus leucocephalus</i>
Black Rail	<i>Laterallus jamaicensis</i>
Black Skimmer	<i>Rynchops niger</i>
Black-throated green warbler	<i>Dendroica virens</i>
Brown-headed nuthatch	<i>Sitta pusilla</i>
Fox Sparrow	<i>Passerella iliaca</i>
Gull-billed Tern	<i>Gelochelidon nilotica</i>
Hudsonian Godwit	<i>Limosa haemastica</i>
Least Bittern	<i>Ixobrychus exilis</i>
Least Tern	<i>Sterna anillarum</i>
Lesser Yellowlegs	<i>Tringa flavipes</i>
Loggerhead Shrike	<i>Lanius ludovicianus</i>
Marbled Godwit	<i>Limosa fedoa</i>

Nelson's Sparrow	<i>Ammodramus nelsoni</i>
Peregrine falcon	<i>Falco peregrinus</i>
Pied-billed Grebe	<i>Podilymbus podiceps</i>
Prarie Warbler	<i>Dendroica discolor</i>
Prothonotary Warbler	<i>Protonotaria citrea</i>
Purple Sandpiper	<i>Calidris maritima</i>
Red Knot	<i>Calidris canutus rufa</i>
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>
Rusty Blackbird	<i>Euphagus carolinus</i>
Saltmarsh Sparrow	<i>Ammodramus caudacutus</i>
Seaside Sparrow	<i>Ammodramus maritimus</i>
Sedge Wren	<i>Cistothorus platensis</i>
Short-billed Dowitcher	<i>Limnodromous griseus</i>
Short-eared Owl	<i>Asio flammeus</i>
Snowy Egret	<i>Egretta thula</i>
Swainson's Warbler	<i>Limnothlypsis swainsonii</i>
Whimbrel	<i>Numenius phaeopus</i>
Wood Thrush	<i>Hylocichla mustelina</i>
Worm Eating Warbler	<i>Helmitheros vermivorum</i>
Yellow Rail	<i>Coturnicops noveboracensis</i>

State Listed Endangered and Threatened Species

Table 10-8 provides additional state listed species in addition to those that are federally listed that have the potential to occur within a three-mile radius of the ROI (VDGIF 2017). There are only two known populations of the eastern chicken turtle (*Deirochelys reticularia reticularia*); one population is in the Isle of Wight County and the other is at First Landing State Park in Virginia Beach. Both of these areas are outside of the ROI for this project and therefore, there would be no impacts to this species and it is dismissed from further consideration. State-listed birds and bats have the potential to forage within, migrate through, and stopover in the ROI. The canebrake rattlesnake (*Crotalus horridus*) has the potential to forage and breed in the ROI. However, it is uncertain if they occur or breed in the ROI. Barking treefrogs (*Hyla gratiosa*) would have the potential to forage and breed in the ROI as they can occur in brackish wetlands

in the southeastern U.S. However, after initial coordination with the Virginia Department of Environmental Quality (VDEQ), and the Virginia Game and Inland Fisheries (VDGIF) through the Coastal Zone Management Act (CZMA), neither of these species were identified as being likely to be impacted by this project.

Table 10-8. State Listed Species with the potential to occur in the Region of Influence.

Common Name	Scientific Name	State Status
Eastern chicken turtle	<i>Deirochelys reticularia reticularia</i>	Endangered
Ratnesque's eastern big eared bat	<i>Corynorhinus ratnesquii</i>	Endangered
Black rail	<i>Laterallus jamaicensis</i>	Endangered
Tri-colored bat	<i>Perimyotis subflavus</i>	Endangered
Canebrake rattlesnake	<i>Crotalus horridus</i>	Endangered
Peregrine falcon	<i>Falco peregrinus</i>	Threatened
Loggerhead shrike	<i>Lanius ludovicianus</i>	Threatened
Barking treefrog	<i>Hyla gratiosa</i>	Threatened
Migrant loggerhead shrike	<i>Lanius ludovicianus migrans</i>	Threatened

10.13 CULTURAL RESOURCES

10.13.1 Definition of Resource

Several federal laws and regulations have been established to manage cultural resources, including the National Historic Preservation Act (NHPA) of 1966, the Archeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archeological Resource Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1990. In addition, DoDI 4710.02, *Department of Defense Interactions with Federally-Recognized Tribes* (2006) governs DoD interactions with federally-recognized tribes and EO 13175, *Consultation and Coordination with Indian Governments* (2000), charges federal departments and agencies with regular and meaningful consultation with Native American tribal officials in the development of policies that have tribal implications. There are seven federally recognized tribes in Virginia but only one with a state recognized reservation, the Pamunkey Indian Tribe. Other than their 1200 acre reservation, when it enters federal trust, there are no federal tribal lands and no treaty rights areas in Virginia. In order for a cultural resource to be considered significant, it must meet one or more of the following criteria for inclusion on the National Register of Historic Places (NRHP):

“The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and: a) that are associated with events that have made a significant contribution to the broad patterns of our history; or b) that are associated with the lives or persons significant in our past; or c) that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or d) that have yielded, or may be likely to yield, information important in prehistory or history” (36

CFR 60.4).

10.13.2 Methodology

The significance of a property under NHPA as a historic and cultural resource can be determined only when it is evaluated within its historic context. Historic contexts compile information about the time period, the place, and the events that created, influenced, or formed the backdrop to the historical resources. A single property may represent more than one historic context, and conversely, numerous property types may represent a single historic context. For the purposes of the Affected Environment chapter we will look at the entire area of the city of Norfolk as the Region of Influence (ROI), narrowing to more specific potential effects on historic properties in the Environmental Consequences chapter.

In order to be considered a historic and cultural resource as defined by NHPA, a property must demonstrate significance within its historic context. Significance is evaluated by applying the following four criteria, which define the kind of significance that a property can represent. A property need only meet one criterion to be considered a historic and cultural resources under NHPA. The criteria are:

- Association with events that have made a substantial contribution to the broad patterns of our history;
- Association with the lives of persons substantial in our past;
- 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 values, 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.

An assessment of integrity must be completed on any resource to determine if it retains the ability to represent its significance as a historic and cultural resource under NHPA. A property that retains integrity will embody several, and usually most, of the seven aspects of integrity (NPS 1997):

1. *Location* is the place where the historic property was constructed or the place where the historic event occurred;
2. *Design* is the combination of elements that create the form, plan, space, structure, and style of a property;
3. *Setting* is the physical environment of a historic property;
4. *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;
5. *Workmanship* is the physical evidence of the crafts of a particular culture or people during a given period in history or prehistory;
6. *Feeling* is a property's expression of aesthetic or historic sense of a particular period of time; and
7. *Association* is the direct link between an important historic event or person and a historic property.

10.13.3 Framework

Table 10-9 presents those laws, regulations, EOs, and policies that protect and preserve historic resources under the jurisdiction of federal agencies.

Table 10-9. Laws, Regulations, Executive Orders, and Guidelines

Law/Regulation	Title
16 USC 461-467	Historic Sites Act of 1935, and Implementing Regulations
36 CFR § 65	National Historic Landmarks Program
Public Law 89-665	National Historic Preservation Act of 1966
36 CFR § 60	National Register of Historic Places
36 CFR § 67	The Secretary of the Interior's Standards for Rehabilitation
36 CFR § 68	The Secretary of the Interior's Standards for Preservation Projects
36 CFR § 79	Curation of Federally Owned Archaeological Resources
36 CFR § 800	Protection of Historic and Cultural Properties
Public Law 91-190	National Environmental Policy Act of 1969
Public Law 96-95	Archaeological Resources Protection Act of 1979
32 CFR § 229	Protection of Archaeological Resources
43 CFR §7	Protection of Archaeological Resources, Uniform Regulations and Department of the Interior Supplemental Regulations
Public Law 101-601	Native American Graves Protection and Repatriation Act of 1990
43 CFR §10	Native American Graves Protection and Repatriation
16 USC 469c-2	Archaeological and Historic Preservation Act of 1974
42 USC 1996-1996a	American Indian Religious Freedom Act of 1978
EO 11593 (1971)	Protection and Enhancement of the Cultural Environment
EO 13007 (1996)	Indian Sacred Sites – May 24, 1996
EO 13175 (1998)	Consultation and Coordination with Indian Tribal Governments

10.13.4 Existing Conditions

Archeological and Historical Setting

Earliest human inhabitation of the Americas remains one of the most debated issues in archaeology, but Native Americans began to inhabit the Chesapeake Bay region over 12,000 years ago. Many of the sites left by the 'Paleo-Indians' of this period may now be submerged on the bottom of the bay and the Atlantic continental shelf; sea-levels during the Wisconsin Glaciation of the Pleistocene epoch, or Ice Age, were some 400 feet below contemporary levels.

During the Archaic Period, 8000 – 1200 BCE (Before Common Era, synonymous with B.C.), populations were evidently low, but grew considerably. The Archaic Period is divided into Early (8000-6500 BCE), Middle (6500 to 3000 BCE) and Late (3000 to 1200 BCE) Archaic Periods. Along with increasing population, there is evidence of an increased diversity in resources

hunted and gathered for food, with a particularly notable expansion in fishing and shellfish gathering.

Around 1200 BCE, people in the region began making and using pottery. This marks the beginning of the Woodland Period, also divided into Early (1200-500 BCE), Middle (500 BCE to CE 900), and Late (CE 900-1600) Woodland Periods. There seems to have been little change in settlement between the Late Archaic and Early Woodland Periods, apart from the use of pottery, but during the Middle Woodland people seem to have dispersed into smaller, though perhaps more sedentary settlements. It was during this period that the maize-beans-squash crop combination of American Indians was adopted in the region. During the Late Woodland Period, populations increased with the expansion of agriculture, as did political hierarchy. Village districts consisting of a series of hamlets, or in the native language “hattos” were strung along the shores of the major estuaries, with a nucleated, often palisaded chief’s residence central to them. This was the state of native culture in the Chesapeake Bay region during early exploration and settlement, and the direct historical accounts of that period give the name Protohistoric Period to 1600-1650 CE. John Smith’s map, based on observations made in 1608, shows no native settlements in the vicinity of the project area.

English Captain Arthur Barlowe explored what would later be called the Elizabeth River in 1584, and described the area as an extensively inhabited settlement called Skicoak. When the Jamestown colonists arrived in the area in 1607, the Norfolk and Virginia Beach areas were inhabited by the Chesapeake, who no longer had a village in the vicinity of downtown Norfolk called Skicoak. The larger Native American sites in the Tidewater region of Virginia are most often located on points and near the mouths of major tributaries, and often include artifacts from several, sometimes all of the periods of prehistory. Norfolk would have been a very appealing area for settlement to Native Americans for both good agricultural lands and abundant aquatic resources. Their absence in 1607 is thought by some to have been the result of conflict with Powhatan as he expanded his realm.

History of Area 1: Pretty Lake-Ocean View-Willoughby

Historical records indicate that the first European settler in the Willoughby-Ocean View area was Thomas Willoughby, who came to Virginia in 1610, settled in Hampton, and moved to what is now Norfolk in the 1630s. He received several land grants in southeastern Virginia from King James I, including a 500-acre parcel in Ocean View about 1625. Later he acquired additional land west of Little Creek along the shore and constructed a home known as “Willoughby Hope” on high ground overlooking the bay. His son, Thomas II, and other descendants lived there for more than 100 years.

Popular accounts indicate Willoughby Spit was initially formed during a hurricane in 1749 as a sandy shoal at the end of Willoughby Point. Subsequent storms, including one in 1806, built up the shoal until it grew into a sizeable spit known as Willoughby’s Sand Point or Sandy Point and today as Willoughby Spit. However, it was not until 1807 that the spit first appeared on maps, indicating that the feature might have actually developed somewhat later than popular reports indicated.

The area to the east of Willoughby Spit and west of Little Creek was originally a 360-acre tract called the Magagnos Plantation. In 1854, the tract was surveyed with lots, streets laid out, and

named Ocean View City. An 1863 Coast Survey chart shows a cluster of 5 buildings near the later location of Ocean View pier and amusement park. No inhabitation is shown for Willoughby Spit at that time. A narrow gauge steam passenger rail line between Ocean View and what is now downtown Norfolk was begun in 1879, and a large hotel was built at the terminus. Little development occurred in the area until after the turn of the century, with a few additional buildings around the hotel but little other development in Ocean View, and still none at all on Willoughby Spit. This was to change dramatically in only a few years with the expanding system of electric-powered streetcars. A building boom ensued as the trolley lines extended from Norfolk to Sewells Point for the Jamestown Exposition in 1907, and elsewhere to Ocean View and to the end of Willoughby Spit. In just a few years these were lined with houses as the new transportation system made the beaches accessible suburban residential areas. By the beginning of the 20th century an amusement park had been built at the end of the streetcar line and a boardwalk adjacent to it along the beach. This was common throughout the country, where trolley lines also extended electrical power to the amusement parks.

Area 2: The Lafayette River Basin

There was little in this area but farms until the 20th century. Suburban development began in the World War I era as the Naval Base was founded in 1917. In 1930 the Norfolk Division of the College of William and Mary opened in the old Larchmont (elementary) School building. This would prove to be the founding of what became Old Dominion College in 1962 and then Old Dominion University 1969. World War II would bring even greater military activity with the Army establishing a depot just south of the Naval Base, and most of this area, the neighborhoods of Larchmont, Colonial Place, Park Place, Riverview, and Winona arose during or between the wars.

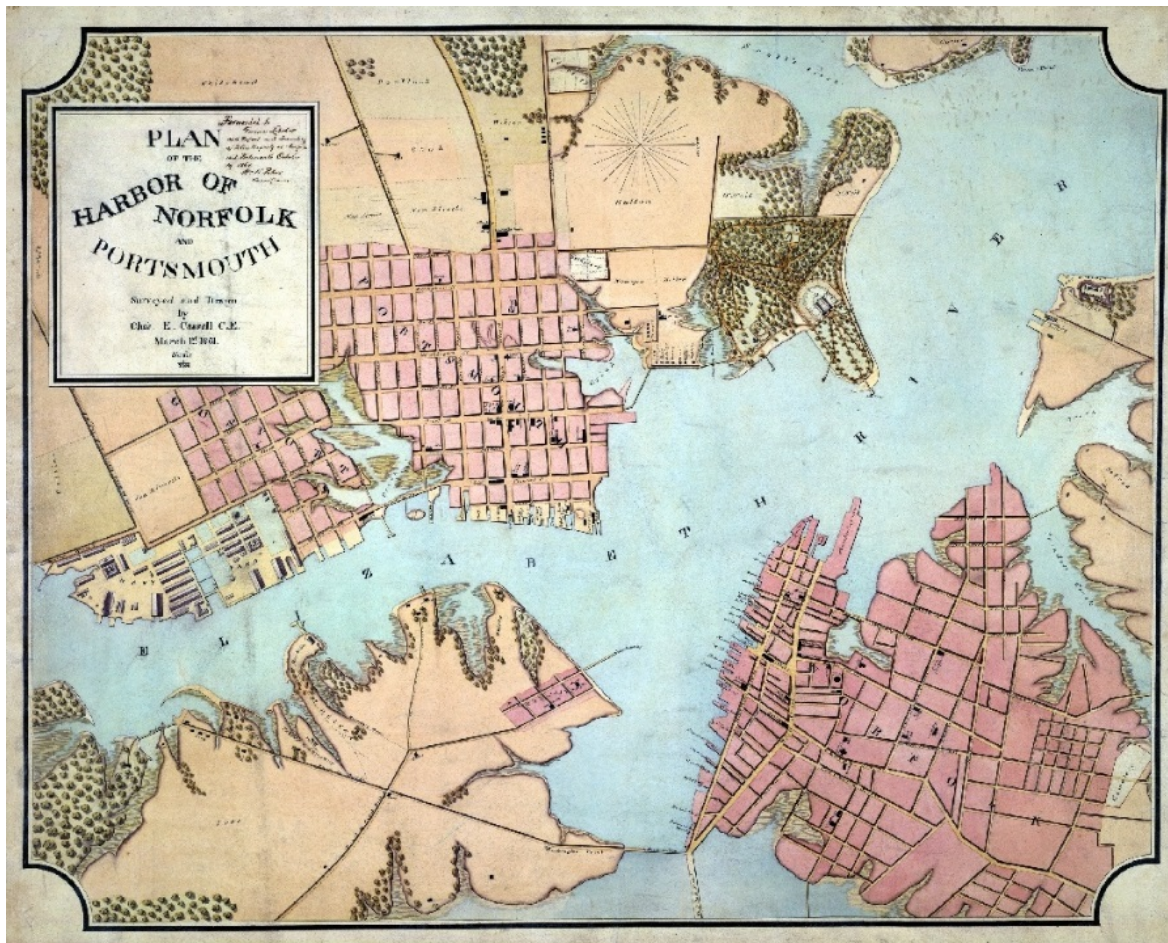


Figure 10-28. 1861 Map of Norfolk

Area 3: Ghent and Downtown

The city of Norfolk, which was a part of Norfolk County, was incorporated as a borough in 1705 and granted a royal charter in 1736. By 1775, the city had developed into one of the most prosperous cities in Virginia. It was a major shipbuilding center and an important export point for tobacco, corn, cotton, and timber and an import point for rum, sugar, and manufactured products and was incorporated as a city in 1845. Throughout the 18th and early 19th centuries settlement was focused on what is now the downtown area, which at the time was nearly an island with creeks extending inland on either side of the little peninsula roughly where City Hall Avenue is today. Beyond this only the West Freemason Street area was developed. By 1861 with commerce continuing strong the city had expanded beyond Bute Street, despite the disastrous yellow fever epidemic of 1855. The waterfront from Town Point to near the current site of the Berkley Bridge was lined with wharves, warehouses, and shipyards, shown in detail on an 1861 map. The area around Fort Norfolk and Ghent remained rustic. In contrast, in the 1891 map the street system had expanded dramatically to the west, spreading to Ghent and West Ghent, and with Smith's Creek being steadily filled in to become the sculpted body of water which came to be known as the Hague. Many streams and wetlands were filled during the late 19th and early 20th century, a trend no doubt increased with Walter Reed's identification of mosquitos as the carriers of yellow fever.

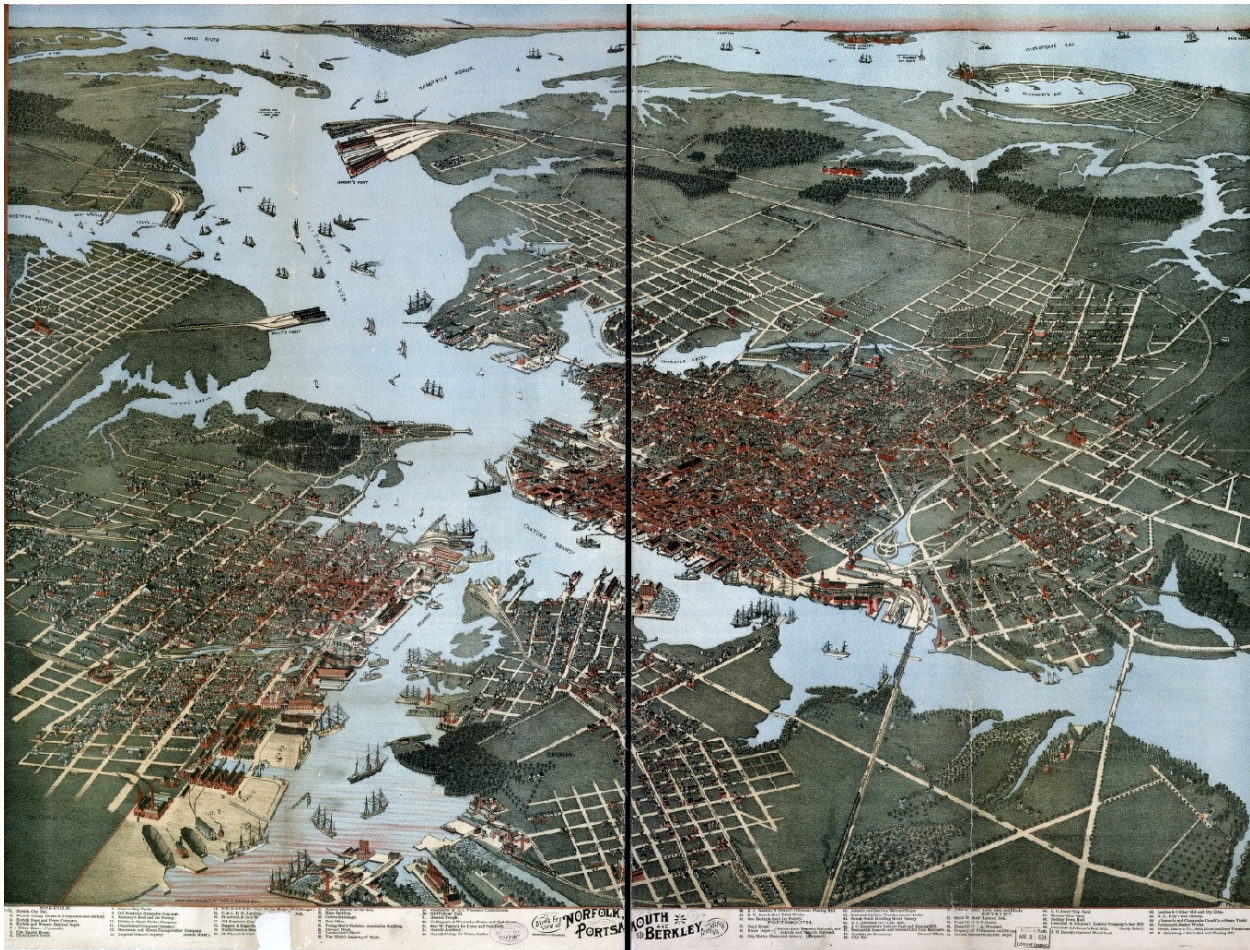


Figure 10-29 1891 Bird's Eye View Map of Norfolk, Portsmouth, and Berkley

Area 4: Eastern Branch of the Elizabeth River and Broad Creek

Berkley, Campostella, and other areas along the Eastern Branch of the Elizabeth River developed well after Norfolk and Portsmouth had become sizable towns. In 1861 south of the river was mostly open land, with a small community called Ferry Point the only development, but by 1891 the area had filled out with both industrial and residential development, and Berkley gains equal billing with Norfolk and Portsmouth on a “birds eye view” map produced at the time (Figure 10-29). Further development came as the demands of both military and civilian maritime kept ship yards along both shores of the Eastern Branch busier than ever in the 20th century, joined in 1925 by the Ford Norfolk Assembly Plant which produced millions of vehicles over its 82 year period of operation.

Inventory of Historic Properties in Norfolk

As of May 25, 2017 there were 104 properties in the city of Norfolk that have been either listed in the NRHP, determined eligible for listing, or are considered potentially eligible. Many of these properties are historic districts, some with very large numbers of contributing properties. If all of the contributing properties in listed or eligible historic districts are counted along with the individual listed or eligible properties, the total is 6474. Only 45 archaeological sites have been recorded within the city limits, and only two of these 44NR0009 and 44NR0012 have been determined NRHP eligible, although 44NR0001 contributes archaeological significance to

NRHP listed Fort Norfolk. Individual properties and historic districts listed in, determined eligible or potentially eligible for listing in the NRHP are mapped (with the exception of archaeological sites) in Figure 10-30 and listed in Table 10-10. Those properties in the Virginia Landmarks Registry (VLR) are also indicated. While VLR does not affect the NRHP Section 106 process, the VLR listing puts the property under the protection of the Virginia Antiquities Act.

Table 10-10. Current Status of Historic Resources in Norfolk (VDHR 2017)

DHR ID/Study Area	Property Name	NRHP Status
122-0001/Area 3	Allmand-Archer House (Historic/Current), House, 327 Duke Street (Function/Location)	NRHP Listing, VLR Listing
122-0002/Area 2	Boush, John, House (Historic), Boush-Tazewell House (Historic)	NRHP Listing, VLR Listing
122-0007/Area 3	Fort Norfolk (NRHP Listing)	NRHP Listing, VLR Listing
122-0008/Area 3	Freemason Street Baptist Church (Historic)	NRHP Listing, VLR Listing
122-0016/Area 3	Kenmure (Historic), Lamb, William Wilson, House (Historic)	NRHP Listing, VLR Listing
122-0017/Area 3	Moses Myers House (Historic/Current)	NRHP Listing, VLR Listing
122-0018/Area 3	Norfolk Academy (Historic), Norfolk Juvenile Court (Historic)	NRHP Listing, VLR Listing
122-0019/Area 3	MacArthur Memorial (Current), Norfolk City Hall (Historic)	NRHP Listing, VLR Listing
122-0021/Area 3	Purdy-Whittle House (Historic), Taylor-Whittle House (Current), Whittle House (Historic)	NRHP Listing, VLR Listing
122-0024/Area 4	St. Mary's Catholic Church (Historic/Current), St. Mary's Church (Historic/Current)	NRHP Listing, VLR Listing

122-0025/Area 3	Borough Church (Historic), St. Paul's Episcopal Church (Historic/Current)	NRHP Listing, VLR Listing
122-0032/Area 3	U.S. Customs House (Historic/Current)	NRHP Listing, VLR Listing
122-0033/Area 3	Willoughby-Baylor House (Historic)	NRHP Listing, VLR Listing
122-0040/Area 3	First Baptist Church (Historic/Current)	NRHP Listing, VLR Listing
122-0043/Area 2	L.R. Associates Apartments (Current) Lafayette Grammar and High School (Historic), Lafayette I.D.P. Center (Historic)	NRHP Listing, VLR Listing
122-0045/Area 4	Poplar Hall (Historic/Current)	NRHP Listing, VLR Listing
122-0047/Area 4	Church of Christ Disciples (Historic), St. James Holiness Church (Current), St. Peter's Episcopal Church (NRHP Listing)	NRHP Listing, VLR Listing
122-0054/Naval Base (not in study))	Admirals Row, Jamestown Quarters (Current), Jamestown Exposition Historic District (Descriptive), Jamestown Exposition Site Buildings (Historic/Current)	NRHP Listing, VLR Listing
122-0058/Area 3	U.S. Post Office and Courthouse (Historic), Walter E. Hoffman U.S. Courthouse (Current)	NRHP Listing, VLR Listing
122-0060/Area 3	West Freemason Street Area Historic District (NRHP Listing), West Freemason Street Historic District (Historic/Current)	NRHP Listing, VLR Listing
DHR ID	Property Name	NRHP Status

122-0061/Area 3	Ghent Historic District (NRHP Listing)	NRHP Listing, VLR Listing
122-0066/Area 3	Monticello Arcade (Historic/Current)	NRHP Listing, VLR Listing
122-0067/Area 3	Wells Theatre (Historic)	NRHP Listing, VLR Listing
122-0070/Area 2	Cphoon House (Current), Sycamore View (Historic)	DHR Staff: Eligible
122-0073/Area 4	First Calvary Baptist Church (Historic/Current)	NRHP Listing, VLR Listing
122-0074/Area 4	Crispus Attucks Theatre (Historic/Current)	NRHP Listing, VLR Listing
122-0075/Area 3	Christ and Saint Luke's Church (Historic), Christ Church (Historic), St. Luke's Episcopal Church (Historic/Current)	NRHP Listing, VLR Listing
122-0076/Area 2	Hermitage Foundation Museum (Current), Hermitage Museum (Current)	DHR Staff: Eligible
122-0077/Area 3	Collier, George C., Skipjack (Historic), Skipjack Allegheny(Historic), Skipjack Norfolk(Current)	DHR Staff: Eligible
122-0078/Area 3	Auslew Gallery (Current), Old Virginia Bank and Trust Building (Historic), Southern Bank of Norfolk (Historic), Virginia Bank and Trust (Historic), Virginia Savings Bank (Historic)	NRHP Listing, VLR Listing
122-0082/Area 3	Old Norfolk City Hall (Historic), U.S. Post Office and Courts Building (Historic)	NRHP Listing, VLR Listing

DHR ID	Property Name	NRHP Status
122-0100/Area 4	Brambleton Baptist Church (Historic), Freemason Baptist Church Sunday School (Historic), Park Avenue Baptist Church (Historic), Shiloh Baptist Church (Current)	DHR Board Det. Eligible
122-0104/Area 3	Cedar Grove Cemetery (Historic/Current)	DHR Board Det. Eligible
122-0110/Area 3	Norfolk United Methodist Church (Current), Zion Methodist Episcopal Church (Historic)	NRHP Listing, VLR Listing
122-0111/Area 2	Cedar Level (Historic), Hardy House (Current), Talbot-Cocke House (Historic)	DHR Staff: Eligible
122-0116/Area 3	Elmwood Cemetery (Historic/Current)	NRHP Listing, VLR Listing
122-0121/Area 3	Center Theater/Arena Municipal Auditorium (Historic), Harrison Opera House (Current Name)	DHR Staff: Eligible
122-0143/Area 3	Birtcherd's Dairy (Historic)	DHR Staff: Eligible
122-0165/Area 3	Queen Street Baptist Church (Historic)	NRHP Listing, VLR Listing
122-0171/Area 3	Lorraine Hotel (Historic), Thomas Nelson Hotel (Current)	DHR Staff: Eligible
122-0178/Area 3	Epworth United Methodist Church (Historic)	NRHP Listing, VLR Listing
122-0187/Area 3	Andrew Carnegie Free Public Library (Descriptive), Norfolk	DHR Staff: Eligible

	Theatre Centre (Historic), Old Norfolk Public Library (Historic/Current)	
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DHR ID	Property Name	NRHP Status
122-0193/Area 3	Charlie Falk's (Function/Location), Falk's Auto (Function/Location), Hudgins-Luhring Motor Company (Historic), Meekin's Motor Company (Historic), Motor Company (Historic), The Motor Sales and Service Company (Historic), Wright Motor Company (Historic)	DHR Staff: Eligible
122-0194/Area 4	Greater Metropolitan A.M.E. Zion Church (Current), Metropolitan A.M.E. Church(Historic/Current), Queen Street Station of Methodist Episcopal Church, South	DHR Staff: Eligible
122-0211/Area 4	St. John's African Methodist Episcopal Church (Historic)	NRHP Listing, VLR Listing
122-0246/Area 3	Ghent Methodist Church(Historic), Ghent United Methodist Church(Historic/Current)	DHR Board Det. Eligible
122-0255/Area 3	Sacred Heart Church(Historic/Current)	DHR Staff: Eligible
122-0259/Area 3	Central Baptist Church(Historic), New Central Baptist Church	DHR Board Det. Eligible

	(Current)	
122-0264/Area 3	Koerner House (Historic)	DHR Staff: Eligible
122-0265/Area 3	Downtown Norfolk Historic District (Historic)	NRHP Listing, VLR Listing
122-0333/NNB-NIT (outside of study areas)	Norfolk International Terminals (Historic/Current)	DHR Staff: Potentially Eligible
122-0407/Area 3	Brooks Cottage (Historic)	DHR Staff: Eligible
122-0474/Area 1	Blair Middle School (Current), James Blair Junior High School(Historic)	NRHP Listing, VLR Listing
122-0531/Area 3	Cemetery, 8100 Granby Street (Function/Location), Forest Lawn Cemetery	DHR Staff: Potentially Eligible
DHR ID	Property Name	NRHP Status
122-0550/Area 2	Maury High School(Historic/Current)	DHR Staff: Eligible
122-0559/Area 2	Riverview Theater(Historic/Current)	DHR Board Det. Eligible
122-0572/Area 3	Colley Theater (Historic), Naro Theater (Current)	DHR Staff: Eligible
122-0590/Area 4	Colonna's Shipyard(Historic/Current)	DHR Staff: Eligible
122-0658/Area 2	American Cigar Company Stemmerly (Historic/Current), Norfolk Recycling, 1148 East Princess Anne Rd(Historic/Location)	NRHP Listing, VLR Listing
122-0681/Area 4	Corner Stone Christian Center(Current), Trinity A.M.E. Church (Historic)	DHR Staff: Eligible

122-0726/Area 3	Coca Cola Bottling Company, Inc. (Historic/Current), Coca Cola Bottling Plant (Historic), Coca Cola Bottling Works(Historic)	DHR Staff: Potentially Eligible
122-0823/Area 2	Riverview Historic District	NRHP Listing, VLR Listing
122-0823-0194/Area 2	Nabers House, Tracy B. (Current)	NRHP Listing
122-0823-0207/Area 2	Butler House, T. Melvin & Deborah A. (Current)	NRHP Listing
122-0824/Area 4	Berkley North Historic District(NRHP Listing), Ferry's Point(Historic), Herbertsville(Historic), Powder Point(Historic), Town of Berkley(Historic), Washington Point(Historic)	NRHP Listing, VLR Listing
122-0825/Area 2	Colonial Place Historic District(Current)	NRHP Listing, VLR Listing

DHR ID	Property Name	NRHP Status
122-0826/Area 2	Lafayette Residence Park	NRHP Listing, VLR Listing
122-1007/Area 1	Norfolk Azalea Garden(Historic), Norfolk Botanical Garden (Current), Norfolk(NRHP Listing), Lafayette Residence Park Historic District (Descriptive)	NRHP Listing, VLR Listing
122-0827/Area 3	North Ghent Historic District(Historic/Current)	NRHP Listing, VLR Listing
122-0828/Area 2	Winona Historic District(Current)	NRHP Listing, VLR Listing

122-0829/Area 2	Ballentine Place Historic District (Historic/Current)	NRHP Listing, VLR Listing
122-0853/Area 3	Texaco Building (Historic), Texas Company Building(Historic)	DHR Board Det. Eligible
122-0901/Area 3	American Tobacco Co. Warehouse (Historic), Sears, Roebuck and Co. Warehouse Historic), Security Storage & Safe Deposit Co. Warehouse (NRHP Listing), Warehouse, 517-523 Front Street(Function/Location)	NRHP Listing, VLR Listing
122-0912/Area 1	Cottage Place (Current)	DHR Staff: Eligible
122-0934/Area 2	Atlantic Ordnance & Gyro Company (Current), Lambert's Point Knitting Mills(Historic/Current), Old Dominion Paper Company(Historic)	NRHP Listing, VLR Listing
122-0954/Area 1	Ocean View Elementary School(Current Name), Ocean View Elementary School (Historic)	DHR Staff: Eligible
DHR ID	Property Name	NRHP Status
122-1024/Area 2	Ballentine School (Historic/Current)	DHR Staff: Eligible
122-1056/Area 3	N & W Railyard Site- Norfolk Southern Railway Historic District (Descriptive), & Western Railway (Historic), Norfolk Southern Railway(Current)	DHR Staff: Eligible
122-1077/Area 4	Barry Robinson Center(Descriptive)	DHR Staff: Potentially Eligible
122-1201/Area 4	Chesterfield Heights	NRHP Listing, VLR Listing

(due to an existing risk management project no measures are being considered for this district)	Historic District (Current)	
122-5002/Area 3	Huntington Tugboat (NRHP Listing), Huntington Tugboat Museum (Current), Tug Huntington (Historic)	NRHP Listing, VLR Listing
122-5010/Naval Base, not in study	Naval Supply Depot Historic District (Current)	DHR Staff: Potentially Eligible
122-5043/Naval Base, not in study	Naval Administration/Recruit Training Station Historic District (Naval Base) (Current)	DHR Staff: Eligible
122-5045/Naval Base, not in study	Golf Club Historic District, Norfolk Naval Base(Historic/Current)	DHR Staff: Eligible
122-5046/Naval Base, not in study	Naval Air Station Historic District (Historic/Current), Norfolk Naval Base Chambers Field (Historic)	DHR Staff: Eligible
122-5087//Area 2	Kensington (Historic), Old Dominion Place (Historic), Park Place (Historic), Park Place Historic District (Current Name), Virginia Place(Historic)	NRHP Listing, VLR Listing

DHR ID	Property Name	NRHP Status
122-5120/Area 4	Warehouse, 5786 Sellger Drive	DHR Staff: Potentially Eligible

122-5181/Area 3	Calvary Cemetery (Historic), Potter's Field (Historic), West Point Cemetery(Historic/Current)	NRHP Listing, VLR Listing
122-5360/Area 4	Hospital, 2539 Corprew Av(Function/Location), Norfolk Community Hospital(Current), Old Community Hospital, Norfolk State University (Historic/Location)	DHR Staff: Eligible
122-5407/Area 3	Hampton Roads Transit Bus Barn (east), 509 East 18th St	DHR Staff: Potentially Eligible
122-5408/Area 3	Hampton Roads Bus Barn(west), 509 East 18th Street(Historic/Location)	DHR Staff: Potentially Eligible
122-5414/Area 3	U.S.S. Wisconsin (BB-64) (NRHP Listing), Wiskay(Historic)	NRHP Listing, VLR Listing
122-5423/Area 3	Krisp-Pak (Historic), Norfolk Cold Storage and Processing Company, Inc. (Historic), Riverview Lofts (Current Name), Virginia Ice & Freezing Company Cold Storage Warehouse (NRHP Listing)	NRHP Listing, VLR Listing
122-5434/Area 1	Merrimack Landing Apartment Complex, 8807 Monitor Way(Current), Merrimack Park Historic District (Historic), Merrimack Park, Housing Authority Development (Historic)	DHR Staff: Potentially Eligible
122-5435/Area 1	House, 729-731 West Ocean View Avenue (Function/Location)	DHR Staff: Potentially Eligible

122-5436	House, 1163 Little Bay Avenue	DHR Staff: Potentially Eligible
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DHR ID	Property Name	NRHP Status	
122-5768/Area 1	House, 1518 West Ocean View Avenue (Function/Location)	DHR Staff: Potentially Eligible	
122-5795/Area 3	Williamston-Woodland Historic District (NRHP Listing)	NRHP Listing, VLR Listing	
122-5796/Area 1	Sussex-at-Norfolk Apartments Historic District (Current Name)	DHR Board Det. Eligible	
122-5797/Area 3	Auto Row Historic District (Current Name), Granby Street Auto Row Historic District(Historic), Norfolk Auto Row Historic District (NRHP Listing)	NRHP Listing, VLR Listing	
122-5799/Areas 2 & 3	Norfolk & Western Railroad Historic District (NRHP Listing)	NRHP Listing, VLR Listing	
122-5818/Area 2	Oakwood Elementary School (Historic), Oakwood School(Historic)	DHR Board Det. Eligible	
44NR0009/Area 4	Archaeological Site, 18th c. well	DHR Staff Det. Eligible	
44NR0012/Area 4	Archaeological Site, 18th c. dwelling	DHR Staff Det. Eligible	

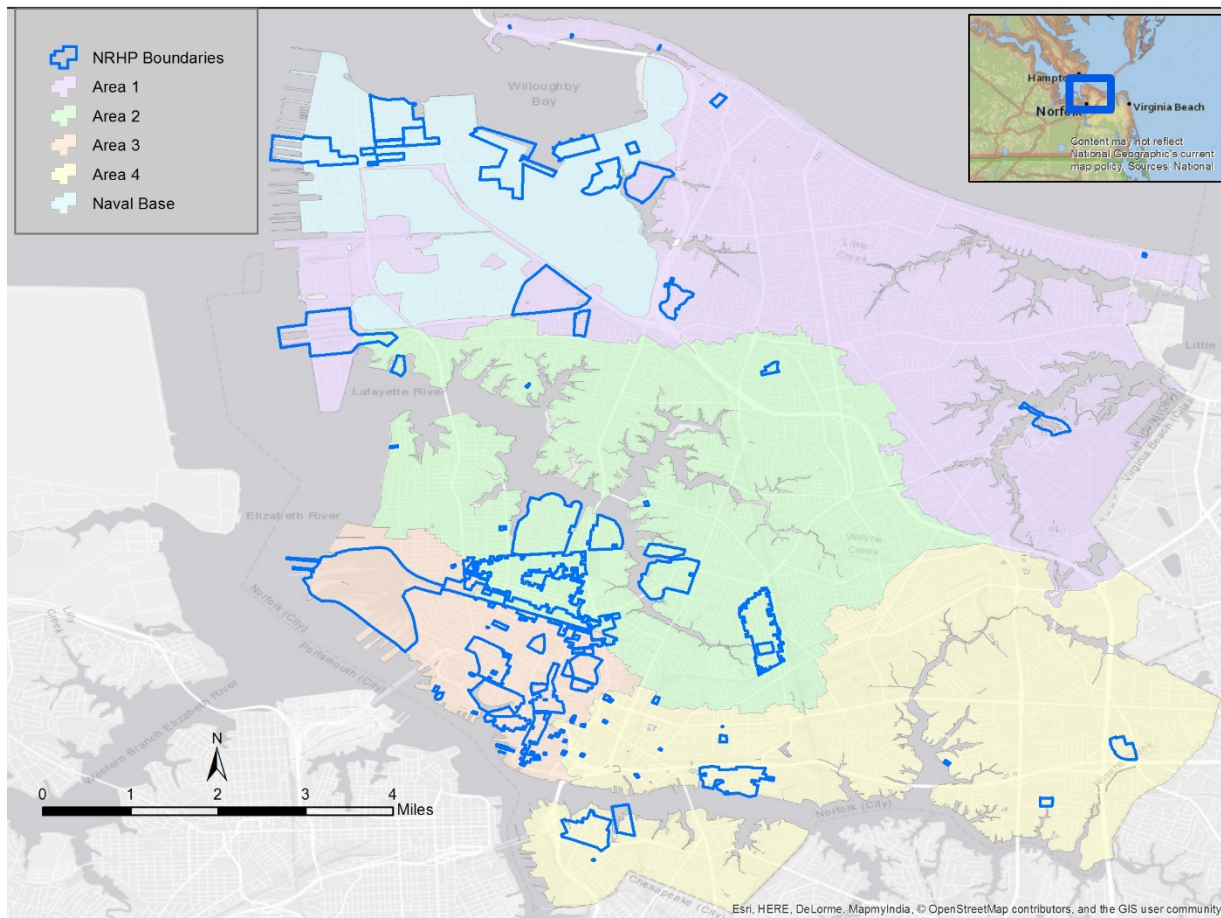


Figure 10-30. Boundaries of NRHP listed, eligible, or potentially eligible properties in Norfolk from DHR data.

Potential for Unidentified Historic Properties

As prodigious as the number of recorded, and evaluated, historic properties in Norfolk is, there may be many more that have not been identified through survey and evaluation of eligibility. Along with listed high profile historic districts like Ghent and West Freemason, large potentially eligible districts along the Lafayette River and potentially in the area of effect of some project measures include Larchmont and Algonquian Park.

Only limited areas have had archaeological survey (Figure 10-31), and nearly a third of the archaeological sites identified in the city, including the two determined NRHP eligible, came from a small areas where an expanded interchange for I-64/264 is planned. Two types of terrain may have elevated potential for archaeological sites. One is the urban waterfront downtown, this and many surrounding areas are extensively composed of filled in areas of the waterfront and creeks. Urban waterfronts frequently yield well preserved historic period sites. Examples include the Richmond floodwall project, the Indigo Hotel site in Alexandria where a ship was found, and the World Trade Center site in New York City where a ship was found as well. In Norfolk during the development of the Waterside mall an 18th century cannon was found in fill of brick and cobblestone (site 44NR18). The second high potential terrain are shorelines in suburban areas where there has been less development, and some sites may be relatively intact. Native Americans focused on the waterways for subsistence and transportation, and

larger sites from that period are found in those settings. This is also true of early historic period sites, a time when like the Native Americans, the inhabitants depended on the waterways as their primary means of transportation.

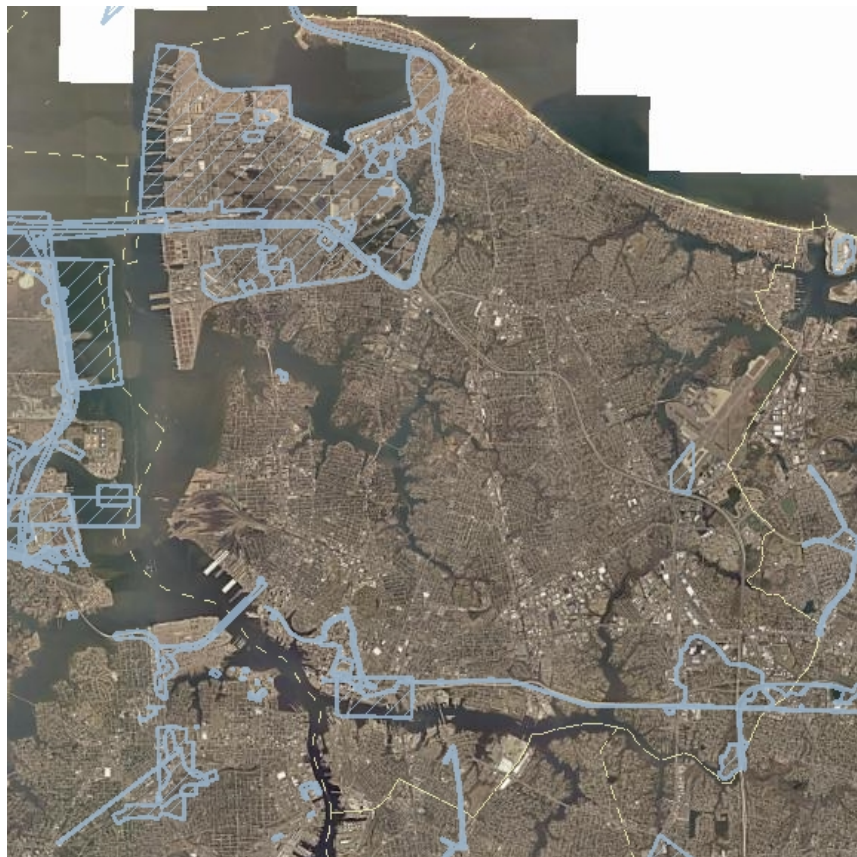


Figure 10-31. Phase I Archaeological Surveys in Norfolk

Field surveys for the identification and evaluation for the Selected Plan will be conducted during the Preconstruction Engineering and Design stage of this project if it is supported. This would include Phase I or reconnaissance survey, the identification of archaeological sites or potentially eligible historic buildings or districts in previously unsurveyed areas; followed by evaluations of NRHP eligibility of sites or buildings identified as potentially eligible, known as Phase II or intensive survey. A programmatic agreement between USACE, the State Historic Preservation Officer, and the City has been drafted to guide this process and any mitigation (Phase III) that may be needed (Environmental Appendix).

10.14 RECREATIONAL RESOURCES

10.14.1 Definition of Resource

Recreational facilities are defined as those amenities that provide for relaxation, rest, exercise, activity, enjoyment, education, or opportunities for leisure and community support that enrich the quality of life. These include, but are not limited to, parks, trails, boat ramps, piers, marinas, athletic fields, playgrounds, and community centers. Recreational areas may include any type of activity in which residents or visitors may participate. Activities include hiking, bike riding, boating, fishing, swimming, sunbathing, picnicking, playground use, or participation in sports. It

should be noted that recreational navigation is covered under Section 10.19, Transportation and Navigation.

10.14.2 Methodology

A culturally rich city, Norfolk has very numerous arts, historical, large community centers, and special events venues. These range from small to large, and are too numerous to mention by name. They are interspersed throughout Areas 1-4 of the City, with many of the more significant ones located in Area 3, in or near the Downtown area.

The ROI is defined as all recreational lands and facilities within the City that would be affected either directly or indirectly by the project. This includes recreational areas where structure or fill is being placed for storm surge barriers, floodwalls, pump stations, natural and nature-based features, or other measures or activities associated with the project, including all areas that are filled, graded, cleared, excavated, or otherwise converted to another use as, or that will result in limited recreational use, as a consequence of the construction of the measures. It also includes areas indirectly and/or temporarily adversely affected by the project, such as by means of construction activities.

10.14.3 Framework

The City of Norfolk Recreational Master Plan (2012). Adopted by Norfolk City Council in spring 2012, the City of Norfolk Recreation, Parks and Open Space Master Plan serves as a twenty year guide for enhancements to Norfolk's park system and recreation amenities. This plan provides the framework and recreational goals that the City has adopted. The Plan states that its goals are twofold:

- "To identify improvements needed to meet residents' top priority recreation, parks, all and open space needs," and
- "To help solve some of the city's most pressing urban problems and improve the quality of life."

The Master Plan also states that the City would like to create pedestrian and bicycle friendly streetscapes by improving sidewalks, enhancing crosswalks, and reducing speed limits.

Local Zoning Ordinance. The city of Norfolk is conducting a comprehensive rewrite of its Zoning Ordinance. Norfolk is evolving: the City's planning and development goals have changed. The current Zoning Ordinance, adopted in 1992 and amended several times, does not reflect the recently adopted plaNorfolk 2030 General Plan. A draft ordinance is currently available for public review. The City plans adopt a new ordinance in fall/winter 2017.

plaNorfolk 2030. Adopted by the City Council March 26, 2013, and revised January 2017, plaNorfolk 2030 is considered The General Plan of the City of Norfolk. (City of Norfolk, 2013). PlaNorfolk 2030 is used to guide decision making about physical development and public infrastructure. It is intended to be sufficiently flexible to respond to changes in development patterns and contains the broad outlines neighborhoods will use to guide and plot their path to the future. The Plan calls for a wide variety of cultural and recreational opportunities that lead to a fun and healthy lifestyle for a diverse population.

Vision 2100. Adopted by Council on November 22, 2016, Vision 2100 provides a long-term strategy to address the challenges of sea level rise, infrastructure needs, and population growth. Its overall goal is to design the coastal community of the future, ensuring that Norfolk will be a dynamic, water-based City well into the future. Vision 2100 guides the City's decisions about public infrastructure investments or its response to development proposals. Vision 2100 aims to ensure that resources are used efficiently, with an eye towards the future.

10.14.4 Existing Conditions

Area 1 --- Willoughby Spit, Ocean View, Mason Creek, Pretty Lake, and Lake Whitehurst

From the eastern end of Ocean View (known as "East Beach") to the western end of Willoughby Spit, Norfolk has 7.3 miles of Chesapeake Bay beachfront, all of which is open to the public. There are public beach access points located every few blocks. These locations provide access to the beach for swimming, boating, fishing and sunbathing. There are also six kayak launches from Willoughby to East Beach (City of Norfolk website, 2017).

In addition to the public beach, the City of Norfolk Department of Recreation, Parks, and Open Space maintains three beach parks: Ocean View Beach Festival Park, Community Beach Park, and Sarah Constant Beach Park. All three feature parking, restrooms, benches and shade trees (City of Norfolk website, 2017).

Recently the USACE completed a beach nourishment and breakwater project for the Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project along the entire 7.3 miles of beachfront. According to the USACE Environmental Assessment (EA) for the project, the primary project purpose was coastal storm risk management rather than recreational benefits. Changes in visitation volume from existing condition as a result of the project were anticipated to be minimal. Based the user survey conducted during that study, the heaviest beach use was expected to continue to occur in the central portion, with the remaining areas continuing to experience lighter usage (USACE, 2014).

Within Little Creek and Pretty Lake watershed, there are private piers, boathouses, and ramps. Three marinas are located within Fisherman's Cove, immediately east of Pretty Lake and the Route 60 Shore Drive Bridge: Baypoint Marina and Little Creek Marina are on the north side of Fishermans Cove; and Cobbs Marina is on the south side. According to their joint website, Baypoint Marina has 224 boatslips, and neighboring Little Creek Marina has 120 boatslips; and they have 224 dry storage space between them. Cobbs Marina can accommodate up to 95 boats (Cobbs Marina website, 2017). There is also a City kayak launch at the Route 60 Bridge, and two others in Pretty Lake. The navigational use of these facilities is discussed further in the Transportation and Navigation Section of this document.

There are bicycle paths along Ocean View Avenue, as well as across the Shore Drive Bridge over Pretty Lake. There are several park facilities in the watershed, including the Virginia Botanical Gardens, adjacent to the Norfolk International Airport and Lake Whitehurst.

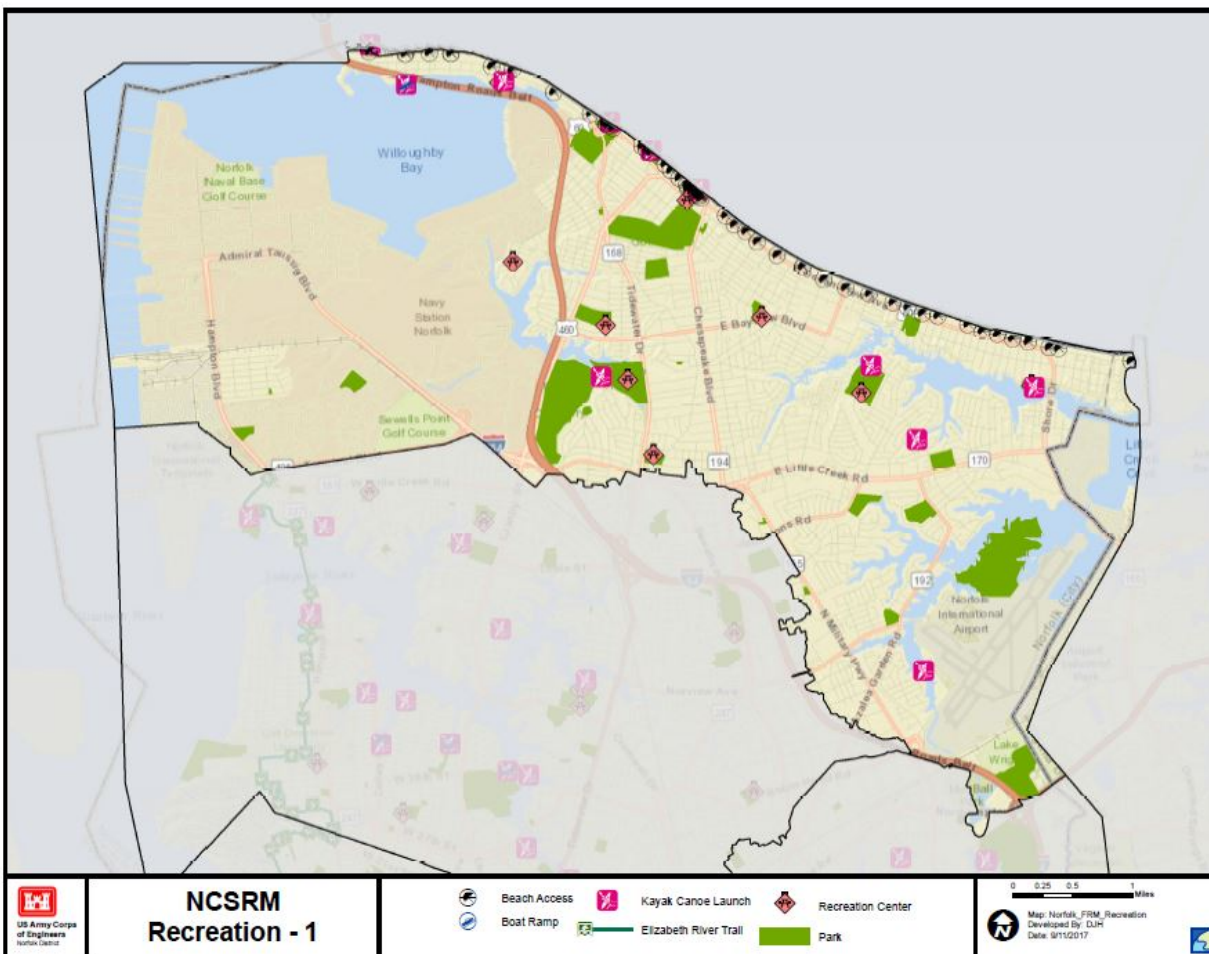


Figure 10-32. Recreation for Area 1

Area 2 — Lafayette River watershed

The Lafayette River watershed is largely residential, however there are also commercial/recreational businesses such as marinas and a golf course within its limits. The River is widely used recreationally by residents for boating and other water activities. According to the Shoreline Inventory study for Norfolk, sponsored by the Virginia Institute of Marine Science (2014), there are approximately 750 currently serviceable private piers, boathouses, and boat ramps; seven marinas, and 14 kayak launches within the river. Approximately 43 piers are located along the Larchmont neighborhood shoreline, on the southeast bank of the river near the mouth.

The Lamberts Point Golf Course is a nine-hole golf course, located at 4301 Powhatan Avenue, along the southern bank at the mouth of the Lafayette River, west of the Old Dominion University campus. It is under the management of Virginia Beach Golf Management, Inc.

Norfolk Yacht and Country Club is located at 7001 Hampton Boulevard, along the northern bank of the Lafayette River, just west of the Hampton Boulevard Bridge. According to its website, it has three floating docks and one fixed pier, and can accommodate up to 200 boats (Norfolk Yacht Club website, 2017).

The Elizabeth River Trail (ERT), which is a total of 10.5 miles long from beginning to end, is an urban biking and pedestrian trail that runs from Norfolk Naval Base, located in the northern portion of the city, into Downtown Norfolk, ending at Norfolk State University; therefore it is also discussed in the sections for Areas 3 and 4 herein. Within Area 2, the Elizabeth River Trail extends approximately 1.32 miles. It parallels and adjoins the Hampton Boulevard bridge, past Old Dominion University's campus, and then through the Larchmont-Edgewater residential areas (Elizabeth River Trail website, 2017).

The Virginia Zoological Park is located at the intersection of Church Street, Monticello Avenue, and Granby Street, and also abuts the Lafayette River.

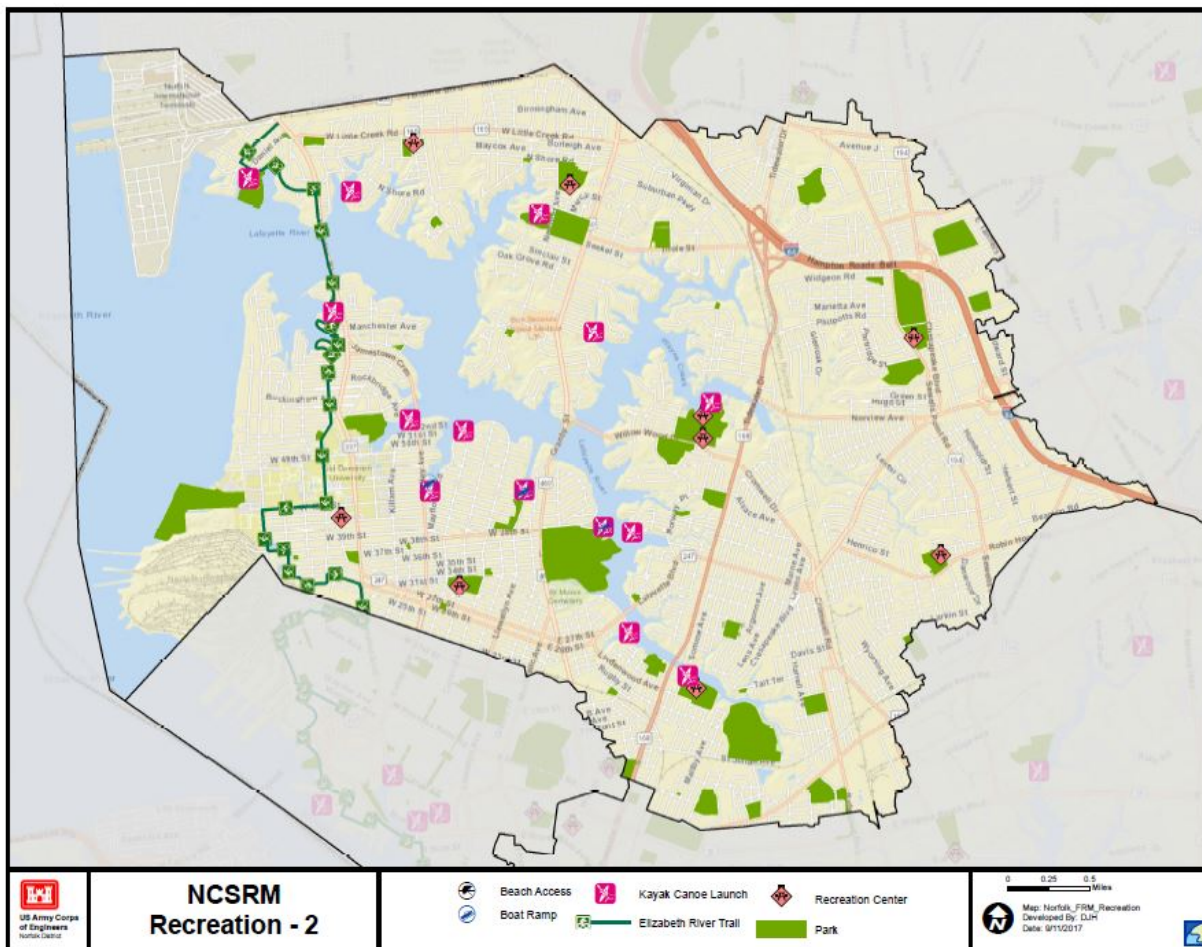


Figure 10-33. Recreation for Area 2

Area 3 — West Ghent, The Hague, Fort Norfolk, Freemason, and Downtown

Town Point Park, a 7-acre park, is located in Downtown Norfolk adjacent to Waterside along the Elizabeth River. Town Point Park is designated as one of the City's two festival parks, which are a specially designated parks that allow for increased festival support, gated events, power/water access, and alcohol consumption at special events. It serves as a waterfront entertainment venue and a destination for signature festivals, cultural, and educational events. When not in use for events, it serves as a passive recreation park for walking, picnicking, or biking. It also has a wharf along the perimeter of the Elizabeth River.

The wharf area along Town Point Park and Waterside is also used heavily for both recreational and commercial navigational purposes, as is discussed in the Transportation/Navigation section of this document.

The ERT continues through Area 3, making many twists and turns as it weaves through the more developed areas of the City. Within Area 3, the ERT extends from east of Lamberts Bend through the Downtown Norfolk waterfront. The trail's path takes it through Chelsea section of the City, which includes neighborhoods on the water, restaurants, and breweries etc. The trail also passes through Fort Norfolk and Plum Point Park, a small park that is located on the Elizabeth River, in the vicinity of the Midtown Tunnel. The trail's "Sentara Loop" crosses The Hague and parallels Brambleton Avenue. Then it runs 0.73 miles through Freemason, one of Norfolk's oldest and architecturally stunning neighborhoods. It ultimately passes by Nauticus Museum, Town Point Park, Waterside, and then east of the Downtown Tunnel (Elizabeth River Trail website, 2017).

There are also five boat/kayak launches in Area 3: three in The Hague, one at Fort Norfolk that is on USACE property, and one near Harbor Park. It is unclear how much the ones in The Hague and near Harbor Park are used. The USACE boat ramp is not open to public use.

Stockley Gardens is an urban park located just north of The Hague. It is a small linear-shaped passive use park often used for small events and walking. The Hague dog park is also located adjacent to the Hague.

Located near Downtown, within several blocks from the waterfront, are two of the larger venues in the Area that draw significant crowds for sporting events and/or concerts, and conventions: Scope and Chrysler Hall. Numerous museums and historical landmarks are nearby as well.

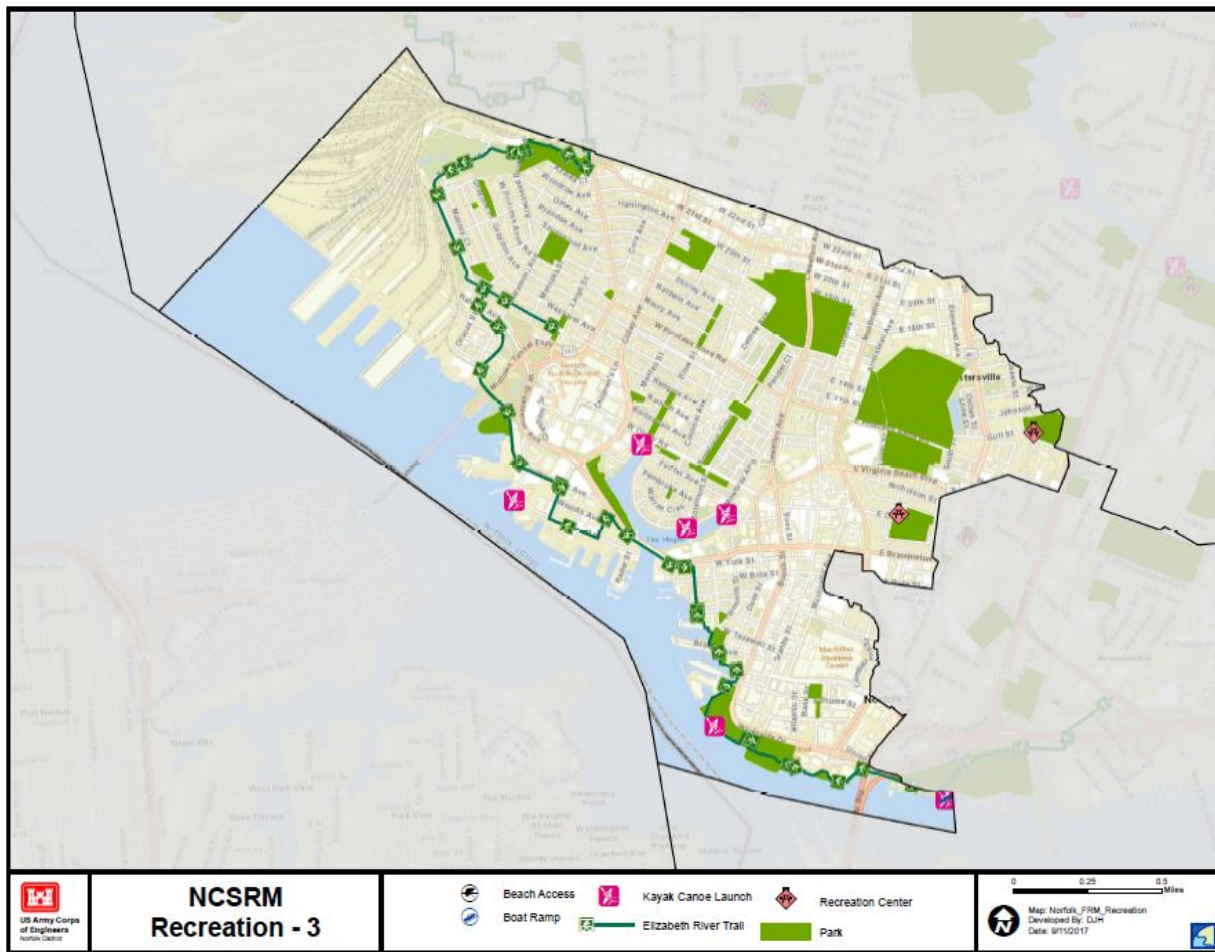


Figure 10-34. Recreation for Area 3

Area 4 —The Eastern Branch of the Elizabeth River, Broad Creek, and Campostella

The most notable recreational facility in Area 4 is Harbor Park, the regional baseball stadium located near the Downtown Tunnel and the Eastern Branch of the Elizabeth River. It draws large crowds and hosts mostly minor league baseball games. In addition, the last 0.89-mile segment of the Elizabeth River trail extends through the Harbor Park property, around the baseball stadium, and ends at Norfolk State University.

There is also recreational use of the Eastern Branch of the Elizabeth River and Broad Creek. Nine public kayak/canoe launches and numerous private piers are located in these areas (VIMS 2014a).

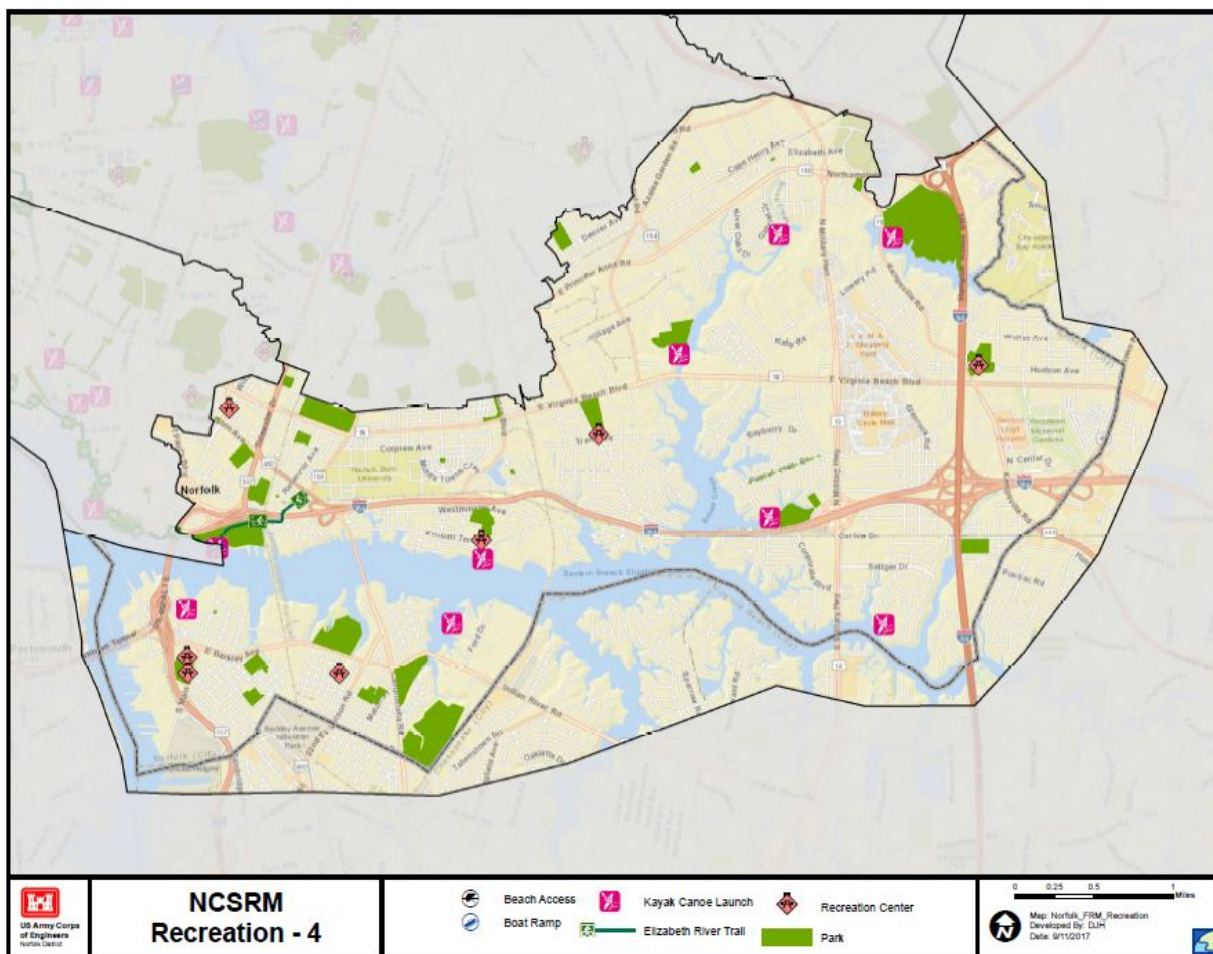


Figure 10-35. Recreation for Area 4

10.15 VISUAL RESOURCES

10.15.1 Definition of Resource

Visual resources are the natural and man-made features that comprise the visual qualities of a given area, or “viewshed.” These features form the overall impression that an observer receives of an area or its landscape character. Topography, water, vegetation, man-made features, and the degree of panoramic view available are examples of visual characteristics of an area.

10.15.2 Methodology

Visual resources can be subjective by nature, and therefore the level of the proposed project’s visual impacts can be challenging to quantify. Generally, projects that create a high level of contrast to the existing visual character of a project setting are more likely to generate adverse visual impacts due to visual incompatibility. Thus, it is important to assess project effects relative to the existing conditions of the area. On this basis, project components effect on the visual environment are quantified and evaluated for impact assessment purposes based on factors affecting setting compatibility such as changes in visual vividness, intactness, and unity from the existing conditions.

The following definitions were used to determine the magnitude of adverse impacts on visual

resources:

- **Negligible:** Visitors or residents would likely be unaware of impacts associated with the implementation of the alternative. There would be no noticeable change to the scenic views and visual resources or in any defined indicators of the scenic landscape
- **Minor:** Changes in scenic views and visual resources would be slight and detectable, but would not appreciably limit critical characteristics of the area. Visitor satisfaction would remain stable or residents would not likely register complaints.
- **Moderate:** Few critical characteristics of the desired scenic views and visual resources would change. The number of participants engaging in a specified activity could be altered. Some visitors/residents who want to continue using and enjoying the area might pursue their choices in other available local or regional areas. Visitor satisfaction would begin to decline, or residents would express some dissatisfaction in the change of landscape.
- **Significant:** Multiple critical characteristics of the desired scenic views and visual resources would change and/or the number of participants engaging in an activity would be greatly reduced. Visitors who want to continue using and enjoying the area would pursue their choices in other available local or regional areas. Visitor satisfaction would markedly decline or residents would register numerous complaints due to the heavily altered natural landscape.

Within a discrete viewshed, an individual's visual perception is a function of the area's spatial properties, visual content, and an individual's previous experiences. The visual character of an area can be altered by actions that would modify the landscape. In addition, views toward a given location in the viewshed can be affected by a proposed action. To provide a baseline for assessing potential visual impacts of actions on a viewshed, the ROI must be described in terms of its visual characteristics (using visual assessment elements), and a description of the user groups (viewer groups) who would experience any changes in visual character.

Visual Assessment Elements

The following characteristics were used to describe and assess visual resources: viewshed, visual character, visual quality (vividness, intactness, and unity), visual sensitivity, and key observation points.

Viewshed

Viewshed is an area of the landscape that is visible from a particular location (e.g., an overlook) or series of points (e.g., a road or trail). To identify the importance of views of a resource, a viewshed may be broken into distance zones consisting of: (1) foreground, (2) middleground, and (3) background. Generally, the closer a resource is to the viewer, the more visually dominant it is and the greater its significance to the viewer.

Visual Character

Visual character is based on defined attributes of an area. A change in visual character cannot be described as having good or bad attributes until it is compared with the viewer response to that change. If there is public preference for the established visual character of a regional landscape and a resistance to a project that would contrast that character, then changes in the visual character can be evaluated.

Visual Quality

Visual quality is determined by analyzing three elements of the visual environment: vividness, intactness, and unity. None of these is itself indicative of visual quality, and all three must be high to indicate high visual quality. Vividness is the visual power or memorability of landscape components as they combine in striking or distinctive visual patterns. Examples of significant vividness include views of areas such as the Grand Canyon or the Statue of Liberty. Intactness is the visual integrity of the natural and artificial landscape and its freedom from encroaching elements. Intactness can be present in well-kept urban and rural landscapes, as well as in natural settings. Intactness relates to the physical setting. For example, in a natural setting, it is the freedom from development or infrastructure; in a rural setting, it is the freedom from urban influences; and in an urban/suburban setting, it is the freedom from uses such as industrial smokestacks in an area with office buildings or intensive commercial development in a residential area. Unity is the visual coherence and compositional harmony of the landscape considered as a whole; it frequently attests to the careful design of individual components in the artificial landscape. Examples of high unity would include a well-maintained master-planned community or a mixed-use downtown development.

Visual Sensitivity

Visual sensitivity is based on the visibility of resources in the landscape, the proximity of viewers to the visual resource, the relative elevation of viewers to the visual resource, and the types and expectations of individuals and viewer groups. The criteria for identifying the importance of views are related in part to the position of the viewer relative to the resource.

Visual sensitivity also depends on the number and type of viewers and the frequency and duration of views. Generally, visual sensitivity increases with an increase in total number of viewers, the frequency of viewing (e.g., daily or seasonally), and the duration of views (i.e., how long a scene is viewed). In addition, visual sensitivity is higher for views seen by people who are driving for pleasure; people engaging in recreational activities, such as hiking, biking, or camping; and homeowners. Views from recreation trails and areas, scenic highways, and scenic overlooks are generally assessed as having high visual sensitivity.

Key Observation Points

Key observation points are official (e.g., a vista point) or unofficial (e.g., mountain peak) viewing locations that individuals identify as providing a place from which to take in remarkable views.

Viewer Groups

Viewers are placed into one of two groups based on activities and functions within a viewshed: (1) those with a view of the Proposed Action, and (2) those with a view from the Proposed Action. For example, while viewers with a view from an existing roadway will generally experience a similar visual landscape, viewers of a new road could observe a new visual landscape. All viewers can have different types of perception and thus impressions of the viewshed depending on their viewing perspective (e.g., motorist, resident, recreational user, business employees/patrons).

The Region of Influence (ROI) for visual resources is defined by those parts of the areas in which temporary or permanent visual changes could occur. For the Study Area, this includes the four sub-areas within the city of Norfolk in which actions could take place i.e. Area 1, Area 2,

Area 3, and Area 4 (refer to Figure 1-2).

10.15.3 Framework

Visual resources are mentioned in NEPA and CEQ regulations to implement NEPA under the heading of aesthetics. These regulations identify aesthetics as one of the elements or factors in the human environment that must be considered in determining the effects of a project. As prescribed by NEPA and CEQ, it is the “continuous responsibility” of federal and state governments to “assure all Americans” an environment that is composed of “aesthetically pleasing surroundings.

10.15.4 Existing Conditions

The general visual landscape of the study area can be described as mostly urban, with a network of parks and associated waterways including various freshwater lakes, Little Creek/Pretty Lake, Ocean View (which includes extensive beach view of the lower Chesapeake Bay), Willoughby Spit (which includes beach views of Chesapeake Bay on its North side and Willoughby Bay on its South side (refer to Figure 1-2). Among the dominant features in the visual landscape is the extensive transportation network within the city of Norfolk. This network includes, but is not limited to, railroads, highways, the Norfolk International Terminal and related loading docks, Campostella and Berkley Bridges, The Tide and its railway, bus stations, airports (both civilian and military), as well as three bridge-tunnels. The Elizabeth River trail, a major walking trail with wetlands and open space views, is located in the southeast region of the City. These visual landscapes are located within the project ROI. Because much of the ROI exists at low elevations with very slight relief, viewers can typically see long distances from locations that are only slightly higher than the surrounding area. In this case all parts of the viewshed can be seen (foreground, middle ground and background). The Elizabeth River proper, which borders the western and southern sides of the City, is an industrial river with major shipping channels to accommodate both industry and military use. Views along the Elizabeth River include a waterfront with a mix of industrial, commercial, naval, marine, and urban shoreline uses. South of the downtown areas, the Elizabeth River waterfront is highly industrialized and includes a number of port facilities that support the U.S. Navy and the commodities shipping industry (Navy, 2009). Figure 10-36 illustrates the extent of waterfront development for commercial, industrial, and military use; the photograph is looking North within the southern branch of the Elizabeth River with the Enviva Port of Chesapeake in the foreground and downtown Norfolk in the background. The Southern Branch of the Elizabeth River extends towards the right of the photo.

Throughout the Elizabeth River portion of the ROI, there are numerous towering cranes and related land-side infrastructure used for loading and unloading ships along the waterfront. Navigation within the ROI includes large Navy vessels, commercial deep draft navigation vessels, smaller tugs and service vessels, as well as small recreational vessels. There are attractive waterfronts in downtown Norfolk that include marinas, riverfront parks, and tourist venues, but all reflect the visual character of a highly industrialized, working waterfront. Additionally, there is a floodwall, approximately 7 feet high and 0.5 miles long, in downtown Norfolk, along Boush Street and Waterside Drive. Ocean View/Willoughby Spit are coastal areas (Figure 10-37) with scenic views of beaches and lower Bay waters near the confluence with the Atlantic Ocean (Area 1). There is also a small boardwalk area in Ocean View, and a

park area where various outdoor events are held. The Lafayette River (Area 2) is largely bordered by residential housing with private docks and access points; this area also includes a public boat ramp, as well as the Norfolk Yacht and Country Club. The remainder of the rest of the project ROI is the urban landscape of the city of Norfolk (Areas 1-4). There are numerous parks that provide for nature viewing opportunities throughout the city. The city also has a number of historic buildings, mostly concentrated in the southwestern portion of the City (Area 3). The Elizabeth River Trail, which begins in Area 4 and extends for a 10.5 miles through the western portions of Areas 2 and 3, is a rehabilitated and converted railroad spur that serves as a walking/biking trail. The Trail has numerous access points along its length, and provides a number of scenic views as well as interpretive signage. It is a major recreational destination for residents of the city. Other major sites of interest include the Virginia Zoological Park, a 60 acre zoo located in the central portion of the city. Another major scenic site is the Norfolk Botanical Garden, a large historical park covering 175 acres, located near the Norfolk International Airport. It has 12 miles of paved and mulched walking trails, with approximately 100,000 plants of over 7000 taxa on display. Figure 10-37 displays the Elizabeth River Trail, parks, beach access points, as well as buildings that are listed, or considered for listing in the National Register of Historic Places. These attributes are overlaid with classification types of the shorelines for the majority of the city has shorelines that are hardened for military and economic purposes (CCRM 2014).



Figure 10-36. Development along the Main Stem, Eastern Branch and Southern Branch of the Elizabeth River.

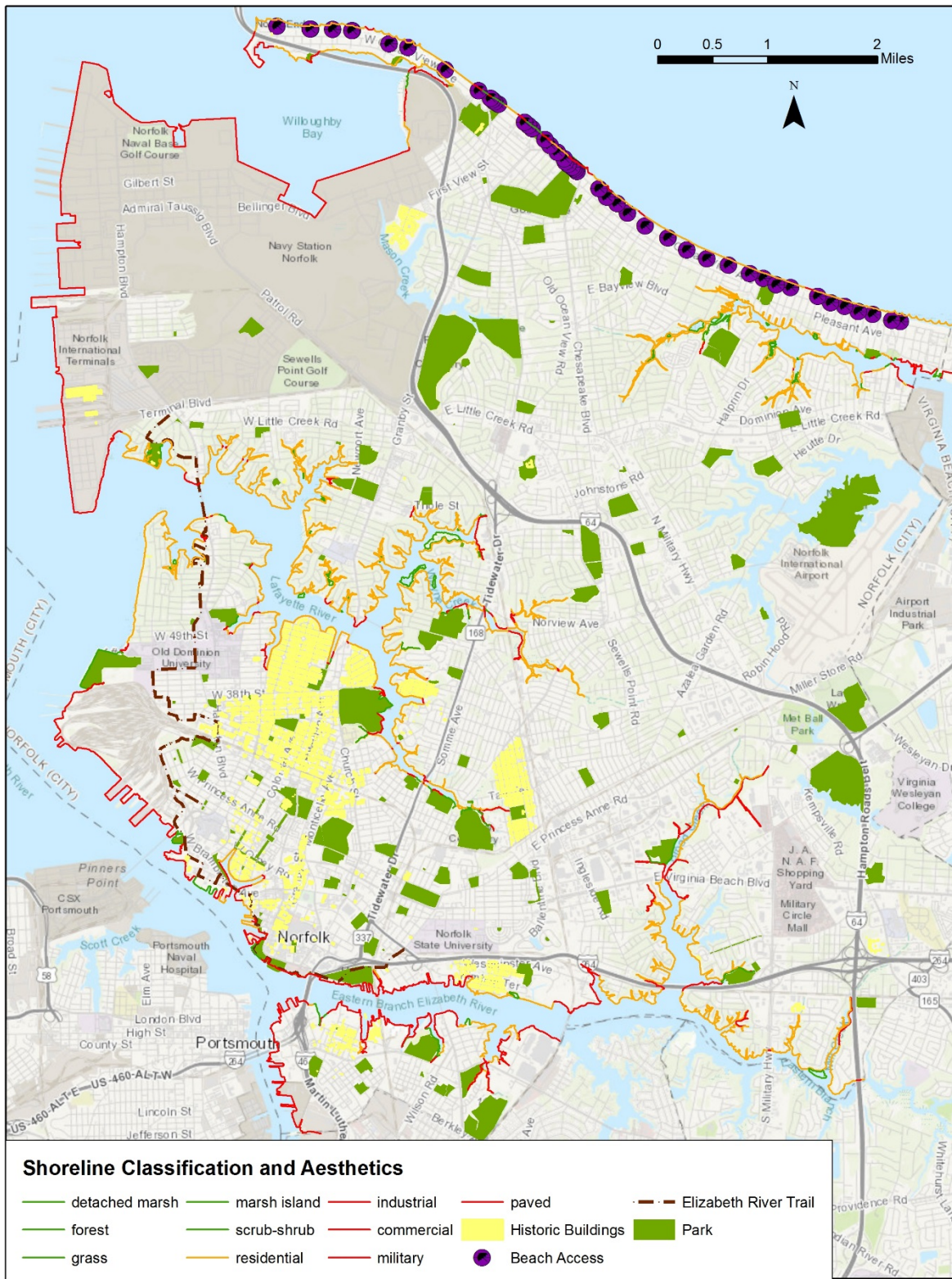


Figure 10-37. City of Norfolk Shoreline Classification and Local Aesthetics

10.16 SOCIOECONOMICS

10.16.1 Definition of Resource

Socioeconomics is defined as the basic attributes and resources associated with the human environment, particularly population, demographics, and economic development. Demographics entail population characteristics and include data pertaining to race, gender, income, housing, poverty status, and educational attainment. Economic development or activity typically includes employment, wages, business patterns, an area's industrial base, and its economic growth. Impacts on these fundamental socioeconomic components can also influence other issues such as housing availability.

The USEPA describes 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 (USEPA 2010). Fair treatment means that no group of people, including racial, ethnic, or socioeconomic, should bear a disproportionate share of the negative environmental consequences resulting from the execution of federal, state, local, and tribal programs and policies. The goal of fair treatment is not to shift risks among populations but to identify potential disproportionately high and adverse effects and identify alternatives that may mitigate these effects. Federal agencies must provide minority and low-income communities with access to information on matters relating to human health or the environment and opportunities for input in the NEPA process, including input on potential effects and mitigation measures.

The demographic information, including age, race and income of the populace, is vital to framing both a socioeconomic analysis and an analysis of environmental justice conditions. Thus, the existing conditions presented in Section 3.9.2 applies to both areas. However, the analysis of impacts between the concepts is different in scale. While a socioeconomic analysis can be completed separate from other resources, impacts that may affect environmental justice may be tied to several other resources, such as water quality and air quality.

10.16.2 Methodology

The methodology for socioeconomics and environmental justice consists of establishing an ROI, developing existing conditions (an economic baseline for socioeconomics and a geography-specific minority and low-income population area baseline for environmental justice).

The ROI for socioeconomics and environmental justice are defined by the census tracts that are within the city of Norfolk. The U.S. Census of 2010 has been the primary data source rather than interim surveys and estimates due to its higher standards of data collection, and because interim surveys and estimates have not identified substantial changes in demography and economy in Norfolk since 2010.

10.16.3 Framework

The CEQ regulations implementing NEPA state that when economic or social effects and natural or physical environmental effects are interrelated, the EIS will discuss these effects on the human environment (40 CFR 1508.14). The CEQ regulations further state that the "human environment shall be interpreted comprehensively to include the natural and physical

environment and the relationship of people with that environment.” Following from these CEQ regulations, the socioeconomic analysis evaluates how elements of the human environment such as population, employment, education, and housing might be affected by the Proposed Action.

In 1994, **EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low- Income Populations**, was issued to focus the attention of federal agencies on human health and environmental conditions in minority and low-income communities. In addition, EO 12898 aims to ensure that the environmental effects of federal actions do not fall disproportionately on low-income and minority populations. To support an evaluation of environmental justice issues, this section includes data related to the existence of minority and low-income populations in the vicinity of the Proposed Action that could potentially be disproportionately affected. For an analysis of impacts to minority, low-income, and child populations, refer to Chapter 6, Other Considerations Required by NEPA.

EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, tasks “each federal agency [to] make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high adverse human health and environmental effects of its programs, policies, and activities on minority populations and low-income populations.” EO 12898, dated February 11, 1994, aims to: (1) focus the attention of federal agencies on the environmental and human health conditions in minority communities and low-income communities with the goal of achieving environmental justice; (2) foster non-discrimination in federal programs that substantially affect human health or the environment; and (3) give minority communities and low-income communities greater opportunities for public participation in, and access to public information on, matters relating to human health and the environment.

Because children may suffer disproportionately from environmental health risks and safety risks, **EO 13045, Protection of Children from Environmental Health Risks and Safety Risks**, was issued on April 21, 1997 to help ensure that federal agencies’ policies, programs, activities, and standards address environmental health and safety risks to children. EO 13045 requires all federal agencies to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and ensure that its policies, programs, activities, and standards address disproportionate risks to children that may result from environmental health risks or safety risks.

10.16.4 Existing Conditions

Population

Norfolk is part of the Norfolk-Virginia Beach-Newport News Metropolitan Statistical Area (MSA) which is the second largest metro area between Washington, D.C. and Atlanta and the seventh largest metro area in the southeast United States (Figure 10-38). In 2010 the MSA had a population of 1,674,902 (U.S. Census Bureau 2017a). Although Norfolk is the largest urban core area within the MSA, the city contributes only about 15% of the population. However, of the incorporated cities in the state, Norfolk has the second largest population behind neighboring Virginia Beach.

The Norfolk rate of population growth is about the same as that for the MSA as a whole, yet has a significant decrease from the 50 percent growth that occurred in the city between 1980 and 1990. As of 2010, the city had an estimated population of 242,803, a 3.6 percent growth from the year 2000 (U.S. Census, 2012). Projections from the Virginia Employment Commission show Norfolk's population declining by 2.21 percent from 2010 to 2020, but rebounding slightly by 0.62 percent out to 2030.

Employment

Employment in Norfolk grew by 0.76 percent in the 1999 - 2000, but shrank by 1.84 percent between 2009 and 2010. Personal income grew in both periods, but more in the 1999-2000 (6.45 percent) than in 2010 (3.78 percent). As of the fourth quarter of 2011, there were 139,194 people working in the city, not including proprietors' employment. Unemployment rates for Norfolk tracked the national rate staying about half of one percent lower than the national rate, while typically about 1 percent higher than that for Virginia between 2001 and 2011, with a low of 4.1 percent in 2007 to a high of 9 percent in 2010 (Virginia Employment Commission [VEC], 2012).

Table 10-11. City of Norfolk, Public and Private Sector Employment (Bureau of Labor Statistics 2017)

Employer	Employed		Total Annual Wages		Avg. Annual Pay
Total	140210	100.00%	\$7,401,458,471	100.00%	\$52,788.0
Federal Govt.	20531	14.64%	\$1,646,458,079	22.25%	\$80,195.0
State Govt.	6554	4.67%	\$331,687,709	4.48%	\$50,610.0
Local Govt.	12365	8.82%	\$521,885,617	7.05%	\$42,208.0
Private	100761	71.86%	\$4,901,427,066	66.22%	\$48,644.0

Table 10-12. City of Norfolk Employment and Wages by Industry Sector

Industry	Employed		Wages	
Goods-producing	9657	4.89%	\$495,931,326	5.17%
Manufacturing	5617	2.84%	\$290,660,214	3.03%
Service-providing	91104	46.13%	\$4,405,495,740	45.90%
Trade, transportation, and utilities	22784	11.54%	\$1,022,631,378	10.66%
Information	2740	1.39%	\$177,899,120	1.85%
Financial activities	7553	3.82%	\$560,421,650	5.84%
Professional and business services	16639	8.43%	\$1,055,449,190	11.00%
Education and health services	24911	12.61%	\$1,236,287,679	12.88%
Leisure and hospitality	12330	6.24%	\$222,490,671	2.32%
Other services	4020	2.04%	\$127,126,797	1.32%
Unclassified	127	0.06%	\$3,189,255	0.03%
Total	197482		\$9,597,583,020	

Source: (Bureau of Labor Statistics 2017)

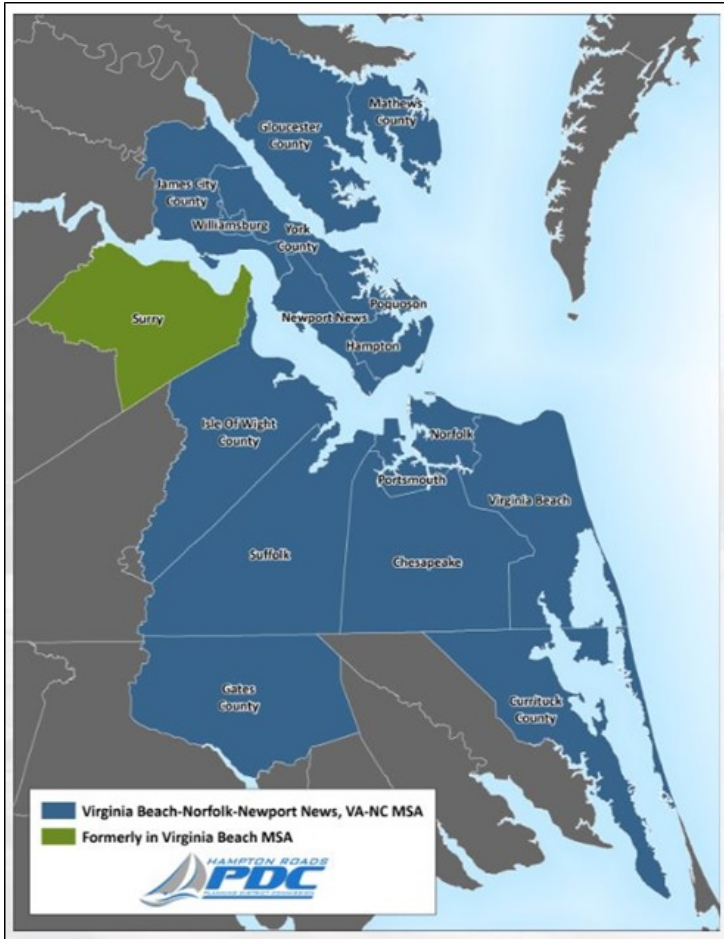


Figure 10-38. Metropolitan Statistical Area

Table 10-13. Population and Population Change in the MSA by Municipality

MSA Component	2000 Census	2010 Census	Change
City of Chesapeake	199,184	222,209	11.6%
City of Hampton	138,437	137,436	-0.7%
City of Newport News	180,150	180,719	0.3%
City of Norfolk	234,403	242,803	3.6%
City of Poquoson	11,566	12,150	5.1%
City of Portsmouth	100,565	95,535	-5.0%
City of Suffolk	63,677	84,585	32.8%
City of Virginia Beach	425,257	437,994	3%
City of Williamsburg	11,998	14,068	17.3%
Currituck County, NC	18,190	23,547	29.5%
Gates County, NC	10,516	12,197	16%
Gloucester County	34,780	36,858	6%
Isle of Wight County	29,728	35,270	18.6%
James City County	48,102	67,009	39.3%
Surry County	6,829	7,058	3.4%
York County	56,297	65,464	16.3%
Total MSA Population	1,569,679	1,674,902	6.7%

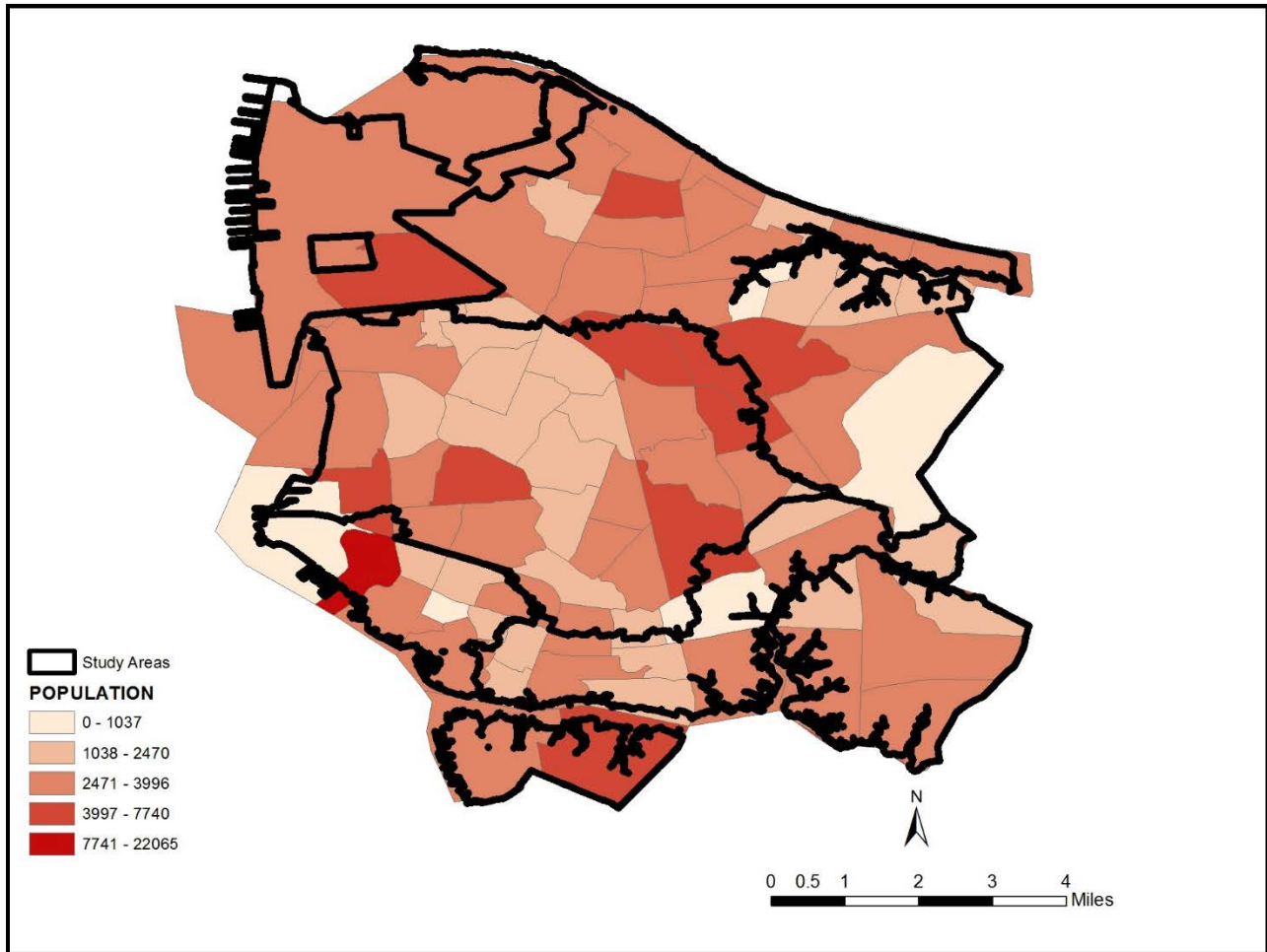


Figure 10-39. Population by Census Tract, 2010 Census

Source: (US Census Bureau 2017a)

Income

Income levels for the city’s residents are lower than those for the state and slightly lower than those for the nation, based on median household and per capita income estimates. Census data show that 2010 median household income was \$42,677 for Norfolk compared to \$61,406 for the state and \$51,914 for the US as a whole (U.S. Census Bureau, 2012). Per capita income for 2010 was \$23,773 for Norfolk while it was \$32,145 for the state. Norfolk’s per capita income was also below the national average of \$27,334. There are strong differences in income between census tracts, as shown in Figure 10-40.

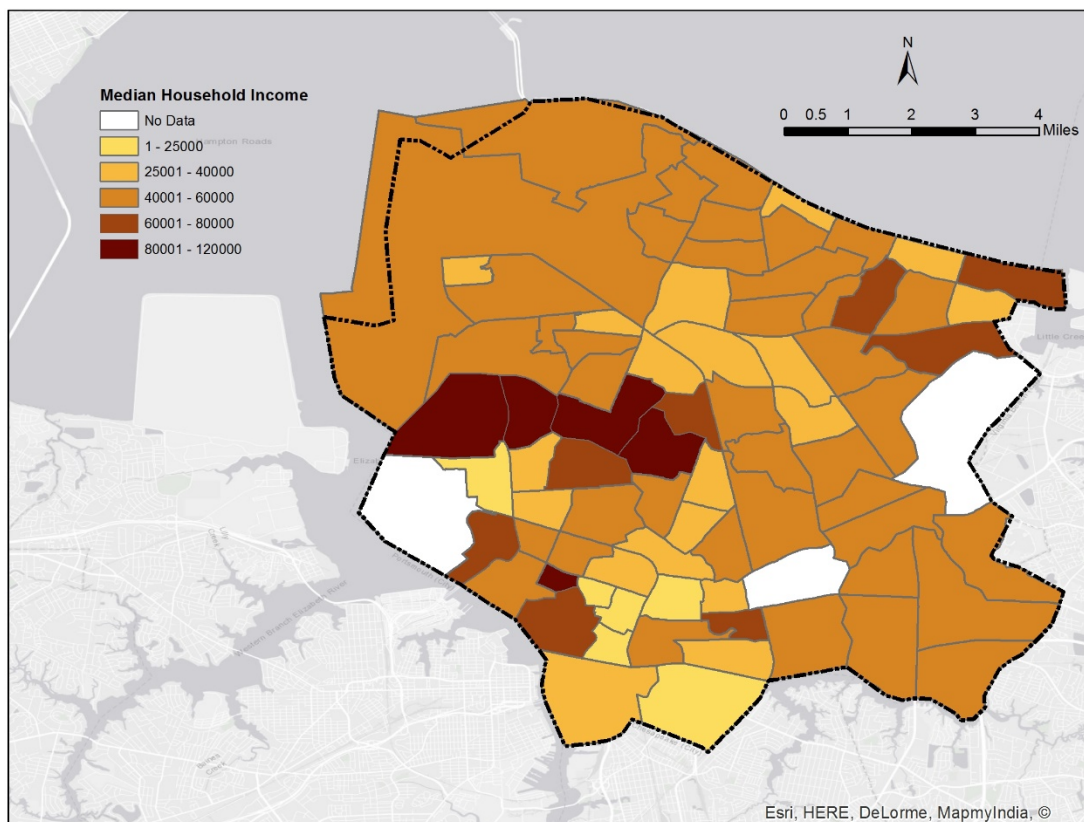


Figure 10-40. Income by Census Tract

Source: (US Census Bureau 2017b)

Environmental Justice and Protection of Children

Executive Order (EO) 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income Populations (February 11, 1994) requires Federal agencies to conduct their programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies, and activities because of their race, color, or national origin.

Figure 10-41 shows the distribution of census tracts with predominately minority populations and average annual incomes of \$35,000 or less in the 2010 census. Census Tract 46, the Chesterfield Heights neighborhood, is the subject of a separate coastal storm risk management project, and is not being considered for measures in this study.

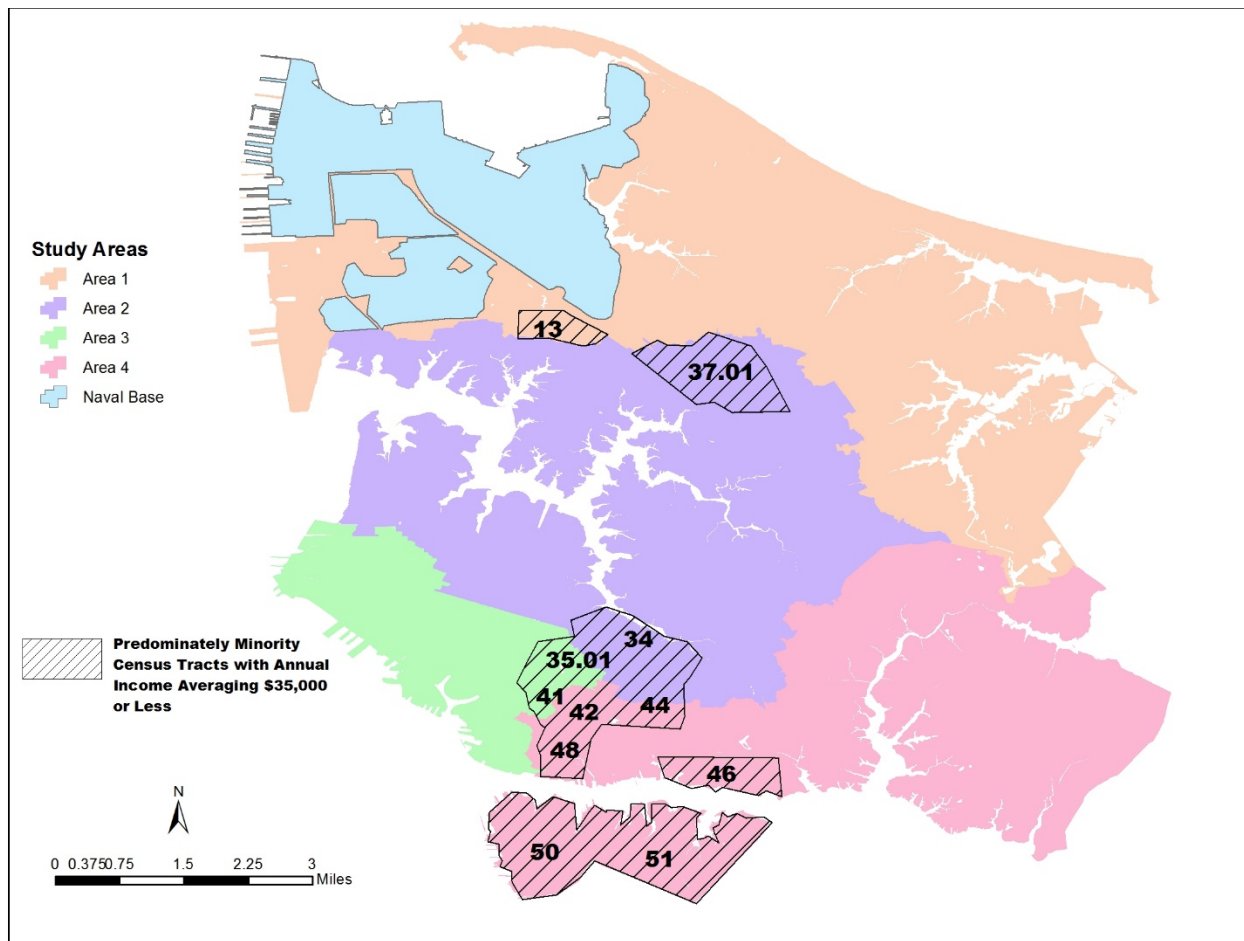


Figure 10-41. Predominately Minority Low Income Census Tracts
 Source: (US Census Bureau 2017b)

U.S. Census data for 2010 shows that the non-white population for the city of Norfolk as a whole was 52.92 percent. Portions of the study area that may be impacted by specific measures, or consequences of no-action, may have a significant minority population that could be affected by project implementation. Nonstructural measures would be more likely to significantly impact disadvantaged neighborhoods than structural measures protecting properties in their current states. As can be seen in Figure 10-42 and Table 10-14, minority populations are concentrated in certain areas, most notably along the Eastern Branch of the Elizabeth River.

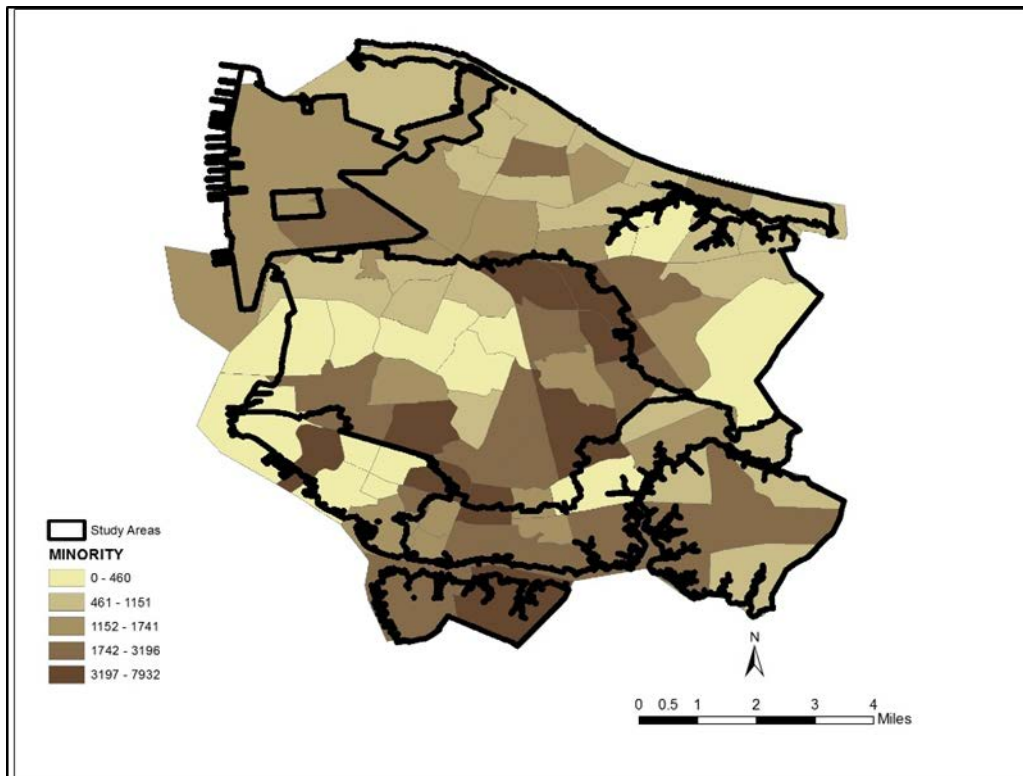


Figure 10-42. Minority Population by Census Tract

Table 10-14. Ethnic Make-Up of Norfolk

	2010 Population	White	Black	Native American	Hispanic	Percent Below Poverty
City of Norfolk	242,803	47.1	43.1	0.5	6.6	18.2

Younger and older people may be more vulnerable during emergencies, a consideration for preparedness as a non-structural measure. Ages are more evenly distributed through the city than ethnicity or income, as seen in Figure 10-43 and Figure 10-44, and should therefore not be a significant geographic factor in weighing the relative impacts of alternatives.

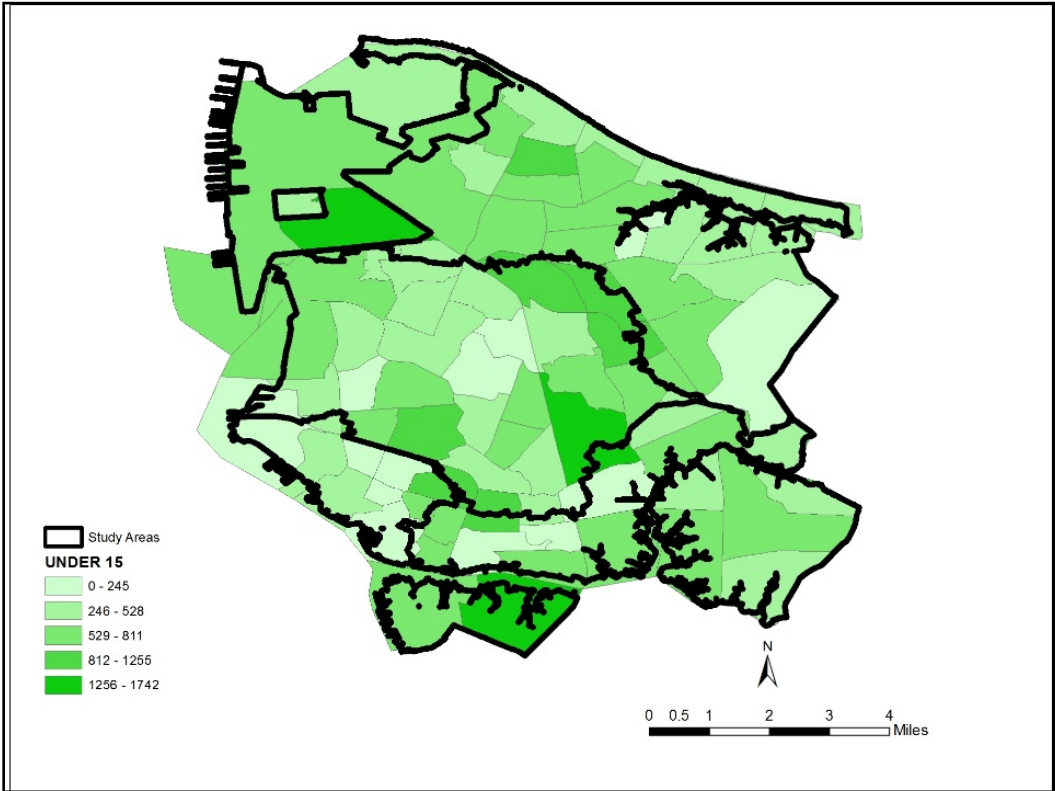


Figure 10-43. Population Under 15 by Census Tract, 2010 Census

Source: (US Census Bureau 2017a)

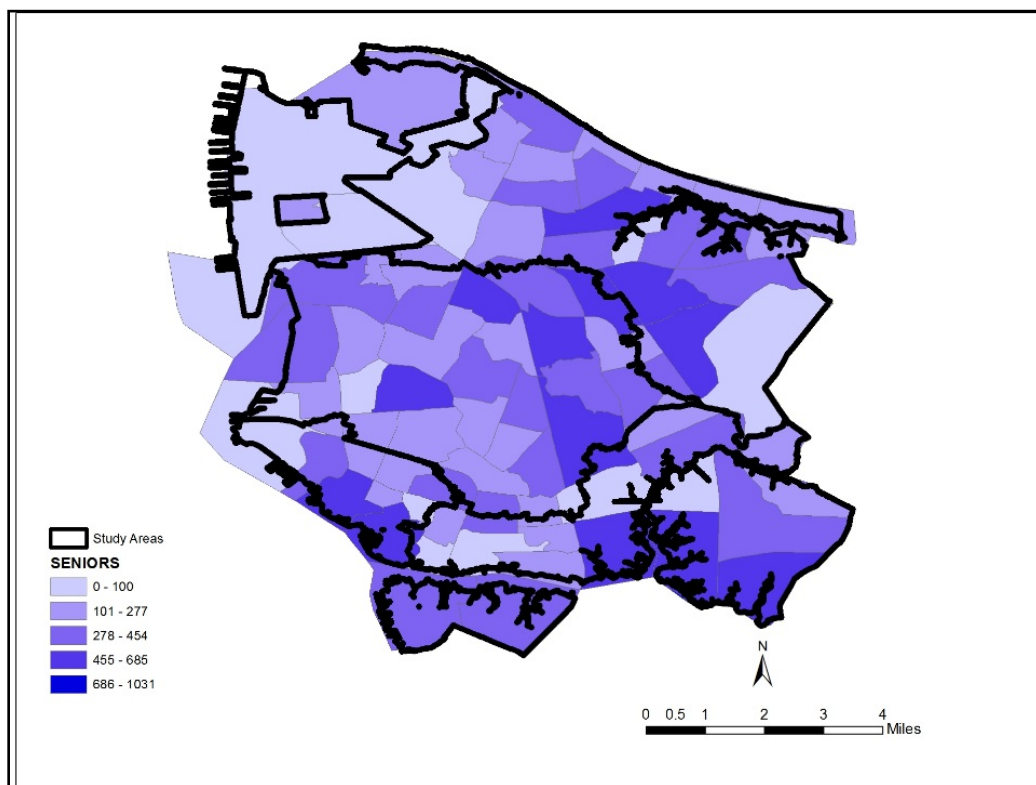


Figure 10-44. Population Over 65, 2010 Census

Source: (US Census Bureau 2017a)

10.17 HAZARDOUS MATERIALS AND WASTES

10.17.1 Definition of Resource

Hazardous materials include, but are not limited to, hazardous and toxic substances (biological, chemical, and/or physical) and waste, and any materials that pose a potential hazard to human health and the environment due to their quantity, concentration, or physical and chemical properties. Hazardous wastes are characterized by their ignitability, corrosivity, reactivity, and toxicity. Hazardous materials and wastes, if not controlled, may either (1) cause or significantly contribute to an increase in mortality, serious irreversible illness, or incapacitating reversible illness, or (2) pose a substantial threat to human health or the environment.

10.17.2 Methodology

The following analysis of hazardous materials and wastes includes a description of existing contamination and the risk of exposure to hazardous materials and waste related to the contamination and to routine use, storage, and transportation of hazardous materials, along with the associated regulatory framework.

At this phase of the study, we have completed an overview in the form of a database search of Environmental Protection Agency (EPA) and Virginia Department of Environmental Quality (VDEQ) databases, limited visual site inspections, and coordination with appropriate agencies. Phase 1 site assessments will be done as needed during or before the PED phase, but not during this feasibility phase. If contaminated sites are discovered and a Phase 2 or subsequent

work is required, then this document may need to be supplemented to address the previously unknown and unaccounted for impacts.

The ROI for hazardous materials and wastes is defined as the city of Norfolk and locations within four miles.

10.17.3 Framework

The primary relevant federal regulations include those promulgated under the **Resource Conservation and Recovery Act (RCRA) of 1974** and the **Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980**.

The State rules regarding asbestos adopt existing federal **Occupational Safety and Health Administration (OSHA)** and USEPA regulations and apply them to all public facilities in which activities involving the disturbance or removal of asbestos containing material (ACM) may occur. The USEPA maintains guidance on management inspection of facilities that may have lead-based paint (LBP). The TDSHS regulates LBP inspection, remediation and management. The state rules regarding LBP adopt existing OSHA and USEPA regulations and apply them to all public facilities in which activities involving the disturbance or removal of LBP may occur.

10.17.4 Existing Conditions

The Virginia Department of Environmental Quality (VDEQ) Waste Division indicates the following inventories of generators and sites of Hazardous, Toxic, and Radioactive Wastes (HTRW) within the project area:

- 1) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Information System. This database lists potential hazardous release sites under the Superfund Program, a federal program to clean up the most hazardous sites.
- 2) Resource Conservation and Recovery Information System (RCRIS). This is an inventory of hazardous waste handlers.
- 3) Toxics Release Inventory (TRI). This is an information system about toxic chemicals that are being used, manufactured, treated, transported, or released into the environment.
- 4) Solid Waste Facilities Inventory. This is an information system about large facilities for the storage and handling of solid waste, whether transported or left in place.
- 5) Pollution Response Program (PREP) database lists all reports by agencies and citizens to VDEQ of anything, whether it is strictly pollution or not.

CERCLA Sites

Only one CERCLA site, Naval Base Norfolk, which was on the National Priorities List (NPL), is located in the city of Norfolk. Remedial actions at Naval Base Norfolk site were completed in 2010. Little Creek Amphibious Base (Joint Expeditionary Base Little Creek – Fort Story) is adjacent to the city line, but in Virginia Beach. Across and upriver from the Berkley section of

Norfolk, there are five Superfund sites along the Southern Branch of the Elizabeth River in Portsmouth. These, from north to south, are: Abex Corp., Norfolk Naval Shipyard, Peck Iron and Metal, Atlantic Wood Corp., and Saint Juliens Creek Annex (Figure 10-45).

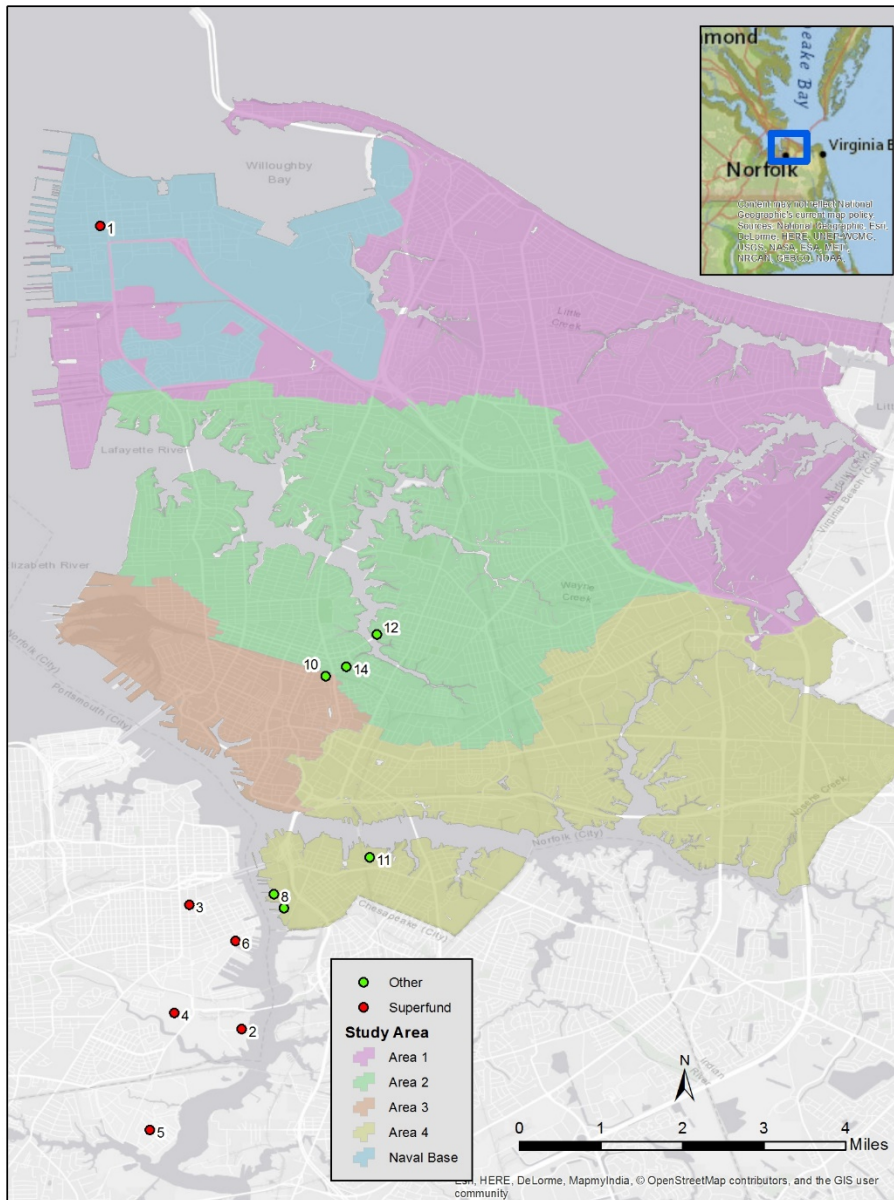


Figure 10-45. EPA Cleanup Sites in the Vicinity of Norfolk
 Source: (EPA 2017)

Table 10-15. EPA Cleanup Sites

Map #	Name	Site Type
1	Norfolk Naval Station	Superfund
2	Atlantic Wood	Superfund
3	Abex Corp.	Superfund
4	Peck Iron and Metal	Superfund
5	St Juliens Cr Annex	Superfund
6	Norfolk Naval Shipyard	Superfund
7	Little Creek Amphibious Base	Superfund
8	BAE Systems	RCRA
10	Downtown Used Auto Parts	OSC
11	Kinder Morgan	OSC
12	Powell McClellan Lumber	OSC
13	Saint Helena Annex	Other
14	Square Deal Demolition	OSC

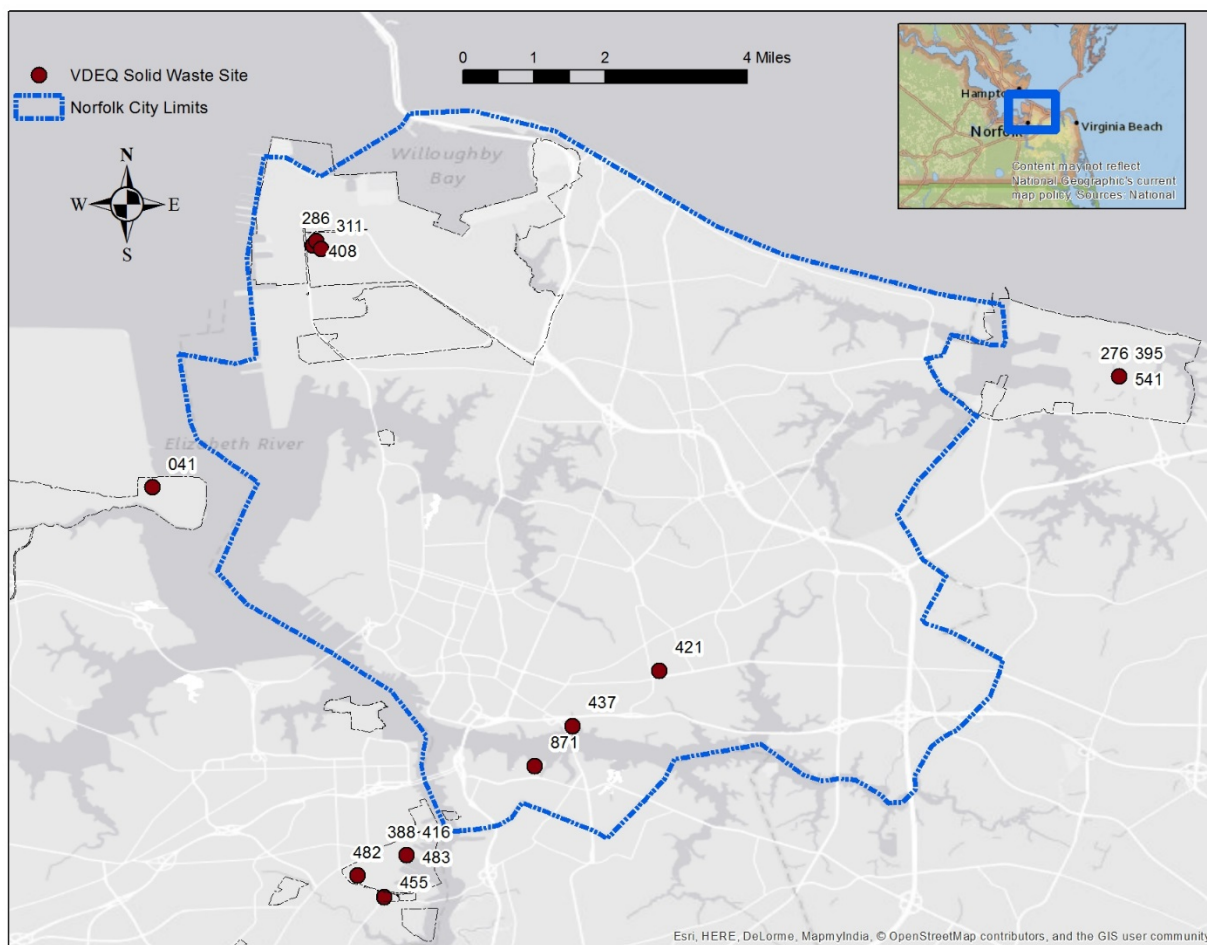


Figure 10-46. Virginia Department of Environmental Quality Solid Waste Site Inventory
Source: (DEQ 2017)

RCIS Sites

These RCRIS generators include dry cleaning establishments, gasoline stations, fiberglass manufacturers and other industrial facilities. Previous reports have also identified RCRIS generators within 4 miles of the project area (USACE, 2006). The only Toxic Release Inventory (TRI) site identified is the Naval Base Norfolk (also identified as an NPL site). A review of the aggregate TRI data from Naval Base Norfolk indicates minimal releases to surface water from the site. Less than 500 lbs of TRI classified chemicals have been reported released to surface water since 2000.

The Virginia Department of Environmental Quality (VDEQ) requires the registration of Above-ground Storage Tanks (AST) and Underground Storage Tanks (UST) for these kinds of materials. There are 787 tanks registered in the city of Norfolk, and hundreds more in surrounding areas (Figure 10-47).

PREP Database

The PREP data available from VDEQ’s website as of October 4, 2017 listed all calls or other notifications VDEQ received from October 31, 2001 to October 7, 2009. Of these 1690 were listed as having been in Norfolk. Naval installations reported 756 of the incidents. Of the other

935 there were 474 petroleum related, 215 water related, 131 about substances released into the air, 10 fish kill reports, and eight reports of wetlands being filled. There were also 80 reports on solid waste, of which 43 were termed hazardous. Other incidents recorded in the data base include drills for responding to hazardous materials situations and terrorist attacks, although these made up only a handful of the total, and other reports where nothing was found. If the report proves to be consequential, it is recorded under another program, such as the Remediation/AST & UST program, which includes geocoding the location. "VDEQ does not certify this data to be all inclusive or complete. This data is provided to the citizens of the Commonwealth of Virginia free of charge for informational purposes only. (VDEQ 2017)"

HTRW Sites

No significant HTRW releases to the project area have been documented. As with any active industrial area, there is the potential for HTRW contaminants to be released to the environment from a multitude of sources; however no evidence has been found to suggest that sediments in the borrow site have been exposed to HTRW.

Brownfields Sites

Brownfields is a term used in the US and UK to describe tracts of land formerly used for industrial or commercial purposes. They may contain construction debris and contaminants, but not to the degree of a Superfund site. EPA has a grant program for the rehabilitation of brownfields sites, but there are none in Norfolk identified under that program. The city does, however, identify the area around Harbor Park on the Eastern Branch of the Elizabeth River as a brownfields site. The area was the site of various commercial and industrial activities in the past, and much of the area is fill in what was Newton Creek. The construction of Harbor Park 25 years ago, and more recently the Amtrak station, are first steps in an extensive redevelopment plan.

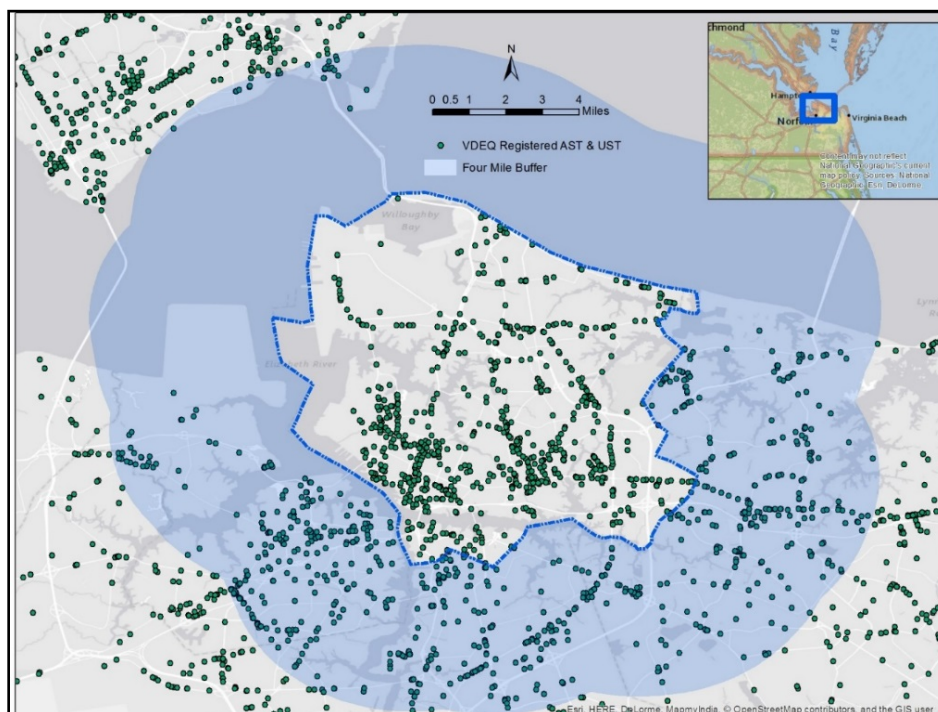


Figure 10-47. Virginia Department of Environmental Quality Registered Tanks

10.18 SAFETY

10.18.1 Definition of Resource

The safety resource examines those elements of the Study Area that might be at risk of harm from a flood event, as well as the emergency response systems in place to respond to such events. Intense, heavy rainfall and tidal flooding that has the ability to cause property damage and destruction, life-threatening injuries, and the possibility of loss of life for those affected. Occupational health and safety plan will also need to be implemented for the personnel that will be constructing, operating, and maintaining the project features within the Study Area for their safety and health.

10.18.2 Methodology

In reviewing public safety, the safety of the public may be evaluated in terms of flood risk to life and property. This analysis considers flood extents and identifies structures potentially affected by a major flood event. For tidal flooding improvements, the major flood event would be tropical storms, hurricanes, or nor'easters. For the interior drainage, the major flood event considered is the 100 year storm event. Safety is evaluated in terms of initial risk, emergency response, and communication of emergency procedures to the potentially affected populations. The potentially affected population consists of the public at risk of harm from flooding, including those working on project construction, maintenance, and operation along the coast line of the city of Norfolk.

10.18.3 Framework

The Occupational Safety and Health Act (OSHA) of 1970 and implementing USEPA regulations created the Occupational Safety and Health Administration to require the assurance of safe and healthful working conditions for working men and women by setting and enforcing

standards and by providing training, outreach, education, and assistance.

The Commonwealth of Virginia Emergency Operations Plan provides the framework for how the state will support impacted local governments, individuals and businesses. It is compatible with the National Response Framework and outlines how Virginia will work with the Federal Government to better deliver federal disaster assistance and improves capability to respond to and recover from natural and human-caused disasters.

Code of Virginia, §44-146.19E, requires each jurisdiction to prepare and keep current a local emergency operations plan. Every four years the jurisdiction shall conduct a comprehensive review and revision of its emergency operations plan to ensure it remains current. The revised plan shall be formally adopted by the jurisdiction's governing body.

FEMA Disaster Operations Legal Reference Version 2.0. The second Edition of the Disaster Operations Legal Reference describes the legal authorities for FEMA's readiness, response, and recovery activities.

Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-707, signed into law November 23, 1988; amended the Disaster Relief Act of 1974, PL 93-288. This Act constitutes the statutory authority for most Federal disaster response activities especially as they pertain to FEMA and FEMA programs (Stafford).

Presidential Policy Directive 8 is aimed at strengthening the security and resilience of the United States through systematic preparation for the threats that pose the greatest risk to the security of the nation, including acts of terrorism, cyber-attacks, pandemics, and catastrophic natural disasters.

10.18.4 Existing Conditions

Coastal Flooding

Norfolk is situated in a combination of coastal and estuarine environments where it is bound by a number of different water bodies that include the Chesapeake Bay, the Hampton Roads Harbor, the Elizabeth and Lafayette Rivers and their numerous tributaries as well as small lakes. The City is located in a low-lying physiographic region, which presents additional challenges in flood mitigation because drainage gradients are limited and nearly all portions of Norfolk are below an elevation 15 feet. Close proximity to water paired with low drainage gradients results in a significant percentage of Norfolk being susceptible to flooding from high tides, nor'easters, hurricanes, and tropical storm events. The intensity of this flooding ranges from nuisance flooding, typically associated with high tides, to severe, albeit less frequent flooding from hurricanes and major nor'easters such as occurred in August 2011 (Hurricane Irene) and November 2009, respectively (Fugro, 2012).

In recent years, Norfolk has recognized an increased need to address coastal flooding problems. Historically, the City has addressed flood mitigation through stand-alone, small to intermediate-sized capital improvement projects. Today, the remaining flood mitigation projects are numerous, complex, and may require considerably larger capital improvement budgets than in the past. As with all municipalities in the region, implementation of flood mitigation and flood defense improvement projects is primarily constrained by the ability to fund such a large-scale

project (Fugro, 2012).

In addition, relative sea level in the local area is rising (at a current projected rate of 1.45 feet per 100 years). Assuming that this trend continues (or increases), both nuisance flooding and flooding from storm events capable of causing significant damage will increase. This will further the need to address the issue of coastal flooding on both project-specific and a holistic basis (Fugro, 2012).

Significant events like the November 2009 Nor'easter and Hurricane Irene have served to: 1) reinforce Norfolk's decision to proactively evaluate coastal flooding and 2) elevate the City's needs and priorities for flood defense mitigation. In addition, smaller events such as the short but intense localized storm over the Broad Creek area in August 2009 can also cause local flooding and damage. Flood damage stemming from such short duration but intense storms can be significantly affected by the tidal conditions at the time of the storm. The August 2009 storm occurred at low tide but the large volume of rainfall captured in the Broad Creek basin caused water levels in the basin to increase by more than 1 foot and were elevated for about 6 hours (as measured by the local tide gauge). While the flooding and damage during that storm were significant, they were much less than would have occurred if that storm had coincided with peak rather than low tide conditions (Fugro, 2012). Figure 10-48 below depicts the projected FEMA base flood elevation (BFE) plus sea level rise for both the 50 year period of analysis and at 100 years.

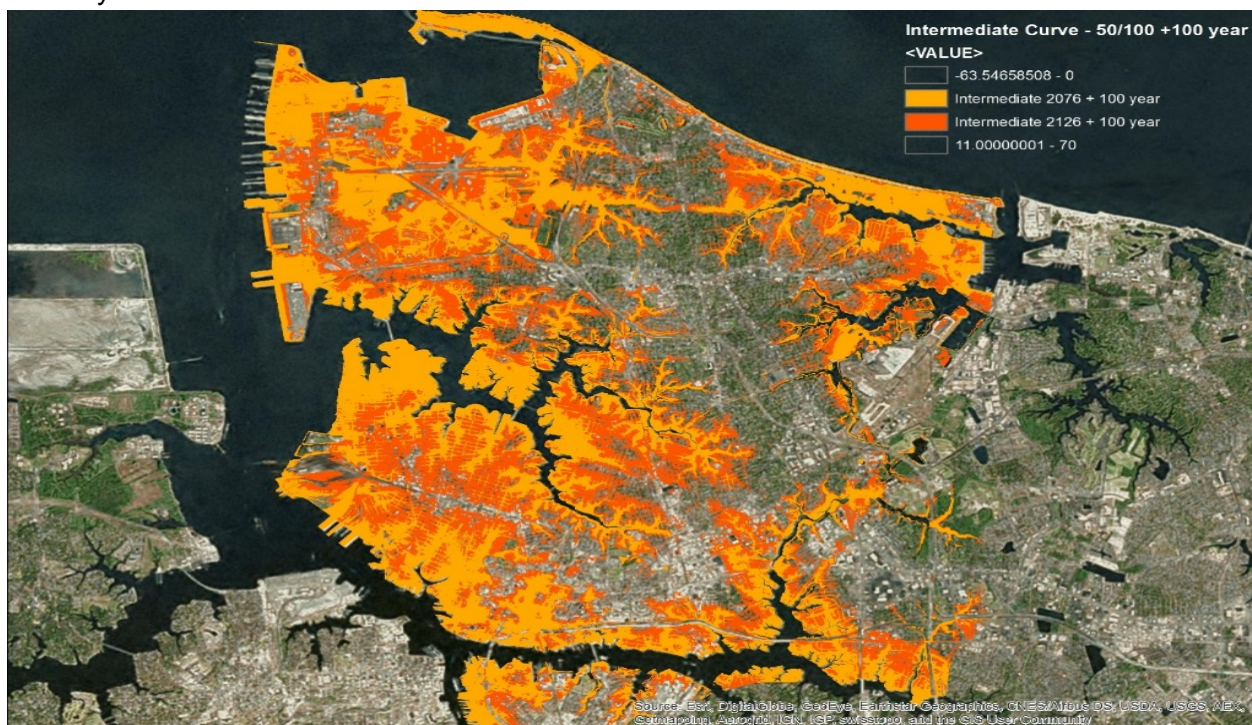


Figure 10-48. Projected FEMA 100 Year Floodplain Map

Interior Drainage Systems

Norfolk experiences frequent flooding due to rain. Residents are accustomed to annual events that produce hazards and inconveniences due to road conditions and other flooding-induced safety issues.

Norfolk is an older colonial city with some original historical infrastructure dating back to the 1800s. Infrastructure improvements were most recently performed in the 1950s due to rapid urbanization. That upgraded infrastructure is currently approaching the end of its serviceable life and is due for upgrades. Early stormwater system designs did not consider future development or tidal impacts.

The existing municipal stormwater system is separated from the sewer system and is managed by the City of Norfolk Public Works Stormwater Division. The portions of the system designed before the 1950s was sized to accommodate a 2-year storm; the newer portions were designed to accommodate a 10-year storm event. Stormwater behind the downtown floodwall is managed by a pump station along Waterside Drive. Stormwater in Harbor Park is managed by an underground collection conveyance pipe network that discharges stormwater directly into the Elizabeth River or to a series of concrete-lined ditch systems under the elevated section of I-264. The concrete-lined ditches discharge to a waterway near the Norfolk Southern railroad tracks. Norfolk also has stormwater pump stations at railroad underpasses along primary transportation routes, and other areas around the city.

The City has installed several backflow prevention measures on outfalls in the Larchmont and Hague areas of Norfolk with more planned in the future.

Emergency Services

Police Department

Police protection for the citizens of and visitors to the city of Norfolk is provided by the City of Norfolk Police Department, which is made up of 775 sworn police officers and 74 civilian employees. The Department is capable of responding to all emergency incidents throughout the city that require police intervention, including natural disasters. The Department is geographically divided into four patrol divisions. Each division acts independently of the other three. Police administration is located at 100 Brooke Avenue, Norfolk, Virginia that is downtown (City of Norfolk).

The Study Area includes all four of the divisions. Each division is divided into “major neighborhoods” with 44 neighborhoods operating within the Study Area. In the year 2016, the City of Norfolk Police Department was dispatched 237,284 times (City of Norfolk).

Fire-Rescue Services

Fire protection, fire suppression, rescue, and emergency medical services for the city are provided by the Norfolk Fire-Rescue Department, which is made up of 495 firefighters and paramedics and respond to 47,491 calls in 2016. Norfolk Fire-Rescue is capable of responding to all hazards and emergencies, including technical rescue and water rescue incidents, and all types of medical emergencies. The department is geographically divided within the city with 14 engine companies, seven ladder companies, and two heavy rescue companies divided into three battalions. All 14 engine companies are located within the Study Area (City of Norfolk).

The Norfolk Fire-Rescue Department’s technical rescue team responds to all water emergencies. The technical rescue team responds to all water emergencies, especially incidents where people are trapped in fast moving water. Technical rescue response and water rescue emergencies are answered by firefighters who are properly trained and prepared to respond on those calls (City of Norfolk).

Norfolk Fire-Rescue is responsible for providing all emergency medical service within the city of Norfolk. This is accomplished with a medic (ambulance) fleet that consists of 12 advanced life support licensed units that are in service 24/7, with a 13th unit available in times of heavy call volume. The Norfolk medic units are staffed with one firefighter/advanced life support provider that is certified in the State of Virginia. Ambulance services can transport to one of the three hospitals within the Study Area. However, access to the local hospitals may be restricted in the event of a major flood event (City of Norfolk).

Emergency Management

Norfolk has two emergency management plans. The Hampton Roads Hazard Mitigation Plan (region) is vulnerable to a wide range of hazards that threaten the safety of residents and have the potential to damage or destroy both public and private property and disrupt the local economy and overall quality of life. While the threat from hazards may never be fully eliminated, the Hampton Roads Hazard Mitigation Plan recommends specific actions designed to protect residents, business owners and the built environment.

The purpose of this Emergency Operations and Resilience Framework is to provide an organizational framework and response capability with which the City and its partners can

conduct special events and response to natural, technological, man-made, or war-caused emergency incidents requiring a comprehensive, integrated response. The Framework identifies that which must be done and by whom; agency-specific plans detail how. Special focus is on facilitating a community centric approach to emergency management-to make that leap from mere collaboration to effective coordination. It is designed to meet the legal mandates outlined by Federal, State and local code in the areas of emergency services and emergency management. Likewise, this collection of plans should serve as a resource for continuous disaster planning, and also written in a style to be useful to the community as well as a responding individual or agency unfamiliar with the locality (Norfolk Emergency Operations 2017).

Norfolk has a Mayor-Council government system with a strong City Manager to oversee and otherwise lead the City's day-to-day operations. Team Norfolk's response to a disaster/catastrophic incident would be to activate the emergency management system. The emergency management system's purpose is to provide a framework for an appropriate response to major emergencies or special events when centralization and coordination become critical. In such situations, for City operations, the City Manager assumes the role of Emergency Management Director and receives staff support and advice from the Emergency Management Coordinator and others in the establishment and administration of the emergency management organizational structure. For incidents involving the entire community, the Director of Emergency Preparedness and Response (Emergency Management Coordinator), assumes the role of the incident Commander. For all others, the Emergency Operations Center provides logistical support to on-scene incident command. During city-wide response, specific departments and agencies, are tasked with emergency management functions including emergency public information, damage assessment, sheltering, etc. When possible, operational departments continue the normal delivery of services, to be coordinated under the emergency management structure. Once this system is activated, emergency operations are typically run from the Emergency Operations Center (Norfolk Emergency Operations 2017).

10.19 TRANSPORTATION AND NAVIGATION

10.19.1 Definition of Resource

Transportation refers to the operational characteristics of the land transportation network, including the network's capacity to accommodate existing and projected future travel demand. Networks may encompass many different types of facilities that serve a variety of transportation modes, such as vehicular traffic, public transit, and non-motorized travel. Access to, within, and from the Study Area is provided via a network of freeways, arterial streets, connector streets, public transit services, freight rail lines, and non-motorized transportation facilities (including bicycles, sidewalks, and pedestrian trails). However, it should be noted that recreational trails are covered under the Recreation section of this document.

Navigation refers to the use of waterways, either primarily for transportation or recreational purposes, by any type of vessel. Vessels include ships, barges, ferries, boats, sailboats, small craft, and the like.

10.19.2 Methodology

The ROI for transportation includes all roadways (freeways, major and minor arterial roads, collector roads, and neighborhood roads); train, light rail, bus routes, other mass transit, and pedestrian sidewalks within the Study Area, that will be affected directly or indirectly by the project.

The ROI for navigation includes the navigable waterways surrounding and within the Study Area limits that can be used by any type of vessel.

10.19.3 Framework

U.S. Department of Transportation (USDOT), Virginia Department of Transportation (VDOT), Virginia Department of Rail and Public Transportation (DRPT), Hampton Roads Transit (HRT), and Hampton Roads Transportation Planning Organization (HRTPO). 23 US Code 134, 135, 217,315; 42 USC 7410; 49 USC 5803-6. This law, and its implementing regulations (23 Code of Federal Regulations 450), “requires each state to carry out a continuing, comprehensive, and intermodal statewide transportation planning process, including a statewide transportation plan and transportation improvement program that facilitates the efficient, economic movement of people and goods in all areas of the state. In accordance with 23 CFR 450, the HRTPO produces a financially constrained Regional Long-Range Transportation Plan every four years that addresses a planning horizon of 20 years. The purpose of these plans is to guide transportation investments to projects designed to meet the transportation goals of the HRTPO--economic vitality, safety, mobility, and environmental protection. These regulations also address the content of metropolitan plans. Norfolk participates in the federally-mandated, regionally-based long-range transportation planning process for urbanized areas, which is coordinated through the HRTPO. The HRTPO's long-range transportation plans cover several modes of transportation, including personal vehicle, public transportation bicycling, and walking.” (HRTPO website, 2017).

USDOT, VDOT. Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU): Signed into law on August 10, 2005, SAFETEA-LU addresses improving safety, reducing traffic congestion, improving efficiency in freight movement, increasing intermodal connectivity, and protecting the environment. It is intended to promote more efficient and effective federal surface transportation programs by focusing on transportation issues of national significance, while giving State and local transportation decision makers more flexibility for solving transportation problems in their communities (FHWA, 2017a).

USDOT/VDOT. Moving Ahead for Progress in the 21st Century Act (MAP-21) Signed into law on July 6, 2012, MAP-21 is intended to create a streamlined and performance-based surface transportation program and builds on many of the highway, transit, bike, and pedestrian programs and policies established in under previous laws (FHWA, 2017b).

U.S. Rivers and Harbors Act 1899 (33 USC 403). Prohibits the creation of any unauthorized obstruction to the navigable capacity of any of the waters of the U.S. Requires authorization by the Chief of Engineers for construction of any wharf, pier, dolphin, boom, weir, breakwater, jetty, or other structures or fill in any port, raven, harbor, canal, navigable waterway. Also requires authorization for any alteration or modification of any course, location, condition or capacity of

any port, haven, harbor, canal, or other navigable waterway. The Act also authorizes the U.S. Coast Guard to impose requirements for navigational safety, and for establishment of anchorage grounds for vessels in navigable waters of the US whenever it is apparent that these are required by the maritime or commercial interests of the United States for safe navigation.

The “**plaNorfolk 2030**” was adopted by Norfolk on March 2013. While not intended to function as land use regulations, it instead serves as the City’s Comprehensive Plan as the basis for local land use decisions and transportation goals, through a long range vision of the community in the future (City of Norfolk, 2017).

10.19.4 Existing Conditions

Transportation and navigation are first discussed herein, in an overarching sense, in terms of the Study Area as a whole; then they are considered in further detail for Areas 1-4. It should be noted that intention of this section of the report is not to describe all transportation corridors within the Study Area, which would be an exhaustive document in and of itself. Rather, the intention is to first describe an overview of transportation and navigation network and options within the City as a whole, while focusing in greater detail on those areas that will be directly or indirectly affected by the project.

Transportation. As a highly urbanized locality, the city of Norfolk contains a network of Interstates, principal arterial, minor arterial, collector routes, and private roadways, as well as a variety of multimodal transportation options. Norfolk’s network of highways and arterial streets is the City’s primary link to the larger Hampton Roads region, and points beyond. Highways and arterials generally provide the fastest method of travel and typically have limited accessibility from neighboring roads, while collector roads are used as a connection between local and arterial roads (plaNorfolk 2030). According to the report by the USDOT, entitled, “Hampton Roads Climate Impact Quantification Initiative, Baseline Assessment of the Transportation Assets, and Overview of Economic Analyses Useful in Quantifying Impacts” (2016), there are a total of 1,094 roadway centerline miles within Norfolk. These include approximately 102 miles of interstate, 98 miles of primary, 169 miles of secondary, 643 miles of local or private, and 82 miles of military roads (USDOT, 2016).

Interstate highways. Norfolk contains four interstate highways: I-64, I-264, I- 564, and I-464 (Figure 10-50). I-64 begins in the City of Chesapeake, passes east through the Cities of Portsmouth and Norfolk, and extends through the Hampton Roads Bridge Tunnel to the Virginia Peninsula and points west. It is the most heavily-travelled of three routes from the Southside to the Peninsula in the Hampton Roads area; in 2015 it had weekday average traffic counts of up to 83,800 vehicles per day. I-264 is the east-west route from the Virginia Beach Oceanfront west through Norfolk to Downtown, the Downtown Tunnel, and the city of Portsmouth, terminating in the city of Chesapeake at I-664. In 2015, I-264 had weekday average traffic counts of up to 71,400 vehicles per day. I-564 is a short interstate that extends from I-64 and terminates at the Naval Station Norfolk; I-564 had 2014 weekday average traffic counts of up to 19,600 (HRTPO 2017b). The northernmost section of I-464 begins adjacent to the Downtown Tunnel and is the major north-south connection between the cities of Norfolk and Chesapeake (Figure 10-50).

Tunnels. Norfolk has direct access to three tunnels, which are also the three main routes from Norfolk to points west: the Hampton Roads Bridge Tunnel (I-64) located north of the City,

extending from the city of Norfolk to the city of Hampton; and the Downtown (I-264) and Midtown Tunnels (Route 58), both along the southwestern city boundary, extending from the city of Norfolk to the city of Portsmouth. According to 2015 average weekday traffic counts from the Hampton Roads Transportation Planning Organization (HRTPO 2017b), the tunnels carried approximately 83,800; 74,000; and 35,300 vehicles per day, respectively. These are also crucial components of the hurricane evacuation routes.

Principal Arterial Roadway Network. The north-south roadways within the City that have been functionally classified as principal arterials are: Hampton Boulevard (Route 337), Granby Street (Route 460), Tidewater Drive (Route 168), and Military Highway (Route 13). The principal east-west arterial roadways are: Little Creek Road (Route 165), Terminal Boulevard (Route 406), Brambleton Avenue (Route 337), Virginia Beach Boulevard (Route 58), Princess Anne Road (Route 166), and Shore Drive/Ocean View Avenue (Route 60). According to 2015 data, these roadways have weekday average traffic counts ranging from 22,000-48,000 vehicles per day (HRTPO, 2017b). See Figure 10-51. These are all important links in the hurricane evacuation routes for the residents of Norfolk.

There are numerous minor arterial and collector roadways within the City that will be discussed in further detail, as applicable, later in this section.



Figure 10-50. Interstate and other Principal Arterial Roadways within the City of Norfolk
Source: City of Norfolk 2017 "plaNorfolk 2030"



Figure 10-51. Minor Arterial and Collector Roadways within the City of Norfolk
Source: City of Norfolk 2017 “plaNorfolk 2030”

Evacuation Routes. Evacuation routes as determined by the Virginia Department of Emergency Management (VADEM) are shown in Figure 10-52 below. For Norfolk the identified evacuation routes are Interstate 64 and Interstate 264. Residents of Norfolk would be expected to use the principal arterial network to access the evacuation routes. Other routes out of the city, such as the tunnels and principal arterials mentioned above, are expected to be used by citizens to exit the city and access the designated evacuation routes.

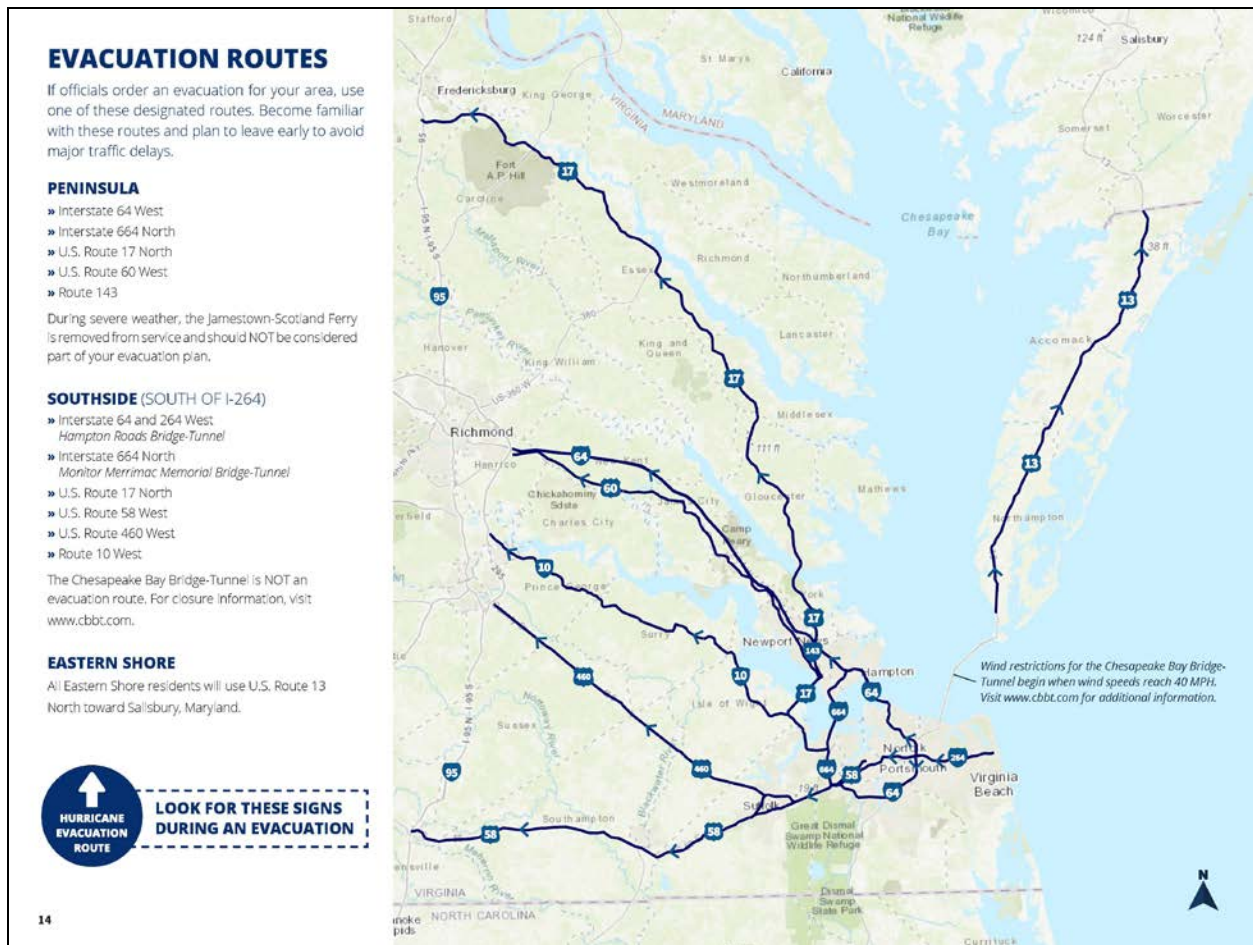


Figure 10-52. Hurricane Evacuation Routes for Eastern Virginia

Mass transit. In addition to its roadway network, the following important mass transit options and services are also available in the city of Norfolk:

- **Norfolk International Airport**, Southside Hampton Roads' only major airport facility.
- **A Hampton Roads Transit (HRT) Elizabeth River Ferry** from Norfolk to Portsmouth.
- **A 14.8-mile light rail line (The "Tide")**, and two miles of Amtrak passenger rail line. (These figures include both east and westbound rail lines) (USDOT, 2016).
- **HRT Public Bus service** throughout the entire City and other neighboring localities.
- Bicycle routes, sidewalks, and pedestrian trails.

Other rail lines. There are approximately 68 miles of freight (non-passenger) rail lines within Norfolk (USDOT, 2016).

Maintaining the efficient connectivity between the ports and the roadway/railway networks are a key transportation priority for the city (plaNorfolk 2030). It is important to note that currently many of the transportation corridors in the city of Norfolk contain roadways that are already prone to flooding after heavy rain events and/or storm surge, under existing conditions. Due to limited drainage gradients and the design of the storm sewer system in some areas of the city, sometimes high tide events will cause the storm sewer inlets to overflow, allowing storm water to flood roadways. (USACE, 2013).

Navigation. In terms of waterborne navigation, Norfolk is home to one of the busiest international ports on the East Coast of the US, as well as the world's largest naval base (plaNorfolk 2030). The USACE maintains a deep draft federal navigable channel system in the Norfolk Harbor and connecting waters encircling the Study Area. The Norfolk Harbor channels include the Atlantic Ocean Channel; the Thimble Shoal Channel, which passes through the Chesapeake Bay; the Norfolk Harbor Entrance and Channel; the Craney Island Reach, Southern Branch, and Eastern Branch, all within the Elizabeth River; and the Newport News channel and anchorages. This channel system makes up the main navigational thoroughfare into and out of the Norfolk, Hampton Roads Harbor, and the Port of Virginia. These channels are vital to the military, the ports, and other maritime and recreational interests of Hampton Roads.

A USACE/Virginia Port Authority feasibility study is currently underway to determine whether to deepen the Norfolk Harbor and the Elizabeth River Southern Branch channel network; this will be further discussed in the Future Without Project section of this document. These channels, plus Little Creek in Area 1, and the Eastern Branch of the Elizabeth River in Areas 3 and 4, are the major navigation channels serving the Norfolk area.

In addition to these, the USACE maintains smaller federal channels in Willoughby Bay, the Lafayette River, Knitting Mill Creek, and Haven Creek within the Study Area. These will be discussed in more detail under the subheadings "Areas 1-4."

Area 1--Willoughby, Ocean View, Mason Creek, Little Creek, Pretty Lake, and Lake Whitehurst Watershed.

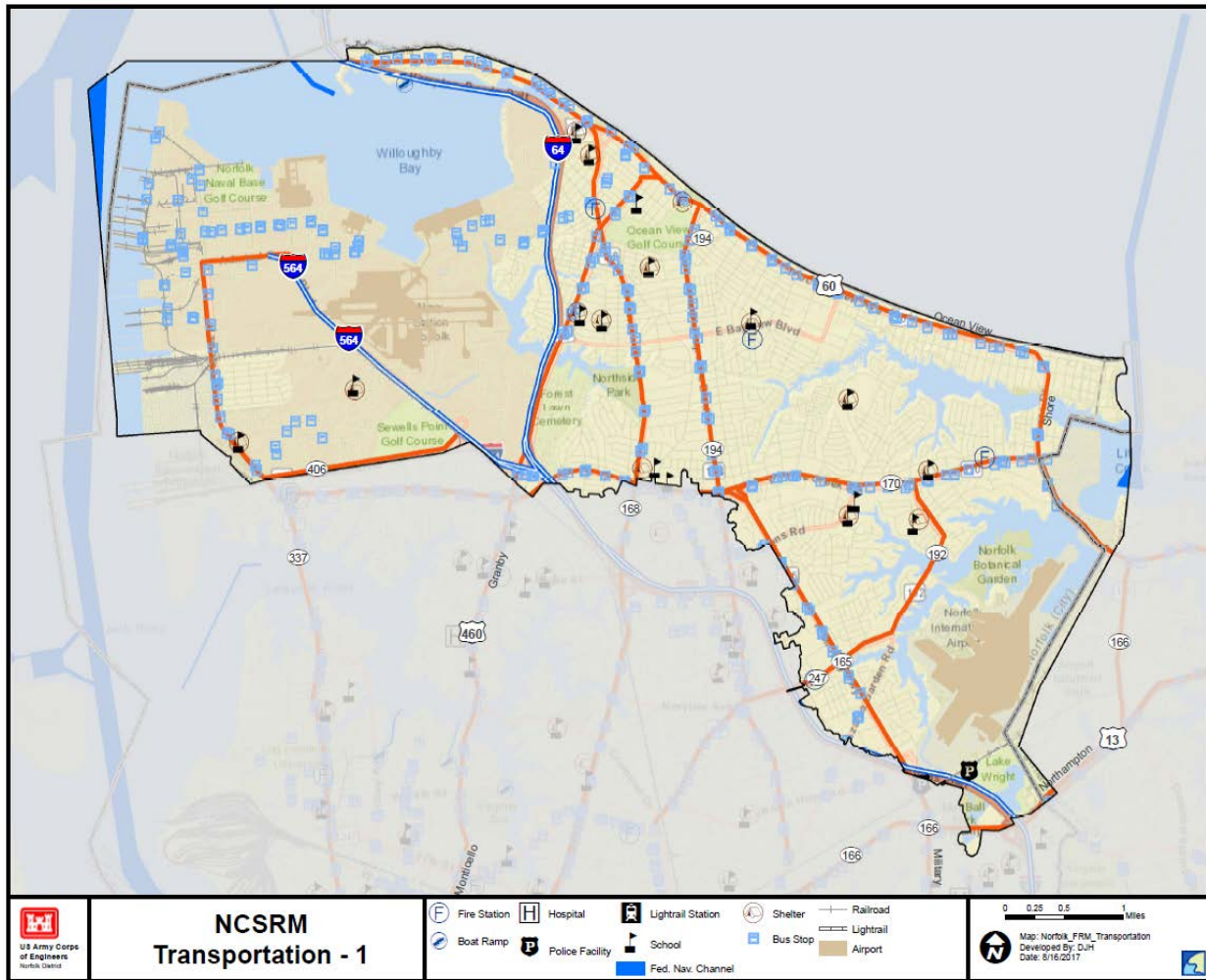


Figure 10-53. Transportation Area 1

Transportation. Area 1 contains the following important transportation links:

- Norfolk International Airport, Southside Hampton Roads' only major airport facility. Located at 2200 Norview Avenue in the northeast corner of the city, it serves coastal Virginia and northeastern North Carolina. Airport terminals are open 24 hours, seven days a week.
- The I-64 segment that connects commuters to the Hampton Roads Bridge Tunnel (HRBT), the Peninsula, and points west.
- The I-564 and Terminal Boulevard, the main entranceways into Naval Station Norfolk.
- Route 60 (Shore Drive), the main route from northern Virginia Beach through northeastern Norfolk, including Willoughby and Ocean View. The existing Route 60 Shore Drive bridge over Pretty Lake was replaced in 2002. It was widened and now includes a combination sidewalk and bicycle path. This roadway had average daily traffic counts of approximately 34,700 in 2015 (HRTPO 2017b).
- The northern sections of the following primary arterial roads: Granby Street (U.S. Route

460), Chesapeake Boulevard (U.S. Route 194), and Tidewater Drive (Route 168), and Little Creek Road (Route 165/170).

- Numerous bus routes along all three arterial roads as well as on the Base. Bus stop locations are shown on the map.

The Naval Station Norfolk, Norfolk International Airport, and the HRBT (and points west), are major destinations for commuters in Area 1. Naval Station Norfolk, in particular, is not only the area's largest employer, it is the largest naval base in the world.

Navigation: Area 1 contains the following important navigable water resources.

The major navigable waterways within Area 1 are the Chesapeake Bay, Little Creek, Fisherman's Cove, Pretty Lake, Willoughby Bay, and the Elizabeth River. The Atlantic Ocean Channel, the Thimble Shoal Channel, and the Norfolk Harbor entrance, north of the City, range from 1,000-1,400 feet wide, and 50-52 feet deep. The Norfolk Harbor Reach, and Craney Island Reach, to the north and northwest of the City, range from 800-1,200 feet wide and are 50 feet deep. All of these channels are collectively known as the Norfolk Harbor.

Along the Elizabeth River's Norfolk Harbor Entrance and Channel and Craney Island Reach Channel, are Naval Station Norfolk and the Norfolk International Terminals (NIT), which have numerous piers and terminals and depend on extensive navigable access. Naval Station Norfolk has 14 piers and is home to numerous air craft carrier ships. Norfolk International Terminals (NIT), owned by the Port of Virginia (POV) is one of the region's four container cargo facilities. NIT container port operates on 378 of its total 567 acres with 14 super post panama ship-to-shore cranes. In addition to these terminals, there are a number of privately owned marine terminals critical to the region's cargo movement. These ports in Norfolk and neighboring cities are responsible for the movement of a variety of goods (USDOT, 2016). It should be noted that NIT is discussed under both Area 1 and Area 2, because one of its main transportation corridors is located in Area 1, and the actual facility is located in Area 2.

Connecting to the Thimble Shoal channel section of the Norfolk Harbor is the USACE-maintained Little Creek channel. The Little Creek Channel is 1,160 feet long, 20 feet deep, and 400 feet wide and includes a basin at the terminals that is 20 feet deep, 400-1,240 feet wide. The U.S. Navy Little Creek Amphibious Base is located to the east of the channel, straddling the Norfolk/Virginia Beach city line, and the channel is vital to its operations. Connecting to the Little Creek Channel to the west is a waterway known as Fisherman's Cove. A proposed navigation channel there was studied but not dredged by the USACE; therefore it is not part of the USACE's federal navigation channel system. The Fisherman's Cove channel would have extended from the existing federal channel in Little Creek to the US Route 60 (Shore Drive) Bridge, a distance of 4,560 feet (USACE 2004).

The area adjacent to Fisherman's Cove is developed with commercial and recreational boating and related facilities from the US Route 60 bridge east to Little Creek. Boat sales, restaurants, and related business are also located on the waterway, and USACE Fisherman's Cove Final Environmental Assessment (FEA) also noted that the waterway is extensively used by charter

fishing boats, commercial work boats, and many transient boats visit the boatyards on the waterway for crabbing and fishing. The FEA noted that as of 2004, over 1,200 pleasure boats were based permanently in Fisherman’s Cove, and another 3,500 were launched annually from adjacent ramps, and another 1,200 transient boats visit the creek annually. (USACE 2004).

Pretty Lake is located immediately west of the Route 60 Shore Drive bridge and directly connects to Fisherman’s Cove. Pretty Lake does not have a defined navigation channel; however, the City has specified that the channelized entrance to Pretty Lake should provide a minimum draft of 4’, relative to MLLW datum. That elevation corresponds to EI -6.7 feet re: NAVD88 Datum. (Fugro Atlantic, 2012a). Pretty Lake is almost entirely surrounded by residential development, contains private piers, and is largely used by small recreational water craft.



Figure 10-54. Google Earth Image of Pretty Lake, Route 60 bridge, and Fishermans Cove

Willoughby Bay, at the northwest corner of the City, contains another USACE channel. This channel is approximately 300 feet wide, 10 feet deep, and about 1.5 miles long from deep water in the Norfolk Harbor, to a point opposite the extreme tip of Willoughby spit. Several marinas

that serve both commercial and pleasure craft utilize this channel and waterway.

Area 2 - Lafayette River Watershed

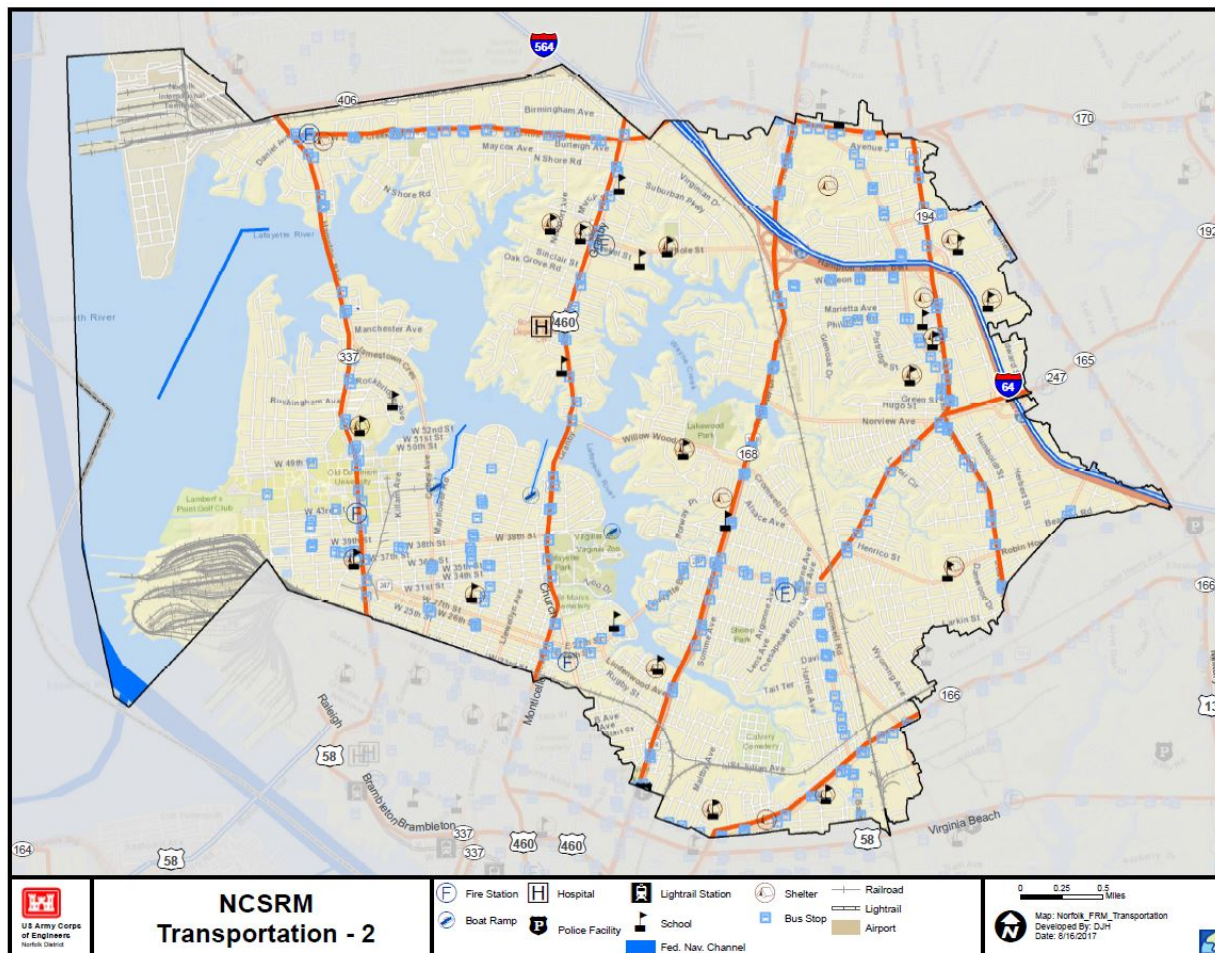


Figure 10-55. Transportation Area 2

Transportation. Area 2 contains both large residential areas and primary arterials with commercial development. It also includes Old Dominion University (ODU), and the two of the City's main terminals: Lambert's Point Coal Terminal and Norfolk International Terminals (NIT). A portion of I-64, an interchange, and the three primary arterial roadways pass through Area 2: Hampton Boulevard, Granby Street, and Tidewater Drive. These three arterials, which had 2015 average daily traffic counts of approximately 37,300; 35,800; and 41,800 respectively, all cross the Lafayette River and/or its tributaries (HRTPO, 2017b). The USACE Initial Technical Analysis, Flood Risk Management Comprehensive Study (2013) noted that these are already prone to flooding during small events, such as large high tides. They provide access to Naval Station Norfolk; therefore, flooding can affect mission readiness. Flooding impacts access to ODU and NIT. ODU has cancelled classes several times a year due to roadway flooding and storm surge events. Additionally, all three of these arterials are important routes to Sentara Norfolk General Hospital (USACE 2013).

A new transportation project, the I-564 intermodal connector project, is under construction, to be completed in 2018. Components of that project are in both Areas 1 and 2. It is a collaborative

transportation partnership between the Federal Highway Administration (FHWA), Eastern Federal Lands Highway Division (EFLHD), the Virginia Department of Transportation (VDOT), and the U.S. Navy. The new high-speed roadway will connect the existing I-564 through Naval Station Norfolk and NIT. The new roadway, to terminate near Hampton Boulevard (Route 337), will provide a safer high-speed highway that should decrease congestion, redirect heavy truck traffic from Norfolk city streets, and provide improved access for the 80,000 vehicles entering and exiting the Navy base every day. (VDOT, 2017a).

Navigation. The major navigable waterways within Area 2 are the main stem of the Elizabeth River, and the Lafayette River and its tributaries.

The Elizabeth River main stem contains the Craney Island Channel section of the USACE Norfolk Harbor channel system, which passes to the west of the city. This channel is crucial to NIT, Lamberts Point, and all maritime interests in the connecting Southern and Eastern Branch channels and waterways. The Craney Island Reach connects to the Norfolk Harbor Entrance Reach to the north, and the main stem of the Elizabeth River Southern Branch to the south. The Norfolk Harbor Entrance Reach channel ranges from 1,000-1,400 feet width and is 50 feet deep. The Craney Island Reach is 800 feet wide and 50 feet deep.

The Port of Virginia (POV) is the gateway for waterborne cargo flowing through the region. Within this region there are state-owned and privately owned terminals. State owned or operated facilities are managed by the Virginia Port Authority (VPA), which owns or leases the regions' four contained cargo facilities, one of them being NIT. The VPA created the Virginia International Terminals, a private nonprofit organization, which oversees daily operations. NIT container port operates on 378 of its total 567 acres with 14 super post panama ship-to-shore cranes with capacity to move 820,000 containers, equivalent to 1,426,800 20-foot equivalent units (TEUs). In addition to these terminals, there are a number of privately owned marine terminals critical to the region's cargo movement. These ports in Norfolk and neighboring cities are responsible for the movement of a variety of goods. About 65% of the deep draft ships call at the container terminals, 15% carry export coal moved through the coal terminals, and 20% call other private bulk terminals. (USDOT 2016). Therefore, the Norfolk Harbor and its connecting channels are vital to these operations.

The Lafayette River, which is approximately 6,600 feet wide at the mouth, contains a USACE channel that begins at the mouth and extends roughly 7,000 feet up the center of the river to the vicinity of the Norfolk Yacht Club. The channel is 8 feet deep and 100 feet wide. The USACE also maintains two additional federal channel in the Lafayette watershed: in Knitting Mill Creek, the channel is 6 feet deep with a maximum width of 80 feet, up to a settling basin at the head of the creek that is 8 feet deep, 50 feet wide and 100 feet long. The East Haven channel is located at the upstream limits of the Lafayette river project, immediately downstream of the Granby Street bridge, and provides for a channel 50 feet wide and 6 feet deep, from that depth in the Lafayette River to the upstream end of the creek, a distance of approximately 2500 feet. (All depths refer to MLW, which is -0.988ft NAVD88).

The Lafayette River and its channels accommodate a significant amount of recreational vessel traffic. Also, recreational boats gain access to the waterway at the Haven Creek boat ramp, and the ODU Sailing Center located near the Lambert's Point Golf Course. (Fugro Atlantic,

2016). There are seven (7) marinas located within the Lafayette river watershed. One is located on the Lafayette at Hampton Boulevard; and six are located in Knitting Mill Creek. There are other locations where boats are moored, including the ODU sailing center (URS 2010).

Area 3 – The Elizabeth River Mainstem, Ghent/West Ghent, the Hague, Freemason, Downtown Watershed.

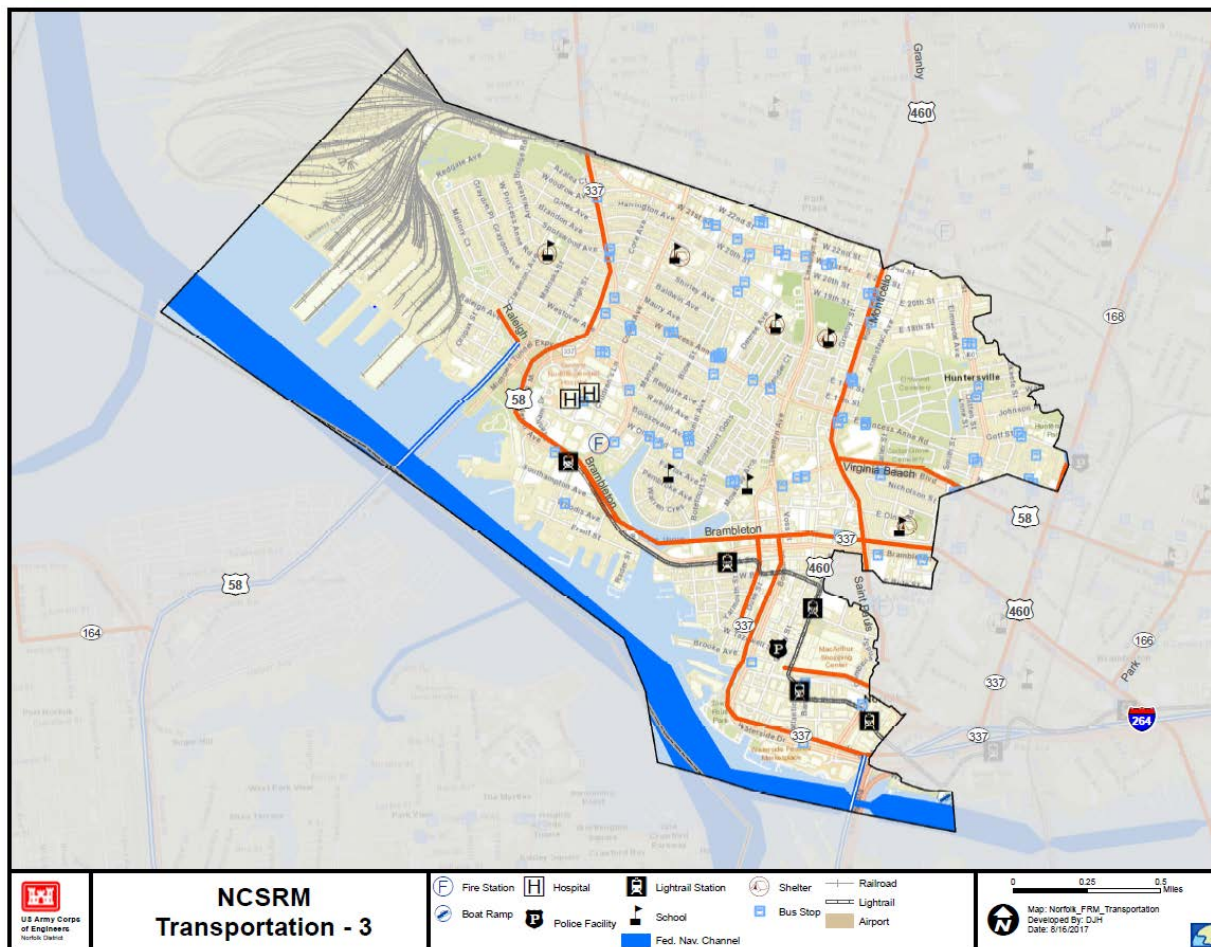


Figure 10-56. Transportation Area 3

Transportation. Downtown Norfolk is the area located to the east of The Hague/Ghent neighborhood and Freemason, and to the west of Interstate 264 and St. Paul’s Boulevard. It is a regionally significant urban commercial center that includes office buildings, shopping, dining, and entertainment. This area includes Scope and Chrysler Hall, two regionally important venues for concerts, professional sports, conventions, and similar large events. It also contains Macarthur Mall, Waterside, Town Point Park, Nauticus Museum, several historic churches, and numerous dining and smaller shopping venues, along with some mixed development high rises, condominiums, as well as historic residential communities. A portion of the Lamberts Point Coal Terminal, with its many rail lines, is also within Area 3. Area 3 also contains Eastern Virginia Medical School, which includes Sentara Norfolk General Hospital and the Children’s Hospital of the Kings Daughters, all regionally important medical facilities.

In 2015, Brambleton Avenue, a major east-west corridor had average daily traffic counts of over 38,600 in the vicinity of Colley Avenue. Hampton Boulevard, in the area near Brambleton Avenue, had an average daily traffic count of 35,800 (HRTPO, 2017b). Much of this traffic is heading to and from the Midtown Tunnel (U.S. Route 58), one of the only two direct routes from Norfolk to Portsmouth. During Hurricane Isabel in 2003, the Midtown Tunnel flooded, and had to be closed for approximately one month for pump out and repairs; and extensive traffic delays resulted, due to detours.

The Tide, the Hampton Roads Transit's light rail system, passes through both Areas 3 and 4. In Area 3, its western terminus is currently at Colley Avenue. From there, it runs parallel to Brambleton Avenue, then it passes through the Freemason area, and through Downtown Norfolk. Its last station in Area 3 is the Government Center Station near City Hall Avenue. In Area 4, it passes through Harbor Park, Norfolk State University, then crosses, and parallels I-264 to the south. Its eastern terminus is at Newtown Road, near the Norfolk/Virginia Beach line. The map below shows greater detail of the existing route for the Tide.

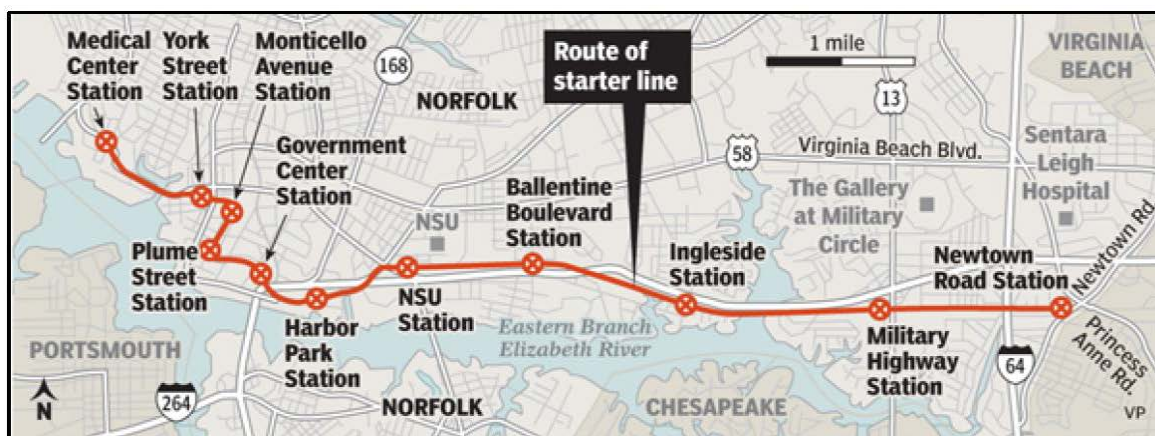


Figure 10-57. The Tide Light Rail Line route, in Areas 3 and 4
Source: USDOT 2016.

Navigation. The Elizabeth River continues to be a major navigation corridor into Area 3 and beyond. Beginning at Lamberts Point, the Elizabeth River Southern Branch “Elizabeth River Reach” channel is 40 feet deep and 750 feet wide, extending for a length of approximately 3 miles, into the Southern Branch of the Elizabeth River channel. This channel also connects to the USACE Elizabeth River Eastern Branch channel. The Eastern Branch of the Elizabeth River channel is 25 feet deep and 500 feet wide from the junction of the river branches to the Norfolk and Western Railway bridge, including within its limits near the mouth, a channel 30 feet deep, 300 feet wide, and 1,000 feet long; from the Norfolk and Western Railway bridge, a channel 25 feet deep and 300 feet wide to the Campostella Bridge; thence a channel 25 feet deep and 200 feet wide including a turning basin 25 feet deep, to the Norfolk and Western Railway “Swinging” Bridge. The Eastern Branch channel extends into both Areas 3 and 4.

The section of the Elizabeth River within Area 3, between Downtown Norfolk (Waterside and Town Point Park), and Downtown Portsmouth, is very widely used for industrial, military, commercial, and recreational boat traffic. The Norfolk Naval Shipyard, along with many

maritime dependent businesses are located in the Southern Branch, must traverse this section of the Elizabeth River to leave Port of Hampton Roads. There are many maritime industries, such as boat repair businesses and various other small shipping terminals, and other water-dependent businesses and industries along the Eastern Branch.

The harbors and waterways area is so widely recognized as vital to our region that the junction of the Southern and Eastern Branches of the Elizabeth River is the site of the Norfolk-Portsmouth “Harborfest” and the “Seawall Festival” that is held every June, as well as fireworks and other special events held in Town Point Park periodically. During Harborfest in particular, this section of the Elizabeth River is filled with all sizes and types of vessels from huge ships to recreational small craft.

Another established navigational use at this location is the Hampton Roads Transit’s Elizabeth River Ferry. The fleet operates routes from Norfolk to Portsmouth, and includes three 150-passenger ferry vessels that utilize four ferry docks (two in Downtown Portsmouth, one at Norfolk’s Waterside, and one at Norfolk’s Harbor Park). The current routes are shown on the map below. According to HRT, ridership typically averages 350,000 ferry passenger trips a year (VDPT et al, 2011)

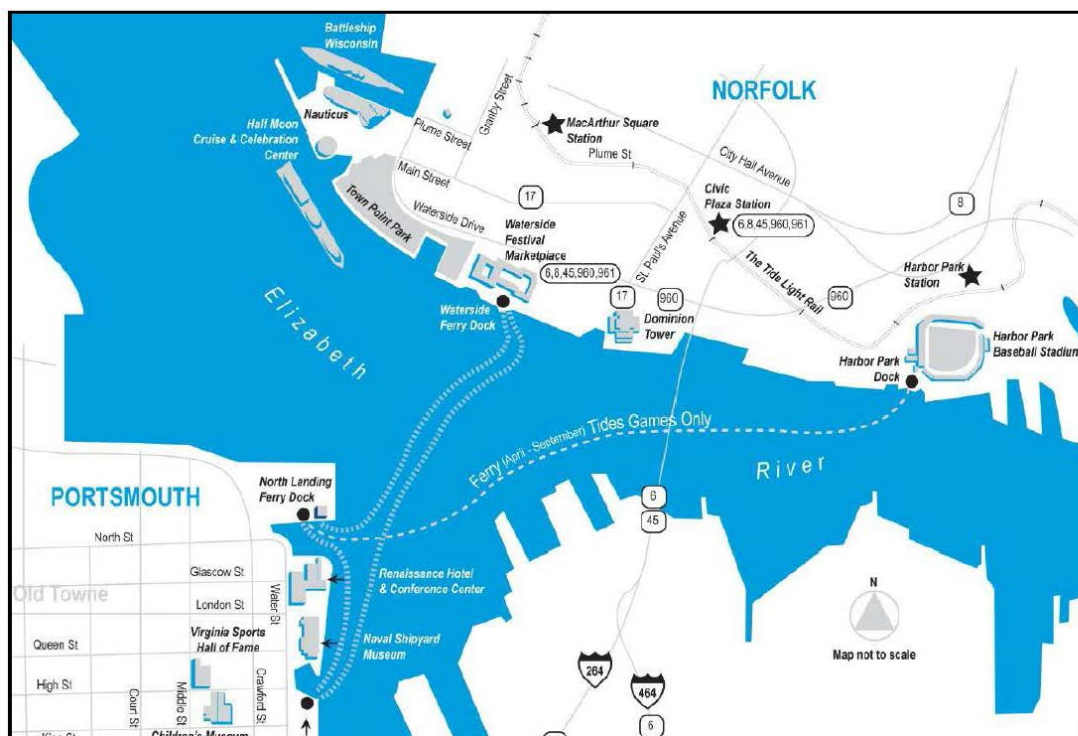


Figure 10-58. Route Map of the HRT Elizabeth River Ferry.

Source: (USDOT, 2016)

The Hague is the small U-shaped waterbody that is crossed by the Brambleton Avenue bridge, and connects to the Elizabeth River. On the downstream side of the bridge, the waterway is approximately 375 feet wide from shore to shore. Although The Hague does not have a defined maintained navigation channel, the current bridge navigation clearances are 48 feet horizontal and 13 feet vertical clearance, the existing water depths are navigable by small craft, and there

is a historical incidental usage of it by small power boats and canoes/kayaks (Moffat Nichol 2014). The Hague is officially designed, as per U.S. Coast Guard regulation 33 CFR 110.168, as “Anchorage O”, or as a safe haven for recreational watercraft, as needed; although the Coast Guard has verbally indicated that they are not aware of any such specific usage.

Area 4—Elizabeth River Eastern Branch Watershed and Broad Creek

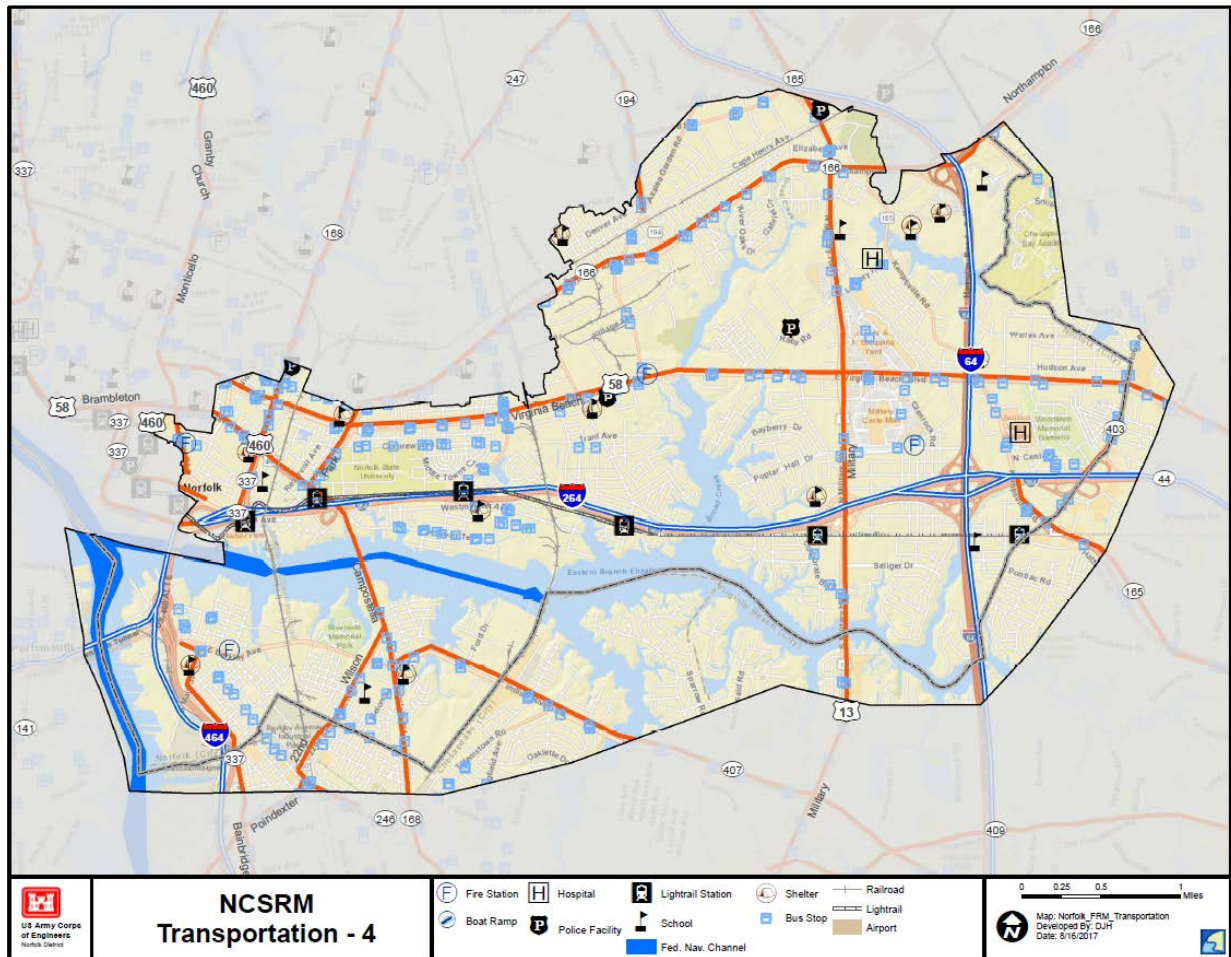


Figure 10-59. Transportation Area 4

Transportation. I-264 is the major east-west route from Downtown Norfolk to and from points east. It carried more than 76,000 average daily traffic in 2014. Parallel to I-264, and often used as an alternate route during incidents, is the primary arterial Route 58 Virginia Beach Boulevard, which carried up to 31,700 average daily traffic in 2015 (HRTPO, 2017b). Both run roughly parallel to the Eastern Branch of the Elizabeth River. I-64 runs north-south through Area 4; and the I-264/I-64 interchange is a major interchange for traffic to and from Norfolk, Virginia Beach, and Chesapeake. I-464 is a major route from Downtown Norfolk to Chesapeake; and the I-264 Downtown Tunnel carries traffic from Norfolk and Virginia Beach to Portsmouth.

Area 4 is a blending of residential, commercial, industrial, and institutional uses—including Norfolk State University, Virginia Wesleyan College, and many other public and private schools. The Area includes the Military Highway major corridor, which consists of a large number of commercial and industrial businesses. Area 4 also includes low-lying areas along Tidewater

Drive, and Broad Creek, tributaries of the Elizabeth River, which are subject to tidal and storm surge flooding.

As mentioned under Area 3, the Tide light rail line runs from Area 3, parallel to I-264 through Area 4. Also, a new Amtrak passenger rail station is located at 280 Park Avenue, east of and adjacent to Harbor Park near Downtown Norfolk. Opened in 2012, it services daily Amtrak trains to Petersburg, Richmond, Washington D.C., Philadelphia, New York, and Boston (Amtrak, 2017). In fiscal year 2015, there were a total of 160,292 Amtrak boardings and alightings in Hampton Roads, with 44,852 boardings and alightings being in Norfolk (USDOT, 2016).

Navigation. The USACE Eastern Branch channel, as described under Area 3, extends from the Elizabeth River mainstem to the Norfolk Southern “Swinging” Railroad Bridge east of Campostella Road. In Area 4, there are many maritime industries, such as boat repair businesses and various other small shipping terminals, and other water-dependent businesses and industries along the Eastern Branch. There is some residential recreational use as well, as evidenced by many private piers and docks, particularly east of the limits of the Swinging Rail bridge and the eastern limits of the channel.

Broad Creek’s watershed is mostly residential; and the waterway is largely used recreational traffic. There is not a navigation channel there, and much of Broad Creek currently is very shallow; the bottom can often be seen at mean low low water (MLLW) from I-264.

10.20 UTILITIES

10.20.1 Definition of Resource

This section focuses on the following utilities within the Study Area: gas, communications, electricity, potable water, wastewater, and stormwater management though the primary focus will be on potable water, wastewater and stormwater management as these utilities have the most potential to affect or be affected by the proposed project. The Hampton Roads Sanitation District (HRSD), a political subdivision of the Commonwealth of Virginia formed in 1940, owns and operates a regional system of waste water interceptors, pump stations and treatment plants. The City of Norfolk collects and pumps waste water from Norfolk customers for delivery to HRSD’s regional treatment system.

Potable water is simply water that is suitable for drinking or use for cooking without risk of illness and has typically been through treatment that includes filtration and disinfection to ensure its safe use. Wastewater is potable or other water that has been adversely affected in quality by human use. This water comes from Norfolk homes, business and industrial and medical facilities. Before its release into the environment, it is treated at a wastewater treatment plant to reduce contamination to acceptable levels.

Norfolk’s department of public works maintains and operates the City’s stormwater system.

10.20.2 Methodology

The following analysis of utilities describes regional utility conditions within the Study Area, describes the ROI, and identifies Floodway utility encroachments. Potential impacts and mitigation measures related to implementation of the Proposed Action are assessed based on

their affects in relation to the existing utility system. The ROI for utilities is the Study Area, the city of Norfolk and its bordering waterways.

10.20.3 Framework

The Underground Utility Damage Prevention Act regulates the notification, reporting, and management of excavation activities in the Commonwealth of Virginia. All utilities, meaning any item of public or private property which is buried or placed below ground or submerged for use in connection with the storage or conveyance of water, sewage, telecommunications, electric energy, cable television, oil, petroleum products, gas, or other substances, and includes but is not limited to pipes, sewers, combination storm/sanitary sewer systems, conduits, cables, valves, lines, wires, manholes, attachments, and those portions of poles below ground. The term "sewage" as used herein does not include any gravity storm drainage systems. Except for any publicly owned gravity sewer system within a county which has adopted the urban county executive form of government, the term "utility line" does not include any gravity sewer system or any combination gravity storm/sanitary sewer system within any counties, cities, towns or political subdivisions constructed or replaced prior to January 1, 1995. No excavator shall be held liable for the cost to repair damage to any such systems constructed or replaced prior to January 1, 1995, unless such systems are located in accordance with § 56-265.19.

10.20.4 Existing Conditions

Utilities within the Study Area

Major utilities within the Study Area include:

- Buried gas lines;
- Buried and aboveground telecommunications cables (telephone, television, and fiber optic);
- Buried and aboveground electric transmission lines;
- Buried potable water supply lines;
- Buried wastewater lines; and
- Buried and aboveground stormwater management infrastructure

Regarding utilities, gas, telecommunication and electric are all operated by privately owned companies that provide service to the city of Norfolk. Information on gas lines is proprietary so discussion on gas lines will be limited.

Water

The City of Norfolk's department of utilities provides drinking water to the approximately 246,000 residents of Norfolk. Norfolk has a large drinking water capacity for clean fresh water. The City owns nine reservoirs: Lake Whitehurst, Little Creek Reservoir, Lake Lawson, Lake Smith, Lake Wright, Lake Burnt Mills, Western Branch Reservoir, Lake Prince and Lake Taylor. Lake Gaston, on the Virginia-North Carolina border, also supplies fresh water to the City's reservoir system via a 76 mile long, 60 inch diameter pipe capable of pumping up to 60 million gallons/day. Two Rivers, the Blackwater and Nottoway Rivers, also supply water to the City as well as four deep wells. Potable water is treated at either the 37th Street Water Treatment Plant or the Moore's Bridge Water Treatment Plant in the City. The City's water supplies provide for Norfolk, as well as the city of Chesapeake and Virginia Beach, Naval Station Norfolk, Fort Story,

and the Port of Norfolk International Terminal. In total, the city of Norfolk supplies water to approximately 850,000 people.

Power

Due to confidentiality concerns, detailed information on mappings of the electrical distribution system is limited and only maps of transmission-level substations and power lines operated by Dominion Power, the power supplier for Norfolk, is available. The transmission system is hardened to a category III hurricane, though smaller lines and associated infrastructure, substations and power distribution system, are often damaged throughout the city during such a storm event and it can take days for power to be restored to individual residents. Flooding of +3 feet of sea level rise can damage transmission substations, though most of these have been raised by 28 inches higher in recent years and will escape flooding at a current +3 foot flooding event, but chances of flooding increase with sea level rise, as can be seen in the following figure that shows inundation extents of the FEMA 100 year with 3 feet of SLR.

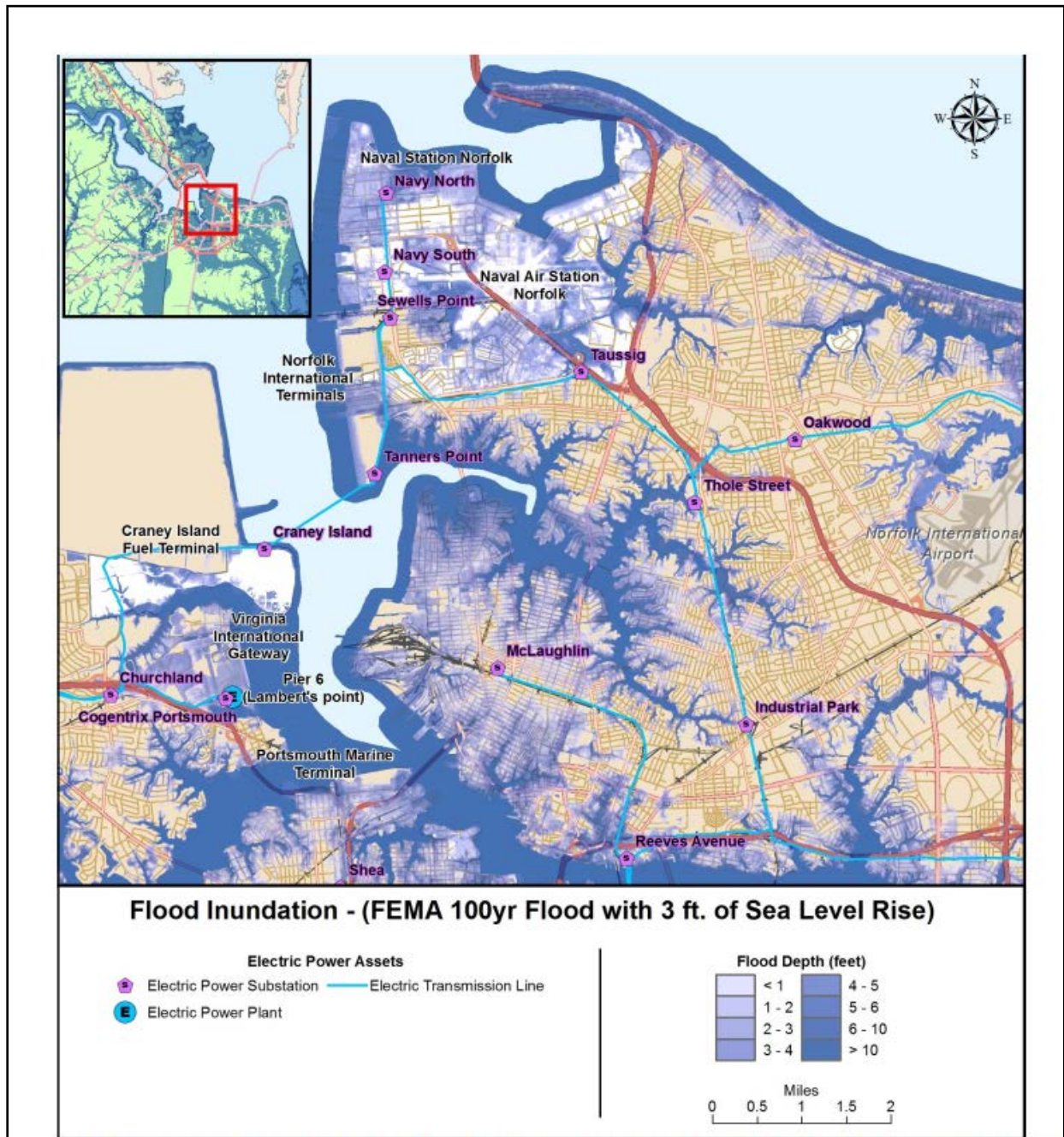


Figure 10-60. Flood Mapping with Transmission Level Electric Power Assets

Source: Sandia National Laboratories 2016

Telecommunications

Multiple carriers serve the city of Norfolk, including Verizon, Cox, NTelos, Sprint, AT&T, U.S. Cellular and Vonage. All communication is directed through wire centers, which are physical locations that contain telecommunications switches, including mobile services. Wire centers are vulnerable to flooding. Few in the City are vulnerable, due to the elevation they are located in as well as back-up centers and back-up power. However, there are some that can be flooded during a major storm event along with +3 feet of sea level rise, with the most vulnerable area in the City for a telecommunications failure being in the Lambert’s point area. In general,

telecommunications is the least vulnerable utility in the city of Norfolk.

10.21 AIR QUALITY

10.21.1 Definition of Resource

Existing air quality at a given location can be described by the concentrations of various pollutants in the atmosphere. The USEPA defines air quality as the ambient air concentrations of specific pollutants determined by the USAEPA to be of concern to health and welfare of the public. These “criteria pollutants” include ozone (O₃), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), particulate matter less than or equal to 2.5 microns in aerodynamic diameter (PM_{2.5}), particulate matter less than or equal to 10 microns in aerodynamic diameter (PM₁₀), and lead (Pb).

Criteria Pollutants

Ozone. The majority of ground-level (O₃) (commonly known as “smog”) is formed from the complex photochemical reactions in the atmosphere between Volatile Organic Compounds (VOCs), oxides of nitrogen (NO_x), and oxygen. VOCs and (NO_x) are considered precursors to the formation of (O₃), a highly reactive gas that can damage lung tissue and effect respiratory function (USEPA 2012).

Carbon Monoxide. (CO) is a colorless, odorless, poisonous gas produced by the incomplete combustion of fossil fuels. Elevated levels of (CO) can result in harmful health effects, and can contribute to global climate change (USEPA 2012).

Nitrogen Dioxide. (NO₂) is a brownish, highly reactive gas produced primarily from the burning of fossil fuels. (NO₂) can also lead to the formation of (O₃) in the lower atmosphere (USEPA 2012).

Sulfur Dioxide. (SO₂) is emitted primarily from the combustion of coal and oil by steel mills, pulp, and paper mills, and from non-ferrous smelters. High concentrations of (SO₂) can aggravate existing respiratory and cardiovascular disease, and also contribute to acid rain, which can, in turn, lead to the acidification of lakes and streams (USEPA 2012).

Particulate Matter. (PM_{2.5}) is referred to as fine particles, which are believed to pose significant health risks as they can lodge deeply into the lungs. Studies have linked increased exposure to (PM_{2.5}) to respiratory and cardiovascular disease. (PM₁₀) is typically comprised of dust, ash, soot, smoke, or liquid droplets emitted into the air. Fires, dust from paved or unpaved roads, construction activities, and natural sources (wind and volcanic eruptions) can contribute to increased PM₁₀ concentrations (USEPA 2012).

Lead. Sources of (Pb) include pipes, fuel, and paint although the use of lead in these materials has declined dramatically in recent years. (Pb) can be inhaled directly or ingested indirectly by consuming lead contaminated food, water, or dust (USEPA 2012).

Criteria pollutant emissions affecting air quality in a given region can be characterized as being from either stationary or mobile sources. Stationary sources of emissions, also known as point sources, are typified by emissions from smokestacks. Mobile sources of emissions, also termed

non-point sources, categorize emissions from vehicles and aircraft. Air quality for a region is a function of the type and concentration of pollutants in the atmosphere, the size and topography of the air basin, and local and regional meteorological influences. The significance of a pollutant concentration in a region or geographical area is determined by comparing it to federal and/or state ambient air quality standards.

Greenhouse Gas Emissions

Greenhouse gases (GHGs) are gases that trap heat in the atmosphere. These emissions occur from natural processes and human activities. The accumulation of GHGs in the atmosphere can influence the earth's temperature. Predictions of long-term environmental impacts due to global climate change include sea level rise, changing weather patterns with increases in the severity of storms and droughts, changes to local and regional ecosystems including the potential loss of species, and a significant reduction in winter snow pack. In Virginia, predictions of these effects include exacerbation of air quality problems, increased storm frequency, and drastic impacts from sea level rise (USEPA 2012).

Federal agencies are, on a national scale, addressing emissions of GHGs by reductions mandated in federal laws and EOs, most recently, EO 13423, *Strengthening Federal Environmental Energy, and Transportation Management*. Several states have promulgated laws as a means to reduce statewide levels of GHG emissions. In particular, Senate Bill 184 (September 1, 2009), required the State Comptroller to develop strategies to reduce GHG emissions by December 31, 2010.

10.21.2 Methodology

The ROI for air quality is defined by the U.S. Environmental Protection Agency's (USEPA's) regulatory boundary of the Hampton Roads Area, which comprises the cities of Chesapeake, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, Virginia Beach, and Williamsburg, and the counties of Gloucester, Isle of Wright, James City, and York, Virginia.

10.21.3 Framework

Federal Requirements

Under the authority of the **Clean Air Act (CAA) of 1972**, the USEPA has established ambient air quality standards to protect health and welfare, with an adequate margin of safety. These federal standards, the National Ambient Air Quality Standards (NAAQS), are defined in terms of concentration (e.g., ppm, ppb, micrograms per cubic meter [$\mu\text{g}/\text{m}^3$]) determined over various periods of time (averaging periods). The VDEQ has adopted the NAAQS. In addition, **The City of Norfolk Air Pollution Control Program** is the authority for compliance assessment, ambient air monitoring, and enforcement within City limits for the State's Air Pollution Control Rules and Regulations.

Short-term standards (1-hour, 3-hours, 8-hours, or 24-hour periods) are established for pollutants with acute health effects and may not be exceeded for longer than one a year. Long-term standards (annual periods) are established for pollutants with chronic health effects and may never be exceeded.

The USEPA designated areas of the U.S. as having air quality equal to or better than the

NAAQS (attainment) or worse than the NAAQS (nonattainment), based on measured ambient criteria pollutant data. Upon achieving attainment, areas that were previously in nonattainment are considered to be in maintenance status. Areas are designated as unclassified for a pollutant when there is insufficient ambient air quality data for the USEPA to form a basis of attainment status; unclassifiable areas are treated similar to areas that are in attainment of NAAQS.

The ROI for air quality is defined by the regulatory boundary of the Hampton Roads Area, which comprises the cities of Chesapeake, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, Virginia Beach, and Williamsburg, and the counties of Gloucester, Isle of Wright, James City, and York, Virginia.

Regulatory Requirements

Air quality in a given location is described by the concentration of various pollutants in the atmosphere. A region's air quality is influenced by many factors including the type and amount of pollutants emitted into the atmosphere, the size and topography of the air basin, and the prevailing meteorological conditions. The significance of the pollutant concentration is determined by comparing it to the federal ambient air quality standards. The CAA and its subsequent amendments (CAAA) established the NAAQS for seven "criteria" pollutants:

- Ozone (O₃)
- Carbon Monoxide (CO)
- Nitrogen dioxide (NO₂)
- Sulfur dioxide (SO₂)
- Particulate matter (PM) less than ten microns (PM₁₀)
- PM less than 2.5 microns (PM_{2.5})
- Lead (Pb)

These standards represent the maximum allowed atmospheric concentrations that may occur while ensuring protection of public health and welfare, with a reasonable margin of safety. Short term protection of public health and welfare, with a reasonable margin of safety. Short term standards (1-, 8-, and 24-hour periods) are established for pollutants contributing to acute health effects.

Long term standards (quarterly and annual averages) are established for pollutants contributing to chronic health effects. The VDEQ, Division of Air Quality has adopted the NAAQS in its USEPA-approved State Implementation Plan (SIP) and approved monitoring program (USEPA, 2015 (a)).

Hampton Roads Regional Air Quality

A locality's air quality status and the stringency of air pollution standards and regulations depend on whether monitoring pollutant concentrations attain the levels defined in the NAAQS. Ambient air quality concentrations are expressed in parts per million (ppm) or micrograms per cubic meter, but the standard used for describing existing and proposed air emissions is expressed in tons of pollutant per year. To ensure the NAAQS are achieved and/or maintained, the CAAA requires each state to develop a SIP. According to the plans outlined in the SIP, designated state and local agencies implement regulations to control sources of criteria

pollutants.

The CAAA also provides that Federal actions occurring in nonattainment and maintenance areas shall not hinder future attainment with the NAAQS and will conform to the applicable SIP (i.e., Virginia's SIP). The Hampton Roads Area is considered by USEPA to be attainment for all priority pollutants, including the recent re-designation of the area to attainment for the O₃ eight-hour standard. This re-designation to attainment occurred in June 2007.

The CAAA also establishes a national goal of preventing degradation or impairment in any federally-designated Class I area. As part of the Prevention of Significant Deterioration (PSD) program, mandatory Class I status was assigned by Congress to all national parks, national wilderness areas, memorial parks greater than 5,000 acres and national parks greater than 6,000 acres. In Class I areas, visibility impairment is defined as a reduction in visual range and atmospheric discoloration. Stationary sources, such as industrial complexes, are typically an issue for visibility within a Class I PSD area. Action proponents must consider the impact of the action's emissions on any Class I areas within 62 miles (100 kilometers). There are no PSD Class I areas located within 62 miles of the Norfolk Flood Risk Management Study.

10.21.4 Existing Conditions

Relevant Local Area

The Hampton Roads Area was designated a marginal eight-hour O₃ nonattainment area in a *Federal Register* notice signed on April 15, 2004 and published on April 30, 2004 (69 FR 23857), based on its exceedance of the eight-hour, health-based standard for O₃ during the years 2001-2003. Prior to the area's designation as an eight-hour O₃ nonattainment area, the Hampton Roads Area was a maintenance area for the one-hour O₃ NAAQS.

Under 40 CFR part 50, the eight-hour O₃ standard is attained when the three-year average of the annual fourth-highest daily maximum eight-hour average ambient air quality O₃ concentrations is less than or equal to 0.08 ppm (i.e., 0.084 ppm when rounding is considered). On October 16, 2006 the VDEQ formally submitted a request to re-designate the Hampton Roads Area from nonattainment to attainment of the eight-hour NAAQS for O₃. On October 18, 2006 Virginia submitted a maintenance plan for the Hampton Roads area as a SIP revision to ensure continued attainment in the area over the next 11 years. VDEQ also submitted a 2002 base-year inventory for the Hampton Roads area as a SIP revision on October 12, 2006, and supplements to the base-year inventory were submitted on November 20, 2006 and February 13, 2007.

On June 1, 2007, the attainment designation for the Hampton Roads area became formally effective. In conjunction with this approval, USEPA also approved a SIP revision consisting of a maintenance plan for 11 years, until 2018. USEPA also approved the adequacy determination for the motor vehicle emission budgets (MVEBs) that are identified in the Hampton Roads eight-hour maintenance plan for purposes of transportation conformity, and approved those MVEBs. Additionally, USEPA approved the 2002 base year emissions inventory for the area. USEPA approved the re-designation request, the maintenance plan, and the 2002 base year emissions inventory as revisions to the Virginia SIP in accordance with the requirements of the CAAA.

The attainment and nonattainment designations for the Commonwealth of Virginia for all the NAAQS are codified at 40 CFR 81.347; the region is in attainment for all the NAAQS standards (USEPA, 2015 (b)).

The Commonwealth of Virginia has maintained a network of air monitoring stations in Virginia since 1980 and the ROI falls within the Air Quality Control Region 6 (AQCR 6)¹ as defined in 9 VAC5-20-200 as the Hampton Roads Intrastate Air Quality Control region (VDEQ, 2015). The long term air quality trends since 2004 for all criteria pollutants demonstrate decreasing ambient concentrations (VDEQ, 2015).

10.22 NOISE

10.22.1 Definition of Resource

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by the human ear as well as most fauna. Noise is generally defined as loud, unpleasant, unexpected, or undesired sound that is typically associated with human activity and that interferes with or disrupts normal activities of humans and wildlife. The human environment is generally characterized by a certain consistent noise level that varies by area. This is called ambient, or background, noise. Although exposure to high noise levels has been demonstrated to cause hearing loss, the principal human response to environmental noise is annoyance. The response of individuals to similar noise events is diverse and influenced by the type of noise; perceived importance of the noise and its appropriateness in the setting; time of day and type of activity during which the noise occurs; and sensitivity of the individual. Wildlife near areas of human activity and associated noise react similarly. Boating noise can carry for long distances underwater, and disrupt the behavior of aquatic life for considerable distances from the source, depending on the size of and noise produced by marine engines. The city of Norfolk also holds an international airport, with frequent jet airplane take offs and landings, as well as nearby Naval facilities, which also conduct extensive training flights in local airspace.

The normal human ear can detect sounds that range in frequency from about 20 Hz to 20,000 Hz. However, all sounds in this wide range of frequencies are not heard equally well by the human ear, which is most sensitive to frequencies in the range of 1,000 Hz to 4,000 Hz. This frequency dependence can be taken into account by applying a correction to each frequency range to approximate the human ear's sensitivity within each range. This is called A-weighting and is commonly used in measurements of community environmental noise. The A-weighted sound pressure level (abbreviated as dBA) is the sound level with the "A-weighting" frequency correction. For aquatic life, the hearing range can be significantly different. All baleen whales 7 Hz to 22 kHz, Odontocete species 150 Hz to 180 kHz, Harbor porpoise 200 Hz to 180 kHz¹⁶, Pinnipeds in water All 75 Hz to 75 kHz, Fish 20 Hz to 1000 Hz (1HZ = 0.001 kHz) have a sensitivity to a wide range of sound. Reptiles tend to have a similar hearing range as fish, most bird species have a hearing range similar to humans, while many mammals can hear much

higher frequencies than humans.

Changes in noise are typically measured and reported in units of decibels (dBA), a weighted measure of sound level. The A-weighted sound level (dBA) is a single number measure of sound intensity with weighted frequency characteristics that corresponds to human subjective response to noise (FHA, 2001). Noise ranging from about 10 dBA for the rustling of leaves to as much as 115 dBA (the upper limit for unprotected hearing exposure established by the Occupational Safety and Health Administration (OSHA, 2016)) is common in areas where there are sources of industrial operations, construction activities, and vehicular traffic.

Over the past 20-years, the Federal Highway Administration (FHWA) and Virginia Department of Transportation (VDOT) have collaborated on a number of highway, bridge, and tunnel projects proximate to the project area (FHWA, 2001; FHWA, 2014; VDOT, 2011). FHA and VDOT EISs are required to assess noise and vibration effects of their proposed improvements on adjacent communities (FHWA, 2014). As a result, there have been a number of baseline noise studies within the ROI, each of which summarized the worst noise hour conditions at between 60 and 70 dBA (FHWA, 2001; FHA, 2014; VDOT, 2011). The highway and local street traffic represented the dominant sources of existing noise in the Hampton Roads study corridors. At locations proximate to the Norfolk Naval Air Station (NAS), aircraft operations contributed to the existing noise environment; however, aircraft operations noise is intermittent and depends very strongly on wind direction and time of day (FHWA, 2001).

Noise impacts result from perceptible changes in the overall noise environment that increase “annoyance” or affect human health. Human health effects such as hearing loss and noise-related awakenings can result from noise. “Annoyance” is a subjective impression of noise wherein people apply both physical and emotional variables. To increase “annoyance”, the cumulative noise energy must increase measurably (Navy, 2009).

Table 10-16. Common Sounds and Their Levels

Outdoor	Sound level (dBA)	Equivalent
Snowmobile	100	Subway train
Tractor	90	Garbage disposal
Noisy restaurant	85	Blender
Downtown (large city)	80	Ringling telephone
Freeway traffic	70	TV audio
Normal conversation	60	Sewing machine
Rainfall	50	Refrigerator
Quiet residential area	40	Library

Source: <http://chcheating.org/noise/common-environmental-noise-levels>

10.22.2 Methodology

The impact analysis of the Proposed Action is focused upon potential noise increases at sensitive noise receptors resulting from the construction and operation of the various project components. Noise sensitive receptors are buildings or parks where quiet forms a basic element of their purpose; residences and buildings where people normally sleep (e.g., homes, hotels, hospitals), where nighttime noise is most annoying; and institutional land uses (e.g., schools, libraries, parks, churches) with primarily daytime and evening use. Because noise levels at sensitive receptors are reduced by obstructions (such as sound walls) lying between them and the noise source, special emphasis is placed on sensitive receptors having a direct line of sight to the Proposed Action construction sites and facilities. The ROI for noise analysis consists of the City of Norfolk, nearshore waters of Chesapeake Bay off of Ocean View and Willoughby Spit, Willoughby Bay, and most of the Elizabeth River system, including the Lafayette River, The Hague, and Broad Creek.

10.22.3 Regulatory Framework

Section 4(b) of the **Noise Control Act (NCA) of 1972 (42 USC §§ 4901-4918)** directs federal agencies to comply with applicable federal, state and local noise requirements with respect to the control and abatement of environmental noise. Congress defined environmental noise in the NCA of 1972 to include the intensity, duration, and character of sounds from all sources. Applicable federal guidelines for noise regulation derive from the USDOT or, more specifically, the Federal Transit Administration and the FHWA.

The City of Norfolk does have a noise ordinance, **Section 1 of Ordinance No. 36,406**, adopted April 30, 1991, amended Ch. 26 to read as set out in §§ 26-1--26-13. This ordinance contains time restrictions on specific types of noise producing activities, such as construction, and aims to protect citizens from offensively loud noise and vibration. Examples of which are use of power tools, including lawn mowers, music, vehicles and their associated noise, pets, and others. It does not cover aircraft, which are regulated under applicable federal laws and regulations.

Table 10-17. Maximum Permitted Sound Levels with the City of Norfolk

Use Category	Sound Level Limit db(A).	
	7:00 a.m - 10:00 p.m.	10:00 p.m - 7:00 a.m
Noise sensitive zone	55	50
Residential	57	52
Park and recreational	67	62
Business (commercial)	67	62
Industrial	77	77

10.22.4 Existing Conditions

The Elizabeth River is a working waterway, with heavy industrial, military, and cargo ship traffic as well as significant recreational boating. The Port of Virginia implements the following noise pollution mitigation strategies at its facilities: use of noise barriers to reduce noise levels in surrounding neighborhoods; limits on vehicle speeds; and alteration of roadway surface texture. The Elizabeth River and Southern Branch of the Elizabeth River are also home to the world's largest naval station (NPS, 2015) and three airports within 15 miles (Norfolk International Airport, Chamber's Field, and Langley Air Force Base). The two airfields within the City borders, Chambers field at NAS Norfolk and Norfolk International Airport, are the largest single sources of noise in the City. As can be observed, the area of sound associated with each airfield are limited to non-residential areas in large part, though areas that approach 75 db do encroach on residential areas and likely produce nuisance levels of noise there. The City does not enforce the local ordinance here, as noted earlier. Noise levels are typical for a City otherwise, and in general stay within limits described in the City's noise ordinance.

Existing land uses adjacent to the proposed channel improvements consist of industrial features from the Port of Virginia (e.g., Norfolk International Terminals, Virginia International Gateway, Norfolk Southern Railroad, Portsmouth Marine Terminals, Lambert's Point Coal) and military uses (e.g., Norfolk Naval Shipyard, Lamberts Bend Deperming Station), municipal parks (e.g., Hospital Point Park, Town Point Park, Portsmouth's River Front Park), marinas (e.g., Tidewater Yacht Marina, Waterside Marina, Ocean Marina Yacht Center), and very limited residential land use. The nearshore waters of Chesapeake Bay bordering the City are a mix of residential, commercial, and industrial development with significant public beaches (Ocean View) for public recreational use. The City has a number of medical facilities, hospitals, schools as well as extensive residential and commercial areas where the noise ordinance standards apply.

10.23 CLIMATE CHANGE

10.23.1 Definition of Resource

Global climate change is a transformation in the average weather of the Earth, which is measured by changes in temperature, wind patterns, and precipitation. Emission of greenhouse gases above natural levels is suggested to be a significant contributor to global climate change. Greenhouse gases are known to trap heat in the atmosphere and regulate the Earth's temperature. These gases include water vapor, carbon dioxide, methane, nitrous oxide, ground-level ozone, and fluorinated gases such as chlorofluorocarbons, and hydrochlorofluorocarbons.

10.23.2 Methodology

The ROI for climate change includes the entire Study Area. For the Study Area, this includes the four sub-areas within the city of Norfolk in which actions could take place i.e. Area 1, Area 2, Area 3, and Area 4.

10.23.3 Framework

Executive Order 13834, Efficient Federal Operations, was signed on May 22, 2018, is intended to eliminate unnecessary use of resources, and protect the environment. It further directs agencies to achieve and maintain annual reductions in building energy use and

implement energy efficiency measures that reduce costs; and meet statutory requirements relating to the consumption of renewable energy and electricity.

10.23.4 Existing Conditions

The Earth's average temperature has increased by more than one degree Fahrenheit over the last century and many scientists, but not all, have attributed this temperature rise to the burning of fossil fuels and the resulting release of carbon dioxide into the atmosphere (Intergovernmental Panel on Climate Change 2013, referenced in Strauss et al. 2014). Global sea level rise has resulted from this warming with a cascading effect of melting glaciers and ice sheets. Scientists estimate sea level has risen approximately two times faster in the last two decades as compared to the 20th century (Strauss et al. 2014). Along the east coast, coastal flooding is anticipated to increase with sea level rise, as higher sea level increases the potential for more severe storm surge (Sallenger et al. 2012), the nearest tide gauge to the city of Norfolk, the Sewells Point gauge, shows that in recent decades the rate of sea level rise has been accelerating, with the present rate being 4.65 mm/yr, while earlier in the 20th century the rate was 4.0 mm/yr, and this rate is expected to continue to increase into the future (Boon 2012).

Climate change and related sea level rise is anticipated to be accelerated along the eastern coastal portions of the United States. A recent sea level rise study for Virginia predicts that record-breaking coastal flooding is likely to occur under mid-to-high range projections within the next 20 to 30 years (depending on location within Virginia) (Strauss et al. 2014). Using scenarios from a National Oceanic and Atmospheric Administration-led technical report to the National Climate Assessment (Parris et al. 2012, referenced in Strauss et al. 2014), the Strauss et al. (2014) study estimated mid-range or "intermediate high" local sea level rise projections for different locations in Virginia of roughly 1.2-1.5 feet by mid-century, and 4.0 to 4.8 feet by 2100 (using 2012 as the baseline). Hampton Roads is one of the most vulnerable areas to storm surge flooding, and this will worsen with sea level rise (Kleinowsky et al. 2007).

Land subsidence, sea level rise, flat and low tidewater topography and intensive coastal real estate and infrastructure development puts southeastern Virginia, namely Virginia Beach/Norfolk/Hampton Roads region, at extreme risk from storm surges. CoreLogic, a real estate data firm, estimates that in the event of a major storm more than one-third of the houses in the Hampton Roads region would suffer flood damages. Hurricanes also, are becoming more intense with climate change as they generate power from warm, moist air over warm ocean waters. (Robert Repetto, 2012)

CHAPTER 11 ENVIRONMENTAL CONSEQUENCES

11.1 SUMMARY OF IMPACTS

A summary and comparison of resource impacts for the final array of project alternatives is provided in Table 11-1. Chapter 10 provides a baseline for the impact analysis by presenting an overview of the existing conditions for each resource. A detailed analysis of potential impacts for each of the final array of project alternatives for each resource area is provided in this chapter following the summary of impacts description as well.

Table 11-1. Summary of impacts for the final array of project alternatives

Environmental Factor	No Action	Alternative 2a	Alternative 3	Alternative 4d (NED/TSP)
Land Use	Short-term and long-term potentially significant impacts due to increased flooding and increased vulnerability to and damage from coastal storms. Land use will be negatively and permanently impacted by the No Action Alternative	Short-term, minor impacts during construction and maintenance of features, including maintenance of pump stations and tide gates. Long-term impacts due to structures and NNBFs; land use in the project footprint will be permanently altered. But these are, in general, positive, though some current parking and other structures may be displaced. However, these structures are very vulnerable to flooding which is why their use will be altered. Berms and floodwalls may restrict land use in some areas, and these will also require periodic maintenance.	Minor, short-term impacts during construction, and minor long-term impacts to land use, due to NNBF. Impacts would be limited to the immediate vicinity of the structure receiving treatment.	As 2a and 3 combined.
Geology and Soils	Moderate, long-term land loss will occur, due to land subsidence, erosion, and flooding. Due to a lack of significant geological resources, there are no resulting significant impacts anticipated.	Minor, short-term impacts due to construction. Adverse impacts to soils limited to construction footprint of levees, walls and surge barriers. Minor long-term adverse impacts due to land subsidence. However, overall long-term effect would be beneficial, due to less land erosion. No geologically significant impacts.	Negligible to minor, short-term impacts due to construction. Moderate, long-term adverse effects, due to land subsidence and erosion, because only structures are being protected. No geologically significant impacts.	As 2a and 3 combined.
Hydrology, Hydraulics and Bathymetry	Minor, long-term impacts due to sea level rise.	Minor, short-term and long-term impacts to bathymetry, except where surge barriers are placed, where impacts are significant. Short-term adverse impacts would also occur to tidal flushing when the gates are closed.	No effect	As 2a
Water Quality	Minor but permanent, long-term impacts due to sea level rise alterations in salinity, DO and nutrients in project ROI waters	Short-term impacts in turbidity and DO possible during construction. Minor but permanent, long-term impacts to water quality due to project construction. Significant, temporary impacts to upper reach waters of Pretty Lake over the long-term, during a storm-	No effect	As 2a

Environmental Factor	No Action	Alternative 2a	Alternative 3	Alternative 4d (NED/TSP)
		event driven closure, but water quality will return to normal within a month post-storm.		
Floodplains	Significant long-term adverse impacts, due to increased flooding and insurance needs	Significant, beneficial short-term and long-term impacts, due to floodplain protection.	Significant and beneficial short-term and long-term due to protection of structures in the floodplain.	As 2a and 3 combined.
Wetlands	Long-term predicted loss and/or retreat of wetlands landward, due to sea level rise and land subsidence. Increases in salinity may alter species composition	Short-term impacts may occur during construction; areas would be restored after construction. Minor insignificant short-term impacts in local water quality due to closures during storm events. Direct, long-term significant impacts to approximately 2-3 acres of tidal emergent and scrub/shrub wetlands due to construction. Impacts to vegetated and non-vegetated wetlands will require compensatory mitigation to achieve no significant impact.	No or negligible short and long-term impacts to wetlands; as impacts would be confined to existing structure footprints.	As 2a
Submerged Aquatic Vegetation	None present in project ROI, no effect.	None present in project ROI, and based on past monitoring efforts unlikely to colonize ROI. No effect.	None present in project ROI, no effect.	As 2a; no effect.
Terrestrial Wildlife and Upland Vegetation	Minor short-term and long-term adverse impacts to wildlife and upland, as the city experiences greater flooding frequency. Terrestrial species expected to migrate inland.	Minor, short-term impacts due to construction. Minor, long-term, adverse impact due to permanent removal of upland vegetation to accommodate berms and floodwalls in some areas; however, trees cleared within the Resource Protection Areas must generally be replaced. Minor short-term impacts to terrestrial wildlife during construction; and minor long-term impacts due to placement of structures.	Minor short-term and long-term adverse impacts to wildlife and upland, as the city experiences greater flooding frequency. Species expected to migrate inland.	As 2a and 3 combined.
Plankton	Significant potential for species alteration due to climate change.	Minor and short-term adverse impacts due to operation of pumps during storm events and plankton mortality due to impacts in salinity in upper reach waters of Pretty Lake due to closure during storm event. Impacts not significant due to the project itself; however, significant potential for species alteration due to climate change.	As No Action.	As 2a.

Environmental Factor	No Action	Alternative 2a	Alternative 3	Alternative 4d (NED/TSP)
Fish and Fishery Resources	Negligible and temporary	Minor and temporary during construction. Construction of Alternative 2A is predicted to produce adverse effects to fish and fishery resources within the ROI that range from negligible to minor and temporary to permanent in duration. The operation and maintenance of Alternative 2A could result in temporary to permanent significant adverse impacts to fish and fisheries resources.	Negligible and temporary adverse impacts to fish and fisheries resources within the ROI due to project construction and maintenance.	As 2a and 3 combined.
Benthic Resources	No effect	Minor and Short-term adverse for construction of surge barriers, which will be compensated for using mitigation. Due to this, overall impacts are adverse, but temporary and minor	No effect	Same as Alternative 2a
Special Status Species	Negligible and minor for marine mammals, minor and short-term to birds, minor and long-term to fish	Negligible to minor short-term effects during construction. Minor, long-term adverse impacts due to surge barriers. Likely to Adversely Affect sturgeon and sea turtles by storm surge barriers. May affect, not likely to adversely affect to no effect for all other listed species in project ROI.	Negligible, short-term adverse effects during construction	As 2a and 3 combined.
Cultural Resources	Significant, long-term adverse effects, due to more frequent flood damage.	Impacts ranging from negligible, altering viewsheds, some potential to affect sunken historical sites. Any potential negative impacts would be mitigated	Extensive, significant impacts to historical structures due to buyouts, demolition, and alteration of buildings to raise them	As 2a and 3 combined.

Environmental Factor	No Action	Alternative 2a	Alternative 3	Alternative 4d (NED/TSP)
Recreational Resources	Potentially significant direct and indirect, short-term and long-term impacts on land use and associated recreation, as recreational facilities may flood more frequently.	Short-term adverse impacts during construction of some features (surge barrier at Lafayette, berm/floodwall construction along Elizabeth River trail. Long-term impacts to parking at Harbor Point due to floodwall/berm construction. Moderately beneficial long-term due to decreased flooding, which will improve site access in the future as sea level continues to rise.	Minor and beneficial long-term effects to negligible to moderate adverse short-term effects (during construction)	As 2a and 3 combined.
Visual Resources	Minor adverse, long-term impacts	Short-term and long-term adverse effects (Lafayette surge barrier ,levees and floodwalls altering viewshed)	Minor, long-term impacts to viewshed due to raised buildings.	As 2a and 3 combined.
Socioeconomics	Short-term and negligible to significant and negative, as vulnerable populations more susceptible to flooding.	Short-term and minor during construction. Long-term effect should be more beneficial than adverse, as larger areas are protected from flooding	Adverse impacts due to buyouts concentrated in low-income areas. Raised houses may make access more difficult to disabled and elderly, potential adverse impact.	Same as 2a and 3 combined
HTRW	Short-term and long-term increased chance of exposure due to rising seas and coastal erosion near currently contaminated sites	Negligible to minor short-term effects during construction, minor benefits post-construction due to increased protection against coastal erosion.	Negligible to minor short-term effects during construction.	Same as Alternative 2a
Safety	Significant adverse impacts due to flooding risk.	Minor short-term impacts during construction, as safety regulations will be followed. Moderate long-term benefits.	Minor short-term impacts during construction, as safety regulations will be	As 2a and 3 combined.

Environmental Factor	No Action	Alternative 2a	Alternative 3	Alternative 4d (NED/TSP)
			followed. Minor long-term benefits	
Transportation	Potentially significant and negative short-term and long-term impacts in general, due to increased flooding in transportation corridors. Minor and beneficial to navigation due to higher water levels in navigation channel	Short-term, adverse impacts during construction and maintenance. Post-construction, long-term and beneficial effects. However, potentially significant temporary effects over the long-term on transportation and navigation post construction, due to storm surge barrier and street gate closures during flooding events. Minor and adverse short-term effect on navigation during construction; and minor adverse long-term effect on navigation, due to restrictions caused by surge barriers	Minor to negligible, short-term and adverse effects during construction. Long-term adverse and effects due to lack of protection of transportation infrastructure.	As 2a - the adverse long-term impacts due to lack of protection of transportation infrastructure would be ameliorated by 2a. Construction impacts from 3 are similar, but less than, those of 2a.
Utilities	Short-term and long-term adverse due to rising waters, which will impact utilities	Short-term, adverse and minor during construction. Post construction, long-term significant and beneficial impacts due to greater protection from damage.	Minor and adverse short-term impacts during construction. Long-term and beneficial post construction.	As 2a and 3 combined.
Air Quality	Negligible short-term and long-term impacts.	Short-term and minor impacts during construction.	Short-term and minor during construction.	Short-term and minor during construction.
Noise	Negligible short-term and long-term impacts.	Short-term and minor during construction.	Short-term and minor during construction.	Short-term and minor during construction.
Climate Change	Significant, permanent and adverse	Short-term and negligible during construction.	Short-term and negligible during construction	Short-term and negligible during construction

11.2 LAND USE

11.2.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk.

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue as a result of burning of fossil fuels and deforestation in the ROI over the next 50 years. Predicted climate change impacts such as increased sea level rise, have the potential to

cause changes in the nature and character of the land use in the ROI.

As the 2012 Fugro Coastal Risk Study commissioned by the City of Norfolk notes, “Zoning rules, land use plans, and coastal zone management can be used to prevent construction or restrict the types of development (Building size, density, use, open space preservation) within flood prone areas and to direct future development with regard to relative sea level rise risks. The intent of such planning measurements is to minimize negative impacts associated with building structures that will not optimally withstand events that may occur in a particular area that is prone to flooding. While these plans do not prevent flooding in flood prone areas, they can reduce the damage and risk” (Fugro Atlantic, 2012b). This study has guided the development of the City’s subsequent planning framework, and would be assumed to guide future land use decisions.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed; rewriting of zoning code to support resilience; and implementation of an additional three feet of required elevation, above the effective FEMA BFE for structures located within the 1% annual chance floodplain (100 year) and an 18 inch freeboard above grade required within the 0.2% annual chance floodplain (500 year) floodplain. The project, which is located in Area 4 and is shown on the maps herein as “EB-6”, will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy, in Area 1 is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is approximately 95-97% developed; therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. Zoning ordinances were updated in 2018 to include more stringent development standards for reducing future flood risk. The City’s plan Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City’s comprehensive plan, “The Plan for Restoring the Lafayette River”, with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project into the future, in Area 1. USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel (Area 1) and the Eastern Branch of the Elizabeth River (Area 4). The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects, which are located in the main stem of the Elizabeth River to the west of Norfolk and stretch from Areas 1-3, would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion (CIEE), to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre

expansion that would ultimately have a port built on it, once is it filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, underneath the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing (Area 1) a roadway project which includes the widening of I-64 from I-564, and the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned. This is located off the coast of Virginia Beach, at the mouth of the Chesapeake Bay. In addition to these actions, USACE also considered effects on all existing and proposed living shorelines in Norfolk.

Without implementation of an action alternative, it is expected that the inhabitants of City of Norfolk will become increasingly susceptible to coastal inundation. Current and future projected yearly damages, excluding the Chesterfield Heights area, from coastal storms are expected to reach \$231 million. Due to the synergistic effects from combination of factors, including land subsidence, eustatic and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for City of Norfolk. During storm events and exceptionally high tides, these climate change impacts already negatively impact the land uses currently present within the coastal City of Norfolk, causing low lying areas to be increasingly affected by flooding, or even permanently flooded. Residences, businesses, schools, industries, and recreational areas, may become increasingly vulnerable to flooding, and could be damaged more frequently and therefore, land could be less accessible for use by the citizens of Norfolk. Therefore, the No Action Alternative/Future Without Project Alternative could entail potentially significant direct and indirect, temporary and permanent impacts on land use within the City.

11.2.2 Alternative 2a: Structural Only Alternative

Under this alternative, all of the existing ongoing projects and initiatives described under the No Action Alternative, as well as climate change and sea level rise, would be assumed to occur.

Area 1: Willoughby and Oceanview Beach, Little Creek, Pretty Lake, and Mason Creek

The floodwalls would extend primarily through commercial districts: there are three privately owned marinas located along Fishermans Cove. This could temporarily restrict use of the marinas during construction within the direct construction footprint, as well as temporary construction staging areas. Floodwalls will also extend adjacent to the Little Creek Amphibious Base's westernmost boundary. Outright purchase of property, as well as both temporary and permanent easements, would likely be needed along the alignment of the floodwall, for the storm surge barrier, and for a generator building. In order to reduce impacts on naval missions, the USACE has been coordinating with the Navy and would continue to do so during the Preconstruction, Engineering, and Design (PED) phase.

Temporary construction access may further restrict some usage of those facilities. However, use of the marinas could resume upon completion of the project. Further minor temporary impacts to land use could occur occasionally for maintenance personnel to gain access to the storm surge barrier, to conduct periodic testing of the gates. Natural and nature based features, where compatible with land and water use, may be implemented to the inside or outside of the

proposed storm surge barrier.

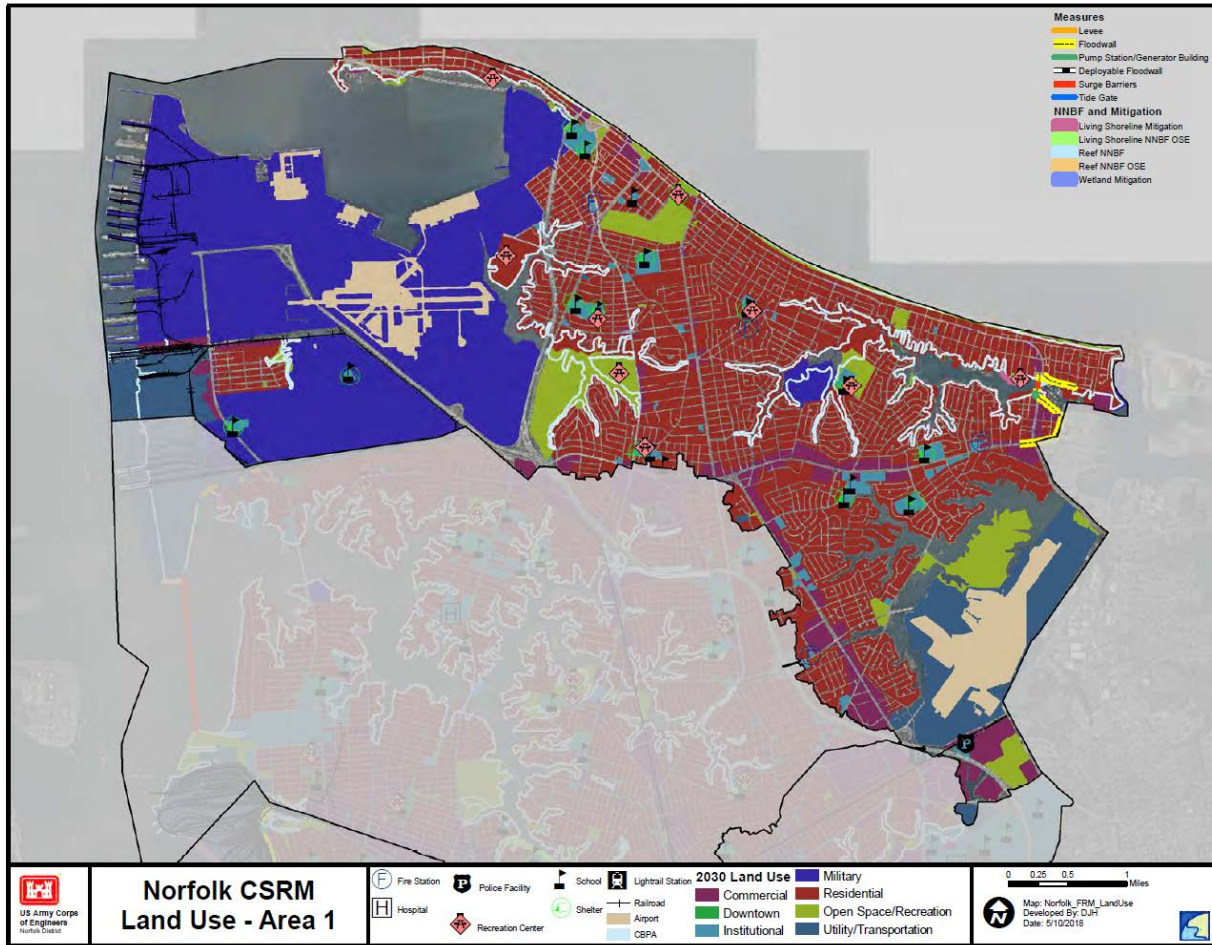


Figure 11-1. Land Use - Area 1

Area 2: Lafayette River Watershed

The northern land connection for the storm surge barrier would occur at NIT, and the southern land connection would occur along the banks of the Lamberts Point Golf Course. Property would need to be acquired from both, resulting in a permanent impact on land area for those facilities. Current use of these properties, as a marine terminal and a golf course, respectively, would be reduced or at least would need to be modified. More property would need to be acquired on the north (NIT) side for the generator/pump station facility. The potential natural and nature-based feature of a living shoreline and submerged oyster reef along the southern bank of NIT to help augment the storm surge barrier would be a compatible land use, because this area is not within the berthing areas for the terminal and would be adjacent to the newly acquired land for the generator building. This would also be a compatible land use at that location, because the waterfront at this location is not actively used.

Care would need to be taken during the PED phase of the southern land connection on the golf course, which was formerly a landfill. The barrier would need to be constructed in such a way that it would not compromise the contents of the landfill.

Temporary construction access may further restrict some usage of those facilities. Further

minor temporary impacts to land use could occur occasionally for maintenance personnel to gain access to the storm surge barrier, to conduct periodic testing of the gates. Likewise, temporary access would be needed to the gates on occasions where the gates must be closed for storms.

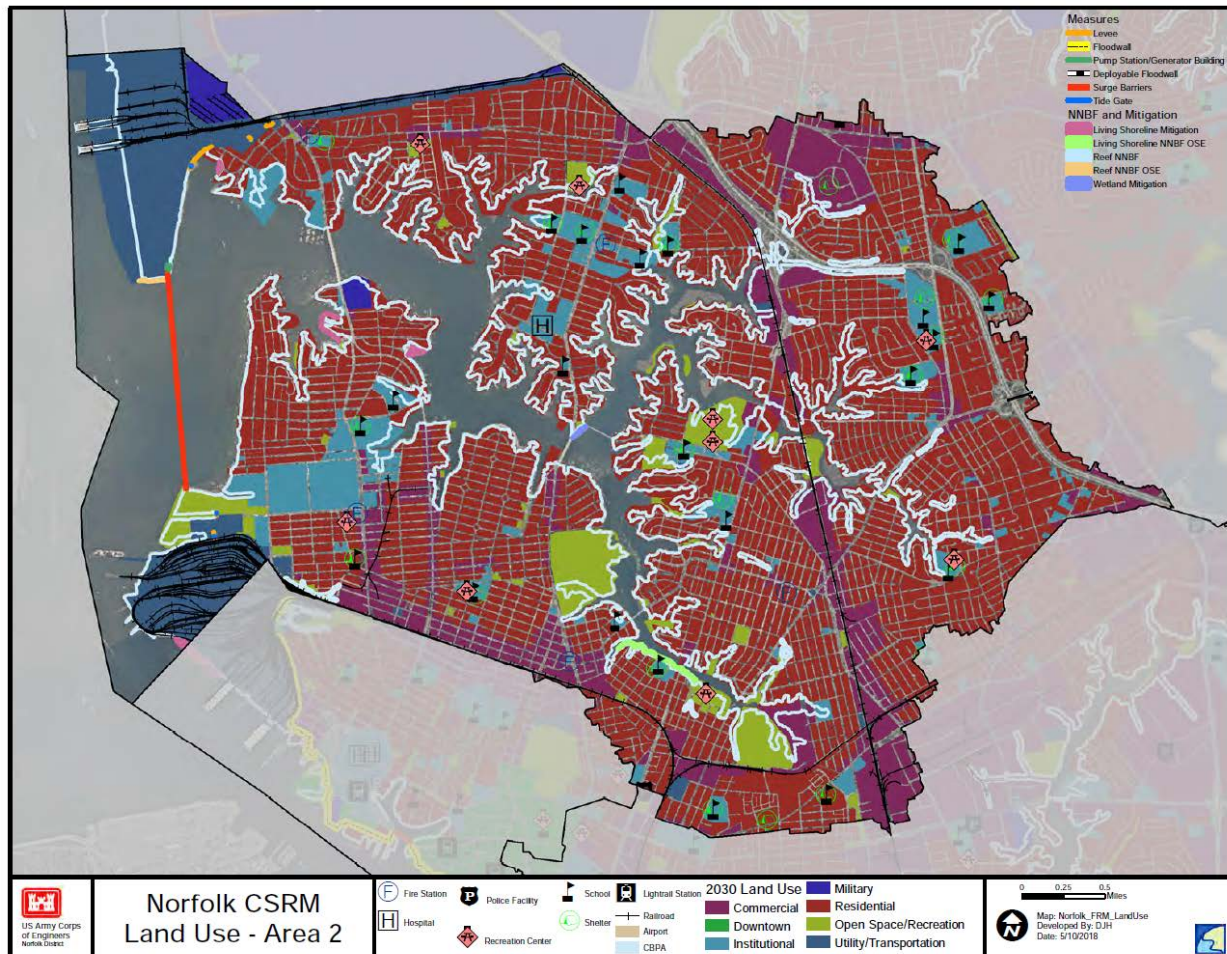


Figure 11-2. Land Use - Area 2

Area 3: Lamberts Point, The Hague, Freemason, Downtown

This floodwall and storm surge barrier would cross numerous properties. This is a very densely developed corridor with numerous different land uses: commercial business, high density residential, recreational, and transportation. Outright purchase of property, as well as both temporary and permanent easements, would likely need to be acquired from several property owners along the alignment of the wall, and for a few generator buildings. Therefore, there are likely permanent impacts to land use at these locations. The construction would impact access to some types of properties and possibly others near the alignment at least temporarily. Residents and commercial property owners alike would experience temporary inconveniences near their properties as construction is going. The public's use of popular venues for concerts and other events, like Waterside and Town Point Park, could be impacted temporarily by construction and maintenance activities, access, and/or staging areas as well.

While the extensive development of the City of Norfolk's shorelines will inhibit the creation of

large wetland sites, there are plenty of sites where natural and nature-based features such as oyster reefs, in conjunction with protection and restoration of fringing wetlands, could be implemented. Living shorelines can also be placed adjacent to hard structures, to aid and/or enhance in their function, reduce maintenance costs and improve the aesthetics of the area. Where appropriate and compatible with current and future land uses, they may be implemented along the floodwall. Living shoreline measures are considered for Lamberts Point.

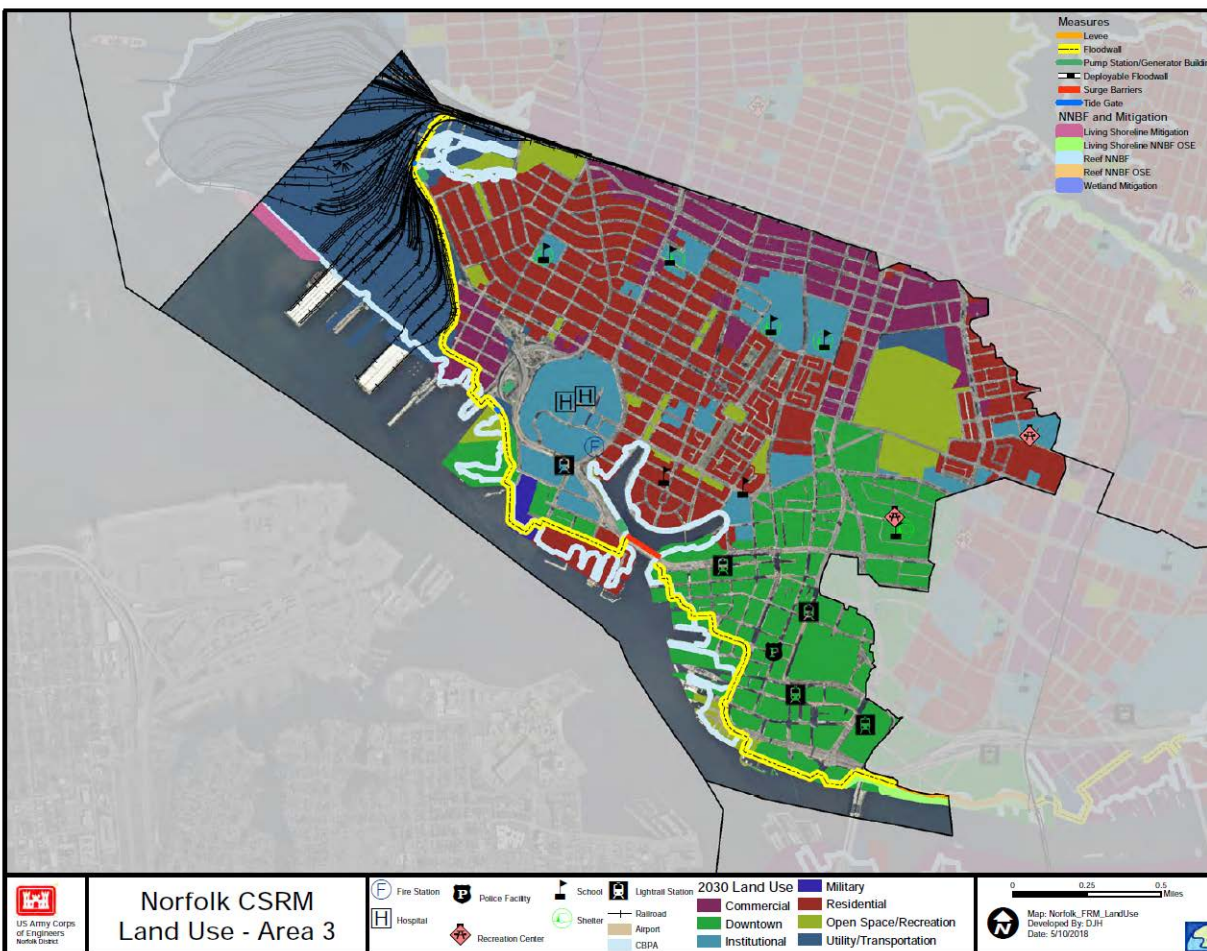


Figure 11-3. Land Use – Area 3

Area 4: Eastern Branch Elizabeth River, Broad Creek, Berkley, Campostella

As with the floodwalls and storm surge barriers in the previous Areas, outright purchase of property, as well as both temporary and permanent easements, would likely be needed along the alignment of the wall, for the storm surge barrier, and for a few generator buildings. However, overall, the alignment through Area 4 appears to affect and disrupt fewer land uses than through Area 3, as the Area 4 alignment crosses fewer areas that are actively used. The construction would impact access to these types of properties and possibly others near the alignment at least temporarily. There will be minor permanent land use impacts at Harbor Park, however; the berm to be constructed there may reduce available parking. In addition, the existing parking area could be used for construction staging, thereby reducing use of the facility temporarily. As a result, use of the stadium during construction could be limited. Residents, too, would experience temporary inconveniences near their homes as construction is going.

The residential neighborhood adjacent to Harbor Park is bordered by commercial/industrial water-dependent land uses along the Eastern Branch of the Elizabeth River waterfront (Lyons Shipyard and Morans Environmental Recovery). The wall is aligned landward of the commercial waterfront property, but channelward of the residential property. It is likely that construction of the wall and storm surge barrier parallel to The Tide may temporarily affect its operation, but no permanent impacts to the Tide would be anticipated.

While the extensive development of the City of Norfolk's shorelines will inhibit the creation of large wetland sites, there are plenty of sites where natural and nature-based features such as oyster reefs, in conjunction with protection and restoration of fringing wetlands, could be implemented. Living shorelines can also be placed adjacent to hard structures, to aid and/or enhance in their function, reduce maintenance costs and improve the aesthetics of the area. Where appropriate and compatible with current and future land uses, natural and nature-based features such as living shoreline with rock toe and subtidal oyster reef may be implemented along the floodwall and adjacent to the storm surge barrier at Broad Creek. Constructed reefs of oyster castles are anticipated adjacent to the mouth of Broad Creek, and along its eastern and western banks, south of the I-264 bridge.

Construction access requirements could temporarily impact land use in the immediate vicinity of the structure footprints. Post-construction, further minor temporary impacts to land use at all four storm surge barrier locations, as well as at gate locations in the floodwalls, could occur occasionally for maintenance personnel to gain access and conduct periodic testing of the gates. Likewise, temporary access would be needed to the gates on occasions where the gates must be closed for storms.

Overall, Alternative 2a contains many of the same measures that the City has previously explored, and would be in keeping with its goals of future development for resiliency. Most critical infrastructure would be protected behind storm surge barriers in the event of a major storm. However, this alternative would not protect any buildings or structures channelward of the storm surge barriers and floodwalls. As a result, the current land uses in those unprotected areas may be adversely impacted in the future by storm surge flooding and sea level rise. However, the storm surge barriers are designed to protect the property and land uses that occur landward of them; therefore, this Alternative would still protect most of the City's land uses from storm surge for the design storm event.

Any of these build alternatives (2a, 3, or 4d) would require compliance with the environmental laws applicable to land use in coastal areas, including the Coastal Zone Management Act (CZMA), the Chesapeake Bay Preservation Act (CBPA) (if within 100 feet of a tidal shoreline), and the Virginia Pollution Discharge Elimination System (VPDES) (for temporary and permanent construction discharges). All of these require review by the VDEQ. In addition, all proposed work must be conducted in compliance with the City of Norfolk's land use regulations.

Short-term impacts due to construction could be reduced by phasing work to cause less disruption at a time. Although the permanent effect on land use in the direct footprint of the project would be adverse, the overall effect of the project on land use would be moderately beneficial *Areas 1-4*: Under this alternative, all of the existing ongoing efforts, initiatives, and projects described under the No Action Alternative, as well as climate change, would be

assumed to occur.

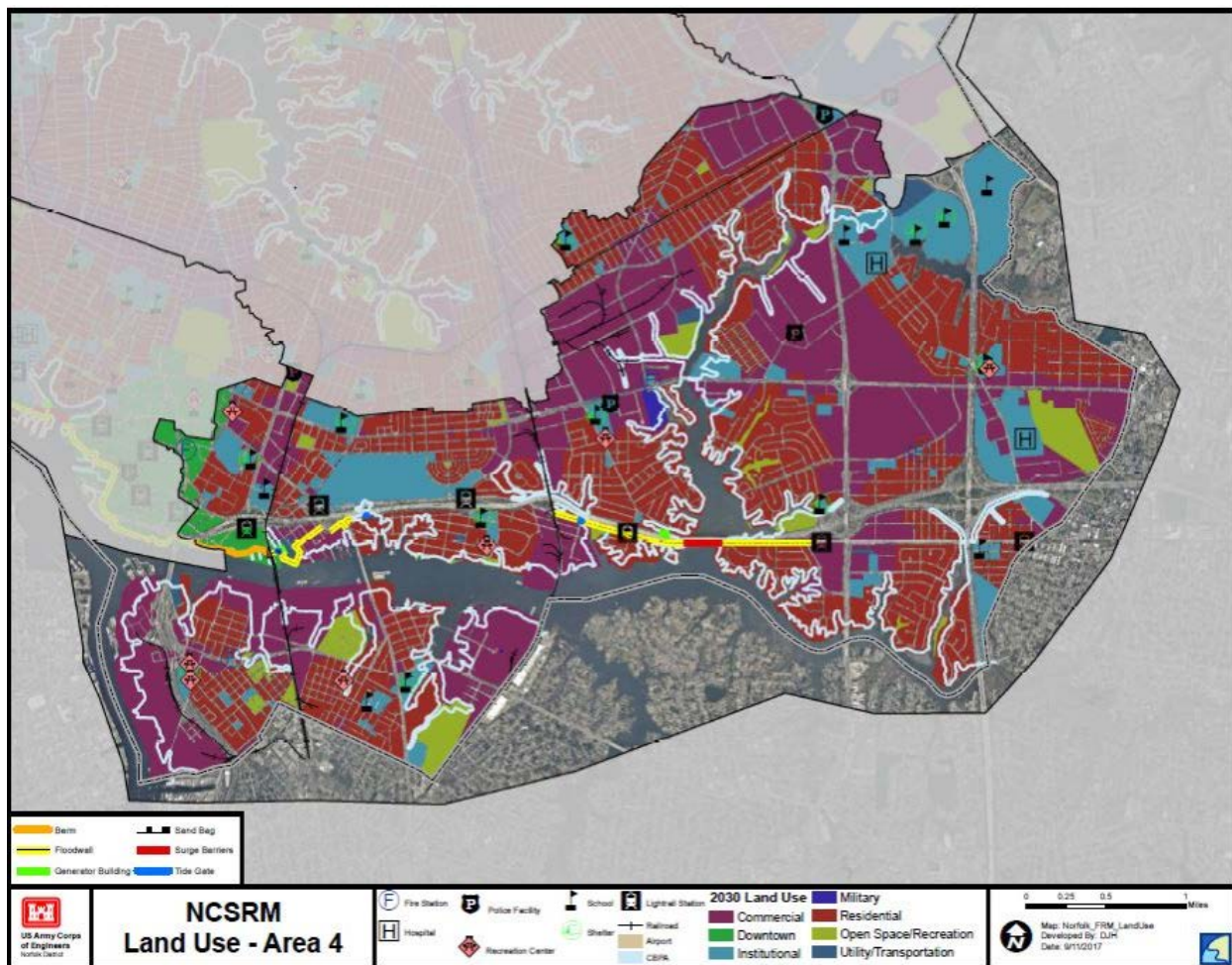


Figure 11-4. Land Use - Area 4

11.2.3 Alternative 3: Nonstructural Alternative

For this alternative, all critical infrastructure, as well as various commercial and residential buildings, would be protected by structure raises, basement fills, floodproofing, etc., but would help protect only individual structures from storm surge. This could disrupt land uses temporarily during construction, as measures are being constructed. However, the land use disruption would likely be mostly limited to those specific structures being protected, and this Alternative should not cause many permanent impacts to land use. Very few outright property acquisitions are being considered; therefore, few major changes in land use due to land acquisition would occur overall. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

The nonstructural measures throughout the City are very numerous, so they likely protect the most significant at-risk buildings and structures of the City's land uses. In addition, of the four alternatives, Alternative 3 would have the fewest temporary construction and maintenance impacts to the public. However, because this alternative would only address very localized and relatively small selected areas and structures, it would not protect wide expanses of area from storm surge. Transportation corridors, and open areas such as neighborhoods, school yards, or

parks would likely remain vulnerable to storm surge flooding; therefore, land use would still be adversely affected, at least temporarily during design storm events. Warning systems and preparedness plans would not allow people more time to evacuate as needed; however they would not prevent most kinds of property losses and associated impacts to land use.

Any of these build alternatives (2a, 3, or 4d Recommended Plan) would require compliance with the environmental laws applicable to land use in coastal areas, including the CZMA, the CBPA (if within 100 feet of a tidal shoreline), and the VPDES (for temporary and permanent construction discharges). All of these require review by the VDEQ. In addition, all proposed work must be conducted in compliance with the City of Norfolk's land use regulations.

Short-term and long-term adverse impacts would be negligible to minor.

11.2.4 Alternative 4d: Recommended Plan

Under this alternative, all of the existing ongoing efforts, initiatives, and projects described under the No Action Alternative, as well as climate change, would be assumed to occur.

Alternative 4d, is a combination of structural and some of the nonstructural components. For each of the four Areas, this alternative entails construction of all of the structures described in Alternative 2a, plus nonstructural components for some structures channelward of the storm barriers and floodwalls. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

The impacts for Alternative 4d plan would be the same as those described for Alternative 2a Structural and for the Alternative 3 Nonstructural, except that there would be no nonstructural measures implemented landward of the storm surge barriers. As described above, the nonstructural measures effects of Alternative 3 are minimal, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

Any of these build alternatives (2a, 3, 4d) would require compliance with the environmental laws applicable to land use in coastal areas, including the CZMA, the CBPA (if within 100 feet of a tidal shoreline), and the VPDES (for temporary and permanent construction discharges). All of these require review by the VDEQ. In addition, all proposed work must be conducted in compliance with the City of Norfolk's land use regulations.

Alternative 4d contains many of the same measures that the City has previously explored, and would be in keeping with its goals of future development for resiliency. Of the four alternatives, Alternative 4d would protect the most of City's land uses from storm surge impacts. Although some property would have to be acquired, changing various land uses into components of this project, this would not significantly alter land use in the city. In addition, cumulative permanent land use impacts would be mostly beneficial. USACE and the City have strategized a construction sequence which is described in Chapter 13. Temporary impacts would be reduced if construction is phased.

11.2.5 Cumulative Effects

The past, present, and reasonably foreseeable effects of other actions in or near the ROI, as

described in the No Action Alternative, generally apply to land use and all other resource categories in this EIS.

The roadway and tunnel projects have little effect on land use, as they are mostly in the water, and along existing highway corridors and in VDOT rights-of-way on land.

The risk from coastal inundation will rise in the coming years for Norfolk due to the combined effects of land subsidence and SLR. During storm events and exceptionally high tides, these climate change impacts already negatively impact the land uses currently present within the coastal City of Norfolk, causing low lying areas to be increasingly affected by flooding, or even permanently flooded.

For the No Action Alternative, this effect will be further exacerbated during major storms, and could adversely affect other planned projects as described. Specifically, the HUD flood risk project would be able to tie into, or rely upon, any protective measures from this project. There would be potentially significant cumulative adverse impacts to the City's land use if this alternative is chosen.

Implementation of Alternative 2a, 3, or 4d would not be predicted to substantially cumulatively or synergistically interact with climate change and/or other effects for land use. Therefore, effects to land use from implementation of Alternative 2a, 3, or 4 are predicted to range from moderately beneficial and permanent to minor to moderate adverse effects that are temporary to permanent in duration. However, Alternative 4d (Recommended Plan) would protect the most land use and could best be designed to complement the Chesterfield Heights/Grandy Village (shown as EB6) projects.

11.3 GEOLOGY AND SOILS

11.3.1 No Action Alternative/Future Without Project

The No Action/Future without Project Alternative would involve no action from the USACE to mitigate against coastal storm risk. Due to the synergistic effects of a combination of factors, including land subsidence, eustatic and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for City of Norfolk. Additionally, Norfolk is expected to increase redevelopment in the coming years. Without implementation of an action alternative, it is expected that the inhabitants of Norfolk will become increasingly susceptible to coastal inundation. As a result of land subsidence, climate change, global temperatures and sea level are expected to rise in the foreseeable future. Increased erosion of soil, particularly along unprotected shorelines, would be expected to increase as a result of increased storm surge.

As the 2012 Fugro Coastal Risk Study commissioned by the City of Norfolk notes, "Zoning rules, land use plans, and coastal zone management can be used to prevent construction or restrict the types of development (Building size, density, use, open space preservation) within flood prone areas and to direct future development with regard to relative sea level rise risks. The intent of such planning measurements is to minimize negative impacts associated with building structures that will not optimally withstand events that may occur in a particular area that is prone to flooding. While these plans do not prevent flooding in flood prone areas, they

can reduce the damage and risk” (Fugro Atlantic, 2012b). This study has guided the development of the City’s subsequent planning framework, and would be assumed to guide future land use decisions.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed; rewriting of zoning code to support resilience; and implementation of an additional three feet of required elevation, above the effective FEMA BFE for structures located within the 1% annual chance floodplain (100 year) and an 18 inch freeboard above grade required within the 0.2% annual chance floodplain (500 year) floodplain. The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

Norfolk is approximately 95-97% developed; therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City’s plan Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City’s comprehensive plan, “The Plan for Restoring The Lafayette River”, with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project into the future. USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion (CIEE), to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564, and the Hampton Roads Bridge Tunnel up to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

Without implementation of an action alternative, it is expected that the inhabitants of City of Norfolk will become increasingly susceptible to coastal inundation. Current and future projected yearly damages, excluding the Chesterfield Heights area, from coastal storms are expected to

reach \$231 million. Due to the synergistic effects from combination of factors, including land subsidence, eustatic and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for City of Norfolk. During storm events and exceptionally high tides, these climate change impacts already negatively impact the land uses currently present within the coastal City of Norfolk, causing low lying areas to be increasingly affected by flooding, or even permanently flooded. Residences, businesses, schools, industries, and recreational areas, may become increasingly vulnerable to flooding, and could be damaged more frequently and therefore, land could be less accessible for use by the citizens of Norfolk. Therefore, the No Action Alternative/Future Without Project Alternative could entail potentially significant direct and indirect, temporary and permanent impacts on land use within the City.

Implementation of the No Action/Future without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. The topography of the area would largely go unchanged besides shoreline erosion and subsidence around the City of Norfolk. As sea level rises over time, the natural morphological processes of erosion and siltation would occur. Under the Future Without Project, erosion, subsidence, and flooding in the City of Norfolk are anticipated to continue to occur.

11.3.2 Alternative 2A: Structural Only Alternative

The structural only alternative, Alternative 2A, assumes solutions for coastal risk management can be solved with structural measures. These measures include structures such as berms, floodwalls, surge barriers, tide gates, and pump stations. Along with structural barriers, drainage improvements and flap gates on outfalls have also been included in Alternative 2A. Short-term effects would include temporary soil disturbance in the construction access areas; however, these would be restored upon completion of construction. The direct, long-term impacts to geology and soils have the potential to produce minor impacts to geology and soils from the implementation of these measures; however, adverse impacts beyond the footprint of the berm, generator/pump stations, or surge barrier would be negligible. There are no geologically significant features in the ROI; therefore, none would be affected.

11.3.3 Alternative 3: Nonstructural Alternative

The nonstructural only alternative, Alternative 3, consists of measures that are applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Physical nonstructural measures include elevation, relocation, buyout, or floodproofing of structures. Nonphysical measures include flood warning systems, flood preparedness plans, and zoning and flood insurance regulations. Short-term effects would include temporary soil disturbance in the construction access areas; however, these would be restored upon completion of construction. The direct, long-term impacts to geology and soils have the potential to produce minor impacts to geology and soils from the implementation of these measures; however, adverse impacts beyond the footprint floodproofing of structures would be negligible.

11.3.4 Alternative 4d: Recommended Plan

Alternative 4d would provide structural and nonstructural coastal storm risk management for nearly the entire City of Norfolk. This plan is a combination of structural and nonstructural

measures that would reduce coastal storm risk and address residual risk to the extent possible within the authority and planning guidance. Therefore, effects would be similar to a combined Alternative 2a and 3. As described above, the nonstructural measures effects of Alternative 3 are negligible, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

In many areas, buildings that are located outside of the structural measures in the alternative that are experiencing high damages will have their risk reduced through nonstructural measures such as elevation and flood proofing. In addition, there are other nonstructural measures under consideration such as floodplain management and zoning. Short-term effects would include temporary soil disturbance in the construction access areas; however, these would be restored upon completion of construction. Overall, Alternative 4d would provide the most long-term soil erosion protection of any of the alternatives.

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, and Mason Creek

The measures proposed in Area 1 for Alternative 4d include surge barrier, pump station, and floodwall system for protecting the Pretty Lake neighborhood to the west of Shore Drive. The direct impacts to geology and soils have the potential to produce minor impacts to geology and soils from the implementation of these measures; however, impacts to geology and soils beyond the footprint of the floodwall, pump/generator stations, or surge barrier would be negligible.

Area 2: Lafayette River Watershed

Structures including berms, surge barriers and pump/generator stations are planned to be constructed in industrial and developed areas along the Lafayette River. The direct impacts to geology and soils has the potential to produce minor impacts to geology and soils from the implementation of these measures; however, impacts to geology and soils beyond the footprint of the berm, generator/pump stations, or surge barrier would be negligible.

Area 3: Elizabeth River, The Hague, Freemason, Downtown

The measures proposed in Area 3 for Alternative 4d include a floodwall, along which, there a number of proposed tide gates and generator buildings/pump stations, as well as a surge barrier. The direct impacts to geology and soils have the potential to produce minor impacts to geology and soils from the implementation of these measures; however, impacts to geology and soils beyond the footprint of the floodwall, generator/pump stations, surge barrier, or tide gates would be negligible.

Area 4: Eastern Branch Elizabeth River, Broad Creek, Berkley, Campostella

The measures proposed in Area 4 for Alternative 4d include construction of a berm and floodwall with associated tide gates and generator buildings/pump stations. The direct impacts to geology and soils have the potential to produce minor impacts to geology and soils from the implementation of these measures; however, impacts beyond the footprint of the berm, generator/pump stations, floodwall, tide gates, or surge barrier would be negligible.

11.3.5 Cumulative Effects

Implementation of Alternative 2A, 3, or 4(D) (Recommended Plan) is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects to

geology and soils. There are no geologically significant features within the ROI; therefore, none would be affected.

11.4 COASTAL HYDRAULICS

11.4.1 No Action Alternative/Future Without Project

If the Recommended Plan is not implemented, hydrology, hydraulics, and bathymetry of local waters in the ROI will not be affected. The natural system would continue to function as it has, and no tidal gates or storm surge barriers would be installed across any waterways in the project ROI as described for Areas 1-4. Periodic beach nourishment along Willoughby Spit and Ocean View is expected to continue. USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River.

The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships.

The changes to hydrology, hydraulics and bathymetry due to the deepening of the navigation channels were minor and not significant (US Army Corps of Engineers, 2017). Sea level rise will bring with it increased water volume in the project ROI, but when compared to the water volume present at this time, the predicted change within the next 50 years (from 2026-2076) is considered minor but permanent.

Construction of the Craney Island Eastward Expansion (CIEE), to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564, and the Hampton Roads Bridge Tunnel up to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. With implementation of the No Action/Future Without Project Alternative, impacts are minor and permanent (climate change and associated sea level rise) to hydrology, hydraulics and bathymetry.

11.4.2 Alternative 2a: Structural Only Alternative

Water quality modeling, which included aspects of hydrology and hydraulics, such as flushing times and water age, has been done at all locations where surge barriers have been proposed, with the exception of The Hague, where only preliminary modeling was done due to the fact that

it has been so highly modified from its original condition it was determined there were little impacts to this waterbody by further modification.

Area 1: Willoughby Spit, Ocean View Beach and Pretty Lake

For Pretty Lake, a storm surge barrier with tidal gate and associated pump station is proposed. A flood wall will connect the surge barrier to higher ground to further control flooding. The normal condition of the gate would be open. It is anticipated that only closing during major storm events (approximately the 1.4% storm event; approximately at 4.0 feet of stillwater elevation. However, the barrier and gate, when open, could modify the hydrology, hydraulics and potentially bathymetry by altering flow patterns in Pretty Lake. Hydrodynamic modeling (Moffatt & Nichol, 2017) indicated that the proposed structures, when the gates are open, would alter hydrology and hydraulics as follows. For salinity, the average Bay wide was estimated at 21.9 ppt without project and 22.0 with project, in the upper reaches salinity was estimated at 19.9 ppt for both without and with project. Constraining the opening with the surge barrier and tide gate increases the velocity near the mouth of Pretty Lake, decreasing flushing time by almost a day, from 9.5 days without project to 8.6 days with project. In the upper reaches, flushing time increased by 1.3 days (from 12.3 to 11.0 days) between the without and with project condition. Freshwater age declined by 0.2 days, from 14.6 to 14.4 days with project across all of Pretty Lake and in the upper reaches it declined from 11.6 to 11.5 days. To conclude, tidally-averaged freshwater age, flushing time and tidally averaged salinity changed slightly between the without and with project scenarios; these changes are minor and not significant. These differences in hydrology are minor, permanent, and not significant. Water velocities are expected to increase locally near the tide gate, approximately doubling in the region just downstream of the gate. This increase has been modeled, current without project conditions indicate water velocity at the region of the proposed surge barrier and tide gate at 0.4 m/s. This would increase to 1.3 m/s at peak flood and 1.5 m/s at peak ebb, an average difference of 0.95 m/s in the region near the tide gate, an increase in speed of approximately 1.8 knots or about 2.13 mph. Due to the current water velocities at this point being low, as well as the magnitude of the change in speed due to implementing the project, the increase caused by project implementation should not be enough to induce scour. Due to this, the increase in local velocity downstream of the tide gate is minor and not significant. The proposed pump would only operate during storm events. While this action has the potential to alter local hydrology, the impacts from operating the pump would be far less than the natural impacts occurring during the storm. Pump operation impacts are therefore temporary and minor, not significant. The proposed floodwall is on land and extends into nearby neighborhoods. No impacts to local hydrology or bathymetry are expected from the floodwall. There may be mitigation and/or other NNBF features done in conjunction with the proposed project in this area. Living shorelines would be constructed. These NNBF (mitigation will consist of oyster reefs and/or wetland restoration, both of which are NNBF) would result in temporary increases to local TSS and long-term, assist in abating incoming storm surge. The increase in TSS will not affect H&H or bathymetry, though oyster reefs and restored wetlands will cause minor, permanent changes in bathymetry due to their alteration of bottom conditions.

Area 2: Lafayette River

A proposed surge barrier with gates is proposed across the mouth of the Lafayette River. The present navigation channel will have a gate that spans most of its width (150 feet, the channel is

200 feet wide). Due to this, the bathymetry of the River will not be altered and navigation through the channel will remain unrestricted except during closure events, though the channel will be significantly narrower in width even when the gates are open. This impact is considered minor but permanent to local H&H due to modeling results (VIMS, 2017). The restriction of both the barrier and gates when the gates are open, however, will limit boat traffic to the main navigation channel and the other, smaller gates only as the barrier will block most of the present opening of the River mouth. The impacts to navigation are minor but permanent, as boat traffic will now be restricted to the main channel and other tide gate openings rather than the entire river mouth as it is at present. The proposed structures could also alter the flow patterns and velocities of tidal currents, and hydrodynamic modeling was done to assess potential changes (VIMS, 2017). Changes to velocity were minor and insignificant when the proposed barrier with gates open was compared to the without project conditions. Typical river water velocity ranged from near 0 m/s at slack tide to 0.8 m/s under normal conditions. The difference in river water velocity due to proposed project implementation ranged from approximately 0.02-0.08 m/s, (VIMS 2017). Upon closure during a major storm event, river velocities will drop to zero, as there will temporarily be no tidal exchange or release of river water to surrounding Bay waters. This condition will last for approximately five days, at which time all gates will be opened as it is expected the storm surge outside the gates will have subsided by this time. Velocities will quickly return to normal, although the most upriver reaches will experience minor fluctuations (up to 0.04 m/s) for up to 90 days as the River hydraulics return to pre-closure conditions. The change in velocity during the time the gates are closed is significant, but temporary. Fluctuations that occur once the gates are re-opened are temporary and minor. Salinity changes were also noted, but in general were minor, being less than 1 ppt when gates were open. During a gate closure event, salinity will initially drop by several (typically 2-3 ppt) throughout the Lafayette River while the gates are closed. Once reopened, salinity will then increase by, on average, several ppt over the next few days as salinity levels return to normal. These changes are induced by the temporary changes in River hydrology due to the gate closure, and are temporary, minor and not significant. The proposed pump station with this surge barrier and tide gate also has potential to alter the local hydrology. However, as it is designed to operate only during storm events, the natural events that would cause pump activation will have much greater flow-induced impacts than the pumps, so the impacts from pump operation on local hydrology are considered minor and not significant. There may be mitigation and/or other NNBF features done in conjunction with the proposed project in this area. Approximately 4,650 feet of living shoreline (fringing wetlands with a nearshore oyster reef) are proposed in the Lafayette River. These NNBF (mitigation will consist of oyster reefs and/or wetland restoration, both of which are NNBF and identical to proposed living shorelines) would result in temporary increases to local TSS and long-term, assist in abating incoming storm surge. The increase in TSS will not affect H&H or bathymetry, though oyster reefs and restored wetlands will cause minor, permanent changes in bathymetry due to their alteration of bottom conditions. The slight increase in tidal restriction may enable for increased larval retention in the Lafayette River, which would be a minor but positive benefit to oyster reefs there, as they rely on oyster larvae to settle on present reef structure to maintain it over time. No negative impacts to oyster larvae due to placement of the surge barrier and typical operations with open gates is expected. During closures, this area would retain all larvae temporarily (5 days out of the approximately 21 day larval period), if the closure occurred during

the summer months (July-September) which would again be a minor, positive benefit to local oyster populations. The increase in residence time is small, and unlikely to increase the probability of harmful algal blooms.

Area 3: West Ghent, Hague, Ft. Norfolk, Downtown, Freemason

Proposed construction under the Recommended Plan is mostly alongshore, though a surge barrier with tide gate would be placed across The Hague. As most of this construction is nearshore on land, the floodwalls and berms are not expected to have any impacts or effects to local H&H or bathymetry. At The Hague, the proposed construction could also alter the flow patterns and velocities of tidal currents, and hydrodynamic modeling was done to assess potential changes and limited hydrodynamic modeling was done (Moffatt and Nichol 2012) to assess the potential for alterations to these parameters. It was determined that the flushing rate may be slowed by up to one day, a minor and not significant change in local hydrology with the surge barrier in place with the gate open. Local water velocity will change at the opening of the tide gate, as water flow will be restricted due to the associated surge barrier, which will enclose part of the opening between The Hague and Elizabeth River. The velocity may close to double in speed, but considering the current low speed (less than 1 knot) the change will not alter local hydrology significantly and this impact is considered minor but permanent. The proposed floodwalls and berms may impact shallow water habitat at several small areas, which will alter local bathymetry but this change should not alter significantly local hydrology or hydraulics. The proposed pump station has potential to alter the local hydrology. However, as it is designed to operate only during storm events, the natural events that would cause pump activation will have much greater flow-induced impacts than the pumps, so the impacts from pump operation on local hydrology are considered minor and not significant. There may be mitigation and/or other NNBF features done in conjunction with the proposed project in this area. These NNBF (mitigation will consist of oyster reefs and/or wetland restoration, both of which are NNBF) would result in temporary increases to local TSS and long-term, assist in abating incoming storm surge. The increase in TSS will not affect H&H or bathymetry, though oyster reefs and restored wetlands will cause minor, permanent changes in bathymetry due to their alteration of bottom conditions.

Area 4: Elizabeth River Eastern Branch (Newton's Creek/Tidewater Dr., Ohio Creek, Broad Creek, Berkley, and Campostella

A length of the Eastern Branch of the Elizabeth River in this area will be protected by a floodwall and berm system. Impacts are expected to be similar to those in other areas, small, permanent but not significant changes to local bathymetry and hydrology. Most floodwall and berm construction will take place on dry land, though there are several locations where the project footprint is at the shoreline or in shallow nearshore waters. Navigation should not be impacted, the finding for navigation is no effect. Broad Creek has a proposed surge barrier with tidal gates at its confluence with the Elizabeth River, which has the potential to significantly alter local hydraulics, hydrology and bathymetry whether open or closed. Hydrodynamic modeling was done to address these potential impacts (Moffatt and Nichol 2017) and results, in general, revealed minor but permanent changes with the tide gate open. For flushing times, changes were minor and not significant, the average flushing time without project being 22.2 days, with project it is 22.3 days for a six gate barrier option and 21.7 days for a two gate barrier option with gates open. These changes are minor, permanent and not significant. Freshwater age

was also examined, under without project conditions it averages 10.3 days at present. With project conditions alter this slightly, the six gate option is 10.4 days and with the two gate option, 10.1 days, in both cases with all gates open. These changes to freshwater age are considered minor, permanent and not significant. Salinity in Broad Creek, being located far up the Eastern Branch of the Elizabeth River, is near oligohaline, averaging 5.4 ppt without project at present. This changes to 5.2 ppt with the six gate surge barrier option, and to 6.2 ppt with the two gate surge barrier option. These changes are minor, permanent but not significant, as waters will still remain in the near oligohaline range they are at present without project. Local bathymetry could be altered by changes in flow rates near the tide gates and surge barrier with the gates open. This was examined and found that the six gate option would not significantly alter water velocities, while the two gate option would increase them from the present 0.15 m/s to 0.4 m/s. While this is a near three-fold increase, the current speed would still be below 1 knot. Such a low speed would not be likely to induce any scouring, so local bathymetry should not be altered by restricting flow through either proposed scenario of tide gate openings.

11.4.3 Alternative 3: Nonstructural Alternative

None of these measures would impact the local waters in the project ROI in any of the four areas. No effect.

11.4.4 Alternative 4d: Recommended Plan

Due to the fact that this is a combination of Alternative 2a and 3, impacts will be similar to those of Alternative 2a as Alternative 3 does not affect the local ROI hydraulics, hydrology and bathymetry. As described above, the nonstructural measures effects of Alternative 3 are negligible, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

11.4.5 Cumulative Effects

There are multiple past, present and reasonably foreseeable future projects within the overall Study Area. The City plans a number of actions to re-develop portions of the City, focusing on areas that are higher ground (Norfolk Vision 2100).

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects of climate change. Minor additive effects are noted, in all cases these are less than those caused by climate change. No changes to local tides are expected, and all areas where construction is proposed will remain estuarine, tidal waters. Due to climate change, there will also be changes in water parameters (salinity, DO in particular) as well as freshwater age and flushing rates throughout waters of the project ROI. Other than direct impacts to local bathymetry by construction of surge barriers with tidal gates, no other impacts are expected. Periodic dredging of navigation channels will continue, likely at present rates, into the future and the proposed project is not likely to either increase or decrease the need for such dredging. CIEE and the proposed Third Crossing will not act cumulatively with the proposed project to significantly alter local hydraulics, hydrology or bathymetry beyond impacts already caused and compensated for with the CIEE project or the Third Crossing. A new VPA port facility may ultimately be constructed on top of the CIEE once it is filled, this should not alter H&H or bathymetry further or act synergistically

with the proposed project to induce further alterations in the future.

Area 1: Willoughby and Oceanview Beaches, Pretty Lake, Little Creek, Fishermans Cove

No significant changes to the hydrology or bathymetry in the Willoughby Spit area beyond those cause by climate change are expected, with climate change impacts being minor, permanent alterations to these parameters. For Pretty Lake, the difference in flushing time in 2076 was modeled to be 7.3 days without project, and 7.0 days with project, a minor increase that would not be significant. Freshwater age declines Pretty Lake wide in the future due to sea level rise, from the present 14.6 days to 13.9 days without project and 13.6 days with project. Minor, permanent but not significant change will occur due to the with project condition in the future, the impacts from sea level rise are considerably larger. Salinity is expected to increase slightly due to climate change in the next 50 years, going from 21.9 ppt to 22.5 ppt without project and 22.6 with project. Based on this information, the proposed project does act cumulatively with expected changes due to sea level rise, though the project additive changes are minor compared to those of sea level rise itself. Overall, these increases are not sufficient to significantly alter the hydraulics, hydrology or bathymetry in Pretty Lake though rising waters in the Lake may require action from homeowners with property abutting the Lake.

Area 2: Lafayette River

In the Lafayette River, salinity will increase slightly due to sea level rise, though waters will remain in the polyhaline range they are at present. The proposed surge barrier with tide gates will not significantly alter the salinity further beyond the expected changes due to climate change, which will be an increase of approximately 1 ppt. Such impacts will be minor, permanent and not significant to local hydrology. The proposed CIEE expansion and Third Crossing will also alter local hydraulics, hydrology and bathymetry. These projects' impacts are either not significant (Third Crossing) or already have a mitigation plan in place (CIEE). The impacts of these projects will not act synergistically with the proposed project to cause additional significant changes beyond those that have occurred. Water velocities will experience minor alterations, in general increasing by approximately 0.08 m/s due to sea level rise near the river mouth and proposed surge barrier site. The mid-river reach experiences a larger increase in velocity due to sea level rise, approximately doubling from the present rate of approximately 0.25 m/s to approximately 0.5 m/s. Further upriver in the upper reaches, velocity changes are smallest, with no significant change being noted. Additional changes in velocity due to the gates coupled with sea level rise are, in general very minor, but permanent. These changes do not appear large enough to induce significant scour at the gate openings. These changes are considered not significant.

Area 3: West Ghent, Hague, Fort Norfolk, Downtown, Freemason

These areas are already entirely built out, and a present floodwall in the Freemason area is proposed for heightening, with additional berms and floodwalls proposed. No other projects directly impacting local waters are expected in the near (50 year) future.

Area 4: Elizabeth River Eastern Branch (Newton's Creek/Tidewater Dr., Ohio Creek, Broad Creek, Berkley, and Campostella

The proposed berms and flood walls should not interact significantly with other present or future projects in the project ROI, and should continue to function to protect the city from storm surge

flooding throughout the 50-year period of analysis. For Broad Creek, sea level rise is expected to decrease the flushing time of Broad Creek from the present 22.2 days to 15.7 days, which would be altered to 16.0 days with the six gate and decreased to 14.0 days with the two gate surge barrier option. Freshwater age would likely increase from the present 10.3 days to 16.8 days without project in 50 years, this would be altered by the six gate option to 17.0 days, and to 15.7 days with the two gate surge barrier option. Salinity is expected to increase significantly due to sea level rise, from the present 5.4 ppt to 8.4 ppt in 50 years. This would be altered by the six gate option to 8.2 ppt, and to 8.8 ppt with the two gate surge barrier option. Considering the magnitude of the changes to local waters by climate change/sea level rise, the additional changes that would result from project implementation along with any expected other projects in the area are minor, permanent but not significant.

11.5 WATER QUALITY

11.5.1 No Action Alternative/Future Without Project

If the Recommended Plan is not implemented, the water quality in the four areas will remain undisturbed by any construction activities or any other modifications to their environment due to the various measures being considered. The natural system would continue to function as it has, no tidal gates or storm surge barriers would be installed across any waterways in the project ROI as described for Areas 1-4. Periodic beach nourishment is expected to continue. The main regions of concern will be Willoughby Spit, Ocean View and Pretty Lake. For Willoughby Spit and Ocean View, an earlier project related to but separate from the present study, periodic beach nourishment will be done as part of maintaining a beach profile sufficient to provide desired levels of storm surge protection (US Army Corps of Engineers, 2014). The initial amount placed on Willoughby Spit, done in 2017, was approximately 1.2 million cubic yards of sand. It is expected that approximately 450,000 cubic yards will need to be placed every nine years during the 50-year period of analysis, though more may be needed if sea level rise accelerates beyond the mid-range scenario predicted. Dredging in the borrow area would result in some short term negative effects to water quality, including localized increases in Total Suspended Solids and turbidity and slight decreases in DO. The dominant substrate at the borrow area is medium-grain sand, which is expected to settle rapidly, causing less turbidity and less oxygen demand than finer-grained (organic) sediments. Studies (Priest, 1981; Barnard, 1978) have concluded that the turbidity created by a dredging operation is restricted to the vicinity of the operation and decreases significantly with increased distance from the dredge. DO, pH, and temperature all influence the welfare of living organisms in water; without an appreciable level of DO, many kinds of aquatic organisms cannot exist. Temporary, minor effects on DO, pH, or temperature are anticipated due to the nature of the dredged material (sand), related low levels of organics and biological oxygen demand, and the hydrodynamic influences within the borrow area in the open ocean where the water column is subject to significant mixing and exchange with oxygen rich surface waters. Beach nourishment would result in increased turbidity at the placement site; however, these impacts are expected to be short term and spatially-limited to the vicinity of the dredge outfall pipe. Nearshore turbidity impacts are directly related to the quantity of fines (silt and clay) in the nourishment material. The nourishment material would consist primarily of beach quality sand, with fine material making up a very small fraction. As a result, turbidity in the area of the sand placement

disappears quickly, within several hours after nourishment operations cease (Van Dolah et al., 1992). Schubel et al., 1978, found that 97-99% of slurry discharged from pipelines settled to the bottom within tens of meters from the discharge point. Nichols et al. (1978) observed that sediment plumes were limited to the area of the discharge, and that after terminating activities, the plumes disappeared within 2 hours. Studies conducted off the coast of New Jersey revealed short-term turbidity at the fill site was essentially limited to a narrow swath (less than 500 m) of beachfront. Dispersed sediment was most prominent in the swash zone in the area of the operation, with concentrations dropping off in the surf zone and nearshore bottom waters. Except for the swash zone, the concentration of sediment was considered comparable to conditions that might occur when sediment becomes re-suspended during storms (USACE, 2001). Van Dolah et al., 1992 reached a similar conclusion: despite a maximum of 200 Nephelometric Turbidity Units (NTUs) confined to a narrow area, background turbidities were close to 100 NTUs during storms and normal fluctuations often elevated turbidity.

USACE would also continue periodic maintenance of its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. The water quality impacts were found not to be significant for those projects.

Construction of the Craney Island Eastward Expansion (CIEE), to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed. It was an EIS with oyster reef mitigation.

Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564, and the Hampton Roads Bridge Tunnel up to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects, including changes to the navigation channels in the Elizabeth River that are outside the proposed project scope. With implementation of the No Action/Future Without Project Alternative, impacts are minor, permanent and adverse (climate change and associated sea level rise) to local benthic fauna. The salinity changes may allow higher-salinity preferring predatory species to penetrate further into the Elizabeth River, exposing more of the benthic community to a wider suite of predators, while limited freshwater species to smaller areas further upriver than at present. Hydrodynamic modeling predicts that DO levels are expected to decline significantly (approximately 30%) in the upper reaches of the Lafayette River due to climate change by year 2076 (VIMS 2017). Although this is a significant drop, DO levels still remain for both surface and bottom waters above 5 mg/L, a safe level for all estuarine life. For all modeled waterbodies (Pretty Lake, Broad Creek, and the Lafayette River) minor changes in flushing times and salinities were noted in the Future Without Project Condition (Moffatt and Nichol 2017; VIMS 2017). In general

flushing times declined by approximately one day, and salinities in general increased by approximately 1 ppt. These changes are considered minor but permanent.

11.5.2 Alternative 2a: Structural Only Alternative

Water quality modeling has been done at all locations where surge barriers have been proposed, with the exception of The Hague, which has been so highly modified from its original condition it was determined there were little impacts to this waterbody by further modification.

Area 1 : Willoughby and Oceanview Beach, Little Creek, Pretty Lake, and Mason Creek

For Pretty Lake, a storm surge barrier with tidal gate and associated pump station is proposed.

These structures could modify the water quality by altering flow rates in Pretty Lake.

Hydrodynamic modeling (Moffatt & Nichol, 2017) indicated that the proposed structures will influence water quality. Minor, negligible changes in salinity, from 22.6 ppt without project to 22.6 ppt with project, and tidally averaged freshwater age, from 13.9 days without project to 13.6 days with project under normal operating conditions (tide gate is open) post construction. Flushing times for Pretty Lake waters are slightly reduced, from 8.7 days without project and 7.8 days with project. These impacts are considered minor and not significant. Modeling was also done to assess potential impacts caused by a closure during a storm event. A gate closure of five days was examined, and indicated that a decrease in salinity will occur due to the closure, as freshwater input from the hurricane is unable to flow out of Pretty Lake while no additional high-salinity water from the Bay mainstem will be able to enter Pretty Lake due to the gate closure to prevent storm surge flooding. Overall, tracer modeling indicates that after a closure event due to a late-summer hurricane, it will take approximately 25 days for salinity in Pretty Lake to return to normal. In approximately the upper 1/5th of Pretty Lake, salinity will decline to almost 0 ppt for approximately three days post-storm. Normal salinity in this reach of Pretty Lake is polyhaline (between 18 and 30 ppt), a decline to near zero for several days is a significant impact, compared to a decline to approximately 7.5 ppt for a single day. Further downstream, salinity also drops due to a storm-induced gate closure, but the drop is not as low, to approximately 10 ppt from the low 20s in the secondmost upstream segment, and only dropping approximately 2-3 ppt in the lowermost 3/5 of Pretty Lake's waters. The impacts below the uppermost segment on salinity are considered minor and not significant. DO (dissolved oxygen) was not modeled during this phase of the study, but will be modeled during PED as designs for this site are refined. NNBF living shorelines are also proposed for this area. During all construction, minor increases to turbidity are expected. These should be short term in duration, and not significant. Post-construction, NNBF should act to improve water quality, lowering turbidity, stabilizing the shoreline and oysters on the reef will actively filter the water.

Area 2: Lafayette River

Water quality monitoring was performed by the Virginia Institute of Marine Science (VIMS, 2017) to assess potential impacts from proposed surge barriers with their tide gates across the mouth of the Lafayette River. The monitoring stations can be seen in Figure 11-5.

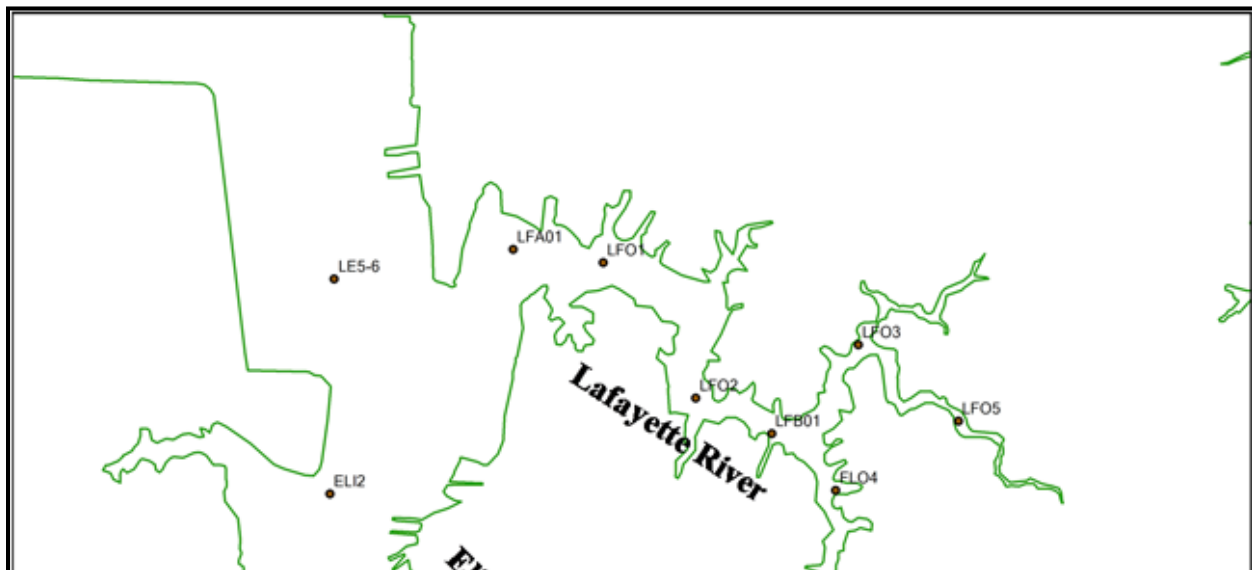


Figure 11-5. Monitoring Stations on the Lafayette River

Various parameters were assessed, including chlA (Chlorophyll A, a measure of the amount of phytoplankton which can also be a proxy for the amount of eutrophication present, if any), N (Nitrogen), P (Phosphorus), DO (Dissolved Oxygen), tidal action, temperature and salinity. Due to the size of the surge barrier, two configurations were modeled, one with 19 gate openings and one with 10 gate openings. For DO, the 19-gate scenario with all gates open, which will be the normal condition, shows little change (< 10%, with all levels remaining well above 5 mg/L, the required minimum for supporting all estuarine life) when the gates are open during both spring and summer, the times of year where DO can drop to low levels due to decomposition coupled with high temperatures and stratification, which can prevent warm surface and cooler bottom waters from mixing and replenishing deeper waters' oxygen. This impact is considered minor and not significant. There are some differences in other parameters, Algae (ChlA) shows a decline during the summer (from roughly 5-6 ug/L to approximately 2 ug/L), with concomitant increases in N (DIN, dissolved inorganic nitrogen, which increases from approximately 0.1 to 0.25 mg/L). Phosphorus shows little change between the without project condition and the with project condition of 19 gates. Overall, changes seen to Algae, N, and P are minor and not significant, and should not impact the flora or fauna in the Lafayette River significantly when the 19 gates are open. These changes should not increase the probability of harmful algal blooms.

Under the 10 gate scenario, having fewer openings resulted in an approximately 11% decline in DO in the uppermost reaches of the Lafayette River, approximately the upper 10% of the river's reach in the spring, and close to 10% in the summer. However, these drops do not result in neither surface nor bottom waters declining to less than 5 mg/L, so this impact is considered minor and not significant. DO increases slightly for more downriver reaches near the gate, likely due to increases in tidal velocity as water flows through fewer openings than the 19-gate option. Under the 10-gate scenario, similar changes were noted for algae, N, and P, with algae showing a decline of approximately 2 ug/L during the summer with a concomitant increase of roughly 0.2 mg/L N and little change noted for P. These impacts are considered minor and not significant. These impacts should not increase the probability of harmful algal blooms. NNBF living shorelines will be constructed in this area also. During construction of all project features, there

will be temporary, minor increases in turbidity, these changes to water quality are not significant. NNBF will cause a minor, permanent benefit to local water quality by stabilizing the shoreline, and by the oysters on the reefs, which will actively filter local waters and improve water quality directly.

Salinity changes were noted during gate closures (see H&H and Bathymetry section of this EIS for details). These changes were several ppt, and not great enough to induce mortality of the non-motile benthos. Salinity levels fluctuate for several days after the gates re-open as salinity levels return to pre-closure conditions. The estuarine life typically found in the Lafayette River can endure such fluctuations, so these impacts are temporary, minor and not significant.

Area 3: Lamberts Point, Elizabeth River, The Hague, Freemason, Downtown,

A length of the Elizabeth River will in this area be protected by berms and floodwalls, and a surge barrier with tidal gate is proposed to be constructed across the mouth of The Hague, the highly modified confluence of the former Smith Creek that is now primarily a stormwater outfall collection area, as approximately 40 stormwater outfalls discharge into The Hague at this time. Little impacts to water quality are expected beyond those of construction, where the footprint of the berms and/or floodwalls touch the water, local Total Suspended Solids and turbidity is expected to increase but these impacts to local water quality are expected to be temporary and minor. Due to the lack of biological resources, extensive water quality modeling was not done for The Hague. Preliminary water quality work done (Moffatt & Nichol 2014) indicated that water quality in The Hague was, in general, fair to poor, with high levels of N (up to 6.9 mg/L, well in exceedance of the 3.0 mg/L CWA limit. Bacteria were also well in exceedance of limits for swimming (104 CFU/100 mL), being measured from 1-4200 CFU/100 mL. There was also preliminary hydrodynamic modeling done (Fugro 2011, 2012) that indicated that the time needed to change 90% of the water may increase by approximately one day if a tide gate/surge barrier as proposed is installed. This impact is considered minor and not significant. During construction of all project features, there will be temporary, minor increases in turbidity, these changes to water quality are not significant. NNBF will cause a minor, permanent benefit to local water quality by stabilizing the shoreline, and by the oysters on the reefs, which will actively filter local waters and improve water quality directly.

Area 4: Elizabeth River Eastern Branch (Newton's Creek/Tidewater Drive, Ohio Creek, Broad Creek, Berkeley, Campostella

A length of the Eastern Branch of the Elizabeth River in this area will be protected by a floodwall and berm system. Expected impacts will be similar to other areas with similar structures, temporary and minor increases in turbidity due to construction where it impacts shallow open waters of the River. These impacts are not significant. A surge barrier with tide gate and pump station is proposed for Broad Creek. Water quality modeling was done to assess potential impacts of surge barrier with tide gate construction at this site (Moffat & Nichol 2017). A six and two gate option were considered. For both of these cases, and all subsequent pre-storm surge closure modeling, all gates are open. Broad Creek's flushing time without project was estimated at 22.2 days, 22.3 days for the six gate option, and 21.7 days for the two gate option. These impacts are considered minor and not significant. Salinity throughout Broad Creek was assessed, the average over the entire tidal creek embayment is 5.4 ppt without project, 5.2 ppt for the six gate option and 6.2 ppt for the two gate option. Upper bay salinities, which are more

likely to vary due to restrictions further downriver, were also assessed and were found to be 1.6 ppt without project, 1.5 with the six gate alternative and 2.8 ppt with the two gate alternative. In all cases, waters in the upper reaches remained oligohaline, while downstream waters near the mouth remained at the low end of mesohaline (5 to < 18 ppt). As salinity changes did not result in any large change in salinity, these changes are considered minor and not significant. Gate closure effects during a storm event were also modeled. Changes in salinity were minor and not significant in the lower and middle reaches of Broad Creek. In the upper reaches, however, salinity declines to 0 for approximately four days during a five-day closure event. However, this area is oligohaline and average salinities (Moffatt & Nichol 2017) fluctuate between near 0 and 5 ppt on a daily basis with the tides. It is not expected that this decline will result in significant impacts, as this salinity is already regularly encountered in this region. As a result, impacts are expected to be minor and not significant to water quality in Broad Creek by constructing either the six or two gate surge barrier. During construction of all project features, there will be temporary, minor increases in turbidity, these changes to water quality are not significant. NNBF in the vicinity of Broad Creek will cause a minor, permanent benefit to local water quality by stabilizing the shoreline, and by the oysters on the reefs, which will actively filter local waters and improve water quality directly.

11.5.3 Alternative 3: Nonstructural Alternative

None of these measures would be constructed in the local waters in the project ROI in any of the four areas. Impacts to stormwater are anticipated to be negligible since there should not be an appreciable increase in impervious surface area from nonstructural measures.

11.5.4 Alternative 4d: Recommended Plan

Due to the fact that this is a combination of Alternative 2a and 3, impacts will be similar to those of Alternative 2a as Alternative 3 does not affect the local ROI water quality. As described above, the nonstructural measures effects of Alternative 3 are negligible, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

11.5.5 Summary

Project features that are in-water will result in temporary and minor impacts to local water quality due to higher levels of turbidity due to construction activities. Post-construction, turbidity should return to normal. A series of water quality models were conducted where any surge barrier was proposed, with the exception of The Hague. The Hague was surveyed for fauna and due to the low levels of biota found and high levels of human impact to The Hague since development in the City began, only preliminary work to assess hydraulics and water quality was done. In most cases, impacts were minor and not significant. The exception was the upper reaches of Pretty Lake, which experience a large salinity shift (from polyhaline to fresh) salinity during a storm and associated gate closure. This impact is considered minor but significant. Due to the need to fully assess the impacts of the proposed structures, as well as to monitor compensatory mitigation sites throughout the project ROI, the USACE and City of Norfolk will be monitoring water quality as the project is constructed and post-construction. During PED, the USACE intends to conduct additional water quality monitoring to fully assess impacts to areas that include Pretty Lake, Broad Creek and possibly The Hague, where only limited modeling has been done at this time. Any differences between model projections and recorded data

significant enough to change any of our findings at this time will be addressed in the future.

11.5.6 Cumulative Effects

There are multiple past, present and reasonably foreseeable future projects within the overall Study Area. The City plans a number of actions to re-develop portions of the City, focusing on areas that are higher ground (Norfolk Vision 2100).

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects, including changes to the navigation channels in the Elizabeth River that are outside the proposed project scope. With implementation of the No Action/Future Without Project Alternative, impacts are minor, permanent and adverse (climate change and associated sea level rise) to local water quality. The salinity changes may allow higher-salinity preferring predatory species to penetrate further into the Elizabeth River, exposing more of the benthic community to a wider suite of predators, while limited freshwater species to smaller areas further upriver than at present. DO levels are expected to decline significantly (approximately 30%) in the upper reaches of the Lafayette River due to climate change by year 2076. Although this is a significant drop, DO levels still remain for both surface and bottom waters above 5 mg/L, a safe level for all estuarine life. Therefore, the impact of climate change on DO in the Lafayette is considered adverse, but minor and permanent. Modeling has indicated that the proposed surge barriers with tidal gates also exert a small impact on DO, generally decreasing it slightly (< 5% throughout the River, but increasing it in the upper reaches where the decline due to climate change is greatest, somewhat compensating for climate change impacts to DO in the upper reaches and would be a small, positive benefit on DO. The difference between the Future Without Project and placing surge barriers with tidal gates resulted in minor, insignificant impacts to other water quality parameters in the Lafayette River (algae, N, P) (VIMS 2017). For all modeled waterbodies (Pretty Lake, Broad Creek, and the Lafayette River) minor changes in flushing times and salinities were noted in the Future Without Project Condition (Moffatt and Nichol 2017; Shen et al. 2017). In general flushing times declined by approximately one day, and salinities in general increased by approximately 1 ppt. These changes are considered minor but permanent.

11.6 FLOODPLAINS

11.6.1 No Action Alternative/Future Without Project

Alternative 1, the No Action/Future Without Project Alternative, would involve no action from USACE to mitigate against coastal storm risk. Existing coastal storm risk management features by the City would continue to be maintained.

The City would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed; enforcement of recent zoning code to support resilience; and implementation of an additional three feet of required elevation, above the effective FEMA Base Flood Elevation (BFE), for structures located within the 1% annual chance floodplain (100 year) and 18 inch freeboard above grade required in the 0.2% annual chance floodplain (500 year) floodplain.

The City is nearly built out at 95%, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's plan Norfolk 2030 Comprehensive Plan would be assumed to remain implemented. Also, the City's "The Plan for Restoring the Lafayette River", with partners the Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

As a Federal project, the Downtown Norfolk Floodwall should continue to provide flood protection, with continued operation and maintenance by the City. Completed in 1971 and closely reaching a 50 year design life, the project provides protection from the FEMA 1% annual chance flood. FEMA updated the City's Flood Insurance Study in 2017, with new and updated 1% annual chance flood BFE (stillwater and wave runup). The floodwall project is currently certified and accredited by FEMA. Facing RSLR, the City is currently analyzing the floodwall and any future improvements to assure the floodwall will maintain the required certificate and accreditation by FEMA. As the local Sponsor for a Federal project, the City is responsible for operations and maintenance of the floodwall, in coordination with the USACE. Because the FEMA 1% annual chance floodplain is based on existing conditions, the City is also evaluating the flood protection system for future sea level rise and wave conditions.

When a floodwall or levee project is certified and accredited by FEMA, the land area and structures on the protected side are removed from the FEMA 1% annual chance floodplain and flood insurance is not required by FEMA, although a lender could still require it. Also, by removing the protected area out of the FEMA 1% annual chance floodplain, floodplain construction regulations are not required. However, a flood protection system can fail or be overtopped and/or flood from interior drainage, thus becoming an adverse and significant impact to the public. When failure, overtopping, and/or flooding from interior drainage occurs, the flooding situation/damages can be worse than if the flood protection system were not in place. Although the impacts to the community may be considered temporary, it could take several years for recovery, individually and for the City, especially if citizens do not have flood insurance. Through outreach and education, the City can inform citizens about the possible residual risks and the need to purchase flood insurance. For those that are located outside the 1% annual chance floodplain, where flood insurance is not required, FEMA offers low-cost flood insurance to owners and tenants of eligible residential and non-residential buildings, called a Preferred Risk Policy. Similarly, the City can also consider having floodplain construction regulations in place on the "protected" side for new development and substantial damage or improvements for existing structures (explained further below).

Although not a certified flood protection system by FEMA, the City has conducted evaluations for the existing tide gate at Mason Creek for various flood scenarios, looking at tidal and rainfall conditions for existing conditions and sea level rise. A 2014 cost/benefit analysis showed nonstructural measures may be best for the Mason Creek area and/or with a pump for interior flooding from rainfall. The City can use public outreach and education to inform citizens about residual risks and the need to purchase flood insurance if they do not currently have it and reside in the FEMA 1% annual chance floodplain.

Also a Federal project completed in May 2017, the Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project was a joint effort, where USACE re-established a beach berm to an existing dune system that is maintained by the City. Although not a certified flood protection system by FEMA, the beach berm and dune system will continue to provide some flood protection, with continued operation and maintenance by the City and necessary nourishments. Over time, the system will possibly need to adjust to sea level rise and climate change by increasing the dune and beach berm size. The City can use public outreach and education to inform its citizens about the need to purchase flood insurance if they do not currently have it and reside in the FEMA 1% annual chance floodplain.

For residential and commercial development, to address uncertainty and future conditions, the City does have freeboard regulations in place for new construction, existing structures substantially damaged from a flood, and existing structures with substantial improvements made, where the regulatory or design flood elevation is three feet above the FEMA 1% annual chance flood BFE. For FEMA coastal AE zones with wave action, the City requires the same construction standards as for coastal high hazard VE zones. For development in the FEMA 0.2% annual chance floodplain, the City requires development to have a finished floor or be flood proofed 18 inches above grade. These actions are beneficial and will help lower flood insurance premiums and reduce flood damage.

The City has completed several natural and nature based projects, such as wetlands and living shorelines, which are beneficial and may provide some protection or lessen the intensity or severity of a storm event. These types of projects are also environmentally friendly as they may provide habitat and improve water quality.

Without implementation of an Action Alternative, it is expected that existing structures within the City, those that are not protected by a certified and accredited flood protection system or have been elevated with three feet of freeboard above the FEMA BFE, will continue to be at risk to flooding or could become more at risk due to sea level rise and climate change. It is well documented that local sea level rise and land subsidence are contributing to nuisance type flooding Norfolk is now experiencing, where the potential impacts from tidal and/or rainfall flooding will likely increase and worsen over time. In addition, it is suggested by the international science community that global climate change is or may be causing more intense and frequent storm events. Four recent weather events provide good examples, with new meteorological records set in several states, including Louisiana in August 2016 with the remnants of a tropical depression (rainfall), Virginia and North Carolina in October 2016 with Hurricane Mathew (rainfall), and this year in 2017, Texas and Louisiana with Hurricane Harvey (rainfall) and Florida with Hurricane Irma (storm surge, rainfall, and wind speed). Major storm events can bring long term impacts that can affect the economic, social, cultural, and/or environmental well-being of a community and its citizens, where it could take several years for full recovery.

11.6.2 Alternatives 2a, 3, and 4d

Alternative 2a, the Structural Alternative, provides structural coastal storm risk management through the use of a storm surge barrier system at four locations within the City: Broad Creek, Ghent/Downtown/Harbor Park, Lafayette River, and Pretty Lake. This plan would reduce flood

risk only to areas that are located behind the flood protection system. The system would typically include the storm surge barrier, tide gates, closures, berms, floodwalls, and/or pump station. Along with structural barriers, drainage improvements and flap gates on outfalls have also been included in Alternative 2a. This alternative includes natural and nature based features, where living shorelines with rock toes with subtidal oyster reefs are being considered in connection with barriers, tidal gates, and berms where applicable.

Alternative 3, the Nonstructural Alternative, looks only at nonstructural measures for 22 locations within the City. Nonstructural measures include elevation, basement fill, flood proofing, basement fill plus flood proofing, basement fill plus elevation, and acquisition. Over 11,500 structures were identified for nonstructural measures, including approximately 9,000 residential, 2,500 commercial, and 1,900 designated as historic. Most residential structures were identified for elevation (4,900), basement fill (2,200), basement fill plus elevation (1,400), and acquisition (600). Most commercial structures were identified flood proofing (2,400). Most historic structures were identified for basement fill (900), basement fill plus elevation (400), elevation (300), and floodproofing (200).

Alternative 4d, the Combination Structural and Nonstructural Alternative, incorporates both structural and nonstructural measures at 16 locations within the City. Four of the locations include the storm surge barriers in Alternative 2a and nonstructural measures, the remainder are for nonstructural measures only. Almost 1,900 structures were identified for nonstructural measures, including approximately 1,100 residential, 800 commercial, and 100 designated as historic. Most residential structures were identified for elevation (700), basement fill (200), basement fill plus elevation (100), and acquisition (100). Most commercial structures were identified for flood proofing (780). Most historic structures were identified for floodproofing (30), basement fill (30), and acquisition (30). This alternative includes natural and nature based features, where living shorelines with rock toes with subtidal oyster reefs are being considered in connection with all barriers, tidal gates, and berms where applicable.

In alignment with EO 11988, the following is a general discussion of the Alternatives collectively for potential impacts with respect to structural measures, nonstructural measures, and natural and nature based features.

11.6.3 Structural Measures

Structural coastal storm risk management projects, such as the storm surge barrier systems in Alternatives 2a and 4d, are typically large scale projects that protect a large number of structures, which is a beneficial and significant impact. The high cost usually reflects the size and complexity of the system, including the storm surge barrier, tide gates, road closures, number of pumps needed for interior drainage, real estate needs for berms, floodwalls, and closures, easements, and right-of-ways, engineering and design, etc. After a community experiences several flood events, the damages prevented can easily justify the costs for such a project. If properly inspected, maintained, and operated, the flood protection system can last and function as designed during its period of analysis.

However, as noted above with the Downtown Norfolk Floodwall, flood protection systems can fail, be overtopped, and/or flood due to interior drainage, which would be an adverse and significant impact to those on the protected side. In these possible flood scenarios, rather than

having minor damage, there could be significant damage within the protected area. Although a temporary impact, recovery could take several years for an individual and the community, especially if citizens do not have flood insurance. In addition to having flood insurance and floodplain regulations in place for new development and substantially damaged or improved structures within the protected area, other things to consider which could influence the severity of the impacts, include outreach and education to citizens on the need for evacuation of the protected area and removing or elevating valued items in advance of a storm event; locating critical structures outside the protected area in case of flooding; and preventing unwise development within the protected area that may aggravate interior flooding due to rainfall.

The City is approximately 95% developed. Impacts to the environment and floodplain areas, including wetlands, upland areas, natural drainage features, utilities, existing structures, etc. will generally be within the footprint of the line of protection. The associated impacts are not considered adverse and will be temporary and negligible/minor in severity. As part of the project, all temporary wetland impacts will be restored to pre-existing condition, and all permanent impacts will be mitigated. For upland areas, the non-Federal Sponsor will be required to acquire lands, easements, and right-of-ways needed for construction. Some property owners may not want sell their property, or upset that their views are obstructed. Road closures during annual inspections could disrupt travel plans for citizens or emergency personnel. Impacts to natural drainage and utilities will be temporary and accounted for during design and construction.

The USACE required Floodplain Management Plan should address the City's outreach and education plan for communicating residual flood risks to its citizens, which is a beneficial and significant component of the flood protection system, and the City's ability to be resilient and sustainable from a storm event. For the protected side, this could include the need to have flood insurance; requiring new structures or substantially damaged or improved structures to be constructed according to existing floodplain ordinances; inventorying the number of people and structures within the floodplain if the flood protection system did fail, was overtopped, and/or from flooded from interior drainage; community and citizen Emergency Action Plans that address flood warning, response, and evacuation; unwise and future development, etc.

11.6.4 Nonstructural Measures

Where a structural flood protection system can protect a large number of structures, nonstructural measures usually apply to one or a few structures. Usually the intent is not only flood protection, but also reducing the cost or eliminating the need for flood insurance.

Nonstructural projects are small in scale, such that any adverse environmental and/or floodplain impacts would be considered temporary and negligible. Any property that becomes permanent open space due to acquisition or relocation will be a beneficial aspect of the project, usually targeted for repetitive loss structures, where flood damage will never occur and the open space can be used for an acceptable use in a floodplain. However, a large number of acquisitions could possibly affect the City's tax base to some degree, which could be an economic adverse impact to the City.

As with structural measures, the City can inform citizens on the need to evacuate in the event of

a flood, to protect themselves and not to put first responders in danger as well.

Nonstructural measures will help reduce flood insurance premiums and keep neighborhoods and communities sustainable and resilient after a flood, which is a beneficial and significant impact to those living and working in a floodplain and to the City. FEMA recognizes elevation, basement fill, acquisition, and relocation in reducing the cost or eliminating the need for flood insurance for residential and commercial structures. For commercial structures only, flood proofing is recognized by FEMA, where a flood proofed building has been designed and constructed to be watertight. Depending on the nonstructural method used and level of protection, a residential or commercial structure could possibly stay flood-free during its design life. An advantage of nonstructural measures when compared to structural measures is the ability of nonstructural measures to be sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement.

If an existing structure does not meet FEMA's regulations, if substantially damaged in any way or the structure has been substantially improved, as may apply with a nonstructural measure, then the structure will need to be brought into compliance with FEMA's and the City's floodplain regulations. Being more restrictive than NFIP minimum requirements, the City requires an additional three feet of required elevation above the effective FEMA BFE for structures within the FEMA 1% annual chance floodplain (100 year) and 18 inches of freeboard above grade for structures within the 0.2% annual chance floodplain (500 year). For the Norfolk project, the design flood elevation is the NACCS 3% annual chance stillwater flood elevation plus sea level rise to the year 2076, which is generally equal to the FEMA 1% annual chance flood plus three feet of freeboard.

As defined by FEMA, a Substantially Damaged Building is a building that has incurred damage of any origin whereby the cost of restoring the building to its pre-damaged condition would equal or exceed 50% of the market value of the building before the damage occurred.

A Substantially Improved Building is a building that has undergone reconstruction, rehabilitation, addition, or other improvement, the cost of which equals or exceeds 50% of the market value of the building before the "start of construction" of the improvement. This term does not include a building that has undergone reconstruction, rehabilitation, addition, or other improvement related to:

1. Any project or improvement of a building to correct existing violations of a State or local health, sanitary, or safety code specifications that have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions; or
2. Any alteration of a "historic building", provided that the alteration will not preclude the structure's continued designation as a "historic building".

Designated historical structures can use any type of nonstructural measure to reduce flood damage, as long as it maintains its historical status, including being exempt from FEMA's Substantial Improvement and Damage regulations. However, the structure is still rated for flood insurance according to its lowest rated floor elevation. If the structure loses its historical status, then it will have to comply with FEMA and City floodplain regulations.

Elevation – for the Norfolk study, elevation is only applied to residential structures. FEMA recognizes elevation as a way to reduce flood insurance premiums. If a structure is located within the FEMA 1% annual chance floodplain, in general, the higher the lowest rated floor is above the 1% chance flood elevation, the cheaper the flood insurance will be.

Basement Fill – for the Norfolk study, basement fill is being applied to residential and commercial structures. For structures with basements, the basement floor is used as the lowest floor for rating the structure for flood insurance premiums. FEMA recognizes basement fill as a way to reduce flood insurance premiums. By filling the basement with fill material/sand, the next higher floor will be rated, which results in a cost savings. The lost square footage can be made up by adding an addition and utilities may need to be moved.

Acquisition – for the Norfolk study, acquisition is being applied to residential and commercial structures. By purchasing property and demolishing or relocating a structure, the need for flood insurance is permanently eliminated. FEMA recognizes acquisition as a way to reduce flood insurance premiums. The community agrees to never develop the property, except for acceptable uses within a floodplain.

Flood Proofing - A flood proofed building has been designed and constructed to be watertight, substantially impermeable to floodwaters, up to a recommended depth of three feet for conventional built structures. Closure panels are used at openings and a sump pump and drain system installed.

As noted previously, the USACE required Floodplain Management Plan should address the City's outreach and education plan for communicating residual flood risks to its citizens.

11.6.5 Natural and Nature Based Features

Both Alternatives 2a and 4d consists of the same structural measures and both alternatives have living shorelines with rock toes with subtidal oyster reefs being considered in connection with all barriers, tidal gates, and berms where applicable.

Living shorelines are a relatively new approach for addressing shoreline erosion and protecting marsh areas. Unlike traditional structures such as bulkheads or seawalls that worsen erosion, living shorelines incorporate as many natural elements as possible which create more effective buffers in absorbing wave energy and protecting against shoreline erosion. The process of creating a living shoreline is referred to as soft engineering, which utilizes techniques that incorporate ecological principals in shoreline stabilization. The natural materials used in the construction of living shorelines create and maintain valuable habitats. Structural and organic materials commonly used in the construction of living shorelines include sand, wetlands plants, sand fill, oyster reefs, submerged aquatic vegetation, stones and coir fiber logs.

Natural and nature based features provide beneficial impacts in many ways, such as reducing flood impacts, valuable habitat, recreational areas, urban landscape diversity, etc. These types of features can be long lasting or temporary as necessary. While the measures will not significantly reduce flood risks during major storms, they may make a difference for small and localized flood events.

11.7 WETLANDS AND MUDFLATS

11.7.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk.

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue as a result of burning of fossil fuels and deforestation in the ROI over the next 50 years. The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed (reference Figure 9-3, “EB-6”). The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. Routine bank stabilization projects on public and private property would continue; some of them affecting vegetated wetlands. The City’s plan Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City’s comprehensive plan, “The Plan for Restoring The Lafayette River”, with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would continue to be implemented.

The USACE would continue maintenance of Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project into the future. USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion (CIEE), to the west of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564, and a new parallel Hampton Roads Bridge Tunnel from Area 1 to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

In addition to these actions, USACE is also aware of many existing and proposed living

shorelines consisting of both vegetated wetlands and oyster reefs, within the City, and many of which are being, or will be, constructed by the City of Norfolk.

Although those projects will not impact wetlands directly, additional development could increase impacts to wetlands along the shorelines or further inland, or to riparian vegetation. Wetlands along shorelines may be permanently filled or converted to create new docking facilities and/or shoreline stabilization measures. Continued development, shipping and navigation operations, and stormwater discharges will also continue to impact wetlands and vegetation within the ROI through boat wake erosion and nutrient inputs. Also, additional development including construction of the Third Crossing of the Hampton Roads Harbor and expansion of the Chesapeake Bay Bridge Tunnel is planned in the future.

Predicted climate change impacts such as increased sea level rise, have the potential to cause changes in the nature and character of the wetlands in the ROI. In general, wetlands both inside and outside of ROI as are at increased risk of damage and loss from potential increases in sea level rise. Wetlands may erode further, or be at increased risk of becoming too inundated to support vegetation. Eventually, sea level rise may cause estuarine and freshwater wetlands to retreat inland.

For all modeled waterbodies (Pretty Lake, Broad Creek, and the Lafayette River), minor changes in flushing times and salinities were noted in the Future Without Project Condition (Moffatt and Nichol 2017; VIMS 2017). In general, flushing times declined by approximately one day, and salinities in general increased by approximately 1 ppt. These salinity changes can generally be tolerated by native tidal wetland vegetation species, which are adapted to a brackish environment. *Phragmites australis* (common reed), a nuisance species, is the least tolerant of the species in the ROI; therefore, increases in salinity could cause it to retreat inland and/or die off.

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects, including changes outside the proposed project scope.

11.7.2 Alternative 2a: Structural Only Alternative

For this and all build alternatives, all of the existing ongoing projects and initiatives described under the No Action Alternative, as well as climate change and sea level rise, would be assumed to occur. The natural and nature-based features described for each Area earlier in this report would also apply to this alternative.

It should be noted that at this early stage, a wetland delineation has not been conducted. Instead, wetlands were spot-checked in the field if publically accessible. Aerial maps and National Wetland Inventory (NWI) maps were also checked to determine an estimate. As project plans and impact areas are finalized later in the study, a wetland delineation will be undertaken pursuant to the 1987 Wetland Delineation Manual and the Atlantic and Gulf Coast Regional Supplement, to ascertain the actual footprint of jurisdictional wetlands impacted by the project. This will be done in the PED phase. Until that time, and until the project is further designed, the wetland impacts can merely be estimated and preliminary, based on existing information, as described under "Methodology."

Area 1: Willoughby and Oceanview Beaches, Pretty Lake, Little Creek, and Fisherman's Cove

There will be direct impacts to wetlands for the installation of the storm surge barrier, floodwalls, and generator building. It is estimated that approximately 0.03 acres of tidal scrub/shrub and 0.20 acres of tidal emergent wetlands would be directly and permanently impacted at that location. Additional temporary fills will also be necessary for construction access; they will be determined during the PED phase.

Natural and nature based features, where compatible, may be implemented to the inside or outside of the proposed storm surge barrier. These could help offset wetland impacts and help to improve water quality and prevent erosion at this location.

Hydrodynamic and water quality modelling was performed by Moffat Nichol (2017), to address the potential temporary or permanent indirect effects to wetlands in the Pretty Lake watershed as a result of the proposed surge barriers and associated tide gates across the mouth of Pretty Lake. Moffatt & Nichol (2017) found that the proposed structures will influence water quality. Minor, negligible changes in salinity, from 22.6 ppt without project to 22.6 ppt with project, and tidally averaged freshwater age, from 13.9 days without project to 13.6 days with project under normal operating conditions (tide gate is open) post construction. Flushing times for Pretty Lake waters are slightly reduced, from 8.7 days without project and 7.8 days with project. These impacts are considered minor and not significant.

Modeling was also conducted to assess potential impacts caused by a closure during a storm event. A gate closure of five days was examined, and indicated that a decrease in salinity will occur due to the closure, as freshwater input from the hurricane is unable to flow out of Pretty Lake while no additional high-salinity water from the Bay mainstem will be able to enter Pretty Lake due to the gate closure to prevent storm surge flooding. Overall, tracer modeling indicates that after a closure event due to a late-summer hurricane, it will take approximately 25 days for salinity in Pretty Lake to return to normal. In approximately the upper 1/5th of the headwaters of Pretty Lake, salinity will decline to almost 0 ppt for approximately three days post-storm. Normal salinity in this reach of Pretty Lake is polyhaline (between 18 and 30 ppt), a decline to near zero for several days is a significant impact, compared to a decline to approximately 7.5 ppt for a single day. Further downstream, salinity also drops due to a storm-induced gate closure, but the drop is not as low, to approximately 10 ppt from the low 20s in the second most upstream segment, and only dropping approximately 2-3 ppt in the lowermost 3/5 of Pretty Lake's waters.

In general, the salinity shifts caused by gate closures, both prior to the design storm event and for periodic maintenance, would be temporary in nature. It is unlikely but possible that these temporary shifts would cause mortality or a corresponding shift in vegetation, because while tidal species are adapted for a brackish water environment, they are also tolerant of freshwater conditions. *Phragmites* reed communities, conversely, are generally salt tolerant up to salinities of 10 ppt for germination and up to 18 ppt vegetatively. However, we anticipate that temporary decreases in salinity due to gate closures would not occur for long enough periods of time to allow the spread of *Phragmites* into existing *Spartina alterniflora* marshes in the Pretty Lake watershed. Therefore, the impacts below the uppermost segment on salinity are considered

minor and not significant.

No wetland impacts would occur within Lake Whitehurst or along the Chesapeake Bay, as no fill or structures are proposed there.

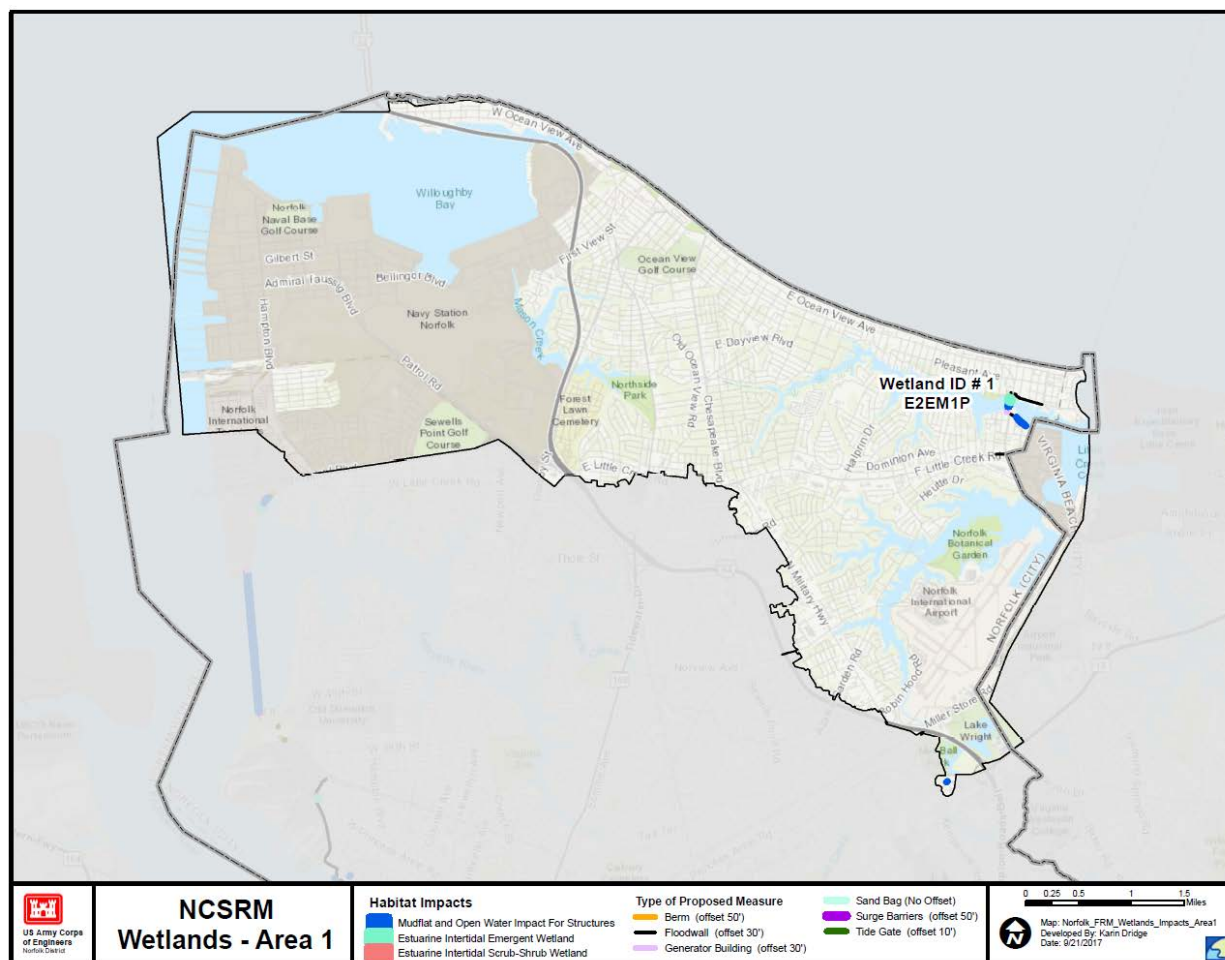


Figure 11-6. Wetlands -- Area 1

Area 2: Lafayette River watershed

There will be no direct short-term or long-term direct impacts on wetlands for the construction of the storm surge barrier at the mouth of the Lafayette River; the entire structure will cross subaqueous bottom. In addition, natural and nature based features, where compatible, may be implemented to the inside or outside of the proposed storm surge barrier. These could help to improve water quality and prevent erosion at this location.

An earthen berm is also proposed adjacent to NIT on the northern bank of the Lafayette River. This berm will be approximately 1,800 feet in length, and will impact approximately 0.2 acres of tidal emergent wetlands.

To address the potential short-term and long-term effects to wetlands in the Lafayette watershed from proposed surge barriers and associated tide gates across the mouth of the Lafayette River, water quality modelling was performed by the Virginia Institute of Marine Science (VIMS, 2017). Various parameters were assessed, including chlA (Chlorophyll A, a

measure of the amount of phytoplankton which can also be a proxy for the amount of eutrophication present, if any), N (Nitrogen), P (Phosphorus), DO (Dissolved Oxygen), tidal action, temperature and salinity. Due to the size of the surge barrier, two configurations were modeled, one with 19 gate openings and one with 10 gate openings.

The results of this modelling are discussed more fully in the Water Quality, Hydrology and Hydraulics, and Bathymetry sections of this document. Overall, changes seen to Algae, N, and P were minor and not significant, and should not impact the flora or fauna in the Lafayette River significantly when the 19 gates are open. Under the 10-gate scenario, similar changes were noted for algae, N, and P, with algae showing a decline of approximately 2 ug/L during the summer with a concomitant increase of roughly 0.2 mg/L N and little change noted for P. These impacts were considered minor and not significant. Salinity changes were noted during gate closures (see H&H and Bathymetry section of this EIS for details). These changes were several ppt, and not great enough to induce plant mortality or result in vegetative community shifts. Salinity levels fluctuate for several days after the gates re-open as salinity levels return to pre-closure conditions.

We anticipate that temporary decreases in salinity due to gate closures will not occur for long enough periods of time to allow the spread of *Phragmites* into existing *Spartina alterniflora* marshes in the Lafayette River watershed. The estuarine wetland species typically found in the Lafayette River can endure such fluctuations, so these impacts are temporary, minor and not significant.

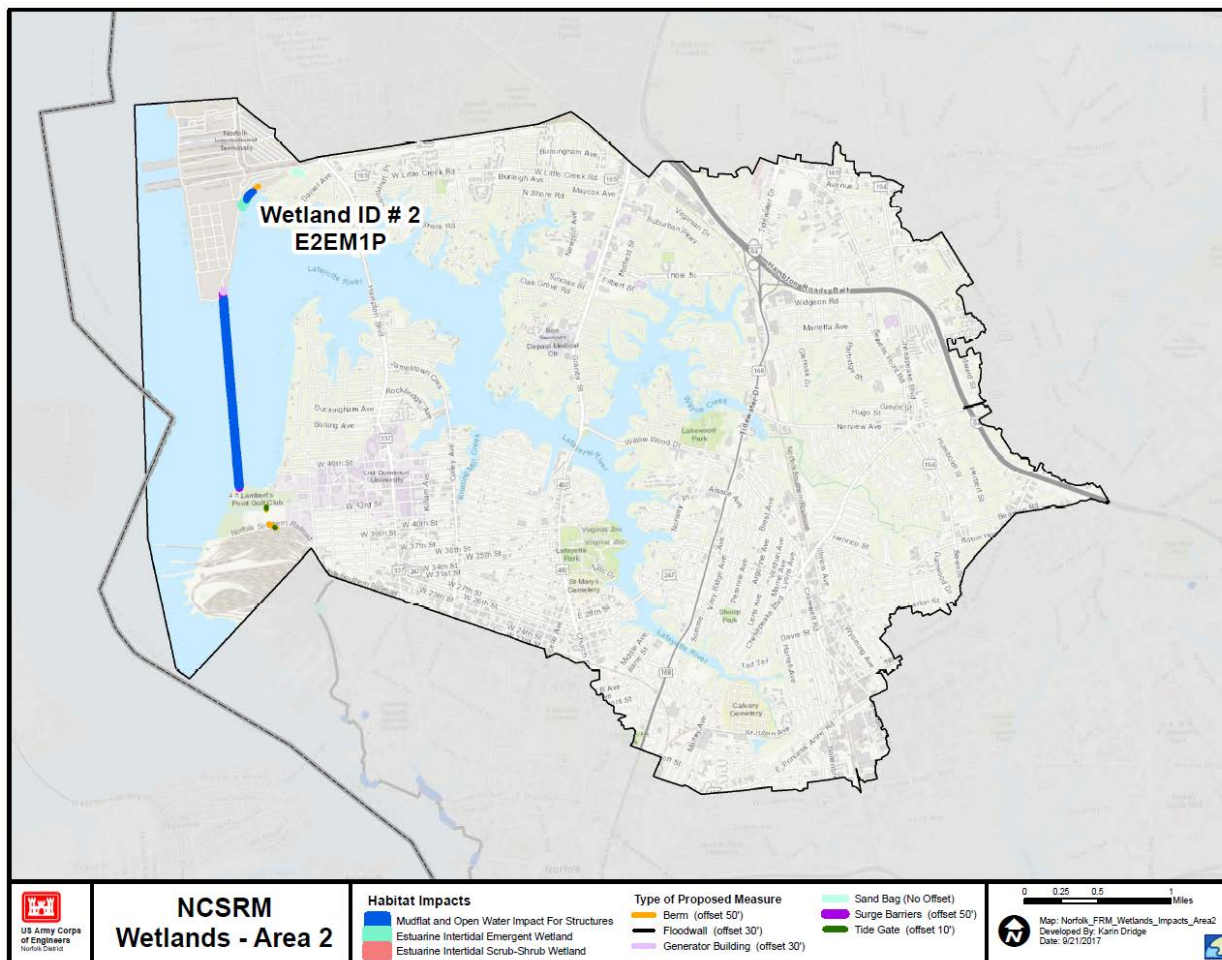


Figure 11-7. Wetlands -- Area 2

Area 3: Elizabeth River, The Hague, Eastern Branch of the Elizabeth River

In this Area, the only vegetated wetland impact would occur in the wetland community at Lamberts Creek. The floodwall alignment will begin along the Lamberts Point rail lines, abutting them and passing through wetland inlet. Approximately 0.075 acres of direct, permanent impact fill in emergent wetlands will occur there. Additional short-term fills will also be necessary for construction access; there will be determined during the PED phase. A tide sluice gate proposed will be placed in the inlet pipe and will only be closed temporarily, during the design storm event, and for periodic maintenance testing. However, as described above, these temporary closures are not expected to have more than a minor impact on the wetland community.

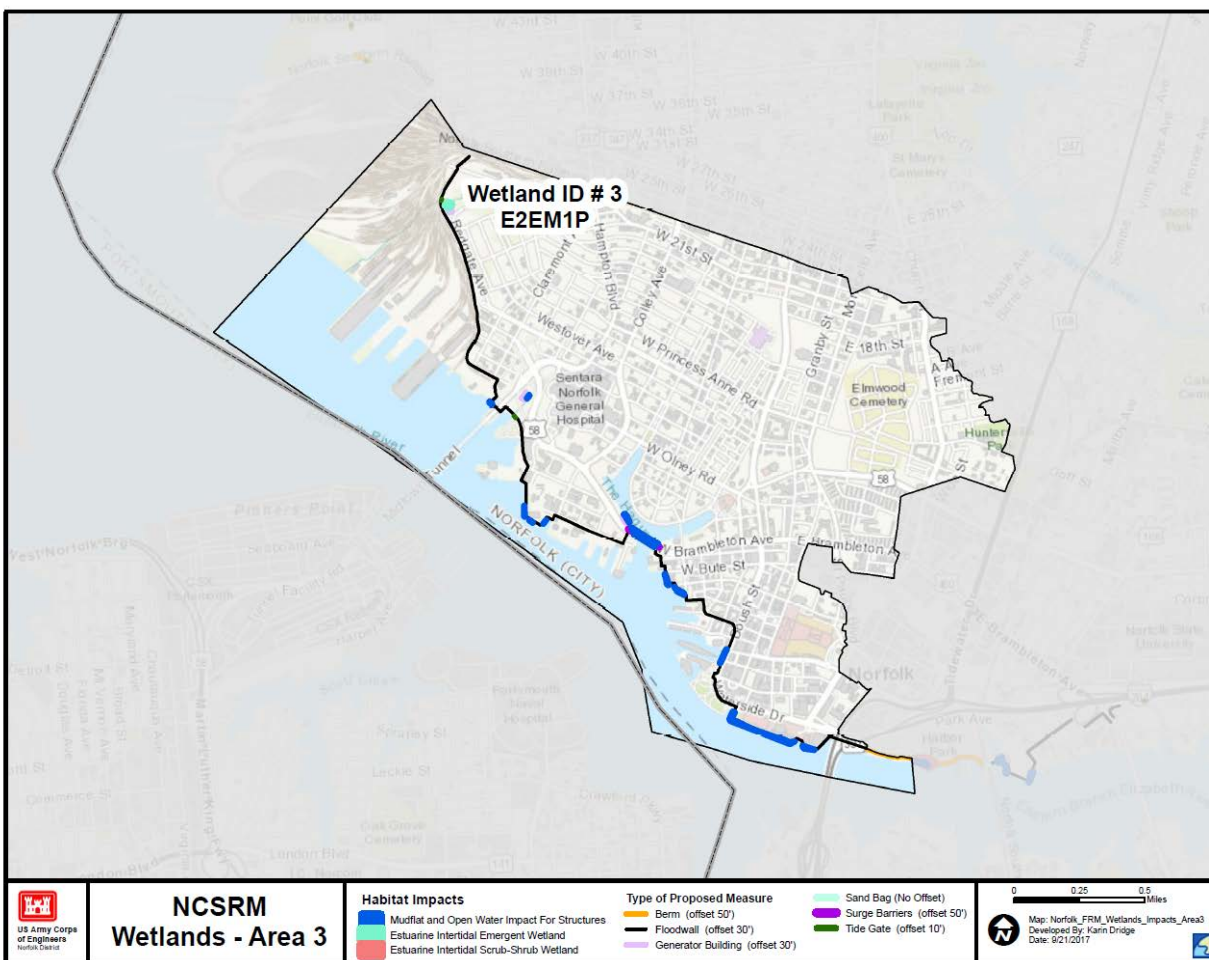


Figure 11-8. Wetlands – Area 3

Area 4: Eastern Branch of the Elizabeth River, Broad Bay

This Area will have multiple wetland impact locations. Approximately 0.59 acres of tidal scrub/shrub wetlands will be permanently impacted by the construction of a berm around Harbor Park. Additional short-term fills may also be necessary for construction access; these will be determined during the PED phase.

Immediately east of Harbor Park, a tide sluice gate will be installed in a tidal canal that contains emergent wetlands. Approximately 0.05 acres of direct, permanent impact fill in emergent wetlands may occur there. Additional short-term fills may also be necessary for construction access; there will be determined during the PED phase. The tide sluice gate proposed will be placed in the inlet pipe and will only be closed temporarily, during the design storm event, and during periodic maintenance testing. However, as described above, these temporary closures are not expected to have more than a minor impact on the wetland community.

The largest direct and permanent wetland impact of the project is parallel to the Tide rail line, along the Eastern Branch of the Elizabeth River. There will be a direct, permanent impact to approximately 0.51 acres of tidal emergent wetland, and 0.606 acres of tidal scrub/shrub wetland for the installation of the floodwall. Further to the east, at the mouth of Broad Creek, there will be a direct permanent fill of approximately 0.02 acres of tidal emergent wetlands for

the installation of the storm surge barrier. Additional temporary fills will also be necessary at both locations for construction access; there will be determined during the PED phase.

Natural and nature based features, where compatible, may be implemented to the inside or outside of the proposed storm surge barrier and along the floodwalls along the Eastern Branch of the Elizabeth River and in the vicinity of Broad Creek. These could help offset wetland impacts and help to improve water quality and prevent erosion at this location.

Hydrodynamic and water quality modelling was performed by Moffatt Nichol (2017), to address the potential short-term or long-term effects to wetlands in Broad Creek watershed from proposed surge barriers and associated tide gates across the mouth of Broad Creek. A two- and six-gate option were considered. For both of these cases, and all subsequent pre-storm surge closure modeling, all gates are open. Broad Creek's flushing time without project was estimated at 22.2 days, 22.3 days for the six gate option, and 21.7 days for the two gate option. These impacts are considered minor and not significant. Salinity throughout Broad Creek was assessed, the average over the entire tidal creek embayment is 5.4 ppt without project, 5.2 ppt for the six gate option and 6.2 ppt for the two gate option. Upper bay salinities, which are more likely to vary due to restrictions further downriver, were also assessed and were found to be 1.6 ppt without project, 1.5 with the six gate alternative and 2.8 ppt with the two gate alternative. In all cases, waters in the upper reaches remained oligohaline, while downstream waters near the mouth remained at the low end of mesohaline (5 to < 18 ppt). As salinity changes were not large, these changes are considered minor and not significant.

Gate closure effects during a storm event were also modeled. Changes in salinity were minor and not significant in the lower and middle reaches of Broad Creek. In the upper reaches, however, salinity declines to 0 for approximately four days during a closure event. However, this area is oligohaline and average salinities (Moffatt & Nichol 2017) fluctuate between near 0 and 5 ppt on a daily basis with the tides. It is not expected that this decline will result in significant impacts, as this salinity is already regularly encountered in this region. As a result, impacts are expected to be minor and not significant to water quality and wetlands in Broad Creek by constructing either the six or two gate surge barrier.

Based on the foregoing, negligible to minor indirect adverse effects are anticipated for the wetlands in Broad Creek watershed, as a result of construction and operation of the storm surge barrier.

Any of these build alternatives (2a, 3, and 4d) would require compliance with the environmental laws applicable to land use in coastal areas. This alternative would require permits pursuant to the Rivers and Harbors Act and the Clean Water Act (for any temporary or permanent impacts to waters of the U.S. including wetlands), and the VPDES (for temporary and permanent construction discharges); and a Virginia Marine Resources Commission permit for encroachment on state-owned bottom. The project must also adhere to the CZMA, the CBPA, and applicable local requirements land use regulations.

All short-term wetland impacts would be restored to preexisting conditions; and all permanent impacts will be mitigated as per the conceptual mitigation plan in this report. Temporary and permanent wetland impact acreages as will the mitigation plan will be finalized, upon completion

of a wetland delineation for the project and a design level adequate to determine the project footprint. The preliminary wetland mitigation plan is in the Environmental Appendix.

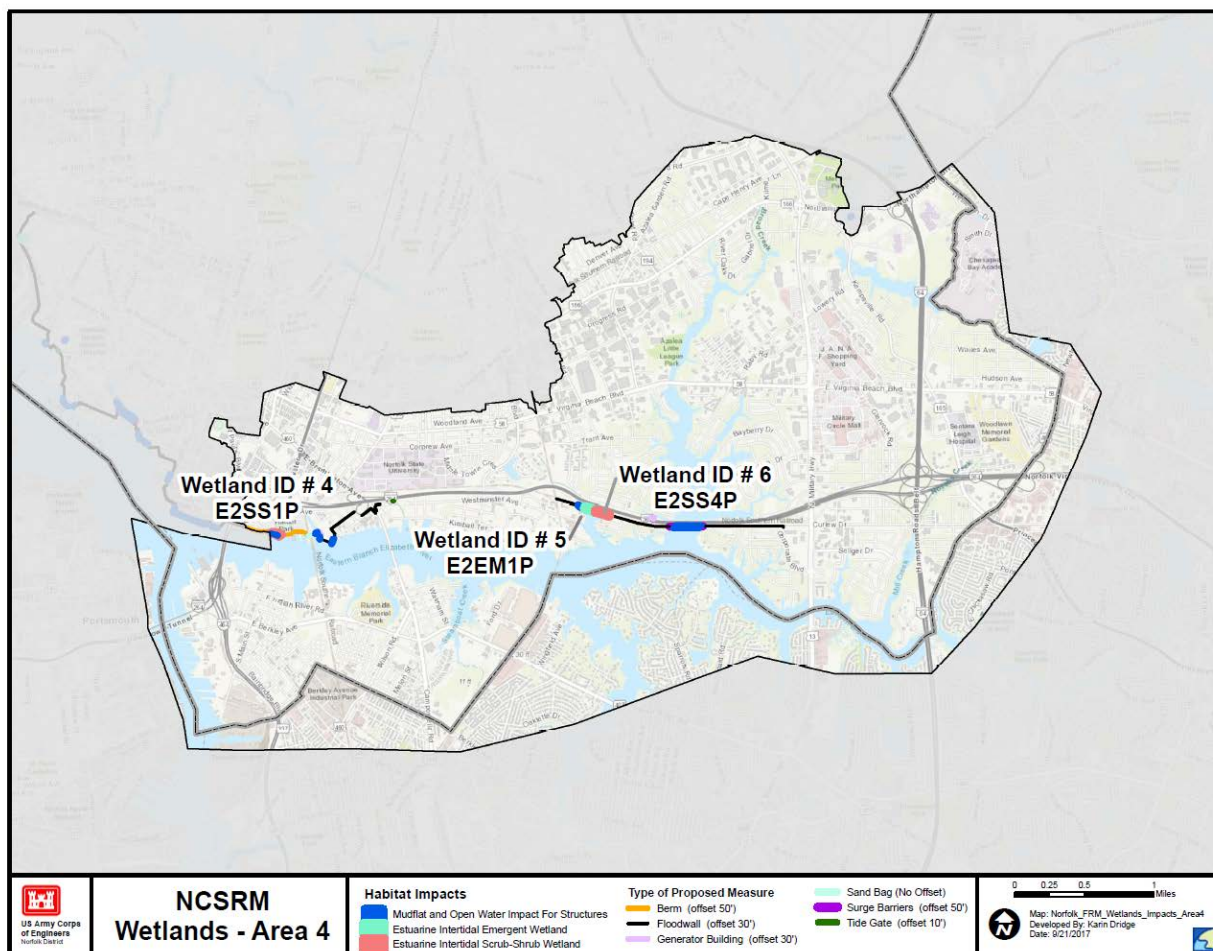


Figure 11-9. Wetlands -- Area 4

11.7.3 Alternative 3: Nonstructural Alternative

For this and all build alternatives, all of the existing ongoing projects and initiatives described under the No Action Alternative, as well as climate change and sea level rise, would be assumed to occur. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

As indicated earlier, a wetland delineation has not been conducted. As project plans and impact areas are finalized later in the study, a wetland delineation will be undertaken pursuant to the 1987 Wetland Delineation Manual and the Atlantic and Gulf Coast Regional Supplement, to ascertain the actual footprint of jurisdictional wetlands impacted by the project. Until that time, and until the project is further designed, the wetland impacts can merely be estimated and preliminary, based on existing information, as described under "Methodology."

For this alternative, the nonstructural measures throughout the City are very numerous, and they would likely be installed around the most significant at-risk buildings and structures of the City's land uses. This land disturbance would be mostly limited to those specific structures

being protected, and thus would be very limited. Floodproofing, basement fills, and building raisings, too, would be limited to existing buildings; this alternative would not facilitate new construction in undeveloped areas.

A few property acquisitions are proposed, whereby existing structures would be torn down and the area converted to open space. If appropriate, such areas could potentially be considered for use as sites for natural and nature-based features, or mitigation.

For these reasons, this alternative would likely have negligible, if any, permanent wetland impacts. There may be very minor temporary wetlands impacts for construction access, as measures are being constructed. The impacts associated with the four storm surge barriers, floodwalls, tide gates, and generator buildings described in Alternative 2a would not occur.

Any of these build alternatives (2a, 3, and 4d) would require compliance with the environmental laws applicable to land use in coastal areas. This alternative likely would not require permits pursuant to the Rivers and Harbors Act and the Clean Water Act (for temporary or permanent impacts to waters of the U.S. including wetlands); or the VPDES (for temporary and permanent construction discharge). But the project must adhere to the CZMA, the CBPA, and applicable local requirements land use regulations.

11.7.4 Alternative 4d: Recommended Plan

Under this combination structural/nonstructural alternative, all of the existing ongoing efforts, initiatives, and projects described under the No Action Alternative, as well as climate change, would be assumed to occur. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

As indicated earlier, a wetland delineation has not been conducted. As project plans and impact areas are finalized later in the study, a wetland delineation will be undertaken pursuant to the 1987 Wetland Delineation Manual and the Atlantic and Gulf Coast Regional Supplement, to ascertain the actual footprint of jurisdictional wetlands impacted by the project. Until that time, and until the project is further designed, the wetland impacts can merely be estimated and preliminary, based on existing information, as described under "Methodology."

The wetland impacts for Alternative 4d plan would be the same as those described for Alternative 2a Structural and the Alternative 3 Nonstructural, except that there would be no nonstructural measures implemented landward of the storm surge barriers. This is because those areas would be protected for the design storm event by the structural measures. Alternative 4d contains many of the same measures that the City has previously explored, and would be in keeping with its goals of future development for resiliency. As described above, the nonstructural measures effects of Alternative 3 are negligible, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated."

Any of these build alternatives (2a, 3, and 4d) would require compliance with the environmental laws applicable to land use in coastal areas. This alternative would require permits pursuant to the Rivers and Harbors Act and the Clean Water Act (for any temporary or permanent impacts to waters of the U.S. including wetlands), and the VPDES (for temporary and permanent

construction discharges); and a Virginia Marine Resources Commission permit for encroachment on state-owned bottom. The project must adhere to the CZMA, the CBPA, and applicable local requirements land use regulations.

All temporary wetland impacts would be restored to preexisting conditions. All permanent impacts will be mitigated as per the mitigation plan in provided in Appendix D. Temporary and permanent wetland impact acreages and the mitigation plan will be finalized, upon completion of a wetland delineation for the project and a design level adequate to determine the project footprint.

The following table summarizes the estimated direct permanent tidal wetland impacts, in acres, associated with the Recommended Plan:

Table 11-2. Estimated Direct Permanent Tidal Wetland Impacts (Wetland Delineation to be completed in PED phase)

Habitat Type	Location	Estimated Impact (acres)	Data Source
Estuarine Intertidal Emergent Wetland	Wetland ID #1	0.20	NWI_Geospatial
Estuarine Intertidal Scrub-Shrub Wetland	Wetland ID #1	0.03	Field
Estuarine Intertidal Emergent Wetland	Wetland ID #2	0.20	NWI_Geospatial
Estuarine Intertidal Emergent Wetland	Wetland ID #3	0.07	NWI_Geospatial
Estuarine Intertidal Emergent Wetland	Wetland ID #4	0.05	Field
Estuarine Intertidal Scrub-Shrub Wetland	Wetland ID #4	0.59	NWI_Geospatial
Estuarine Intertidal Emergent Wetland	Wetland ID #5	0.56	NWI_Geospatial
Estuarine Intertidal Scrub-Shrub Wetland	Wetland ID #6	0.61	NWI_Geospatial
Estuarine Intertidal Emergent Wetland	Broad Creek	0.02	Field
Mudflat and Open Water	All Sites	22.09	NWI_Geospatial
Total Estuarine Intertidal Emergent Wetland Impacts		1.11	
Total Estuarine Intertidal Scrub-Shrub Wetland Impacts		1.23	
Total Mudflat and Open Water Impacts (Nonwetland)		22.09	

Implementation of the No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. Impacts on wetlands from implementation of Alternative 4d, when coupled with an implemented mitigation plan, are predicted to range from indirect to direct, negligible to minor impacts that are temporary to permanent in duration.

11.7.5 Cumulative Effects

As indicated earlier, all of the other actions described under the No Action Alternative would also be assumed to occur for any of the build alternatives. Past, present, and reasonably foreseeable effects on wetlands as a result can or might occur in or near the ROI.

Because Norfolk is mostly an urban and suburban city, it has lost an estimated 50% of its wetlands since World War II (Virginia Department of Environmental Quality, website). Most of the aforementioned projects within or near the ROI: Norfolk Harbor, Little Creek, Eastern Branch Elizabeth River dredging projects, and Craney Island Eastward Expansion—were in subaqueous bottom, rather than wetlands. The Midtown Tunnel Expansion had minimal impacts to wetlands, and was also mostly impacts to subaqueous bottom. Similarly, the parallel tunnel for the Chesapeake Bay Bridge Tunnel would also have subaqueous bottom impacts. The Willoughby Beach Nourishment project also did not have vegetated wetland impacts. Third Crossing, a road widening from I-564 to the City Hampton with a new parallel tunnel, will also largely involve subaqueous impacts, but likely some small areas of tidal and nontidal vegetated wetland impacts as well. The portion within the City of Norfolk is mostly within existing right-of-way and within an area that is degraded.

Naval Station Norfolk in Area 1, and the HUD resiliency project for Chesterfield Heights/Grandy Village in Area 4 are two other reasonably foreseeable projects, with similar project purpose to this project, and with the potential to impact wetlands. The HUD project will entail mostly tidal gates, NNBFs including greenways, pump stations, and stormwater treatment. No storm surge barriers are planned there.

The identified alternatives were designed in consideration of existing and proposed wetland and oyster reefs constructed and/or planned by others.

For Alternative 3, permanent impacts on wetlands are predicted to be negligible or very minor, as the disturbance is mostly confined to the structures they are protecting. Very minor temporary impacts might be necessary for construction access. Therefore, implementation of Alternative 3 is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects.

The wetlands impacted by this project would be mitigated as described in the preliminary wetland mitigation plan in the Appendix D. The mitigation would be in-kind, and in the form of constructed marshes along shorelines within the watershed. The wetland mitigation plan has been determined based on the New England Salt Marsh Functional Assessment Method. The plan will be further refined in the PED phase, once the wetland delineation has been completed and the impact areas are finalized.

However, for any of the alternatives, predicted climate change impacts such as increased sea level rise, have the potential to cause changes in the nature and character of the wetlands in the ROI. In general, wetlands both inside and outside of ROI as are at increased risk of damage and loss from potential increases in sea level rise. Wetlands may erode further, or be at increased risk of becoming too inundated to support vegetation. Eventually, sea level rise may cause estuarine and freshwater wetlands to retreat inland.

Thin layer placement of dredged material onto existing wetlands may be considered in the future; if clean material of the appropriate consistency could be found. Although at this time we do not have a specific dredging operation identified, and which is also covered by a NEPA analysis, this could become a practicable solution for a USACE dredging project in the future.

Overall, implementation of either Alternative 2a or 4d (Recommended Plan) is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on wetlands. Impacts on wetlands from implementation of Alternative 2a or 4d, when coupled with an implemented mitigation plan, are predicted to range from indirect to direct, minor impacts that are temporary to permanent in duration.

11.8 SUBMERGED AQUATIC VEGETATION (SAV)

11.8.1 All Alternatives

The No Action/Future Without Project Alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed (reference Figure 9-3, "EB-6") ; rewriting the City Zoning Code to support resilience; and implementation of an additional three feet of required elevation, above the effective FEMA BFE, for structures located within the 1% annual chance floodplain (100 year) and 18 inch freeboard above grade required in the 0.2% annual chance floodplain (500 year) floodplain.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but will focus primarily on redevelopment with higher standards. The City's plaNorfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's plan entitled, "The Plan for Restoring the Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and increased citizen participation, will continue to be implemented.

The USACE would continue maintenance of Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project into the future. It is also assumed that other major ongoing projects within the City limits and beyond would occur. The USACE and VPA are currently conducting a feasibility study for Norfolk Harbor and Elizabeth River, Southern Branch deepening projects; although these projects are not yet authorized, they may be implemented in the future. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger ships expected as a result of improvements to the Panama Canal. In addition to these deepening, existing maintenance dredging operations, navigation and dredged material placement within the adjoining waterways would continue. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River. Also, additional development including construction of the Third Crossing and expansion of the Chesapeake Bay Bridge Tunnel is planned in the future.

There is no SAV located within the ROI; therefore, none of the alternatives will have any direct or indirect impacts on SAV. Although there are currently two SAV beds documented in Area 1, they are within the Little Creek waterway, rather than in Fisherman's Cove or Pretty Lake, the two waterways to be affected in Area 1. The smaller SAV bed, while closer to the Project Area

than the larger, is still at least 0.3 miles to the east of any proposed structure or fill. Reviews of records from 17 years reflect that SAV beds within the City of Norfolk have not changed much over the course of that time.

Based on the use of best management practices during construction, no permanent or temporary construction or turbidity impacts on SAVs are anticipated from the project.

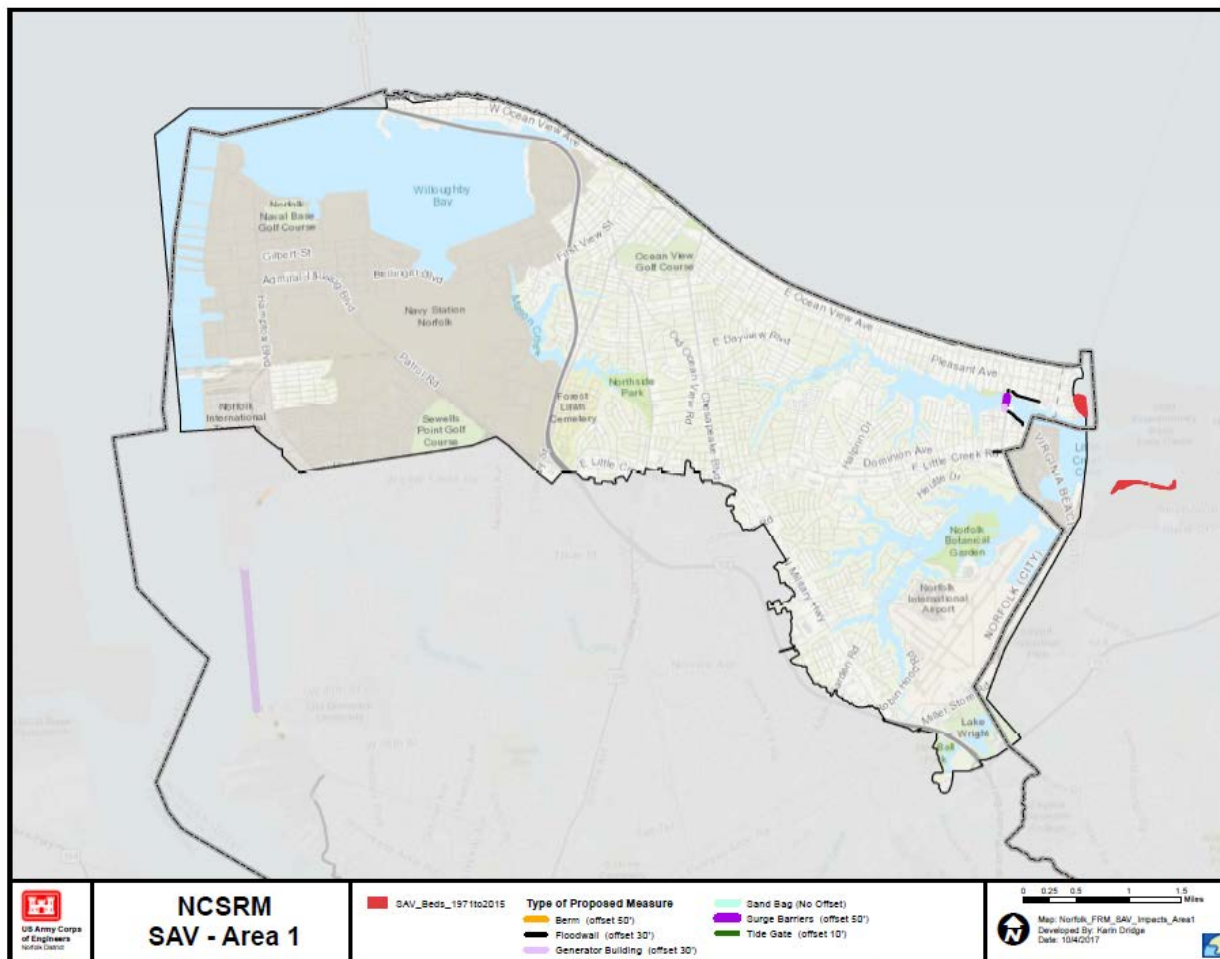


Figure 11-10. SAV - Area 1

11.8.2 Cumulative Impacts

Climatic changes such as sea level rise and increasing global temperatures are predicted to occur as a result of burning of fossil fuels and deforestation. Predicted climate change impacts such as increased temperatures, ocean acidification, sea level rise, and changes in currents, upwelling and weather patterns, have the potential to cause changes in the nature and character of the estuarine ecosystem in the ROI. SAV outside of ROI are at increased risk of damage and loss from potential increases in sea level rise and salinity shifts. The location of these resources may shift in response to climate change and the ensuing sea level rise outside of the ROI. Although climate change has the potential to substantially alter the location, quantity, and SAV in the future outside of the ROI, implementation of any of the alternatives is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on SAVs. Therefore, any permanent or temporary, and direct or indirect effects to

SAVs from implementation of any of the Alternatives are predicted to be negligible.

11.9 TERRESTRIAL WILDLIFE AND UPLAND VEGETATION

11.9.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current or planned future actions to mitigate against coastal storm risk. Existing coastal storm risk management features in the city would continue to be maintained.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed.. The project will include tide gates, natural and nature-based features, and stormwater improvements, the latter two of which could provide limited habitat for wildlife. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is approximately 95-97% developed. Therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's plan Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564 on land, and the construction of a parallel tunnel at the existing Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

It assumed that USACE would continue implementation of major ongoing projects within the City limits and beyond. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening projects have the potential to be implemented in the future. These projects would deepen the required (maintained) depths of the channels to accommodate future, larger Pan-Ex ships. In addition to these deepening, existing maintenance dredging operations, navigation and dredged material placement within the adjoining waterways would continue. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River. Also, additional development including construction of the Third Crossing and expansion of the Chesapeake Bay Bridge Tunnel is planned in the future.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. The placement of sand may result in a temporary, negligible disturbance effect to wildlife inhabiting the beach habitat. Even so, beach replenishment has the potential to produce minor beneficial impacts to wildlife by enhancing the dunes and extent of the coastal beach habitat.

Without implementation of an action alternative, it is expected that the inhabitants of Norfolk will become increasingly susceptible to coastal inundation. Due to the synergistic effects from combination of factors, including land subsidence, global and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for City of Norfolk. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future. Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling, and weather patterns, have the potential to affect the nature and character of the estuarine and coastal ecosystems in the ROI. Terrestrial areas will occasionally flood due to storm surge, temporarily displacing terrestrial wildlife to higher ground; this would be a minor impact to terrestrial wildlife.

11.9.2 Alternative 2a: Structural Only Alternative

The structural only alternative, Alternative 2a, assumes solutions for coastal risk management can be solved with structural measures. These measures include structures such as berms, floodwalls, berms, tide gates, surge barriers, and pump/generator stations.. Along with structural barriers, drainage improvements and flap gates on outfalls have also been included in Alternative 2a. Additionally, natural and nature based features, where compatible, may be incorporated adjacent to project features.

Structures including floodwalls, berms, tide gates, surge barriers and pump/generator stations are planned to be constructed in largely industrial and developed areas along the Lafayette River, Pretty Lake, Mainstem and Eastern Branch of Elizabeth River, and in Broad Creek that have limited areas for terrestrial wildlife and upland vegetation. Due to the fact that Norfolk is nearly completely built out, most species of wildlife within the city are adapted to relatively disturbed conditions. The direct impacts to wildlife from construction of these measures are predicted to be minor and temporary, producing largely a disturbance effect to species within the Region of Influence (ROI). Removal and/or disturbance of some upland vegetation will be required for construction of the structural features proposed in Alternative 2a, these effects could be minor and temporary to permanent in duration. The indirect impacts to wildlife as a result of construction noise and access for Alternative 2a have the potential to be minor and permanent in duration; these impacts include disruption of prey species, including forage fishes and other near-shore aquatic or benthic organisms.

After construction, the measures implemented in Areas 1-4 will be utilized and maintained for years to come. The maintenance of the storm surge barriers and tide gates will likely be a localized negligible and temporary disturbance effect to wildlife. Additionally, operation of the storm surge barrier and tide gates will halt the flow of water, which may affect aquatic prey species availability. These effects would be temporary, as the barriers and tide gates would only be closed during extreme high tide and weather events.

Impacts to wildlife from implementation of Alternative 2a are predicted to be both beneficial and adverse, and negligible to minor. Construction of surge barriers and tide gates has the potential to alter water quality and velocities, which may cause minor, permanent adverse impacts to wildlife by indirectly affecting species utilizing shallow, nearshore areas to forage. Floodwalls will also extend through upland areas for long distances in Areas 3 and 4. Depending on how

many openings will be in the floodwalls for street gates and/or pedestrian gates, this could limit passage of terrestrial wildlife in various locations. However, most of the areas traversed by floodwalls are in developed areas that would be unlikely to serve as established corridors for wildlife. Therefore, this may result in minor and temporary to permanent adverse impacts to wildlife.

Implementation of Alternative 2a will require staging areas for materials and heavy equipment/machinery to elevate or relocate existing structures. In addition, localized maintenance would be needed during the life of the project. Areas disturbed by staging and/or heavy machinery would be restored, to the maximum practical extent, to their original, pre-project state. These effects would result in negligible and temporary adverse impacts to wildlife and upland vegetation within the ROI.

Implementation of Alternative 2a would also include the beneficial effects of protecting upland habitats from storm surge flooding, as well as preventing storm surge damage to upland vegetation. As a result, temporary and/or permanent displacement of terrestrial wildlife might not occur as frequently.

Upland vegetation that is cleared either temporarily or permanently within the Resource Protection Areas (RPAs), which are areas within 100 feet of any tidal water body, would have to be mitigated in the same vicinity, as per requirements of the CBPA. A preliminary upland mitigation plan is included in the Mitigation Plan in the Environmental Appendix. This plan would be further refined during the PED phase.

11.9.3 Alternative 3: Nonstructural Alternative

The adverse impacts to wildlife from implementation of Alternative 3 would be, at most, negligible and temporary in duration, as this Alternative does not require land disturbance in previously undisturbed areas.. Modification of existing features, including elevation or flood proofing could result in a negligible and temporary adverse impacts to wildlife and terrestrial vegetation within the ROI. If a buyout or relocation of homes and/or businesses at risk to coastal flooding occurred, impacts to wildlife have the potential to be moderately beneficial and permanent, as these areas would be reverted back to a natural state, which would provide valuable wildlife habitat where it was previously fragmented and/or non-existent.

Implementation of Alternative 3 may require staging areas for materials and heavy equipment/machinery to elevate or relocate existing structures. In addition, localized maintenance would be needed overtime. Areas disturbed by staging and/or heavy machinery would be restored, to the maximum practical extent, to their original, pre-project state. These effects would result in negligible and temporary adverse impacts to wildlife and upland vegetation within the ROI.

Adverse impacts associated with Alternative 3 are, at most, negligible and temporary in duration. Also, if a buyout occurred, impacts to wildlife and upland vegetation would be moderately beneficial and permanent. Implementation of Alternative 3 is not predicted to cumulatively or synergistically interact with other past, present, and future projects and/or climate change.

11.9.4 Alternative 4d: Recommended Plan

The adverse impacts to wildlife associated with the implementation of Alternative 4d would be similar to the combined impacts as described in Alternatives 2a and 3. As described above, the nonstructural measures effects of Alternative 3 are negligible, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

11.9.5 Cumulative Effects

Implementation of the No Action/Future Without Project Alternative, 2a, 3, or 4d would not be predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on terrestrial vegetation and wildlife.

Effects to wildlife and upland vegetation from implementation of Alternative 4d are predicted to range from moderately beneficial and permanent to negligible to minor adverse effects that are temporary to permanent in duration.

11.10 BENTHIC RESOURCES

11.10.1 No Action Alternative/Future Without Project

If the Recommended Plan is not implemented, the benthic biota in the four areas will remain undisturbed by any construction activities or any other modifications to their environment due to the various measures being considered. The natural system would continue to function as it has, no tidal gates or storm surge barriers would be installed across any waterways in the project ROI as described for Areas 1-4. Sea level will rise, and it is expected that coastal flooding in the City of Norfolk will increase.

The USACE would continue maintenance of Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project into the future. USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once is it filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564, and the Hampton Roads Bridge Tunnel up to the City of Hampton, may be constructed.

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or

synergistically interact with climate change and/or other cumulative effects, including changes to the navigation channels in the Elizabeth River that are outside the proposed project scope. With implementation of the No Action/Future Without Project Alternative, impacts are minor, permanent and adverse (climate change and associated sea level rise) to local benthic fauna. The salinity changes may allow higher-salinity preferring predatory species to penetrate further into the Elizabeth River, exposing more of the benthic community to a wider suite of predators, while limited freshwater species to smaller areas further upriver than at present. DO levels are expected to decline significantly (approximately 30%) in the upper reaches of the Lafayette River due to climate change by year 2076. Although this is a significant drop, DO levels still remain for both surface and bottom waters above 5 mg/L, a safe level for all estuarine life. For all modeled waterbodies (Pretty Lake, Broad Creek, and the Lafayette River) minor changes in flushing times and salinities were noted in the Future Without Project Condition (Moffatt and Nichol 2017; VIMS 2017). In general flushing times declined by approximately one day, and salinities in general increased by approximately 1 ppt. These changes are considered minor but permanent and no impacts to the benthos are expected, beyond those induced by rising water temperatures and salinity, which may alter the range of some species. An analysis of this range alteration is beyond the scope of this draft EIS.

11.10.2 Alternative 2a: Structural Only Alternative

The methodology used and the estimated quantity and location of impacts to benthic resources with implementation of Alternative 2a is described in WETLANDS AND MUDFLATS.

The placement of the storm surge barriers will permanently alter the benthic community of the Lafayette River (Area 2), 15.3 acres of impacts, Pretty Lake (Area 1), 0.63 acres of impact, the Hague (Area 3), 0.91 acres of impacts, and Broad Creek (Area 4), 0.45 acres of impacts, by replacing current open bottom habitat with vertical stone structures that will extend from the current bottom depth to above the water surface. The benthic community in these areas will change from burrowing organisms and motile forms such as blue crabs and bottom-feeding fish (such as drum species) to a sessile community that can utilize stone. In some areas, proposed levees (berms) and floodwalls may encroach into current shallow water habitat. This will alter these areas from current shallow open water habitat to either terrestrial (berm) or floodwall, these impacts are up to 1.2 acres of current shallow open water habitat. Floodwalls may provide some hard structure for sessile benthos to attach to. However, because in most cases these structures permanently transform what is now shallow or deep open bottom habitat to stone and/or terrestrial habitat, these impacts will be mitigated for and the mitigation is described in the compensatory mitigation plan provided in Appendix D. Tide gates are associated with the surge barriers and the floodwalls, these will be closed during storm events but open normally. Because of the proposed mitigation to compensate for the loss of habitat and associated benthic community, these impacts are not significant.

The structures are designed to be closed during storm events to prevent surge-induced flooding within Areas 1, 2, 3, and 4. Water quality (please see the water quality and Hydraulics and Bathymetry sections for details) will be altered significantly during a storm event due to the closures at these surge barriers. The reduction in salinity to 0 or near-0 ppt for several days in the upper reaches of the Lafayette River, Pretty Lake, Broad Creek, and The Hague will impact all non-motile benthic life in these areas. However, due to the already-low salinities in these

areas (< 5 ppt), with the exception of Pretty Lake, where salinity is typically 18-20 ppt, the benthos in these areas should survive. In Pretty Lake, there will be significant mortality of the benthos due to the abrupt and severe salinity shift in the upper reaches of the Lake. It is possible that motile fauna will also experience some mortality if they cannot reach higher salinity waters further downstream in these areas in time. This is likely to occur in the Lafayette River, but less likely in the other areas as these waterbodies are quite small, so motile fauna have only a short distance to travel in order to reach higher salinity waters sufficient to support estuarine life (≥ 5 ppt). As these impacts will only occur during closures, this is not a typical event. The mortality at these sites would have similar impacts to that of a beach nourishment event, which typically kills all non-motile benthos at the site. Such sandy sites typically receive recruitment of the typical benthic community for the area and recover in one to three years (Diaz, Cutter and Hobbs, 2004). Soft sediment sites such as those found in the upriver reaches of the areas proposed for surge barriers could be longer, as soft sediment sites have been found to take longer to recover than coarse sediment sites (Dernie et al. 2003). A local case study on these types of effects examined the after effects of hurricane Agnes (Boesch et al. 1976). In this study, the greatest mortality to benthos occurred in polyhaline waters (18 to 30 ppt) with the least mortality in oligohaline waters (0.5 to 5.0 ppt). The general trend observed was that the more saline the initial environment, the greater the mortality to the benthos caused by the days-long freshet caused by Hurricane Agnes.

Area 1: Willoughby and Oceanview beaches, Little Creek, and Pretty Lake

The main region of concern is Pretty Lake. At Pretty Lake, a surge barrier with a tide gate and a pump station is proposed. The typical operation of the barrier will be the tide gate open, to allow for normal tidal exchange. Pretty Lake is a polyhaline waterbody that supports benthic fauna typical of sand and mud bottoms, both of which can be found in Pretty Lake. There is also at least one oyster reef in Pretty Lake, and it is possible there are more. Oysters are also plentiful on all hard structure visible in the intertidal to shallow-subtidal waters. It is expected that the benthic fauna here will be similar to that of the Elizabeth and nearby (approximately 5 miles further down Bay than Pretty Lake) the Lynnhaven River is Lynnhaven Rivers (Dauer, 2007) whose waters and river bottom is very similar to that of Pretty Lake and both are similarly heavily used by recreational boaters. The Lynnhaven benthic community is dominated by small benthos, with typically several thousand organisms averaging only several grams/biomass/m² are found on open river bottom. The benthic community is dominated by small polychaetes, nematodes and oligochaetes. Much the same can be expected within Pretty Lake, due to its similarity to the Lynnhaven River. As indicated in the water quality section of this document, minor and insignificant changes to water quality result from construction the proposed surge barrier, tide gate and associated pump station (VIMS, 2017). However, during closure due to a storm event, the upper reaches of Pretty Lake will experience a salinity drop from approximately 7.5 ppt pre construction to 0 ppt post-construction. This is due to the retention of freshwater in the upper reaches due to the tide gate closure coupled with freshwater inflow due to the storm event. Based on the water quality model, these waters are polyhaline and therefore it is expected that a closure that reduces salinity to 0 ppt for several days during the time of year when the fauna is metabolically active (temp above 50 F) will result in mortality of all non-motile benthos. There is also potential for mortality of motile benthos, but due to the short distance they will have to travel to escape the region of 0 ppt, most should survive. Recovery in such

areas can take several years. As much of this habitat is softer bottom rather than sand, it is expected that recovery will take somewhat longer than an open beach habitat. Impacts are minor, as this is a relatively small area and it is expected to recover. Changes in velocity due to the placement of the surge barrier are minor, permanent and not significant. There is also a small floodwall associated with the surge barrier at Pretty Lake, this will impact a small amount of wetlands, approximately 0.2 acres, which the impacts to which are addressed in the compensatory mitigation plan. NNBF, in the form of a living shoreline consisting of an oyster reef fringe with wetlands behind it, will also be placed in this area. The NNBF will be a significant, positive impact to the local area, providing for shoreline stabilization and wave dampening during storm events.

Area 2: Lafayette River

The construction of the surge barrier with multiple tide gates will directly impact the benthic community within the construction footprint, near the mouth of the Lafayette River. Impacts will be similar to that of surge barriers with tidal gates in other areas, as described earlier in this section and the mitigation plan will address these impacts.

During gate openings, which will be the normal state for the surge barrier and tidal gates, water quality parameters do not vary much from baseline conditions, including DO (dissolved oxygen) soon after the project is constructed (2026). DO does drop significantly in the upper reaches of the Lafayette River, primarily due to sea level rise/climate change impacts. This drop, though significant, should not induce mortality in the benthos as bottom waters should still remain above 5 mg/l DO. It is not expected that impacts to benthos due to a drop in DO due to project construction will occur, impacts are not significant. A small berm will be constructed within this area, this berm encroaches on shallow open bottom and wetlands, and will be permanent impacts to these habitats. These impacts will be addressed in the compensatory mitigation plan such that there will be no significant impact due to these habitat losses. Oyster reefs in the Lafayette River will not be directly impacted, though one mitigation reef, at its southern tip, will be close (< 100 m) from the north end of the surge barrier. The USACE is well aware of various efforts that have taken place and/or are underway to restore oysters in the Lafayette River, being an active partner in these efforts. The water quality and hydrodynamic impacts due to the surge barrier should not impact the local oyster reefs or their population, except to possibly slightly enhance local oyster recruitment. This enhancement is due to the increase in residence time of water behind the surge barrier, as detailed in other sections of this EIS. If any active oyster leases are impacted, compensation may be necessary. There is one lease that may be impacted, but considering the long-term shellfish closure of the River, it is likely inactive. USACE will coordinate with VMRC during PED to confirm this, and if it is active, measures to compensate will be made.

Regarding impacts to larval and juvenile fish and other species, such as oysters, due to pumping of water during a storm event, most major storms occur outside of larval presence, and blue crab larvae should not be impacted. Oyster larvae are typically in the water in summer, peaking during June and July, which is outside the peak of the hurricane season, which occurs later in the year. The probability of a gate closure occurring during peak oyster larval time is low. Further, major storms typically decrease salinity throughout the river, which can reduce larval survival without any human action occurring, for example Hurricane Agnes caused an

almost complete oyster recruitment failure in the James River region in June of 1972 (Schulte 2017). These pumps operate to pump water out from behind surge barriers during closures, this water would typically be quite fresh during the storm event and it is likely any larvae in these waters would be killed by the sudden and large drop in salinity. We will further examine these impacts during PED, but due to the timing of operation as well as the type of water pumped, impacts to fish and other larvae should be minimal.

Area 3: Elizabeth River, The Hague, Eastern Branch Elizabeth River

For The Hague, a benthic survey was done by the USACE in summer 2017. The sampling was done by both auger and oyster hand tong, the tong can take an areal sample of the bottom. In The Hague, the bottom was almost entirely very soft mud, with the auger able to penetrate several feet deep without resistance. Small numbers of oysters (less than 5/2, considered low density) were noted on the rock walls of The Hague in some areas. Such bottom conditions typically have very little benthic life (Dauer, 2008). Due to this, no water quality modeling was done at this site, as it is not expected that there will be no significant impacts to benthic life at this site due to construction of the surge barrier from a water quality impact perspective. Direct impacts to the benthos by placement of the surge barrier will be mitigated for. Where the floodwall or berm directly impacts the river bottom, these impacts will also be mitigated for and these actions are described in the mitigation plan. No indirect impacts to the benthos are expected from the berms and floodwalls.

Area 4: Eastern Branch Elizabeth River and Broad Creek

Where the floodwalls and berms' construction footprint impacts the shallow open waters and associated benthos, mitigation will be done to compensate for the lost bottom area such that this impact will not be significant. No public oyster grounds lie within 100 m of any structure, and the public oyster grounds in the Southern Branch and Eastern Branch of the Elizabeth River have been inactive since the 1920s, when they were closed due to pollution and bacterial contamination. They have never been actively managed or maintained by the state. Recent hydroacoustic surveys by NOAA revealed little shell present in these public grounds. There should be no impacts to public oyster grounds in this area due to project implementation. No other impacts, other than direct, are expected to the benthos from the floodwalls and berms. The surge barrier and associated gates could impact the benthos in Broad Creek. A study (Moffatt & Nichol 2017) was done to model the potential impacts. Salinity will not vary significantly post-construction when compared to pre-construction conditions throughout Broad Creek. Velocities of water within the Creek and Creek mouth will not vary significantly if the 5 gate option is selected, there will be increases at the mouth of Broad Creek in velocity (approximately doubling from 0.2 to 0.4 m/s). These changes in velocity are minor and not significant, and should not affect the benthos in and near Broad Creek. The upper reaches of Broad Creek will experience a salinity drop from approximately 5 ppt to 0 ppt for four days in the event a storm requires the gate to be shut and subsequent rainfall freshens Broad Creek. This drop in salinity may cause mortality in the benthic fauna at this site, but as such organisms that will be found in these oligohaline waters should be able to survive such a temporary decline in salinity, as these waters fluctuate daily between near 0 and 5 ppt with the tides so very low salinities are a regular occurrence in the upper reach of Broad Creek. These upper reaches are also typically very soft bottom, supporting a limited, low biomass and diversity benthic community. Impacts to the benthos in the upper reaches due to the expected salinity change

during a closure due to a storm event are therefore expected to be temporary and minor, not significant. The benthos here, which are adapted to low-salinity conditions, should survive the closure event. Further downriver, salinity changes due to a closure event, while they do lower the salinity, do not lower it to levels that would produce mass mortality of the non-motile benthos in these regions. Impacts to benthos due to proposed surge barriers with tidal gates, for either the six or two gate option, are considered minor and not significant.

11.10.3 Alternative 3: Nonstructural Alternative

None of these measures would impact the benthic community of local waters in the project ROI in any of the four areas. No effect.

11.10.4 Alternative 4d: Recommended Plan

Due to the fact that this is a combination of Alternative 2a and 3, impacts will be similar to those of Alternative 2a as Alternative 3 does not affect the local ROI benthic community. As described above, there would be no effects from the nonstructural measures of Alternative 3; and they are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

The methodology used and the estimated quantity and location of impacts to benthic resources with implementation of Alternative 4d is described in the Section WETLANDS AND MUDFLATS. A mitigation plan to address wetland, mudflat, and open water, and benthic impacts is provided in Appendix D.

11.10.5 Cumulative Effects

As described earlier, there are multiple past, present and reasonably foreseeable future projects within the overall Study Area. The City plans a number of actions to re-develop portions of the City, focusing on areas that are higher ground (Norfolk Vision 2100).

Many existing maintenance dredging projects, and proposed dredging projects occur within or near the ROI: Norfolk Harbor, Southern Branch of the Elizabeth River (ERSB), Little Creek, and Eastern Branch Elizabeth River. The Norfolk Harbor and the ERSB, two projects that are being considered contemporaneously with this one, were both determined not to have significant environment impacts. Little Creek and the Eastern Branch of the Elizabeth River, are existing USACE channels for which maintenance dredging occurs on an as-needed basis.

The Midtown Tunnel Expansion project was also mostly impacts to subaqueous bottom. Third Crossing, a road widening from I-564 in the City of Norfolk across the James River/Hampton Roads Harbor to the City of Hampton, with a parallel tunnel to the Hampton Roads Bridge Tunnel, will also largely involve subaqueous impacts, as will the parallel tunnel for the Chesapeake Bay Bridge Tunnel, though the latter is further removed from the ROI.

Craney Island Eastward Expansion, across the Elizabeth River from the Lafayette River, will involve a permanent fill to approximately 510 acres of subaqueous bottom. It was an EIS mitigated with oyster reef mitigation and excavation of contaminated material from the Elizabeth River.

These are in areas that are generally at least 20 feet deep, and in habitats differing from those

affected by the current project.

The Willoughby Beach Nourishment project filled existing beach as well as shallow water. It was completed in 2016 and may receive additional nourishment in the future.

Naval Station Norfolk in Area 1, and the HUD resiliency project for Chesterfield Heights/Grandy Village in Area 4 are two other reasonably foreseeable projects with similar project purpose to this project. The HUD project will entail mostly tidal gates, floodwalls, NNBFs including greenways, pump stations, and stormwater treatment. No storm surge barriers are planned there.

Alternatives 2a, 3, and 4d were designed in consideration of existing and proposed wetland and oyster reefs constructed and/or planned by others.

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue over the next 50 years. Predicted climate change impacts such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling and weather patterns, have the potential to cause changes in the nature and character of the estuarine ecosystem, sea levels and surface land temperatures in the ROI. Changes in water quality were modeled, and significant changes due to climate change were noted in a number of areas. However, the proposed construction will not further alter these parameters significantly, beyond those already noted for the upper reaches of the Lafayette River.

Implementation of any of the action alternatives is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects. Therefore, with implementation of the any of the action alternatives we would anticipate that impacts to the benthic community of the project ROI in the future related to the project would be minimal.

11.11 PLANKTON

11.11.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current or planned future actions to mitigate against coastal storm risk. Existing coastal storm risk management features in the city would continue to be maintained. The No Action Alternative assumes that all of the aforementioned actions within and near the ROI will occur.

If no action is implemented continued development and stormwater discharges will continue to negatively impact plankton species composition and populations within the ROI and adjacent areas. However, we would not anticipate that these increased impacts would cause a measurable shift in plankton species composition or abundance. The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects.

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue as a result of burning of fossil fuels and deforestation. Predicted climate change impacts such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling and weather patterns, have the potential to cause changes in the nature and character of the estuarine ecosystem in the ROI. Climate change is anticipated to

potentially increase winter and spring nutrient loading into the Chesapeake Bay and may result in increased phytoplankton production (Najjar et al. 2010). The higher temperatures, lower dissolved oxygen levels, and increased phytoplankton productivity may result in more frequent hypoxic conditions (low dissolved oxygen conditions) in the water column. The anticipated higher temperatures and carbon dioxide levels in the Bay may result in increases in harmful algal blooms (Najjar et al. 2010). Climatic change has the potential to affect the plankton species composition and abundance of plankton populations within the ROI which in turn can affect higher level food chain composition and dynamics. The exact intensity and threshold to plankton populations resulting from climatic change is relatively uncertain but has the potential to substantially alter plankton populations in the ROI.

11.11.2 Alternative 2a: Structural Only Alternative

During construction, TSS may also increase in the local area placement. TSS increases will reduce light penetration, which may have a minor, temporary impact on local phytoplankton. These impacts are temporary and negligible due to the size of the area impacted relative to the Bay and its tributaries, as well as the ability of plankton communities to rapidly recover from local impacts.

In a storm event, the utilization of the few structural measures that would impact the water directly when used are: floodwalls, surge barriers and tide gates. Utilizing these structural measures have the potential to alter water quality, velocities, salinity levels and nutrient levels. These changes in the water environment all impact the survival rate of plankton. A salinity reduction due to structural closures (>5 days) post-hatch larvae could experience a 100% mortality rate. A majority of larvae will not survive past day three (Richmond & Woodin, 1996). Varying growth rates during a salinity drop is dependent on the duration of the salinity reduction and the age of the embryos and larvae when exposed to the reduced salinity environment. Phytoplankton is vulnerable to large salinity changes, with the exception of picoplankton, which is able to survive in salinities from 5ppt and up. In the upper reaches of the waterbodies protected by surge barriers, closures during storm events can decrease salinity to less than 5ppt, in the case of Pretty Lake, salinity is expected to drop from near 20ppt to 0ppt for several days during a closure. Changes this drastic can be expected to cause some mortality of phytoplankton (Lancelot and Muylaert, 2011), as well as zooplankton (Lance, 1963). Any closures are not planned to be for long periods of time so these salinity differences due to closures are minor to moderate and are temporary, but they will cause local mortality of plankton. However, these impacts are temporary and minor due to the size of the area impacted relative to the Bay and its tributaries, as well as the ability of plankton communities to rapidly recover from local impacts. As pump stations are activated during storm events, plankton will also be entrained in the pumping mechanism. This will cause plankton mortality in the local area and waters immediately around the pump station. This impact is minor and temporary, as significant amounts of the plankton will survive this operation and the local population will be able to quickly recover.

11.11.3 Alternative 3: Nonstructural Alternative

None of these measures would impact the plankton community of local waters in the project ROI in any of the four areas. No effect.

11.11.4 Alternative 4d: Recommended Plan

This alternative is a combination of Alternative 2a and 3, impacts will be the same as already mentioned in Alternative 2a and 3, listed above. As described above, there would be no effects from the nonstructural measures of Alternative 3; and they are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.”

11.11.5 Cumulative Effects

Climatic change has the potential to affect the plankton species composition and abundance of plankton populations within the ROI which in turn can affect higher level food chain composition and dynamics. The exact intensity and threshold to plankton populations resulting from climatic change is relatively uncertain but has the potential to substantially alter plankton populations in the ROI. Implementation of any of the action alternatives is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on plankton.

11.12 FISH AND FISHERY RESOURCES

11.12.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current or planned future actions to mitigate against coastal storm risk. Existing coastal storm risk management features in the city would continue to be maintained.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million HUD grant for disaster resilience, to be implemented in Chesterfield Heights. The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City’s Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City’s comprehensive plan, “The Plan for Restoring The Lafayette River”, with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. The placement of sand along may result in a temporary, minor disturbance effect to fish and fishery resources inhabiting the coastal beach habitat. The disturbance from beach replenishment would include increased turbidity and noise disturbances to fish populations in the ROI; however, these affects would be largely diminished within hours of sand placement.

The USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen

the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564 to the City of Hampton, with the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

Without implementation of an action alternative, it is expected that the inhabitants of City of Norfolk will become increasingly susceptible to coastal inundation. Due to the synergistic effects from combination of factors, including land subsidence, global and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for City of Norfolk. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future. Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling, and weather patterns, have the potential to affect the nature and character of the estuarine and coastal ecosystems in the ROI.

Sea level rise may result in an increase in salinity in upstream areas that could affect spawning areas and survival of early life stages (eggs, larvae, and young of the year). There could be shifts in spawning habitat availability and timing and the effects of this change on fish populations could be detrimental, although relatively uncertain at this time. The shifts in salinity, temperature, and sea level rise all have the potential to result in shifts in prey species availability which could also cause detrimental effects to fish resources and habitats. However, implementation of the No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. Therefore, effects to fish and fishery resources from implementation of the No Action/Future Without Project Alternative are predicted to be negligible and temporary in duration.

11.12.2 Alternative 2a: Structural Only Alternative

Structures including floodwalls, berms, tide gates, surge barriers, and pump/generator stations are planned to be constructed in largely industrial and developed areas along the Lafayette River, Pretty Lake, The Hague, Eastern Branch of the Elizabeth River, and in Broad Creek. It is likely that other species of anadromous fish, such as striped bass, utilize the Lafayette River as a foraging area. There are a number of direct and indirect impacts to fish and fishery resources predicted to result from the construction of these measures.

During construction, entrainment and/or siltation of eggs, larvae, and demersal, and/or slow moving fish species may adversely affect the local fish community. Additionally, the production of noise and turbidity during construction of Alternative 2a may cause fishes to exhibit avoidance behaviors, which may reduce the foraging/hunting success of affected species. Construction of the structural alternative may affect benthic prey species and habitats utilized by fishes within the ROI; these effects may limit available habitat and food availability during and after construction of Alternative 2a (Refer to BENTHIC RESOURCES). The construction of tide gates and surge barriers also have the potential to increase flow velocities slightly in the Lafayette River, Pretty Lake, and throughout the areas of the City bounded by water bodies.

Due to the size and extent of the tide gates, and also that they are kept in the open position during anything but a major storm event, migratory fish passage will be more limited but not completely restricted, where surge barriers are proposed: Pretty Lake, the Lafayette River, The Hague, and Broad Creek.

Impacts to fish and fishery resources are predicted to be greatest during the operation and maintenance of built structures proposed in Alternative 2a. Extreme storm and high tide events would trigger the closure of tide gates (throughout the city) and surge barriers (Pretty Lake and Lafayette River), causing shifts in water quality and flow rates (Refer to Water Quality chapter). During tide gate and surge barrier closures, tidal fluxes in water would cease for a period of time, potentially reducing water quality and dissolved oxygen (DO), while increasing the number of harmful nutrients in the water. The changes in water quality, DO, and nutrients could have compound and/or cumulative interactions, causing increased stress levels to fish populations, which may lead to increased susceptibility to disease or even a mortality event (Tietze 2016; Bachman and Rand 2008). Closure of the tide gates and/or surge barriers and operation of the pumps may also cause entrainment or of slow moving or larval fishes. Impediment of movement and/or migration of fishes trapped behind closed tide gates and/or surge barrier is also possible. During a closure, fish would be trapped for a few days, and water quality modeling done indicates that salinity changes in most of these waters would not induce mortality of these fish. The one exception would be the upper reaches of Pretty Lake, but it is doubtful any migratory fish are in these waters and the salinity change would not be so sudden that it would kill highly mobile migratory fish. These fish would likely swim downstream to safer waters during a storm/closure event. However, closures could temporarily affect breeding and/or foraging behaviors.

Additionally, periodic maintenance of the structures proposed for Alternative 2a would be necessary over time; the maintenance would likely result in localized disturbances caused by increased underwater noise and turbidity. The construction, operation and maintenance of Alternative 2a could potentially result in temporary to permanent significant adverse impacts to fish and fisheries resources.

Natural and nature based features (NNBF), where compatible, may be incorporated adjacent to project features. NNBFs may include placement of stone sill and tidal wetland vegetation; these features may provide habitat, food sources, and protection, which could be moderately beneficial to fish species in the area. Even so, construction of Alternative 2a is predicted to produce adverse effects to fish and fishery resources within the ROI that range from negligible

to moderate, and temporary to permanent in duration.

Implementation of Alternative 2a has the potential to result in temporary to permanent significant adverse impacts to fish and fisheries resources.

Pursuant to the Magnuson-Stevens Act, the USACE is coordinating with the National Oceanic and Atmospheric Administration's (NOAA) Fisheries Service with respect to Essential Fish Habitat (EFH). The EFH Assessment in the Environmental Appendix provides greater detail into these impacts and potential mitigation. In addition, we are coordinating with the U.S. Fish and Wildlife Service (USFWS) pursuant to the Fish and Wildlife Service Coordination Act (FWCAR). The results of the coordination are provided in the Environmental Appendix.

11.12.3 Alternative 3: Nonstructural Alternative

All nonstructural measures are assumed to be applicable across all four city areas. The adverse impacts to fish and fishery resources from implementation of Alternative 3 would be, at most, negligible and temporary in duration, as this Alternative does not require disturbance in previously undisturbed estuarine and/or marine environments.. Modification of existing features, including elevation or flood proofing could result in a negligible and temporary adverse impacts to fish and fishery resources within the ROI. If a buyout or relocation of homes and/or businesses at risk to coastal flooding occurred, impacts to fish and fisheries resources have the potential to be moderately beneficial and permanent, as these areas would be reverted back to a natural state, which would provide valuable estuarine habitat where it was previously fragmented and/or non-existent.

Implementation of Alternative 3 would require localized maintenance, as repairs are needed overtime. This could result in negligible and temporary adverse impacts to fish and fisheries resources within the ROI.

Adverse impacts associated with Alternative 3 are, at most, negligible and temporary in duration. Also, if a buyout occurred, impacts to fish and fishery resources could potentially be moderately beneficial and permanent. Implementation of Alternative 3 is not predicted to cumulatively or synergistically interact with other past, present, and future projects and/or climate change.

11.12.4 Alternative 4d: Recommended Plan

The impacts associated with Alternative 4d would be the same as for 2a. The construction, operation and maintenance of Alternative 2a could potentially result in temporary to permanent significant adverse impacts to fish and fisheries resources. As described above, the nonstructural measures effects of Alternative 3 are negligible, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.”

11.12.5 Cumulative Effects

Implementation of Alternative 2a or 4d is predicted to produce both adverse impacts and cumulatively and/or synergistically interact with climate change. Increased storms and rising seas over time could increase the number and length of time that tide gates and storm surge barriers are closed, affecting fish and fishery resources within the ROI. Therefore, effects to fish

and fisheries resources from implementation of Alternative 4d are predicted to be significant and range from temporary to permanent in duration.

As mentioned earlier, the EFH assessment and FWCAR will be found in the Environmental Appendix, and will provide greater detail into these impacts. Further coordination and/or study may occur in the PED phase, if appropriate.

11.13 SPECIAL STATUS SPECIES

11.13.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current or planned future actions to mitigate against coastal storm risk. Existing coastal storm risk management features in the city would continue to be maintained.

Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million HUD-sponsored grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed. That project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

Norfolk is nearly built out, therefore, future conditions will consist of little new development, but rather will consist primarily of redevelopment with higher standards. The City's plan Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Beach and Dunes into the future. It is also assumed that other major ongoing projects within the City limits and beyond would occur. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening projects have the potential to be implemented in the future. These projects would deepen the required (maintained) depths of the channels to accommodate future, larger Pan-Ex ships. In addition to these deepening, existing maintenance dredging operations, such as Little Creek and Eastern Branch of the Elizabeth River channels, and navigation and dredged material placement within the adjoining waterways would continue. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a

roadway project which includes the widening of I-64 from I-564 to the City of Hampton, with the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

Without implementation of an action alternative, it is expected that the inhabitants of City of Norfolk will become increasingly susceptible to coastal inundation. Current and future projected yearly damages, excluding the Chesterfield Heights area, from coastal storms are expected to reach \$231 million. Due to the synergistic effects from combination of factors, including land subsidence, eustatic and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for City of Norfolk. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future. Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling, and weather patterns, have the potential to affect the nature and character of the estuarine and coastal ecosystems in the ROI.

Implementation of the No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects.

11.13.2 Alternative 2a: Structural Only Alternative

The overall, relative adverse impacts to Special Status Species with implementation of Alternative 2a would be slightly less than with implementation of Alternative 4d because none of the nonstructural measures would be implemented with Alternative 2a. Therefore, disturbance impacts to Special Status Species that occur in terrestrial habitats would be slightly less. However, even though relative disturbance impacts would be slightly less for Special Status Species that could be disturbed by construction of nonstructural features, the relative impact threshold and impact findings for Special Status Species with implementation of Alternative 2a would remain at the same threshold level of impact as those described for Alternative 4d. This is because the majority of the impacts to Special Status Species occurs from the construction of the structural features, not the nonstructural features. For habitat impacts, onsite compensatory mitigation would be conducted identical to that planned for Alternative 4d which is described in the Environmental Mitigation Plan located in Appendix D.

11.13.3 Alternative 3: Nonstructural Alternative

Alternative 3 would have considerably less adverse impacts to Special Status Species than either implementation of Alternative 2a or 4d because impacts would be restricted to only those species that occur in terrestrial habitats. For federally and state listed species and migratory birds, there could potentially be a negligible to minor, temporary disturbance to them during construction where they would be disturbed and flush from construction areas. However, this would be unlikely because the features would not be constructed in preferred habitats for any of these species. For any of these species we would not anticipate any significant impacts and the implementation of Alternative 3 may affect but would not likely adversely affect the piping plover, the red knot, or the northern long-eared bat. There would be no impact to fish or marine mammals as there would be no construction of features that would occur in their habitats. No

anticipated impacts to bald eagle nesting sites or their associated primary or secondary buffers are anticipated with implementation of Alternative 3. No high, intermittent sound impacts associated with construction are anticipated to occur within 2,640 feet of any reported eagle nests. Therefore, bald eagle nesting is not likely to be disturbed by this project and no Bald Eagle Permit is anticipated to be required for this project.

11.13.4 Alternative 4d: Recommended Plan

Threatened and Endangered Species Under Jurisdiction of the NMFS

Entrainment by Pump Stations (Green Sea Turtle, Loggerhead Sea Turtle, Kemp's Ridley Sea Turtle, and Atlantic Sturgeon)

We would not expect entrainment of neither Atlantic sturgeon nor sea turtles when pump stations are running for storm surge barriers and/or floodwalls. This is largely due to the fact that the probability of Atlantic sturgeon and/or sea turtles being present upstream of surge barriers and pump stations is extremely low because this would not be their preferred habitat. Additionally, the pipes would be fitted with trash prevention devices that have grates approximately three inches in size, which due to the small opening size and the comparatively large size of Atlantic sturgeon and sea turtles, would prevent entrainment of any adult or subadult Atlantic sturgeon and adult or juvenile sea turtles that happened to be in the vicinity of pump stations. Any potential effects would be discountable.

Benthic Habitat Disturbance (Green Sea Turtle, Loggerhead Sea Turtle, Kemp's Ridley Sea Turtle, and Atlantic Sturgeon)

Construction and maintenance of the Proposed Project may affect the availability of benthic prey species and habitats utilized by Atlantic sturgeon and sea turtles, including loggerhead, green, and Kemp's ridley, within the Action Area. Sediment disturbance, construction machinery, and construction/maintenance of surge barriers and/or floodwalls may affect the behavior of Atlantic sturgeon and sea turtles by limiting the availability of habitat and forage. However, the presence of these species in the Action Area would be unlikely as the Action Area is not their preferred foraging habitat. In the unlikely event that sea turtles are in the Action Area, it would be expected that they would move to adjacent areas where there is ample habitat and benthic forage in deep channels outside the Action Area. If any avoidance behavior or alteration of movements occurred, these effects would be insignificant; therefore, any disturbance of benthic habitat and prey availability may affect, but is not likely to adversely affect Atlantic sturgeon or sea turtles. Overall any potential effects would be discountable and insignificant.

Noise (Pile Driving)

Several sources of ambient noise are present in the Action Area. The ambient noise level includes sounds from natural sources (e.g. wind, waves, fish, tidal currents, mammals) and anthropogenic sources (commercial and recreational ships, dredging, pile driving, etc.). Tidal currents produce sounds which are most significant at low frequencies (e.g. 100 Hz). Ship traffic can generate sound that can travel considerable distances in frequencies ranging from 10 to 1,000 Hz. Biological sounds can generate broadband noise in the frequency of 1 to 10 kHz with intensities as high as 60 to 90 dB.

Underwater noise with the potential to affect Atlantic sturgeon, sea turtles, and whales in the

Action Area would consist of noise generated from the construction, maintenance, and operation of the structural project features. The greatest source of noise generated in the Action Area for the Proposed Project would be from pile driving, which may consist of both impact and vibratory pile driving. Four pile types were evaluated in the NCSRM study:

- One-foot square precast prestressed concrete;
- 1.5-foot square precast prestressed concrete;
- Two-foot steel pipe; and
- Four-foot steel pipe

The construction of the structural features would occur over a period of up to approximately two years for the largest storm surge barrier. The maximum construction hours per day would be estimated at eight hours per day. Dahl (2015) in his review of other studies, noted the impact driving occurs at 220 dB at an approximate range of 10 meters from driving 0.75 meter diameter piles and that an underwater sound of 200 dB can occur at a range of 300 meters from piles that are five meters in diameter. Piles used in this study would be less than five meters in diameter, so we would anticipate lower underwater sound levels than those analyzed by Dahl (2015).

Best management practices and mitigation measures would be implemented, to the extent practicable, to avoid impacts to listed species in the Action Area; for example, cofferdams may be used during construction to reduce underwater noise and environmental impacts. Bellmann (2014) noted in his summary of mitigation measures for noise produced by pile driving that cofferdams could reduce underwater pile driving noise by more than 20 dB. Pile driving would be a temporary noise impact and would mainly occur during construction, but could also occur during maintenance of the structural features as needed.

The NMFS GARFO Acoustics Tool (version updated 11/17/2016) was used in the acoustics analysis to aid in determining impacts from pile driving in the Action Area. Because the exact pile size and type is currently uncertain, a number of proxy projects were used to estimate underwater noise impacts to listed species within the Action Area. The estimated sound levels and distances to species injury and behavioral thresholds associated with the Proposed Project are presented in Table 11-3 and Table 11-4. The effects of noise generated from pile driving to Atlantic sturgeon, sea turtles, and whales are further described below.

Table 11-3. Proxy Projects for Estimating Underwater Noise

Project Location	Water Depth (m)	Pile Size (inches)	Pile Type	Hammer Type	Attenuation rate (dB/10m)
Not Available	0	12"	Concrete	Impact	5
Not Available	3	18"	Concrete	Impact	5
Not Available	15	24"	AZ Steel Sheet	Vibratory	5
Geyserville - Russian River, CA	0	48"	CISS Steel Pipe	Impact	2
Geyserville - Russian River, CA	0	48"	CISS Steel Pipe	Cushioned Impact	2
Rodeo, CA - San Francisco Bay, CA	5	24"	Steel Pipe	Impact	3

Project Location	Water Depth (m)	Pile Size (inches)	Pile Type	Hammer Type	Attenuation rate (dB/10m)
Rodeo, CA - San Francisco Bay, CA	5	24"	Steel Pipe	Vibratory	3
Rodeo, CA - San Francisco Bay, CA	5	24"	Steel Pipe	Cushioned Impact	3

Table 11-4. Proxy-Based Estimates for Underwater Noise.

Type of Pile	Hammer Type	Estimated Peak Noise Level (dB _{Peak})	Estimated Pressure Level (dB _{RMS})	Estimated Single Strike Sound Exposure Level (dB _{sSEL})
12" Concrete	Impact	176	161	146
18" Concrete	Impact	185	166	155
24" AZ Steel Sheet	Vibratory	182	165	165
48" CISS Steel Pipe	Impact	198	185	175
48" CISS Steel Pipe	Cushioned Impact	187	174	164
24" Steel Pipe	Impact	203	189	178
24" Steel Pipe	Vibratory	193	179	168
24" Steel Pipe	Cushioned Impact	192	178	167

Atlantic Sturgeon

Exposure to underwater noise levels of 206 dB_{Peak} and 187 dB_{cSEL} can result in injury to sturgeon (Table 11-5). The proxy based estimates for exposure to peak pressure levels that may result in injury are not expected to occur during construction or maintenance of the Proposed Project. When the sound pressure for a single pile strike is below a certain level, then the accumulated energy from multiple strikes would not contribute to injury, regardless of how many pile strikes occur. At some distance from a pile being driven, a fish is far enough away that, regardless of the number of strikes, injury would not occur, this is referred to as “effective quiet.” For the purpose of this analysis, effective quiet is the distance it takes to attenuate sound to 150 dB_{sSEL} (GARFO 2016). Due to the variability in the size and material of piles that may be used for the Proposed Project, proxy estimates for noise attenuation to 150 dB_{sSEL} range from the 20 to 135 m isopleth. For injurious levels of noise to affect Atlantic sturgeon, they would need to remain within the 20-135 m isopleth and be exposed to injurious noise for an extended period of time. This is unlikely to occur, as we would expect Atlantic sturgeon to modify their behavior and move away from the Action Area upon exposure to noise levels greater than 150 dB_{RMS}. Due to the fact that Atlantic sturgeon would be exposed to noise levels that cause behavioral modification (32-185 m) prior to being exposed to potentially injurious noise (20-135 m), it is expected that sturgeon would move away from the sound source prior to being exposed to injurious noise levels. If any sturgeon were within the 150 dB_{sSEL} isopleth at the time pile driving were to commence, it is expected that they would immediately swim away from the noise. Best

management practices will be implemented as practicable, so techniques such as soft start may be used for impact pile driving; this would allow fish in the Action Area to leave prior to peak sound levels, resulting in no injury to Atlantic sturgeon.

Temporary and intermittent noise generated from either vibratory or impact pile driving is expected to have an effect where Atlantic sturgeon would avoid or move out of the Action Area upon being exposed to sound levels above 150 dB_{RMS}. Behavioral modification is not expected to measurably affect any critical sturgeon behaviors, including spawning, foraging, resting or migration. However, because of the location of the Action Area, in general Atlantic Sturgeon would be unlikely to occur and effects would be discountable. Given the relatively small distance to move away from potential noise impacts and that the presence of Atlantic sturgeon in the Action Area would be highly unlikely, any potential noise effects would be insignificant.

Table 11-5. Estimated Distances to Sturgeon/Salmon Injury and Behavioral Threshold.

Type of Pile	Hammer Type	Distance (m) to 206dB _{Peak} (injury)	Distance (m) to sSEL of 150 dB (surrogate for 187 dBcSEL injury)	Distance (m) to Behavioral Disturbance Threshold (150 dB _{RMS})
12" Concrete	Impact	NA	NA	32
18" Concrete	Impact	NA	20	42
24" AZ Steel Sheet	Vibratory	NA	40	40
48" CISS Steel Pipe	Impact	NA	135	185
48" CISS Steel Pipe	Cushioned Impact	NA	80	130
24" Steel Pipe	Impact	NA	103.3	140
24" Steel Pipe	Vibratory	NA	70	106.7
24" Steel Pipe	Cushioned Impact	NA	66.7	103.3

Sea Turtles (Loggerhead Sea Turtle, Green Sea Turtle, Kemp’s Ridley Sea Turtle)

Exposure to underwater noise levels of 180 dB_{RMS} can result in injury, and exposure to 166 dB_{RMS} can result in behavioral disturbances to sea turtles (Table 11-6). Due to the relative uncertainty of piles and hammer type to be used for the Proposed Project, a number of proxy based estimates have been analyzed; based on the estimates, the 48" CISS Steel Pipe and the 24" Steel Pipe have the potential to produce injurious levels of noise (180 dB_{RMS}) during impact pile driving; the 180 dB_{RMS} isopleth for ranges from 35-40 m from the source (Table 4) (GARFO 2016). The distance it takes for 166 dB_{RMS} to attenuate varies depending on pile size and material and hammer type, based on the proxy estimates. For the 48" CISS Steel Pipe and the 24" Steel Pipe, behavioral effects such as avoidance or disruption of foraging are expected to occur at a distance of 105 m and 86.7 m from the source, respectively. Due to the fact that sea turtles would be exposed to behavioral thresholds of noise prior to injurious thresholds, it would be expected that any sea turtles in the Action Area would move away from the sound source. The remaining proxy based estimates for the 166 dB_{RMS} isopleth range in distance from 10 to

53.3 m from the sound source. If any sea turtles were within the 166 dB_{RMS} isopleth at the time pile driving were to commence, it is expected that they would swim away from the noise. Best management practices will be implemented to the extent practical, so techniques such as cofferdams or soft start may be used for impact pile driving; this would allow any turtles in the Action Area to leave prior to peak sound levels, resulting in no injury to sea turtles.

Temporary and intermittent noise generated from either vibratory or impact pile driving is expected to have an effect where sea turtles would avoid or move out of the Action Area upon being exposed to sound levels above 166 dB_{RMS}. Turtles would be considered highly unlikely to occur in the Action Area where pile driving would occur, and any movement or avoidance behavior would be too small to be meaningfully measured or detected; effects would be discountable. Additionally, the surrounding Norfolk Harbor and offshore areas are sufficiently large enough to support foraging, resting, and/or movement of any turtle avoiding the Action Area. Based on this information, effects of pile driving on sea turtles would be insignificant.

Table 11-6. Estimated Distances to Sea Turtle Injury and Behavioral Threshold.

Type of Pile	Hammer Type	Distance (m) to 180 dB RMS (injury)	Distance (m) to 166 dBRMS (behavior)
12" Concrete	Impact	NA	NA
18" Concrete	Impact	NA	10
24" AZ Steel Sheet	Vibratory	NA	NA
48" CISS Steel Pipe	Impact	35	105
48" CISS Steel Pipe	Cushioned Impact	NA	50
24" Steel Pipe	Impact	40	86.7
24" Steel Pipe	Vibratory	NA	53.3
24" Steel Pipe	Cushioned Impact	NA	50

Whales (Sei Whale and Fin Whale)

Sei and fin whales would be classified per the Technical Guidance as Low-Frequency Cetaceans (baleen whales) that have a generalized hearing range of 7-35 kHz (NMFS 2016). A permanent threshold shift (PTS) can be extrapolated from the temporary threshold shift (TTS), both PTS and TTS refer to hearing loss as a result of exposure to either impulsive or non-impulsive sound sources. Temporary threshold shift onset for impulsive noise, i.e. impact pile driving, occurs at peaks of 213 dB or with cumulative exposure (within 24 hours) to 168 dB; the TTS threshold for non-impulsive noise, i.e. vibratory pile driving, may occur with cumulative exposure of 179 dB (NMFS 2016). Permanent threshold shift onset for impulsive noise occurs at peaks of 219 dB or with cumulative exposure (within 24 hours) to 183 dB; the PTS threshold for non-impulsive noise may occur with cumulative exposure of 199 dB (NMFS 2016). Table 11-7 provides proxy estimates for underwater noise for a variety for piles and pile driving techniques, which would be similar to those used for the Proposed Project; none of the estimated peak noise levels exceed levels that would result in TTS or PTS for low frequency cetaceans. Therefore, based on the peak noise levels for proxy-based estimates of noise, the

Proposed Project is not predicted to result in temporary or permanent hearing loss to either sei or fin whales, which although extremely unlikely, have the potential to occur in the Action Area.

For the assessed proxy projects, the distance from an impulsive noise input that would result in a behavioral change to cetaceans ranges from 92-335 m from the source. The distance to behavioral effects is much lower non-impulsive noise inputs, ranging 21.5-184.8 m from the source. Fin and sei whales have a low probability of occurrence in the Action Area, as their preferred habitat occurs in offshore areas. Pile driving would be a temporary and intermittent occurrence, and any presence of a fin or sei whale in the Action Area would be unlikely, and the occurrence of either species in the Action Area during construction is even more unlikely. Noise generated by either impact pile driving (impulsive) or vibratory (non-impulsive) pile driving has the potential to alter the behavior of fin and sei whales in the Action Area, but the alteration would be limited to avoidance, causing whales to move away from noise. Based on this information and the unlikely occurrence of fin or sei whales in the Action Area, the effects of noise on sei and fin whales would not rise above avoidance behavior, and would therefore be discountable and insignificant.

Table 11-7. Estimated Distances to Cetacean Behavioral Thresholds.

Type of Pile	Hammer Type	Distance (m) to 160 dB RMS (behavior for impulsive noise)	Distance (m) to 120 dB RMS (behavior for non-pulse noise)
12" Concrete	Impact	92	NA
18" Concrete	Impact	102	NA
24" AZ Steel Sheet	Vibratory	NA	21.5
48" CISS Steel Pipe	Impact	335	NA
48" CISS Steel Pipe	Cushioned Impact	280	NA
24" Steel Pipe	Impact	240	NA
24" Steel Pipe	Vibratory	NA	184.8
24" Steel Pipe	Cushioned Impact	203.3	NA

11.14 PASSAGE/TRAPPING EFFECTS

If an extreme storm event were to occur, tide gates and surge barriers would be closed. During tide gate and surge barrier closures, tidal fluxes in water would cease for a period of time, potentially reducing water quality, salinity, and dissolved oxygen (DO), while increasing the number of harmful nutrients in the water. The changes in water quality, salinity, DO, and nutrients could cause increased stress levels to benthic resources and/or fish populations, which may lead to increased susceptibility to disease or even a mortality event, though this is relatively uncertain at this time (Tietze 2016; Bachman and Rand 2008). Based on modeling conducted by the VIMS, closure of the storm surge barriers at Pretty Lake and Broad Creek could potentially result in a freshwater pulse in the upstream areas of both Pretty Lake and Broad Creek. This may result in adverse effects to prey resources, potentially limiting forage opportunities in the Action Area if Atlantic sturgeon, sea turtles, or whales are trapped behind storm surge barriers. However, due to habitat suitability and preference, entrapment of Atlantic sturgeon, and especially sea turtles and whales behind storm surge barriers would be considered extremely highly unlikely and discountable.

Additionally, closure of the storm surge barriers and tide gates could result in a trapping effect by impeding passage to Atlantic sturgeon, sea turtles, and whales that could be moving in and out of upstream estuarine areas to feed. We would not expect any mortality of any listed species in the Action Area to be caused by trapping, and this would be a temporary affect as the storm surge barriers and tidal gates would not likely be closed for a period of more than a week at a time.

The construction of surge barriers and tide gates would restrict waterway widths, which may increase flow velocities by limiting the area where tidal ebb and flow can occur. Increased flow velocities may affect passage of Atlantic sturgeon, turtles, and whales. This could potentially affect their daily movement patterns, migrations in and out of the Action area, and foraging in the Action Area. Even so, Atlantic sturgeon, preferring deep channels to forage and move through would likely not be moving into or out of shallow water areas upstream of surge barriers or tide gates; and because of the predominant offshore distribution of whales (sei and fin), we would consider any whales to be an extremely rare occurrence in the Action Area. Loggerhead, Kemp's ridley, and green sea turtles, all of which occur in Virginia coastal waters, have the potential to move through the Action Area, but are not known to occur or move through the Action Area or areas upstream of surge barriers with any regularity or frequency. Therefore, due to the habitat preferences for Atlantic sturgeon, sea turtles, and whales, any change in behavior due to increased flow velocities would be extremely unlikely and discountable.

11.15 TURBIDITY

The installation of project features will disturb bottom sediments and may cause a temporary increase in suspended sediment in the Action Area. Using available information, we expect pile driving activities to produce total suspended sediment (TSS) concentrations of approximately 5.0 to 10.0 mg/L above background levels within approximately 300 feet (91 meters) of the pile being driven (FHWA 2012). The small resulting sediment plume is expected to settle out of the water column within a few hours of sediment disruption. Studies of the effects of turbid water on fish suggest that concentrations of suspended sediment can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993). The TSS levels expected for pile driving (5.0 to 10.0 mg/L) are below those shown to have adverse effect on fish (580.0 mg/L for the most sensitive species, with 1,000.0 mg/L more typical; see summary of scientific literature in Burton 1993) and benthic communities (390.0 mg/L (EPA 1986)).

Atlantic sturgeon would likely be the most sensitive to increased turbidity levels, as their mechanism for breathing involves the movement of water through gill epithelia; increased TSS can clog gills, and thus reduce respiratory efficiency. However, the increase of 5.0-10.0 mg/L of TSS levels caused by pile driving is much lower than the threshold of 580.0 mg/L for adverse impacts to fish. If an Atlantic sturgeon were to be in the Action Area during a period of increased TSS, they would likely swim through or around the area. Similarly, while sea turtle and whale sensitivity to increased TSS levels is unknown, we would expect the threshold for adverse impacts to be higher than that of fish (580.0 mg/L). In the unlikely event that sea turtles or whales are in the Action Area during a period of increased TSS levels, they would likely either make minor modifications to their movements to avoid the area or would swim through the temporary sediment plume. Any change in behavior for Atlantic sturgeon, sea turtles, or whales is anticipated to be immeasurable, and therefore insignificant. Overall any potential effects

would be discountable and insignificant.

11.16 VESSEL INTERACTIONS

Vessel interactions, or propeller/hull strikes, are a proven source of anthropogenic mortality and/or injury for Atlantic sturgeon, sea turtles, and whales. The Proposed Project will not permanently increase vessel traffic in the Action Area. However, construction of the project features, including surge barriers and tide gates, would temporarily increase the number of vessels transiting the Action Area, which is already highly utilized by commercial and recreational vessels. The effects of vessel interactions to Atlantic sturgeon, sea turtles, and whales are evaluated below.

Atlantic Sturgeon

There is a potential for vessel interactions to occur with construction vessels or barge equipment directly and/or to occur indirectly from vessels transiting the Action Area. Atlantic sturgeon interactions with vessels have been documented to occur in the James River (Balazik et al. 2012). The Balazik et al. (2012) study was conducted in the freshwater portion of the James River from 2007-2010 from 31 carcasses of adult Atlantic sturgeon. Twenty-six of the carcasses had scars from propellers and five were too decomposed to determine the cause of death. Nearly all of the carcasses were recovered (84%) from a narrow reach that was modified to enhance shipping efficiency. Balazik et al. (2012) indicated that the vessel interactions were likely caused by deep draft vessels because of the benthic nature of Atlantic sturgeon based on the telemetry study. For this project, we would expect barges containing construction materials to travel at speeds of 10 knots or less that would allow subadult and adult sturgeon enough time to avoid most strike impacts. Also, we would expect that because the barges would not be deep draft vessels that contact with the benthic environment would be unusual. Therefore, because of the limited speed and drafting nature of the vessels, we would anticipate strike hazards to Atlantic sturgeon to be insignificant, as they would likely move away from the potential effects of the Proposed Project. Also, the presence of Atlantic sturgeon in the Action Area would be unlikely as well as this is not their preferred habitat; therefore, effects would also be discountable.

Sea Turtles (Loggerhead Sea Turtle, Green Sea Turtle, Kemp's Ridley Sea Turtle)

Although there is a low probability of sea turtles to occur in the Action Area, implementation of the Proposed Project would result in a slightly increased risk of vessel interactions with sea turtles, as barges would be used to construct the features in waterways. The risk of a vessel strike would be low because of the limited number barges and/or vessels associated with construction and maintenance of features and controlled slow speeds of project vessels. It is estimated that during most operating conditions, vessels would travel at a speed of 10 knots or less. Therefore, we would anticipate any potential vessel interactions with sea turtles as a result of implementation of the Proposed Project to be highly unlikely and discountable and insignificant.

Whales (Fin Whale and Sei Whale)

Based on our review of the stranding data, there was one sei whale stranding that resulted from

a vessel interaction and one fin whale stranding that resulted from a vessel interaction in the Action Area (Swingle et al. 2017-2010; Virginia Aquarium Foundation/Virginia Aquarium Stranding Response Program 2017b). Because this is stranding data, the location of the strike is unknown and it is uncertain if the vessel strikes to the whales occurred in the Action Area.

The speed of vessels is a factor thought to affect the potential risk for whales and vessel interactions. The NMFS (2017) reports that overall, most ship strikes of large whale species occurred when ships were traveling at speeds of 10 knots or greater and that collisions are more likely to occur with ships traveling at speeds of 14 knots or greater. Based on NMFS (2017), the average vessel speed that resulted in injury or mortality to large whales was 18.6 knots. Speed restrictions are not in place in the Action Area. Also, whale strikes have also been recorded to occur at speeds of only two knots (Jensen and Silber 2003); therefore, even with the vessel speed restriction, the risk of a whale strike is likely reduced but not eliminated. In general, at higher speeds, vessel operators may have less opportunity to detect and avoid interactions with whales (Whale and Dolphin Conservation Society 2006). Likewise, whales would also have less opportunity to detect and avoid interactions, and vessel interactions could result in injury or mortality to the whale. Also, the vessel interactions could result in a disturbance effect where there would be a disruption to whale behavior and could potentially cause a whale movement out of the Action Area. This could potentially affect foraging behavior and/or overall movement patterns.

The size of vessels, whale species, age and gender of a whale may be contributing risk factors for interactions with vessels (NMFS 2017; Laist et al. 2001). Vessel interactions with whales have been reported to occur for a variety of vessel types including cargo ships, ferries, cruise liners, navy ships, recreational vessels, fishing boats, whale-watch vessels, research vessels, and non-motorized vessels (Whale and Dolphin Conservation Society 2006; Jensen and Silber 2003). Laist et al. (2001) also reported that all sizes and types of vessels can hit whales, but indicated that the most serious injuries and mortalities were caused by ships that are 80 meters in length or longer. Laist et al. (2001) reported that fin whales are the species most likely to be hit by vessels; this may be related to the whales foraging behavior or amount time spent at the surface. It could also be related to the swimming speed of the whale in relation to the speed of the vessel. The whale's behavior may also be a contributing strike risk factor because whales that are foraging, socializing, or mating may be distracted enough to not notice an oncoming vessel (Whale and Dolphin Conservation Society 2006). Another factor that could elicit vessel interactions is the age and gender of a whale; the Whale and Dolphin Conservation Society (2006) reported that juveniles and mothers may have greatest risk for collision.

With implementation of the Proposed Project, there is a slightly increased risk that a vessel interaction with a whale could occur, as barges would be utilized to construct features in waterways where whales have the potential to occur. However, the presence of a whale in the Action Area would be extremely unlikely because of the preferred offshore distribution of fin and sei whales and the very rare occurrence of vessel interactions with whales in the Action Area; effects would be discountable. In addition, a risk of a vessel strike would be low because of the very limited amount of barges and/or vessels associated with construction and maintenance of features and the limited speed of the vessels. It is estimated that during most operating conditions, barges would travel at a speed of 10 knots or less. Therefore, we would anticipate

any potential vessel interactions with whales as a result of implementation the Proposed Project to be extremely highly unlikely and discountable and insignificant.

11.17 CUMULATIVE EFFECTS

Potential cumulative threats to Atlantic sturgeon, whales, and sea turtles include ship strikes and noise impacts from commercial and recreational vessels that occur throughout their entire range. Exposure to contaminants such as oil spills may also cumulatively affect these species. Another potential cumulative impact to consider is impacts that occur from fishery entanglement. While some of these threats have the potential to impact the Atlantic sturgeon, sea turtles, and whales, implementation of the Recommended Plan is not anticipated to substantially contribute cumulatively to injuries and mortalities resulting from these impacts.

Virginia Port growth is anticipated to increase throughout the next 50 years and a new port facility is planned, which may increase the number of vessels transiting the Elizabeth River. Also, additional development including construction of the Third Crossing and expansion of the Chesapeake Bay Bridge Tunnel is planned in the future. Additional development could increase the risks for impacts to Atlantic sturgeon, whales, and sea turtles attributed to noise, dredge-related entrainment, and/or ship strikes. However, implementation of the Recommended Plan is not anticipated to substantially contribute to those increased impacts to listed species.

Implementation of the Recommended Plan is not anticipated to significantly cumulatively interact with other actions in the Action Area.

Based on the analysis that all effects of the Proposed Project to federally listed species under the jurisdiction of the NMFS with the potential to occur in the Action Area would be insignificant and/or discountable, we have determined that the Norfolk Coastal Storm Risk Management Project is not likely to adversely affect any federally listed species under the jurisdiction of the NMFS and there is no critical habitat in the Action Area.

Table 11-8. Conclusion Table: Threatened and Endangered Species Under the Jurisdiction of the National Marine Fisheries Service.

Species/ Resource Name	Endangered Species Act Section 7 Determination	Notes / Documentation
Atlantic sturgeon	May Affect, Not Likely to Adversely Affect	The Action Areas is not the preferred habitat for Atlantic sturgeon and any potential effects would be discountable. Entrainment from storm surge barrier pump stations is not expected to affect sturgeon. Project construction and maintenance has the potential to have discountable, temporary affects to benthic habitat and forage opportunities. Noise produced from pile driving during project construction and maintenance may result in sturgeon moving out of the Action Area and temporary, immeasurable disturbances to foraging behavior. Storm surge barrier closures could temporarily trap sturgeon behind barriers, potentially temporarily affecting their swimming patterns or foraging, though these effects are discountable. Construction of structural, in-water features may temporarily and insignificantly increase turbidity levels. Direct

Species/ Resource Name	Endangered Species Act Section 7 Determination	Notes / Documentation
		and indirect vessel interactions with sturgeon are unlikely due to the slow speed of vessels (10 knots or less) and shallow draft of potential project vessels. Overall, any potential effects would be discountable and significant.
Fin whale and sei whale	May Affect, Not Likely to Adversely Affect	Fin and sei whales are highly unlikely to occur in the Action Area; so, project effects would be discountable. Noise produced from pile driving during project construction and maintenance may result in whales avoiding or moving away from the Action Area and temporary, immeasurable disturbances to behavior. The extremely rare occurrence of a whale in upstream areas during storm surge barrier closures could temporarily produce trapping effects, potentially affecting swimming patterns or foraging, though these effects are discountable. Construction of structural, in-water features may temporarily and insignificantly increase turbidity levels. Direct and indirect vessel interactions with whales is unlikely due to the slow speed of vessels (10 knots or less) and shallow draft of potential project vessels. Overall any potential effects would be discountable and insignificant.
Sea turtles: green, Kemp's ridley, and loggerhead	May Affect, Not Likely to Adversely Affect	Sea turtles are highly unlikely to occur in the Action Area; effects would be discountable. Entrainment from storm surge barrier pump stations is not expected to affect turtles. Project construction and maintenance has the potential to have discountable, temporary affects to benthic habitat and forage opportunities. Noise produced from pile driving during project construction and maintenance may result in turtles moving out of the Action Area and temporary, immeasurable disturbances to foraging behavior. Storm surge barrier closures could temporarily trap turtles behind barriers potentially temporarily affecting their swimming patterns or foraging, though these effects are discountable. Construction of structural, in-water features may temporarily and insignificantly increase turbidity levels. Direct and indirect vessel interactions with turtles are unlikely due to the slow speed of vessels (10 knots or less) and shallow draft of potential project vessels. Overall, any potential effects would be discountable and insignificant.
Critical habitat	No effect	There is no designated critical habitat located in the Action Area.
Candidate species	No species present.	

Threatened and Endangered Species Under Jurisdiction of the USFWS

11.17.1 Piping Plover and Red Knot

Both the piping plover and red knot have the potential to forage, rest, and/or migrate through the Action Area but do not currently breed in the Action Area. Construction and maintenance of both structural and non-structural features has the potential to slightly impact flight and foraging behaviors of these avian species. Noise generated during construction and maintenance could produce disturbance effects, flushing both piping plovers and red knots from foraging and/or resting areas. In addition, localized sediment disturbances caused by aquatic construction operations have the potential to indirectly affect the foraging success of the piping plover and red knot by disturbing benthic invertebrates and fish. This could potentially impact prey species availability to piping plovers and red knots. Closure of the storm surge barriers and tide gates can result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability. However, it is anticipated that impacts to these species would be immeasurable, and therefore insignificant.

Cumulative impacts to the piping plover and red knot include the loss of barriers and beach nesting, breeding, and foraging habitat. Increased sea levels also have the potential to impact these species, although the level of impact is relatively uncertain. Implementation of the Proposed Project is not predicted to cumulatively or synergistically interact with other past, present, or future projects in such a way that would significantly adversely affect the piping plover or the red knot.

Therefore, implementation of the Recommended Plan may affect, but is not likely to adversely affect the piping plover or the red knot.

11.17.2 Northern Long-eared Bat

There are no known maternal roosting colonies or hibernacula in the Action Area. There are approximately 1.92 acres of tree and forested habitat removal anticipated with implementation of the Recommended Plan, however, any potential long-term habitat loss impacts will be mitigated for with native tree plantings as described in the Environmental Mitigation Plan (provided in the Draft General Reevaluation Report/Environmental Assessment for this project). In addition, the project would provide for additional mitigation to unvegetated pervious surfaces through planting of native canopy trees which would in the long-term increase the overall acreage of canopy trees in the Action Area. The required estimated mitigation for impacts to pervious, unvegetated surfaces would be 1,168 large canopy trees (1.5-2 inches caliper or large evergreen tree of 6 feet height); 2,337 small canopy trees (1.0 inches to 1.5 inches caliper); and three small shrubs. Over time, after the trees mature, the additional tree plantings could potentially provide additional roosting habitat for the northern long-eared bat as compared to current existing tree roosting habitat in the Action Area.

The noise impacts from construction, maintenance, and operation of the structural features may produce a temporary, disturbance effect to the northern long-eared bat. It is anticipated that if bats are in the area they would flush away from the noise and disturbance impacts.

The NCSRM Project would be excepted from the incidental take prohibitions as addressed in the USFWS Programmatic Biological Opinion on Final 4(d) Rule for the Northern Long-Eared Bat and Activities Excepted from Take Prohibitions. There could be some potential adverse effects resulting from tree removal. Implementation of the Recommended Plan would not be

predicted to cumulatively or synergistically interact with other past, present, or future projects in such a way that would significantly affect the northern long-eared bat.

Therefore, because of the tree removal actions, implementation of the Recommended Plan may affect, and is likely to adversely affect the northern long-eared bat.

11.17.3 West Indian Manatee

Because the west Indian manatee is so unlikely to occur in the Action Area, it is unlikely there would be any interactions or impacts to this species. The presence of a west Indian manatee in the Action Area would not be anticipated. There is no Submerged Aquatic Vegetation in the Action Area and therefore, there is no foraging habitat for manatees. Based on our review of the Virginia Aquarium Foundation/Virginia Aquarium Stranding Response Program marine mammal stranding data collected from 2009-2016 (Swingle et al. 2017-2010), there is no reported stranding of this species in the Action Area. Effects would be discountable.

Therefore, implementation of the Recommended Plan may affect, but is not likely to adversely affect the west Indian Manatee.

11.17.4 Bald Eagle Determination

Figure 11-11 depicts the location of bald eagle nesting sites with the mapped primary and secondary nesting buffers as provided by The Center for Conservation Biology (2017). We also considered effects within 2,640 feet of the storm surge barriers because of the substantive noise impacts that could be caused by impact and/or vibratory pile driving.

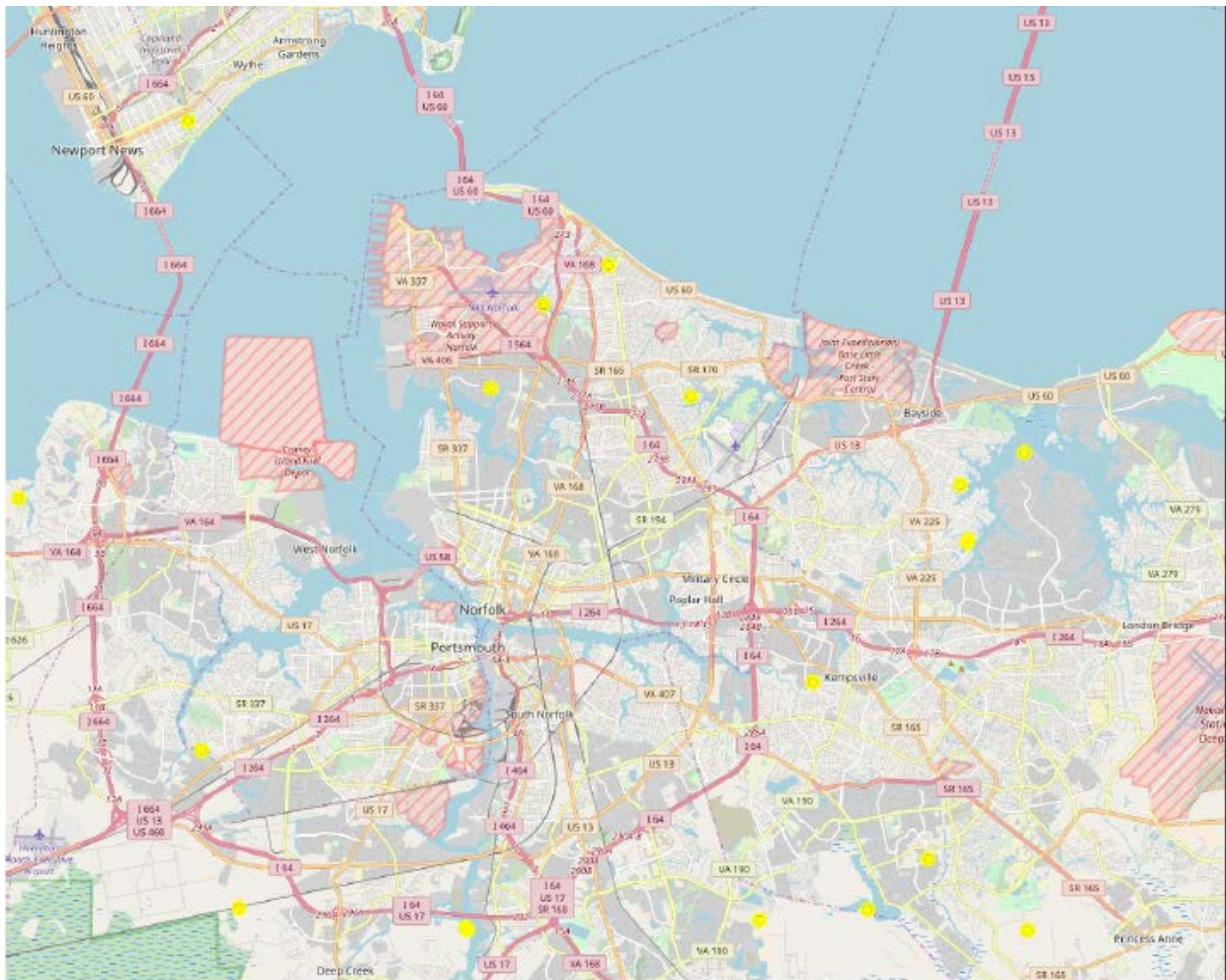


Figure 11-11. Bald Eagle Nesting Sites

Based on this analysis, no impacts to bald eagle nesting sites or their associated primary or secondary buffers are anticipated with implementation of the Recommended Plan. No high, intermittent sound impacts associated with construction are anticipated to occur within 2,640 feet of any reported eagle nests. Therefore, bald eagle nesting is not likely to be disturbed by this project and no Bald Eagle Permit is anticipated to be required for this project. The only potential effect to bald eagles is that construction, maintenance, and operation of the structural features of the project may have a negligible effect to bald eagle foraging in the Action Area. While this could create a negligible to minor disturbance effect, other ample foraging areas would be available and it is not anticipated to have a significant impact on bald eagles that could potentially occur in the Action Area. The Action Area is not located in a Bald Eagle Concentration Area.

Table 11-9 provides the overall summary Species Conclusion Table for federally listed species under the jurisdiction of the USFWS and the bald eagle determination.

Table 11-9. Conclusion Table: Threatened and Endangered Species

Species/Resource Name	ESA Section 7 / Eagle Act Determination	Notes/Documentation
Piping plover and red knot	May Affect, Not Likely to Adversely Affect	Construction and maintenance may slightly impact flight and foraging behaviors but would have a negligible to minor impact. No nesting occurs in the Action Area.
Northern long-eared bat	May Affect, Likely to Adversely Affect	There are no known maternal roosting colonies or hibernacula in the Action Area. Approximately 1.92 acres of tree and forested habitat loss is anticipated but would be mitigated for via native plantings. Project would be excepted from the incidental take prohibitions as addressed in the USFWS Programmatic Biological Opinion on Final 4(d) Rule for the Northern Long-Eared Bat and Activities Excepted from Take Prohibitions. Tree removal could result in some limited take.
West Indian manatee	May Affect, Not Likely to Adversely Affect	Species would not likely occur in Action Area. Effects would be discountable.
Sea turtles: green, hawksbill, Kemp's ridley, leatherback, and loggerhead	No Affect (within the jurisdiction of the U.S. Fish and Wildlife Service)	There is no nesting habitat in the Action Area.
Critical habitat	No effect; Critical habitat not located in Action Area	While there is designated critical habitat for listed species in the Action Area, there is no designated critical habitat located in the Action Area.
Bald eagle	Unlikely to disturb nesting bald eagles. Does not intersect with eagle concentration area. No Eagle Act Permit required.	
Candidate species	No species present.	

Marine Mammals.

The previously described potential risk of impacts to fin and whales from implementation of the project structural features and associated potential cumulative effects would also apply to the remaining non-listed marine mammals.

Similar to the fin and sei whale findings, we would consider risk of other marine mammal vessel strikes to be an insignificant risk because of the limited amount of time the barges or vessels would be in the water and likely due to the limited speed of the vessels (10 knots or less). We would consider any potential noise or disturbance impacts to be insignificant.

In terms of noise impacts, the non-listed marine mammals have varying levels of hearing ranges and therefore, disturbance effects and potentially hearing impacts to the non-listed marine mammals would depend on the species impacted. The marine mammal species that occur in the ROI with their generalized hearing range as described in the NOAA Technical Guidance is summarized in Table 11-10 below.

Table 11-10. Hearing Range of Marine Mammals in the Region of Influence

Hearing Group	Generalized Hearing Range	Marine Mammals in Region of Influence
Low-frequency cetaceans (baleen whales)	7 Hz to 35 kHz	fin whale and sei whale
Mid-frequency cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	bottlenose dolphin, common dolphin, harbor porpoise, long-finned pilot whale, short-finned pilot whale
High-frequency cetaceans (true porpoises, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus cruciger</i> , & <i>L. australis</i>)	275 Hz to 160 kHz	<i>Kogia sp.</i>
Phocid pinnipeds (true seals)	50 Hz to 86 kHz	gray seal, harbor seal

Implementation of the Best Management Practices/mitigation measures as described in Section 6.1 of the Biological Assessment submitted to the NMFS (found in the Appendix) would serve to minimize potential noise, turbidity, and vessel interactions to the maximum extent practicable. Overall, implementation of Alternative 4d would result in insignificant impacts that would not cause population level impacts to any marine mammal Distinct Population Segments or species.

We would consider the cumulative effects described in the fin and sei whale section to also apply to this section and similar to the findings for the previous section, implementation of the Recommended Plan is not anticipated to substantially contribute to cumulative effects.

We would expect impacts to other state listed birds and bats to be similar to those described as the federally listed birds and bats and at the same level of approximate impact. For the barking treefrog and canebrake rattlesnake we would anticipate the potential for a negligible to minor impacts from temporary and permanent loss of some potential habitat as well as disturbance effects that could result from construction of project features. Effects to the habitat could range

from temporary to permanent but permanent effects to habitat would be mitigated through onsite, compensatory mitigation as described in Appendix D. No substantive cumulative or synergistic impacts to state-listed species are anticipated with implementation of Alternative 4d.

11.18 CULTURAL RESOURCES

11.18.1 Approach to Analysis

The analysis of impacts to cultural resources in this study relies on existing information primarily from the Virginia Department of Historic Resources and the designs of project measures available at the time of writing. Although we looked at the entire city of Norfolk as the ROI in the Affected Environment chapter, with the more specific impacts of the final array of alternatives in this chapter we look at more specific areas as the Area of Potential Effect (APE) for NHPA Section 106 compliance.

11.18.2 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no action from the USACE to mitigate against coastal storm risk. It is also assumed that the aforementioned actions by others, as described in the previous sections, would occur.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million HUD grant for disaster resilience, to be implemented in Chesterfield Heights. The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. The placement of sand along may result in a temporary, minor disturbance effect to fish and fishery resources inhabiting the coastal beach habitat. The disturbance from beach replenishment would include increased turbidity and noise disturbances to fish populations in the ROI; however, these affects would be largely diminished within hours of sand placement.

The USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk

Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once is it filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564 to the City of Hampton, with the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

Due to the synergistic effects of factors, including land subsidence and eustatic Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal flooding will rise in the coming years for the city of Norfolk. Without implementation of an action alternative, it is expected that the historic buildings and archaeological sites of the city of Norfolk will become increasingly susceptible to coastal inundation and erosion. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future.

Implementation of the No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. Therefore, effects to cultural resources from implementation of the No Action/Future Without Project Alternative are predicted to be significant and permanent.

11.18.3 Alternative 2a: Structural Only Alternative

The structural only alternative, Alternative 2a, assumes solutions for coastal risk management can be solved with structural measures. These measures include structural measures such as berms, floodwalls, sandbags, surge barriers, and tide gates. Along with structural barriers, drainage improvements and flap gates on outfalls have also been included in Alternative 2a. Implementation of these measures would not cause the demolition or alteration of buildings, historic or otherwise, however there is a potential for landscape and visual effects. Construction of structural measures would involve ground disturbance, and therefore the potential to impact archaeological sites. There are no recorded NRHP eligible archaeological sites in the areas that would be impacted by the proposed structural measures, but little or no survey has been done. Archaeological survey is being deferred to the PED stage of this project through a programmatic agreement.

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, and Mason Creek

The surge barrier, floodwall, and pump station proposed for Area 1 would occur in highly developed areas around Little Creek where there is a low potential for intact sites, so impacts in these areas would have a negligible potential to cause adverse effects.

Area 2: Lafayette River Watershed

Structural measures including berms, tide gates, surge barriers and pump/generator stations are planned to be constructed in industrial and developed areas along the Lafayette River.

Apart from the river bottom, most of the installations on shore areas would not have high archaeological potential due to past disturbances. There are no recorded archaeological sites in or near the measures for this area. Although some measures, particularly the surge barrier across the mouth of the Lafayette River, would be within the viewsheds of some NRHP listed properties, these are closest are the Boush-Tazwell House and the Hermitage Museum and they are respectively .45 and 1 mile away. The outer surge barrier would protect five NRHP historic districts prone to flooding: Colonial Place, Park Place, Riverview, Winona, and Lafayette Residential Annex. These districts include a total of 2,772 contributing properties,

Area 3: Elizabeth River, The Hague, Freemason, Downtown

The measures proposed in Area 3 for Alternative 2a include a floodwall, along which, there a number of proposed tide gates and generator buildings/pump stations, as well as a surge barrier. The Region of Influence (ROI) consists of highly developed residential and urban areas, however this includes sections of the Norfolk waterfront with extensive fill areas. Urban waterfront archaeology has produced significant finds on similar projects, and most of the Area 3 structural measures have a relatively high potential to impact archaeological sites.

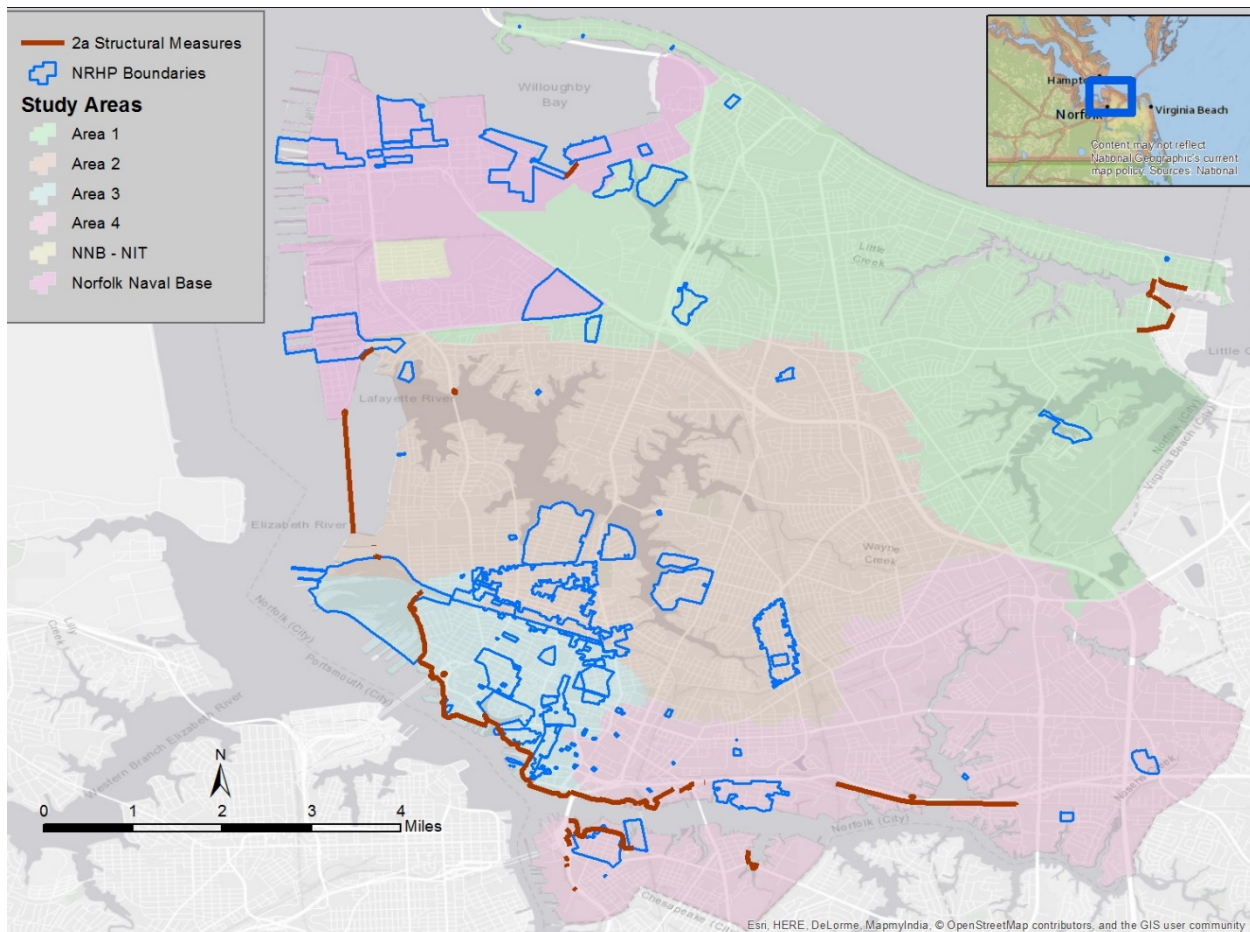


Figure 11-12. Alternative 2a, Structural Only, Measures and NRHP Boundaries

Area 4: Eastern Branch Elizabeth River, Broad Bay, Campostella, Berkeley

The measures proposed in Area 4 for Alternative 2a include construction of a berm and floodwall with associated tide gates and generator buildings/pump stations. Similar to Area 3,

the ROI on the south side of the Eastern Branch (Berkeley) of consists of highly developed residential and urban areas, which like Area 3 may include some fill areas with archaeological potential. On the north side, further upstream where the seawall and surge barrier at Broad Creek is planned the area is more suburban, and there is more potential for early historic and prehistoric sites to be relatively intact.

Adverse impacts to cultural resources from implementation of Alternative 2a are predicted to be potentially significant. Although no recorded archaeological sites are within the areas of potential effect, there is a lack of much prior survey. Creating a surge barrier at the mouth of the Lafayette River could impact shipwreck sites, but extensive prior surveys in nearby areas of the Elizabeth River have not identified significant submerged archaeological sites. Additionally, placement of sand in Area 1 has the potential to create minor, beneficial impacts to unidentified archaeological sites that might be there. Implementation of Alternative 2a is not predicted to cumulatively or synergistically interact with other past, present, and future projects and/or climate change to adversely affect archaeological or built historic properties, other than through the impacts of construction.

11.18.4 Alternative 3: Nonstructural Alternative

The nonstructural alternative, Alternative 3, consists of measures that are applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Physical nonstructural measures include elevation, relocation, buyout, or flood proofing of buildings. Nonphysical measures include flood warning systems, flood preparedness plans, and zoning and flood insurance regulations.

All nonstructural measures are assumed to be applicable across all four city areas. The adverse impacts to historic properties from implementation of Alternative 3 would be, specific to the historic properties treated. Measures that only involve public outreach and more advanced flood warning and preparedness would not result in any land or structure disturbance. If a buyout or relocation of homes and/or businesses at risk to coastal flooding occurred to a building listed or eligible for the NRHP, or contributing to a listed or eligible NRHP historic district, impacts would require mitigation. Figure 11-13 displays the locations for Alternative 3 recommendations for nonstructural treatments on NRHP properties, and unevaluated buildings over 45 years old, and buildings that would have ring walls. The numbers would be staggering (Table 11-11), with 2,072 NRHP listed or eligible buildings subjected to treatments, 138 of them buyouts for demolition.

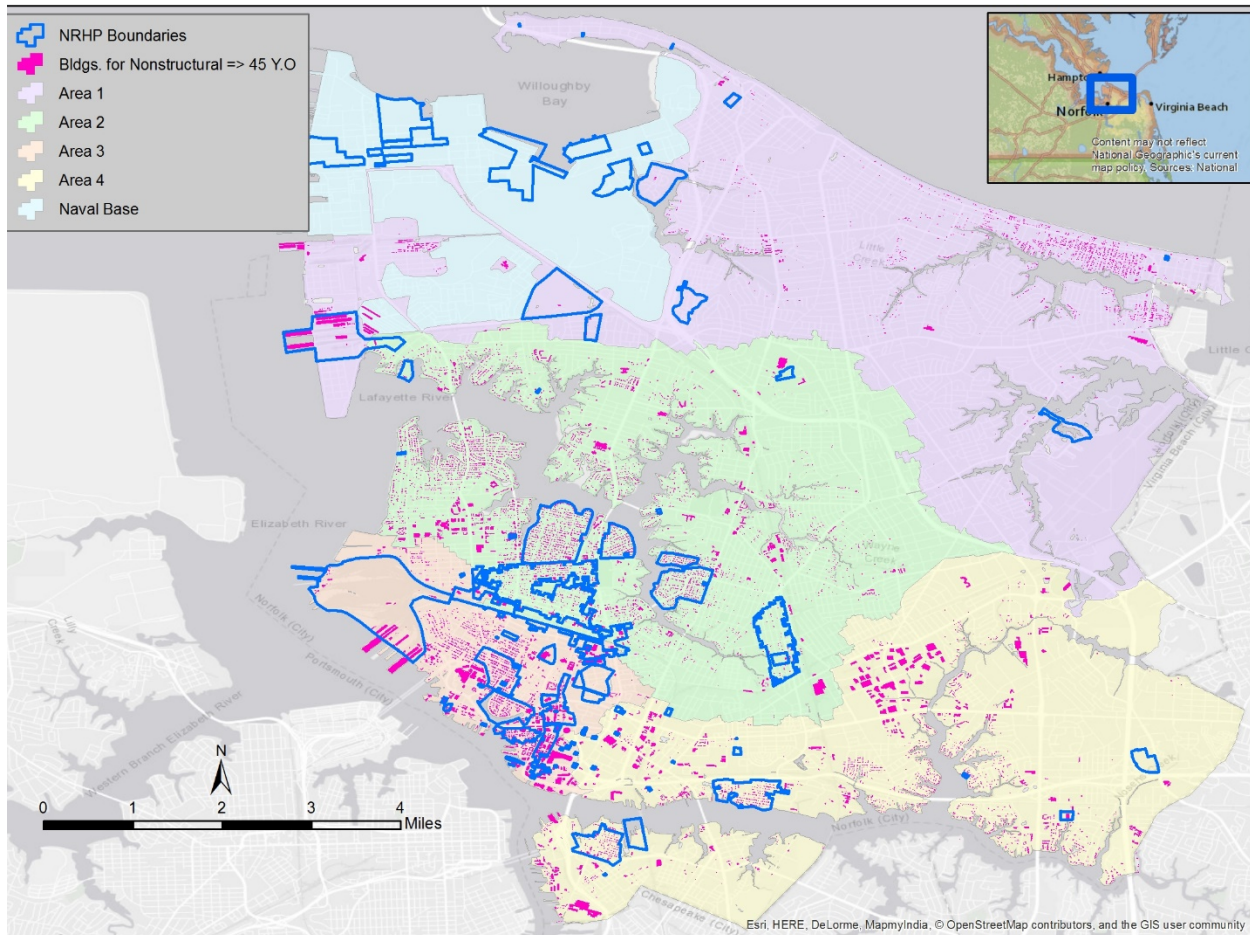


Figure 11-13. Alternative 3 Nonstructural and Ringwall Treatments on NRHP and Potentially Significant Sites

Table 11-11 Number of Buildings Where Nonstructural Measures Would Cause Adverse Effects in Alternative 3

Buildings 45 years or older identified for nonstructural	11,844
Buildings determined NRHP eligible or listed	2,072
Buildings determined not NRHP eligible	1,083
Buildings 45 or older unevaluated for NRHP eligibility	8,689
Nonstructural measure "buyout" on NRHP listed/eligible	138
Nonstructural measure "buyout" on unevaluated	463
Nonstructural measure "raise" on NRHP listed/eligible	291
Nonstructural measure "basement fill + raise" on NRHP listed/eligible	431
Listed/eligible raised total	722
NS measure " raise " on unevaluated	4,164
NS measure " basement fill + raise " on unevaluated	874
Unevaluated raised total	5,038

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, Mason Creek

Very few historic buildings are in Area 1 and few were identified for nonstructural measures; however where ringwalls are prescribed there is the potential to impact archaeological sites.

Area 2: Lafayette River watershed

There are five NRHP listed historic districts subject to flooding on or near the banks of the Lafayette River in Area 2 with a total of 2,772 contributing properties. This area has by far the greatest number of historic properties that may be impacted by nonstructural measures. This area also has an elevated potential for both prehistoric and early historic archaeological sites, due to the resources of the river.

Area 3: Lamberts Point, Elizabeth River, The Hague, Freemason, Downtown

Although fewer in number than in Area 2, Area 3 has many of the oldest buildings in the city, and several historic districts. Prominent among these are the Ghent and West Freemason NRHP listed historic districts where a number of contributing buildings have been identified for nonstructural measures or ringwalls.

Area 4: Eastern Branch Elizabeth River, Broad Creek, Berkeley, Campostella

There are two NRHP listed historic districts in Area 4, Berkley North and Chesterfield Heights, but the latter is already the subject of a flood risk management project and not included in this study, so most of the effects to historic properties from nonstructural measures would be to the Berkley North district.

Potential adverse impacts associated with Alternative 3 are extensive and significant with many NRHP listed or eligible properties identified for physical nonstructural measures. In the case of buyouts this usually means demolition, but even if the building can be relocated, this will generally end its eligibility for the NRHP.

Alternative 3 identifies 2028 buildings for floodproofing protection. Implementation of Alternative 3 is not predicted to cumulatively or synergistically interact with other past, present, and future projects and/or climate change to adversely affect archaeological or built historic properties, other than through the impacts of construction.

11.18.5 Alternative 4d: Recommended Plan

The combination alternative, Alternative 4d, is the NED and the Recommended Plan. It incorporates both structural and nonstructural measures, making the some of the same adverse impacts as the previously mentioned alternatives, Alternative 2a and Alternative 3, but to lesser degrees according to the category of resources. Alternative 2a would implement extensive berms on the Eastern Branch of the Elizabeth River, an area of less intensive suburban development with proven archaeological potential.

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, Mason Creek

Impacts to potential archaeological sites and visual effects to architectural properties from structural measures proposed for Area 1 would be the same as Alternative 2a. Adverse impacts to potential archaeological sites in Area 1 would be minimal, considering the limited areas of structural measures around developed areas near Little Creek. Visual effects to historic properties would be negligible to none due to the lack of identified or potential NRHP properties. There are no NRHP listed or eligible buildings identified for nonstructural measures in Area 1.

Area 2: Lafayette River watershed

Impacts to potential archaeological sites and visual effects to architectural properties from structural measures proposed for Area 2 would be the same as Alternative 2a. Impacts in Area 2 are greatly limited by the creation of the surge barrier across the Lafayette River, protecting five historic districts and obviating the need for ringwalls and nonstructural measures. Although submerged archaeological resources may be there, survey of areas nearby in the Elizabeth River have not found sites. NRHP listed properties are within the viewshed of the surge barrier, as mentioned under Alternative 2a.

Area 3: Lamberts Point, Elizabeth River, The Hague, Freemason, Downtown

Impacts to potential archaeological sites and visual effects to architectural properties from structural measures proposed for Area 3 would be the same as Alternative 2a. Impacts in Area 3 are predicted to be primarily from construction of seawalls where there may be archaeological resources, particularly along the downtown and West Freemason waterfronts.

Area 4: Eastern Branch Elizabeth River, Broad Creek, Berkeley, Campostella

Impacts to potential archaeological sites and visual effects to architectural properties from structural measures proposed for Area 4 would be less than those of Alternative 2a as Alternative 4d does not include seawalls on the southern banks of the Eastern Branch. Impacts in Area 4 may include archaeological impacts, as well as nonstructural measures on buildings contributing to the Berkley historic district. The majority of NRHP listed buildings identified for nonstructural measures in Alternative 4d are in the Berkley North historic district. All NRHP listed buildings and unevaluated buildings over 45 years old identified for nonstructural measures in Alternative 4d are enumerated below in Table 11-12.

Table 11-12 Number of Buildings with Nonstructural Measures in Alternative 4d

NRHP Eligible Buyout	26
Unevaluated Buyout	48
NRHP Eligible Raise	12
Unevaluated Raise	387
NRHP Eligible Basement Fill + Raise	3
Unevaluated Basement Fill + Raise	44

Implementation of Alternative 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on cultural resources. Effects to cultural resources from implementation of Alternative 4d are predicted to be less on the whole than implementation of the other action alternatives, and would protect several historic districts that would be left vulnerable under the no action alternative.

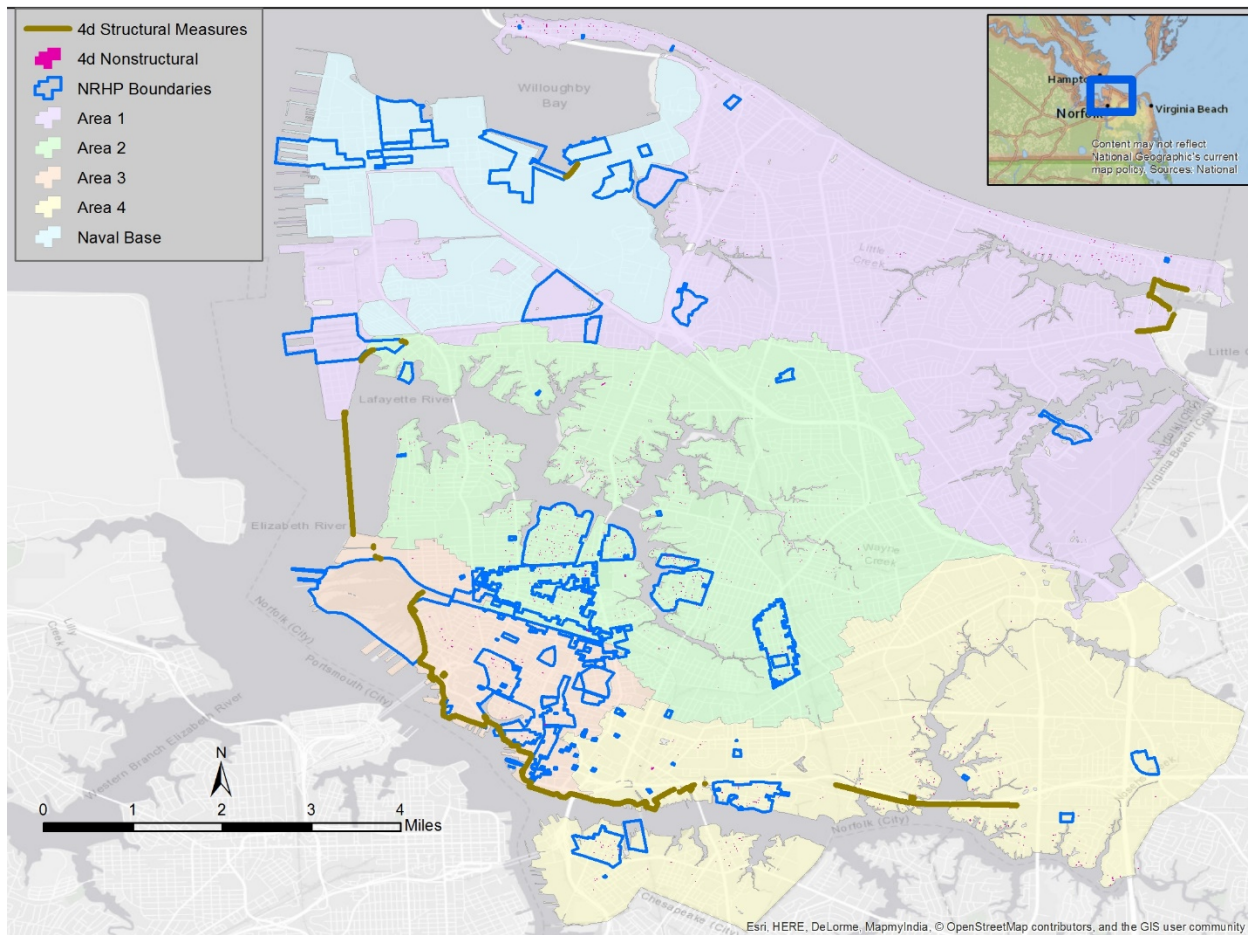


Figure 11-14. Alternative 4d Measures

Most of the historic properties affected by nonstructural measures would be along the Eastern Branch. The surge barrier across the mouth of the Lafayette River would protect the five NRHP historic districts as discussed for Alternative 2a above, and a number of individual listings and potentially eligible unevaluated properties, from the adverse effects of nonstructural measures.

The structural measures only Alternative 2a would have 13.99 linear miles of structural measures (berms, seawalls, etc.), while Alternative 4d would have a little less than that with 12.2 linear miles of structural measures. Based on these figures, Alternative 4d would likely result in less adverse effects to archaeological resources than the other two action alternatives.

As previously mentioned, there has been relatively little archaeological survey within the city of Norfolk. As the selection of a plan with extensive structural measures seemed likely early in this study. This would require extensive archaeological surveys and evaluations of effects to the built environment, forcing excessive costs and delays. Due to time and funding constraints it was decided to defer the completions of cultural resources surveys to the PED stage of the project through a Programmatic Agreement. This document will also set up procedures for resolving adverse effects that may be identified. The draft has been reviewed by the Virginia Department of Historic Resources. The Norfolk Historical Society, Naval History and Heritage Command, and the Delaware Nation have also reviewed and provided comments. A copy of the most recent draft of the Programmatic Agreement (PA) is in the Environmental Appendix.

11.18.6 Cumulative Effects

Implementation of Alternative 2a, 3, or 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects from other actions. The aforementioned PA will address all adverse effects, as the project moves into the PED phase.

11.19 RECREATIONAL RESOURCES

11.19.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk.

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue as a result of burning of fossil fuels and deforestation in the ROI over the next 50 years. Predicted climate change impacts such as increased sea level rise, have the potential to cause changes in the nature and character of the recreational land use in the ROI.

As the 2012 Fugro Coastal Risk Study commissioned by Norfolk notes, “Zoning rules, land use plans, and coastal zone management can be used to prevent construction or restrict the types of development (Building size, density, use, open space preservation) within flood prone areas and to direct future development with regard to relative sea level rise risks. The intent of such planning measurements is to minimize negative impacts associated with building structures that will not optimally withstand events that may occur in a particular area that is prone to flooding. While these plans do not prevent flooding in flood prone areas, they can reduce the damage and risk” (Fugro Atlantic, 2012b). This study has guided the development of the City’s subsequent planning framework, and would be assumed to guide future land use decisions, including recreational land use.

Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed. That project will include tide gates, floodwalls, natural and nature-based features, including greenways, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City’s plan Norfolk 2030 comprehensive plan would be assumed to remain in place. Also the City’s comprehensive plan, “The Plan for Restoring The Lafayette River”, with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place. Such efforts should help improve water quality and thus, recreational use, of the Lafayette River.

The USACE would continue maintenance of the Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project, which is used for recreation. It is also assumed that other major ongoing projects within the City limits and beyond would occur, and that current recreational

facilities mentioned in Chapter 11 would continue to be available for use. The USACE and VPA are currently conducting a feasibility study for Norfolk Harbor and Elizabeth River, Southern Branch deepening projects; although these projects are not yet authorized, they may be implemented in the future. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger ships expected as a result of improvements to the Panama Canal. In addition to these deepening projects, existing maintenance dredging operations, such as Little Creek and Eastern Branch Elizabeth River, and navigation and dredged material placement within the adjoining waterways, would continue. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River. Also, additional development including construction of the Third Crossing from I-564 in Norfolk across the James River/Norfolk Harbor Entrance to the City of Hampton, and expansion of the Chesapeake Bay Bridge Tunnel is planned in the future.

Without implementation of an action alternative, it is expected that the inhabitants of Norfolk, as well as the City's recreational facilities, will become increasingly susceptible to coastal inundation. Due to the synergistic effects from combination of factors, including land subsidence, eustatic and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for city of Norfolk. During storm events and exceptionally high tides, these climate change impacts already negatively impact the recreational land uses currently present within the coastal city of Norfolk, causing low lying areas to be increasingly affected by flooding, or even permanently flooded. Recreational facilities, especially those near waterways such as Town Point Park and Harbor Park, have the potential to experience damage from increased storm surge events. Therefore, the No Action Alternative could entail minor to moderate direct and indirect, temporary and permanent impacts on recreational resources within the City.

11.19.2 Alternative 2a: Structural Only Alternative

Under this alternative, all of the existing ongoing projects and initiatives described under the No Action Alternative, as well as climate change and sea level rise, would be assumed to occur.

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, and Fishermans Cove

The floodwall would extend primarily through commercial districts. It would have temporary adverse impacts including Baypoint Marina, Little Creek Marina, Cobbs Marina, located along Fishermans Cove. Land would also need to be acquired for the construction of generator buildings in this vicinity. Construction within the direct construction footprint, as well as temporary construction staging areas, could temporarily restrict recreational use of the marinas as well as the public kayak launch west of the Route 60 bridge. However, use of the marinas should be able to resume fully upon completion of the project. Natural and nature based features, where compatible with recreational land and water use, may be implemented to the inside or outside of the proposed storm surge barrier. These could also help to improve recreational quality of the waterways by improving water quality.

Negligible to minor temporary and permanent adverse effects on recreational resources are anticipated at this location.

None of the Willoughby/Ocean View beach or its parks, or the Norfolk Botanical Garden, will be affected by this Alternative, as no work is proposed in those areas.

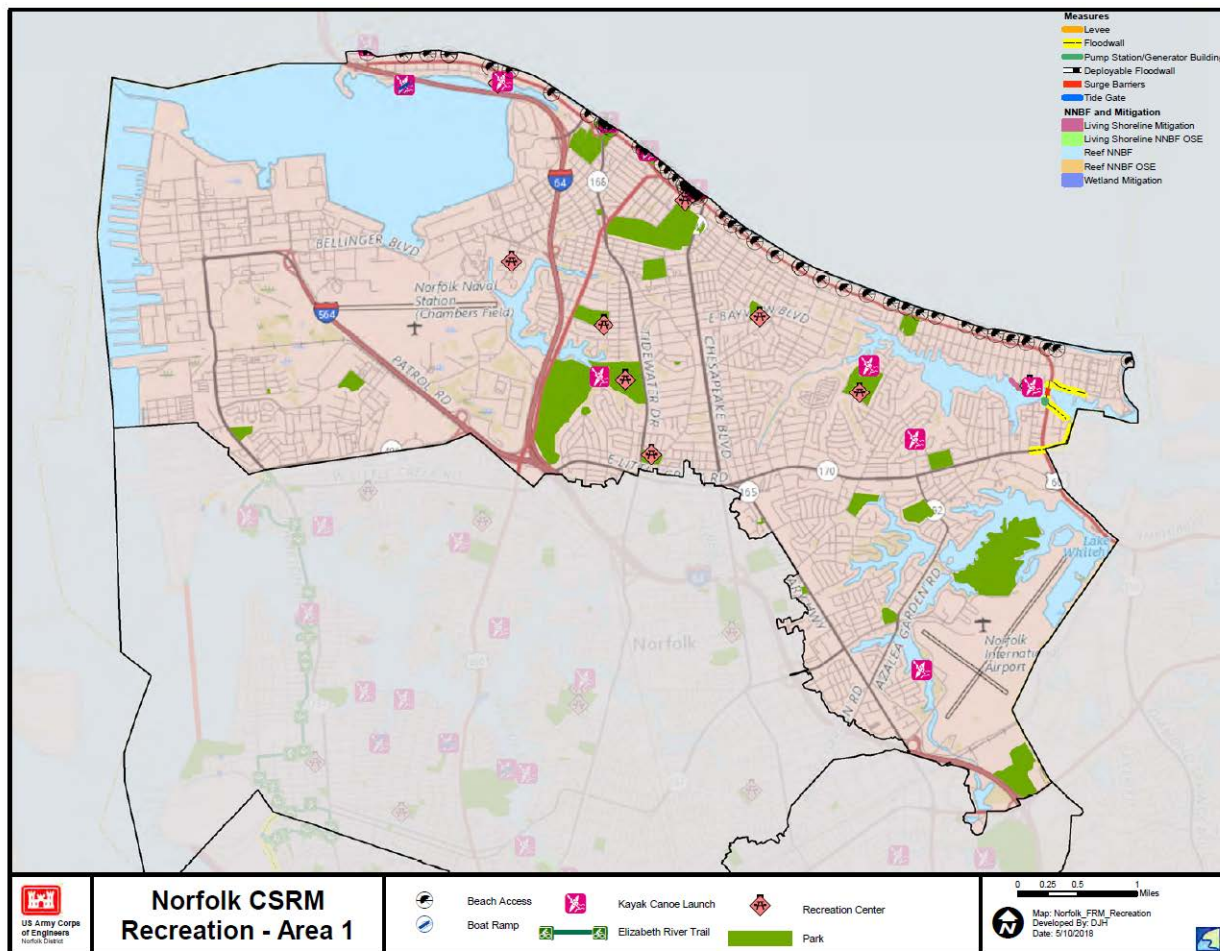


Figure 11-15. Recreational Resources – Area 1

Area 2: Lafayette River watershed

The southern land connection of the storm surge barrier at the mouth of the Lafayette River would occur along the banks of the Lamberts Point Golf Course. Property would need to be acquired for the tie-in to land, and for maintenance, resulting in a permanent impact on the golf course. As a result, use of the golf course will be permanently reduced, and the golf course layout would likely have to be permanently reconfigured in some fashion. In addition, a temporary construction easement would also likely be needed through the golf course for heavy equipment access and possibly construction staging. Part or all of the golf course may need to be closed for use during construction, for safety purposes. This would have both a temporary and a permanent adverse impact on golfers who utilize the course.

Recreational boating will be permanently adversely affected in the Lafayette River by the storm surge barrier, as well as temporarily impacted during construction. Currently, the river is very open at that location, and approximately 6,600 feet wide at the mouth. Mariners are used to having open use of the river through this location; but the barrier will restrict them to approximately nine miter gate openings and one large opening for the USACE Lafayette River

channel. In addition, during construction, the construction area will need to be isolated and thus will be temporarily unavailable for use by mariners, for safety. The navigational impact will be discussed further in the Transportation/Navigation section of this document.

The Elizabeth River Trail (ERT) would not be impacted in Area 2.

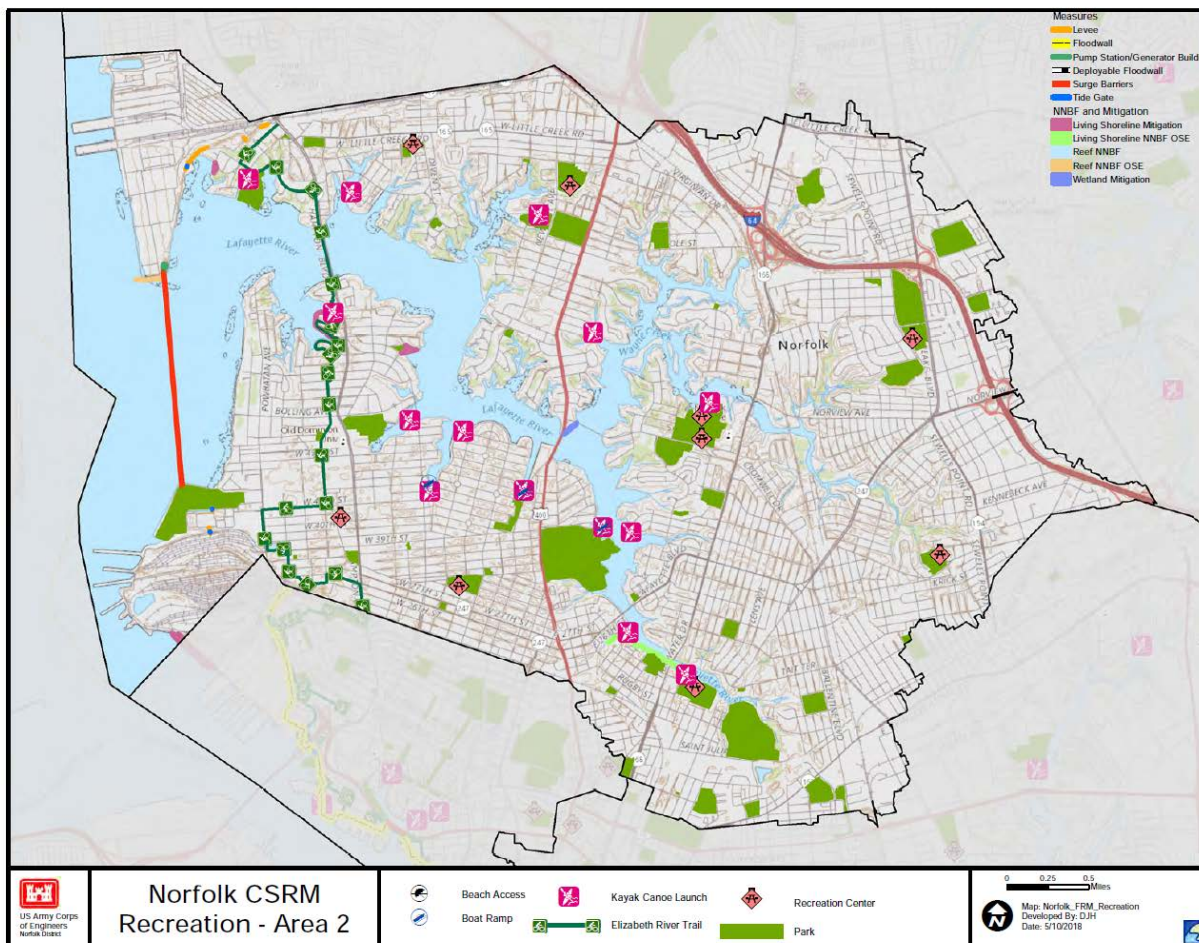


Figure 11-16. Recreational Resources – Area 2

Area 3: Lamberts Point, Elizabeth River, The Hague, Freemason, Downtown

Because the floodwall alignment intersects and/or runs along the same alignment as the ERT, there would be a lot of conflict points during construction. At least portions of the trail would need to be closed during construction, therefore, there would be direct, temporary adverse impacts to use of the trail. However, other areas of the trail that will not be impacted by construction could remain open for use. Once completed, the floodwall should actually complement the trail by helping to prevent storm surge impacts on it; therefore it should have a beneficial permanent impact. Land would also need to be acquired for the construction of generator buildings at various locations along the floodwall, and might have a temporary adverse effect during construction, but is not likely to permanently impact recreational facilities there.

The public’s use of popular venues for concerts and other events, like Waterside and Town Point Park, could be impacted temporarily by construction activities, access, and/or staging

areas as well. However, full use of these areas should resume upon completion of the project, and there should be no permanent impacts there.

Floodwalls will also extend through upland areas for long distances in Area 3, from Lamberts Point, down Brambleton Avenue, through Freemason, and into Downtown. Because the project is in the early stages of design, it is not clear how many openings for pedestrians and bicyclists there will be. Passage of pedestrians and bicyclists in various locations will likely be more limited than it is presently. However, all public and private property would require some type of access; and also, there will be street gates along the floodwall to allow for vehicular, bicycle, and pedestrian use at streets. Public access to popular venues such as Waterside and Town Point Park would be designed into the project. It is not anticipated that the project design would permanently disrupt use of the ERT either. Therefore, the project may result in only minor and temporary to permanent adverse impacts to recreational resources.

While the extensive development of the city of Norfolk's shorelines will inhibit the creation of large wetland sites, there are plenty of sites where natural and nature-based features such as oyster reefs, in conjunction with protection and restoration of fringing wetlands, could be implemented. Living shorelines can also be placed adjacent to hard structures, to aid and/or enhance in their function, reduce maintenance costs and improve the aesthetics of the area.

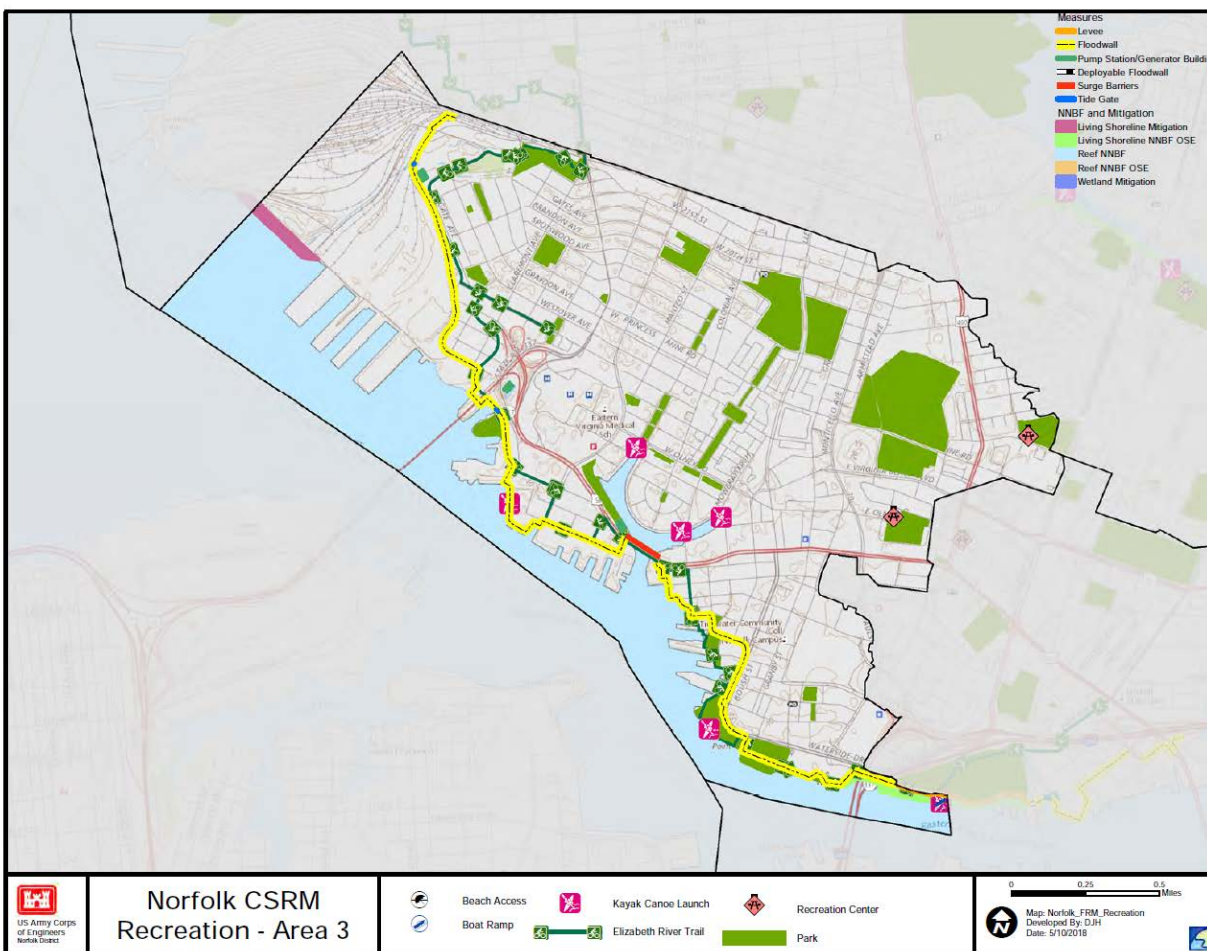


Figure 11-17. Recreational Resources – Area 3

Area 4: Eastern Branch Elizabeth River, Broad Creek, Berkeley, Campostella

The berm to be constructed at Harbor Park will cause minor permanent impacts there, because berm's permanent footprint there may reduce available parking. In addition, there will be temporary impacts at Harbor Park during construction. Existing parking area could be used for construction staging, thereby reducing use of the parking area temporarily. As a result, use of the stadium during construction could be limited.

Floodwalls will also extend through upland areas for long distances in Area 4, from Downtown, past Harbor Park, and ending at the HUD-sponsored Chesterfield Heights/Grandy Village project (shown as EB-6 on the project overview maps). The floodwall resumes east of EB-6, where it parallels the Norfolk Tide rail line to Broad Creek, where there will be a storm surge barrier. Again, it is not clear how many openings for pedestrians and bicyclists there will be along the entire length of the floodwall, although there will be street gates for vehicular, bicycle, and pedestrian use at streets. Passage of pedestrians and bicyclists in various locations will likely be more limited than it is presently. However, all public and private property would require some type of access. Harbor Park is the main recreational use facility within the footprint of the floodwall; and there, the wall and/or berm will be along the shoreline and should not interfere with normal public attendance at baseball games. Therefore, this may result in minor and temporary to permanent adverse impacts to recreational resources.

While the extensive development of the city of Norfolk's shorelines will inhibit the creation of large wetland sites, there are plenty of sites where natural and nature-based features such as oyster reefs, in conjunction with protection and restoration of fringing wetlands, could be implemented. Living shorelines can also be placed adjacent to hard structures, to aid and/or enhance in their function, reduce maintenance costs and improve the aesthetics of the area. Where appropriate and compatible with current and future land uses, natural and nature-based features such as living shoreline with rock toe and subtidal oyster reef may be implemented along the floodwall and adjacent to the storm surge barrier at Broad Creek.

There will be temporary construction impacts associated with the storm surge barrier across Broad Creek. It is likely that the construction area will need to be isolated and restricted from access for safety reasons. Use of Broad Creek is largely for recreational navigation; therefore, there will likely be temporary impact to navigational use and access. However, once completed, the storm surge barrier, with its three gate openings, should be adequate for recreational passage.

Further minor temporary impacts to recreational land and water use at all four storm surge barrier locations, as well as at gate locations in the floodwalls, could occur occasionally for maintenance personnel to gain access and conduct periodic testing of the gates. Likewise, temporary access would be needed to the gates on occasions where the gates must be closed for storms.

Overall, Alternative 2a contains many of the same measures that the City has previously explored, and would be in keeping with its goals of future development for resiliency. However, this alternative would not protect any recreational buildings or structures channelward of the storm surge barriers and floodwalls. As a result, the current recreational uses in those unprotected areas may be adversely impacted in the future by storm surge flooding and sea

level rise. The Lafayette River in particular will be permanently restricted for recreational navigation use at its mouth; however, there will still be adequate access for all such vessels through the gates. The storm surge barriers are designed to protect the property and land uses that occur landward of them; therefore, this Alternative would still protect most of the City's recreational land uses from storm surge for the design storm event.

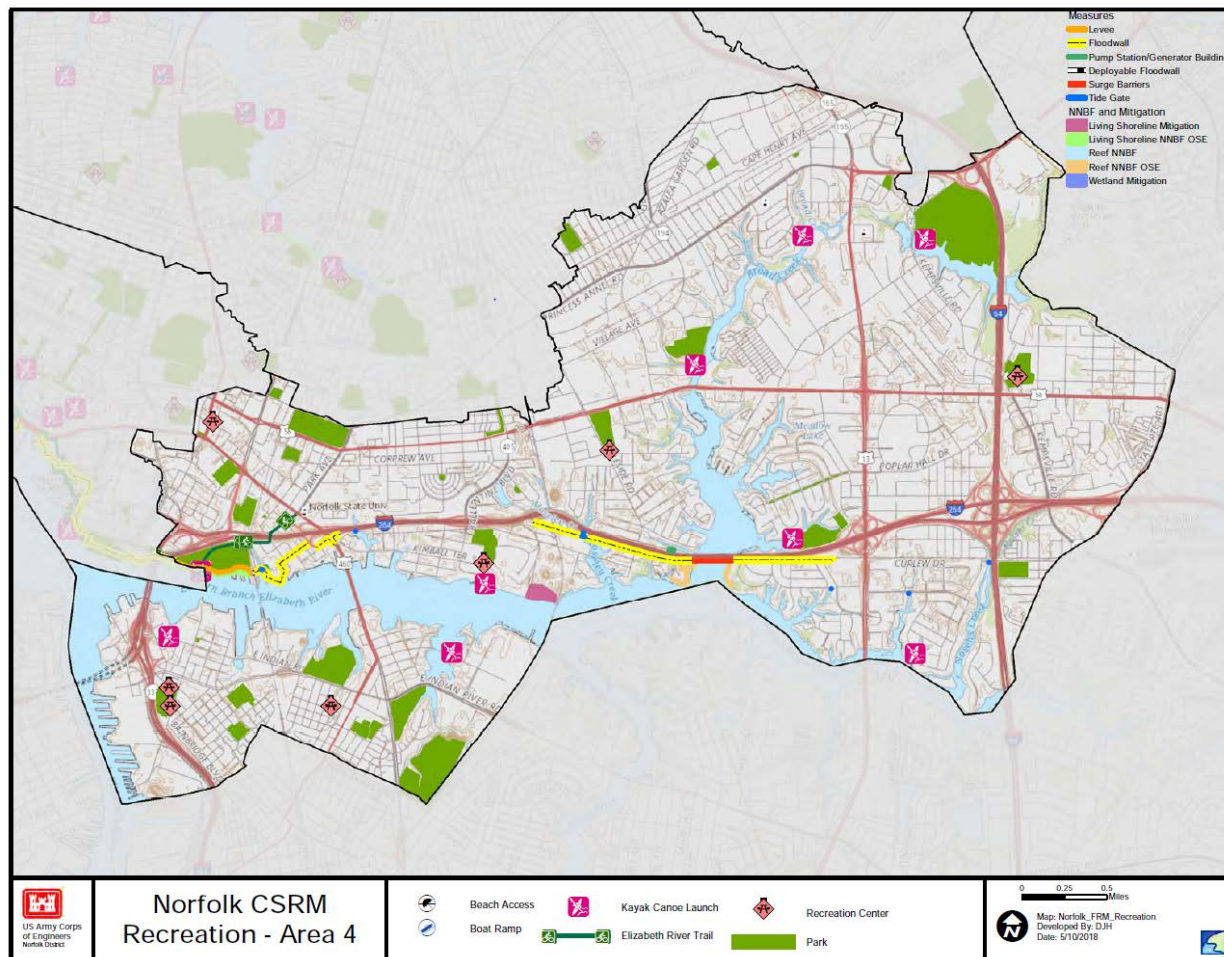


Figure 11-18. Recreational Resources – Area 4

11.19.3 Alternative 3: Nonstructural Alternative

Areas 1-4: Under this alternative, all of the existing ongoing efforts, initiatives, and projects described under the No Action Alternative, as well as climate change, would be assumed to occur. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

For this alternative, structure raises, basement fills, and floodproofing would help protect only individual structures from storm surge. This could disrupt land uses temporarily during construction, as measures are being constructed. However, the land use disruption would likely be mostly limited to those specific structures being protected, and this Alternative should not cause permanent impacts to recreational land and facility use. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

The nonstructural measures throughout the City are very numerous, so they likely protect the most significant at-risk buildings and structures of the City's land uses. In addition, of the four alternatives, Alternative 3 would have the fewest temporary construction and maintenance impacts to the public. However, because this alternative would only address very localized and relatively small selected areas and structures, it would not protect wide expanses of area from storm surge. Open recreational areas such as parks and trails would likely remain vulnerable to flooding; these could still be adversely affected, at least temporarily. Warning systems and preparedness plans would allow people more time to evacuate as needed; however they would not prevent impacts to these resources.

Any of these build alternatives (2a, 3, or 4d) would require compliance with the environmental laws applicable to land use in coastal areas, including the Coastal Zone Management Act (CZMA), the Chesapeake Bay Act (CBPA) (if within 100 feet of a tidal shoreline), and the Virginia Pollution Discharge Elimination System (VPDES) (for temporary and permanent construction discharges). All of these require review by the VDEQ. In addition, all proposed work must be conducted in compliance with the city of Norfolk's land use regulations.

11.19.4 Alternative 4d: Recommended Plan

Areas 1-4: Under this combination structural/nonstructural alternative, all of the existing ongoing efforts, initiatives, and projects described under the No Action Alternative, as well as climate change, would be assumed to occur. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

The impacts for Alternative 4d plan would be the same as those described for Alternative 2a Structural and the Alternative 3 Nonstructural, except that there would be no nonstructural measures implemented landward of the storm surge barriers. This is because those areas would be protected for the design storm event by the structural measures. As described above, the nonstructural measures effects of Alternative 3 are minimal, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

Alternative 4d contains many of the same measures that the City has previously explored, and would be in keeping with its goals of future development for resiliency. Of the four alternatives, Alternative 4d would protect the most of City's recreational land uses from storm surge impacts. Therefore, effects to recreational resource use from implementation of Alternative 4d are predicted to range from moderately beneficial and permanent to minor to moderate adverse effects that are temporary to permanent in duration.

11.19.5 Cumulative Effects

Cumulative temporary impacts from this project on recreational resources could be reduced by phasing work to cause less disruption at a time. Due to the synergistic effects from a combination of factors, including land subsidence, eustatic and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for city of Norfolk. However, implementation of Alternative 2a, 3, or 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or effects from other actions in the ROI, with respect to recreational resources

The following figures show the locations of the measures in relation to recreational use. The floodwalls are shown in yellow; the storm surge barriers are shown in red; the generator buildings are shown in lime green; and the berms are shown in orange. The nonstructural measures are not shown as they are very localized and would be difficult to depict at this scale.

11.20 VISUAL RESOURCES

11.20.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current or planned future actions to mitigate against coastal storm risk. Existing coastal storm risk management features in the city would continue to be maintained.

The city of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in Chesterfield Heights, located in the Ohio Creek Watershed. That project will include tide gates, floodwalls, natural and nature-based features, including greenways, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The city of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's plan Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

It assumed that USACE would continue implementation of major ongoing projects within the City limits and beyond. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening projects have the potential to be implemented in the future. These projects would deepen the required (maintained) depths of the channels to accommodate future, larger Pan-Ex ships. In addition to these deepening, existing maintenance dredging operations, navigation and dredged material placement within the adjoining waterways would continue. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River. Also, additional development including construction of the Third Crossing and expansion of the Chesapeake Bay Bridge Tunnel is planned in the future.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. Placement of sand may result in temporary, minor adverse impacts to the aesthetics of the beach and viewshed. The majority of the Willoughby Beach area is residential and the beach is public, so there is high visual sensitivity in the area.

Without implementation of an action alternative, it is expected that the inhabitants of city of Norfolk will become increasingly susceptible to coastal inundation. Due to the synergistic effects from combination of factors, including land subsidence, global and relative Sea Level

Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for city of Norfolk. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future. Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling, and weather patterns, have the potential to affect the nature and character of the estuarine and coastal ecosystems in the ROI. Without the project, the city is vulnerable to increased storm surge flooding and flood damage. Damaged structures and vegetation could have short-term and long-term effects on visual resources.

Though there are adverse impacts to aesthetics and visual resources, implementation of the No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. Therefore, effects to aesthetics and visual resources from implementation of the No Action/Future Without Project Alternative are predicted to be negligible to minor and temporary to permanent in duration.

11.20.2 Alternative 2a: Structural Only Alternative

Structures including floodwalls, berms, tide gates, surge barriers and pump/generator stations are planned to be constructed and/or augmented in largely industrial and developed areas along the Lafayette River, Pretty Lake, Mainstem and Eastern Branch of Elizabeth River, and Broad Creek. Due to the fact that the city of Norfolk is a highly industrialized port city, approximately 25-55% of the shoreline is hardened with structures for military, commercial, and industrial use (CCRM 2014). Construction of the majority of structures proposed in Alternative 2a would occur in areas where the shoreline has previously been hardened. Structures including berms, floodwalls, tide gates, surge barriers, and generator buildings, would not substantially alter the visual character in Areas 1, 3, and 4; though existing hardening would be augmented, adding height to previously low lying seawalls or revetments. Due to the high volume of people inhabiting and commuting through the city of Norfolk, as well as the small volume of natural/living shorelines, the visual sensitivity is high, so construction and equipment may have moderate and temporary to permanent adverse impacts to the viewshed during the construction and maintenance of the structural measures.

The largest impact to the viewshed would occur in Area 2 where construction of a surge barrier is proposed across the mouth of the Lafayette River. The surge barrier would rise 13.5ft from the riverbed, with approximately 5.5ft of the gate exposed above the surface of the Lafayette River, tide dependent (Figure 11-19). The surge barrier would be constructed in an area of open water with unobstructed views of the Elizabeth and Lafayette Rivers. The banks of the Lafayette River are generally residential, with many of the homes having privately owned docks and watercraft. The Norfolk Yacht and Country Club, as well as the Haven Creek Boat Ramp, are found along the shores of the Lafayette River. As such, the Lafayette River has a high amount of vessel traffic moving into and out of the river through the mouth, which increases the visual sensitivity of the area, especially during the summer months when recreational use of the river is at its peak. Construction of the surge barrier across the mouth of the Lafayette River would reduce the visual quality of the area by impacting the vividness, intactness and unity of the viewshed. The southern end of the surge barrier would abut the Lambert's Point Golf Course, disrupting scenic views from both the golf course and Old Dominion University's Campus boat ramp and dock. Construction of Alternative 2a would produce significant and

permanent adverse impacts to the viewshed within Area 2, while operation and maintenance of the structure would produce additional temporary and minor, localized adverse impacts to the viewshed.

Where compatible, natural and nature based features (NNBF) may be incorporated adjacent to project features. The NNBF would be limited to living shorelines consisting of wetland vegetation, as well as submerged or intertidal rock sills. Creation of living shorelines would improve the visual character in locations disturbed by implementation of Alternative 2a.

Implementation of Alternative 2a has the potential to produce moderate adverse impacts to aesthetics within the city of Norfolk, though the majority of the adverse impacts to the viewshed would occur in Area 2. The structural only alternative would reduce the potential for climate change impacts to disrupt the aesthetics and visual resources in low lying areas of the city of Norfolk. Due to the fact that the city is nearly built out, new construction projects will be limited to primarily redevelopment in the future, though a new port facility in Portsmouth is planned along the mainstem of the Elizabeth River, contributing to the cumulative effects to visual resources in the city of Norfolk.

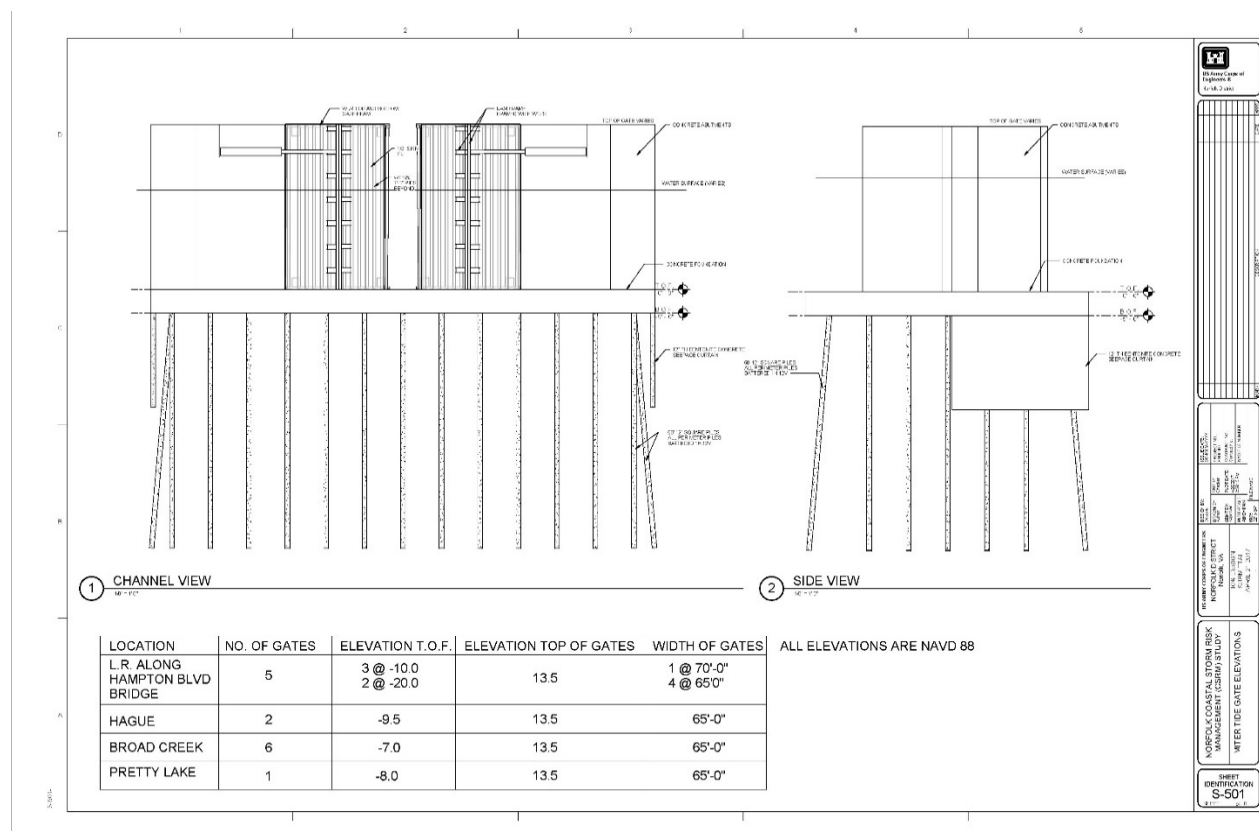


Figure 11-19. Proposed Lafayette River SSB miter gate design (10%)

11.20.3 Alternative 3: Nonstructural Alternative

Implementation of the physical nonstructural measures has the potential to produce varying impacts to aesthetics within the city of Norfolk. Elevating structures susceptible to flooding, including homes and commercial buildings, has the potential to produce minor impacts to the viewshed, depending on the height to which the buildings are raised. In general, the city of

Norfolk is flat, so the raising of homes and/or floodproofing would not inhibit aesthetics from higher vantage points, though construction equipment could adversely affect the visual character of residential and urban areas during the process of raising homes and buildings. Relocation and/or buying-out of residential, commercial, and/or military buildings would alter the viewshed in the city of Norfolk by removing structures that are currently blocking views of scenic/natural areas and restoring built-up areas to their natural state. By removing buildings, there would be permanent moderate, beneficial impacts to aesthetics in the ROI; reverting built-up areas back to their natural state, increasing the visual quality and public access to greenspaces. Removal of structures, followed by natural plantings would result in a temporary and moderate impacts to the viewshed due to the considerable amount of construction equipment necessary to implement the nonstructural component of Alternative 3. Although Relocation of structures could have either beneficial or adverse impacts to aesthetics within the city of Norfolk; but the effects would be minor.

If Alternative 3 were to consist only of nonphysical measures, there would be no impact to aesthetics, as there would be no construction or change to the visual environment within the ROI.

Overall, implementation of Alternative 3 would have the potential to produce minor adverse impacts to the aesthetics within the ROI for structure elevation, relocation, and/or a buyout. The adverse impacts associated with construction of the physical measures proposed in Alternative 3, elevation, buyout, or floodproofing, would be temporary, whereas relocation could result in permanent adverse impacts. A buyout would ultimately revert built-up areas back to a natural state, potentially increasing public greenspaces within the city of Norfolk, thus increasing the visual character and overall aesthetics of the area. Alternative 3 would reduce the potential for climate change impacts to disrupt the aesthetics and visual resources in low lying areas of the city of Norfolk. Due to the fact that the city is nearly built out, new construction projects will be limited in the future, though a new port facility in Portsmouth is planned along the mainstem of the Elizabeth River, contributing to cumulative effects to aesthetics in the city of Norfolk.

11.20.4 Alternative 4d: Recommended Plan

Structures including floodwalls, berms, tide gates, surge barriers and pump/generator stations are planned to be constructed and/or augmented in largely industrial and developed areas along the Lafayette River, Pretty Lake, Mainstem and Eastern Branch of Elizabeth River, and Broad Creek. Due to the fact that the city of Norfolk is a highly industrialized port city, approximately 25-55% of the shoreline is hardened with structures for military, commercial, and industrial use (CCRM 2014). Construction of the majority of structures proposed in Alternative 4d would occur in areas where the shoreline has previously been hardened. Structures including berms, floodwalls, tide gates, surge barriers, and generator buildings, would not substantially alter the visual character in areas 1, 3, and 4; though existing hardening would be augmented, adding height to previously low lying seawalls or revetments. Due to the high volume of people inhabiting and commuting through the city of Norfolk, as well as the small volume of natural/living shorelines, the visual sensitivity is high, so construction and equipment may have moderate and temporary to permanent adverse impacts to the viewshed during the construction and maintenance of the structural measures.

The largest impact to the viewshed would occur in Area 2 where construction of a surge barrier is proposed across the mouth of the Lafayette River. The surge barrier would rise 13.5ft from the riverbed, with approximately 5.5ft of the gate exposed above the surface of the Lafayette River, tide dependent (Figure 11-19). The surge barrier would be constructed in an area of open water with unobstructed views of the Elizabeth and Lafayette Rivers. The banks of the Lafayette River are generally residential, with many of the homes having privately owned docks and watercraft. The Norfolk Yacht and Country Club, as well as the Haven Creek Boat Ramp, are found along the shores of the Lafayette River. As such, the Lafayette River has a high amount of vessel traffic moving into and out of the river through the mouth, which increases the visual sensitivity of the area, especially during the summer months when recreational use of the river is at its peak. Construction of the surge barrier across the mouth of the Lafayette River would reduce the visual quality of the area by impacting the vividness, intactness and unity of the viewshed. The southern end of the surge barrier would abut the Lambert's Point Golf Course, disrupting scenic views from both the golf course and Old Dominion University's Campus boat ramp and dock. Construction of Alternative 4d would produce significant and permanent adverse impacts to the viewshed within Area 2, while operation and maintenance of the structure would produce additional temporary and minor, localized adverse impacts to the viewshed.

Where compatible, natural and nature based features (NNBF) may be incorporated adjacent to project features. The NNBF would be limited to living shorelines consisting of wetland vegetation, as well as submerged or intertidal rock sills. Creation of living shorelines would improve the visual character in locations disturbed by implementation of Alternative 4d.

Implementation of the physical nonstructural measures has the potential to produce varying impacts to aesthetics within the city of Norfolk. Elevating structures susceptible to flooding, including homes and commercial buildings, has the potential to produce minor impacts to the viewshed, depending on the height to which the buildings are raised. In general, the city of Norfolk is flat, so the raising of homes would not inhibit aesthetics from higher vantage points, though construction equipment could adversely affect the visual character of residential and urban areas during the process of raising homes and buildings. Relocation and/or buying-out of residential, commercial, and/or military buildings would alter the viewshed in the city of Norfolk by removing structures that are currently blocking views of scenic/natural areas and restoring built-up areas to their natural state. By removing buildings, there would be permanent moderate, beneficial impacts to aesthetics in the ROI; reverting built-up areas back to their natural state, increasing the visual quality and public access to greenspaces. Removal of structures, followed by natural plantings would result in a temporary and moderate impacts to the viewshed due to the considerable amount of construction equipment necessary to implement the nonstructural component of Alternative 4d.

Implementation of nonphysical, nonstructural measures for Alternative 4d would result in no impact to aesthetics, as there would be no construction or change to aesthetics within the ROI.

Alternative 4d would reduce the potential for climate change impacts to further disrupt the visual character and aesthetics in low lying areas of the city of Norfolk. Due to the fact that the city is nearly built out, new construction projects will be limited to primarily redevelopment in the future,

though a new port facility in Portsmouth is planned along the mainstem of the Elizabeth River. Implementation of Alternative 4d may produce moderate adverse impacts to aesthetics within the city of Norfolk, though the majority of the adverse impacts to the viewshed would occur in Area 2.

11.20.5 Cumulative Effects

Due to the synergistic effects from combination of factors, including land subsidence, global and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for city of Norfolk. However, implementation of Alternative 2a, 3, or 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects in the ROI to affect visual resources.

11.21 SOCIOECONOMICS

11.21.1 Approach to Analysis

Existing demographic and economic information was drawn from the U.S. Census Bureau, Bureau of Labor Statistics, Virginia Employment Commission, and local planning agencies. The impacts of implementing proposed project measures to various segments of the population is considered, especially with regard to the geographic distribution of these population elements and the impacts of the project measures in these areas. U.S. Environmental Protection Agency guidance (USEPA 2010) on environmental justice was considered in evaluating these impacts.

11.21.2 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no action from the USACE to mitigate against coastal storm risk.

As the 2012 Fugro Coastal Risk Study commissioned by the City of Norfolk notes, “Zoning rules, land use plans, and coastal zone management can be used to prevent construction or restrict the types of development (Building size, density, use, open space preservation) within flood prone areas and to direct future development with regard to relative sea level rise risks. The intent of such planning measurements is to minimize negative impacts associated with building structures that will not optimally withstand events that may occur in a particular area that is prone to flooding. While these plans do not prevent flooding in flood prone areas, they can reduce the damage and risk” (Fugro Atlantic, 2012b). This study has guided the development of the City’s subsequent planning framework, and would be assumed to guide future land use decisions.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million grant for disaster resilience, to be implemented in a HUD-sponsored coastal storm risk project in Chesterfield Heights and Grandy Village, located in the Ohio Creek Watershed; rewriting of zoning code to support resilience; and implementation of an additional three feet of required elevation, above the effective FEMA BFE for structures located within the 1% annual chance floodplain (100 year) and an 18 inch freeboard above grade required within the 0.2% annual chance floodplain (500 year) floodplain. The project will include tide gates, natural and nature-

based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is approximately 95-97% developed; therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's plan Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project into the future. USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564, and the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

Due to the synergistic effects of a combination of factors, including land subsidence and eustatic Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for the city of Norfolk. The city of Norfolk is approximately 95-97% built-out; however, it is expected to increase redevelopment in the coming years.

Without implementation of an action alternative, it is expected that the inhabitants of the city of Norfolk will become increasingly susceptible to coastal inundation. These risks include property loss and economic disruption affecting everyone, but often more severely for those who are economically disadvantaged, elderly, disabled, and for those with young children. Some lower income minority communities, such as Spartan Village (Figure 10-41, Census Tract 34), which have experienced impactful flooding in the past would continue to be at risk.

11.21.3 Alternative 2a: Structural Only Alternative

The structural only alternative, Alternative 2a, assumes solutions for coastal risk management can be solved with structural measures. These measures include structures such as berms, floodwalls, sandbags, surge barriers, tide gates, and beach replenishment. Along with structural barriers, drainage improvements and flap gates on outfalls have also been included in Alternative 2a.

Areas 1-4

All have sections where the populace is made up of varying demographics and incomes. Structural measures will benefit all equally, and there would be no apparent disadvantages from the placement of the structures. Natural and Nature-Based Features, along with supporting the ecosystem and reducing maintenance costs of structural measures would improve aesthetics, and these types of measures have been supported by public comments.

Implementation of Alternative 2a would benefit all segments of the population by reducing the dangers of flooding to both persons and property through most of the city of Norfolk. Negative impacts from implementation of Alternative 2a are largely predicted to be negligible and temporary from traffic problems and noise that may result from construction activities. Implementation of Alternative 2a is not predicted to cumulatively or synergistically interact with other past, present, and future projects and/or climate change.

11.21.4 Alternative 3: Nonstructural Alternative

The nonstructural only alternative, Alternative 3, consists of measures that are applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Physical nonstructural measures include elevation, relocation, buyout, or floodproofing of structures. Nonphysical measures include flood warning systems, flood preparedness plans, and zoning and flood insurance regulations.

Benefits from the implementation of Alternative 3 would come from keeping homes livable after a major coastal storm flooding event through raising or floodproofing; and moving residents to less flood prone areas in the case of buyout measures. Negative impacts associated with Alternative 3 are the likelihood that buyout and demolitions are most likely to fall on lower value homes, resulting in displacement of families and segmentation of communities in the case of buyouts. Other measures, such as elevating houses and may prove to be disadvantageous to the elderly and the disabled.

Implementation of nonstructural measures would be administered by the City of Norfolk. Residents would be notified in writing of the eligibility of their properties for these measures. Adoption of the nonstructural measure would be at the discretion of the property owners. The City maintains an Office of Resilience which stages outreach events to inform residents of their options.

11.21.5 Alternative 4d: Recommended Plan

The combination alternative, Alternative 4d, is the NED plan. It incorporates both structural and nonstructural measures.

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, and Mason Creek

This area has the most ethnically and economically diverse population of perhaps any of the four study areas. It does not appear that any residential areas are adversely affected by the measures in Area 1. The floodwall and pump station proposed for Area 1 would protect relatively advantaged areas.

Area 2: Lafayette River watershed

Structures including berms, tide gates, surge barriers and pump/generator stations are planned to be constructed in industrial and developed areas along the Lafayette River, and across its mouth. No homes or residential areas are affected by the footprint of the project. This study area includes a range of incomes and ethnicities, all of which would benefit from flood protection afforded by the measures if implemented.

Area 3: Elizabeth River, The Hague, Freemason, Downtown

The measures proposed in Area 3 for Alternative 4d include a floodwall, along which, there a number of proposed tide gates and generator buildings/pump stations, as well as a surge barrier. The floodwall will cut through residential areas within Freemason; however, those are not disadvantaged neighborhoods. Depending on the land elevation (which varies), the wall may only be a few feet tall in places. Provision of access points will have to be considered in the PED stage of the project. Similar to the measures in Area 2, the impacts would be beneficial for residents.

Area 4: Elizabeth River Eastern Branch, Broad Bay, Berkeley, and Campostella

The measures proposed in Area 4 for Alternative 4d include construction of a berm and floodwall with associated tide gates and generator buildings/pump stations; however, substantial areas would have nonstructural measures only. All structural measures would be on the north side of the Eastern Branch. Due to the nature of the shoreline on the south side of the Eastern Branch and lower property values structural measures could not be economically justified, so only nonstructural measures would be employed there. The south side of the Eastern Branch includes the Berkley and Campostella neighborhoods with more vulnerable, lower income minority populations (Figure 10-41, Census Tracts 50 and 51). Nonstructural measures can impose hardships; however, accepting nonstructural treatments would be voluntary. Buyouts can reduce or break up neighborhood communities. Raising buildings can create difficulties for elderly or disabled people. Although those facts were considered in plan formulation as Other Social Effects (OSE), this was still not sufficient to overcome the low Benefit to Cost Ratios (BCR's) of constructing structural measures.

Structural measures proposed would limit or bar access to the waterways in some areas. These are generally either public areas or affluent residential areas. Provision of access points will have to be considered in the PED stage of the project. Particular areas include the ferry docks at Harbor Park and Waterside, the marina at Waterside, and various private docks near the West Freemason neighborhood and near Broad Creek. The positions of the structures does not divide residential or commercial areas, although they do divide these from industrial areas in some places.

Of the alternatives considered Alternative 4d would have far less impacts to the population of Norfolk than Alternative 3 and the No Action/Future Without Project alternative, if somewhat more than Alternative 2a. Residual risk would pertain to flood levels which exceed the project

levels of protection and malfunction or other failure to properly operate tide gates at flood barriers. Either of these events could result in extensive flooding with disruption of economic and social activity in the city. This study has not modeled the potential for structural measures proposed to induce flooding in other parts of the watershed.

The city has committed to informing vulnerable populations regarding the availability of nonstructural measures. The public will be assisted in performing the steps required to avail themselves of these benefits. The City of Norfolk also participates in the CRS program, which requires properties within the Repetitive Loss Areas to be notified of their flood risk. A postcard is typically mailed to inform residents of their risk; they are directed to the website www.norfolk.gov/reploss. This website can be modified to provide more information for the on other measures to protect property. The City is also in the midst of completing a Program for Public Information which will help to target specific populations of people to provide information too. Vulnerable populations can be added to core groups that will need notification.

Impacts from the implementation of Alternative 4d are predicted to range from highly beneficial to moderately negative. The negative impacts would primarily be the dislocation of families and segmentation of neighborhoods caused by the buyout/demolition of residences; but this could be received as a positive by some residents affected by buyout/demolitions who might rather move to a new house in less flood prone areas.

11.21.6 Cumulative Effects

Due to the synergistic effects from combination of factors, including land subsidence, global and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for city of Norfolk. However, implementation of the No Action Alternative, or Alternative 2a, 3, or 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects in the ROI to affect socioeconomics.

Induced flooding risks were assessed for interior drainage areas and pump stations are recommended where necessary. Regarding inducement of flooding to other areas outside of the project alignment, engineering judgment was used to determine that the risk from a large scale perspective is negligible. On a micro scale there may be wave refraction in areas with structures such as floodwalls. This situation will be modeled in the PED phase.

11.22 HAZARDOUS MATERIALS AND WASTES

11.22.1 Approach to Analysis

Data obtained from the Virginia Department of Environmental Quality (VDEQ) and the U.S. Environmental Protection Agency (EPA) on the locations and nature of hazardous materials and wastes in the Norfolk area were considered for the potential for releases due to the impacts of construction and maintenance activities from project measures, as well as potential for releases due to flooding and erosion in the absence of project measures.

11.22.2 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no action from the USACE to mitigate against coastal storm risk.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million HUD grant for disaster resilience, to be implemented in Chesterfield Heights. The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. The placement of sand along may result in a temporary, minor disturbance effect to fish and fishery resources inhabiting the coastal beach habitat. The disturbance from beach replenishment would include increased turbidity and noise disturbances to fish populations in the ROI; however, these affects would be largely diminished within hours of sand placement.

The USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once is it filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564 to the City of Hampton, with the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

Implementation of the No Action/Future Without Project Alternative could cumulatively or synergistically interact with climate change and/or other cumulative effects. Effects to the distribution of hazardous material from implementation of the No Action/Future Without Project Alternative include exposure of deposits from erosion, and water pollution from the inundation of contaminated areas by flood waters. Therefore, the population of the City of Norfolk, and

surrounding areas, as well as wildlife would be subjected to continued and increasing risks from hazardous materials under the No Action/Future Without Project Alternative.

11.22.3 Alternative 2a: Structural Only Alternative

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, and Mason Creek

The floodwall and pump station proposed for Area 1 would occur in highly developed areas where there could be contaminated sites that might be encountered during construction.

Area 2: Lafayette River Watershed

Construction at the mouth of the Lafayette would have a minimal chance of encountering contaminants, and the structure along with an existing revetment would serve to contain contents of the landfill at Lamberts Point. The storm surge barrier will have to be specially designed to avoid impacts, and particular care must be taken during construction to avoid breaching the landfill.

Area 3: Elizabeth River, The Hague, Freemason, Downtown

The measures proposed in Area 3 for Alternative 2a include a floodwall, along which, there a number of proposed tide gates and generator buildings/pump stations, as well as a surge barrier. Again, the protection of the area from inundation would be a benefit, preventing known and unknown contaminants from floating up in flood waters.

Area 4: Eastern Branch Elizabeth River, Broad Creek, Berkeley, and Campostella

The measures proposed in Area 4 for Alternative 2a include construction of a berm and floodwall with associated tide gates and generator buildings/pump stations. Similar to Area 3, the ROI consists of highly developed residential and urban areas. As with Areas 2 and 3, flood protection would be of benefit with regard to hazardous materials present in this area.

Some of these areas are heavily industrialized and there is the potential for encountering contaminants during construction of floodwalls. Also, in the areas where nonstructural measures would be employed there would be a lesser benefit of avoiding the leaching of contaminants into flood waters.

Adverse impacts involving hazardous materials and wastes from implementation of Alternative 2a are largely predicted to be negligible and temporary during construction; moreover, the implementation of the storm risk management measures would reduce risks of exposure during flooding events. Of particular concern would be the avoidance or removal of underground storage tanks in areas identified for construction.

11.22.4 Alternative 3: Nonstructural Alternative

The nonstructural only alternative, Alternative 3, consists of measures that are applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Physical nonstructural measures include elevation, relocation, buyout, or floodproofing of structures. Nonphysical measures include flood warning systems, flood preparedness plans, and zoning and flood insurance regulations.

Areas 1-4

All nonstructural measures are assumed to be applicable across all four city areas. The adverse

impacts hazardous waste and materials from implementation of Alternative 3 would be minor, and during construction. Those measures that only involve public outreach and more advanced flood warning and preparedness, which doesn't require any land would have no impacts. If a buyout or relocation of homes and/or businesses at risk to coastal flooding occurred, interaction with hazardous materials would be unlikely.. Alternative 3 unlike Alternatives 2a and 4d would offer no general protection from inundation, and therefore would not prevent floodwaters from becoming polluted with contaminants leeching out of the ground.

Adverse impacts associated with Alternative 3 with regard to hazardous materials and wastes are, at most, negligible and temporary during construction. Implementation of Alternative 3 is not predicted to cumulatively or synergistically interact with other past, present, and future projects and/or climate change.

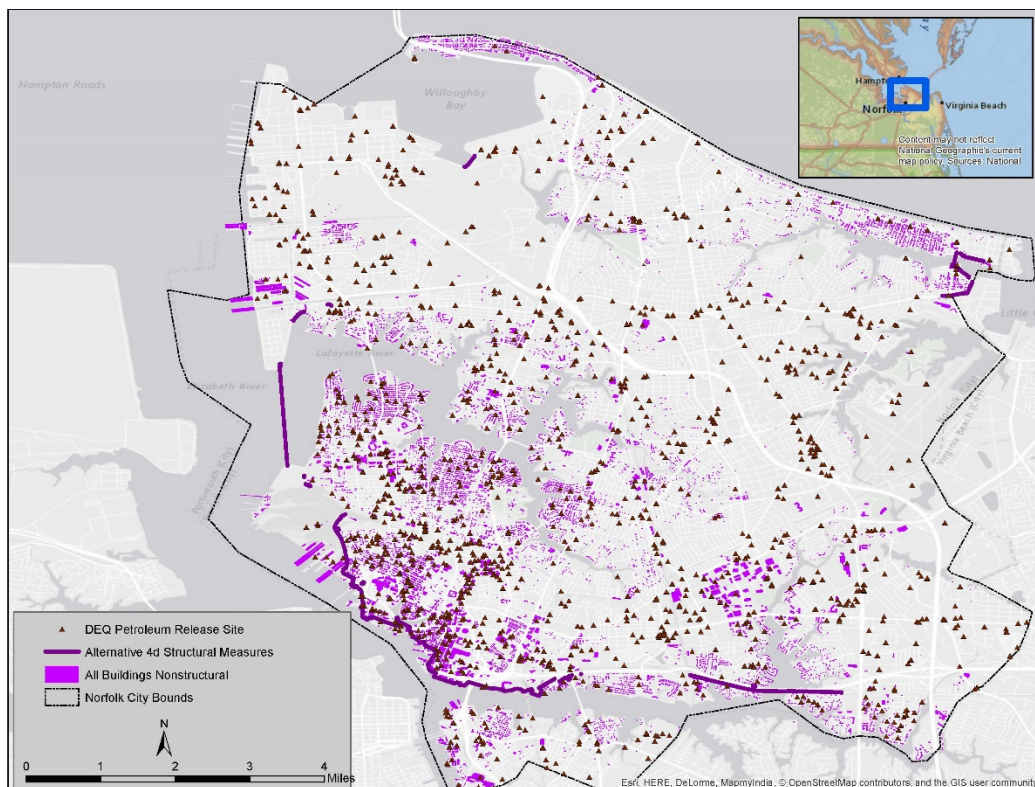


Figure 11-20. Petroleum Release Sites in Norfolk and Project Measures

11.22.5 Alternative 4d: Recommended Plan

The combination alternative, Alternative 4d, is the NED plan. It incorporates both structural and nonstructural measures; therefore its impacts would be the same as Alternative 2a and 3, except that nonstructural measures would only be employed in areas channelward of the storm surge barriers.

We have consulted the databases of EPA and VDEQ, and none of the measures proposed in any of the Action Alternatives would impact any major known hazardous materials and wastes site. The Recommended Plan, Alternative 4d, would have ground disturbing measures, seawalls, in proximity to 4 petroleum release sites; however, these tend to be relatively minor sites. The south end of the Lafayette surge barrier is near a landfill that was not in the VDEQ

database. Impacts to this should be avoided through design, but designs are not yet sufficiently developed to be certain of this.

The greatest potential for significant unknown hazardous materials sites to be impacted is along the main stem and the Eastern Branch where shipbuilding and timber treating industries were located in the late 19th and early 20th centuries, where both Alternative 4d and Alternative 2a would have seawalls. At this stage, there are no known impacts that would require mitigation, but clearly there is the potential for that need.

Typically, a Phase 1 Site Assessment and geotechnical borings are conducted in the PED phase. If contaminated materials are encountered, then a Phase 2 is conducted and a treatment plan is developed. Contaminated materials could be encountered in some of the project areas during construction. Normally the cleanup and removal of any hazardous or contaminated material within a project area is the responsibility of the local sponsor. A report prepared by the local sponsor describing the guidance on the management of materials contaminated, or otherwise, that will be encountered during construction should be considered during the PED phase of the project. The plan would provide information regarding anticipated volume and characteristic of contaminated materials identified so that appropriate plans can be developed to manage the transportation, treatment, and disposal of the contaminated materials.

11.22.6 Cumulative Effects

Recently constructed or proposed projects within or near the ROI, such as the Midtown Tunnel, the Third Crossing, the Chesapeake Bay Bridge Tunnel, and the USACE dredging projects, would be responsible for mitigating the effects of their projects, as per RCRA and/or CERCLA, as applicable. For example, when the Midtown Tunnel was constructed, many contaminated materials, such as creosote piles, lead, and arsenic were discovered, and they were removed and disposed of properly, and/or treated onsite.

Therefore, implementation of Alternative 2a, 3, or 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects within the ROI on hazardous materials. Effects to from implementation of Alternative 4d are predicted to range from moderately beneficial and permanent to negligible to minor and temporary/permanent in duration.

11.23 SAFETY

11.23.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no action from the USACE to mitigate against coastal storm risk. Due to the synergistic effects of a combination of factors, including land subsidence, eustatic and relative Sea Level Rise (SLR), and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for City of Norfolk. Additionally, the City of Norfolk is expected to increase redevelopment in the coming years. Without implementation of an action alternative, it is expected that the inhabitants of City of Norfolk will become increasingly susceptible to coastal inundation. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million HUD grant for disaster resilience, to be implemented in Chesterfield Heights. The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. The USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once is it filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564 to the City of Hampton, with the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

Implementation of the No Action/Future Without Project Alternative is predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. The City of Norfolk is located in a low-lying region, which presents additional challenges in flood mitigation because drainage gradients are limited and nearly portions of the City are below an elevation 15 feet. Close proximity to water paired with low drainage gradients results in a significant percentage of the City being susceptible to flooding from nuisance flooding, typically associated with high tides, to severe, albeit less frequent flooding from hurricanes, tropical storms, and major nor'easters. Under the Future Without Project, erosion, subsidence, and flooding in the City of Norfolk are anticipated to continue to occur which will put the public at risk. Widespread areas within the city would be vulnerable to flooding, leading to various potentially dangerous conditions such as flooded roadways, power outages, and stranded

residents.

11.23.2 Alternative 2a: Structural Only Alternative

The structural only alternative, Alternative 2a, assumes solutions for coastal risk management can be solved with structural measures. These measures include structures such as berms, floodwalls, surge barriers, pump stations, and tide gates. Along with structural barriers, drainage improvements and flap gates on outfalls have also been included in Alternative 2a. NNBFs would also be included where appropriate and practicable. Alternative 2a would protect large areas of the City from storm surge flooding during major storm surge events. It has the potential to produce minor short-term, adverse safety impacts on the public and emergency services during construction; and long-term beneficial effects on safety, due to the prevention of widespread storm surge flooding during major storm events. However, the opening and closing of the many gates may pose temporary safety risks to the public for major storm events, long-term.

11.23.3 Alternative 3: Nonstructural Alternative

The nonstructural only alternative, Alternative 3, consists of measures that are applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Physical nonstructural measures include elevation, relocation, buyout, or floodproofing of structures. NNBFs would also be included where appropriate and practicable. Alternative 3 has the potential to produce minor short-term adverse impacts to the public and emergency services on safety. Implementation will also better protect selected structures within the City of Norfolk from flooding events. However, widespread areas would still be vulnerable to flooding, leading to various potentially dangerous conditions such as flooded roadways, power outages, and stranded residents. Alternative 3 would have minor, short-term adverse effects during construction, and minor beneficial long-term effects.

11.23.4 Alternative 4d: Recommended Plan

Alternative 4d, which is a combination of Alternatives 2a and 3, (structural and nonstructural measures), would reduce coastal storm risk and address residual risk to the extent possible within the authority and planning guidance. In many areas, buildings that are located outside of the structural measures in the alternative that are experiencing high damages will have reduced risk, though nonstructural measures such as elevation and flood proofing. In addition, there are other nonstructural measures under consideration, such as floodplain management and zoning.

Area 1: Willoughby and Oceanview Beaches, Little Creek, Pretty Lake, and Mason Creek

The measures proposed in Area 1 for Alternative 4d include surge barrier, pump station, and floodwall system for protecting the Pretty Lake neighborhood to the west of Shore Drive.

Construction equipment will be operating in the vicinity of roadways the Route 60 (Shore Drive) bridge, and marinas. Construction access may be difficult in places.

Upon completion, it will protect the Pretty Lake watershed and the public from storm surge flooding during a major storm event.

Area 2: Lafayette River watershed

Structures including berms, tide gates, surge barriers, and pump/generator stations are planned

to be constructed in industrial and developed areas along the Lafayette River. Construction equipment will be operating in the vicinity of an existing golf course that was formerly a landfill (Lamberts Point Golf Course), and a major port terminal, Norfolk International Terminals (NIT). Use of both may be temporarily limited during construction. Construction will also occur across the mouth of the Lafayette River, a heavily-used recreational waterway.

Upon completion, the storm surge barrier will protect the Lafayette River watershed—the most at-risk one in the City—from storm surge flooding.

Area 3: Elizabeth River, The Hague, Freemason, Downtown

The measures proposed in Area 3 for Alternative 4d include a floodwall from Lamberts Point to Downtown, along which, there are a number of proposed tide gates, street gates, and generator buildings/pump stations, as well as a storm surge barrier at The Hague. The corridor begins adjacent to neighborhoods near Lamberts Point, extends along a busy primary arterial roadway, and the Elizabeth River Trail (ERT), and then extends through the Freemason neighborhood, which includes very dense residential and commercial development, and Downtown, which is largely dense commercial development, plus popular recreational locations such as Town Point Park. Upon completion, the floodwall and storm surge barrier will protect The Hague watershed and most of Freemason and Downtown.

Area 4: Eastern Branch Elizabeth River, Broad Creek, Berkeley, Campostella

The measures proposed in Area 4 for Alternative 4d include construction of a berm and floodwall with associated tide gates and generator buildings/pump stations. The corridor begins adjacent to Downtown, passes near Harbor Park, a heavily used baseball stadium. It crosses streets, a neighborhood and industrial area, and then parallels the light rail line. A storm surge barrier at Broad Creek will protect its watershed; and the floodwall will protect the southern section of the City, north of the Eastern Branch of the Elizabeth River.

During construction, Alternative 4d has the potential to produce minor adverse short-term safety impacts to the public (motorists, boaters, and pedestrians) and emergency services from the implementation of these measures. Construction areas will have to be secured, in addition to worker safety as prescribed by the Occupational Safety and Health Act (OSHA). The Coast Guard will have specific safety requirements and precautions for construction in navigable waters.

Implementation of Alternative 2a or 4d would produce moderately beneficial long-term effects. However, the opening and closing of the many gates may pose temporary safety risks to the public for major storm events, long-term. To address this and other aspects of the project, the city's Office of Emergency Preparedness will hold very specific public outreach to the entire city regarding these issues. An operation and maintenance manual will also be developed to address the safe operation of the gates.

11.23.5 Cumulative Effects

Implementation of Alternative 2a, 3, or 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on safety. Effects to from implementation of Alternative 4d are predicted to range from moderately beneficial and permanent to negligible to minor temporary adverse effects.

11.24 TRANSPORTATION AND NAVIGATION

11.24.1 No Action Alternative/Future Without Project

The No Action/Future Without Project Alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk.

Transportation. The I-564 intermodal interchange improvements, under construction now, are assumed to be completed.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million HUD grant for disaster resilience, to be implemented in Chesterfield Heights. The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new development, but primarily redevelopment with higher standards. The City's Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. The USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

Construction of the Craney Island Eastward Expansion, to the west of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from two to six lanes, from I-564 to the City of Hampton, with a parallel tunnel at the Hampton Roads Bridge Tunnel, to I-664 in the City of Hampton, may be constructed (The Federal Highway Administration recently completed a Record of Decision, for this project (VDOT, 2017b). A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned. The I-564 intermodal interchange improvements, adjacent to Naval Station Norfolk and Norfolk International Terminals is under construction now and are assumed to be

completed.

In addition, the following transportation projects are on the Hampton Roads Transportation Planning Organization (HRTPO) long-range plan, and may not necessarily all be constructed, but all are assumed so for purposes of this report:

2025:

- High speed ferry from Downtown Newport News to Naval Station Norfolk to Harbor Park.
- High speed ferry from Downtown Hampton to Naval Station Norfolk and Harbor Park.
- High speed ferry from Portsmouth to Downtown Norfolk.
- Light Rail from downtown Norfolk to Naval Station Norfolk.
- Multi-modal transfer activity nodes at Harbor Park, Military Highway, and Norfolk Naval Station for passenger rail, light rail, ferry, bus.

2035:

- I-64 Interchange at Norview Avenue.
- Light Rail from Harbor Park to Greenbrier.
- Street car Harbor Park to Downtown Portsmouth.
- Extension of the Tide from Military Highway Station to Naval Station Norfolk.
- Extension of the Tide from Greenbrier to Military Highway.
- Commuter rail from Harbor Park to Downtown Portsmouth, and points beyond.
- There are also plans for a locally-funded Harbor Park Multimodal High-speed and intercity passenger rail station.
- Hampton Boulevard Railroad Grade Separation.

Improvements to Military Highway (HRTPO, 2017c).

All of these projects would be required to be designed to accommodate expected sea level rise, as per USDOT requirements.

The City of Norfolk would continue coastal and climate resiliency efforts, which includes Vision 2100, a partnership with FEMA Region III for mitigation of flood-prone structures; a \$112 million HUD grant for disaster resilience, to be implemented in Chesterfield Heights. The project will include tide gates, natural and nature-based features, and stormwater improvements. The U.S. Navy is also planning its own resiliency efforts at Naval Station Norfolk.

The City of Norfolk is nearly built out, therefore, future conditions will not consist of new

development, but primarily redevelopment with higher standards. The City's Norfolk 2030 comprehensive plan would be assumed to remain implemented. Also the City's comprehensive plan, "The Plan for Restoring The Lafayette River", with partners Chesapeake Bay Foundation and Elizabeth River Project, whereby the City is participating through storm system and wastewater treatment upgrades, enhancement of riparian corridors, and citizen participation, would be assumed to remain in place.

The USACE would continue maintenance of Willoughby Beach and Dune with the Willoughby Spit and Vicinity Coastal Storm Damage Reduction project into the future. The USACE would also continue to maintain its existing navigation channels as needed: the Little Creek Channel and the Eastern Branch of the Elizabeth River. The USACE and VPA-proposed Norfolk Harbor and Elizabeth River deepening feasibility studies are currently underway, and those projects could possibly be implemented. These projects would deepen the required (maintained) depths of the channels by 1-4 feet, and will accommodate future, larger Pan-Ex ships. Port growth is anticipated to increase throughout the next 50 years, and a new port facility is planned, which may increase the number of vessels transiting the Norfolk Harbor and the Elizabeth River.

In 2014, a parallel two-lane tunnel was added to the Midtown Tunnel, which extends from Area 3, across the Elizabeth River, to the City of Portsmouth. Construction of the Third Crossing, a roadway project which includes the widening of I-64 from I-564 to the City of Hampton, with the Hampton Roads Bridge Tunnel to the City of Hampton, may be constructed. A parallel tunnel along the existing Chesapeake Bay Bridge Tunnel (Route 13), from Virginia Beach to the Eastern Shore, is also being planned.

In addition to considering planned transportation projects, the Future Without Project must consider climatic changes such as sea level rise and increasing global temperatures, which are predicted to continue as a result of burning of fossil fuels and deforestation in the ROI over the next 50 years. Predicted climate change impacts such as increased sea level rise, have the potential to cause changes in the nature and character of the transportation and navigation use in the ROI. As noted earlier, tidal flooding and heavy precipitation events already cause flooding on some roadways in Norfolk.

Many agencies and organizations from local to federal to academia, recognize the potential effects of sea level rise and increased storm surge on transportation infrastructure. In the City of Norfolk alone, numerous studies have been commissioned not only by the City and its consultants, but also the HRTPO, the Virginia Department of Transportation (VDOT), the U.S. Department of Transportation/Federal Highway Administration (USDOT/FHWA), among others.

With regard to land transportation, the City's study done by Fugro Atlantic (2012b) noted the following:

"Flooding of roadways impacts the city via a number of ways. Flooded roadways will require the city to close roads, set detours, and may require special pumps to be deployed to mitigate flooding, which require City manpower and resources to manage. Flooded roadways will also impede vehicular traffic and that traffic may range from City vehicles providing services to the public (eg buses, public works vehicles, etc.) emergency response and police vehicles, vehicles conducted business in the City (eg

delivery truck) and citizen vehicle traffic used to report to work.

Examination of flooded roadway centerline miles highlights areas of possible higher priority in terms of infrastructure projects that address road accessibility reduction and restriction. Three categories of flooding are considered: a) passable at 12" or less is associated with nuisance flooding where flood levels cause inconvenience, but virtually all vehicles ranging from passenger vehicles to emergency response vehicles can still pass, b) emergency only with a flood depth of 12-18" is considered to be passable for emergency response vehicles, but not passenger vehicles, and c) impassable at over 18", which is considered impassable for all vehicles.

Areas more prone to road inundation in terms of extent include the Lafayette River, The Hague, and Pretty Lake project areas. Project areas less prone to road inundation include Downtown and Ohio Creek. The Lafayette River project area displays the largest mileage of flooded roadway centerlines. The Lafayette River project area alone represents half of flooded roadway centerlines for the city. The Hague and Pretty Lake follow the Lafayette River project area in terms of percentage of flooded roadway centerlines.

An understanding of the extent and impact of flooding on a city wide basis aids in identifying roadway prone to flooding, particularly those that are prone to flooding at more severe levels, which can diminish accessibility to vehicles. In a 1% annual chance coastal flood even, significant inaccessibility may occur in Tidewater, The Hague, portions of Lafayette River closest to river waterbody, Larchmont, Willoughby, and Ocean View. When taking 1-foot sea level rise into account, the aforementioned areas have an increased possibility of more widespread road accessibility due to flooding" (Fugro Atlantic, 2012b).

HRTPO is also conducting the Hampton Roads Military Transportation Needs Study: Roadways Serving the Military and Sea Level Rise/Storm Surge. In the first phase (July 2013), HRTPO staff reviewed the "Roadways Serving the Military" to determine deficient locations, such as congested segments, deficient bridges, and inadequate geometrics. This third phase of the study continues the work in Phase One by determining flooding-based deficient locations along the roadway network. It expands upon the work and methodologies developed by the Hampton Roads Planning District Commission (HRPDC) and the Virginia Institute of Marine Science (VIMS), by identifying military roadway segments vulnerable to submergence. Additionally, submergence of other local roadways that provide access to and from the "Roadways Serving the Military" which may be vulnerable to flooding have been identified.

The HRTPO and USDOT also recognize the future impacts on transportation from sea level rise and storm surge, and other climatic changes are affecting the reliability and capacity of the U.S. transportation system. The HRTPO and USDOT recognize that Hampton Roads including the Norfolk area, second only to New Orleans in terms of vulnerability to sea level rise in the United States, is seeing more frequent storm surges and higher tides than before. Based on past storm events, Hampton Roads' East Coast location makes it prone to significant storm surges about every four to five years; and as sea levels continue to rise, some areas that have not seen flooding will start to experience it which will have major infrastructure impacts. Repetitive

flooding at critical transportation facilities can severely impact travel and hurt regional and local economies. When streets are impassable during and after flooding events, it often results in damages to personal property and missed work time, which has a crippling effect on communities (HRTPO, 2017d).

HRTPO has partnered with Hampton Roads Planning Commission District (HRPCD) to conduct a comprehensive GIS-based flooding vulnerability analysis for potential sea level rise and storm surge impacts to regional roadways by 2045 (the next Long-Range Transportation plan horizon year). Their work is based on a more conservative determination of 2.0 feet of rise could occur in Hampton Roads between 2043 and 2083, rather than the 1.5 feet of rise in 50 years upon which this current study is based. HRTPO is also considering the effects of 25-year and 50-year storm surges. They found that the most significant threat to our primary roadway infrastructure was deemed to be the storm surges. The HRTPO also recommended that planners within cities develop a detour plan for all roadways that are projected to be submerged as per these criteria. It also recommended that localities include climate change mitigation measures and adaptation projects into ongoing capital improvement plans, and implement adaptation strategies. (HRTPO, 2016).

In the May 2016 study, Hampton Roads TPO indicated that by Long-Range Design Planning Year 2045, the following scenarios could occur in Norfolk by 2045. This includes all roadways (interstate highways, arterials, collector streets, ramps, and roads on military installations). Of the 788 total centerline miles,

- Approximately 4.8 miles (0.6%) of roadway centerlines would be flooded with two feet of SLR only;
- Approximately 182 miles (23.9%) of roadway centerlines would be flooded with 2 feet SLR plus 25-year storm surge
- Approximately 242.2 miles (30.7%) of roadway centerlines would be flooded with 2 feet SLR plus 50-year storm surge

HRTPO recommended the following strategies: new flood barriers, elevating specific elements of critical infrastructure so they would be above flood elevations; moving entire facilities to higher ground, designing new assets for quick restoration after an extreme weather event, modifying street and/or roadway design standards and guidelines, and evacuation route planning. (HRTPO, 2016).

Hampton Roads Climate Impact Quantification Initiative, Baseline Assessment of the Transportation Assets and Overview of Economic Analyses Useful in Quantifying Impacts (September 2016), was sponsored by the U.S Department of Transportation's Center for Climate and Environmental Forecasting, Research, Development, and Technology office. Its abstract states:

The Hampton Roads Climate Impact Quantification Initiative (HRCIQI) is a multi-part study sponsored by USDOTwith the goals that include developing a cost tool that provides methods for voluntary greater consideration of financial impacts in

infrastructure planning due to climate change and severe weather. This baseline study conducted in collaboration with several DOT modes, and based on extensive consultation with regional governmental military and industry stakeholders, summarizes available data, methodologies, and tools to inform a robust analysis of the economic impacts of climate change and severe weather related disruptions on the regional transportation infrastructure. DOT chose to study Hampton Roads regional based on its unique attributes, including its: extreme vulnerability to SLR, that is beginning to threaten transportation system and military operations, strategic significance as home to the nation's largest concentration of federal facilities, including the world's largest naval station; and the partnership opportunities afforded through the intergovernmental pilot program and its partners' deep expertise in analyzing and addressing these impacts. DOT is intending to conduct follow on work building on this baseline study (USDOT 2016).

Because there would be no storm surge barriers or floodwalls constructed, no direct or indirect temporary or permanent construction impacts would occur with this project. However, as described earlier, there are impacts due to expected storm surge and sea level rise, associated with the No Action Alternative, as mass transit and in particular travel by roadways would become increasingly more impacted by flooding and storm surge. As a result, traffic backups and strandings and re-routing of traffic onto alternate routes might occur, altering existing traffic patterns and causing increased travel delays. This would have the potential to cause a significant impact on impact travel at various locations throughout the Study Area.

Navigation. All USACE federal channels will keep being maintained. As mentioned earlier, the USACE and the Virginia Port Authority (VPA) are currently conducting feasibility studies for the deepening of Norfolk Harbor and Elizabeth River Southern Branch, and those may be implemented in the future. Additionally, the VPA, and likely others, will be planning deepening of their terminals area at NIT and other locations, in response to the channel deepening. All of these would be assumed to be implemented.

Construction of the Craney Island Eastward Expansion, to the west of the city of Norfolk and across the main stem of the Elizabeth River, would also be constructed. It is a 510-acre expansion that would ultimately have a port built on it, once it is filled. It is not within the ROI for this study, but is within the watershed.

Because there would be no storm surge barriers constructed at waterways that are currently used for navigation, there would be no new navigational restrictions at Pretty Lake, the Lafayette River, and Broad Creek. In addition, there would be no temporary construction impacts on any of the marinas and/or recreational boating traffic in Pretty Lake, the Lafayette River, or Broad Creek. There also would be no temporary construction impacts anywhere within the Study Area. This Alternative would have no direct adverse effects on the navigation channel system.

However, as described earlier, under this Alternative, vehicular access on roadways to and from navigationally-dependent military, industrial, and commercial facilities, could be hampered in the future by flooded and/or damaged roads. This could indirectly hamper the navigation operations. Therefore, based on the foregoing, implementation of the No Build/Future Without Project would have direct and indirect, potentially significant, beneficial to adverse effects that are temporary to permanent in duration.

11.24.2 Alternative 2a: Structural Only Alternative

Area 1--Willoughby, Ocean View, Mason Creek, Little Creek, Pretty Lake,

Under this alternative, all of the existing ongoing transportation and navigation efforts, initiatives, and projects described under the No Action Alternative, as well as climate change, would be assumed to occur. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

Transportation. The alignment passes through marinas, cuts along East Little Creek Road and extends west across Shore Drive. Total alignment length of floodwall is estimated to be approximately 2,300 linear feet. A street gate will be required for the section of wall that crosses Shore Drive (Rt 60). The gate will remain open for traffic flow during low water periods and will be closed only during major storm events that necessitate closure. The walls are assumed to be approximately 2 to 3 feet in height with an elevation of 10 feet NAVD88.

Long lengths of floodwall will parallel Pretty Lake Avenue, south and adjacent to Joint Expeditionary Base Little Creek Fort Story, and Little Creek Road. The number of pedestrian gates to be built into the floodwalls has not been determined at this stage of design; but pedestrian access could be more restricted in places.

The floodwall and a gate crossing will cross Shore Drive, a primary arterial roadway, near Little Creek Road. Temporary, direct, and potentially significant impacts to transportation flow in northeastern Norfolk could occur due to closures of the gateway across Shore Drive (Route 60). During storm events that necessitate closure of the street gate, Shore Drive would be blocked at that location by the gate closure, potentially requiring those who are evacuating or sheltering in place and emergency vehicles to use an alternate route—most likely Little Creek Road (Route 165) or Northampton Boulevard (Route 13). The closures could last several days. This would also increase congestion on the alternate routes. In addition, temporary gate closures across Shore Drive may be necessary from time to time for maintenance and to test the operation of the gates. These could be timed for low traffic volume timeframes.

USACE recognizes the close proximity of the floodwalls and street gates to the Naval Base south of Fisherman's Cove, as well as the adverse effect that it and street gate closures, may have on the Naval Base. Specifically, the Shore Drive street gate is located in the Base's Gate 1 entrance. The Navy has indicated that during certain events, Gate 1 is the only ingress and egress point for the Base. The Navy has indicated that it is vital that Gate 1 not be impacted by closures of the Shore Drive street gate.

The project is in the early stages of design at this time. During the PED phase of the project, the USACE and the City will coordinate with the Navy to ensure that both the needs of the City and Navy operational needs are considered, and adverse impacts are minimized.

In addition, an operation and maintenance manual will ultimately be developed for the project. It will have much more detailed information about how and when the gates will close, notification procedures and instructions to the public, and how the maintenance operations will be conducted. The City is also in the midst of completing a Program for Public Information to educate citizens about the project and its operation. The Office of Emergency Preparedness will hold very specific public outreach to the entire city regarding these issues. Short-term, direct

and indirect impacts to transportation will occur during construction. Roadway lane closures and/or detours might be necessary, particularly for construction along the roadways, and traffic congestion could occur as a result. Floodwall construction in the vicinity of the marinas could cause traffic congestion for those entering and existing the business.

Long-term and short-term, direct beneficial effects to transportation should also occur in Area 1 as a whole: through the closure of the gates and prevention of storm surge, transportation infrastructure could be spared damage as well as temporary flooding impacts. However, there will also be temporary impacts that are potentially significant, both during construction, and after construction during temporary gate closures.

Navigation. Pretty Lake is mostly residential and used by small recreational water craft; and west of Pretty Lake in Fishermans Cove there are several marinas with a high capacity of recreational water craft. It is likely that most of the water craft docked at the marinas travels east into Little Creek and into the Chesapeake Bay, rather than west into Pretty Lake. Joint Expeditionary Base Little Creek has 15 piers and two boat ramps that may be affected by the floodwalls.

The storm surge barrier crossing Pretty Lake at the Shore Drive bridge will include one gate with a 50-foot opening. Because the gate assembly would be located in-line with the existing navigational channel and fender system of the bridge, and would allow a 50-foot horizontal navigation clearance, there will be long-term but minor impacts on navigation. This location is already restricted immediately west of Shore Drive, by the marinas to either side of Fishermans Cove and the Base; therefore, navigation traffic must already travel slowly and carefully through this area. At the gate location, a navigation clearance to at least elevation -6 feet NAVD 88 would be necessary to allow small boat traffic to access Pretty Lake through the navigation span of the existing bridge.

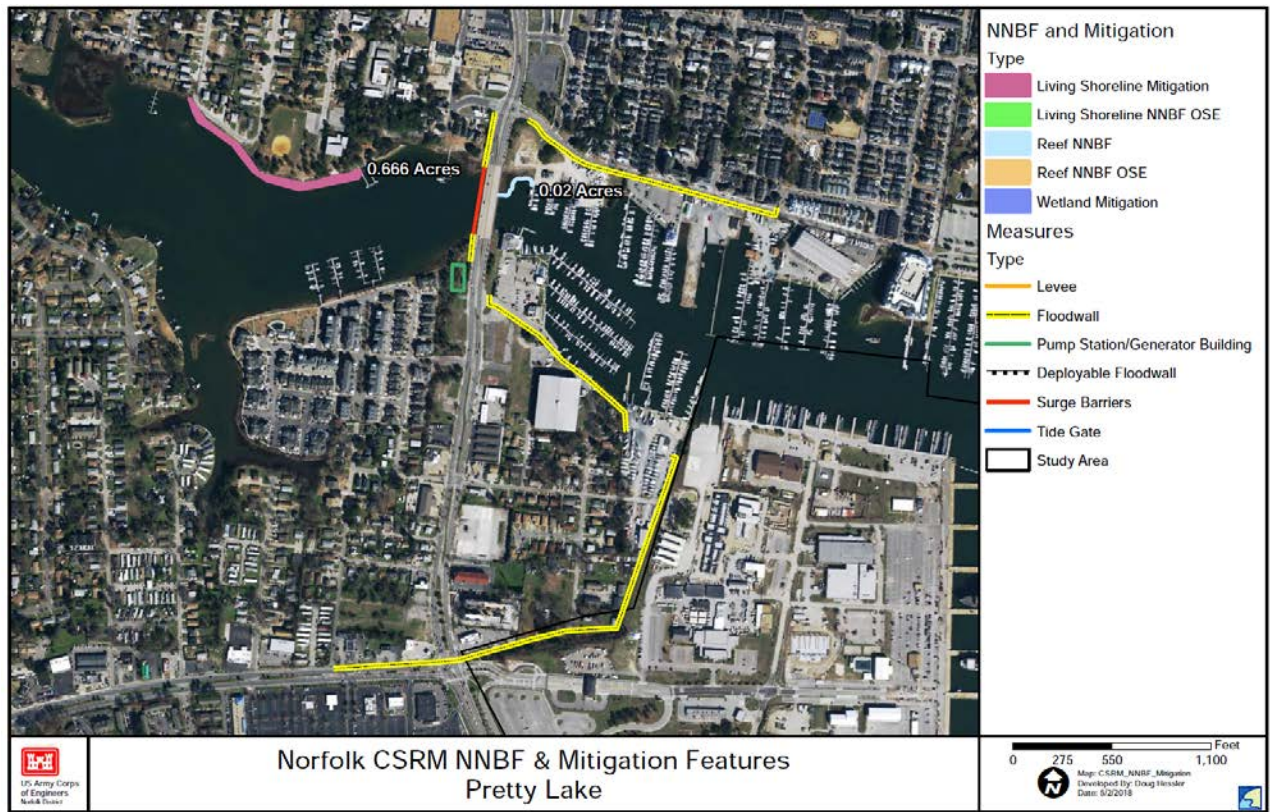


Figure 11-22. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 1

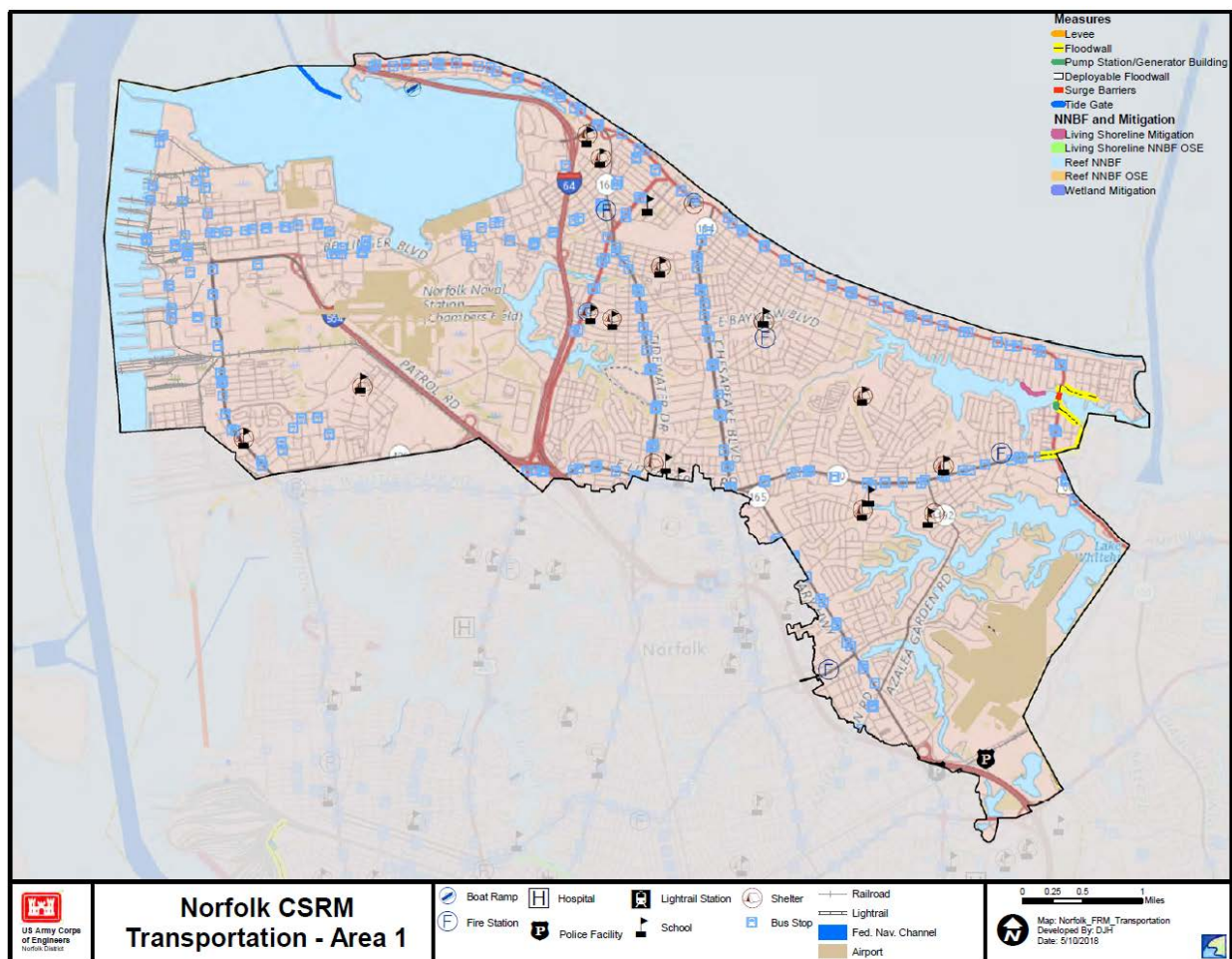


Figure 11-23. Transportation and Navigation – Area 1

Area 2--Lafayette River watershed

Transportation. Because the only construction within the Lafayette watershed is the storm surge barrier across the mouth, and construction and staging will not occur near any transportation corridors, no permanent adverse impacts will occur. Temporary, negligible, indirect impacts to transportation could occur through the transportation on roadways of construction equipment. Transportation within the NIT may be temporarily impacted during construction; however, this impact should be minor.

Permanent and temporary, direct, beneficial impacts should occur in the transportation system in the Lafayette watershed. As its transportation infrastructure was determined in the Fugro Atlantic study (2012) to be the most at-risk in the watershed from storm surge and flooding, the storm surge barrier should help spare it permanent storm damage as well as temporary flooding impacts caused by the design event storm.

Navigation. The storm surge barrier will extend approximately 6,635 linear feet across the mouth of the Lafayette River, and will have a permanent, moderate navigational impact. As indicated earlier, no deep water access is available on Lafayette River and no major industry use occurs there; it is mostly used for recreational boating by residents, marinas, and visitors. The current practice of boaters using the entire width of the mouth for recreational boating and

other water activities would become limited to ten navigational openings across the mouth. However, USACE Lafayette River channel with its -8 foot depth and 100-foot width would remain in use. A large sector gate with a 150-foot horizontal navigational opening at that channel would be available for all vessel traffic. Generally, commercial businesses are already required by their insurance to utilize only the designated navigation channel, if one is available. In addition to the large sector gate, there will be nine smaller miter gate openings, approximately 600 feet apart, with approximately 50 feet of horizontal navigational clearance each. This is enough width for two small craft recreational vessels to pass safely; larger craft may use the channel. The new structure will require boaters to slow their speed and perhaps alter their use; but it will not unreasonably restrict access to navigable use of the waterway. Likewise, NNBFs as well as mitigation will be incorporated along or near the banks of the Lafayette River, but they will not be near the channel or any gate openings. They are anticipated to have a minor effect on navigation. They will not be near any navigation channels; but they would need to be avoided by the construction of piers

All gates would remain open except for the necessary closures for design storm events to prevent storm surge from entering the Lafayette River. In addition, periodic testing of the operation, as well as maintenance of the gates would occur. This could result in minor, temporary impacts to navigation. Construction of these features as well as closures of the main navigation channel itself will require coordination and approval by the U.S. Coast Guard.



Figure 11-24. Proposed Sector Gate at the Lafayette Navigation Channel



Figure 11-25. Proposed Storm Surge Barrier Wall and Miter Gate

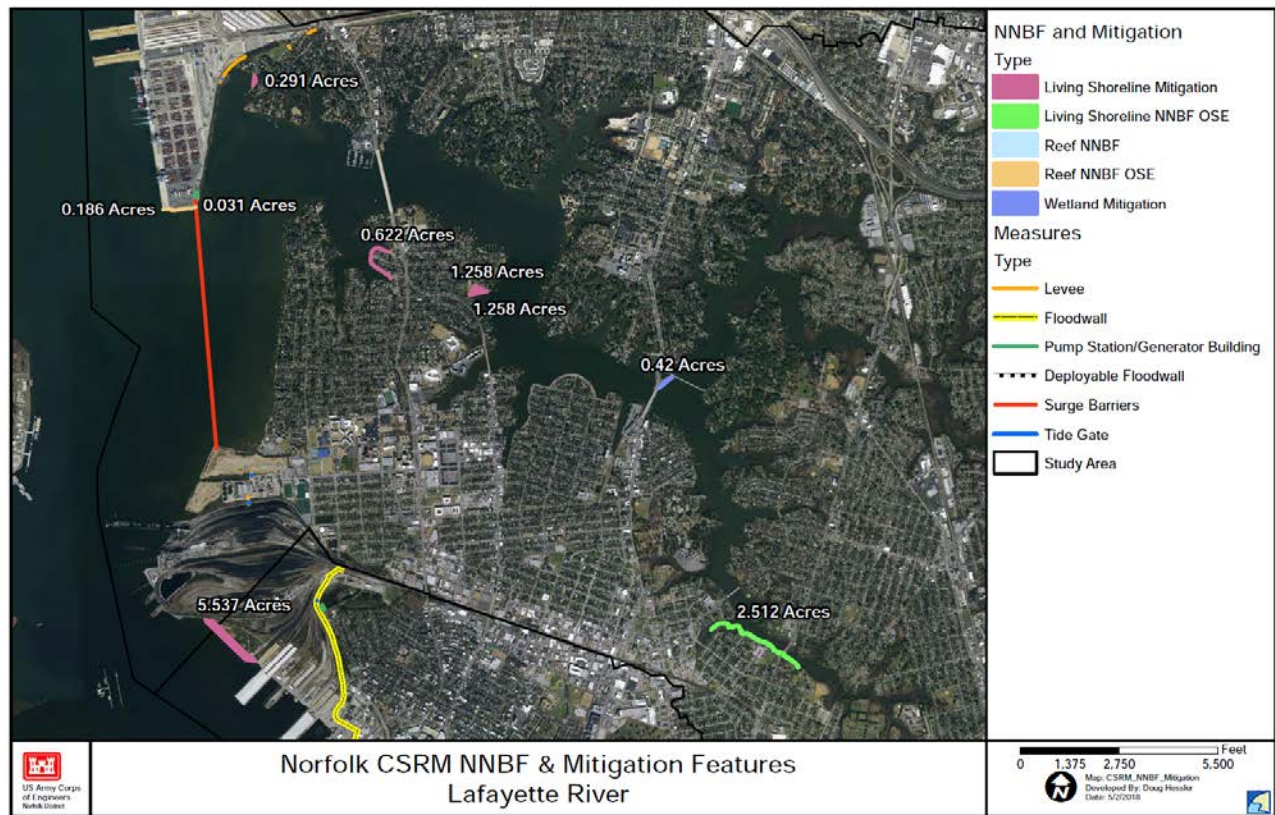


Figure 11-26. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 2

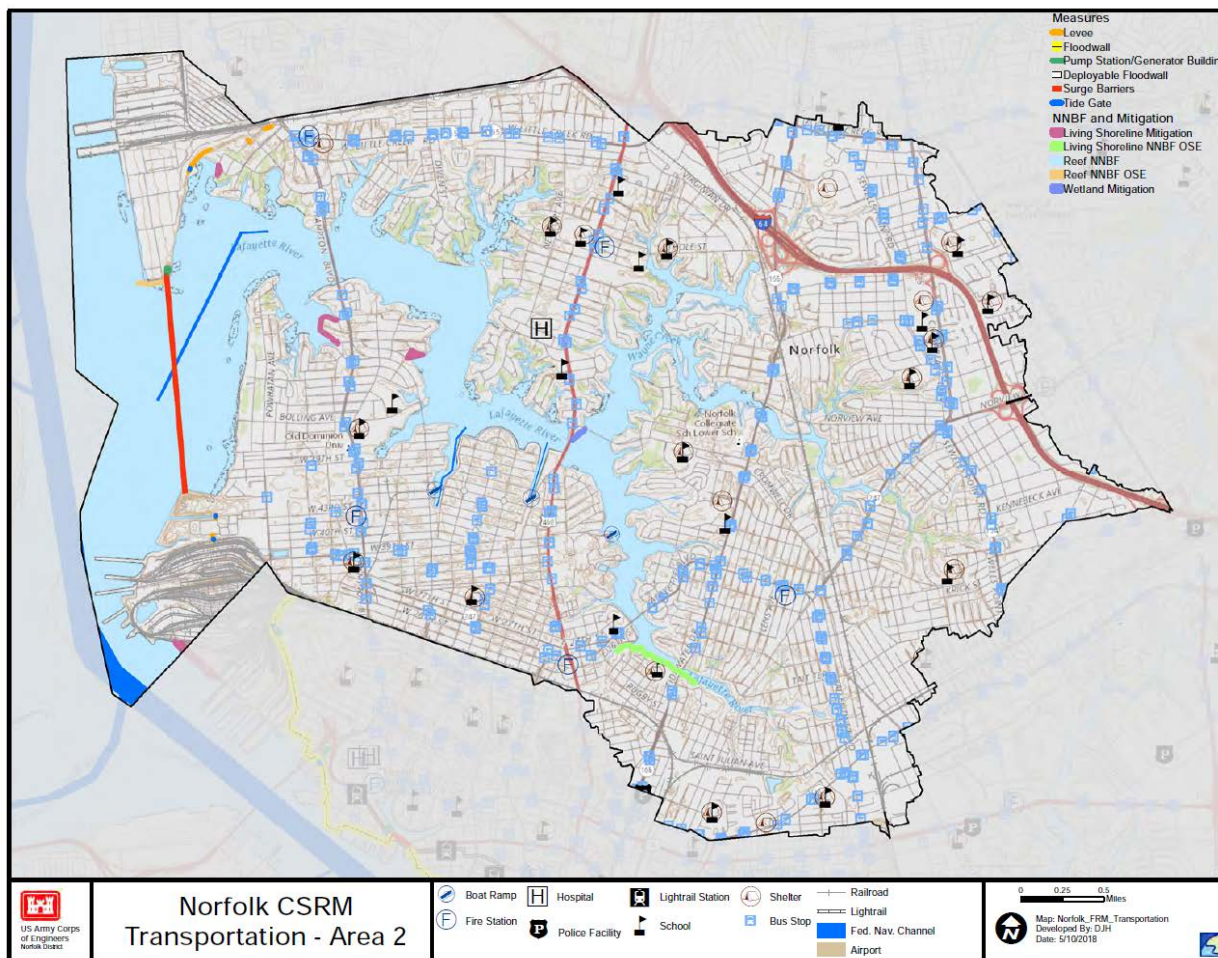


Figure 11-27. Transportation and Navigation – Area 2

Area 3 – The Elizabeth River Mainstem, Ghent/West Ghent, The Hague, Freemason, Downtown Watershed.

Transportation. Area 3 would include a system of a floodwall/surge barrier across the mouth of The Hague, and the overall system will extend from high ground near the Norfolk Southern train tracks to the northwest of the West Ghent neighborhood near Lamberts Point, through The Hague, Freemason, and Downtown Norfolk areas of the city.

A floodwall will be constructed from Lamberts Point, and parallel to Brambleton Avenue. The floodwall will cross Brambleton Avenue as well as certain locations along smaller streets through the Freemason section of the city between Brambleton Avenue and Downtown Norfolk. Locations where the wall crosses all known street crossings, will require the construction of street gates across those roadways. The existing floodwall in front of Nauticus will tie in and be modified to a new design or it will be rebuilt entirely and incorporated into the system. The existing floodwall will be extended along the Elizabeth River to the east of Downtown to cover existing development and neighborhoods along the Elizabeth River.

There will be long lengths of floodwalls in Area 3. The number of pedestrian gates to be built into the floodwalls has not been determined at this stage of design; but pedestrian access could be more restricted in places. Temporary, direct, and potentially significant impacts to

transportation flow in southwestern Norfolk could occur due to closures of the street gate across Brambleton Avenue (Route 337), a primary arterial roadway, and streets within Freemason. During storm events that necessitate closure of the street gates, Brambleton Avenue and the streets within Freemason would be blocked at the crossing locations by gate closure, potentially requiring those who are evacuating or sheltering in place and emergency vehicles to use an alternate route. The closures could last several days; therefore, the section of Freemason channelward of the street gates would likely be inaccessible. Closures related to periodic maintenance would be expected to be minor; these may be planned for off-peak hours.

In addition, an operation and maintenance manual will ultimately be developed for the project. It will have much more detailed information about how and when the gates will close, notification procedures and instructions to the public, and how the maintenance operations will be conducted. The City is also in the midst of completing a Program for Public Information to educate citizens about the project and its operation. The Office of Emergency Preparedness will hold very specific public outreach to the entire city regarding these issues.

Temporary, direct, minor impacts to transportation will occur during construction. Roadway lane closures and/or detours might be necessary, particularly for construction along the roadways, and traffic congestion could occur as a result. Floodwall construction in the vicinity the aforementioned areas could cause traffic congestion for those entering and existing the businesses and residences. Parking areas and sidewalks will likely also be affected.

Navigation. USACE's The Elizabeth River Eastern Branch federal navigation channel, which passes through Areas 3 and 4, would continue to be maintained and used. It is not anticipated that the channel itself or maintenance of it would not be impacted by any of the structures, either temporarily or permanently.

The storm surge barrier near the mouth of The Hague will be located on the northern side of the Brambleton Road Bridge. Miter gates will be approximately 50 feet wide, allowing for recreational boat traffic. The gates will line up with the bridge piers and will allow for typical ebbs and flows. The gates will close during flood conditions in order to prevent storm surge from entering The Hague neighborhood. Natural and Nature Based Features could be constructed inside of the Hague, and along the waterfront in front of floodwalls near Downtown, where appropriate.

The storm surge barrier gates at The Hague will close during flood conditions in order to prevent storm surge from entering The Hague watershed. In addition, periodic testing of the operation, as well as maintenance of the gates would occur. Although The Hague contains Coast Guard-designated Anchorage "O" for recreational watercraft mooring, and the project will require approval by the Coast Guard, the Coast Guard has verbally acknowledged that The Hague is not a commonly used waterway for navigation. This project is expected to have a negligible impact on navigation at The Hague.

There may be a need to utilize open space areas near Waterside for staging, during construction of the floodwalls near Waterside, and as a result, there may be temporary disruption of navigable access. The HRT Elizabeth River ferry service schedule could be temporarily disrupted or may need to be altered, or service may need to move to differing

locations during construction if possible. Some areas along the Waterside may temporarily be inaccessible to boats that pull up and moor there during construction as well.

NNBFs will be incorporated along or near the banks of the Eastern Branch of the Elizabeth River, but they will not be near the channel or any gate openings. They are anticipated to have a minor effect on navigation, as they are planned along Harbor Park. They will not be near any navigation channels; but they would need to be avoided by the construction of piers. They would be designed not to interfere with the Elizabeth River ferry terminal.

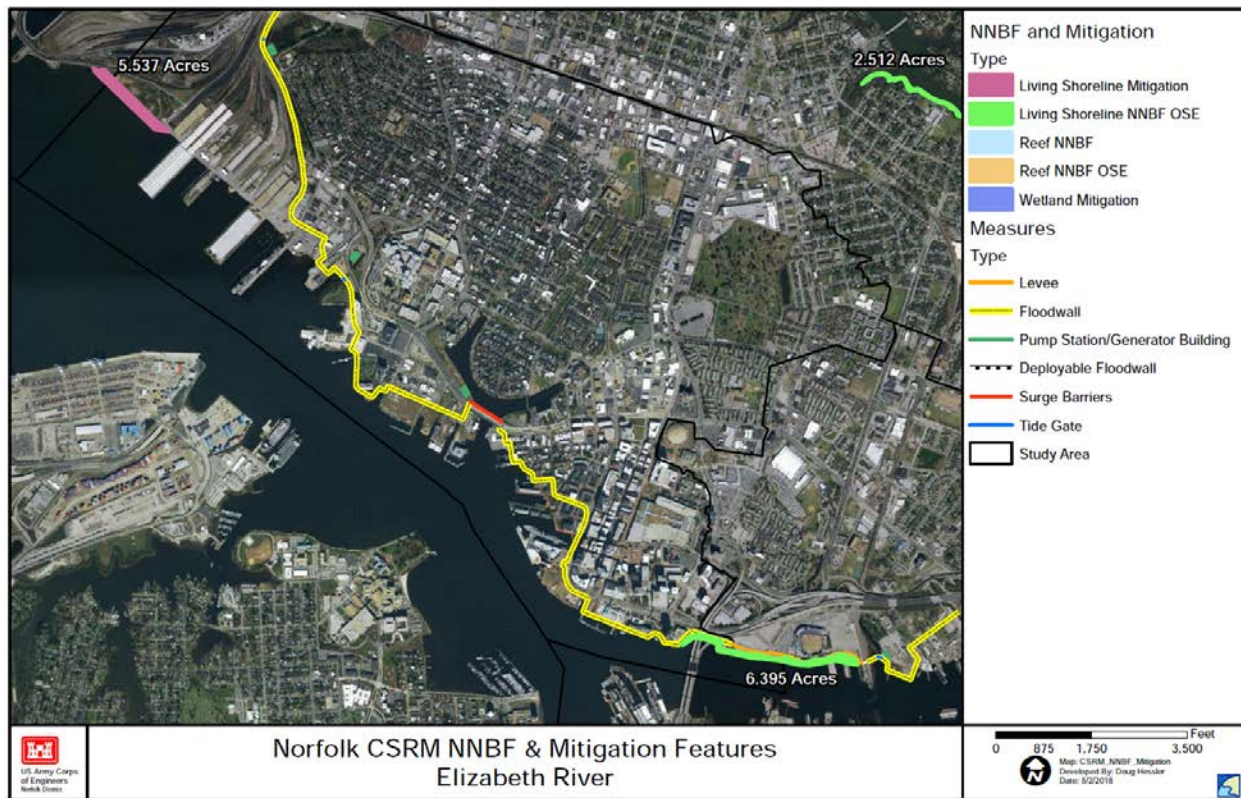


Figure 11-28. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 3, and part of Area 4

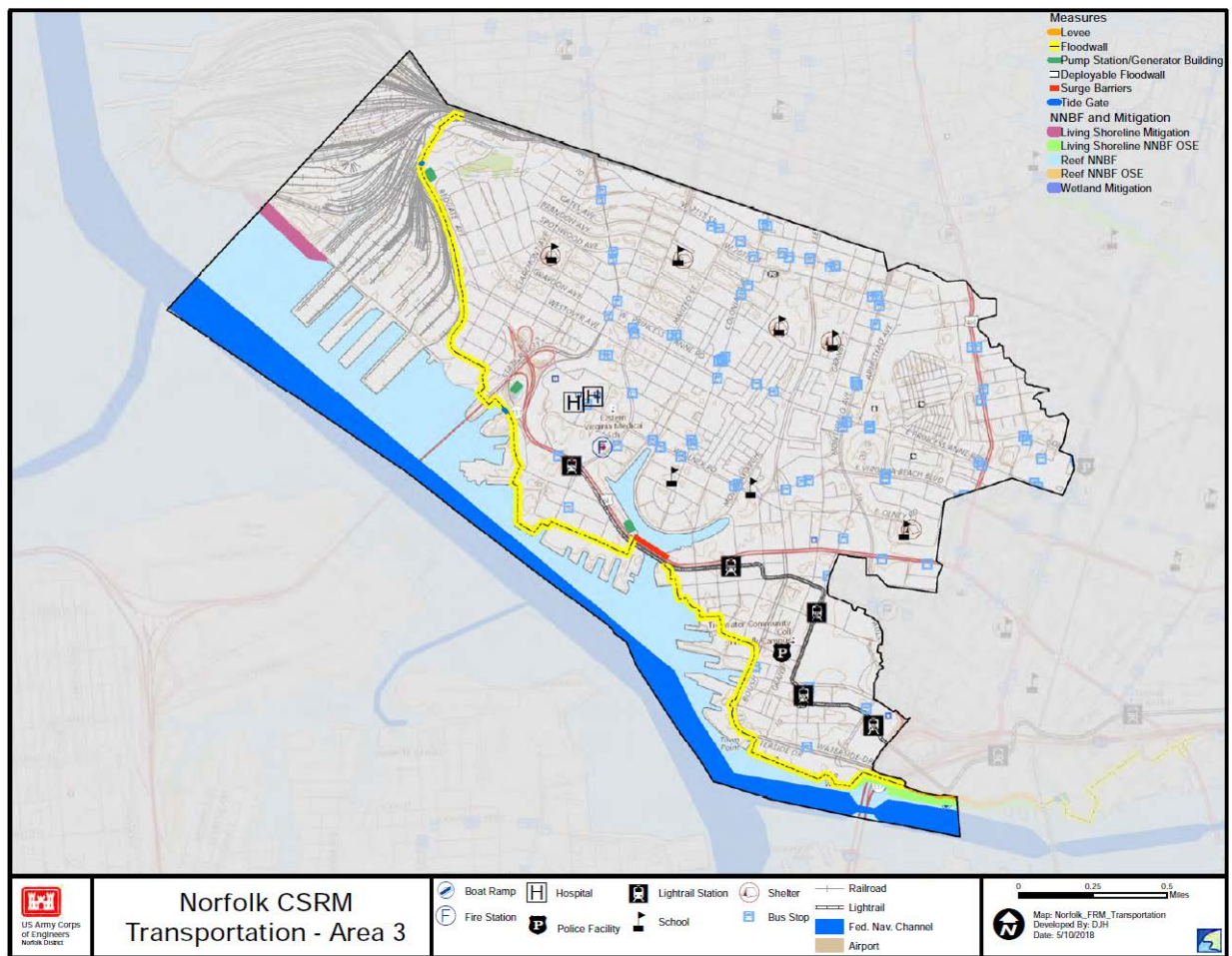


Figure 11-29. Transportation and Navigation – Area 3

Area 4 –Eastern Branch of the Elizabeth River and Broad Creek

Transportation. The wall passing underneath the Berkley Bridge (I-264), terminating to the west of the Harbor Park baseball stadium, and then tying into an earthen berm east of the Amtrak railroad tracks near Harbor Park, will require a street gate at all known street crossings. As with all gates, these will remain open except during major storm events that necessitate closure. In such instances, detours will be required, if available, and residents and businesses must be prepared to consider alternate routes, or to plan ahead if evacuation becomes necessary. Temporary street gate closures may be necessary from time to time for maintenance and to test the operation of the gates. These could be timed for low traffic volume timeframes.

During construction, the project has the potential to impact traffic flow into and out of Harbor Park and the Amtrak station. Amtrak and the Tide light rail service could be temporarily disrupted or altered during the construction of the berm and the floodwalls; as the floodwall will be constructed adjacent to and immediately south of the Tide light rail line for the duration of Area 4, up to Broad Creek; and at that point the storm surge barrier proposed at Broad Creek will continue to parallel it. There also may be a need to utilize open space areas near Harbor Park and Amtrak station for staging, during construction of the floodwalls berms, and as a result, there may be temporary disruption of transportation in and out of these locations. No impacts to I-264 or any other arterial roadway are anticipated.

be dredged in it in the future. It is used by recreational small craft. The six paired miter gates will have a horizontal navigational clearance of approximately 50 linear feet each. Tide gates proposed at Broad Creek inlet would not restrict navigation use clearance-wise. Waterway is almost entirely residential. Even if a channel was dredged there in the future navigation would not be disrupted.

Access to the construction sites may be difficult in some areas along the floodwalls where there is limited space between the floodwall proposed location and the I-264, light rail tracks, and water/marsh areas. Some of the construction may have to be done from barges in difficult-to-reach locations, but these would not be stationed in any navigation channels.

Natural and Nature Based Features will be incorporated along or near the banks of the Broad Creek or the Eastern Branch of the Elizabeth River, but they will not be near the channel or any gate openings, so they will have minor impacts on navigation. Currently, a wetland mitigation site is planned west of the railroad bridge, if practicable. Constructed oyster reef NNBF living shorelines would be placed along the west and east banks at the mouth of Broad Creek. There are some residences there, so these would need to be planned to minimize impacts on residents' navigable access.

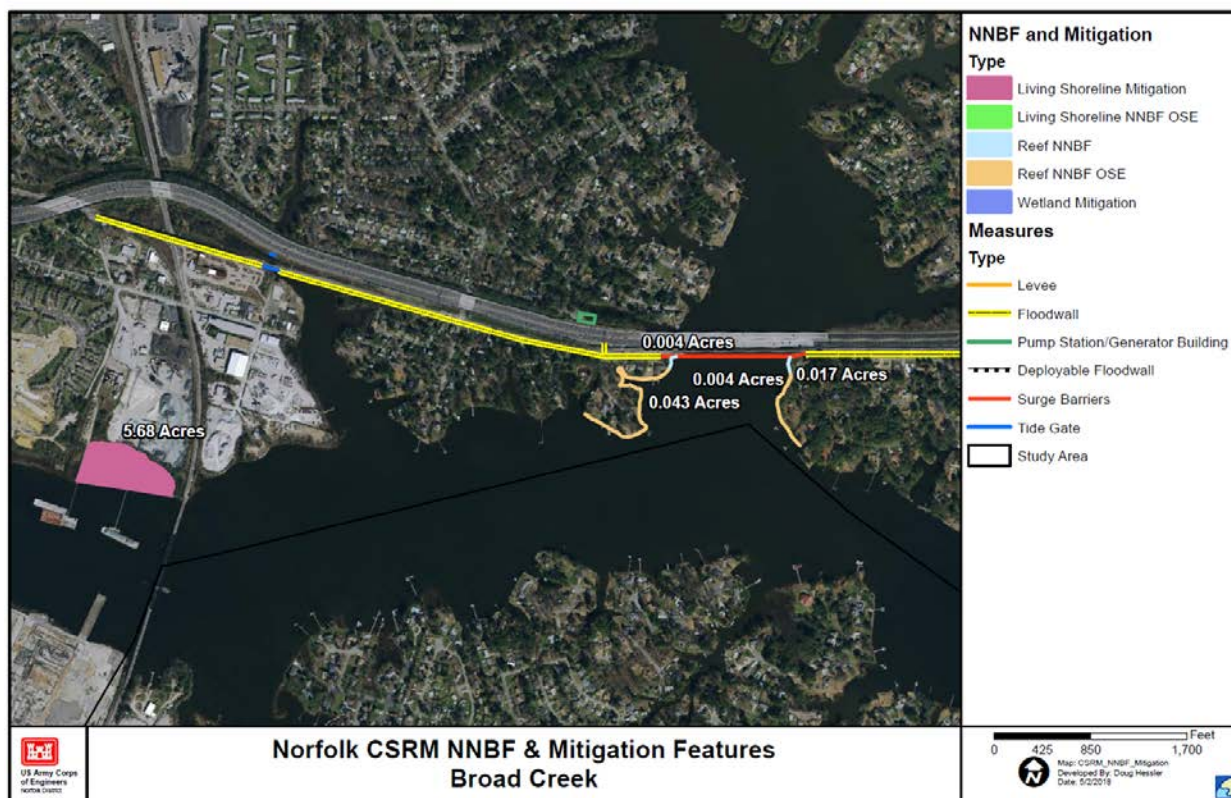


Figure 11-31. Proposed Wetland Mitigation, Living Shorelines, and Reefs – Area 4

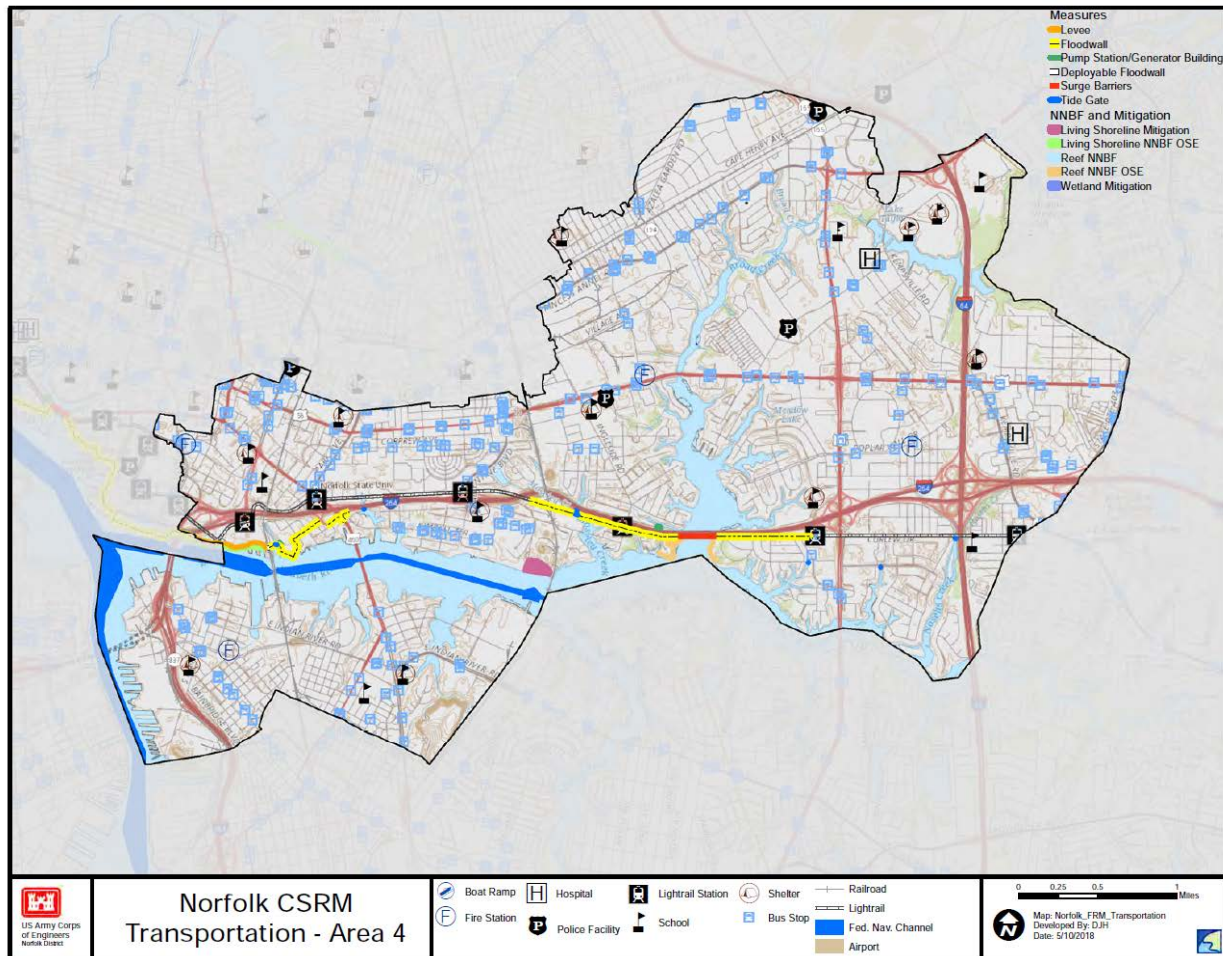


Figure 11-32. Transportation and Navigation – Area 4

Summary of Impacts for Alternative 2a

As described, Norfolk is a densely developed and busy locality from the standpoint of both transportation and navigation. After completion, gate closures for both the storm surge barriers and the street gates will have recurring, periodic, temporary impacts to various forms of transportation and navigation.

Temporary, direct, and potentially significant impacts to transportation flow in northeastern Norfolk across the Shore Drive Bridge (Route 60), and southwestern Norfolk across Brambleton Avenue (Route 337), two primary arterial roadways, as well as within the Freemason neighborhood, could occur due to closures of the gateways during storm events. During those times, those who are evacuating or sheltering in place and emergency vehicles would have to use an alternate route. These temporary closures for storm events could last for several days.

Construction of a project as encompassing as this one will entail many temporary impacts in many areas during construction. In addition, all gates will need to be tested for operation and maintenance periodically, and these will entail shorter duration temporary but minor impacts to transportation.

City Public Works staff has acknowledged that there will be temporary, direct, but minor impacts during construction which would include lane closure but it is not anticipated that any roadways

will be blocked. There may be restrictions on when lane closures may occur during the day or if work may be required to be performed at night. These restrictions will be a factor of the type of neighborhood the work is being done, residential or commercial, traffic flow and time of day. The city has experience with construction on all these streets (paving, utility construction, etc.) the traffic impacts during construction are mitigatable.

The City also recognizes that part of the implementation of this barrier system will need to be an outreach plan explaining evacuation routes to citizens. The City already has a website set up with evacuation guidance, which could be expanded upon. It is currently located at: <http://www.norfolk.gov/index.aspx?nid=659>. The City intends for an outreach plan to be integrated into the construction and implementation plan.

Cumulative adverse impacts on transportation are far greater for the No Build/Future Without Project Alternative and for the Nonstructural Alternative, than for Alternative 2a. Although there are potentially significant impacts to transportation that would be caused by closure of street gates such as Shore Drive, cumulative permanent impacts would overall be positive in the protection transportation infrastructure from storm surge flooding. This is positive from an economic, safety, and transportation perspective, both temporarily and permanently. Implementation of Alternative 2a is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects.

Therefore, based on the foregoing, effects to transportation and navigation from implementation of Alternative 2a are predicted to range from indirect to direct, negligible to significant, beneficial to adverse effects that are temporary to permanent in duration.

11.24.3 Alternative 3: Nonstructural Alternative

Areas 1-4: Under this alternative, all of the existing ongoing transportation and navigation efforts, initiatives, and projects described under the No Action/Future Without Project Alternative, as well as climate change, would be assumed to occur. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

For this alternative, structure raises, basement fills, etc., would help protect only individual structures from storm surge. This could cause very minimal temporary impacts on transportation during construction; existing structures that are close to roadways may rarely require temporary construction access in or near roadways. However, of the three build alternatives, Alternative 3 would have the fewest temporary construction and maintenance impacts to the public. Most of the temporary construction impacts would likely be limited to those specific structures being protected, and this Alternative should not cause any permanent impacts to transportation or navigation. Very few outright property acquisitions are being considered; therefore, any resulting changes in terms of traffic volumes would be negligible.

However, this Alternative is focused mainly on localized protection of buildings; therefore, it would not protect wide expanses of transportation corridors from storm surge. Transportation corridors would likely remain vulnerable to flooding and damage during storm events. Warning systems and preparedness plans would allow people more time to evacuate as needed; reducing the impact on temporary transportation travel. However warning system and preparedness plans would not prevent temporary or permanent impacts on transportation

infrastructure. For purposes of transportation and navigation, this effects of this alternative would be similar to the No Build/Future Without Project.

Cumulative temporary impacts could be reduced by phasing work to cause less disruption at a time. Implementation of Alternative 3 is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects. Based on the foregoing, effects to transportation and navigation from implementation of Alternative 3 are predicted to range from indirect to direct, negligible to significant, beneficial to adverse effects that are temporary to permanent in duration.

11.24.4 Alternative 4d: Recommended Plan

Areas 1-4: Under this alternative, all of the existing ongoing efforts, initiatives, and projects described under the No Action Alternative, as well as climate change, would be assumed to occur.

Alternative 4d, the Recommended Plan, is a combination of structural and nonstructural components. For each of the four Areas, this alternative entails construction of all of the structures described in Alternative 2a, plus nonstructural components for some structures channelward of the storm barriers and floodwalls. The natural and nature-based features described for each Area in Alternative 2a would also apply to this alternative.

The impacts for Alternative 4d plan would be the same as those described for the Alternative 2a Structural, and for the Alternative 3 Nonstructural, except that there would be no nonstructural measures implemented landward of the storm surge barriers. As described above, the nonstructural measures effects of Alternative 3 are minimal, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated

Alternative 4d contains many of the same measures that the City has previously explored, and would be in keeping with its goals of future development for resiliency. Of the four alternatives, Alternative 4d would protect the most of City's land uses from storm surge impacts.

The following figures show the locations of the measures in relation to land use. The floodwalls are shown in yellow; the storm surge barriers are shown in red; the generator buildings are shown in lime green; and the berms are shown in orange. The nonstructural measures are not shown as are very localized and would be difficult to depict at this scale.

11.24.5 Cumulative Effects

Cumulative adverse impacts on transportation are far greater for the No Build/Future Without Project Alternative and for the Alternative 3, than for Alternative 2a or 4d. Although there are potentially significant impacts to transportation that would be caused by closure of street gates such as Shore Drive, cumulative permanent impacts would overall be positive in the protection transportation infrastructure from storm surge flooding. This is positive from an economic, safety, and transportation perspective, both temporarily and permanently.

Cumulative temporary construction impacts could be reduced by phasing work to cause less disruption at a time. The effects of other actions that are going on in the ROI would be

beneficial for navigation and transportation. Implementation of Alternative 4d is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on transportation and navigation. Therefore, based on the foregoing, effects to transportation and navigation from implementation of Alternative 4d are predicted to range from indirect to direct, negligible to significant, beneficial to adverse effects that are temporary to permanent in duration.

11.25 UTILITIES

11.25.1 No Action Alternative/Future Without Project

If the Recommended Plan is not implemented, the utilities in the City would continue to change over time as expected as improvements and upgrades will continue to be made that are already planned by the City independent of the USACE, particularly to the stormwater infrastructure. Stormwater main lines are being replaced with larger diameter pipes to improve drainage in many areas of the City. These improvements will continue into the future regardless of whether or not any USACE/City project is implemented. The City has additional capacity built into the potable water infrastructure that could accommodate increases in population beyond levels at present. It is expected that overall demand for utilities will increase over time into the future due to population increases and redevelopment. It can be expected that utility providers for other services (power, telecommunications, gas) will anticipate demand and plan for it to ensure the City has full utility services available to all residents and commercial enterprises. Power infrastructure improvements, although not controlled by the City, are also planned. The main improvement is the relocation of power lines from above ground wires suspended by poles to below ground power lines, which are less vulnerable to storm damage than present above ground wiring. Dominion power is also in the process of raising many currently vulnerable power substations by 28 inches, which will improve their ability to maintain operations during a storm event. Such improvements are likely to continue into the future. The majority of the Future Without-Project Condition projects would likely result in the temporary or permanent relocation of utilities. During construction, there would likely be short-term, pre-approved, scheduled, and controlled utility service interruptions; however, upon completion of construction these temporary service interruptions would cease. The City and/or private entities that control the various utilities are expected to continue to upgrade and maintain them as needed, this will also include some relocations as the City infrastructure and needs change over time.

Within the rest of the project ROI, utilities will be repaired and upgraded as needed. This is due to the fact that the City of Norfolk is 97% developed so there is little opportunity to expand into new areas. Though City plans include re-development and some alterations, based on expected sea level rise and the associated flooding risk throughout the City, the main regions where people live, work and where industry are located and the associated noise levels for each type of activity should remain approximately the same. Areas of higher ground will be the focus of re-development and major investment in new infrastructure (Norfolk Vision 2100) and one area, the Ohio Creek watershed, the City has obtained a HUD grant for and will employ a number of measures independently of the current project to protect this area from RSLR and storm surge. Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling, and weather patterns, have the potential to affect the nature and character of the estuarine and coastal ecosystem in the ROI.

Waters will continue to rise in the Chesapeake Bay region, which will negatively impact the City of Norfolk by increased flooding, including both nuisance and after major storm events.

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects, including changes to City housing and other urban and suburban re-development. With implementation of the No Action/Future Without Project Alternative, impacts are permanent and adverse (climate change and associated sea level rise).

11.25.2 Alternative 2a: Structural Only Alternative

For stormwater services, proposed construction will significantly enhance stormwater drainage due to the pumps at a number of locations along the floodwall as well as the tide gates. The storm surge barriers at Broad Creek, Pretty Lake and the Lafayette River will significantly enhance flood control within their associated drainages, which will allow for more efficient stormwater drainage in these areas of the City. Both Broad Creek and Pretty Lake also have pump stations associated with these gates, which will further enhance stormwater drainage in their areas of influence. Stormwater drainage outfalls that connect directly with the Elizabeth River may be in the location of levee and flood wall features. Construction will occur such that no existing or planned stormwater features will be directly impacted by the proposed construction. Levees and floodwalls can be designed to accommodate underlying stormwater drainage pipelines, if necessary. Since the levee improvements would involve construction activities on the surface, no underground utilities are anticipated to be impacted. If pile driving for floodwalls is necessary, utility location investigations would be undertaken for all areas in order to avoid any underground service lines. When proposed construction would occur near overhead electrical transmission lines, low clearance and work platforms would be utilized to avoid damage to electrical lines and maximize worker safety. Stormwater outfalls will be improved and fitted with backflow preventers as part of City upgrades. Also, when the levee flattening and improvements would occur near bridge crossing locations, utility location investigations would be undertaken as utilities are often suspended underneath bridges.

The construction of the main storm surge gate across the mouth of the Lafayette River's connection at NIT abuts the underground (and underwater) power transmission line to Craney Island and care will be needed to ensure this line is not affected by the construction. Floodwall construction along the Eastern Branch of the Elizabeth River will also occur near another underwater power transmission line and the same care in construction will be necessary to avoid impacting it.

Telecommunications services should not be impacted by any of the proposed construction, no effect is expected on this utility due to the use of low clearance and low work platforms as well as avoiding any service stations.

Impacts due to construction on utilities will be temporary, minor and not significant. Benefits to utilities, in particular stormwater management, will be significant and positive.

11.25.3 Alternative 3: Nonstructural Alternative

Most of these construction measures will only require local investigations for existing utilities such as service lines to individual buildings for gas, water, sewage and in some cases (where

lines are underground) power. Telecommunications should have no effect due to proposed nonstructural construction activities. Elevations are the measures most likely to require utilities investigations as well as local alterations of utilities that service individual buildings. Such actions include raising of local HVAC structures, power substation raising, and possibly relocating and/or altering water service lines. Such impacts would be minor, temporary and limited to individual buildings throughout the City. These impacts, being minor and temporary, are not significant.

11.25.4 Alternative 4d: Recommended Plan

The combination alternative, Alternative 4d, is the TSP and NED plan. It incorporates both structural and nonstructural measures, making the adverse impacts the same as the previously mentioned alternatives, Alternative 2a and Alternative 3. Adverse impacts in Areas 1, 3, and 4 are predicted to be minor to temporary in duration. Impacts in Area 2 are greater; creation of the surge barrier across the Lafayette River could require possible alteration or relocation of service lines to Craney Island. Various best management practices described for Alternative 2a and 3, which Alternative 4d is a combination of, will reduce the negative impacts on utilities to temporary and minor, but less than significant. Benefits to utilities, in particular stormwater management, will be significant and positive. As described above, the nonstructural measures effects of Alternative 3 are minimal, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated.

11.25.5 Cumulative Effects

There are multiple past, present and reasonably foreseeable future projects within the overall Study Area. The City plans a number of actions to re-develop portions of the City, focusing on areas that are higher ground (Norfolk Vision 2100).

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue over the next 50 years. Predicted climate change impacts such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling and weather patterns, have the potential to cause changes in the nature and character of the estuarine ecosystem, sea levels and surface land temperatures in the ROI. Most of these impacts will not directly affect utilities, though rising waters will increase flooding and the need to elevate utility services and structures on the ground level.

Implementation of any of the action alternatives is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on utilities. The proposed project will reduce flooding in the City of Norfolk. Therefore, with implementation of the any of the action alternatives, we would anticipate that impacts to utilities in the future related to the project would be adverse and temporary during construction, and significant and positive post-construction due to the protection provided utilities by project features.

11.26 NOISE

11.26.1 No Action Alternative/Future Without Project

If the Recommended Plan is not implemented, the noise levels in the City would remain as they

are now as no significant changes over time are expected. The Norfolk International Airport, Chamber's Field and are expected to continue operations in the future similar to those at present. Within the rest of the project ROI, noise levels are expected to remain the same, as the City's current uses for various areas (residential, commercial, and industrial) are likely to remain located in the same areas they are at present. This is due to the fact that the City of Norfolk is 97% developed so there is little opportunity to expand into new areas. Though City plans include re-development and some alterations, based on expected sea level rise and the associated flooding risk throughout the City, the main regions where people live, work and where industry are located and the associated noise levels for each type of activity should remain the same. Areas of higher ground will be the focus of re-development and major investment in new infrastructure (Norfolk Vision 2100) and one area, the Ohio Creek watershed, the City has obtained a HUD grant for and will employ a number of measures independently of the current project to protect this area from RSLR and storm surge. Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling, and weather patterns, have the potential to affect the nature and character of the estuarine and coastal ecosystem in the ROI. Waters will continue to rise in the Chesapeake Bay region, which will negatively impact the City of Norfolk by increased flooding, including both nuisance and after major storm events.

The No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects, including changes to City housing and other urban and suburban re-development. With implementation of the No Action/Future Without Project Alternative, impacts are permanent and adverse (climate change and associated sea level rise). Noise levels will likely remain the same into the future, as industrial areas will likely remain used as such, with the same for commercial and residential areas.

11.26.2 Alternative 2a: Structural Only Alternative

During construction of these various features, there will be associated noise from the operation to construct the floodwalls, levees and associated tide gates and pump stations. These noise levels are typical of construction sites, typical levels of such noise on site are described as follows:

- Backhoe (maximum noise level: 80.0 dBA₁₀)
- Compactor (maximum noise level: 80.0 dBA)
- Dozer (maximum noise level: 85.0 dBA)
- Dump truck (maximum noise level: 84.0 dBA)
- Excavator (maximum noise level: 85.0 dBA)
- Front end loader (maximum noise level: 80.0 dBA)
- Tractor (maximum noise level: 84.0 dBA)

Based on this, these noise levels exceed those typically encountered in residential areas, recreational, commercial and industrial areas. It is possible that the typical City noise in these areas exceeds the City Noise ordinance levels, as high-density urban areas can average up to 78 dBA and average density urban areas can average up to 65 dBA during the day and early evening (EPA 1978). They also exceed levels listed in the City of Norfolk's Noise Ordinance. Noise sensitive zones (schools, medical facilities) are not found immediately adjacent to

proposed construction sites. However, construction will take place within a few hundred feet of residential areas in a number of locations. Other locations will be in commercial or industrial areas. Noise abates at a level of -6 dBA per 50 feet away from the source if no obstructions (buildings, vegetation, etc.) are present to further reduce noise transmittance. Construction would also take place only during normal business hours. At these times, however, noise will approach that of an industrial area within 100 feet of the construction. Noise due to construction will likely be 10dBA higher than ambient noise up to 400 feet away from the construction site. Sound can be abated by vegetation and objects (including buildings) that are between the location and a direct line-of-sight of the construction. Although the construction would result in temporary and localized noise increases during construction, these activities would be limited to normal business hours and not occur at night, early mornings, or on Sundays. Construction of the barrier across the mouth of the Lafayette River will involve the driving of large concrete pilings, the equipment necessary to do this can produce noise as loud as 110 dBA (impact pile driver). This structure will anchor to land at NIT (Norfolk International Terminal, an industrial site) and Lamberts Point Golf Course, a recreational site, neither of which are residential or noise-sensitive. Most of the pile-driving will occur offshore in the Lafayette River. Motile wildlife may avoid the construction area due to the noise, which would be a temporary, minor and not significant impact. Therefore, construction noise impacts would be temporary and minor, but less than significant.

11.26.3 Alternative 3: Nonstructural Alternative

The nonstructural only alternative, Alternative 3, consists of measures that are applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Physical nonstructural measures include elevation, relocation, buyout, or floodproofing of structures. Nonphysical measures include flood warning systems, flood preparedness plans, and zoning and flood insurance regulations.

Elevation of individual structures will involve construction equipment, whose noise levels have already been described in Alternative 2a. These impacts will be similar, though smaller, than that of Alternative 2a as, in general, less equipment and a shorter time will be needed to raise a structure than construct the larger flood control structures recommended in Alternative 2a. Non-physical actions will not affect noise levels. Associated construction noise with elevation and floodproofing of structures would be temporary and minor, less than significant.

11.26.4 Alternative 4d: Recommended Plan

The combination alternative, Alternative 4d, is the TSP and NED plan. It incorporates both structural and nonstructural measures, making the adverse impacts the same as the previously mentioned alternatives, Alternative 2a and Alternative 3. As described above, the nonstructural measures effects of Alternative 3 are minimal, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated

Adverse impacts in areas 1, 3, and 4 are predicted to be, at most, negligible and temporary in duration. Impacts in Area 2 are greater; creation of the surge barrier across the Lafayette River could produce noise sufficient to impact local wildlife but this impact is expected to be minor and temporary in nature. Therefore, construction noise impacts would be temporary and minor, but

less than significant.

11.26.5 Cumulative Effects

There are multiple past, present and reasonably foreseeable future projects within the overall Study Area. The City plans a number of actions to re-develop portions of the City, focusing on areas that are higher ground (Norfolk Vision 2100).

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue over the next 50 years. Predicted climate change impacts such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling and weather patterns, have the potential to cause changes in the nature and character of the estuarine ecosystem, sea levels and surface land temperatures in the ROI. Due to impacts from climate change, it is possible the extent of waters high enough in salinity to support estuarine life will extend further up the tributaries of the Chesapeake Bay, including the Elizabeth River. Local nuisance flooding will increase, as well as higher levels of flooding during storm events. Climate change is anticipated to potentially increase winter and spring nutrient loading into the Chesapeake Bay and may result in increased phytoplankton production (Najjar et al. 2010). The higher temperatures, lower dissolved oxygen levels, and increased phytoplankton productivity may result in more frequent low dissolved oxygen conditions, which could impact the benthic community.

Implementation of any of the action alternatives is not predicted to substantially cumulatively or synergistically interact with climate change and/or other effects on noise. Therefore, with implementation of the any of the action alternatives we would anticipate that noise impacts in the future related to the project would be negligible.

11.27 CLIMATE CHANGE

11.27.1 No Action Alternative/Future Without Project

Norfolk is located at the mouth of the Chesapeake Bay and is bordered to the west by the Elizabeth River. It also shares land borders with Chesapeake to its south and Virginia Beach to its east. Norfolk has a humid subtropical climate with moderate changes of seasons and has an average annual precipitation of 46.55 inches.

Climate change may lead to increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling and weather patterns and has the potential to cause changes in the nature and character of the estuarine ecosystem in the ROI.

The pace of sea level rise at Norfolk is the highest on the East Coast because the shoreline is subsiding and global warming is increasing the rate of sea level rise, both because of thermal expansion and the melting of land ice (J.A. Church and N.J. White). Flooding from high tide events will increase in the City of Norfolk, and storm induced flooding will be significantly amplified by sea level rise if no action is taken.

Implementation of the No Action/Future Without Project Alternative is not predicted to substantially cumulatively or synergistically interact with climate change and/or other cumulative effects.

11.27.2 Alternative 2a: Structural Only Alternative

The Structural Only alternative on climate change is predicted to be temporary and negligible. Emissions produced during construction would be below thresholds under the present status of attainment of air quality, impacts to air quality would be temporary, minor and negligible. Few structural measures that will be utilized, such as floodwalls, storm surge barriers and tide gates would temporarily alter water levels, impacting the city of Norfolk behind the structures. This temporary water level fluctuation is only expected to happen during a flooding event.

Localized increases in fuel combustion-related emissions during construction, the operation of generators and pump stations and emissions from maintenance of the structures are predicted to occur. If Greenhouse gas (GHG) emissions remain constant, the world would be committed to several centuries of increasing global mean temperatures and sea level rise (Steven J. Davis, 2010). Post-construction, there will be a significant increase in the City of Norfolk's resilience against changes due to climate change. The City will be less vulnerable to coastal flooding, both nuisance and storm-induced. City improvements outside the scope of the proposed project, such as raising utilities, shifting to underground power transmission lines, will also improve the City's resilience against climate change impacts. Implementation of Alternative 2a is not predicted to substantially cumulatively or synergistically interact with climate change.

11.27.3 Alternative 3: Nonstructural Alternative

The Nonstructural Only Alternative is predicted to be temporary and negligible. Greenhouse gas (GHG) emissions would increase slightly from operation of heavy equipment, the driving of construction vehicles to/from areas 1, 2, 3 and 4 to construct flood proofing structures, such as ring walls and maintenance and reconstruction of houses and roads following storm events.

GHG emissions are predicted to be so small with a global mean temperature increase of 0.7-1.4 degrees Celcius (Steven J. Davis, 2010). Implementation of Alternative 3 is not predicted to substantially cumulatively or synergistically interact with climate change.

11.27.4 Alternative 4d: Recommended Plan

This alternative maximizes both structural and nonstructural elements of the project. During the development of the proposed project, emissions from internal combustion engines and generation of dust from the vehicles involved with earthmoving activities could temporarily increase levels of some pollutants. There may also be emissions from fugitive dust associated with vehicles using unpaved roads, windblown dust from areas not covered by vegetation, material handling, etc. As described above, the nonstructural measures effects of Alternative 3 are negligible, and are also only in areas channelward of storm surge barriers. Therefore, cumulative effects beyond what is described under each of the Alternatives 2A and 3 are not anticipated

Implementation of Alternative 4d is not predicted to substantially cumulatively or synergistically interact with climate change.

11.28 AVOIDANCE, MINIMIZATION, AND MITIGATION MEASURES

11.28.1 Project Implementation

1) An operation and maintenance manual will ultimately be developed for the project. It will be

have much more detailed information about how and when the gates will close, notification procedures and instructions to the public, and how the maintenance operations will be conducted.

- 2) The City is also in the midst of completing a Program for Public Information to educate citizens about the project and its operation. The Office of Emergency Preparedness will hold very specific public outreach to the entire city regarding these issues.
- 3) The project is in the early stages of design at this time. During the PED phase of the project, the USACE and the City will coordinate with the Navy to ensure that both the needs of the City and Navy operational needs are considered, and adverse impacts are minimized.

11.28.2 Public Outreach and Environmental Justice

- 1) The City has committed to informing vulnerable populations regarding the availability of nonstructural measures. The public will be assisted in performing the steps required to avail themselves of these benefits.
- 2) The City of Norfolk also participates in the CRS program, which requires properties within the Repetitive Loss Areas to be notified of their flood risk. A postcard is typically mailed to inform residents of their risk; they are directed to the website www.norfolk.gov/reploss. This website can be modified to provide more information for the on other measures to protect property.
- 3) The City is also in the midst of completing a Program for Public Information which will help to target specific populations of people to provide information too. Vulnerable populations can be added to core groups that will need notification.

11.28.3 Wetlands, Mudflat, and Open Water

Standard mitigation measures for impacts to jurisdictional wetlands would be specified in the Clean Water Act, Section 404 Permit and the 401 Water Quality Certification.

- Avoid wetland and water impacts where practicable;
- Minimize potential impacts to wetlands and waters; and;
- Compensate for any remaining, unavoidable impacts to wetlands or waters;
- Wetland compensation will be completed using the New England Salt Marsh Model
- A preliminary wetland mitigation plan is found in Appendix D;
- Mudflats and open water compensation will be completed using the Oyster Habitat Equivalency Assessment
- A preliminary mudflat and oyster mitigation plan is found in Appendix D.

11.28.4 Natural and Nature Based Features

Although not required as mitigation, natural and nature based features (NNBF), where compatible and practicable, may be incorporated adjacent to project features. NNBFs may include placement of stone sill and tidal wetland vegetation, or constructed oyster reefs.

11.28.5 Chesapeake Bay Preservation Act

- 1) Upland vegetation that is cleared either temporarily or permanently within the Resource Protection Areas (RPAs), which are areas within 100 feet of any tidal waterbody, would have to be mitigated in the same vicinity, as per requirements of the Chesapeake Bay

Preservation Act (CBPA).

- 2) A preliminary upland mitigation plan is included in the Mitigation Plan in the Environmental Appendix. This plan would be further refined during the PED phase.
- 3) Upland Vegetation in within the Resource Protection Areas (RPAs) would be done in accordance with the Mitigation Plan in Appendix D.

11.28.6 Water Quality

Due to the need to fully assess the impacts of the proposed structures, as well as to monitor compensatory mitigation sites throughout the project ROI, the USACE and Norfolk will be monitoring water quality as the project is constructed and post-construction. During PED, the USACE intends to conduct additional water quality monitoring to fully assess impacts to areas that include Pretty Lake, Broad Creek and possibly The Hague, where only limited modeling has been done at this time. Any differences between model projections and recorded data significant enough to change any of our findings at this time will be addressed in the future.

11.28.7 Cultural Resources and Historic Properties

- 1) Mitigation for and historic properties will be determined in accordance with the Programmatic Agreement (PA).
- 2) To avoid construction impacts any historic or archaeological sites would be marked with a sign stating "Sensitive Area" and fenced with a 50 feet surrounding buffer prior to any construction activities and during construction activities. Any tree felling within cultural resources sites would be restricted to the minimal necessary to remove trees and trees in adjacent areas will be felled away from the cultural resources sites.
- 3) If any archaeological resources or human remains are encountered during construction, work would cease and the USACE archaeologist would be notified.

11.28.8 Special Status Species and Essential Fish Habitat

To minimize potential impacts to EFH, managed species, and their prey within the Action Area, a number of potential Best Management Practices (BMPs) or mitigation measures may be incorporated into construction and maintenance activities for the Proposed Project. NMFS, in cooperation with the Federal Highway Administration produced a manual of potential BMPs for Transportation Actions within the Greater Atlantic Region (2017). Based on this guidance, BMPs applicable to the Proposed Project are identified below.

The following BMPs may be implemented, to the extent practicable, to reduce noise impacts on EFH, managed species, and their prey within the Action Area:

- Conduct noise-generating work in a way that minimizes acoustic effects and avoids injury (single strike and cumulative exposure) to managed species.
- Use noise attenuation and minimization measures during pile driving, such as:
 - Surrounding piles with an air bubble curtain system, turbidity curtain, isolation casing, or dewatered cofferdam.
 - Driving piles in the dry or during low water conditions for intertidal areas.
 - Using vibratory hammers and/or construction phasing to minimize acoustic impacts.

- Minimizing the number and size of temporary and permanent piles (e.g., micropiles).
 - Limiting the daily window for pile driving activities to no more than approximately 12 hours wherever feasible.
 - Providing a 12-hour quiet (recovery) period between pile driving days wherever feasible.
 - Using a “soft start” or “ramping up” pile driving (e.g., driving does not begin at 100% energy).
 - For load-bearing piles, driving piles as deep as possible with a vibratory hammer prior to using an impact hammer wherever feasible.
 - Using cushion blocks when using an impact hammer wherever feasible.
 - Using drilled shafts for permanent construction instead of hammered piles where appropriate and feasible.
- To maintain water quality and limit turbidity during construction/maintenance of project features, the following BMPs may be implemented, to the extent practicable:
 - Limit the amount and extent of turbidity and sedimentation by using appropriate sedimentation and turbidity controls such as silt curtains, settling basins, cofferdams, and/or operational modifications such as conducting the work at low tide. Specify the measures to be used in the construction plans.
 - Install erosion control measures prior to ground-disturbance;
 - Survey erosion and sediment control measures daily for deficiencies: repair or replace deficiencies immediately;
 - Prevent sediment and debris from entering the water using geo-textile fabric, hay bales, or other methods. Use nets, tarps, and pans when demolishing bridge superstructures; remove demolition debris that falls into the water; and
 - Upon project completion, remove and stabilize all temporary construction materials with sediment and erosion control measures to prevent reentry into waterways.
 - Minimize the amount of new impervious surfaces, and maintain a vegetated buffer between the water and upland activities.
 - Incorporate stormwater controls to minimize pollutants in aquatic habitats.
 - Ensure temperature and DO levels remain within the appropriate ranges to reduce any effects to ESA-listed and managed species.
 - Remove cofferdams or other diversion structures only after water quality is consistent with ambient levels outside the structure.
 - BMPs related vessel interactions with managed species and/or their prey in the Action Area may also be implemented to the extent practicable:
 - Ensure that vessels are operated in adequate water depths to avoid propeller scour and grounding at all tides. Use shallow draft vessels that maximize the navigational clearance between the vessel and the bottom in shallow areas.
 - Keep vessel speeds below 10 knots during transit activities to avoid sturgeon interactions, and avoid certain times of year (spawning run) or areas where sturgeon may congregate for spawning or foraging.
 - Implement appropriate precautions to ensure an ESA-listed species’ protection (e.g., parallel course and speed, do not attempt head-on approach, approach and leave stationary whales at no wake speed, etc.), if seen within 100 yards of vessel movement.
 - Ensure vessels maintain at least a 500-yard minimum distance from whales.
 - Other: Any other conditions that arise as a result of Essential Fish Habitat consultation or Endangered Species Act consultation.

- Conclusions and REcomemndations at the conclusion of the Fish and Wildlife Coordination Act consultation will be considered.

11.28.9 Hazardous Materials

- 1) We have consulted the databases of EPA and VDEQ, and none of the measures proposed in any of the Action Alternatives would impact any major known hazardous materials and wastes site. The Recommended Plan, Alternative 4d, would have ground disturbing measures, seawalls, in proximity to 4 petroleum release sites; however, these tend to be relatively minor sites. The south end of the Lafayette surge barrier is near a landfill that was not in the VDEQ database. Impacts to this should be avoided through design, but designs are not yet sufficiently developed to be certain of this.
- 2) The greatest potential for significant unknown hazardous materials sites to be impacted is along the main stem and the Eastern Branch where shipbuilding and timber treating industries were located in the late 19th and early 20th centuries, where both Alternative 4d and Alternative 2a would have seawalls. At this stage, there are no known impacts that would require mitigation, but clearly there is the potential for that need.
- 3) Typically, a Phase 1 Site Assessment and geotechnical borings are conducted in the PED phase. If contaminated materials are encountered, then a Phase 2 is conducted and a treatment plan is developed.
- 4) Contaminated materials could also be encountered in some of the project areas during construction. Normally the cleanup and removal of any hazardous or contaminated material within a project area is the responsibility of the local sponsor.
- 5) A report prepared by the local sponsor describing the guidance on the management of materials contaminated, or otherwise, that will be encountered during construction should be considered during the PED phase of the project. The plan would provide information regarding anticipated volume and characteristic of contaminated materials identified so that appropriate plans can be developed to manage the transportation, treatment, and disposal of the contaminated materials.

11.28.10 Noise and Worker Safety

Best management practices that would be implemented to minimize noise effects would include the following:

- 1) Clearing activities would occur during normal weekday business hours.
- 2) Equipment mufflers would be properly maintained.
- 3) Personnel or contractors conducting tree removal, cutting, topping and mowing operations would wear required Personal Protective Equipment at all times.
- 4) Personnel would be excluded from work zones during tree removal, cutting, and topping operations and mowing operations to ensure occupational safety and health risks to personnel are not increased from implementation of any of the action alternatives.
- 5) A safety plan would be developed in accordance with current regulations.

11.28.11 Erosion and Sediment Control

An erosion and sediment control plan approved by the VDEQ would be developed that minimizes soil exposure and compaction during construction and controls stormwater discharges to minimize soil erosion. Specific measures to minimize soil exposure and

compaction and reduce potential impacts to stormwater that would be required to be followed during construction would consist of the following:

- 1) Equipment and vehicles would be operated outside of wetlands wherever feasible and use mats when work in wetlands would be unavoidable.
- 2) Heavy equipment, located in temporarily impacted wetland areas, would be placed on mats, geotextile fabric or use other suitable measures to minimize soil disturbance to the maximum extent practicable.
- 3) Personnel and contractors would install and monitor erosion-prevention BMPs such as silt fences, sediment berms, and/or other equivalent sediment control measures as appropriate and in accordance with the approved Stormwater Pollution Prevention Plan.
- 4) Personnel and contractors would apply permanent or temporary soil stabilization to denuded areas within seven days after final grade is reached on any portion of the site.
- 5) Personnel and contractors would conduct soil testing prior to application of native seed mixes to determine if fertilizer would be necessary and to determine the appropriate nutrients and ratio of nutrients in the fertilizer.
- 6) Personnel and contractors would apply fertilizer to planting sites in accordance with manufacturer's recommendations and do not apply nutrients during rainfall events.
- 7) Personnel and contractors would inspect stormwater water BMPs and potential risks to stormwater (e.g. material stockpiles, silt fences, etc.) (i) at least once every four business days or (ii) at least once every five business days and no later than 48 hours following a measurable storm event. In the event that a measurable storm event occurs when there are more than 48 hours between business days, the inspection would be conducted on the next business day.
- 8) Disturbed areas would be stabilized immediately whenever any clearing, grading, excavating, or other land-disturbing activities have permanently ceased on any portion of the site, or temporarily ceased on any portion of the site and would not resume for a period exceeding 14 days.

11.28.12 Other Standard Best Management Practices

Standard Best Management Practices (BMPs) would be implemented during project implementation to minimize potential impacts to resources to the extent practical. Tree removal and cutting operations would be controlled in accordance with forestry BMPs to reduce potential disturbances to soils, natural resources, and cultural resources. Stormwater BMPs would be used to mitigate any potential erosion and sedimentation impacts.

Stormwater BMPs would be used to prevent and mitigate erosion and sedimentation impacts that have the potential to cause short-term and long-term impacts to soils as well as water quality. Prior to construction, a Stormwater Pollution Prevention Plan approved by the VDEQ, as authorized under the Virginia Stormwater Management Program Regulation (9VAC25-870), that includes erosion control practices, inspection procedures, and other BMPs will be required.

Other BMPs that would be employed during project implementation would include the following:

- 1) Forestry BMPs for selecting temporary road/trail sites, constructing temporary roads/trails, road and associated drainage practices would be followed as described in the *Virginia's Forestry Best Management Practices for Water Quality* Technical Manual (Virginia

- Department of Forestry 2011).
- 2) Crossing of saturated areas would be avoided if possible but if deemed necessary, crossings would be temporarily constructed as described in the *Virginia's Forestry Best Management Practices for Water Quality* Technical Manual (Virginia Department of Forestry 2011).
 - 3) Use of access roads/trails would be minimized and would not cross through saturated areas if possible or within 50 feet of any cultural resources sites. Existing roads will be used whenever possible and would not cross cultural resource sites. The width of roads would be restricted to the width of the largest vehicle that would be used onsite for the tree removal efforts. Turn around areas would be restricted and limited to minimize impacts to soils and vegetation. All access points would avoid existing water bodies/saturated areas to the maximum, practical extent. Should a crossing be necessary for vehicles and equipment, a bridge, culvert, pole ford or other equivalent BMP would be employed to minimize potential erosion and rutting.
 - 4) Tree removal sites or sites disturbed by temporary access roads would be brought back to original grade and replanted with a native, perennial seed mixture.
 - 5) Application of any pesticides to control tree re-growth would be limited solely to the target vegetation.
 - 6) Equipment and cut trees would only be stored onsite during designated, upland staging areas. Any cut trees would not be left in wetland areas for more than one day after being cut.
 - 7) Surveyor's flagging or an equivalent methodology would be used to flag sensitive areas where equipment is not allowed to cross.
 - 8) No storage of fuels or chemicals or refueling of vehicles or equipment would occur in environmentally sensitive areas including the upland forest areas or wetland sites.
 - 9) The contractor would be required to carry a spill control kit at all times should a spill of a hazardous material occur or if there is a vehicle or equipment leak. The spill kit would include absorbent material, clamps and plugs for leaks, a sturdy catch basin for leaks, digging tools, and tarps to protect soil during repair jobs.
 - 10) Any dragging of logs or further disturbance to soils following felling operations would be minimized to the maximum practical extent to reduce impacts to surrounding natural resources.
 - 11) Where feasible, equipment modifications would be used in the wetland sites to reduce potential impacts to soils, such as rubberized tracks, use of low ground pressure equipment, and use of lightweight equipment.
 - 12) No equipment or vehicles would be parked or stored in wetlands at any time.
 - 13) The tree removal operations should occur during suitable ground moisture conditions in order to avoid excessive site damage. When avoidable, do not conduct tree removal in excessively wet weather.
 - 14) Vehicles and equipment would be shut off when not in use.
 - 15) Any areas temporarily impacted by the project such as access roads would be restored to their pre-project condition.
 - 16) Blades of mowing equipment would remain above the ground surface to reduce potential soil disturbances to the maximum extent practical.
 - 17) Dust minimization measures such as application of water to trails/roads or equivalent

measures would be implemented as needed.

CHAPTER 12 ENVIRONMENTAL COMPLIANCE

Compliance with the following environmental laws (and implementing regulations) and Executive Orders is required for the project alternatives under consideration (note: this is not necessarily an exhaustive list of all applicable environmental requirements).

Table 12-1. Table of Environmental Compliance

Title of Law	U.S. Code	Compliance Status
Abandoned Shipwreck Act of 1987	43 United States Code (U.S.C.) 2101	Coordination with federal and state agencies, is ongoing
American Bald and Golden Eagle Protection Act of 1962, as amended		Coordination with the U.S. Fish and Wildlife Service (USFWS) is ongoing
Anadromous Fish Conservation Act of 1965	16 U.S.C. 757 a et seq	Coordination with the NMFS is ongoing
Clean Air Act of 1972, as amended	42 U.S.C. 7401 et seq	Coordination with the DEQ is ongoing
Clean Water Act of 1972, as amended	33 U.S.C. 1251 et seq	Coordination with the DEQ is ongoing
Coastal Barrier Resources Act	16 U.S.C. 3501 et seq	There are no resources within the ROI. N/A
Coastal Zone Management Act of 1972, as amended	16 U.S.C. 1451 et seq	Full Compliance
Comprehensive Environmental Responses, Compensation and Liability Act of 1980	42 U.S.C. 9601	Full Compliance
Deepwater Port Act of 1974, as amended	33 U.S.C. 1501	Full Compliance
Emergency Wetlands Resources Act	16 U.S.C. 3901-3932	N/A
Endangered Species Act of 1973	16 U.S.C. 1531	Coordination with the USFWS is ongoing
Estuary Protection Act of 1968	16 U.S.C. 1221 et seq	N/A
Fish and Wildlife Coordination Act of 1958, as amended	16 U.S.C. 661	Coordination with the USFWS and state wildlife agencies is ongoing
Flood Control Act of 1970	33 U.S.C. 549	Full Compliance
Land and Water Conservation Act	16 U.S.C. 460	Full Compliance
Magnuson-Stevens Fishery Conservation and Management Act	16 U.S.C. 1801	Coordination with the NMFS is ongoing
Marine Mammal Protection Act of 1972, as amended	16 U.S.C. 1361	Coordination with the NMFS is ongoing
Marine Protection, Research, and Sanctuaries Act of 1972	33 U.S.C. 1401	N/A; on open ocean disposal of dredged material is anticipated
Migratory Bird Conservation Act of 1928, as amended	16 U.S.C. 715	Coordination with the USFWS is ongoing

Migratory Bird Treaty Act of 1918, as amended	16 U.S.C. 703	Coordination with the USFWS is ongoing
National Environmental Policy Act of 1969, as amended	42 U.S.C. 4321 et seq	NEPA will conclude and be in compliance upon the publishing of a final Record of Decision
National Historic Preservation Act of 1966, as amended	16 U.S.C. 470	Coordination with federal, state, local agencies, tribal governments, and the public is ongoing
National Historic Preservation Act Amendments of 1980	16 U.S.C. 469a	Coordination with federal, state, local agencies, tribal governments, and the public is ongoing
Native American Graves Protection and Repatriation Act of 1990	25 U.S.C. 3001	N/A
Noise Control Act of 1972, as amended	42 U.S.C. 4901	Full Compliance
Resource Conservation and Recovery Act of 1976	42 U.S.C. 6901 et seq	Full Compliance
River and Harbor Act of 1888, Section 11	33 U.S.C. 608	Full Compliance
River and Harbor Act of 1899	33 U.S.C. 401 et seq	Coordination to occur with the U.S. Coast Guard during permit process to obtain permits for storm surge barriers, permits for channel closure or constriction, and aids to navigation
Safe Drinking Water Act of 1974, as amended	42 U.S.C. 300	Full Compliance
Submerged Lands Act of 1953	43 U.S.C. 1301 et seq	Full Compliance
Toxic Substances Control Act of 1976	15 U.S.C. 2601	Full Compliance

Title of Executive Order	Executive Order Number	Compliance Status
Protection and Enhancement of Environmental Quality	11514/11991	Full Compliance
Protection and Enhancement of the Cultural Environment	11593	Coordination with federal, state, local agencies, tribal governments, and the public is ongoing
Floodplain Management	11988	Full Compliance
Protection of Wetlands	11990	Full Compliance
Federal Compliance with Pollution Control Standards	12088	Full Compliance
Offshore Oil Spill Pollution	12123	Full Compliance

Federal Compliance with Right-to-Know Laws and Pollution Prevention	12856	N/A
Federal Actions to Address Environmental Justice and Minority and Low-income Populations	12898	Full Compliance
Protection of Children from Environmental Health Risks and Safety Risks	13045	Full Compliance
Invasive Species	13112	Full Compliance
Marine Protected Areas	13158	N/A
Consultation and Coordination with Indian Tribal Governments	13175	Full Compliance
Responsibilities of Federal Agencies to Protect Migratory Birds	13186	Coordination with the USFWS is ongoing
Facilitation of Cooperative Conservation	13352	N/A
Preparing the United States for Impacts of Climate Change	13659	Full Compliance
Efficient Federal Operations	13834	Full Compliance

Law	Agency Responsible	Permit, Agreement, Authorization, or Notification Required
American Bald and Golden Eagle Protection Act of 1962, as amended	U.S. Fish and Wildlife Service (USFWS)	"Take" permit if any eagles are accidentally harmed or killed; no take permit is required
Chesapeake Bay Preservation Act	VDEQ/City of Norfolk	Permits for development and/or clearing within the Resource Protection Area
Comprehensive Environmental Responses, Compensation and Liability Act of 1980, as amended	U.S. Environmental Protection Agency (USEPA)	Full Compliance
Clean Water Act, Section 401*	Virginia Department of Environmental Quality (VDEQ)	401 Water Quality Certification (Will be coordinated under CZMA process)
Coastal Zone Management Act (CZMA)	VDEQ	CZMA Federal Consistency Concurrence
Endangered Species Act of 1973	NMFS	Biological Opinion with Incidental Take statement (Formal Consultation)
Endangered Species Act of 1973	USFWS	Concurrence Determination (Informal Consultation)

Fish and Wildlife Coordination Act (FWCA)	USFWS	FWCA Report
Magnuson-Stevens Fishery Conservation and Management Act	NMFS	Notification of any noncompliance; none anticipated
Marine Mammal Protection Act of 1972, as amended	NMFS	Incidental Take Authorization
Marine Protection, Research, and Sanctuaries Act of 1972*	USEPA	N/A
Migratory Bird Treaty Act of 1918, as amended	USFWS	“Take” permit; no take permit is required
National Historic Preservation Act of 1966, as amended	Advisory Council on Historic Preservation, Virginia Department of Historic Resources	Programmatic Agreement drafted
National Pollutant Discharge Elimination System (NPDES)/Virginia Pollutant Discharge Elimination System (VPDES)	VDEQ	Permits required only if there are any point source discharges to surface waters, to dischargers of stormwater from Municipal Separate Storm Sewer Systems (MS4s)
Noise Control Act of 1972	USEPA	Notification of any noncompliance; none anticipated
Resource Conservation and Recovery Act of 1976	USEPA, VDEQ	Testing, quantification, and notification for any hazardous materials
Rivers and Harbors Act of 1899	U.S. Coast Guard	Permits to construct storm surge barriers, for channel closures or restrictions, and aids to navigation
Virginia Code, Title 28.2, Fisheries and Habitat of the Tidal Waters	Virginia Marine Resources Commission (VMRC)	Permit for structures and fill to encroach upon state-owned bottom
Virginia Code, Title 9.25 Virginia Stormwater Management Program	VDEQ	Permits to dischargers of stormwater from construction activities

N/A = Not Applicable; DEQ = Virginia Department of Environmental Quality; NMFS = National Marine Fisheries Service; USEPA = U.S. Environmental Protection Agency; USFWS = U.S. Fish and Wildlife Service

12.1 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969, AS AMENDED, 42 U.S.C. 4321 *et seq.*

The NEPA requires that all federal agencies use a systematic, interdisciplinary approach to protect the human environment. This approach promotes the integrated use of natural and social sciences in planning and decision-making that could have an impact on the environment. NEPA requires the preparation of an environmental impact statement (EIS) for any major federal action that could have a significant impact on quality of the human environment and the preparation of an Environmental Assessment (EA) for those federal actions that do not cause a

significant impact but do not qualify for a categorical exclusion. The NEPA regulations issued by CEQ provide for a scoping process to identify and 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. As previously stated, the USACE used this process to comply with NEPA and focus this General Investigation (GI) study on the issues most relevant to the environment and the decision making process. For a description of the agency, tribal, and public coordination completed to date and information on the NEPA scoping that was completed, please refer to Section 1.7 PUBLIC AND AGENCY COORDINATION. The Draft Final EIS will undergo a 30-day agency, tribal, and public review period. All comments/edits will be addressed in the development of the Final GI/EIS, and will include responses to the comments. The GI/Final EIS, including all appendices and supporting documentation will fulfill requirements of the NEPA for the Norfolk Coastal Storm Risk Management Project. Upon completion of the GI/FEIS, which is signified by the signing of the Record of Decision, the project will be in full compliance with the NEPA.

12.2 CLEAN WATER ACT

The USACE will obtain a Water Quality Certification pursuant to Section 401, from the Commonwealth of Virginia, Department of Environmental Quality, pursuant to the Clean Water Act (CWA). The VDEQ has stated the requirement to obtain a 401 water quality certification for the project, but does not issue conditional certifications in response to NEPA documents. The appropriate permits will be obtained during the PED phase of the project.

In addition, the CWA Section 404(b)(1) guidelines analysis is provided in Appendix D.

12.3 WETLANDS

Section 404 of the CWA and 33 C.F.R. 336(c)(4) and 33 C.F.R. 320.4(b) require the USACE to avoid, minimize, and mitigate impacts to wetlands. Jurisdictional wetlands are anticipated with implementation of this project. Minor to moderate impacts are anticipated. An estimated 1.2 acres of tidal scrub/shrub, and 0.8 acres of tidal emergent wetland impacts to jurisdictional wetlands are anticipated with implementation of this project. A wetland delineation has not been completed yet. It will be completed in the Preconstruction, Engineering, and Design (PED) phase of the project, once real estate access is secured and the project design is more finalized. Final impact amounts will be determined upon more complete design of the project. A functional assessment using the New England Salt Marsh Model is being completed, and a wetland mitigation plan is being developed. The plan will be finalized as wetland impacts are determined in greater detail. However, it is noted that wetland mitigation will also be required to be done in compliance with the requirements under State laws, regulations, and requirements.

A conceptual wetland mitigation has been developed for this project and will be coordinated with regulatory agencies for approval.

12.4 RIVERS AND HARBORS ACT, 33 U.S.C. 401 ET AL.

This law and its implementing regulations prohibit the construction of any bridge, dam, dike, or causeway crossing over or in navigable waters of the U.S. without Congressional approval. The U.S. Coast Guard administers Section 9 and issues permits for construction of crossings over navigable waters. This law and its implementing regulations also allows the U.S. Coast Guard to

require necessary lighting and aids to navigation, and to approve any temporary or permanent closures or restrictions of navigation channels.

The storm surge barriers constitute crossings by definition, therefore, a permit must be obtained from the USCG once the barriers are designed. The USACE or the City will go through the permit process and obtain approval prior to construction.

12.5 FEDERAL COASTAL ZONE MANAGEMENT ACT, 16 U.S.C. 1451 ET SEQ.

The Federal Coastal Zone Management Act (CZMA) requires each federal agency activity performed within or outside the coastal zone (including development projects) that affects land or water use, or natural resources of the coastal zone to be carried out in a manner which is consistent to the maximum extent practicable, i.e. fully consistent, with the enforceable policies of approved state management programs unless full consistency is prohibited by existing law applicable to the federal agency.

To implement the CZMA and to establish procedures for compliance with its federal consistency provisions, the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), promulgated regulations which are contained in 15 C.F.R. Part 930. As per 15 CFR 930.37, a federal agency may use its NEPA documents as a vehicle for its consistency determination.

The Virginia Coastal Management Program was established under the guidelines of the national Coastal Zone Management Act (1972) as a state-federal partnership to comprehensively manage coastal resources. The DEQ is the designated state coastal management agency and is responsible for the implementation of the state's Coastal Management Program. Implementation includes the direct regulation of impacts to coastal resources within the critical areas of the state including coastal waters, tidelands, beaches and beach dune systems; and indirect certification authority over federal actions and state permit decisions within the eight coastal counties.

The goals of the Virginia Coastal Management Program are attained by enforcement of the policies of the State as codified within the Virginia Code of Regulations. "Policy" or "policies" of the Virginia Coastal Management Program means the enforceable provisions of present or future applicable statutes of the Commonwealth of Virginia. The statutes cited as policies of the Program were selected because they reflect the overall program goals of developing and implementing a balanced program for the protection of the natural resources, as well as promoting sustainable economic development of the coastal area. In accordance with the CZMA, it has been determined that the proposed Norfolk Coastal Storm Risk Management Project would be carried out in a manner that is fully consistent with the enforceable policies of the Virginia CMP (The Federal Consistency Determination with the CZMA is provided in Appendix D).

12.6 CLEAN AIR ACT, AS AMENDED, 42 U.S.C. 7401 ET SEQ.

There will be negligible, temporary increases in air emissions from operation of construction equipment during construction and maintenance operations. These emissions will be below *de minimis* levels. The Hampton Roads Intrastate Air Quality Control Region is in attainment with all National Ambient Air Quality Standards. Therefore, no conformity analysis is required for this

project.

12.7 U.S. FISH AND WILDLIFE COORDINATION ACT, 16 U.S.C.661-666(C)

The project is undergoing coordination with the U.S. Fish and Wildlife Service and the Commonwealth of Virginia. A Fish and Wildlife Coordination Act Report is being prepared by the U.S. Fish and Wildlife Service.

12.8 ENDANGERED SPECIES ACT

A Biological Assessment evaluating the potential impacts of the proposed action on endangered and threatened species has been prepared and is provided in Appendix D. Critical habitat has been designated for some of the species that occur in the action area, but there is no critical habitat in the action area. Coordination with the USFWS and the NMFS pursuant to Section 7 of the ESA for the species provided in Table 12-2 below is ongoing.

Formal consultation with the NMFS is anticipated because of the potential, adverse effects to Atlantic Sturgeon and sea turtles construction of storm surge barriers in the Action Area. Other effects to federally listed are all either no affect or may affect, not likely to adversely affect determinations and the analysis and findings are described in detail in the Special Status Species Section and in the Biological Assessment (Appendix D).

Table 12-2. Federally listed species known or with the potential to occur in the Action Area.

Taxonomic Category/Common Name	Scientific Name	Status	Critical Habitat	Affect Determination
Birds				
Piping plover	<i>Charadrius melodus</i>	T	Y*	May Affect, Not Likely to Adversely Affect
Red knot	<i>Calidris canutus rufa</i>	T	N	May Affect, Not Likely to Adversely Affect
Fish				
Atlantic sturgeon	<i>Acipenser oxyrinchus oxyrinchus</i>	T, E	Y*	May Affect, Not Likely to Adversely Affect
Mammals				
Fin whale	<i>Balaenoptera physalus</i>	E	N	May Affect, Not Likely to Adversely Affect
Northern long-eared bat	<i>Myotis septentrionalis</i>	T	N	May Affect, Likely to Adversely Affect
Sei whale	<i>Balaenoptera borealis</i>	E	N	May Affect, Not Likely to Adversely Affect
West Indian manatee	<i>Trichechus manatus</i>	T	Y*	May Affect, Not Likely to Adversely Affect
Reptiles				
Green sea turtle	<i>Chelonia mydas</i>	T	Y*	May Affect, Not Likely to Adversely Affect (NMFS

				jurisdiction): No Affect (USFWS jurisdiction)
Kemp's Ridley sea turtle	<i>Lepidochelys kempii</i>	E	N	May Affect, Not Likely to Adversely Affect (NMFS jurisdiction): No Affect (USFWS jurisdiction)
Loggerhead sea turtle	<i>Caretta caretta</i>	T	Y*	May Affect, Not Likely to Adversely Affect (NMFS jurisdiction): No Affect (USFWS jurisdiction)

DPS = Distinct Population Segment; T = Threatened; E = Endangered; Y = Yes; N = No; ^Species status is reported as it pertains to the DPS/Action; *Critical Habitat not located in Action Area.

12.9 MAGNUSON-STEVENSON FISHERY CONSERVATION AND MANAGEMENT ACT (MSA), 16 U.S.C. 1801 ET SEQ.

This Act requires federal action agencies to consult with the National Marine Fisheries Service (NMFS) if a proposed action may affect Essential Fish Habitat (EFH). The USACE evaluated potential project impacts on NMFS-managed fish species and their Essential Fish Habitats (Appendix D). Direct and indirect adverse impacts to EFH, managed species, and their prey are anticipated to range from negligible to significant, however, the vast majority of impacts are anticipated to be temporary. Coordination with the NMFS is ongoing.

12.10 ANADROMOUS FISH CONSERVATION ACT, 16 U.S.C. 757, ET SEQ.

The project considered habitat impacts to the anadromous fish listed below in Table 12-3. Coordination with the NMFS Fisheries and the Virginia Department of Game and Inland Fisheries, to do determine whether or not the project would restrict anadromous fish migration. Coordination with the NMFS is ongoing.

Table 12-3. Anadromous fish known or with the potential to occur in the Region of Influence

Common Name	Scientific Name
Atlantic sturgeon	<i>Acipenser oxyrinchus oxyrinchus</i>
Alewife	<i>Alosa pseudoharengus</i>
American shad	<i>Alosa sapidissima</i>
Blueback herring	<i>Alosa aestivalis</i>
Hickory shad	<i>Alosa mediocris</i>
Striped bass	<i>Morone saxatilis</i>
Yellow perch	<i>Perca flavescens</i>

12.11 MARINE MAMMAL PROTECTION ACT, 16 U.S.C. 1631, ET SEQ.

The Marine Mammal Protection Act (MMPA) prohibits the take of marine mammals including the West Indian manatee, and all cetaceans found in the ROI. The project is being coordinated with USFWS and NMFS. No incidental take permit is anticipated to be required for this project. Coordination with the NMFS is ongoing with this project.

12.12 SECTION 106 AND 110(F) OF THE NATIONAL HISTORIC PRESERVATION ACT, 16 U.S.C. 470 ET SEQ.

The National Historic Preservation Act (NHPA) applies to properties listed in or eligible for listing in the National Register of Historic Places (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. Section 106 of the NHPA and its implementing regulations at 36 CFR Part 800, require the lead federal agency to assess the potential effects of an undertaking on historic properties that are within the proposed project’s Area of Potential Effect (APE), which is defined as “the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist” (36 C.F.R. § 800.16[d]).

The USACE evaluated the potential for adverse impacts to archaeological or historic resources. There are Historic Districts and historical architecture that may be adversely affected by this project. Archaeological sites may also exist within unsurveyed parts of the APE. As per a Programmatic Agreement with the Virginia State Historic Preservation Office, surveys and further coordination will be conducted for these areas during the Preconstruction, Engineering, and Design (PED) Phase of the Project. The procedures for any mitigation if adverse effects to NRHP eligible properties are identified are also described in the Programmatic Agreement.

12.13 RESOURCE CONSERVATION AND RECOVERY ACT, AS AMENDED, 42 U.S.C. 6901 ET SEQ.

The Resource Conservation and Recovery Act (RCRA) RCRA controls the management and disposal of hazardous waste. “Hazardous and/or toxic wastes”, classified by the Resource Conservation and Recovery Act (RCRA), are materials that may pose a potential hazard to human health or the environment due to quantity, concentration, chemical characteristics, or physical characteristics. This applies to discarded or spent materials that are listed in 40 CFR 261.31-.34 and/or that exhibit one of the following characteristics: ignitable, corrosive, reactive, or toxic. Radioactive wastes are materials contaminated with radioactive isotopes from anthropogenic sources (e.g., generated by fission reactions) or naturally occurring radioactive materials (e.g., radon gas, uranium ore).

For this report, we searched the Virginia Department of Environmental Quality (VDEQ) Waste Division records and Environmental Protection Agency (EPA) records to determine the number of Superfund sites, Brownsfield sites, hazardous waste handlers, underground storage tanks (USTs), and other regulated hazardous material locations.

Adverse impacts involving hazardous materials and wastes from implementation of Alternative 2a are largely predicted to be negligible and temporary during construction; moreover, the implementation of the storm risk management measures would reduce risks of exposure during flooding events. Of particular concern would be the avoidance or removal of underground storage tanks in areas identified for construction. Additionally, placement of sand in Area 1 has the potential to create minor, beneficial impacts in protection against erosion and potential exposure of contaminants.

12.14 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT, 42 U.S.C. 9601 ET SEQ.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) governs the liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous substance disposal sites.

Only one CERCLA site, Naval Base Norfolk, which was on the National Priorities List (NPL), is located in the City of Norfolk. Remedial actions at Naval Base Norfolk site were completed in 2010. Little Creek Amphibious Base (Joint Expeditionary Base Little Creek – Fort Story) is adjacent to the city line, but in Virginia Beach. Across and upriver from the Berkley section of Norfolk, there are five Superfund sites along the Southern Branch of the Elizabeth River in Portsmouth. These, from north to south, are: Abex Corp., Norfolk Naval Shipyard, Peck Iron and Metal, Atlantic Wood Corp., and Saint Juliens Creek Annex. However, none of these will be affected by this project.

12.15 MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

The Act has two essential aims: to regulate intentional ocean disposal of materials, and to authorize any related research. While the MPRSA regulates the ocean dumping of waste and provides for a research program on ocean dumping, it also provides for the designation and regulation of marine sanctuaries.

No ocean dumping will occur as a result of this project.

12.16 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 proposed project could have impacts, ranging from negligible to significant, that could affect the floodplain, including people, property, and the environment. Existing conditions and project alternative impacts associated with flooding and floodplain management are discussed further in Chapter 10, Section 10.5 and Chapter 11, Section 11.6, respectively.

12.17 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. An estimated 1.2 acres of tidal scrub/shrub, and 0.8 acres of tidal emergent wetland impacts to jurisdictional wetlands are anticipated with implementation of this project. A wetland delineation has not been completed yet, but will be completed once a jurisdictional determination can be completed. Final impact amounts will be determined upon more complete design of the project. A functional assessment using the New England Salt Marsh Model is being completed, and a wetland mitigation plan is being developed. The plan will be finalized as wetland impacts are determined in greater detail. However, it is noted that wetland mitigation will also be required to be done in compliance with the requirements under State laws, regulations, and requirements.

12.18 EXECUTIVE ORDER 13112, INVASIVE SPECIES

Under this EO, the introduction of invasive species has been evaluated in Section 6.22. The project would not induce the introduction of invasive species to the project area.

12.19 EXECUTIVE ORDER 12898, FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE IN MINORITY POPULATIONS AND LOW INCOME POPULATIONS

In accordance with this EO, the USACE has determined that no group of people would bear a disproportionately high share of adverse environmental consequences resulting from the proposed work.

12.20 EXECUTIVE ORDER 13045, PROTECTION OF CHILDREN FROM ENVIRONMENTAL HEALTH RISKS AND SAFETY RISKS

This EO ensures that all federal actions address the unique vulnerabilities of children. In accordance with this EO, the USACE has determined that no children would bear a disproportionately high share of adverse environmental consequences resulting from the proposed work.

12.21 MIGRATORY BIRD TREATY ACT, 16 U.S.C. 703 ET SEQ.; EXECUTIVE ORDER 13186, FEDERAL RESPONSIBILITY TO PROTECT MIGRATORY BIRDS

This Act makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to federal regulations. Temporary to permanent impacts to migratory birds would range from adverse to beneficial effects that would range from a negligible to a minor level of impact.

CHAPTER 13 CONCLUSIONS AND RECOMMENDATIONS

As a result of Hurricane Sandy in 2012, Congress authorized the USACE to study coastal storm risk management strategies for the North Atlantic coast of the United States. Norfolk was identified as a focus area of that study. This report follows up on the NACCS study with more detailed recommendations for reducing coastal storm risk and improving the resiliency of Norfolk to potential shocks created by sea level rise and coastal storms.

The NACCS study, as well as studies by others, have given a clearer picture as to the frequency of intense coastal storms and their associated water surface elevations. Add to this the predicted rate of RSLR, and it is clear that risks to the city are not static and will increasingly affect the city into the future. The manner of attaining risk reduction, as well as the level attainable, is influenced by a range of considerations presented in this report. Economics are only a part of the picture. The USACE, along with the City of Norfolk, and engaged stakeholders, have also considered impacts to cultural resources, vulnerable populations, the environment, and national security, along with the more traditional economic evaluations.

Based on all the analysis conducted, the team recommends a combination of structural and nonstructural measures, along with NNBF, that are described as the Recommended Plan (RP). The RP is a large project with a cost of \$1.6 billion. The project will provide extensive risk reduction to residents and businesses in Norfolk. It will also provide flood risk reduction for roads that are necessary for egress and ingress to the largest naval base in the world and the second largest port on the U.S. East Coast.

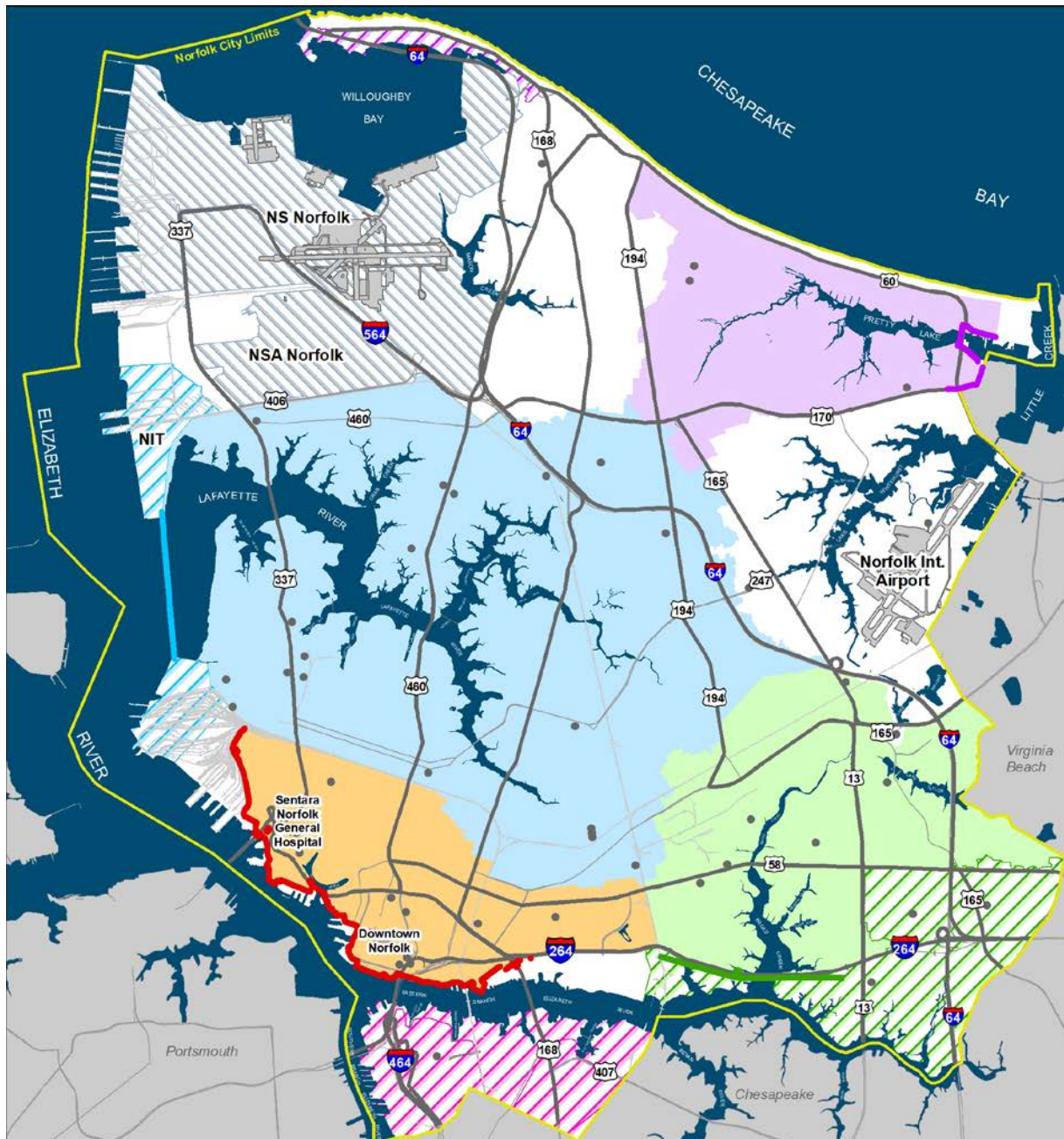
Due to the size and cost of the RP, it is unlikely that funding for construction would be available all at once. The PDT and the City of Norfolk have discussed the need to develop a strategy for implementation and sequencing of the RP in order to be prepared for available construction funds and to communicate the construction priority to stakeholders. The following sections describe a recommended path forward for project implementation.

13.1 CONSTRUCTION SEQUENCING STRATEGY FOR THE RECOMMENDED PLAN

A construction sequencing strategy has been developed by the USACE PDT and the City of Norfolk. The sequencing recommendation is as follows by highest priority:

1. Critical infrastructure floodproofing
2. Area 3 – EBS (Ghent, Downtown, Harbor Park) flood barrier system
3. Area 1 – PL-2S (Pretty Lake) flood barrier system, WB-1N (Willoughby Spit) nonstructural
4. Area 2 – LR-1aS (Lafayette River) flood barrier system
5. Area 4 – BC-1S (Broad Creek) flood barrier system, EB-7N and EB-8N (Broad Creek & Elizabeth Park) nonstructural, EB-4N, EB-4aN, EB-4bN (Campostella & Berkley) nonstructural

The project components listed above are shown in Figure 13-1 below and described further in the following sections.



LEGEND

Structural Flood Risk Management Measures

- Ghent-Downtown-Harbor Park
- Pretty Lake Surge Barrier
- Lafayette Outer Surge Barrier
- Broad Creek Surge Barrier

Structural Measures Risk Management Area

Hatched Area Indicates Non-Structural Measures

- Ghent-Downtown-Harbor Park
- Pretty Lake Surge Barrier
- Lafayette Outer Surge Barrier
- Broad Creek Surge Barrier

- Campostella-Berkley Non-Structural Measures Area

- Critical Infrastructure
- Evacuation Route
- Navy Base
- Water
- Major Road
- Railroad

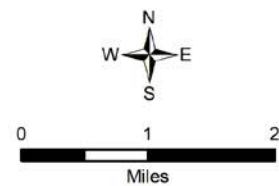


Figure 13-1. Norfolk CSRM Project Sequencing Map

13.1.1 Critical Infrastructure Floodproofing

Critical infrastructure floodproofing measures identified in the RP will be prioritized for implementation. Reducing the risk to critical infrastructure will increase the resilience of Norfolk to future impacts from coastal flooding.

13.1.2 Area 3 - Ghent, The Hague, and Downtown Areas

The EBS measure will provide flood risk reduction in the economic core of the city by providing a continuous project alignment from West Ghent to the Harbor Park area. Measure EBS is selected as the first priority of major construction based on the economic value of the area as well as important infrastructure such as the region's only Tier 1 trauma hospital, the region's children's hospital, emergency services, the region's only medical school, critical transportation corridors used for evacuation, city hall, city institutional network, cultural assets, and adjacent historic districts as well as well as public housing. Measure EBS will also provide flood risk management to portions of Area 4 in the Tidewater area of the city.

13.1.3 Area 1 - Pretty Lake Area and Willoughby Spit Nonstructural

This area consists of measures PL-2S and WB-1N. This system of measures would provide flood risk reduction for the Pretty Lake area that include residential neighborhoods, emergency evacuation routes for northern Norfolk, and routes that provide access to Little Creek Amphibious Base. In particular, Route 60 (Shore Drive), used by military personnel, has average annual daily traffic volume of 26,000. Nonstructural measures in WB-1N will reduce flood risks for properties along Willoughby Bay.

13.1.4 Area 2 - Lafayette River Area

This area would consist of measures LR-1aS and MS-2N. Measure LR-1aS is the Lafayette River outer storm surge barrier. This structural measure would provide coastal storm risk management to the Lafayette River watershed, which is the largest, geographic economic reach in the study, representing approximately 26% of the study land area. The watershed includes six historic districts, Old Dominion University, and Bon Secours DePaul Medical Center. The measure would protect portions of Hampton Boulevard, which is used by military personnel to access Naval Station Norfolk. Average annual daily traffic volume on this road is 36,000. Measure MS-2N would provide nonstructural flood risk reduction to the primarily industrial areas on the western side of the storm surge barrier.

13.1.5 Area 4 - Broad Creek, Berkley, and Campostella Areas

This area would consist of measures BC-1S, EB-4N, EB-4aN, EB-4nN, EB-7N, and EB-8N. A storm surge barrier and associated floodwalls are proposed for preventing floodwaters from the Elizabeth River from entering the Broad Creek watershed. The barrier system will be aligned parallel with the southern side of I-264 and the light rail tracks. Nonstructural measures are proposed for the Elizabeth Park neighborhood and areas south of the floodwalls. Nonstructural measures are proposed south of the Elizabeth River in the Berkley and Campostella neighborhoods.

13.2 PLAN IMPLEMENTATION

The implementation process would carry a plan that is recommended through the pre-construction engineering and design (PED) phase of a project, including development of plans

and specifications, and construction. Funding by the Federal Government to support these activities would have to meet traditional civil works budgeting criteria.

13.2.1 Consistency with Laws and Policy

This feasibility report has been prepared in accordance with relevant laws and USACE policy. Specifically, this section of the report addresses:

- the specific requirements necessary to demonstrate that the project is technically feasible, economically justified, and environmentally compliant;
- and the costs and cost-sharing to support a Project Partnership Agreement (PPA).

Economic justification and environmental compliance of the RP are described and demonstrated to be technically feasible within this report. The report also identifies that the RP has benefits greater than costs. The Environmental Impact Statement has been prepared to meet the requirements of NEPA and demonstrate that the RP is compliant with environmental laws, regulations, and policies and has effectively addressed any environmental concerns of resource and regulatory agencies.

13.2.2 Cost Sharing and Real Estate Costs

The non-Federal costs include the value of lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRDs). Total LERRDs are estimated to be \$47,159,784. Total real estate costs, which include Federal review and assistance costs, are estimated to be \$61,175,084.

In accordance with the cost share provisions in Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213), project design and implementation are cost shared 65% Federal and 35% non-Federal.

Project First Cost is the constant dollar cost of the RP at current price levels and is the cost used in the authorizing document for a project. Total Project Cost is the constant dollar fully funded with escalation to the estimated midpoint of construction. Total Project Cost is the cost estimate used in Project Partnership Agreements for implementation of design and construction of a project. Total Project Cost is the cost estimate provided to non-Federal sponsors for their use in financial planning as it provides information regarding the overall non-Federal cost sharing obligation. The RP First Cost is \$1.37 billion and the RP Project Cost is \$1.57 billion.

Table 13-1. First Cost Apportionment Table

	Federal (65%)	Non-Federal (35%)	Total
Initial Project Cost	\$ 889,783,000	\$ 479,114,000	\$ 1,368,897,000
LERRD Credit		\$ 36,276,757	
Cash Contribution		\$ 442,837,243	

Table 13-2. Total Project Cost Apportionment Table

	Federal (65%)	Non-Federal (35%)	Total
Initial Project Cost	\$ 1,020,942,000	\$ 549,738,000	\$ 1,570,680,000
LERRD Credit		\$ 47,159,784	

Cash Contribution		\$ 502,578,216	
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Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) requirements are considered in the economic analysis for the project. The non-Federal sponsor is responsible for 100% of annual OMRR&R requirements, estimated at \$1,759,000 per year. The Federal government is responsible for preparing and providing an OMRR&R manual to the sponsor.

13.2.3 Project Partnership – Local Sponsor Responsibilities

A Project Partnership Agreement (PPA) package will be prepared, coordinated, and executed subsequent to the approval of this document. The PPA serves as the agreement for the next phase of the project. The PPA reflects the recommendations of the Feasibility Study. The non-Federal partner, the City of Norfolk, VA, has indicated support for recommendations presented in this document and its desire to execute a PPA for the Norfolk CSRM Recommended Plan by letter dated September 18, 2017. This Letter of Intent is included in Appendix F.

As the non-Federal project partner, the City of Norfolk must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

A. In a cost sharing coordination with the Federal Government, who shall provide 65% of the initial project cost, provide 35% of the costs of project construction:

1. provide all lands, easements, rights of way and relocations (LERR), including suitable borrow areas, uncontaminated with hazardous and toxic wastes, and perform or ensure performance of any relocations determined by the Federal Government to be necessary for the initial construction, operation, and maintenance of this project.
2. perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the construction, operation, and maintenance of the Project. However, for lands that the Federal Government determines to be subject to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal project partner with prior specific written direction, in which case the non-Federal project partner shall perform such investigations in accordance with such written direction.
3. coordinate all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project.
4. cost-share of the cost of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project.

B. For fifty years, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and

any specific directions prescribed by the Government in the Operations, Maintenance, Replacement, Repair and Rehabilitation (OMRR&R) manual and any subsequent amendments thereto.

C. Provide the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls for access to the project for the purpose of inspection, and, if necessary after failure to perform by the non-Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the non-Federal project partner of responsibility to meet the non-Federal project partner's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.

D. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors.

E. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal regulations (CFR) Section 33.20.

F. As between the Federal Government and the non-Federal project partner, the non-Federal project partner shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

G. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

H. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense directive 5500.11 issued pursuant thereto, as well as Army regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

I. Participate in and comply with applicable Federal flood plain management and flood insurance programs and comply with the requirements in Section 402 of the Water Resources

Development Act of 1986, as amended.

J. Not less than once each year inform affected interests of the extent of storm risk management afforded by the project.

K. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the degree of storm risk management provided by the project.

L. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities which would degrade the benefits of the project.

M. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

N. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non- Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.

O. Quarterly and after storm events, perform surveillance of the project to determine project maintenance or repair needs and provide the results of such surveillance to the Federal Government.

13.2.4 Design and Construction Considerations and Schedule

In order for PED to be initiated, USACE must sign a PPA with a non-Federal sponsor to cost share PED and construction. This project would require congressional authorization for PED and construction. PED and construction are cost shared 65% Federal and 35% non-Federal. Implementation would then occur, provided that sufficient funds are appropriated to design and construct the project.

The draft schedule for plan implementation was developed for planning and cost estimating purposes. Actual construction timelines are subject to future project approval and funding requirements. See Appendix B for the proposed construction schedule.

Table 13-3. Implementation Schedule

City of Norfolk, Virginia Coastal Storm Risk Management Project	
Milestone	Date
Submission of Chief's Report	July 2018
Chief Signs Report	January 2019

Execute Design Agreement*	July 2019
Pre-Construction Engineering and Design (PED)*	September 2019
Congress Authorizes Project	WRDA 2018 / 2020
New Start Approval	May 2020
Project Partnership Agreement (PPA)*	December 2020
First Construction Contract Award*	June 2021
Construction Complete*	August 2026

*Required additional funding beyond Feasibility Report

13.2.5 Real Estate Requirements

USACE projects require the non-Federal sponsor provide LERRDs for a project. Currently, the RP will require the non-Federal sponsor to acquire temporary and permanent easements for construction. Total LERRDs cost is estimated to be \$61,175,084.

13.2.6 Views of the Non-Federal Sponsor and Other Agencies

The non-Federal sponsor, the City of Norfolk, VA, has indicated their support for releasing this report for public and agency input. The non-Federal sponsor’s letter of support for the RP is provided in Appendix F.

13.3 PATH FORWARD

A Chief's Report, the Report of the U. S. Army Corps of Engineers Chief of Engineers, is developed when a water resources project would require Congressional authorization for construction. After the final feasibility report is submitted to USACE Headquarters, a Chief's Report is developed. Once the Chief of Engineers signs the report, the Chief of Staff signs the notification letters forwarding the Report to the chairpersons of the Senate Committee on Environment and Public Works and the House of Representatives Committee on Transportation and Infrastructure. The signed Chief's Report is also supplied to the Office of the Assistant Secretary of the Army for Civil Works for review by the Administration.

This report, “Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study / Environmental Impact Statement” is scheduled to be submitted to USACE Headquarters in July 2019. A signed Chief’s Report is anticipated in January 2019.

Using the information in this feasibility report, the USACE will continue to coordinate with the City of Norfolk to implement the recommended project in accordance with current policy and in the most expeditious manner available by maximizing the use of available construction and study authorities (i.e. modifications of on-going projects/studies, post-authorization change reports, or new authorizations).

13.4 RECOMMENDED ACTIONS FOR OTHERS

While the USACE RP provides a significant suite of measures to reduce flood risk in Norfolk, the plan will not solve all of Norfolk’s flooding problems. Under the RP there remains residual risk from flooding beyond the design limitations, there are areas of the city that are outside the alignment of the RP, and nonstructural areas will still see impacts to roadways, utilities and the

environment due to flooding. The USACE recognizes that the USACE authority and formulation methodology is limited in what it can provide, therefore, the study includes recommended actions for sponsor and other entities to consider in a holistic approach to flood risk mitigation and overall resiliency.

13.4.1 Nonstructural Recommendations

Regional Intergovernmental Sponsor for Coastal Flooding and Sea Level Rise Adaptation

The resilience of each Hampton Roads municipality is tied to one another. As such, the USACE encourages the region to promote a state or regional organization that can sponsor and/or execute large scale studies for the benefit of the entire Hampton Roads region. A regional approach, for example, the Joint Land Use Study currently underway with Norfolk, Virginia Beach, and the US Navy, will allow for a more efficient and holistic study of a region so interconnected by water.

Norfolk Zoning Regulations

Norfolk currently has a zoning code that includes requirements for new and expanding development to build first floor elevations to the FEMA BFE plus three feet and the FEMA 0.2% (500-yr). These zoning regulations are encouraged to be maintained throughout the city regardless of whether or not properties are behind the recommended plan alignment. It is standard for cities to seek to have floodplain delineations removed from an area where a structural flood risk management project exists. The floodwalls and surge barriers in the RP may meet future FEMA certifications and therefore those areas behind those structures may be outside of the floodplain per FEMA standards. The USACE encourages the City of Norfolk to maintain the higher building standards even for structures that are behind the project alignment. Doing such would be a responsible way to increase resiliency and safety for the City.

Silver Jackets Study

Due to the scope of this study individual properties were not analyzed for detailed mitigation strategies. This proved problematic for commercial structures in areas where nonstructural measures were recommended. Buyouts of commercial properties are not desirable due to the lost tax base for the city. Most of the efforts by private businesses to mitigate themselves are also unknown, therefore, appropriate recommendations for measures were difficult to determine. Floodproofing is a viable option for commercial facilities and a site by site inspection of the structural integrity and layout of the facility would be needed to provide appropriate floodproofing recommendations. Norfolk is encouraged to seek a Silver Jackets Study to perform a detailed assessment of the nonstructural flood risk management measures for these commercial properties.

13.4.2 Natural and Nature Based Features

The City of Norfolk is encouraged to continue pursuing natural and nature-based features. The greenways that were screened out of the RP generally do not fall under the USACE authority as they are primarily for mitigating rainfall related urban stormwater and water quality problems. Neither of these fall under the USACE authority for coastal storm risk management. However, the USACE does acknowledge that the City has flooding and water quality related problems with rainfall related stormwater. Greenways can assist with mitigating these problems while also allowing opportunities for recreation and urban renewal.

13.5 LIST OF AGENCIES CONTACTED

Table 13-4. Agencies Contacted.

Agency	Name of Contact People
Advisory Council on Historic Preservation (ACHP)	Brian Lusher, Christopher Daniel
U.S. Navy (USN)	Michael King, Brian Ballard, Mercedes Holland
U.S. Coast Guard (USCG)	Barbara Wilk, Ken Koestecki, Anthony Lloyd
Federal Emergency Management Agency (FEMA)	Mari Radford
U.S. Army Corps of Engineers	Peter Kube
U.S. Environmental Protection Agency (USEPA)	Barbara Rudnick, Kevin Magerr
National Marine Fisheries Service (NMFS)	Christine Vaccaro, David O'Brien
U.S. Fish and Wildlife Service (USFWS)	Troy Andersen, Chris Guy
Virginia Department of Environmental Quality (VDEQ)	Bert Pariolari, Bettina Sullivan
Virginia Marine Resources Commission (VMRC)	Tony Watkinson, Rachael Peabody
Virginia Department of Historic Resources (VDHR)	Marc Holma, Greg LaBudde
Virginia Department of Game and Inland Fisheries (VDGIF)	Amy Ewing, David Whitehurst
Virginia Department of Conservation and Recreation (VDCR)	Ali Baird, Charley Banks
Virginia Institute of Marine Science (VIMS)	Pam Mason
Pamunkey Tribal Government	Ashley Atkins-Spivey
Delaware Nation	Nekole Alligood
Delaware Tribe of Indians	Susan Bachor
Naval History and Heritage Command	Robert Neyland
Norfolk Historical Society	Peggy McPhillips

13.6 LIST OF REPORT PREPARERS

Table 13-5. Report Preparers.

Name	Contribution/Education	Years of Experience
John Haynes	Cultural Resources/MA, Anthropology	29
Alicia Logalbo	Environmental Analyst/MS, Biology	19
Jason O'Neal	GIS Mapping/BS, Geology	13
Miranda Ryan	Environmental Analyst/BS, Biology	3
David Schulte	Environmental Analysis/MS, Marine Science	19
Alicia Farrow, P.E.	Coastal Engineering/ME, Civil Engineering	9
Niklas Hallberg, P.E.	Project Planning/MS, Civil Engineering	11
Jane Bolton, P.E.	Geotechnical Engineering/MS, Civil Engineering	30
Douglas Hessler	GIS Mapping/BS, Atmospheric Sciences	6
Robin Williams, P.E.	Hydraulics & Hydrology/ BS, Civil Engineering	28
Beth Babineau	Real Estate/BS	6
Brian Maestri	Economics/ MA Economics	32
Robertas Simonavicius	Economics/ MS Finance	2
Paul Moye, P.E.	Floodplain Management/BS Civil Engineer	31
Richard Harr	Environmental Analysis/BS, Environmental Science	16
Karin Dridge	GIS Mapping/BS, Geography	25
Michelle Hamor, CFM	Floodplain Management/ Economic Analysis/ BS, Civil Engineer	11
Daniel Hughes, Ph.D.	Project Planning/ Ph.D. Applied Anthropology	28
Faraz Ahmed	Floodplain Management/ ME, Civil Engineering	6
Leonard Mule, P.E.	Structural Engineering/ BS, Civil Engineering	29
Luan Ngo	Cost Engineering/ BS, Chemical Engineering	16
Kathy Perdue	Environmental Analysis/BS, Environmental Science	26
Candice Miranda	Floodplain Management/ BS, Civil Engineering	2

13.7 STATEMENT FROM THE DISTRICT ENGINEER

I concur with the findings of the Norfolk District PDT and advise the Recommended Plan, as fully detailed in this Integrated Feasibility Study and Environmental Impact Statement, be authorized for construction as a Federal project.

I have given consideration to all significant aspects of the public interest. These interests include environmental, social, and economic effects that are anticipated from the implementation of the Recommended Plan. The engineering feasibility and compatibility of the project with the policies, desires, and capabilities of the City of Norfolk, the Commonwealth of Virginia, and other non-Federal interests have also been considered.

The recommendations contained herein reflect the information and policies available at this time. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of highest review levels within the Executive Branch. Consequently, the recommendations may be modified (by the Chief of Engineers) before they are transmitted to Congress as proposals for authorization and implementing funding. However, prior to transmittal to Congress, the partner, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Patrick V. Kinsman, PE
Colonel, U.S. Army
Commanding

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INDEX

A

American shad, 169, 438
 Atlantic sturgeon, 169, 178, 179, 180, 181, 437, 438

B

Bald Eagle, 176, 177, 187, 193, 346, 468
 BC-1, 27, 28, 67, 71
 Berkley, 5, 28, 67, 68, 71, 72, 75, 79, 80, 84, 104, 121, 133, 138, 174, 200, 201, 208, 224, 238, 299, 301, 368, 386, 411, 440
 Biological Assessment, 16, 176, 437
 Blueback herring, 438
 Broad Creek, 6, 28, 46, 60, 67, 104, 120, 131, 133, 134, 138, 147, 151, 157, 158, 161, 174, 220, 245, 266, 289, 299, 301, 302, 303, 306, 308, 310, 316, 321, 322, 325, 330, 333, 336, 341, 375, 379, 381, 400, 411, 412, 413, 418, 459

C

Campostella, 5, 28, 60, 67, 68, 71, 72, 75, 79, 80, 84, 104, 121, 133, 138, 174, 201, 220, 224, 263, 266, 301, 386
 Chesapeake Bay, 1, 4, 6, 7, 8, 10, 13, 17, 45, 56, 113, 116, 118, 120, 121, 122, 123, 124, 131, 132, 133, 134, 135, 136, 137, 141, 150, 151, 152, 154, 161, 162, 163, 164, 166, 167, 168, 169, 170, 173, 179, 180, 181, 185, 186, 193, 197, 198, 216, 224, 244, 256, 258, 276, 277, 284, 289, 293, 309, 315, 316, 318, 327, 329, 339, 340, 344, 362, 369, 370, 371, 377, 378, 384, 388, 392, 395, 397, 402, 418, 420, 422, 433, 455, 456, 459, 460, 462, 463, 469, 471
 Clean Air Act of 1972, 431
 Clean Water Act, xxxii, 134, 135, 148, 150, 163, 322, 324, 431, 433, 435
 Coastal Zone Management Act of 1972, 431
 Comprehensive Environmental Responses, Compensation and Liability Act of 1980, 431, 433

D

Downtown Norfolk, 5, 118, 119, 156, 207, 218, 219, 262, 263, 265, 266, 309, 311, 396, 408

E

Eastern Branch of the Elizabeth River, 120, 138, 174, 256, 263, 300
 EB-1, 28, 71
 EB-1a, 28, 67

EB-2, 28, 67
 EB-3, 28, 67
 EB-3a, 28
 EB-3a,, 67
 EB-4, 28, 29, 71, 80
 EB-4a, 28, 29, 79, 80
 EB-4b, 28, 29, 79, 80
 EB-5, 28, 67, 71
 EB-5a, 28
 EB-6, 28, 104, 315, 327
 EB-7, 28, 67, 71
 EB-8, 28, 67, 71
 Elizabeth River, 2, 4, 5, 6, 7, 17, 45, 48, 68, 104, 118, 119, 120, 121, 123, 128, 131, 132, 133, 134, 137, 138, 147, 151, 154, 156, 157, 167, 170, 172, 173, 174, 198, 201, 218, 219, 220, 224, 234, 239, 242, 255, 256, 258, 261, 262, 263, 264, 265, 266, 276, 277, 282, 284, 289, 293, 299, 301, 303, 308, 309, 315, 321, 322, 327, 329, 330, 333, 340, 341, 344, 362, 365, 367, 370, 371, 373, 378, 379, 380, 381, 383, 384, 388, 392, 395, 397, 400, 408, 409, 411, 412, 413, 418, 422, 440, 455, 457, 463
 Endangered Species Act of 1973, 174, 176, 431, 433

F

Fin whale, 178, 437
 Flood Control Act of 1970, 431
 Freemason, 5, 68, 118, 119, 133, 137, 156, 173, 200, 202, 203, 205, 213, 218, 219, 262, 263, 368, 408

G

Ghent, 5, 28, 60, 67, 68, 118, 119, 133, 137, 173, 200, 204, 206, 208, 213, 218, 262, 299, 301, 310, 408, 444
 Green sea turtle, 178, 437
 Greenways, 47, 48, 57

H

H-1, 28, 67
 Hickory shad, 438

J

James River, 132, 169, 180, 181, 182, 454, 455

K

Kemp's Ridley sea turtle, 178, 185, 438

L

Lafayette River, 4, 27, 28, 46, 51, 58, 68, 74, 78, 79, 102, 117, 118, 128, 131, 133, 137, 138, 147, 151, 154, 156, 167, 170, 172, 173, 174, 199, 213, 217, 218, 225, 256, 260, 261, 276, 284, 293, 297, 301, 303, 304, 305, 306, 308, 309, 310, 315, 316, 318, 319, 327, 329, 330, 333, 335, 338, 340, 341, 342, 344, 362, 363, 365, 368, 369, 370, 372, 376, 378, 379, 380, 381, 382, 384, 386, 388, 392, 394, 395, 397, 398, 400, 405, 406, 418, 419, 421, 444, 455, 456, 457, 469

Lafayette River Watershed, 4, 117, 118, 154, 456, 469

Lake Whitehurst, 4, 27, 28, 45, 68, 72, 115, 116, 131, 133, 134, 136, 149, 154, 165, 170, 172, 216, 256, 267, 318

Living Shorelines, 47, 48

Loggerhead sea turtle, 178, 438

LR-1, 28

LR-2, 27, 28, 70, 71

LW-1, 27, 71

LW-2, 27, 28, 60, 71

M

Marine Mammal Protection Act of 1972, 175, 176, 431, 434

Mason Creek, 4, 27, 28, 45, 46, 60, 69, 72, 115, 146, 165, 216, 256, 309, 401, 459

Migratory Bird Treaty Act, 175, 177, 192, 193, 432, 434

Miter gates, 51, 409

MS-2, 28, 71

N

National Ambient Air Quality Standards, xxxii, 271, 436, 467, 468

National Environmental Policy Act of 1969, 197, 432

Natural and Nature-Based Features, 18, 19, 48

NEPA, xxxii, 7, 17, 85, 92, 224, 227, 228, 434, 436, 445, 459

North Atlantic Coast Comprehensive Study, xxxii, 1, 11, 62

Northern long-eared bat, 178, 437

P

Piping plover, 177, 468

PL-1, 27, 29, 67, 71, 79

PL-1a, 27, 29, 67, 79

PL-2, 27, 67, 71

Pretty Lake, 4, 27, 46, 60, 62, 67, 68, 69, 79, 101, 104, 115, 116, 131, 132, 134, 136, 147, 151, 152, 154, 167, 171, 172, 174, 198, 216, 224, 256, 257, 258, 259, 279, 280, 291, 297, 301, 302, 303, 304, 307, 308, 310, 316, 317, 327, 330, 333, 334, 339, 341, 342, 379, 381, 393, 398, 400, 401, 402, 403, 416, 418, 444, 457, 459, 460, 469

R

Ra, 27, 28, 67

Rb, 27, 67

Rc, 27, 67

Red knot, 177

Resource Conservation and Recovery Act, 238, 432, 434, 439

Ringwalls, 8, 47, 50, 60, 74, 84, 312, 365

S

Safe Drinking Water Act of 1974, 432

Sector gates, 51

Sei whale, 178, 437

Standalone Wetlands, 47

Storm Surge Barrier, 45, 154, 156

Striped bass, 169, 438

Subtidal oyster reefs, 56

Subtidal Reef Structures, 47

T

The Hague, 5, 21, 46, 60, 67, 68, 118, 119, 131, 133, 137, 156, 169, 173, 218, 219, 262, 264, 307, 398, 408, 409, 458, 460

W

WB-1, 28, 71

WB-2, 27, 28, 71

WB-2a, 28

West Indian manatee, 178, 184, 188, 437, 438

Willoughby Spit and Vicinity Coastal Storm Damage Reduction Project, 85, 101, 146, 165, 171, 216, 284, 293, 310, 315, 327, 332, 370, 384, 466, 469

Y

Yellow perch, 438