LIMITED REEVALUATION REPORT
WILLOUGHBY SPIT AND VICINITY
NORFOLK, VIRGINIA

Prepared by:
U.S. Army Corps of Engineers
Norfolk District
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EXECUTIVE SUMMARY

This report presents the results of a limited reevaluation phase investigation to reanalyze the findings of a 1983 Feasibility Report which recommended an implementable plan and the extent of Federal participation in a coastal storm damage reduction project for the Chesapeake Bay shoreline in the city of Norfolk, Virginia. This recommended plan was later authorized for construction in the Water Resources Development Act of 1986 (WRDA 1986). Design efforts leading to the construction of the Authorized Project were put on hold in the mid-1990s and early 2000s due to a shift in local priorities in the study area resulting from the construction of two major Navy dredging/sand placement projects and state funding for the construction of offshore breakwaters. The damages wrought by Hurricane Isabel in 2003 brought about a renewed interest in the Authorized Project and in support at the local and Federal levels for the conduct of the limited reevaluation investigation.

This present limited reevaluation investigation used current planning criteria, policies, and conditions and conducted the reanalysis to reflect three available options: (1) the affirmation of the Authorized Project; (2) the reformulation and/or modification of the Authorized Project, as appropriate; and (3) the determination that no plan is currently justified. This limited reevaluation investigation was cost shared between the Federal Government and the city of Norfolk and was conducted under the provision of a Design Agreement executed in May 2005.

The specific area addressed by this investigation is the 7.3 miles of shoreline and adjacent land area extending along the Chesapeake Bay from the eastern limit at the jetties at Little Creek Inlet to the western limit at the tip of Willoughby Spit. It includes the areas known as Willoughby Spit, West Ocean View, Central Ocean View, and East Ocean View. 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 hurricanes and northeasters, cause severe losses of sand and structural damage to buildings and infrastructure located landward of the beach.

The limited reevaluation investigation found that, while the Authorized Project remains an economically viable coastal storm damage reduction project, it is no longer the NED Plan, the plan that maximizes National Economic Development (NED). The new NED Plan consists of a berm with an average width of 50 feet constructed at an elevation of 3.5 feet, NAVD 88, with a foreshore slope of one on 20 extending to the natural bottom. The plan would also include the enhancement of the existing dune system, where needed, to provide for a system with an elevation of at least 14 feet, NAVD 88, a crest width of 30 feet, and a foreshore slope of one on five. The plan would require periodic nourishment on the average of once every 11 years on average in order to maintain the integrity of the protective berm and dune system. Annual monitoring would determine the actual nourishment requirements. The Thimble Shoal Auxiliary Channel is the designated borrow area. The estimated initial construction (fill) costs for the NED Plan are $37,210,000 and the estimated costs for each renourishment are $8,000,000. Based on October 2012 price levels and a discount rate of 3.75 percent, the plan would provide average annual benefits of $4,513,000 which when compared to average annual costs of $2,393,000 yields a benefit-to-cost ratio of 1.89 with net benefits of $2,120,000.

The Authorized Project consists of a berm with an average width of 60 feet constructed at an elevation of 5 feet above mean low water [3.5 feet, North American Vertical Datum, 1988 (NAVD 88)] with a foreshore slope of one on 20 extending to the natural bottom. The city of Norfolk would continue to maintain the existing dune system at local expense throughout the life of the project. The project would require periodic nourishment on the average of once every nine years in order to maintain the integrity of the protective berm. Annual monitoring would determine the actual nourishment requirements. The Thimble Shoal Auxiliary Channel is the designated borrow area. The estimated initial construction (fill) costs for the Authorized Project are $18,394,000 and the estimated costs for each renourishment cycle are $7,487,000. Based on October 2012 price levels and a discount rate of 3.75 percent, the project would provide average annual benefits of $2,383,000 which when compared to average annual costs of $1,799,000 yields a benefit-to-cost ratio of 1.32 with net benefits of $584,000.

The results of the plan selection process, specifically concerning the Authorized Project and the new NED Plan, have been discussed with the non-Federal sponsor, the city of Norfolk, and city officials have expressed continued support for the Authorized Project. This support is based on the rationale that the Authorized Project would provide a reasonable balance between an acceptable degree of protection for the project area and the maintenance of the existing character and aesthetics of the beach and dune environment. The project would also allow for the maintenance and appearance of the existing dune system as a continued local responsibility which would afford city officials greater flexibility in effectively addressing issues regarding dune encroachment and the existing view of the Chesapeake Bay. This project would also provide for lower implementation and maintenance costs and a shorter construction period. City officials understand the level and extent of protection provided by the project and the need to continue to operate its storm warning system and temporary evacuation program to evacuate local residents from the project area well in advance of a major coastal storm. The Authorized Project is, therefore, designated the Locally Preferred Plan. It is also the plan provisionally recommended for implementation and is, therefore, designated the Tentatively Selected Plan.

The Tentatively Selected Plan is one of several "authorized but unconstructed" coastal and storm damage reduction projects covered by the provisions of the Disaster Relief Appropriations Act of 2013 [Public Law (P.L.) 113-2] which was passed by the Congress and signed into law by President Obama in response to the catastrophic damages to the Atlantic coastline caused by Hurricane Sandy in late October 2012. For this category of projects, P.L. 113-2 stipulates specific implementation changes and acknowledgements to the normal Civil Works process including specific changes to cost-sharing to support a Project Partnership Agreement and changes in the applicability of project cost limits required by Section 902 of WRDA 1986, as amended. The Tentatively

Selected Plan has been found to address these specific implementation changes and acknowledgements stipulated by P.L. 113-2 and is deemed implementable under the provisions of P.L. 113-2.

Cost sharing for the Tentatively Selected Plan would be in accordance with the requirements of Section 103(d) of WRDA 1986, as amended, and P.L. 113-2 and the modifications to reflect the impact of the Little Creek Federal navigation project on the recession of the adjacent project area shoreline. Coastal storm damage reduction projects involving beach fill and periodic nourishment are typically cost shared on a 65 percent Federal-35 percent non-Federal basis for initial construction and on a 50 percent Federal-50 percent non-Federal basis for periodic nourishment. In addition, the cost sharing for the Tentatively Selected Plan has been specifically modified to reflect the impact of the Little Creek Federal navigation project on the recession of the adjacent project area shoreline. With estimated initial construction costs of $18,394,000, the resultant Federal cost share for initial construction is currently estimated at 70.2 percent or $12,914,000 and the non-Federal cost share at 29.8 percent or $5,480,000. With estimated periodic nourishment costs of $7,487,000 for each renourishment cycle, the resultant Federal cost share for periodic nourishment is currently estimated at 57.4 percent or $4,301,000 and the non-Federal cost share at 42.6 percent or $3,186,000. Average annual equivalent operation, maintenance, repair, rehabilitation, and replacement costs are currently estimated to be $250,000 and would be a 100 percent non-Federal responsibility. In accordance with the provisions of P.L. 113-2, the Federal Government will provide upfront funding of the entire cost of initial project construction, with the non-Federal sponsor repaying its share financed over a period of 30 years from the date of completion of initial construction in accordance with the provisions of Section 103(k) of P. L. 99-662.

The estimated initial construction costs of the Tentatively Selected Plan and the estimated renourishment costs over the 50-year life of the project exceed the Section 902 Limit calculated for the project in accordance with the guidance contained in WRDA 1986. This would normally require that a new cost limit be established for this project through a post-authorization change process; however, this requirement has been waived by P.L.113-2 for “authorized but unconstructed” projects such as the Tentatively Selected Plan.

The Tentatively Selected Plan was evaluated on the basis of the effects that its implementation would have on the entire ecosystem, including the land, air, and water resources at both the Willoughby Spit placement site and the Thimble Shoal Auxiliary Channel borrow site. Cumulative impacts of other activities were also considered in this evaluation. It was concluded that implementing the Tentatively Selected Plan would not have a significant adverse effect on the environment. Design features and best management practices would be incorporated into the project in order to minimize the adverse impacts. The expected long term positive economic effects from the nourishment of the Willoughby project area would be greater than the short term, minor negative impacts resulting from construction activities. Due to the absence of significant adverse environmental impacts, an Environmental Impact Statement was not required.

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NORFOLK, VIRGINIA
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LIMITED REEVALUATION REPORT
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1.0 INTRODUCTION

This Limited Reevaluation Report presents the findings, conclusions, and recommendations of a limited reevaluation study of the coastal storm damage problems and needs of 7.3 miles of Chesapeake Bay shoreline within the city of Norfolk, Virginia. A 1983 Feasibility Report recommended an implementable plan and the extent of Federal participation in a coastal storm damage reduction project which was later authorized for construction by the Congress in the Water Resources Development Act of 1986. The Authorized Project consisted of the construction and the periodic nourishment of a protective beach berm along the entire study area shoreline where an adequate berm did not exist. Preconstruction Engineering and Design (PED) investigations leading to the construction of the Authorized Project were put on hold from the mid-1990s to the early 2000s due to a shift in local priorities in the study area resulting from the construction of two major Navy dredging/sand placement projects and state funding for the construction of offshore breakwaters. Hurricane Isabel in 2003 brought about a renewed interest in the Authorized Project and in support at the local and Federal levels for a restart of the PED investigations to include the conduct of a limited reevaluation study to determine continued Federal and local interest in the construction of the Authorized Project or a reformulated project.

1.1 STUDY AND CONSTRUCTION AUTHORITIES

1.1.1 Feasibility Study Authority

The 1983 Feasibility Report was conducted in compliance with resolution adopted September 15, 1971, by the Committee on Public Works of the Senate, which reads:

> "That in accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army, be, and hereby requested to cause to be made under the direction of the Chief of Engineers, a survey of the shores of Willoughby Spit in the city of Norfolk, VA, and such adjacent shores as may be necessary, in the interest of beach erosion control and hurricane protection and other related matters."

1.1.2 Project Construction Authority

The recommendations in the 1983 Feasibility Report were authorized for construction as a Federal Civil Works project by the Congress in Section 501 (a) of the WRDA of 1986 provided Congressional authorization of the recommendations in the 1983 Feasibility Report as a Federal project for construction. The authorization reads:

> "Willoughby Spit, Virginia. The project for shoreline protection, Willoughby Spit and Vicinity, Norfolk, Virginia: Report of the Chief of Engineers, dated 17 April 1984, at a total cost of $5,690,000, with an estimated first Federal cost of $4,250,000 and an estimated first non-Federal cost of $1,440,000."

1.1.3 limited Reevaluation Study Authority

A September 2004 Reconnaissance Level Report of the Authorized Project was accomplished in response to Congressional direction and funding following the damages sustained to the study area by Hurricane Isabel in September 2003. The reconnaissance level report concluded that a detailed investigation of the study area was warranted and recommended the conduct of a limited reevaluation study to be documented in a Limited Reevaluation Report (LRR). The authority to conduct the limited reevaluation study was granted in Memorandum, CENAD-PSD, dated February 18, 2005, subject "Willoughby Spit and Vicinity, Norfolk, VA, Reconnaissance Level Report" which approved the reconnaissance level report.

1.2 STUDY AREA

The study area, as shown on Plate 1, is located within the city of Norfolk in the southeastern region of Virginia known as Hampton Roads. The city is about 100 highway miles southeast of Richmond, VA, and 200 highway miles southeast of Washington, D.C. Comprising approximately 66 square miles and with a population of 242,803 (U.S. Census, 2010 estimates), the city contains the business, financial, cultural, educational, and medical centers of Hampton Roads. The city of Norfolk is bordered by the Chesapeake Bay to the north; the city of Virginia Beach to the east; the city of Chesapeake to the south; and the Elizabeth River and the city of Portsmouth to the west.

The city has a total of 144 miles of shoreline fronting various bodies of water including the Chesapeake Bay, Hampton Roads Harbor, and various rivers and lakes.

The specific study area, identified in this report as the Willoughby Spit and Vicinity area, is actually a group of five distinct communities comprising the northern-most portion of the city of Norfolk. In addition to Willoughby Spit, the communities include the Central Ocean View Area, the Cottage Line Area, the East Ocean View Area, and East Beach and vicinity. The communities are fronted by 7.3 miles of Chesapeake Bay shoreline extending from the tip of Willoughby Spit to the entrance to Little Creek Inlet, as shown on Plate 2. Land use in this area is predominantly residential with commercial and public use interspersed. Both ends of the shoreline are bordered by Federal military reservations. The United States Naval Base Norfolk is situated at the western end, along Willoughby Bay and the Elizabeth River. Naval Amphibious Base Little Creek, now part of the Joint Expeditionary Base Little Creek-Fort Story, is located at the eastern end, along the Chesapeake Bay and adjacent to Pretty Lake. Three public beaches, Ocean View Beach Park, Sarah Constant Shrine Beach Park, and Community Beach are located along the shoreline. These parks account for about nine acres of open space each containing parking, life guards, restrooms and shower facilities.

1.3 AUTHORIZED HURRICANE PROTECTION AND BEACH EROSION CONTROL PROJECT

The hurricane protection and beach erosion control project authorized by the Water Resources Development Act of 1986 consists of the construction of a protective beach berm with an average width of 60 feet at an elevation of 5 feet above mean low water [3.5 feet, North American Vertical Datum, 1988 (NAVD 88)] along the entire 7.3-mile shoreline where an adequate berm does not presently exist. The project also includes periodic nourishment and a beach monitoring program. Nonstructural features of the project include the development of open space for uses compatible with the potential flood hazard, the placement of warning signs on the flood plain, continued participation in the National Flood Insurance Program (NFIP), and continued use of flood plain and subdivision regulations. The project also includes the further review and development of an improved forecasting, warning, and temporary evacuation system.

Project cost sharing is 65 percent Federal and 35 percent non-Federal modified to account for 5 percent of the shoreline being privately owned and 12 percent of erosion attributable to the effects of the Little Creek Federal navigation project on beach erosion along the East Ocean View portion of the study area. The final modified cost sharing percentages are 74.7 percent Federal and 25.3 percent non-Federal.

1.4 STUDY PURPOSE AND SCOPE

This study examines the feasibility of coastal storm damage reduction for the 7.3 miles of Chesapeake Bay shoreline within the city of Norfolk. The location and orientation of this shoreline, which is in the southern Chesapeake Bay and immediately within the mouth of the bay, have made the entire study area readily susceptible to damage associated with coastal storms such as hurricanes and northeasters. Storm tides, high winds, and wave action have impinged on developed areas resulting in loss of land, property damage, and endangered health and safety. The August 1933 hurricane and the March 1962 northeaster caused significant damage to the beach front areas. More recent storms to impact the area include Hurricane Isabel in 2003 and the November 2009 Nor’easter.

Specifically, this study is a reanalysis of the findings of the 1983 Feasibility Report, the recommendations of which were authorized as a Federal project in the WRDA of 1986, as amended. This reanalysis uses current planning criteria, policies and conditions and the results of this study can affirm the Authorized Project; reformulate and or modify it as appropriate; or conclude that no plan is currently justified. In order to facilitate the engineering and economic analyses conducted during the course of this study, the 7.3 miles of study area shoreline have been divided into three individual segments. These segments include the 10,030-foot East Ocean View Segment which encompasses East Beach and vicinity and the East Ocean View Area communities; the 16,370-foot Central and West Ocean View segment which encompasses the Cottage Line Area and the Central Ocean View Area communities; as well as the 11,770-foot Willoughby Spit segment which encompasses the Willoughby Spit community, and is shown on Plate 3.

1.5 NATIONAL OBJECTIVE

The National Environmental Policy Act (NEPA) of 1969 and the Principles and Guidelines provide the basis for Federal Policy concerning multi-objectives planning. The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Water and related land resources project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective.

Contributions to National Economic Development (NED) increase the net value of the national output of goods and services as expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the study/project area and in the rest of the Nation and apply to those goods and services that are marketed, as well as those that may not be marketed.

Federal water resources' planning is responsive to state and local concerns, therefore, state and local participation is critical to proper water resources planning. The non-Federal sponsor, the city of Norfolk, participated extensively in all phases of the study process.

1.6 PRIOR STUDIES AND REPORTS

Several reports and studies of varying scope and detail which concern the flooding, erosion, and related water resources problems of the study area have been previously accomplished by the Corps of Engineers, other Federal agencies, the Commonwealth of Virginia, and the city of Norfolk. A brief description is presented in the following paragraphs.

a. The problem of erosion along Willoughby Spit was the subject of a 1937 report by the Beach Erosion Board which was published as House Document No. 482, 75th Congress, 3rd Session. This report recommended a system of groins and a bulkhead to extend along the entire north shore of the spit, designed to protect against all waves and tides, except the extremely high tides which accompany the severest storms. It was the opinion of the Beach Erosion Board that it was not advisable for the United States to adopt a project, as no federally owned property was involved. The groin system recommended by the board, minus the bulkhead, was constructed by the city of Norfolk in 1939.

b. The report on the "March 1962 Storm on the Coast of Virginia" recorded the pertinent meterologic and hydrologic phenomena associated with this event. It included a description of the storm's effect on the populace and property in Virginia and estimates of the damage caused by tidal flooding.

c. In March 1970, the Norfolk District, United States Army Corps of Engineers (USACE) published a flood plain information report which addressed the coastal flooding situation in the city of Norfolk, including the current study area shoreline. This report pointed out the severe flooding hazard to the city of Norfolk and, in particular, to the study area from an Intermediate Regional Flood or a Standard Project Flood.

d. In 1975, the Virginia Institute of Marine Science (VIMS), College of William and Mary, Gloucester Point, VA, prepared a “Summary of Shoreline Situation Reports for Virginia’s Tidewater Localities,” which assessed the characteristics, erosion rates, land uses, etc., of Virginia’s river and bay front shoreline communities.

e. An analysis of the market potential in the Willoughby Spit-Ocean View area was accomplished for the city of Norfolk during 1975 by the South Carolina firm of Vismor, McGill, and Bell. This study addressed markets in the area including hotels, and motels, campground facilities, boating facilities, residential development, and retirement complexes. The study concluded that the Willoughby Spit-Ocean View area would continue to serve primarily as a residential community of the city of Norfolk with some potential for an upgrading of the hotel/motel establishments. (Currently it is projected that the demand for boating and camping facilities will continue to increase with the Willoughby Spit-Ocean View area representing an excellent location for expansion and new development. It also projected that retirement complexes could flourish as they have in other areas of the country.)

f. In March 1978, the Hampton Roads Water Quality Agency completed a study of the quality of the waters of the Tidewater Virginia area including those surrounding Willoughby Spit-Ocean View. This study included a sampling and modeling program in Little Creek Inlet and addressed the sewage treatment needs and nonpoint source controls for the southeastern Virginia area.

g. The 1983 Feasibility Report, which was accomplished in compliance with a resolution adopted September 15, 1971 by the Committee on Public Works of the United States Senate, investigated the areas along the Chesapeake Bay shoreline of the city of Norfolk in order to determine which areas may be subject to serious damages by storm tides and waves and beach erosion and to develop the most suitable plans for protection of these areas. The study concluded that the most practical and efficient plan for addressing the problems and needs of the study area consisted of beach berm construction and periodic nourishment where an adequate berm does not presently exist along the entire 7.3-mile shoreline from Little Creek Inlet to the tip of Willoughby Spit. The WRDA of 1986, as amended, authorized the recommendations in the 1983 Feasibility Report as a Federal project.

h. The "Chesapeake Bay Tidal Flooding Study (Baltimore and Norfolk Districts)" dated September 1984, was authorized by Section 312 of the River and Harbor Act of 1965, adopted on October 27, 1965. The objectives of the study were to assess the existing physical, chemical, biological, economic, and environmental conditions of the Chesapeake Bay; to project the future water resource needs of the bay region to year 2020; and to formulate and recommend solutions to priority problems using the Chesapeake Bay Hydraulic Model. The report concluded that in view of residential, commercial, and industrial development in the Hampton Roads area, further comprehensive consideration of both structural and non-structural measures for providing coastal storm protection was warranted.

i. The "Norfolk Harbor and Channels, Virginia, General Design Memorandum 1," dated June 1986, contains the preconstruction engineering and design information associated with the navigation project authorized by the WRDA of 1986. The project provides for deepening the 45-foot channels to 55 feet, constructing a new 60-foot deep channel in the Atlantic Ocean, deepening the 40-foot portion of the Elizabeth River and its Southern Branch to 45 feet, and deepening the 35-foot portion of Southern Branch to 40 feet up to the Gilmerton Bridge and providing an 800-foot turning basin.

j. In August 1990, the Commonwealth of Virginia requested that consideration be given to Federal cost sharing in placing beach-quality sand dredged from the Norfolk Harbor and Channels project on the Chesapeake Bay shoreline in the city of Norfolk under authority of Section 933 of the WRDA of 1986. Three locations along the Norfolk shoreline were considered for the placement of sand including East Ocean View, Central Ocean View, and Willoughby Spit. The studies, completed in December 1989, concluded in a favorable recommendation for Federal cost sharing in the one-time placement of sand on the beaches at Central Ocean View and Willoughby Spit Area. Federal cost sharing in the placement of sand on the beach at East Ocean View was not economically justified at the time primarily due to the relatively high incremental cost for sand placement.

k. In 1999, Andrews, Miller and Associates, Inc., Cambridge, MD, a consultant for the city of Norfolk, prepared a “Beach Management Plan, City of Norfolk, Virginia, January 1993” that recommended the construction of a series of offshore breakwaters along the Willoughby Spit-Ocean View shoreline.

l. In November 2002, the Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA, prepared “City of Norfolk Shoreline Situation

Report," which assessed the characteristics, erosion rates, land uses, etc., of the city's bay front shoreline.

m. In September 2004, the Norfolk District Corps of Engineers completed a reconnaissance level report entitled "Willoughby Spit and Vicinity, Norfolk, Virginia, Hurricane and Storm Damage Reduction Study". The purpose of this study was to evaluate the likelihood that at least one suitable plan remains viable for the protection of the Chesapeake Bay Shoreline in the city of Norfolk from damages and losses caused by storm tides, waves, and beach erosion as presented in the Feasibility Report dated January 1983. Based on the findings of this study, it was recommended that planning should proceed to a limited reevaluation study, the results of which were to be documented in a GRR. This reconnaissance report is the basis for the current GRR.

n. On September 27, 2011, the city of Norfolk adopted the "Chesapeake Bay Coastal Management Area (CBCMA) Guidance Document", a comprehensive guide to appropriate practices and activities within the city's Chesapeake Bay Coastal Management Area. This report, which was amended on February 28, 2012, addresses typical structures and specifies appropriate uses, practices, and activities on city land and in the various public rights-of-way that border the Chesapeake Bay. Typical structures include, but are not limited to, walkways, stairs, decks, patios, bulkheads, revetments, flagpoles, swing sets, volleyball poles and nets, benches, signs, fences, boats and watercraft storage.

1.7 CURRENT STUDIES

At the request of the city of Norfolk and the direction of Corps of Engineers higher authority, the Norfolk District Corps of Engineers is currently conducting a study of the flooding problems being experienced in the Pretty Lake area in the East Ocean View portion of the study area. The study will determine whether there is Federal interest in providing a flood risk reduction project in the Pretty Lake area upstream of the Shore Drive Bridge.

1.8 EXISTING WATER PROJECTS

1.8.1 Norfolk Harbor and Channels, Virginia

The Norfolk Harbor and Channels Federal Navigation Project (shown on Plate 4) as modified by the WRDA of 1986 (Public Law 99-662) provides for deepening the existing 45-foot (at mean lower low water [m.l.l.w.]) channels to 55 feet (m.l.l.w.); constructing a new 60-foot deep (m.l.l.w.) channel off Virginia Beach's oceanfront referred to as the Atlantic Ocean Channel; deepening the existing 40-foot (m.l.l.w) portion of the Elizabeth River and its Southern Branch to 45 feet (m.l.l.w); and deepening the existing 35-foot (m.l.l.w) portion of the Southern Branch to 40 feet (m.l.l.w.) up to the Gilmerton Bridge (River Mile 17.5) and providing an 800-foot turning basin at that point.

Improvements to the Channel to Newport News were also authorized by the WRDA of 1986. This most recent modification provides for a channel 55 feet deep (m.l.l.w) and 800 feet wide from the Norfolk Harbor Channel in Hampton Roads to Newport News, a distance of about 5.4 miles. The channel is used extensively by deep-draft ships en route to both the port of Newport News and to the Richmond Deepwater Port via the James River channel.

Deepening of the Newport News Channel and the outbound lanes of Thimble Shoal and Norfolk Harbor Channels to a depth of 50 feet (m.l.l.w.) was completed in 1988. Construction of the full-width channel at 50 feet (m.l.l.w.) for Thimble Shoal Channel was completed in 2004 and for Norfolk Harbor Channel in 2005. Construction of the full-width Atlantic Ocean Channel at 52 feet (m.l.l.w) was completed in 2007.

1.8.2 Cape Henry and York Spit Channels

The Cape Henry and York Spit Channels, which are part of the Baltimore Harbor and Channels Federal navigation project, are located in the Chesapeake Bay offshore of the study area. The Cape Henry Channel was authorized by the River and Harbor Act of July 3, 1958 and modified by the River and Harbor Act of December 31, 1970. The York Spit Channel was authorized by the River and Harbor Act of March 3, 1905 and modified by the River and Harbor Acts of March 4, 1913, July 3, 1930, March 2 1945, July 3, 1958, and December 31, 1970. Both projects provide for channels 50 feet deep (m.l.l.w.) and 1,000 feet wide. The Cape Henry Channel is 2.3 miles long between the 50-foot (m.l.l.w.) contours at the entrance to the Chesapeake Bay and the York Spit Channel is 18.2 miles long between the 50-foot (m.l.l.w.) contours in the Chesapeake Bay opposite York Spit.

1.8.3 Little Creek Inlet and Channel

The channel at Little Creek is located about nine miles west of Cape Henry and immediately east of the Norfolk-Virginia Beach city boundary line. Covering a distance of 1.4 miles from the Chesapeake Bay to the location of the former Pennsylvania Railroad Terminal, the channel is 20 feet deep and 600 feet wide. The channel is used extensively by the Joint Expeditionary Base Little Creek-Fort Story and provides water transport for commodities of sand, gravel, and general cargo. Little Creek Inlet is also used extensively by shallow draft boats for recreational purposes.

1.8.4 Willoughby Bay Channel

The Willoughby Channel, which is located at the western end of Willoughby Spit, provides for a channel ten feet deep and 300 feet wide into the mouth of Willoughby Bay. The channel was constructed in 1931 principally for the operation of vehicle-passenger ferries between the cities of Norfolk and Hampton, a function which was discontinued with the opening of the Hampton Roads Bridge-Tunnel in 1957. Willoughby Bay is one of the best sailing areas in the region and the channel currently serves the many sailboats, as well as power boats, that frequently cruise within the bay. The channel also serves a yacht basin with storage and repair facilities as well as commercial fish catches that are transported through docks located within the bay.

1.9 PLANNING PROCESS

The Corps of Engineers planning process utilized throughout this report follows a six-step process that consists of a structured approach to problem solving and provides a rational framework for sound decision making. The six steps are:

Step1 – Identify Problems, Needs, and Opportunities

Step 2 – Inventory and Forecast Conditions

Step 3 – Formulation of Alternative Plans

Step 4 – Evaluation of Alternative Plans

Step 5 – Comparison of Alternative Plans, and

Step 6 – Plan Selection

These steps are defined and accomplished in the sections to follow.

2.0 IDENTIFICATION OF PROBLEMS, NEEDS, AND OPPORTUNITIES

This step involves properly identifying the problems, needs, and opportunities of the study area and defining the study planning objectives and constraints that will guide the efforts to solve the identified problems and needs and to achieve the identified opportunities.

2.1 PROBLEMS AND NEEDS

The study area has experienced and will continue to experience major damages to residential, commercial, and public development; the loss of land; and the threat to human life and safety resulting from tidal flooding and wind-generated waves associated with the occurrence of major coastal storms. In response, the city of Norfolk has expended significant and limited resources in the study area over the years in an attempt to reduce and/or mitigate these damages and protect its citizens.

2.1.1 The Coastal Storm and Tidal Flooding Problem

The most critical problem in the study area is the potential for damages resulting from severe coastal storms in the form of hurricanes and northeasters. The most severe hurricane to affect the study area was the Chesapeake-Potomac hurricane of August 1933, a Category 1 storm when it made landfall along the Virginia-North Carolina coast, with the center of circulation passing directly over the city of Norfolk. The most severe northeaster to affect the study area was the March 1962 storm, commonly referred to as the “Ash Wednesday Storm of 1962” as the heaviest damages occurred on March 7^{th}, which coincided with Ash Wednesday, the start of the Christian Lenten season that year.

The large expanse of open water in the Chesapeake Bay to the northwest, north, and northeast allows storm-generated waves to gain strength and wreak havoc on the protective beaches and dunes of the east-west oriented shoreline. This further exposes the commercial and residential buildings behind the beaches and dunes to major damages from waves and flooding, especially during periods of extreme high tides. Most of the damages are attributable to direct wave attack on the buildings and to the collapse of structures due to the undermining of foundations. A significant amount of damage also results when flood waters saturate floors, floor coverings, walls, furniture, appliances, and other items in structures located adjacent to the beach. This is especially a problem at the eastern and western ends of the study area where backwater flooding from Pretty Lake and Willoughby Bay, respectively, contributes to the flooding from the Chesapeake Bay.

2.1.2 Beach Recession and Loss of Land Problem

In addition to and related to the hurricane and northeaster problem of the study area, there is the very significant problem of beach recession and loss of land. Not only does the eroding beach and loss of land diminish the protective barrier for property along the bay front, it also adversely affects the many recreational aspects of the beach including swimming, fishing, and sunbathing. Historically, the beaches in the study area have experienced periods of alternating recession and accretion with an overall trend toward recession as most of the beaches ultimately lose more sand than they gain over time. In general, the beaches along Willoughby Spit and the western portion of Central Ocean View are mildly erosional with rates estimated upward of 1.3 feet per year. The eastern portion of Central Ocean View is relatively stable due to the beneficial deposit of the sand migrating from beach nourishment projects to the east. The East Ocean View beaches are the most erosional of the entire study area due to the interruption of the westerly longshore movement of sand by the Little Creek Jetties. Erosion rates up to 5.5 feet per year have been estimated for East Ocean View in the past and storms continue to have an impact. However, the construction of the offshore breakwaters in this area has helped to alleviate some of the erosion, resulting in rates possibly upward of 2.5 feet per year.

The improved property value to use in the evaluation of damages/losses to improved property was determined by comparing the market value of the land adjacent to the beach with nearshore land values. Corps of Engineers procedure requires the use of nearshore land values to estimate the value of land lost. Nearshore land is defined as upland sufficiently removed from the shore to lose its significant increment of value because of its proximity to the shore when compared to adjacent parcels that are more inland. The market value of typical lots adjacent to the beach range from a low of $300,000 to over $1,500,000 with average values per square foot ranging from $26.80 to $75.72. In the study area, real estate investigations indicate that nearshore land values to be about 31.5 percent of market value of land located directly on the beach or a cost of $16.14 per square foot.

2.1.3 Beach Recreational Needs

The 2007 Virginia Outdoors Plan lists the availability of public beaches and additional boating facilities as the two most pressing recreation needs in the region. Beach use in the immediate study area, both now and in the foreseeable future, will be primarily concentrated in the three city beaches; Community Beach Park, Sarah Constant Shrine Beach Park, and Ocean View Beach Park, as shown on Plate 5. These beaches are where public parking is located and where access is most convenient for users. Also, bathhouses, the boardwalk, picnic facilities, the public park, and other related activities are located in these areas to enhance the beach experience. In these areas, lifeguard service is available from Memorial Day through Labor Day.

A detailed survey was conducted by Corps of Engineers personnel during the summer of 2005 to obtain information regarding existing users of beaches in the study area. Based on this survey, discussions with the City Parks and Recreation Department personnel, and beach counts accomplished by lifeguards, it is estimated that the existing beach provides sufficient capacity for peak day use. The surveys confirmed that the beach is primarily a day use beach with the majority of users coming from Norfolk and the immediate surrounding area. The beach is generally not a vacation destination for tourists and there is little overnight visitation. Consequently, use is concentrated during weekends and holidays when nearby residents have available leisure time. It is estimated that 85 percent of the annual beach use in the study area occurs on peak days, i.e., weekends and holidays, and 15 percent occurs on weekdays.

The data indicates beach use is distributed throughout the entire study area, but the beaches located at the three city parks are the most visited beaches in the study area. These beaches are expected to become more deficient in meeting the needs of recreational users in the future as demand increases in response to population growth in the city of Norfolk and the surrounding area. The city is continually redeveloping and upgrading the area, including the provision of additional access points and public parking. Other sections of the study area have sufficient beach area to adequately accommodate existing and future needs for recreation. The following table shows the estimated existing and future annual beach use in the study area.

Table 1. ESTIMATED ANNUAL USE (1)

Year	Total Number of Users
2005	53,200
2010	54,200
2020	56,100
2030	58,200
2040	60,300
2050	62,500
2060	64,800
2065	65,900

(1) Based on a 100-day beach recreational season.

2.1.4 Local Concerns and Needs

As discussed in the previous sections of this report, the city of Norfolk has expended significant resources over the years in its efforts to reduce coastal storm induced wave and flood damages and beach erosion in the study area. In this regard, the city clearly views its partnership with the Federal Government in the design and implementation of a Federal Civil Works Coastal Storm Damage Reduction project as a major component in the long term solution to these problems. The following points summarize the city's expressed concerns and needs regarding a coastal storm damage reduction project:

- The primary need for a systematic and efficient program in place along the study area shoreline that will respond to the sand nourishment needs of the study area. Of particular interest are the construction and maintenance of a protective beach berm; the backfilling of the areas behind the city constructed offshore breakwaters; and the renourishment of the shoreline after coastal storms.

- The continued support for the Authorized Project and any similar project resulting from the current reevaluation effort.

- As is the case with most municipalities during difficult economic times nationwide, a concern about the initial and long term costs that would be associated with such a project and the ability to provide its ultimate share of those costs. The city has indicated that it would consider forgoing some damage reduction benefits in order to implement a project that presents a reasonable and acceptable balance between lower costs and increased risks.

- The expressed need for the implementation of a project as soon as possible and the support for any reasonable means taken to this end.

- The understanding that the Authorized Project and any similar coastal storm damage reduction project is primarily a wave damage reduction project and, therefore, would not afford significant protection from the tidal flooding associated with coastal storms.

- The need to maintain the character and aesthetics of the beach environment in the study area, especially with regard to the natural appearance of the existing beach and dune and preserving the existing view of the Chesapeake Bay from residences lining the shoreline.

2.2 OPPORTUNITIES

Based on the discussion of the problems and needs of the study area in the previous paragraphs, there are opportunities in the study area to reduce damages to property and the loss of land resulting from the occurrence of coastal storms through the development and implementation of an affordable and timely storm damage reduction project that concurrently addresses the recreational, environmental, and aesthetic needs of the area.

2.3 PLANNING OBJECTIVES

Based on the coastal storm damage and related problems, needs, and concerns identified in the study area, a number of general and specific planning objectives have been established to assist in the development and evaluation of alternative protection measures.

In general, the primary Federal objective is to contribute to NED. The pursuit and attainment of this objective must be consistent with national legal statutes, applicable executive orders, and other Federal planning requirements. The general and specific planning objectives for this study take an integrated systematic approach to the solution of the coastal storm damage problems associated with coastal storms that impact the shoreline in the study area. Accordingly, the following specific objectives have been identified:

- Provide coastal storm damage reduction over a 50-year project life, as measured by increases in National Economic Development benefits, to the entire study area shoreline.

- Minimize or avoid, where possible over the 50-year project life, impacts to natural resources.

- Reduce, where possible over the 50-year project life, the hazard to human life and the hardships and anguish resulting from major coastal storm activity;

- Reduce the existing and future coastal storm-generated wave damages to existing and future development and the beach erosion potential of the Chesapeake Bay along the study area shoreline;

- Reduce maintenance costs of existing and future coastal storm damage reduction works;

- Reduce emergency costs to the city of Norfolk and residences, businesses, and public entities located within the study area;

- In accordance with the limits of institutional participation, all plan components must meet NED objectives;

- Preserve and maintain the environmental character of the study areas, including such considerations as aesthetic, environmental, and social concerns, as directly related to plans formulated for implementation by the Corps of Engineers;

- Enhance recreational opportunities within the study area, where possible;

- Complement, where possible, other related programs and projects in the study area; and

- Give consideration to local financial and institutional capabilities and public support.

2.4 IMPLEMENTATION CONSTRAINTS

Constraints are any policy, technical, environmental, economic, local, regional, social, and institutional considerations that act to restrict or otherwise impact the project implementation process. With regard to general considerations, there are no specific laws or policies that would prevent or limit the implementation of a Federal coastal storm damage reduction project in the study area. With regard to specific considerations, the following points of discussion are offered:

- There is the potential that the implementation of a coastal storm damage reduction project could have an impact on one or more endangered species identified in the vicinity of the study area.

- Section 902 of the Water Resources Development Act of 1986 defines the maximum amount that a project may cost, often referred to as the 902 Limit or Project Cost Cap. There is the possibility that the Authorized Project, if reconfirmed as the NED Plan through this reevaluation study, could have a current implementation cost estimate that would exceed the Section 902 Cost limit. This would require that a new cost limit be established through an appropriations or post-authorization change process.

- As presented earlier in the report, the city of Norfolk is concerned about the initial and long term costs that would be associated with a project and its ultimate share of those costs. The city has indicated that it would consider forgoing some damage reduction benefits to implement a project that presents a reasonable and acceptable balance between lower costs and increased risks.

2.5 SELECTION AND DECISION CRITERIA

Within the framework of Federal Water Resources Laws and Policy, the following are the criteria which will guide the decisions regarding the selection of a plan for implementation in the study area:

- Selected plan must be consistent with local, regional, and state goals for water resources development;

- Selected plan must represent sound, safe, and acceptable engineering solutions;

- Selected plan must satisfactorily address the identified concerns and needs of the non-Federal sponsor with regard to the tidal flooding and wave damages resulting from coastal storms;

- Selected plan must have tangible benefits that equal or exceed project economic costs;

- Selected plan will avoid adverse impacts to the environment where possible and mitigate at least to a level of insignificance in cases where adverse impacts cannot be avoided;

- Selected plan must give consideration to public health, safety, and social well-being, including possible loss of life; and

- Selected plan must be implementable with respect to financial and institutional capabilities.

3.0 INVENTORY AND FORECAST OF CONDITIONS

This step involves the development of the inventory and forecasting of the critical physical, demographic, economic, social, archeological, etc. resources relevant to the problems and opportunities under consideration in the study area. This includes a quantitative and qualitative description of these resources for the current and future conditions.

3.1 EXISTING CONDITIONS

The understanding of the existing conditions within the framework of the study area shoreline and adjacent coastal waters is necessary to analyze the effects on development and to design and evaluate potential storm damage reduction measures. More detailed information on the existing conditions can be found in the Environmental Assessment, which is included in this report.

3.1.1 Physical Setting

3.1.1.1 Native Beach (Potential Placement Site). The Norfolk shoreline is one long curvilinear coast that is mostly beach and dune with individual sites containing bulkheads, breakwaters, and groins. The littoral system is sand rich from material coming through the mouth of the bay. This is evidenced by mostly sand beaches along the coast and a complex system of offshore sand bars. These sand bars greatly influence and are themselves influenced by the impinging wave climate (Hardaway, 2005).

Beaches typically consist of several conspicuous regions. Dunes are areas where sand accumulates sand and represents a net positive sediment budget at the site. Swales are low-lying areas between and behind secondary and primary dunes. Furthest away from the waterline, a beach profile begins at the secondary dune; while the primary dune is the first sandy ridge backing the beach. Primary dunes absorb the initial impact of strong storms and help protect man-made structures built behind them. The secondary dune is usually more stable than the primary dune, because primary dunes block most of the wind and salt spray. However, all beach habitat is dynamic and sediment accumulation or loss is dependent on coastal location. Typically, there are no secondary dunes along the Willoughby Spit-Ocean View beach.

The backshore is the region of a beach from the berm crest landward (to the foredune ridge, vegetation line, seawall, etc.) and is typically beyond the reach of ordinary waves and tides but is influenced by wind. Common plant species found in this area include sea oat (*Uniola paniculata*), seaside goldenrod (*Solidago sempervirens*), and sea rocket (*Cakile edentula*). The backshore is an area subject to harsh environmental and physical changes, including a wide temperature range, salinity fluctuations, and wave action that cause cycles of erosion and accretion as shown in Plate 6.

The foreshore is the sloping portion of the beach between the limits of high tide and low tide swash which includes the entire intertidal (beach face and low tide terrace) area affected by swash and backwash. The beach face is commonly separated by a plunge step, a small trough filled with coarse sand or shells formed by the breaking of small plunging waves at the base of the beach face. The foreshore is the zone that is submerged at high tide and exposed at low tide.

The nearshore is seaward of the foreshore, and is submerged even at low tide. This zone extends seaward from the mean low water line to well beyond the breaker zone. Most sediment is transported in the nearshore, both along the shore and perpendicular to it.

3.1.1.2 <u>Potential Sand Borrow Areas</u>. The Chesapeake Bay began to form as a partially enclosed coastal water body separated from the open ocean in the late Pliocene and developed through the Pleistocene and into the Holocene in response to coastal marine processes and major cycles of sea level rise and fall. During times of emergence and low sea level, the rivers excavated channels in the broad coastal plain and subaerial processes eroded and modified existing landforms. During periods of high sea level, the Delmarva Peninsula lengthened as a major barrier spit, progressively enclosing what was to become the Chesapeake Bay (Hobbs, 2004).

In conjunction with the borrow site investigations conducted for this study, the Norfolk District focused on three general areas in the Lower Chesapeake Bay:

Willoughby Bank; Middle Ground (south of Fisherman's Island); and the area between the Horseshoe and Tail of the Horseshoe. Although sediment samples taken near the Middle Ground contained several areas of good quality material, consultation with the project delivery team resulted in the identification and evaluation of three offshore borrow sites within the lower Chesapeake Bay as alternative sources of sand for a beach-fill project along the study area shoreline, as shown on Plate 7. These sites are the Thimble Shoal Auxiliary Channel east of the Chesapeake Bay Bridge-Tunnel, the Willoughby Banks Site which is located immediately east of the Hampton Roads Bridge-Tunnel, and the Hampton Borrow Area (Borrow Site A) which lies within the area known as the Tail of the Horseshoe offshore of the city of Hampton.

3.1.2 Natural Forces

3.1.2.1 Climate. Norfolk's climate is temperate with moderate, seasonal changes. Winters are generally mild, and summers, though long and warm, are frequently tempered by cool periods resulting from winds off the Chesapeake Bay and nearby Atlantic Ocean. Occasionally during brief periods, the climatic conditions vary extremely due to storms of both extra-tropical and tropical origin. The average annual precipitation is approximately 46.41 inches and is fairly evenly distributed throughout the year, with average monthly amounts ranging from 3.12 inches in February to 5.43 inches in August. Measurable amounts occur on an average of about one day out of three.

3.1.2.2 Coastal Storms. Two general types of major storms affect the Chesapeake Bay area in the form of hurricanes and northeasters. The term "hurricane" is applied to an intense cyclonic storm originating in the tropical and subtropical latitudes of the Atlantic Ocean north of the equator. These storms normally gain intensity as they move over water in the southern latitudes and decay or decrease in intensity as they pass over land or move into the northern latitudes, where conditions are such that the energy of the storm cannot be maintained. A hurricane is characterized by low barometric pressure, high winds (over 74 miles per hour), heavy rainfall, large waves, and tidal surges. The most severe hurricanes affecting the study area were the August 1933 Chesapeake-Potomac Hurricane and Hurricane Isabel in September 2003. The Chesapeake-Potomac

Hurricane produced wind gusts as high as 82 mph; tides of seven feet to nine feet; and a storm surge of six to nine feet.

Hurricane Isabel effects came from the storm surge which inundated areas along the coast and resulted in severe beach erosion. Hurricane Isabel high water marks resembled and approached the water levels witnessed during the 1933 Chesapeake-Potomac Hurricane. The height of the waves during the week when both Hurricane Isabel and the 1933 Hurricane approached the study area is shown in Plate 8. Plates 9 and 10 show the observed water levels (red curves) in Hampton Roads, VA (measured at Sewells Point Tide Gage), the predicted water levels at the same location (blue curves), and the storm surge (green curve), which is the difference between the predicted wave heights and the observed wave heights.

The following table summarizes the graphs in Plate 8 and shows the differences between the August 1933 Hurricane and Hurricane Isabel. Plate 11 shows the track of both storms.

Table 2. COMPARISON BETWEEN HURRICANE ISABEL AND AUGUST 1933 HURRICANE

Storm	Storm Tide (height above MLLW)	Storm Surge (height above normal)	Mean Water Level (height above MLLW)
August 1933	8.018 ft (2.444 m)	5.84 ft (1.78 m)	0.95 ft (0.29 m)
September 2003	7.887 ft (2.404 m)	4.76 ft (1.45 m)	2.30 ft (0.70 m)

"Northeaster" (also Nor'easter) is the term given to storms that occur during the fall, winter, and spring months along the Atlantic Coast. A northeaster is characterized by high winds circulating around an essentially stationary low pressure, producing high tides, large waves, and heavy rainfall along the coast. Like all cyclonic wind systems in the northern hemisphere, the wind direction is always rotating inward and counter-clockwise about the low pressure area. Typically, winds originate from the northeast quadrant relative to this area, hence the term "northeaster." Northeasters sometimes develop into complex storms with more than one influencing pressure cell. The location of high pressure centers and low pressure centers with respect to each other may greatly intensify the wind speeds that would be expected from a single storm cell. Strong winds reaching almost hurricane strength may occur over many thousands of square miles. Northeasters may form with little or no advance warning and have been known to persist for as long as a week to ten days; however, the average duration of a northeaster is only about two or three days.

Noteworthy northeasters of the last decade occurred in April 1956, March 1962, and November 2009. The March 1962 northeaster caused serious tidal flooding and widespread damage along the Mid-Atlantic Coast. The November 2009 Mid-Atlantic northeaster (also known as Nor'Ida) was a vigorous fall northeaster that caused widespread damage throughout the Atlantic coast. This extra-tropical cyclone formed in relation to Hurricane Ida's mid-level circulation across southeastern Georgia, migrated east-northeast offshore North Carolina before slowly dropping south and southeast over the next several days. As the storm traveled southeast of the Chesapeake Bay, persistent onshore waves carried elevated water levels to some areas for up to four days, bringing a storm surge to much of the region and reaching record levels set by Hurricane Isabel in 2003. In the city of Norfolk, a maximum storm surge of 7.74 feet was measured. Plates 12 and 13 show the water level data as a result of Nor'Ida with peaks from November 1, 2009 to November 30, 2009 as measured at Sewells Point.

3.1.2.3 Winds. A study of recorded and possible wind velocities, duration, and direction is necessary to determine their effect on the characteristics of waves likely to be experienced in the study area. Wind generated waves are the primary cause of loss of material from the beaches. The design height of storm damage reduction structures is dictated to a great degree by the height and force of the waves likely to be experienced.

A compilation of wind velocities, durations, and directions was made from the records of the United States Weather Bureau Station located at Cape Henry, VA.

Destructive wave attack and elevated water levels are caused by winds which have components ranging from a north-northeast clockwise to an easterly direction. Analysis of available wind data indicates that the prevailing local winds were from the southern quadrants, but that the velocities and total wind movement were greater from the northern quadrants. This data covers the most severe periods which have been experienced to date and are considered adequate for this study.

3.1.2.4 Waves and Swells. 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. Normally, the waves are moderate in height since 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. The beach erosion and practically all of the structural and property damage along the beach is a direct result of storm-generated waves.

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 gage or historical observations are considered critical to the formulation of plans. Historically, the study area was among the hardest hit sections of the city during northeasters and hurricanes. Wave heights on the order of seven to ten feet were reported during these events by observers within the area and are shown on Plates 14, 15, 16, and 17. Further discussion on wave conditions used for design purposes is contained in Section 6.3: Design and Construction Considerations of this report and in Appendix A.

3.1.2.5 Tides. 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 approximately 2.6 feet and the spring range is 3.1 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 nine feet have resulted from storms, and studies indicate that tides in excess of ten feet above mean sea level are possible.

3.1.2.6 Littoral Transport. 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 an alongshore current which moves sediment that has been placed in suspension by wave action. 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 eastern 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.

3.1.2.7 Coastal Storm Tides and High Water Marks. No tide gage presently exists at Willoughby Spit; however, maximum stillwater levels known to have occurred in the project area were from the August 1933 hurricane and the March 1962 northeaster. While the 1962 northeaster produced the lower water level, it endured for a much longer period. Tide data is available for the Norfolk Harbor gage located approximately ten miles inside the Chesapeake Bay and the Sewells Point gage located near Naval Base Norfolk and Taussig Boulevard, near Pier 6. There are historical accounts of tidal flooding for over 300 years, but reasonably accurate readings have been available only since 1908 with a complete record only since 1928. There has been a gradual rise in sea level over the investigated period of record at Norfolk Harbor.

The tidal data in the following table has been adjusted to incorporate the historic rate of sea level rise from the date of the historic storm. The historic values were adjusted by a rate of 0.145 feet/yr.

Table 3. ESTIMATED TIDAL STILLWATER LEVELS AS A RESULT OF A REPEATED HISTORICAL RECORD AT NORFOLK HARBOR

Date	Maximum Elevations in feet (NGVD)	Maximum Elevations in feet (NAVD) '88
23 August 1933	8.05	8.85
18 September 1936	7.55	8.35
7 March 1962	7.06	7.86
16 September 1933	6.35	7.15
11 April 1956	6.34	6.14
12 September 1960	6.09	6.89
18 September 1928	5.85	6.65
27 April 1978	5.84	6.64
27 September 1956	5.74	6.54
6 October 1957	5.53	6.33
5 October 1948	5.35	6.15

3.1.2.8 Sea Level Change. Sea level change (SLC) is predicted to continue in the future as the global climate changes. A recent study by VIMS, conducted for the Corps of Engineers, entitled "Chesapeake Bay Land Subsidence and Sea Level Change" (Boon et al., 2010) predicts a change in relative sea level rise ranging from 0.114 in/year to 0.22 in/year in the Chesapeake Bay. This equates to approximately one-half foot to one foot of Sea Level Rise (SLR) over the next 50 years. Additionally, USACE recently issued document EC 1165-2-212, "Sea Level Change Considerations in Civil Works Program." This guidance document provides three different accelerating eustatic, (worldwide changes in sea level) SLC scenarios: a conservative scenario (historic rate of sea level change), an intermediate scenario and a high scenario. The scenarios presented in the USACE guidance estimate SLC thru 2065 to be 0.73 feet for the conservative approach, 1.14 feet for the intermediate approach and 2.52 feet for the high scenario.

3.1.2.9 Geology and Soils.

3.1.2.9.1 *General Vicinity and Placement Area* - Willoughby Spit beach consists mostly of sandy material which has originated from the site, was placed there during beach renourishment projects, or was deposited by wave action. Mean grain size at the placement site ranges between 0.25 mm and 0.35 mm. The mean diameter for all sediment found in the project area is 0.13 phi (0.9 mm). Broken shell hash make up 50 percent of the largest particles and approximately 10 percent to 15 percent 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 mm.

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 one phi (0.5 mm). In April 2004, Moffatt and Nichol analyzed samples from the Ocean View area and reports an average D (50) at mid-dune of 0.31 mm, mid-beach 0.39 mm and between high and low water of 0.45 mm. For the purposes of sand compatibility and overfill calculations, the mean sand grain size of the existing beach will be conservatively set at 0.5 mm.

3.1.2.9.2 *Potential Sand Borrow Area*s - In conjunction with the borrow site investigations conducted for this study, the Norfolk District contracted with Alpine Ocean Seismic Survey to acquire 46 vibracore samples in the Lower Chesapeake Bay. The Norfolk District performed a total of 115 vibracores in the Thimble Shoal Channel during 1983, 1984, 1985, and 1990. Six vibracores were performed in the Willoughby Banks area in 2007 and 51 vibracores in the Hampton Borrow Area in 1999. In addition to these sampling programs, an extensive review of available information from sediment sampling was conducted dating back to the mid 1970's.

Most samples taken in the Willoughby Bank area contained high percentages of silt and clay; however there were some areas of compatible sand. Sampling results in the

Hampton Borrow Area were found to contain fine to medium sand with varying amounts between three and 17 percent of silt/clay content. The mean sand size was approximately 0.21 mm The sediment found at Thimble Shoal Channel is composed of silt (35 percent) and sand (65 percent) to a depth of 15 feet. From a depth of 15 feet to greater depths the percentage of silt is 7 percent (USACE, 2002). Suitable beach-quality sand collected from the Channel ranged in mean size from 0.18 to 0.32 mm, with an average size of 0.30 mm.

3.1.3 Environmental Resources

3.1.3.1 Terrestrial Wildlife. Beach surfaces present a harsh environment as the temperature of the sand on a hot, sunny day may be extremely high, but less than an inch below the surface, the temperature is lower and more conducive to life. Therefore, most permanent residents of the upper parts of the beach are burrowers and come out primarily at night. The upper beach, above mean high water, is generally dry except during storms. Storms can significantly modify the physical environment by eroding or accreting the upper beach and altering the beach animal communities. Characteristic species of the backshore region are ghost crabs (*Ocypode spp*.), sandfleas (*Talitridae*), hermit crabs (*Pagurus sp.*), and sand fiddler crabs (*Uca pugilator*). Many birds also use the beach for breeding, nesting, and feeding. Gulls (*Larus spp*.), sanderlings (*Crocethia alba*), fish crows (*Corvus ossifragus*), and grackles (*Quiscalus quiscula*) are the most noticeable bird species in this community. Raccoons, mice, rats, opossums, rabbits, snakes, lizards, and foxes forage in the primary and secondary dunes. While sea turtles use beaches as nesting areas, there are no recorded nests at Willoughby Beach because sea turtles utilize ocean beaches and the Willoughby Spit is located on the Bay.

Resident species of the lower beach, nearshore below mean high water, include annelid worms, clams (*Donax spp*.), and mole crabs (*Emerita spp*.). These species provide important ecological functions in coastal environments including the cycling of organic matter and nutrition and the transfer of both primary and secondary production to surf zone fishes and shore birds. As in most harsh environments, the fauna and flora species are limited in number and often in number of individuals. Animals that live in shifting sands on marine beaches are well adapted and tolerate environmental extremes in order to feed, burrow, and reproduce.

3.1.3.2 Terrestrial Vegetation. Due to the added stability of a secondary dune and the harsh living conditions experienced on the primary dune, greater plant diversity is found on the secondary dune. Strong winds, salt spray, low soil nutrients, unreliable water supply, shifting sand, and blazing sun cause the dune habitat to resemble a desert. Many of the plants living on the primary dunes have developed adaptations similar to those of desert flora, with succulent leaves, extensive root systems, and vertical runners that help the plant stay above the shifting sands. Some common plants which occur on the beach, foredune, dune, and backdune areas include sea rocket (*Cakile edentula*), seabeach orach (*Atriplex arenaria*), sea oat (*Uniola paniculat*), dune primrose (*Oenothera humifusa*), sandspur (*Centrus tribuloidesa*), beach elder (*Iva imbricate*), and American beach grass (*Ammophila breviligulata*). Typical beach vegetation zones are shown in Plate 18.

In 2008, an invasive plant called beach vitex (*Vitex rotundifolia*) was discovered on Willoughby Spit, the first discovery of the plant in Virginia. Beach vitex is a native plant of Asia that has ravaged sand dunes in North and South Carolina for many years. Its vines, or runners, can spread up to 60 feet in one year and will overtake native plants and grasses. The city of Norfolk has been trying to control the plant from spreading by applying an herbicide mix and digging up remaining remnants (Harper, 2008).

3.1.3.3 Aquatic Wildlife. The aquatic habitats included in the project area include the surf zone and nearshore zone. Aquatic organisms are associated with each habitat type. The surf zone is the area of breaking waves. Seasonal wave patterns, sediment movement, and storms are major physical forces that influence the distribution and abundance of animals in this zone. Most of the benthic animals, or animals associated with the ocean bottom, living in the surf are adept burrowers, a behavior enhancing survival by maintaining position. The pelagic (i.e., living in the water column) and benthic animals in the surf are limited by wave action, lack of cover, and food supply.

Some of the animals migrate onshore and offshore with the tides and seasonal sediment movement; populations are influenced significantly by physical factors (USACE, 1992).

3.1.3.3.1 *Non-commercial Benthos* **-** Species composition varies within different zones of the beach (Plate 6), with less species diversity occurring in the backshore, the area furthest away from the waterline and before the dune habitats. The following types of organisms are typically found along sandy beaches in their respective zones: 1) backshore - burrowing organisms such as talitrid amphipods (sand fleas), ocypodid crabs, and isopods; and transient animals, such as scavenger beetles; 2) midlittoral zone, an area of the foreshore that is covered and uncovered by water each day - polychaetes, isopods, and haustoriid amphipods; and interstitial organisms that feed on bacteria and unicellular algae among the sand grains; 3) swash zone - polychaete worms, coquina clams, and mole crabs; and 4) surf zone - shellfish, forage fish, and predatory birds. Offshore migrating predators are most common in this zone.

3.1.3.3.2 *Commercial Benthos* - The Commonwealth of Virginia offers commercial licenses for the harvest of a number of benthic organisms, including the American oyster (*Crassostrea virginica*), blue crab (*Callinectes sapidus*), hard clams (*Mercenaria mercenaria),* soft clams (*Mya arenaria*), surf clams (*Spisula solidissima*), channeled whelks *(Busycotypus canaliculatus*), and lobster *(Homarus americanus*). Benthic organisms support a significant part of the seafood industry in Virginia. The VMRC reports that more than 48,000,000 pounds of shellfish were harvested commercially in 2010 with a value of over $124,000,000 (VMRC 2010).

3.1.3.3.3 *Essential Fish Habitat* **-** Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act as "those waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity.” The designation and conservation of EFH seeks to minimize adverse effects on habitat caused by fishing and non-fishing activities. The 1996 amendments to the Magnuson-Stevens Fishery Management and Conservation Act require Federal agencies to consult with the

National Marine Fisheries Service (NMFS) regarding the potential effects of their actions on EFH. The project area includes the waters of the borrow site and seven miles of ocean shore from Willoughby Spit to Little Creek Inlet.

The “Essential Fish Habitat Mapper” provided on NOAA Habitat Conservation website was used to identify fourteen fish species, including three skate species, that have EFH in the project area that includes the Thimble Shoal Bank borrow area and the shoreline from Willoughby Spit to Little Creek Inlet (designated by the limits North 37° 00.0, East 76° 10.0, South 36° 50.0, West 76° 20.0). These species are listed in the following table (NOAA, 2010). A summary for each fish species, including a discussion of the life cycle and history of the animal as well as the status of the fishery, is in Appendix C.

Table 4. ESSENTIAL FISH HABITAT AS DESIGNATED BY NOAA FISHERIES FOR THE WILLOUGHBY SPIT PROJECT AREA.

Species	Eggs	Larvae	Juveniles	Adults
Windowpane flounder (*Scopthalmus aquosus*)	X		X	X
Bluefish (*Pomatomus saltatrix*)			X	X
Atlantic butterfish (*Peprilus triaccanthus*)	X	X	X	X
Summer flounder (*Paralicthys dentatus*)		X	X	X
Black sea bass (*Centrophristus striata*)			X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Red drum (*Sciaenops occelatus*)	X	X	X	X
Dusky shark (*Charcharinus obscurus*)		X	X	
Sandbar shark (*Charcharinus plumbeus*)		HAPC	HACP	HACP
Clear nose skate (*Raja eglanteria*)		X	X	X
Little skate (*Raja erinacea*)			X	X
Winter skate (*Raja ocellata*)			X	X

* The “X” indicates the lifestage for which this habitat is important.

Bottom habitats with mud, gravel, and sand substrate that occur within the project area are designated as EFH for the clearnose skate. Bottom habitats with soft, rocky, or gravelly substrates that occur within the project area are designated as EFH for the little skate. For the winter skate, bottom habitats with a substrate of sand and gravel or mud that occur within the project area are designated as EFH.

The NMFS designated a "habitat area of particular concern" (HAPC) for the sandbar shark but not for any other Atlantic highly migratory species (HMS) due to a general lack of scientific information detailing HMS habitat associations. The lower Chesapeake Bay, including the project site, has been identified as a HAPC, which is described in regulations as a subset of EFH that is rare; particularly susceptible to human induced degradation, especially ecologically important, or located in an environmentally stressed area. This area is has been given this designation because it is an important nursery and pupping area.

3.1.3.3.4 *Threatened and Endangered Species* - Preliminary review of this action identified species on the Department of Commerce, NMFS and the Department of the Interior, U.S. Fish and Wildlife Service (USFWS) list of Threatened and Endangered Wildlife and Plants in Virginia. The following table identifies the federally listed species that may occur along the Atlantic Coast of southern Virginia.

Table 5. FEDERALLY LISTED SPECIES THAT MAY OCCUR ALONG THE ATLANTIC COAST OF SOUTHERN VIRGINIA

Common Name	Scientific Name	Status
Whales		
Blue whale	*Balaenoptera musculus*	LE
Finback whale	*Balaenoptera physalus*	LE
Humpback whale	*Megaptera novaengliae*	LE
Right whale	*Eubalaena glacialis*	LE
Sei whale	*Balaenoptera borealis*	LE
Sperm whale	*Physeter macrocephalus*	LE
Birds		
Piping plover	*Charadrius melodus*	LT
Roseate tern	*Sterna dougallii dougallii*	LE
Fish		
Shortnose sturgeon	*Acipenser brevirostrum*	LE
Atlantic sturgeon	*Acipenser oxyrinchus*	LE
Turtles		
Loggerhead sea turtle	*Caretta caretta*	LT
Green sea turtle	*Chelonia mydas*	LT
Leatherback sea turtle	*Dermochelys coriacea*	LE
Hawksbill sea turtle	*Eretmochelys imbricate*	LE
Kemp's ridley sea turtle	*Lepidochelys kempii*	LE
Plants		
Seabeach amaranth	*Amaranthus pumilus*	LT
Insects		
Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	LT

LE - Listed Endangered
LT - Listed Threatened
(Last Updated: July 3, 2012 – Through coordination with the USFWS, Virginia Field Office.)

Of the listed species, only the sea turtles, piping plover, roseate tern, right whale, humpback whale, finback whale, and Northeastern beach tiger beetle may be potentially affected by the recommended plan. A review of the listed shortnose sturgeon indicated a low likelihood of occurrence within the project area; however, since its habitat range (historically) is within a proximate distance, continued consideration by this document was warranted. At one time, seabeach amaranth thrived in coastal environments from Massachusetts to South Carolina. A review of the species indicated it has been reduced to about one-third of historical distribution, found only on a few protected undeveloped beaches. It is currently found only in Accomack and Northampton counties in Virginia; therefore, seabeach amaranth was not assessed further.

3.1.3.5 Wetlands. Due to the high porosity of beach sands, sufficient hydrology does not exist to support the development of hydric soils or hydrophytic vegetation in the site for beach nourishment. Conversely, due to the open water estuarine environment of the proposed borrow sites located in the Chesapeake Bay, hydrology conducive to hydrophytic vegetation does not exist. Therefore, no jurisdictional wetlands exist within the site for beach nourishment or the study areas.

3.1.3.6 Water Quality. The water quality of the Chesapeake Bay is impaired due to the negative impacts resulting from the development and land use within the watershed. The Chesapeake Bay Program reported on the health of the bay and found the following (Chesapeake Bay Program, 2010):

- 38 percent of the combined water volume of the bay and its tidal tributaries met dissolved oxygen standards during the summer months.
- 18 percent of Chesapeake Bay tidal waters met or exceeded goals for water clarity, which was a decrease from 26 percent in 2009.
- 28 percent of the ninety tidal waterways analyzed in the bay had no impairment for chemical contaminants; 72 percent of the waterways have a persistent problem with PCBs in fish tissue.
- 22 percent of the tidal waters of the Chesapeake Bay had chlorophyll *a* concentrations that allow the growth of SAV.

It is estimated that 278 million pounds of nitrogen, 16 million tons of phosphorus and nine million tons of sediment entered the Chesapeake Bay in 2010. These pollutants have a negative effect on the health of the bay by reducing water clarity and fueling the growth of algae that reduce dissolved oxygen in the water column. In December of 2010, the EPA established Total Maximum Daily Load (TMDL) for nitrogen, phosphorus, and sediment for the entire Chesapeake Bay. The TMDL was designed to ensure that all actions to control pollution entering the tidal rivers and the bay will be in place by 2025.

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and creating surface waters quality standards. The CWA requires each state to establish water quality standards for all bodies of water in its boundaries. Water quality standards must include designated beneficial use or uses for each water body.

3.1.3.6.1 *Placement Site* - Virginia DEQ water quality testing has shown that the placement site fully supports recreational use; however the site does not fully support other designated uses. The placement site is included on the Virginia "Draft 2012 305(b)/303(d) Water Quality Assessment Integrated Report" as impaired for fish consumption due to the polychlorinated biphenyls (PCBs) found in the tissue of fish collected from the site.

As previously described, this impairment is common to most of the waters of Chesapeake Bay. Also, the area does not meet the aquatic life use due to insufficient levels of submerged aquatic vegetation growing in the sampling area. Finally, the entire placement site fully supports shellfishing except for the area adjacent to the Little Creek Inlet, which is closed to shellfishing due to fecal coliform contamination. The sources of the impairments are identified as atmospheric deposition of nitrogen, industrial point source discharge, internal nutrient recycling, loss of riparian habitat, municipal point source discharges, and stormwater discharge.

3.1.3.6.2 *Borrow Site* - The potential borrow sites are included in a water quality assessment unit which includes the section of the Chesapeake Bay between the mouth of the James River and mouth of the Chesapeake Bay. The area fully supports all of the designated uses that are applicable (open-water aquatic life and shellfishing). However, it is included in the 2012 list of impaired waters of Virginia for not meeting two designated uses: the area does not meet water quality standards for aquatic life due to lack of sufficient levels of submerged aquatic vegetation; and the fish consumption usage is not supported due to the high level of PCB found in fish tissue. The cause of these impairments include nitrogen entering the bay through atmospheric deposition, industrial point source discharge, internal nutrient recycling, loss of riparian habitat, stormwater discharges, and other, unknown non-point sources.

Even with the impairments described above, the lower section of the Chesapeake Bay, in which the potential borrow sites are located, is showing evidence of improvement to water quality. From 1985 to 2010, trend analysis indicates that the amount of bottom total suspended solids and inorganic and total phosphorus throughout the water column have decreased. During the same time frame, secchi depths (which indicate water clarity) and concentrations of dissolved oxygen have increased.

3.1.4 Socioeconomic Resources

3.1.4.1 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. In 2010 the MSA had a population of 1,671,683. Although Norfolk is the largest urban core area within the MSA, the city contributes only about 15 percent of its population. However, of the incorporated cities in the state, Norfolk has the second largest population behind neighboring Virginia Beach.

3.1.4.2 Land Use. Norfolk consists of a total area of 96.3 square miles (249 km^2), of which, 53.7 square miles (139 km^2) is land and 42.6 square miles (110 km^2 or 44.22%) is water. Norfolk is bounded by the Chesapeake Bay on the north, Elizabeth River on the west, the city of Chesapeake to the south, and the city of Virginia Beach on the east. Norfolk is a modern sea port city with virtually all of the land in urban or suburban areas in use as commercial districts, industrial complexes, military bases, and residential neighborhoods.

The late 1990's saw a general decline in the then existing and proposed future development in substantial portions of the Willoughby Spit-Ocean View area. This situation was reversed after 2000 with the reemergence of growth in the entire coastal property market. Older communities of beach cottages and small motels along the resort strip were replaced by new upscale residential communities, such as East Beach, at the eastern terminus of the area. Bay front properties have regained and often exceeded their past values, and renewed growth and increased tourism have generated increased revenues for the area.

3.1.4.3 Employment. Employment in Norfolk grew by 0.76 percent from 1999 to 2000, but shrank by 1.84 percent between 2009 and 2010. Personal income grew in both periods, but more during 1999-2000 (6.45%) than in 2010 (3.78%). 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 one 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, 2012).

3.1.4.4 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 the 2010 median household income was $42,677 for Norfolk compared to $61,406 for the state and $51,914 for the U.S. 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.

3.1.4.5 Military Use Navigation. The potential borrow areas are located near Thimble Shoal Channel, the approach to Hampton Roads. The Port of Virginia in Hampton Roads ranks second on the east coast for cargo behind New York/New Jersey and is home to the United States Navy's largest operating base and largest shipyard. Dredging operations are publicized weekly in the Coast Guard's Local Notice to Mariners. The dredging equipment and the pump-out buoys would not be located within a navigational channel, and should not pose a hazard to navigation, military or otherwise.

3.1.4.6 Environmental Justice. 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 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. The study area does have a significant minority population that could be affected by project implementation; however, the minority population was not concentrated in any of the six census tracts which are within the study area. Income levels for the study area show that income levels for residents of the area are slightly lower than those for the city's residents as a whole. Median household income for the study area was $40,958 in 2010, which is 95.75 percent of the $42,677 median household income for Norfolk as a whole. In summary, the study area is relatively balanced in race, ethnicity, and income and does not comprise a socio-economic enclave.

3.1.5 Historic Context

Earliest human inhabitation of the Americas remains one of the most debated issues in archaeology, but clearly Native Americans began to inhabit the Chesapeake Bay region over 12,000 years ago. Initially, populations were evidently low, but grew considerably during the Archaic Period, which is divided into Early (8000-6500 BC), Middle (6500 to 3000 BC) and Late (3000 to 1200 BC) Archaic Periods. Along with increasing population, there is evidence of an increased diversity in resources hunted and gathered for food, with a notable expansion in fishing and shellfish gathering. Around 1200 BC people in the region began making and using pottery. This marks the beginning of the Woodland Period, also divided into Early (1200-500 BC), Middle (500 BC to AD 900), and Late (AD 900-1600) Woodland Periods.

Historical records indicate that the first European settler in the Willoughby Spit-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. 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 what is now the Commonwealth of Virginia. Norfolk 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.

Through the 18th and 19th centuries the Willoughby Spit and Ocean View areas were sparsely populated rural areas. An 1863 map (Plate 19) shows a cluster of five buildings near the later location of Ocean View pier and amusement park where a small development was begun; however, 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 (Plate 19 -1886 map). 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 areas were lined with houses as the new transportation system made the beaches tenable as 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 (Plate 19 -1909 Map). By the 1920's 'the Rocket,' a large wooden roller-coaster was built, which would become iconic of Ocean View Amusement Park (Plate 20). Ocean View remained a major resort, though it was slowly eclipsed by Virginia Beach after World War II. The amusement park was a major local attraction through the 1960's, but afterward declined as regional theme parks took up that market. As a result, Ocean View Amusement Park was closed in the late 1970's.

Both Ocean View and Willoughby Spit were part of Norfolk County until they were annexed by the independent city of Norfolk in 1923. In the 1920s and 1930s, both large and more modest single family summer houses were built in the area. During the 1940s and 1950s, small, one story frame beach cottages became popular and were the predominant type of building during this time. Very few of the pre-World War II structures still remain in the area, and many of those that do have since been significantly altered. During the second half of the 20th century, large apartment buildings, residential motels, and elevated, wood-sided houses and condominiums were constructed. The 21st century has seen new, upscale residential development replacing the old beach cottages and small motels along the beach front.

3.1.6 Archaeological Resources

3.1.6.1 Submerged Resources. Marine archaeology remote sensing surveys (Plate 21) for the Hampton (Buckroe) beach nourishment borrow area and the earlier study for beach nourishment on Willoughby Spit have covered all of the Willoughby Bank borrow area (Tidewater Atlantic Research [TAR] 2007); nearly all of the Hampton borrow area (Mid-Atlantic Technology and Environmental Research, Inc. [MATER] 2000 and [TAR] 2004); and all of the Thimble Shoal Auxiliary Channel borrow area (Tidewater Atlantic Research [TAR] 2000 and 2007, Panamerican Maritime [PM] 2000). The purpose of the surveys was not only to identify potentially significant historic resources, but also to identify potential ordnance hazards. The surveys had the same methodology, transects at close intervals plotted by real-time GPS resulting in near 100 percent coverage of the survey areas with marine magnetometer and side-scan sonar. No diving was undertaken in the MATER 2000, TAR 2000, 2004, and 2007 surveys, but the PM 2000 survey included both intensive remote sensing and diving on targets identified by the TAR 2000 survey.

In summary, both the Buckroe and Willoughby Banks areas have very high incidences of ordnance and a number of targets with archaeological potential which would have to be avoided. No potential shipwrecks requiring avoidance were identified in the Thimble Shoal Auxiliary Channel borrow area after Phase II underwater survey. Although fewer potential ordnance targets were identified due to distance and direction from shore batteries, historical records indicate the potential for World War I and II mines, both American and German in the Thimble Shoal Auxiliary Channel area. The TAR 2007 report recommends relocation and testing of anomalies to determine the nature of the material generating potential ordnance signatures and, if ordnance, whether it is explosive or inert.

3.1.6.2 Terrestrial Resources in the Sand Placement Areas. Only one archaeological site has been recorded in or near the berm placement area. Site 44NR0019 is reported as a prehistoric (Native American/Pre-Colonial) shell midden site on the beachfront near the beginning of Willoughby Spit. Shell middens are accumulations of shell sometimes developed over long periods of time when the mollusks were seasonally exploited by native peoples.

3.1.7 Architectural Resources

There are 19 properties recorded in the Department of Historic Resources Data Sharing System (DSS) architectural database. These are listed with a brief description and status in the following table and illustrated in Plate 22.

Table 6. RECORDED ARCHITECTURAL PROPERTIES POTENTIALLY AFFECTED BY THE PROJECT

DHR ID	Name	Location	Date	Description	NRHP Status
122-0957	House	1522 Lea View Avenue	1935	two story dwelling	not evaluated
122-0958	House	1526 Chela Avenue	ca 1932	one story dwelling	not eligible
122-0961	**Lynch Anchorage Cottage**	**850 W. Ocean View Avenue**	**1932**	**American Legion Post 35**	**not evaluated**
122-5048	Willoughby Beach Historic District	Willoughby Spit	post 1900	District	not eligible
122-5498	House	1504 Chela Avenue	ca 1900	one story dwelling	not eligible
122-5499	House	1508 Chela Avenue	ca 1960	two story apartment building	not eligible
122-5500	House	1510 Chela Avenue	ca 1935	one story dwelling	not eligible
122-5502	House	1534 Chela Avenue	ca 1954	one story dwelling	not eligible
122-5506	House	1548 Chela Avenue	ca 1920	one story dwelling	not eligible
122-5508	House	1552 Chela Avenue	ca 1920	one story dwelling	not eligible
122-5509	House	1556-1560 Chela Avenue	ca 1920	1.5 story dwelling	not eligible
122-5510	Apartment Complex	1540 Chela Avenue	ca 1940	1.5 story apartment building	not eligible
122-5765	House	1438 W. Ocean View Avenue	ca 1947	1.5 story dwelling	not eligible
122-5767	Apartment Building	1452 W. Ocean View Avenue	ca 1955	2 story apartment building	not eligible
122-0148	**House**	**450 W. Ocean View Avenue**	**1917**	**2.5 story dwelling**	**not evaluated**
122-0953	Commercial Building	9643-9661 1st View Street	1942	2 story commercial building	not evaluated
122-0962	**House**	**650 W. Ocean View Avenue**	**1940**	**2 story dwelling**	**not evaluated**
122-0964	**House**	**550 W. Ocean View Avenue**	**1895**	**2 story dwelling**	**not evaluated**
122-0965	**House**	**502 W. Ocean View Ave.**	**1906**	**2.5 story dwelling**	**not evaluated**

The properties on Chela Avenue were surveyed by Dovetail Cultural Resources for Virginia Department of Transportation planning in November 2011, and were found to be not eligible for listing on the National Register of Historic Places (NRHP), as were two nearby on West Ocean View Avenue. The Willoughby Spit area was evaluated as a potential NRHP historic district and found not eligible. Although not evaluated, 1522 Lea View is separated by dunes and a distance of about 200 feet from the APE.

Commercial buildings on 1st View Street are separated from visual effects by existing structures. Five other buildings on West Ocean View Avenue appear to be little altered in their historic character and are not separated from the beach by other structures or an existing dune line. These are marked in bold in Table 6 and illustrated in Plate 22 and generally they may be as little as 50 feet from the proposed sand berm installation. Two properties in East Ocean View listed in the DSS, 'Cottage Place' at 4343 East Ocean View Avenue (DHR ID 122-0912) and a Cottage Court at 3706 East Ocean View Avenue (DHR ID 122-0552) have been demolished since they were recorded in 1994. Records of these five were generated by a professional Phase I survey in 1996; however, while it is not known if all structures over 50 years old at that time were inventoried, it is unlikely.

3.1.8 Aesthetics

Visual and aesthetic features include a beach of varying width, in some places with a dune system along the project length. Most of the Willoughby Spit-Ocean View shore is residential and privately owned; however, a small percentage of the shoreline is held in public domain where there are three city beach parks. Overall, the entire length of the project area is aesthetically pleasing bringing local residents and some tourists in during the summer months for bay front activities such as swimming, surfing, dining, and entertainment.

3.1.9 Noise

Noise is defined as an undesirable or "unwanted sound." Noise affects the full range of human activities and must be considered in local and regional planning (NYDEC, 2001). Noise levels are measured in units called decibels. Since people cannot perceive all pitches or frequencies equally, noise production is frequently reported in A-weighted decibels, or dBA, where noise is weighted to correspond to human hearing.

Noise levels in the area are typical of recreational and beach activities and fluctuate with the highest levels usually occurring during the spring and summer months due to increased tourism, boating, fishing, and coastal activities. The project vicinity does not encompass any noise-sensitive institutions, structures, or facilities such as churches, parks, or hospitals.

The city of Norfolk has established allowable noise limits in Chapter 26 of the Code of Ordinances. It is unlawful to generate a sound pressure level that exceeds limits set by the city when measured outside the real property boundary of the noise source or at any point within any other property affected by the noise. Allowable noise levels are higher from 7:00 in the morning to 10:00 at night than at other times and maximum noise levels have been established for different land use categories. The maximum noise level for residential areas during the day is 57 dBA; while noise up to 67 dBA is allowed in parks, recreational areas and commercial zones. Industrial sites are allowed the highest daytime noise levels, at 77 dBA. The placement site includes residential, commercial and parks and recreational zones. Norfolk's noise ordinance state that when a noise is measured in more than one district classification (commercial, residential, etc.), the limits of the most restrictive classification will be applied except in the cases of some exempt activities, including sounds generated by construction. In the case of this project, the sound level limits would be the higher level allowed for commercial zones and recreational areas or 77dbA.

3.1.10 Hazardous Materials

The 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.
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.

According to the CERCLIS database, there are two CERCLA sites located within four miles of the project area. The CERCLA sites are located on land and are not expected to have resulted in HTRW related impacts on the potential borrow site at Willoughby Bank. Fort Story is a Non-National Priorities List (NPL) site and is located approximately two miles south of the potential borrow area at the Thimble Shoal Auxiliary Channels. Remedial actions have been completed at Fort Story and there are no anticipated HTRW-related impacts on the potential borrow site at the Thimble Shoal Auxiliary Channels. The second CERCLA site, Naval Base Norfolk, which is on the NPL, is located more than four miles from the proposed borrow site. Remedial actions at Naval Base Norfolk site were completed in 2010.

A number of hazardous waste handlers, RCRIS, are located within four miles of the project area and include dry cleaning establishments, gasoline stations, fiberglass manufacturers, and other industrial facilities. Previous reports also identified RCRIS generators within four miles of the project area (USACE, 2006). No large facilities for the storage and handling of solid waste were identified within four miles of the project area.

The only TRI site identified in the area is 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 pounds of TRI classified chemicals have been reported released to surface water since 2000.

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 into 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. Additionally, the conditions found at the borrow and placement sites, i.e., the course grained material and moderate to high energy environment, do not support the accumulation of HTRW contamination. Overall, the potential borrow sites and beach nourishment activities would not be expected to result in the identification and/or disturbance of HTRW.

The potential for munitions and explosives of concern (MEC) to be present in each of the three potential borrow sites does exist. As discussed in Section 3.1.6.1 of this report, numerous magnetic anomalies have been identified during past marine surveys; many of which contained electronic signatures consistent with ordnance items. The anomalies identified during marine surveys along with the past military activity in the area during the 19^{th} and 20^{th} centuries, indicate that the potential for ordnance to be present in the borrow areas does exist. Therefore, it is recommended that the USACE Environmental and Munitions Design Center (EMDC), currently located in NAB District, be consulted during the design phase of the project. Specifically, the EMDC should be consulted in order to evaluate the need for screens to be utilized during dredging. The EMDC should also be consulted for guidance on the size, configuration, and O&M procedures of the dredge screens if they are required.

3.1.11 Air Quality

The project area is located in the Hampton Roads Intrastate Air Quality Control Region (Chapter 20, Section 200). In June 2007, this Air Quality Control Region was re-designated as a maintenance area (Chapter 20, Section 203) for eight-hour ozone. The region is not a maintenance area or a non-attainment area of any other pollutants (Chapter 20, Section 204, VDEQ, 2012).

Maintenance areas are geographic areas that had a history of non-attainment but are now consistently meeting the National Ambient Air Quality Standards (NAAQS). These areas have been re-designated by the EPA from "non-attainment" to "attainment with a maintenance plan." The maintenance area, pursuant to the Air Regulations of the State Air Pollution Control Board (9 VAC 5-160), requires that the total of direct and indirect emissions caused by a Federal action be less than 100 tons per year for ozone, which is identified as nitrogen oxide ($NO_{x)}$ and volatile organic compounds (VOCs).

3.1.12 Existing Structural Storm Damage Reduction Projects and Measures

3.1.12.1 General Beach History. The impinging wave climate, with the consequent littoral processes, has had a significant impact on the Willoughby Spit shoreline. The beach has also been altered by human interventions to protect the properties and recreational value of the area through projects such as dredging, fill placement, and structures built along the shoreline.

3.1.12.2 Existing Shoreline Protection Structures. There are a variety of coastal protection structures located along the beach within the study area including groins, jetties, bulkheads, breakwaters, and revetments. The condition of these structures ranges from good to poor with ages varying from relatively new to over 70 years old. The following paragraphs provide a summation of the coastal structures present along the beach.

3.1.12.2.1 *Little Creek Inlet and Jetties* - Little Creek Inlet, which forms the eastern end of the study area shoreline, was constructed in 1927 by the Pennsylvania

Railroad System. The project involved the dredging of a 300-foot wide, 18-foot deep channel through the then intermittent connection between Little Creek and the Chesapeake Bay leading to a proposed railroad terminal. Two stone jetties were also constructed at the inlet to reduce shoaling of the new channel. Approximately 800,000 cubic yards of dredged material were placed at two sites, one east and one southwest of the channel. The channel was widened to 600 feet a year later, and in 1942, the Department of the Navy took over maintenance of the entrance channel and jetties in conjunction with the expansion of the Naval Amphibious Base Little Creek during the Second World War.

3.1.12.2.2 *Willoughby Spit Groin System* - The city of Norfolk maintains a system of timber groins along the Willoughby Spit shoreline that was originally constructed in 1939. A 1937 report by the Beach Erosion Board and published as House Document No. 482, 75th Congress, 3rd Session recommended the construction of the groins and a bulkhead to extend along the entire north shore of the spit, "designed to protect against all waves and tides, except the extremely high tides which accompany the severest storms." The city constructed the groin system without the bulkhead after the Beach Erosion Board determined that it was not advisable that the recommended project be constructed by the Federal Government as no Federal property was involved.

As originally constructed, the groin system consisted of 37 creosoted timber Wakefield sheet pile groins, 275 feet long, placed perpendicular to the beach and spaced approximately 500 feet apart. Over the years, the groin system has generally proven effective in controlling erosion along Willoughby Spit. Many of the original groins were in various states of deterioration by the late 1970s which led to the initiation of a city program of removing, replacing, or rehabilitating two or three groins each year. Since that time, the city replaces, rehabilitates, or removes the groins as determined necessary within funding constraints. In 1990, the city enhanced the western-most timber groin at the tip of Willoughby Spit with a larger and longer stone terminal groin. The purpose of the terminal groin was to trap sand migrating west around the tip of the spit and depositing in the area of the Hampton Roads Bridge-Tunnel. This groin has been moderately successful; however, the city still continues to report sand losses.

The following table summarizes groin construction and maintenance efforts accomplished by the city of Norfolk.

Table 7. GROIN CONSTRUCTION AND MAINTENANCE BY CITY OF NOROFOLK

Date	Work Description	Location
1939	Construction of a system of 37 timber groins	Along the entire Willoughby Spit shoreline
1981	Reconstruction of five timber groins	Willoughby Area
Late 1970s	City initiates maintenance program of timber groin system	Along the entire Willoughby Spit shoreline, as needed
1983	Removal of three groins	Ocean View Park Area
1983	Construction of five groins	Western end of Willoughby Spit
1990	Raising and extension of original timber groin using stone	Western end of Willoughby Spit at Lea View Avenue
Mar 1997	Terminal groin elevated +4 feet	Western end of Willoughby Spit at Lea View Avenue
Nov-Dec 1999	Construction of a spur on an existing groin	Critical Area 1: Worth St. to 8th View (Willoughby Spit)
Jun 2002	Removal of timber groin channel ward of existing stone spur	Critical Area 1: Worth St. to 8th View (Willoughby Spit)
Jan-Feb 2006	Construction of three nearshore breakwaters	Critical Area 3: 29th Bay to Little Creek Inlet (East Ocean View)
To be determined	Planned improvements to terminal groin and removal of derelict timber groins	Along Willoughby Spit

3.1.12.2.3 *Offshore Breakwater System* - The city of Norfolk, with funding assistance from the Commonwealth of Virginia, has constructed a series of offshore breakwaters along the Willoughby Spit-Ocean View shoreline over the last 15 years. The breakwaters were recommended in the "Beach Management Plan, City of Norfolk, Virginia, January 1993" prepared by the city's consultant, Andrews, Miller and Associates, Inc., Cambridge, MD. Based on city records, eight breakwaters were constructed along the Willoughby Spit shoreline, four along the Central Ocean View shoreline, and fourteen along the East Ocean View shoreline. State funding was discontinued before beachfill behind the breakwaters could be accomplished, leaving the project area with a reduced level of protection.

The city of Norfolk has recently submitted an Invitation for Bid for the construction of seven new breakwater structures along the Willoughby Spit shoreline. The proposed work would also include the removal of derelict timber groins and improvements to an existing terminal groin located at the western end of the spit.

The following table summarizes the offshore breakwater construction projects undertaken or planned by the city of Norfolk.

Table 8. OFFSHORE BREAKWATER CONSTRUCTION PROJECTS BY CITY OF NOROFOLK

Date	Work Description	Location
1990	Construction of two nearshore breakwaters	Western end of Willoughby Spit near Lea View Avenue
Jan 1997- Apr 1997	Construction of four nearshore breakwaters	Critical Area 1: Worth St to 8th View (Willoughby Spit)
Dec 1997 - Mar 1998	Construction of five nearshore breakwaters	Critical Area 1: Worth St to 8th View (Willoughby Spit)
1999	Construction of four nearshore breakwaters	Critical Area 2: Just east of Community Beach (Central Ocean View)
Aug 2000	Construction of three nearshore breakwaters	Critical Area 3: 21st Bay to Little Creek Inlet (East Ocean View)
Nov 2001	Construction of four nearshore breakwaters	Critical Area 3: 21st Bay to Little Creek Inlet (East Ocean View)
Mar - Apr 2002	Construction of toe extensions	Critical Area 1: Breakwater 7 (Willoughby Spit)
Jan-Feb 2006	Construction of one nearshore breakwater	Critical Area 1: East of 8th View (Willoughby Spit)
Jan-Feb 2006	Construction of three nearshore breakwaters	Critical Area 3: 29th Bay to Little Creek Inlet (East Ocean View)
To be determined	Planned construction of seven nearshore breakwaters	Along Willoughby Spit

3.1.12.2.4 *Private Shore Protection Structures* - Over the years, private property owners have also constructed a number of coastal protection structures along the study area shoreline for the purpose of protecting property or stabilizing a shoreline. These structures include timber bulkheads, rubble-mound revetments, and retaining walls. At the current time, there are only a few remaining structures along the entire shoreline, with one revetment remaining in East Ocean View and the rest located along Willoughby Spit. Such structures are very expensive for individual property owners to have designed by professional engineers and built and maintained by licensed contractors. The city's Coastal Primary Sand Dune Ordinance requires a permit for the construction of these structures within the coastal primary sand dune.

3.1.12.3 Federal Beach Nourishment and Related Activities. Historically, the city of Norfolk has taken the lead on beach nourishment activities along the study area shoreline with the occasional assistance of the Departments of the Navy and the Army. The following paragraphs summarize the beach renourishment and related activities accomplished by the Departments of the Navy and Army.

3.1.12.3.1 *East Ocean View* - Records indicate the placement along the East Ocean View shoreline of approximately 50,000 cubic yards of sand in 1948, 700,000 cubic yards in 1953, and 159,000 cubic yards in 1960 from the dredging of Little Creek Inlet by Corps of Engineers contracts. Limited data suggest that in general, the material consisted of finer-grained sand than the native beach sand. In 1982, a Department of the Navy contractor dredged approximately 120,000 cubic yards of sand from the entrance channel at Little Creek and placed it along the East Ocean View shoreline.

In 2005, the Norfolk District Corps of Engineers pumped approximately 359,000 cubic yards of sand along the East Ocean View shoreline from Little Creek Inlet to 17th Bay Street. The sand was dredged in conjunction with the deepening of the Thimble Shoal Channel portion of the 50-foot Inbound Element of the Norfolk Harbor and Channels Project. The city paid for the incremental cost of placing the sand on the beach versus placement in the designated dredged material management area.

3.1.12.3.2 *Central Ocean View* - Historically, the Central Ocean View shoreline, especially the eastern portion, has been relatively stable, a beneficiary of the sand migrating from beach nourishment projects to the east. No Federal beach nourishment projects have been accomplished along this shoreline segment.

3.1.12.3.3 *Willoughby Spit* - Emergency nourishment of the Willoughby Spit shoreline took place after the Northeaster of 1962 resulting in the placement of approximately 176,000 cubic yards of sand along an estimated 6,000 feet of shoreline extending east from the tip of the spit. The fine grained sand was dredged from an area immediately offshore in the bay.

In 1984, the Department of the Navy, in coordination with the city, placed approximately 540,000 cubic yards of material along 12,000 feet of shoreline extending from the tip of the spit to 4th View Street. The material was dredged from the construction of a new U.S. Navy carrier pier and the deepening of an existing pier at the Naval Base Norfolk. Limited available geotechnical data indicated that the material consisted of calcium carbonate (shell hash) instead of quartz sand which was comparable to fine-to-medium grain sand.

3.1.12.4 <u>City Beach Nourishment Projects and Related Activities</u>. Since at least the early 1980's, the city of Norfolk has expended significant resources each year in an effort to stabilize the beach and maintain its ability to provide some level of protection from moderate coastal storm activities. More recently, the city has also embarked on a large scale program to repair the study area shoreline from the damages incurred from Hurricane Isabel and damaging northeasters. The city has focused its attention on three critical stretches of shoreline, East Ocean View, Central Ocean View, and West Ocean View and Willoughby Spit, respectively that exhibit high rates of beach loss as compared to surrounding beach areas. The following table highlights the various renourishment projects undertaken along the study area shoreline by the city since 1982. Also included are the beach surveys that were accomplished to monitor the condition of the beach and works accomplished in the dune system. Information is based on a review of work by Hardaway et al., 2005 and city of Norfolk records.

Table 9. BEACH NOURISHMENTS AND SURVEYS BY THE CITY OF NORFOLK

Date	Activity/Project Type	Location	Volume (cy)	Extent (ft)
1982	Beach Nourishment	East Ocean View	400,000	Not known
Jan-Apr 1984	Beach Nourishment	Terminal Groin to 5th View St (Willoughby Spit)	537,500	11,000
Aug-Nov 1984	Beach Nourishment	21st Bay St to East End Parking Lot (East Ocean View)	400,000	3,000
1985	Beach Nourishment	6th View St to Sarah Constant Shrine Beach Park	50,000	
1987	Beach Nourishment	5th View St to Mason Creek	50,000	2,000
1988	Construction of 19 pedestrian beach access ways constructed	Willoughby Spit and Ocean View	N/A	Not known
Spring 1988	Dune Repair (Sand fill)	Willoughby Beach	10,000 cy of accretion from terminal groin	Not known
June 1989	Dune Repair (Sand fill)	Willoughby Beach	25,000 cy of accretion from terminal groin	Not known

Table 9. BEACH NOURISHMENTS AND SURVEYS BY THE CITY OF NORFOLK (cont'd)

Date	Activity/Project Type	Location	Volume (cy)	Extent (ft)
1989	Beach Nourishment	21st Bay St to East End Parking Lot (East Ocean View)	133,000	3,000
1990	Beach Nourishment	Willoughby Spit-Near Terminal Groin	100,000	Not known
1990-1991	Dune vegetation planting, sand fence construction, elevated public access way, cross-over structures, and timber roads for vehicles	Various Locations	N/A	Not known
1995	Beach Nourishment	Willoughby Spit	240,000	Not known
Dec 1995	Beach Nourishment	13th View St to 12 View St (in 4 groin pockets)	4,000	Not known
Dec 1995	Beach Nourishment	Critical Area 1: 8th View St to 7th View St	30,000	1,000
Oct 1998	City Survey	Entire Ocean View Shoreline	N/A	N/A
Dec 1998	Beach Nourishment	Critical Area 1: East of 8th View St-near site of future groin spur	500	175

Table 9. BEACH NOURISHMENTS AND SURVEYS BY THE CITY OF NORFOLK (cont'd)

Date	Activity/Project Type	Location	Volume (cy)	Extent (ft)
Oct 1999	City Survey	Entire Ocean View Shoreline	N/A	N/A
Nov-Dec 1999	Groin Spur Construction	Critical Area 1: Worth St to 8th View	N/A	N/A
Dec 1999	Beach Nourishment	Center of COV breakwaters	4,000	Not known
Dec 1999	Beach Nourishment	Critical Area 1: East of 8th View St-leeward of newly constructed groin spur	1,000	200
Jul 2000	City Survey	From Approx. 9th View St to Little Creek Inlet	N/A	N/A
Oct 2000	City Survey	From Approx. 12th View St to Little Creek Inlet	N/A	N/A
Jul 2001	Beach Nourishment	Critical Area 1: Worth St to 8th View	500	Not known
Sep 2001	Beach Nourishment	Critical Area 1: East of 8th View St-between breakwater 7 and groin spur	2,000	300

Table 9. BEACH NOURISHMENTS AND SURVEYS BY THE CITY OF NORFOLK (cont'd)

Date	Activity/Project Type	Location	Volume (cy)	Extent (ft)
Oct 2001	City Survey	Entire Ocean View Shoreline	N/A	N/A
May 2002	Beach Nourishment	Critical Area 1: East of 8th View St-between breakwater 7 and groin spur	3,438	300
Jun 2002	Removal of timber groin channel ward of rock spur	Critical Area 1: Worth St to 8th View	N/A	N/A
Jul 2002	City Survey	Entire Ocean View Shoreline - excluding approx. Sherwood Pl. to Warwick Ave.	N/A	N/A
Oct 2002	City Survey	Entire Ocean View Shoreline - minimal survey data (no beach or bathymetric survey points)	N/A	N/A
Mar 2003	City Survey	East Ocean View Shoreline (19th Bay to Little Creek Inlet)	N/A	N/A
Apr 2003	City Survey	East Ocean View Shoreline (17th Bay to Little Creek Inlet)	N/A	N/A
Jun 2003	Waterway Survey	East Ocean View Shoreline (17th Bay to Little Creek Inlet)	N/A	N/A

Table 9. BEACH NOURISHMENTS AND SURVEYS BY THE CITY OF NORFOLK (cont'd)

Date	Activity/Project Type	Location	Volume (cy)	Extent (ft)
Sept 2003	Beach Nourishment	Critical Area 1: West of 8th View St beach access	1,100	350
Oct 2003	Waterway Survey	Post-Isabel Survey - East Ocean View Shoreline (17th Bay to Little Creek Inlet)	N/A	N/A
Oct 2003	Beach Nourishment	Critical Area 3: 19th Bay St	6,000	545
Oct 2003	Beach Nourishment	Critical Area 3: East of 30th Bay St	1,000	150
Dec 2003	Beach Nourishment	Critical Area 3: 17th Bay St to Little Creek Inlet	359,000	5,280
Dec 2003	Beach Nourishment	Critical Area 1: 9th View St to 7th View St (+400 ft)	39,800	1,260
Nov-Dec 2003	Post-Fill Survey	East Ocean View Shoreline (17th Bay to Little Inlet Creek)	N/A	N/A
Feb-Apr 2004	Waterway Survey	From Approx. Willoughby Spit to 17th Bay St	N/A	N/A
Aug 2004	Beach Nourishment	13th View to 11th View, Behind Western 4 Breakwaters at 800 Block, 1200' East of dogleg	37,000	4,950

Table 9. BEACH NOURISHMENTS AND SURVEYS BY THE CITY OF NORFOLK (cont'd)

Date	Activity/Project Type	Location	Volume (cy)	Extent (ft)
Jan-Mar 2005	Dune Restoration	Willoughby Spit to Central Ocean View (14th View St to Warwick Ave)	504,329	18,300
Jan-Mar 2005	Post-Fill Survey	Willoughby Spit to Warwick Ave.	N/A	N/A
Sep 2005	McKim & Creed Periodic Survey	Entire Ocean View Shoreline	N/A	N/A
Mar 2006	McKim & Creed Periodic Survey	Entire Ocean View Shoreline	N/A	N/A
Oct 2006	McKim & Creed Periodic Survey	Entire Ocean View Shoreline	N/A	N/A
Mar 2007	McKim & Creed Periodic Survey	Entire Ocean View Shoreline	N/A	N/A
Oct 2007	McKim & Creed Periodic Survey	Entire Ocean View Shoreline	N/A	N/A
Mar 2008	McKim & Creed Periodic Survey	Entire Ocean View Shoreline	N/A	N/A
Dec (?) 2009	Emergency Dune Restoration	Willoughby Spit	47,100	N/A

3.1.13 Existing Nonstructural Storm Damage Reduction Programs and Measures

3.1.13.1 General. In addition to the existing shoreline structures and local beach nourishment program, there are also several non-structural flood damage reduction measures currently in place within the study area. Non-structural measures are directed at controlling or regulating the use of land and buildings such that loss of life and damage are reduced or eliminated. No attempt is made to reduce, divert, or otherwise control the level of flooding within the flood prone area. Generally, these measures include flood plain regulations, storm warning and temporary evacuation, flood proofing, the National Flood Insurance Program, and permanent relocation and/or evacuation. Within the study area, all of these measures are employed to various degrees.

3.1.13.2 Local Non-Structural Measures. In a typical storm event, pre-storm expenditures, including starting up the Emergency Operations Center (EOC), pre-positioning equipment, and removing items from the beach, are all activities that will continue to occur even with a Federal project in place. Expenditures made during storms to support activities such as EOC staffing, opening blocked drains, evacuating low-lying areas, and maintaining shelters will continue as well. Post-storm activities, including damage assessment, maintaining emergency shelters, security patrol, and clean-up will also continue. Annual activities that include flood plain regulation review, residential plans inspections, building inspections, as well as erosion and sediment inspections will also continue.

3.1.13.2.1 *Emergency Warning and Evacuation* - A very important non-structural measure which has been in effect in the study area for many years and is constantly undergoing review and improvement is the emergency warning and evacuation program operated by the city of Norfolk. City emergency staff members monitor coastal storm conditions and advise residents to be prepared and listen to the TV, radio, or check the city's website. Where and when appropriate, city officials will, in an effort to protect life, advise the residents of the voluntary or mandatory decision to stay where they are or to leave the area. Residents may choose to leave at any time when "voluntary evacuations" are ordered or when they feel it is necessary. Residents must leave when “mandatory evacuations" are ordered. Residents who choose to stay are warned that they do so at their own risk and that emergency responders may or may not be able to reach them due to the storm conditions at the time.

3.1.13.2.2 *Flood Plain Regulations* - The city of Norfolk has adopted appropriate flood plain regulations to promote the public health, safety, and general welfare; to minimize flood losses in areas subject to flood hazards; and to reduce the hazards of floods to life, property, and human health. These regulations include the full range of coastal building and sanitary codes, zoning ordinances, and subdivision regulations related to the use of land and construction within flood-prone areas. Flood plain regulations limit the uses of the designated flood-prone areas to those compatible with the degree of flood risk and mold the flood plain development in such a manner as to lessen the damaging effects of floods.

The city of Norfolk established the Chesapeake Bay Coastal Management Area (CBCMA) in 2011 to address issues regarding the "degree of overlap and ambiguity in the various city of Norfolk codes and regulations governing structures, uses and activities within the city's beach and dune system" (CBCMA Guidance Document). The CBCMA extends along the entire study area shoreline with the exception of the area from Warwick Street to 1st Bay Street and generally includes the area between mean low water and the landward limits of the coastal primary sand dune or beach. A CBCMA Guidance Document was adopted on September 27, 2011 (amended on February 28, 2012) to provide property owners in the study area with guidance on "what uses and structures are appropriate on city property or unimproved public rights-of-ways along the beach and dunes of the Chesapeake Bay."

3.1.13.2.3 *Redevelopment Activities* - Since the 1990s, the city of Norfolk has encouraged and supported the long term revitalization of the study area through a strategy of public and private redevelopment. As stated earlier in this report, the study area is fully developed with older and newer residential and commercial structures that are located within the study area 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 regulations. In several areas, entire older residential communities are continually being replaced by new residential developments. The city and local civic groups prefer this slow and progressive redevelopment to a program consisting of the permanent relocation and demolition of existing developments subject to flood damages.

3.1.13.3 National Flood Insurance Program. The city of Norfolk is a participant in the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA). This program is designed to provide insurance at affordable rates through a Federal subsidy. In return, the city of Norfolk has agreed to adopt and administer local flood plain management regulations and practices directed at protecting lives, existing property, and new construction from future flooding. Based on information from the state coordinator for flood plain management activities in Virginia, there were 12,401 flood insurance policies in effect in the city of Norfolk as of September 2012. Total annual premiums for these policies are over a million dollars for coverage of over one billion dollars in property value. A number, but not all, of the flood insurance policies are in effect for properties located along the Chesapeake Bay in the reaches of beach under consideration in this study.

3.2 WITHOUT-PROJECT CONDITION

The without-project condition is the land use and related conditions likely to occur in the study area in the event that a Federal project is not implemented; including existing and future improvements, actions, laws, and policies. The without-project condition also provides the basis for the evaluation of potential measures for addressing the storm damage and beach erosion problems described in Section 2.0 of the report entitled “Identify Problems, Needs, and Opportunities”.

Hurricanes and northeasters will continue to impact the study area, whether or not there is a Federal Hurricane and Storm Damage Reduction Project in place. However, without a Federal project major coastal storms would continue to inflict significant damage on the study area from storm surge and erosion along the Chesapeake Bay shoreline as residential, commercial, and public development is subjected to wave activity, undermining, and inundation.

In the absence of a Federal project, it is likely that conditions as they currently exist would continue into the foreseeable future. Norfolk's immediate solution is to initiate a city funded beach nourishment program. This program is intended to be both proactive and reactive in nature. In the East Beach area of the project, the city would increase the size of the current beach. In other areas where the beach is more stable, the city would respond as necessary to storm damage. These nourishment activities would supplement the protection provided by the breakwaters the city has constructed in four areas of the study. However, this program is intended to be a stop gap measure until a Federal project is implemented and it is uncertain when the city's nourishment program will be implemented. The Commonwealth's regulatory agencies have been very restrictive in the dredging it has allowed in the lower Chesapeake Bay, to the extent that other Corps of Engineers beach projects have needed to go outside the three-mile limit in the Atlantic Ocean for sand. The cost to do this may be too prohibitive for the city to continue long term beach nourishment on its own.

If projected over the 50-year period of analysis, the conditions are estimated as follows:

- The city of Norfolk would try to maintain a 12-foot berm along the beach and maintain the current dune profile;

- Conditions would not change until the beach is constructed to closure depth and properly renourished over its full extent with adequate advance nourishment.

Other structural and non-structural flood damage reduction measures described in this report would also be continued in the without-project condition, including the offshore stone breakwaters located in East Beach, Central Ocean View, and Willoughby Spit. Additionally, on July 27, 2012, the public notice for a permit application by the city of Norfolk was issued. This permit would allow the city to construct seven new breakwaters, relocate an existing breakwater, demolish seven timber groins, improve the existing terminal groin, and excavate sandy material to be used to construct a dune and nourish the beach from approximately 8th View Street to Lea View Avenue. This area is located in Reach 3 in the Willoughby Spit section of the study area.

Proper project formulation of storm damage reduction alternative measures requires that costs and benefits associated with the existing local project be evaluated. A separate evaluation of costs and benefits associated with the local project is necessary to determine the appropriate allocation between storm damage reduction and recreation values since policy and cost sharing for storm damage reduction outputs differ from recreation outputs. For this reason, a base condition that assumes that the local nourishment project would not be maintained is required. The existing beach berm would be permitted to erode back to its pre-local project conditions. Therefore, the storm damage reduction and recreation benefits attributable to the local project are estimated, given this assumed base condition.

3.3 WITHOUT-PROJECT HYDRAULIC ANALYSIS

Elevated storm water levels can be caused by tropical storms (hurricanes) or by extra-tropical storms (northeasters). Both can cause beach erosion and damage to coastal structures. Hurricanes are associated with extreme low pressure systems and can result in large increases in water level. A hurricane can result in significant flooding and damage as a result of elevated water levels and wave attack. Northeasters cause damage principally through wave attack of the shoreline and adjacent structures and can be as damaging, or more damaging, than hurricanes depending on their duration, which can extend over several tidal cycles.

Storm damages within the project area can occur from erosion, direct wave attack, and inundation. A review of available storm records indicated a set of 12 hurricanes and

30 northeasters that have impacted the study area with maximum water levels above four feet, NAVD. The stillwater levels for these storms were subsequently increased by 0.0137 feet per year to account for historical sea level rise. This historical rate of sea level change (SLC) is the "low" scenario in the analysis of potential SLC impacts on the project area. Complete SLC analysis for the without-project condition can be found in Appendix B.

To evaluate the effects of various storms, eight northeaster and seven hurricane events were hindcast to estimate the stillwater levels, wave heights, wave periods, and storm duration for each storm. Actual data from a deployed wave gauge was available for the November 2009 northeaster. These representative storms denote a range in stillwater frequency from 56 percent to 0.5 percent exceedance probability (2-year to 200-year). The frequencies of these storms were estimated based on available nearby gage station stillwater frequency relationships data summarized in the following table.

Table 10. STORM PARAMETERS

Storm Event	Event Probability	Maximum Stillwater Level (1) (NAVD)	Duration Wave > 2ft (hours)	Maximum Wave Height (feet)	Maximum Period (sec)
		Hurricanes			
August 1933	0.005	7.51	42	9.65	14
September 2003 (Isabel)	0.024	6.37	43	8.50	14
September 1936	0.030	6.17	65	7.81	14
September 1933	0.060	5.61	71	8.96	20
September 1960 (Donna)	0.120	5.02	34	7.81	11
September 1999 (Floyd)	0.250	4.50	30	7.12	11
August 1986 (Charley)	0.500	4.04	17	5.51	11
		Northeasters			
March 1962 (Ash Wed)	0.026	6.29	95	4.59	14
November 2009	0.032	6.12	76	5.72	13
April 1956	0.070	5.48	51	4.36	14
April 1978	0.090	5.25	49	4.82	14
October 1982	0.190	4.68	70	7.81	14
October 1958	0.270	4.45	102	7.58	14
October 1977	0.340	4.27	29	3.44	11
January 1987	0.420	4.14	13	3.90	11
October 1991 (Halloween)	0.560	3.98	78	5.28	20

(1) Includes historic sea level rise through 2010.

The Storm-Induced Beach Change (SBEACH) module of the Coastal Engineering and Design and Analysis System is a tool that is utilized in support of storm damage reduction and beachfill design activities. SBEACH simulates beach profile change under varying storm waves and water levels. Various beach profiles, in this case the without-project profiles, are input as well as the various storm parameters listed in the previous table. The responses of these profiles to the various storm parameters are then measured based on the storm-induced erosion, wave, and inundation outputs. This output information is then utilized in the Beach-*fx* model discussed later to estimate the expected damages.

Plates 23 to 27 display the 100-year and 500-year without-project flood plain areas located within the study area. Further details on the hydraulic analyses are contained in Appendix A.

3.4 WITHOUT-PROJECT ECONOMIC ANALYSIS

3.4.1 Structural Inventory and Replacement Costs

The without-project condition displays the implication of storm damage and erosion if a Federal project is not constructed in the study area. The base year for the without-project condition is the same year that construction of an authorized Federal project would be completed. Construction is estimated to begin in December 2015 with completion in 2016, making the base year 2016.

Based on historical building patterns, it is assumed that the study area will be almost fully developed by the base year. Although there are currently existing vacant lots, it is assumed that most of these lots will be built on by the base year since the infrastructure (electricity, sewer, etc.) is already available. Some lots that have been vacant for an extended period of time will remain vacant. Those structures that were added to vacant lots were given the characteristics of the most recent structures built near the vacant lots. The first floor elevation, footprint, and value were duplicated to match the surrounding new construction trends. This means the structures also meet the current local first floor requirements.

Each structure was specifically inventoried and mapped on a geographic information system (GIS) from aerial ortho-digital photography dated March 2007. Database information provided by the city of Norfolk included the address, value of the structure, and value of the land and detailed structure descriptions that included number of stories, construction and quality type, and type of foundations. The city also provided the square footage, number of bathrooms, type of heating system, and the presence of basements, fireplaces, garages, and central air conditioning. This information was used to estimate the depreciated replacement cost utilizing cost guides by Marshall and Swift and RSMeans for a subset of the population. The values per square foot were then applied to other structures in the floodplain that were similar to an individual structure in the subset. First floor and ground elevations were obtained from field surveys by district personnel.

Storm damages in the study area include damages to structures and contents, as well as transportation infrastructure. Unlike long term erosion, which can be predicted to some extent based on past trends and observed shore processes, damages from wave attack can occur any year and can be predicted only as a mathematical probability. Average annual coastal storm damages for the study area were computed using Beach-*fx*. This model integrates coastal engineering data, including storm frequency, storm surge, and long term erosion rates, with economic data, including the values of structures which could be damaged or destroyed. The Beach-*fx* model is addressed in greater detail in Appendix A and Appendix B.

When evaluated at an interest rate of 4.00 percent over the 50-year period of analysis, the present worth (October 2012 price levels) of the expected structural damages totals $79.8 million; equivalent average annual damages are $3.71 million. Present value of expected land loss is $7.4 million with an equivalent average annual loss of $0.34 million. Total damages are $87.2 million to include structural and land loss with an average annual equivalent of $4.05 million. Local costs are estimated at $1.04 million for storm protection. For Reach 1, the present worth of the expected damages totals $17.07 million; equivalent average annual damages are $0.79 million. For Reach 2, the present worth of the expected damages totals $45.14 million; equivalent average annual damages are $2.10 million. For Reach 3, the present worth of the expected damages totals $24.96 million; equivalent average annual damages are $1.16 million.

The without-project condition damages are presented over time at non-discounted values in the graph included as Plate 28. It should be noted that the reaches are not in order so that all data was visible. As the graph shows, initially there is a large amount of damage. This is due to structures being damaged, but later in the analysis they are not rebuilt. Structures are allowed to be rebuilt twice in the model.

Damage types in the analysis are calculated for four categories. These are erosion, wave attack, flood inundation, and land loss. The graph included at Plate 29 shows the average annual damages by damage type by reach for the study area. Erosion damages and wave attack are the two highest damaging mechanisms with erosion being the most prevalent. The following table presents the average annual damages by structure type and reach.

Table 11. AVERAGE ANNUAL DAMAGES BY STRUCTURE TYPE AND REACH

Reach	Single Family Residences	Multifamily Residences	Retail	Motels	Restaurants	Garages	Crossovers, Pools and Recreational Structures
1	$470,700	$220,400	$1,400	$5,300	$64,700	$3,500	$9,100
2	$743,900	$944,300	$19,700	$177,100	$4,000	$6,800	$19,900
3	$341,300	$607,900	$3,000	$26,900	$35,100	$9,200	$0

3.4.2 Storm Damage Methodology

Storm damage is computed using Beach-*fx,* which is an analytical framework for performing engineering-economic analyses associated with storm damage reduction studies. The model has been implemented as an event-based Monte Carlo life cycle simulation tool. Beach-*fx* relies on user populated databases which describe the coastal area under study; the environmental forcing in the form of a suite of historically-based plausible storm events; an inventory of infrastructure that can be damaged; and estimates of morphology response of the anticipated range of beach profile configurations to each storm in the plausible storm suite. These are combined with damage driving parameters for erosion, inundation, and wave impact damages. It is a data driven model in that all site-specific information is contained within the input databases, which generalizes the model and makes it easily transportable between study areas. Beach-*fx* integrates the engineering and economic analyses and incorporates uncertainty in both physical parameters and environmental forces which enables quantification of risk with respect to project evolution and economic costs and benefits of project implementation.

Beach-*fx* is a planning level tool used to evaluate proposed project alternatives in comparison with a similar evaluation of the without-project condition. As such, a pragmatic approach to the simulation of beach evolution over time scales of project life cycles, on the order of 50 years, is employed within the model. In Beach-*fx,* only the dry beach (the berm width, dune height, dune width, and upland width) is dynamic, whereas the submerged portion of the beach profile is assumed to remain constant. Storms can produce changes in the berm width, dune height, dune width, and upland width depending on the intensity and duration of the event.

In Beach-*fx* the beach profile response to storm events is obtained from the pre-computed input shore response database by a look-up procedure. The shore response database is populated by extracting estimated berm width, dune height, dune width, and upland width changes from SBEACH simulations. The post-storm profile is obtained by applying the looked-up profile responses to the pre-storm beach profile. A post-storm berm width recovery factor of 90 percent is applied over a 45-day recovery interval to simulate the observed natural berm width recovery process after passage of storm events. Conceptually, this procedure implies that the cross-shore sand transport associated with storm events is mostly, but not completely, recovered. Changes in the dune and upland morphology do not recover naturally and can only be restored by planned management actions such as beach nourishment or emergency nourishment. In this way, project life cycles that involve more storms produce higher rates of shoreline change than those life cycles that involve fewer storms.

Beach-*fx* data is also used to determine the appropriate renourishment cycle for each individual plan. This is accomplished through the Monte Carlo simulations utilizing historic storm data and the SBEACH derived storm response database. An initial berm template and a minimally acceptable berm template are specified for the model, along with a minimum period between allowed renourishments. Additionally, within Beach-*fx*, the modeler specifies the minimum cost of a renourishment and a minimum quantity of material required to trigger a renourishment.

Beach-*fx* also includes an input for the "applied erosion rate," which is intended to account for longer term processes that produce shoreline change such as regional or local longshore sand transport gradients or losses due to overwash processes or sea level change. The applied erosion rate can be either positive (produces a progradation of the shoreline) or negative (produces regression of the shoreline). The idea here is that the sum of the storm-induced shoreline change, together with the 90 percent berm width recovery factor and the applied erosion rate on average over multiple simulated project life cycles, should return the long-term historical shoreline change rate. This procedure is the calibration strategy for Beach-*fx.*

Beach-*fx* is calibrated to return on average, over multiple (hundreds) project life cycles, the long-term historical shoreline change rate on a reach-by-reach basis through adjustment of the applied erosion rate. The end result is that each simulated life cycle produces a unique shoreline change rate that depends on the random sequence of storm events encountered in that life cycle. Some life cycles produce shoreline change rates that are less than the historical shoreline change rate and some produce shoreline change rates that are greater than the historical shoreline change rate, but on average, across hundreds of simulated project life cycles, the target historical rate of shoreline change is returned. The above described concepts of how Beach-*fx* operates are the framework for how damages are computed.

4.0 FORMULATION OF ALTERNATIVE PLANS

This step involves the formulation of alternative plans to identify specific ways to achieve the planning objectives in order to solve the identified problems and realize the identified opportunities.

4.1 GENERAL

Congress has authorized Federal participation in the cost of restoring and protecting the shores of the United States, its territories, and its possessions. Under current policy, shore protection projects are designed to reduce damages caused by wind generated and tide generated waves and currents along the Nation's ocean coasts, Gulf of Mexico, Great Lakes, and estuary shores. Hurricane protection was added to the erosion control mission in 1956 when Congress authorized cost shared Federal participation in shore protection and restoration of publicly owned shore areas. Protection of private property is permitted only if such protection is incidental to the protection of public areas, or if the protection of private property would result in public benefits. Federal assistance for periodic nourishment was also authorized on the same basis as new construction, for a period to be specified for each project, when it is determined to be the most suitable and economical remedial measure.

Single purpose storm damage reduction projects are formulated to provide coastal storm damage reduction. The highest priority is for reducing damage to existing development; reducing flooding on, or erosion to, undeveloped lands is not a high priority. Alternative protection measures are formulated exclusively for coastal storm damage reduction with economic benefits equal to or exceeding the costs and are based solely on damage reduction benefits, or a combination of damage reduction benefits and recreation benefits. Under current policy, recreation is incidental in the formulation process and may not account for more than 50 percent of the total benefits required for economic justification. If the standard for participation is met, then all recreation benefits are included in the benefit-to-cost analysis.

Federal participation in coastal storm damage reduction has developed historically in relation to beaches, generally with efforts to stabilize, create, or restore beaches. It is intended that beaches receiving public assistance should not provide exclusively private benefits; therefore, whenever a coastal storm damage reduction project involves beach improvement, public ownership and use of the beach is required. Adequate parking and access are necessary for public use and are important considerations for Federal participation.

4.2 IDENTIFICATION, EXAMINATION, AND SCREENING OF MEASURES

Several potential measures are available to address, individually or in combination, the coastal storm damage and other identified problems, needs, and opportunities of the study area. All of these measures were identified and evaluated in the 1983 feasibility report and are reexamined at this time on the basis of their suitability, applicability, and merit in meeting the planning objectives and avoiding the constraints for the study. The measures are classified under two principal categories, nonstructural, and structural. Structural measures directly affect the conditions that result in storm damage and loss of land while nonstructural measures reduce damages without directly affecting those conditions. Lastly, there is the No Action Plan which does not involve the application of an institutional or structural measure.

4.2.1 Non-Structural Measures

Non-structural measures are directed at controlling or regulating the use of land and buildings such that loss of life and damage to property are reduced or eliminated. No attempt is made to reduce, divert, or otherwise control the level of flooding on the flood plain. Nonstructural measures include flood plain regulations; storm warning and emergency evacuation; the National Flood Insurance Program; retreat; permanent relocation; demolition; and flood proofing. As indicated earlier in this report, flood plain regulation, storm warning, and emergency evacuation are ongoing programs currently in place by the city of Norfolk and the city is a participant in the National Flood Insurance Program These measures are considered part of the existing conditions and thus are eliminated from further consideration.

Also, as indicated earlier, the city of Norfolk has encouraged and supports the long term revitalization of the study area through a strategy of public and private redevelopment. 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 regulations. In several areas, entire older residential communities are continually being replaced by new residential developments. The city and local civic groups prefer this slow and progressive redevelopment to a program consisting of the permanent relocation and demolition of existing developments subject to flood damages. Due to the extensive development in the study area, retreat is not considered to be a viable option. These measures are considered part of the existing conditions and are expected to continue in the future and are eliminated from further consideration.

Flood proofing is any combination of structural changes and adjustments incorporated in the design, construction, and alteration of individual buildings, structures, properties, and contents primarily for the purpose of eliminating or reducing water entry and therefore, reducing flood damage. Although it is more simply and economically applied to new construction, flood proofing is also applicable to existing facilities. Typical flood proofing methods include: (1) the raising of existing and new structures; (2) the provision of individual dikes around existing structures; (3) the provision of temporary and permanent closures for openings in existing buildings; (4) the rearranging or protection of damageable property within an existing structure; and (5) the anchoring of floatable structures and facilities. Some of these flood-proofing measures have been and are currently being utilized within the study area. For many years, new buildings have been constructed with the first floor of the living area above the 100-year flood level in accordance with state and city building regulations and many ground floor levels are used as garages and/or for storing of property that is less susceptible to water damage. Where appropriate, temporary and permanent closures for openings have been added to existing structures and floatable structures have been anchored. These practices are expected to continue in the future and are part of the existing condition; therefore, they are eliminated from further consideration.

The construction of individual dikes around existing buildings and the raising of older buildings have been found to be impractical due to space limitations in closely constructed developments and high implementation costs. Both measures also received very low support from local citizens and public officials; therefore both are eliminated from further consideration.

4.2.2 Structural Measures

Structural measures are generally intended to physically prevent or control flooding. In coastal flood protection, this is accomplished by beachfill with and without enhanced dunes, as well as by building seawalls, bulkheads, revetment, groins, breakwaters, and/or a combination of some or all of these methods.

Beachfill with or without enhanced dunes is the physical increase in beach/dune width and/or height by the placement of a suitable quality and quantity of sand on the beach/dune at proper intervals of time. This measure involves the placement of sand from offshore and/or onshore borrows sources directly onto the beach in order to widen and stabilize the existing berm profile. Usually, the sand is pumped from an offshore borrow site onto the beach using a dredge and pipeline. An appropriate design uses borrow material that has similar properties to the existing beach sand. The beach is initially built to the specifications of a construction berm/profile that will be reshaped by the area's coastal dynamics and reach a quasi-equilibrium state. The beach requires renourishment on a periodic basis so that the design berm width and elevation are maintained. Beachfill, with or without enhanced dunes, is very compatible with the natural environment and offers design dimension flexibility in addressing coastal storm damage reduction. This measure will be considered further.

Seawalls, bulkheads, and revetments are also appropriate for reducing structural damage; however, they do not meet the goal of preserving the environmental value of the beach, are not compatible with the existing dune system, and would reduce the usable recreation area of the beach at high tide. These alternative measures are not considered further.

Groins are long, narrow structures constructed perpendicular to a shoreline for the purpose of building or at least stabilizing a beach by trapping the longshore movement of sand. While groins do not specifically provide storm protection, a system of groins can reduce the loss of beach sand, thereby reducing renourishment costs and prolonging the life of a beachfill project. To be economically feasible, the expected reduction in renourishment costs must exceed the relatively high costs to construct and maintain the groin system. Additionally, groin systems tend to have an adverse impact on down drift beaches as they reduce the amount of sand reaching those areas. As discussed earlier in this report, the existing system of groins along the Willoughby Spit shoreline was constructed by the city of Norfolk in 1939 to take advantage of a general westward movement of sand and the absence of a down drift beach. The city's ongoing efforts to maintain those groins that continue to be effective and remove those that are not is part of the existing condition and will not be considered further. The feasibility of extending the groin system and/or constructing an additional system in the eastern portion of the study area have been eliminated from further consideration due to the significant concern of adversely affecting the performance of the existing system along the Willoughby Spit shoreline and the expected high cost of groin construction in comparison with any expected reduction in renourishment costs associated with a beachfill project.

Offshore breakwaters are typically rubble-mound structures which are built individually or in series spaced along a shoreline. They are constructed close to shore to protect a stretch of shoreline from low to moderate wave action and reduce severe wave action and beach erosion. Sand transported along the beach is carried into the sheltered area behind the breakwaters where it is deposited in the lower wave energy region. Beachfill is often preplaced in the areas shoreward of the breakwaters to increase their performance. As discussed in Section 3.1.12.2.3 of the report, entitled "Offshore Breakwater System", the city of Norfolk with funding assistance from the Commonwealth of Virginia, has constructed and maintained a series of offshore breakwaters along much of the study area shoreline over the past 15 years and has plans to construct an additional seven breakwaters. Since the existing and planned breakwaters are located in the most problematic areas of the study area, there does not appear to be a need for the construction of additional breakwaters. These structures are part of the existing conditions and will not be considered further. However, the placement of beach-fill behind the existing and planned breakwaters would still be required to increase the performance and effectiveness of the structures. Due to limited funding, backfilling behind the existing breakwaters was not accomplished by the city and there is a need to carry this forward for further consideration.

4.2.3 Summary

The following table presents a summary of the initial screening of the potential measures considered. All nonstructural measures were eliminated from further consideration as they are part of the existing condition. The selected structural measure for detailed consideration and evaluation is beachfill with and without enhanced dunes. The No Action alternative is carried forward as the basis of comparison for any plan of improvement and implies acceptance of the existing flooding problems. The No Action alternative is automatically adopted in cases where all other alternatives fail to be feasible.

Table 12. SUMMARY OF INITIAL SCREENING OF POTENTIAL MEASURES

Measure	Reduce Land Loss	Reduce Wave Damage	Reduce Tidal Flooding	1983 Feasibility Findings	Current Assessment	Likely Public Support	Considered Further?
Nonstructural Measures							
Flood plain regulation, storm warning, and emergency evacuation	No	Yes	Yes	Recommended for continued utilization by the city throughout the study area	Part of the existing condition	High	No
Permanent relocation, demolition of existing structures, and retreat	No	Yes	Yes	Recommended for continued utilization by the city, where applicable	Part of the existing condition	Not likely	No
Flood proofing	No	Yes	Yes	Not economically feasible study area-wide; feasible in limited cases	Part of the existing condition	Moderate	No
Individual dikes and floodwalls	No	Yes	Yes	Not economically feasible. Impractical due to space limitations in dense developments	Impractical due to space limitations in dense developments; High costs	Very low	No
Elevating individual structures	No	Yes	Yes	Not economically feasible. Impractical due to space limitations in dense developments	Impractical due to space limitations in dense developments; High costs	No	No

Table 12. SUMMARY OF INITIAL SCREENING OF POTENTIAL MEASURES (Cont'd)

Measure	Reduce Land Loss	Reduce Wave Damage	Reduce Tidal Flooding	1983 Feasibility Findings	Current Assessment	Likely Public Support	Considered Further?
Structural Measures							
Beachfill with and without enhanced dunes	Yes	Yes	Yes	Most appropriate and cost efficient means of addressing coastal storm damage and beach erosion	Very compatible with natural environment and offers design dimension flexibility	High	Yes
Seawalls, bulkheads, and revetments	Partial	Yes	Yes	Not economically feasible; do not preserve environmental value of beach; not compatible with existing dune system; would reduce usable recreation area	Do not preserve environmental value of beach; not compatible with existing dune system; and would reduce usable recreation area	Moderate	No
Groins	Yes	No	No	Existing groin field marginally effective; additional groins not cost-effective	Part of the existing condition	Moderate	No
Offshore Breakwaters	Yes	Partial	No	High construction costs; not compatible with a recreational beach	Part of the existing condition	High	No

4.3 DEVELOPMENT OF INITIAL ALTERNATIVE PLANS

The two measures selected for further consideration in the development of alternative plans, beachfill with and without enhanced dunes and the No Action alternative, are discussed in the following paragraphs.

4.3.1 Borrow Site Evaluation

Reports describe the sediments on the beach and nearshore at the western end of Willoughby Spit as having been derived and reworked from the 1984 beachfill project. The material was characterized by a mean diameter of 0.13 phi (0.9 mm) with broken shell hash comprising 50 percent of the larger size fraction and 10 to 15 percent of the finer sized material. In May and September of 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 mm with a D (16) and D (84) of 0.81 mm and 0.18 mm, respectively. In June 1994, the Virginia Institute of Marine Science collected 53 samples along the entire beach profile at six locations along the western portion of the study area. Mean grain sizes ranged from 0.5 to 2.2 phi with an average of approximately one phi (0.5 mm). In April 2004, Moffatt and Nichol analyzed samples and the Ocean View area and reports an average d 50 at mid-dune of 0.31 mm, mid-beach 0.39 mm, and between high and low water of 0.45 mm. For the purposes of sand compatibility and overfill calculations, the mean grain size of the existing beach will be conservatively set at 0.6 mm.

As discussed in Section 3.1.2.9.2, Potential Sand Borrow Areas, and in Appendix A, borrow site investigations were focused on three general areas of the lower Chesapeake Bay: Willoughby Bank; Middle Ground (south of Fisherman’s Island); and the area between the Horseshoe and Tail of the Horseshoe. As part of this effort, the Norfolk District Corps of Engineers performed numerous vibracores throughout the lower bay between 1983 and 2007 which was supplemented by an extensive review of available information from sediment sampling dating back to the mid 1970’s.

The investigation ultimately focused on the identification and evaluation of three offshore borrow sites within the lower Chesapeake Bay as alternative sources of sand for a beachfill project along the study area shoreline, as shown on Plate 7. These sites are the Thimble Shoal Auxiliary Channel located east of the Chesapeake Bay Bridge-Tunnel, the Willoughby Banks Site which is located immediately east of the Hampton Roads Bridge-Tunnel, and the Hampton Borrow Area (Borrow Site A) which lies within the area known as the Tail of the Horseshoe offshore of the city of Hampton.

The borrow site evaluation was based on dredging the volume of sand necessary for an estimated placement of one million cubic yards of sand on the beach. The major factors in evaluating the three alternative sites are the quantity of sand required and available, the quality of sand placed on the beach, and the costs associated with dredging the sand and placing it on the beach. Volume estimates indicate that each of the sites contains several million cubic yards of sand, so available quantity is not a problem for initial construction or periodic nourishment.

Sand quality is the grain size compatibility and performance of the borrow site sand with that of the placement beach sand as reflected in a factor referred to as the overfill ratio. The overfill ratio is the proportion of sand required to compensate for differences between grain size distributions of the borrow source compared to the beach. For example, an overfill factor of 1.28 would indicate that the sand volume must be increased by 28 percent in order to achieve the same performance as sand identical to the beach had been used, due to the finer grain size of the fill. The following table presents the pertinent information developed in connection with the evaluation of the three borrow sites.

Table 13. EVALUATION OF THE THREE OFFSHORE BORROW SITES

Potential Borrow Area	Placement Volume on Beach (CY)	Overfill Ratio	Total Volume Dredged at Borrow Site (CY)	Total Volume Available at the Borrow Site (CY)	Average Distance between Borrow Site and Placement Site (miles) (1)	Unit Cost Per Volume Dredged ($/CY)	Total Placement Cost ($)	Unit Cost Per Volume Placed on Beach ($/CY)
Thimble Shoal Auxiliary Channel	1,000,000	1.2	1,200,000	24,000,000	10	10.09	12,110,000	12.11
Willoughby Bank Site	1,000,000	1.8	1,850,000	13,000,000	4	6.84	12,654,000	12.65
Hampton Borrow Area (Borrow Site A)	1,000,000	1.2	1,200,000	15,000,000	7	10.52	12,620,000	12.62

(1) Distances shown represent the rounded average of the distances measured from the center of each borrow site to the eastern and western end of the project area, respectively.

As shown in the previous table, the overfill ratios at the Thimble Shoal Auxiliary Channel site and the Hampton Borrow Area (Borrow Site A), are both 1.2, while the ratio at the Willoughby Banks Site is 1.85. These ratios indicate that the sand at the Thimble Shoal Auxiliary Channel site and the Hampton Borrow Area (Borrow Site A), when compared to the Willoughby Banks site, are more compatible with the existing beach and would perform better and require less dredging at the borrow site. Based on an estimated placement of one million cubic yards of sand on the beach, the respective overfill ratios indicate that 1,200,000 cubic yards of sand will need to be dredged from the Thimble Shoal Auxiliary Channel site and the Borrow Site A and 1,850,000 cubic yards dredged from the Willoughby Bank site.

The costs associated with dredging the sand at the borrow site and placing it on the beach are based on the proximity of the borrow site to the placement beach and the volume of sand that must be dredged to provide the necessary quantity of sand on the beach. As shown in the previous table, the Thimble Shoal Auxiliary Channel site, the

Willoughby Bank site, and the Borrow Site A are an average of ten, four, and seven miles from the project area, respectively. This corresponds with unit dredging costs of $10.09 per cubic yard of sand dredged at the Thimble Shoal Auxiliary Channel site, $6.84 per cubic yard dredged at the Willoughby Bank site, and $10.52 per cubic yard dredged at the Borrow Site A. The cost per cubic yard of sand placed on the beach for each borrow area is determined by first multiplying the total volume to be dredged at the borrow site by the unit cost per volume of sand dredged and then dividing the total by one million cubic yards. As indicated in the previous table, the cost per cubic yard of sand placed on the beach is $12.11 for the Thimble Shoal Auxiliary Channel site, $12.65 for the Willoughby Bank site, and $12.62 for the Borrow Site A. Based on this evaluation, the Thimble Auxiliary Shoal Channel site is the optimal sand borrow site.

As a back check, the Beach-*fx* model was run for ten iterations using an alternative beach plan consisting of a 50-foot construction berm, a dune with a 30-foot crest width, and a 10-foot dune height for each of the borrow sites. These iterations were run utilizing the same simulation seed so that the storm generation and impacts on the shoreline would be the same for each site considered. The costs of the planned nourishment output from Beach-*fx* are compared in the following table.

Table 14. BORROW SITE ANALYSIS USING BEACH-*FX* MODEL

Borrow Site	Average Annual Costs
Thimble Shoal Auxiliary Channel	$ 1,326,000
Hampton Borrow Site (Borrow Site A)	$ 1,382,000
Willoughby Banks	$ 1,340,000

As shown in the table above, the lowest cost borrow site on the basis of average annual costs is the Thimble Shoal Auxiliary Channel site. While the Willoughby Bank site is very close in average annual costs, the nature of the material and its characteristics in relation to the native material preclude it from further consideration. This confirms the selection of the Thimble Shoal Auxiliary Channel site as the optimal site and its use for the evaluation of the alternative plans.

4.3.2 Beachfill With and Without Enhanced Dune Plans

Utilizing the Beach-*fx* model, beachfill plans were formulated on the basis of developing and evaluating initial berm and dune templates and minimally acceptable templates. In the realm of Beach-*fx*, a life cycle model, the terms construction berm and design berm are obsolete. The model simply utilizes the initial templates and the minimally acceptable templates with a minimum period between allowed renourishments as parameters for its Monte Carlo simulations utilizing historic storm data and the SBEACH derived storm response database. Additionally, within Beach-*fx*, the modeler specifies the minimum cost of a renourishment and a minimum quantity of material required to trigger a renourishment. In the Willoughby Beach-*fx* modeling, these values were specified as:

- Initial Berm Width: Specified by Individual Plan (50, 100, and 150 feet plus 60 feet for the Authorized Project)

- Minimally Acceptable Berm Width: Set as 50 percent of the Initial Berm Width

- Dune Crest Elevations: Specified by Individual Plan (10 & 14 ft NGVD - not applicable for the Authorized Project) - Note: As presented later in this report, Dune Crest Elevations of 12 and 16 were ultimately included to bracket the 14-foot Dune Crest Elevation

- Minimum Time between Renourishments: Set as five and seven years

- Minimum Amount of Material Required to Trigger Renourishment: 100,000 CY

- Minimum Cost of Renourishment: $1,000,000

Beach-*fx* utilizes these parameters and provides the renourishment quantities and the number of occurrences for each plan. These values are then used to determine the average renourishment cycle and quantities.

Plans are designated in the format, Plan DW##H#B#-#, where DW## represents the dune width, H# represents dune crest elevation in feet NGVD datum, B# represent the initial berm width template (this is equal to twice the minimally acceptable berm width) from the seaward toe of the dune to the top of the foreshore slope. The "-#" after the berm width represents the minimum nourishment cycle used in the Beach-*fx* modeling. This is only a minimum constraint and the actual average beach renourishment interval is determined by the results of the Beach-*fx* life cycle Monte Carlo simulations. For example, a plan with a 30-foot dune width, a 10-foot elevation dune, a 50-foot wide berm, and a 5-year minimum nourishment cycle is named Plan DW30H10B50-5. The full array of plans and descriptions are shown in the following table.

Table 15. ALTERNATIVE PLANS

Alternative Name	Dune Width	Dune Height	Berm Width	Applied Nourishment Cycle (1)
DW30H10B50-5	30	10	50	5
DW30H10B100-5	30	10	100	5
DW30H10B150-5	30	10	150	5
DW30H14B50-5	30	14	50	5
DW30H14B100-5	30	14	100	5
DW30H14B150-5	30	14	150	5
DW30H10B50-7	30	10	50	7
DW30H10B100-7	30	10	100	7
DW30H10B150-7	30	10	150	7
DW30H14B50-7	30	14	50	7
DW30H14B100-7	30	14	100	7
DW30H14B150-7	30	14	150	7
Authorized Project	N/A	N/A	60	5 (1)
"No Action"	N/A	N/A	N/A	N/A

(1) The Willoughby Beach-*fx* model is programmed to allow a 5-year or 7-year minimum renourishment cycle. The Authorized Project has varying nourishment cycles that were considered in the original report. Reach 1 had a 5-year nourishment cycle, Reach 2 had a 10-year nourishment cycle, and Reach 3 had a 15-year nourishment cycle. The analysis used the 5-year cycle.

5.0 EVALUATION OF ALTERNATIVE PLANS

This step involves the comparison of each alternative from the standpoint of the with-project and without-project conditions. The purpose of the evaluation of alternative plans is to further evaluate and reduce the number of alternatives to be carried forward. This evaluation is accomplished through a review of technical, environmental, social, and institutional considerations as they apply to each of the three study area segments.

5.1 GENERAL

Each alternative plan is evaluated in consideration of four criteria: (1) completeness, (2) efficiency, (3) effectiveness, and (4) acceptability. Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities. Efficiency is the extent to which an alternative plan is the most cost-effective means of achieving the objectives. Effectiveness is the extent to which the alternatives plans contribute to achieve the planning objectives. Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies. Appropriate mitigation of adverse effects shall be an integral component of each alternative plan.

5.2 ECONOMIC EVALUATION OF ALTERNATIVE PLANS

Economic benefits for alternative plans are derived from the reduction in storm damages, reductions in loss to improved property, and local costs foregone. With respect to the administrative costs associated with the National Flood Insurance Program and due to the theoretical nature of the cost reduction and the difficulty in measuring the claimable amount, no reduction in administrative costs is claimed for the study area. Recreation is not a Federal priority benefit category and is not utilized in the optimization of the NED Plan. The benefits leading to project optimization are summarized in the following paragraph and discussed in detail in Appendix B.

As explained previously, the Beach-*fx* program is used to estimate benefits of alternative plans according to the user populated databases which describe the coastal area under study and account for the impact of sea level change on the shoreline. To evaluate alternative plan storm damage reduction benefits, a comparison was made between the without-project damages and the with-project residual damages. The difference defines the storm damage reduction benefits and these benefits were determined for each reach and for each alternative.

Beach-*fx* also estimates present worth costs for the alternative beachfill plans based on initial sand volumes and renourishment sand volumes needed to replenish sand lost due to long term and storm induced erosion. Beach-*fx* applies unit costs for dredging these sand volumes and applies mobilization and demobilization costs for each job. Other estimated costs included are engineering and design costs and contract supervision and administration.

5.2.1 Average Annual Benefits

Optimization of the alternative plans was based on the priority benefit category of storm damage reduction based on October 2012 price levels. These benefits represent the direct reduction in erosion, wave attack, and inundation to the structures and improved property within the study area. Also included are local costs foregone, which are an additional benefit category that is appropriate for incorporation into the assessment of economic benefits. As previously discussed, the city of Norfolk has made a good faith effort over the years to reduce the storm vulnerability of the study area. With construction of a Federal project, future local beach nourishment efforts would become unnecessary. Therefore, an estimate of the costs to perform future local efforts by the city is incorporated into the total NED benefits as local costs foregone. These costs are based on an assessment of the city of Norfolk maintaining the existing dune profile and a 12-foot design berm. A summary of the reduction in storm damages, including local costs foregone, attributable to the various with-project alternatives in each study area section is shown in the following table.

Table 16. AVERAGE ANNUAL BENEFITS (1)

Alternative	Damages/Costs	Average Annual Benefits
Without Project Condition	$4,060,000	$0
Authorized Project	$2,680,000	$2,420,000
DW 30 H10 B 50 - 5	$2,030,000	$3,090,000
DW30 H10 B100-5	$1,650,000	$3,470,000
DW30 H10 B 150-5	$1,460,000	$3,650,000
DW30 H14 B50-5	$540,000	$4,570,000
DW30 H14 B100-5	$580,000	$4,530,000
DW30H14B150-5	$620,000	$4,490,000
DW30H10B50-7	$2,230,000	$2,880,000
DW30 H10 B100-7	$1,790,000	$3,320,000
DW30 H10 B150-7	$1,580,000	$3,530,000
DW30H14B50-7	$540,000	$4,570,000
DW30H14B100-7	$570,000	$4,540,000
DW30 H14 B150-7	$620,000	$4,490,000

(1) October 2012 price levels utilizing a 4 percent discount rate. There may be some variations in the values due to rounding. Includes local costs foregone.

5.2.2 Average Annual Costs

Costs are developed for the various alternative plans based on the estimated fill volumes provided by engineering and renourishment volumes estimated by Beach-*fx*. The costs are annualized for comparison to the average annual benefits for individual project alternatives. The costs include estimates for initial construction and periodic nourishment as well as costs for monitoring and maintenance. Beach-*fx* does not include nourishments for segments that already meet the design profile. The model waits for the construction template trigger to be met for renourishment construction to begin. The costs reflect October 2012 price levels and were annualized over the 50-year period of analysis at a discount rate of 4 percent. As mentioned previously, recreation benefits are not used in the optimization procedure. A summary of the average annual costs for the various alternative plans considered for optimization for each of the study area sections is shown in the following table.

Table 17. AVERAGE ANNUAL COSTS

Alternative	Average Annual Costs (1)
Without Project Condition	$0
Authorized Project	$1,830,000
DW 30 H10 B 50 - 5	$1,670,000
DW30 H10 B100-5	$2,710,000
DW30 H10 B 150-5	$3,510,000
DW30 H14 B50-5	$2,470,000
DW30 H14 B100-5	$3,480,000
DW30H14B150-5	$4,310,000
DW30H10B50-7	$1,910,000
DW30 H10 B100-7	$2,800,000
DW30 H10 B150-7	$3,580,000
DW30H14B50-7	$2,500,000
DW30H14B100-7	$3,510,000
DW30 H14 B150-7	$4,350,000

(1) October 2012 price levels utilizing a 4.0 percent discount rate. There may be some variations in the values due to rounding.

6.0 COMPARISON OF ALTERNATIVE PLANS

This step involves the comparison of the final array of plans, including the No Action Plan, against each other, with the emphasis on the outputs and effects that will influence the decision-making process.

6.1 GENERAL

As stated earlier in this report, the ultimate purpose of the plan formulation effort under this limited reevaluation investigation was to determine: (1) if the currently Authorized Project contained in the Water Resources Development Act of 1986 was still economically justified and remains the final plan recommended for implementation (i.e., the original NED Plan) or (2) if there is another plan (i.e., a new NED Plan) that would optimize at higher net remaining benefits. The following table shows average annual net benefits, costs, and net remaining benefits, exclusive of recreation, attributable to the alternative plans considered for optimization by study area sections. The numbers indicate that, with the exception of beach fill alternative plan DW30 H10 B150-7, the alternative plans are economically feasible with benefit-to-cost ratios greater than 1.0. The Authorized Project has a benefit-to-cost ratio of 1.32 with net remaining benefits of $590,000; however, it is no longer the NED Plan. The new NED Plan is beachfill alternative DW30H14B50-5 with a benefit-to-cost ratio of 1.85 to 1 and net remaining benefits of $2,100,000.

Table 18. AVERAGE ANNUAL BENEFITS AND COSTS, BENEFIT COST RATIOS, AND NET REMAINING BENEFITS FOR THE ALTERNATIVE PLANS (1)

Alternative	Average Annual Benefits (2)	Average Annual Costs	Benefit Cost Ratios	Net Remaining Benefits
Without Project Condition	$0	$0	-	$0
Authorized Project	$2,420,000	$1,830,000	1.32	$590,000
DW 30 H10 B 50 - 5	$3,090,000	$1,670,000	1.84	$1,420,000
DW30 H10 B100-5	$3,470,000	$2,710,000	1.28	$760,000
DW30 H10 B 150-5	$3,650,000	$3,510,000	1.04	$140,000
DW30 H14 B50-5	$4,570,000	$2,470,000	1.85	$2,100,000
DW30 H14 B100-5	$4,530,000	$3,480,000	1.30	$1,050,000
DW30H14B150-5	$4,490,000	$4,310,000	1.04	$180,000
DW30H10B50-7	$2,880,000	$1,910,000	1.51	$970,000
DW30 H10 B100-7	$3,320,000	$2,800,000	1.19	$520,000
DW30 H10 B150-7	$3,530,000	$3,580,000	0.99	($50,000)
DW30H14B50-7	$4,570,000	$2,500,000	1.83	$2,070,000
DW30H14B100-7	$4,540,000	$3,510,000	1.29	$1,030,000
DW30 H14 B150-7	$4,490,000	$4,350,000	1.03	$140,000

(1) October 2012 price levels utilizing a 4 percent discount rate. There may be some variations in the values due to rounding.
(2) Equals damages prevented plus local costs foregone.

6.2 INTIAL AND RENOURISHMENT COSTS FOR THE AUTHORIZED PROJECT AND THE NEW NED PLAN

A summary of the estimated total project costs for the initial fill and renourishment associated with the Authorized Project and the new NED Plan is presented in the following table.

Table 19. TOTAL PROJECT COST ESTIMATE FOR INTITIAL FILL AND RENOURISHMENT--AUTHORIZED PROJECT AND NED PLAN (1)

FEATURE	AUTHORIZED PROJECT			NED PLAN		
Item	Quantity	Unit Cost	Total Cost	Quantity	Unit Cost	Total Cost
Initial Fill						
Mobilization	1	LS	$1,750,000	1	LS	$2,500,000
Dredging	1,218,000 CY	$10.27/CY	$12,509,000	2,702,400 CY	$9.77/CY	$26,402,000
Standby	1	LS	$100,000	1	LS	$100,000
Subtotal 1			$14,359,000			$29,002,000
Contingencies	17.6%		$2,527,000	17.8%		$5,162,000
Total Construction Cost			$16,886,000			$34,164,000
S&A (2)	5%		$754,000	5%		$1,523,000
Subtotal 2			$17,640,000			$35,687,000
PED Costs (3)	5%		$754,000	5%		$1,523,000
Total Project Cost			**$18,394,000**			**$37,210,000**
Renourishment						
Mobilization	1	LS	$800,000	1	LS	$800,000
Dredging	445,100 CY	$11.16/CY	$4,968,000	481,169 CY	$11.16/CY	$5,370,000
Standby	1	LS	$100,000	1	LS	$100,000
Subtotal 1			$5,868,000			$6,270,000
Contingencies	17.1%		$1,003,000	17.1%		$1,072,000
Total Construction Cost			$6,871,000			$7,342,000
S&A (2)	5%		$308,000	5%		$329,000
Subtotal 2			$7,179,000			$7,671,000
PED Costs (3)	5%		$308,000	5%		$329,000
Total Project Cost			**$7,487,000**			**$8,000,000**

(1) Values are rounded from those presented in Appendix A.
(2) Supervision and Administration.
(3) Preconstruction, Engineering, and Design.

6.3 INCREMENTAL ANALYSIS

The following table shows the average annual net benefits, costs, and net remaining benefits, exclusive of recreation, attributable to the Authorized Project and the NED Plan by economic reaches. As indicated, each reach is incrementally justified.

Table 20. AVERAGE ANNUAL BENEFITS AND COSTS, BENEFIT COST RATIOS, AND NET REMAINING BENEFITS FOR THE AUTHORIZED PROJECT AND THE NED PLAN BY PROJECT ECONOMIC REACH(1)

Economic Reach	Hydraulic Reaches	Cost of Initial Construction (Fill)	Average Annual Cost	Average Annual Benefit	Benefit Cost Ratio	Net Remaining Benefits
Authorized Project						
1	11-13	$4,966,000	$538,000	$600,000	1.12	$62,000
2	6-10	$7,229,000	$724,000	$1,100,000	1.52	$376,000
3	1-5	$6,199,000	$569,000	$720,000	1.27	$151,000
NED Plan						
1	11-13	$8,930,000	$620,000	$984,000	1.59	$364,000
2	6-10	$18,047,000	$1,181,000	$2,330,000	1.97	$1,149,000
3	1-5	$10,233,000	$669,000	$1,255,000	1.88	$586,000

(1) Reach 1—Willoughby Spit
(2) Reach 2—Central and West Ocean View
(3) Reach 3—East Ocean View

7.0 PLAN SELECTION

This step involves the selection of the final alternative plan for implementation. For purposes of reducing storm damages, the alternative plan selected for implementation is the plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment, designated the National Economic Development or NED plan.

In some cases, the alternative plan selected for implementation may deviate from the NED Plan if requested by the non-Federal sponsor and approved by the Assistant Secretary of the Army for Civil Works (ASA [CW]). This deviated plan is identified as the Locally Preferred Plan (LPP) and typically involves instances where a non-Federal sponsor may not be able to afford or otherwise support the NED Plan. When the LPP is clearly of less scope and cost but still meets the Administration's policies for high-priority outputs, an exception for deviation is usually granted by the ASA (CW).

7.1 NATIONAL ECONOMIC DEVELOPMENT PLAN

As presented in the previous section, the new NED Plan consists of a berm with an average width of 50 feet constructed at an elevation of 3.5 feet, North American Vertical Datum 1988 (NAVD 88), with a foreshore slope of one on 20 extending to the natural bottom. The plan would also include the enhancement of the existing dune system, where needed, to provide for a system with an elevation of at least 14 feet, NAVD 88, a crest width of 30 feet, and a foreshore slope of one on five. The plan would require periodic nourishment in order to maintain the integrity of the protective berm and dune system. Based upon final Beach-*fx* modeling, as discussed earlier in this report, the average renourishment interval for the NED Plan was determined to be 11 years with a renourishment quantity of 481,169 cubic yards. The actual nourishment requirements would be evaluated on an annual basis in conjunction with a monitoring program.

7.2 LOCALLY PREFERRED PLAN

The results of the plan selection process, specifically concerning the Authorized Project and the new NED Plan, have been discussed with the non-Federal sponsor. The non-Federal sponsor has indicated its continued support for the Authorized Project because it would provide a reasonable balance between an acceptable degree of protection for the study area and the maintenance of the existing character and aesthetics of the beach and dune environment. The Authorized Project would also allow for the maintenance and appearance of the existing dune system as a continued local responsibility which would afford the City greater flexibility in effectively addressing issues regarding dune encroachment and the existing view of the Chesapeake Bay. This project also provides for lower implementation and maintenance costs and shorter construction period. The Authorized Project is therefore designated the LPP.

The LPP (Authorized Project) consists of a berm with an average width of 60 feet constructed at an elevation of 3.5 feet, NAVD 88, with a foreshore slope of one on 20 extending to the natural bottom. The LPP would require periodic nourishment in order to maintain the integrity of the protective berm. Although the actual nourishment requirements would be evaluated on an annual basis in conjunction with a monitoring program, nourishment cycles were projected in the original feasibility report to be five, ten, and 15 years for East Ocean View, Central Ocean View, West Ocean View and Willoughby Spit, respectively. Based upon final Beach-*fx* modeling, the average renourishment interval for the LPP was determined to be nine years with a renourishment quantity of 445,100 cubic yards. The city of Norfolk would continue to maintain the existing dunes entirely at local expense.

7.3 RESIDUAL RISKS AND LOST OPPORTUNITIES

The LPP (Authorized Project) would forego some coastal storm damage benefits as compared to the benefits provided by the new NED Plan. The following table compares the average annual benefits associated with each plan and shows the benefits foregone with the LPP.

Table 21. COMPARISON OF AVERAGE ANNUAL BENEFITS (1)

Benefit Category	NED Plan	LPP (Authorized Project)	Benefits Foregone
Damages prevented	$3,520,000	$1,380,000	$2,140,000
Local costs foregone	$1,050,000	$1,040,000	$10,000
Recreation	0	0	0
Total	$4,570,000	$2,420,000	$2,150,000

(1) Rounding may cause some variations in calculations.

7.4 EVALUATION OF RISK AND UNCERTAINTY

7.4.1 Residual Risks

As implementable projects, the NED Plan and the LPP would reduce average annual storm damages and the non-Federal sponsor's costs for storm damage protection; however, some storm damages would continue to occur as shown in the following table. While the LPP would reduce estimated average annual storm damages of $1,380,000 over a 50-year period of analysis (approximately 34 percent reduction), estimated average annual storm damages of $2,680,000 would continue to occur (residual risk of 66 percent). The NED Plan would reduce estimated average annual storm damages of $3,520,000 over a 50-year period of analysis (approximately 86 percent reduction) with average annual residual damages of $540,000 (residual risk of 14 percent).

Table 22. RESIDUAL RISKS (1)

Damage Categories	No Action	LPP (Authorized Project)	NED Plan
Total Damages	$4,060,000	$4,060,000	$4.060,000
Damages Prevented	$0	$1,380,000	$3,520,000
Residual Damages	$4,060,000	$2,680,000	$540,000
Damage Reduction (%)	0%	34%	86%

(1) Average annual values, 50-year duration, 4% interest rate, and October 2012 price levels

Both projects are designed to protect mainly against storm waves and storm-induced erosion, two major categories of storm damage. They would not prevent any damage from back-bay flooding; therefore, any ground level floors of structures, ground level floor contents, vehicles, landscaping, and property stored outdoors on the ground in the Willoughby Spit-Ocean View area would still be subject to saltwater flooding that would flow in from Willoughby Bay, the end of Willoughby Spit beyond the terminal groin, and from Pretty Lake. Because both projects do not claim any benefits beyond Ocean View Avenue, damages from flooding to structures landward of Ocean View have not been calculated. However, in major storm events, the structures on Willoughby Spit-

Ocean View could be subject to back-bay (Willoughby Bay and Pretty Lake) flooding. Structures would also continue to be subject to damage from hurricane winds and windblown debris. Damages from flooding and winds would decrease as older structures are replaced with those that meet floodplain ordinances and wind hazard building construction standards. But even new construction would not be immune to damage, especially from severe storm events. Additionally, the condition of either project, whether represented by the NED Plan or the LPP, at the time of storm occurrence could affect the performance of the project for that event.

The proposed projects would reduce damages, but do not have a specific design level. In other words, the projects are not designed to fully withstand a certain category of hurricane or a certain frequency storm event. The project purpose is storm damage reduction and the berm and dune are not designed to prevent loss of life. Loss of life is prevented by existing non-structural procedures such as storm warning systems and evacuating the area, thereby removing the residents from potential harm well before the expected hurricane or nor'easter's landfall. These policies should be continued both with and without a Federal storm damage reduction project.

The costs for achieving a greater reduction in benefits are shown in the following table. These costs are the average annual cost of initial construction and periodic nourishment over the period of analysis of 50 years. An increase in benefits from the LPP to the NED Plan is a 42-percent increase in costs for an 88-percent increase in benefits.

Table 23. COST OF ACHIEVING BENEFIT REDUCTIONS (1)

Plan	Average Annual Costs
No Action	$0
LPP (Authorized Project)	$1,830,000
NED Plan	$2,470,000

(1) Average annual values, 50-year duration, 4% interest rate, and October 2012 price levels.

7.4.2 Risk and Uncertainty in Economics

The lifecycle approach of Beach-*fx*, to plan formulation explicitly, incorporates risk and uncertainty into the formulation process. Several variables in Beach-*fx* have built-in risk and uncertainty as described below:

- Structure valuation – Most likely value plus 5 percent and minus 10 percent
- Content valuation – Most likely value plus 5 percent and minus 10 percent
- Depth Damage curves – Most likely curve plus or minus one standard deviation (when available)

The following table utilizes the mean of the structure and content damages and applies the standard deviation to the without-project condition, the LPP and the NED Plan to determine the range of possible benefit outcomes. This does not include any changes in benefits due to land loss.

Table 24. THE RANGE OF POSSIBLE BENEFIT OUTCOMES FOR THE WITHOUT-PROJECT CONDITION, THE LPP, AND THE NED PLAN

	Minus One Standard Deviation	Mean	Plus One Standard Deviation
Without-Project	$2,390,000	$ 3,720,000	$5,050,000
LPP (Authorized Project)	$1,660,000	$ 2,680,000	$3,720,000
Benefits	$730,000	$ 1,040,000	$1,330,000
Without-Project	$2,390,000	$ 3,720,000	$5,050,000
NED Plan	$130,000	$ 540,000	$ 970,000
Benefits	$2,260,000	$ 3,180,000	$4,080,000

When minus one standard deviation was tested against all iteration values approximately 65 percent of all the iterations resulted in benefits for the LPP greater than $730,000 for structure and content damage. Conversely, when adding one standard deviation was tested 73 percent of all iterations resulted in benefits less than $1,330,000 for structure and content damage. Considering the NED Plan, when minus one standard deviation was tested against all iterations, 70 percent of all iterations resulted in benefits greater than $2,260,000 for structure and content damage. While adding one standard deviation, 76 percent of all iterations resulted in benefits for structure and content damage less than $4,080,000.

Given the probabilistic nature of the analysis, the alternatives were evaluated to determine the percent chance that the given alternative would have positive benefits, or conversely, the risk of having negative benefits. Based on analysis of 315 lifecycles, the LPP (60-foot berm) has a 98.7 percent chance of having positive benefits and the NED Plan has a 99.6 percent chance of having positive benefits.

7.4.3 Risk and Uncertainty in Storm Generation

The following table presents the number of storms that have impacted the city of Norfolk dating back to 1928. Over the period of record, 42 storms have impacted the city of Norfolk and this includes 12 hurricanes and 30 Nor'easters. Currently, the storm generation in Beach-*fx* has a mean of 24.5 storms over the 50-year period of analysis over 315 iterations. Looking at the period of record over the last 50 years and moving back in 10-year increments, the number of storms that has occurred historically is consistent with the storm generation of the model.

Table 25. STORMS IMPACTING NORFOLK VA SINCE 1928

Time Period	Number of Storms
2010-1960	27
2000-1950	24
1990-1940	20
1980-1930	22
Total Over Period of Record	42

As the model incorporates a probabilistic approach to storm generation, each iteration would be expected to generate a varying number of storms. The range of storms generated was from 13 at the lowest end to 40 storms at the highest end. Plate 30 shows the graph illustrating the range of storm generation in Beach-*fx*.

These results demonstrate that the probabilistic nature of the simulation is presenting a reasonable demonstration of what has occurred in the study area and is bracketing it appropriately to account for the uncertain nature of storm probabilities.

7.4.4 Risk and Uncertainty in Sea Level Change

Climate research has documented global warming during the 20th Century and has predicted continued or accelerated global warming ultimately resulting in continued or accelerated rise in sea level. USACE Engineering Circular, EC 1165-2-212 provides the guidance for considerations of accelerated sea level rise for Federal civil works projects. The guidance uses the updated National Research Council (NRC) projections (updated from 1987) as well as the Intergovernmental Panel on Climate Change (IPCC 2007b) Fourth Assessment Report guidelines. USACE water resources management projects are planned, designed, constructed, and operated locally or regionally. For this reason, it is important to distinguish between global mean sea level (GMSL) and local (or “relative”) mean sea level (MSL). At any location, changes in local MSL reflect the integrated effects of GMSL change plus changes of regional geologic, oceanographic, or atmospheric origin.

Potential relative sea level change (SLC) must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Fluvial studies (such as flood studies) that include backwater profiling should also include potential relative SLC in the starting water surface elevation for such profiles, where appropriate. The base level of potential relative SLC is considered the historically recorded changes for the study site. Areas already experiencing relative SLC or where changes are predicted should analyze this as part of the study.

Alternatives are evaluated using the low curve, or the historical rate of sea level change. The NED Plan and the LPP (Authorized Project) are also then evaluated using the intermediate and high rates of future SLC for both with-project and without-project conditions. The intermediate rate is calculated by adding any subsidence present in the local area to the modified NRC Curve I. The high rate is calculated by adding any subsidence present in the local area to the modified NRC Curve III.

Historical trends in local MSL are determined using measurement data from tide gauge records. Tidal records from nearby National Ocean Service (NOS) tidal station at Sewells Point in Norfolk, VA show a historical trend of 0.0145 feet per year from 1926 to 2009, which is the low scenario as shown on Plate 31. This planning study uses this historical sea level rise (SLR) rate to formulate the project.

The modified NRC SLC projections include three scenarios resulting in three curves of SLR thru 2100. The curves represent the low, moderate, and high global eustatic SLR values of 0.5 meters, 1.0 meters, and 1.5 meters, respectively, over the next 125 years. In order to investigate the sensitivity of the NED Plan and the LPP to SLR, Curves 1 and 3 are used to bracket estimates in SLR. Curve 1 projection indicates a SLC of 1.14 feet 50 years after construction (year 2065), while Curve 3 indicates 2.52 feet of

SLC in 2065. For comparison, the historic SLC rate projects about 0.73 feet of SLR in 2064 as shown on Plate 32.

A sensitivity analysis of SLC effects upon the LPP and the NED Plan was conducted to estimate the with-project and without-project damages, benefits, and costs under each scenario. With accelerated SLC scenarios, the without-project damages could increase about 3.9 percent from the historical SLC scenario to the intermediate SLC scenario. Under the high SLC scenario, there could be an increase of about 13.2 percent in without-project condition damages. Residual damages for the LPP could increase about 2.7 percent from the historical SLC to the intermediate SLC scenario. Under the high SLC scenario, there could be an increase of approximately 9.7 percent in residual damages.

For the NED Plan, the residual damages could increase approximately 8.2 percent from the historical SLC scenario to the intermediate SLC scenario. Under the high scenario, residual damages could increase approximately 37.5 percent. While this percentage seems high when compared to the LPP, total damages for the NED Plan under the high scenario could be expected to be around $750,000 compared to $550,000 under the historical scenario, which is still less than the LPP. Total project costs for the LPP could increase 27.5 percent due to additional erosion (using the most extreme estimate of 2.51 feet of SLC in 50 years) but the project provides an additional 41 percent of damage reduction benefits. The NED Plan could cost an additional 32 percent under the same scenario, but would provide 23 percent more damage reduction.

The proposed beach nourishment project is not a hard structure and adjusts to natural forces. Regardless of the rate of SLC, the beachfill project will be monitored annually and need to be renourished every nine years. Monitoring data provides input used to determine the details of each renourishment of the beach. If accelerated SLC occurs, erosion volumes would increase and thus cause renourishment volumes to also increase. Under the intermediate and high scenarios, approximately 0.3 million and two million additional cubic yards of material would be needed, respectively, for the LPP.

The NED Plan would need an additional one million cubic yards and 3.2 million cubic yards for the intermediate and high scenarios, respectively. If more material is needed to compensate for accelerated SLC, the life of designated borrow areas will be shortened. A Limited Reevaluation Report (LRR) on borrow sources could be conducted to investigate additional borrow sources if necessary.

All alternative plans contain a 3.5-foot, NAVD 88, elevation berm and all would be affected similarly by accelerated SLC. Therefore, accelerated SLC is not expected to have an impact on the selection of the plan to be recommended for implementation, with the exception of a minor modification of the berm elevation and possibly the dune elevation. There is no expectation that accelerated SLC would result in the selection of other major categories of alternative plans such as non-structural or hard-structure plans.

7.4.5 Sensitivity Analysis of Dune Heights

A sensitivity analysis of dune heights was conducted to bracket the NED Plan. This sensitivity analysis consisted of modeling a 16-foot dune and a 12-foot dune to make sure that the NED was properly bracketed and that the NED plan optimized at a 14-foot dune height. The two alternatives were modeled using the same parameters that were utilized in the modeling of the other alternatives. The following table shows the benefits for each alternative in the sensitivity analysis

Table 26. DUNE HEIGHT SENSITIVITY ANALYSIS—AVERAGE ANNUAL BENEFITS FOR THE 16-FOOT AND 12-FOOT DUNE ALTERNATIVES (1)

Alternative	Damages/Costs	Average Annual Storm Damage Benefits	Local Costs Foregone	Average Annual Benefits
Without-Project Condition	$4,060,000	$0	$0	$0
DW 30 H12 B50-5	$990,000	$3,070, 000	$1,050.000	$4,120,000
DW 30 H16 B50-5	$550,000	$3,510,000	$1,050,000	$4,560,000

(1) There may be some variations in the values due to rounding.

The following table shows the results of the sensitivity analysis and that the 14-foot dune height remains the NED Plan with the most net remaining benefits of all plans.

Table 27. DUNE HEIGHT SENSITIVITY ANALYSIS—AVERAGE ANNUAL BENEFITS AND COSTS, BENEFIT COST RATIOS, AND NET REMAINING BENEFITS FOR THE 16-FOOT AND 12-FOOT DUNE ALTERNATIVES (1)

Alternative	Average Annual Benefits	Average Annual Costs	Benefit Cost Ratios	Net Remaining Benefits
DW 30 H12 B50-5	$4,120,000	$2,180,000	1.89	$1,940,000
NED Plan	$4,570,000	$2,470,000	1.85	$2,100,000
DW 30 H16 B50-5	$4,560,000	$3,010,000	1.51	$1,550,000

(1) October 2012 price levels utilizing a 4 percent discount rate. There may be some variations in the values due to rounding.

7.5 SYSTEM OF ACCOUNTS

The significant impacts of the LPP and the NED Plan are compared with those of the No Action Plan in the following table. The plans are compared on the basis of a system of accounts which includes national economic development, environmental quality, regional development, and social and cultural resources.

Table 28. SYSTEM OF ACCOUNTS

Item	Locally Preferred Plan	NED Plan	No Action
Plan Description	60-foot wide beach berm at elevation 3.5 feet, NAVD 88, with a slope of 1 on 20. Renourishment is scheduled when the berm recedes to 30 feet in width. The current dune system will be maintained by the non-Federal sponsor.	50-foot wide beach berm at elevation 3.5 feet, NAVD 88, with a slope of 1 on 20. Enhanced dune system with a crest width of 30 feet at an elevation of 14 feet, NAVD 88, and a foreshore slope of 1 on 5. Renourishment is scheduled when the berm recedes to 25 feet in width.	No Federal action, nor significant changes to existing non-Federal actions.
Damages Prevented (1)	$1,380,000	$3,510,000	$0
Local Costs Foregone (1)	$1,040,000	$1,050,000	$0
Total Benefits (1)	$2,420,000	$4,570,000	$0
Costs (1)	$1,670,000	$2,470,000	$1,040,000
Residual Damages (1)	$2,680,000	$540,000	$4,060,000
Income	Reduced damages to businesses and reduction in the short term decrease in population due to damaged structures could increase income.	Reduced damages to businesses and reduction in the short term decrease in population due to damaged structures could increase income, more so than in TSP. Possible long term effects to business income and property values from viewshed reduction.	Potential for the loss of income when businesses and residences are damaged or permanently destroyed. Viewshed issues are irrelevant if residences and businesses no longer exist.
Employment	Project construction employment increases during winter dredging months.	Project construction employment increases during winter dredging months, more so than in TSP.	Occasional changes due to reconstruction or cleanup, potential for lost employment if businesses are damaged.

(1) Average annual values.

Table 28. SYSTEM OF ACCOUNTS (Cont'd)

Item	Locally Preferred Plan	NED Plan	No Action
Tax Changes	Project construction employment increases during winter dredging months. Possible positive affect to real estate values could result in increased tax revenue.	Project construction employment increases during winter dredging months. Possible positive affect to real estate values could result in increased tax revenue; however reduced views could somewhat negate this.	Destruction of buildings and inability to rebuild results in complete loss of real estate tax revenue.
Security of Life, Health and Safety	Significant reduction in stress related to concern of amount of damage and recovery. Reduction in hazards associated with post-storm recovery and reconstruction.	Significant reduction in stress related to concern of amount of damage and recovery. Reduction in hazards associated with post-storm recovery and reconstruction.	No change. Continued stress during damaging storms.
Preservation of Life	No change. Evacuations may still be required before storm landfall.	No change. Evacuations may still be required before storm landfall.	No change. Evacuations may still be required before storm landfall.
Community Cohesion	Reduces displacements of permanent residents.	Reduces displacements of permanent residents, more than in TSP.	Occasional displacement of permanent residents.
Community Growth	Growth trends in population will continue.	Growth trends in population will continue.	Occasional reductions in population trends.
Man Made Resources	Reduces risks to buildings, houses, and other structures.	Reduces risks to buildings, houses, and other structures.	Continued erosion risks to buildings, houses, and other structures. Occasional replacement of heavily damaged structures.

Table 28. SYSTEM OF ACCOUNTS (Cont'd)

Item	Locally Preferred Plan	NED Plan	No Action
Public Facilities	Reduces erosion and wave damages to streets and utilities nearest the shoreline.	Reduces erosion and wave damages to streets and utilities nearest the shoreline.	Continued threat to streets and utilities near shoreline.
Displacement of Business	Reduces displacement of business.	Reduces displacement of business.	Continued occasional disruption.
Recreation and Public Access	Improved appearance and utility of beach for recreation and requirement to maintain access for public. Infrequent storm litter.	Improved appearance and utility of beach for recreation and requirement to maintain access for public. Infrequent storm litter.	Continued narrow beach width. Occasional littering of beach with storm debris.
Traffic and Transportation	Prevents over-wash of sand on to streets and long term erosion damage to streets.	Prevents over-wash of sand on to streets and long term erosion damage to streets.	Continued risk to streets and highways.
Risk of Failure(Risk that project will not provided stated benefits)	Low. If renourishments occur on schedule, a beachfill plan should continue to provide reduction in damages. The Tentatively Selected Plan has a 98.7% chance of having positive benefits.	Very low. If renourishments occur on schedule, a beachfill plan should continue to provide reduction in damages. The NED Plan has a 99.6% chance of having positive benefits.	N/A
Residual Risk (Risk to structures and population once plan is implemented)	Damages to structures will still occur from back-bay flooding. In storms of greater intensity, some wave and erosion damage will still occur. Structures are not protected from wind or windblown debris. There is still risk to loss of life if evacuation procedures are not followed.	Damages to structures will still occur from back-bay flooding. In storms of greater intensity, some wave and erosion damage will still occur. Structures are not protected from wind or windblown debris. There is still risk to loss of life if evacuation procedures are not followed.	Damages to structures will not be reduced. There is still risk to loss of life if hurricane evacuation procedures are not followed.

Table 28. SYSTEM OF ACCOUNTS (Cont'd)

Item	Locally Preferred Plan	NED Plan	No Action
Risk from Accelerated Sea Level Rise	Damages to structures will increase under the intermediate and high SLC scenarios. The increase is approximately 2.7% and 9.7%, respectively. The project remains justified.	Damages to structures will increase under the intermediate and high SLC scenarios. The increase is approximately 8.2% and 37.5%, respectively. The project remains justified.	The residual damages for the intermediate SLC scenario and high SLC scenario increase 3.9% and 13.2%, respectively.
Ecosystem Restoration	No ecosystem restoration is associated with this project.	No ecosystem restoration is associated with this project.	No ecosystem restoration is associated with the NAA.
Natural Resources	The beach profile will be altered temporarily due to the placement of sand. The slope of the beach will be steeper, but a normal beach profile will quickly be reestablished as waves work the sand. There will also be increased longshore sediment transport away from the filled beaches. 1.2 million cubic yards of sand will be removed from the borrow site, resulting in the deepening of the dredged area between 6 to 10 feet.	The beach profile will be altered temporarily due to the placement of sand. The slope of the beach will be steeper, but a normal beach profile will quickly be reestablished as waves work the sand. There will also be increased longshore sediment transport away from the filled beaches. The NED plan would also result in the construction of a dune system with a crest width of 30 feet at an elevation of 14 feet, NAVD 88. 2.7 million cubic yards of sand will be removed from the borrow site, resulting in the deepening of the dredged area between 6 to 10 feet.	Without re-nourishment, the project area will continue to experience erosion and movement of the shoreline inland. Without the TSP, the sponsor will continue to maintain the shoreline as funding allows and storm events require.

Table 28. SYSTEM OF ACCOUNTS (Cont'd)

Item	Locally Preferred Plan	NED Plan	No Action
Biological Resources	Predicted impacts to the biological resources at the placement site include the loss of some benthic organisms, both terrestrial and aquatic, which may be smothered under material placed on the beach. The benthic community within the project area would be temporarily lost. In addition, temporary increases in turbidity may negatively impact aquatic organisms at the placement site. Placement activities may scare motile organisms away from the project site. All impacts to the placement site are expected to be minor and temporary. Impacts to the borrow site are expected to include temporary increase in turbidity, decreased dissolved oxygen, and decreased water quality associated with dredging activities. These changes to water quality may impact primary production and benthic communities. Dredging will also result in the loss of bottom habitat and the associated benthic community. Recolonization of the area may require a year or more.	The impacts caused by the NED plan are expected to be the same as those of the TSP. The NED will also create dune habit. Initially, the community located where the dune will be constructed will be smothered by the placement of sand. However, dune plants and animals will colonize the new feature.	No expected impacts to the biological resources of the borrow sites. The community associated with the beach will adjust as the beach moves inland. If the areas of the beach are eventually lost, for example if the beach erodes to a permanent, hardened structure, then the beach community will also be lost.

Table 28. SYSTEM OF ACCOUNTS (Cont'd)

Item	Locally Preferred Plan	NED Plan	No Action
Threatened and Endangered Species	No predicted impacts to threatened and endangered species.	No predicted impacts to threatened and endangered species.	No expected impacts to threatened and endangered species.
Water Quality	Temporary and insignificant impacts to water quality are predicted to result from the proposed project. These include increased turbidity at both the placement and borrow site, but will return to normal once dredging and placement as been completed. There may be temporary decreases in dissolved oxygen and water clarity at the borrow site associated with the dredge plume. Sediment disturbed by dredging operations may release contaminants into the water column.	Similar water quality impacts to those predicted for the TSP will be caused by the NED plan. These impacts may be increase due to the duration of construction due to the larger amount of sand required for the NED plan.	No expected impacts to water quality.
Air Quality	The project site falls within a maintenance area for ozone. However, dredging and nourishment activities will produce less than 100 tons/year for NOX and VOC, which are the allowable limits for a maintenance area. A conformity determination is not required.	The project site falls within a maintenance area for ozone. The dredging and nourishment activities of the NED plan will produce more than 100 tons/year for NOX, which are the allowable limits for a maintenance area. A conformity determination would be required for this plan.	No expected impacts to air quality.

Table 28. SYSTEM OF ACCOUNTS (Cont'd)

Item	Locally Preferred Plan	NED Plan	No Action
Noise Level Changes	Nourishment operations are expected to occur 24 hours per day, 7 days a week over a 130-day window. The operation of bulldozers on the beach will result in impacts to ambient noise levels. Noise pollution and construction activities will be monitored to ensure minimum disturbance to the surrounding community.	Nourishment operations are expected to occur 24 hours per day, 7 days a week over a 130-day window. The operation of bulldozers on the beach will result in impacts to ambient noise levels. Noise pollution and construction activities will be monitored to ensure minimum disturbance to the surrounding community.	No expected impacts to ambient noise levels.
Aesthetic Values	Enhancement of beach vistas with the widening of the beach.	Enhancement of beach vistas with the widening of the beach. Elevated dune system may block view of water for some residents.	Narrowed beach with residences and businesses closer to water's edge, some may become uninhabitable, damaged, abandoned, or demolished.
Cultural and Historical Preservation	No adverse effects to viewsheds of potentially National Register of Historic Places eligible buildings; no effects on submerged (Thimble Shoal Auxiliary Channel borrow areas) or terrestrial archaeological resources.	Possible adverse effects to viewsheds of potentially National Register of Historic Places eligible buildings; no effects on submerged (Thimble Shoal Auxiliary Channel borrow areas) or terrestrial archaeological resources.	Damages and possible destruction of potentially National Register of Historic Places eligible buildings; no effects on submerged or terrestrial archaeological resources.
Total Quality of the Environment	The project will result in no long term, negative environmental impacts. The project will increase protection of property and recreation usage of the area.	The project will result in no long term, negative environmental impacts. The project will increase protection of property and recreation usage of the area.	Without re-nourishment, the project area will continue to experience erosion and movement of the shoreline inland. However, the City of Norfolk has an interest in maintaining the shoreline and it is probable that the sponsor will attempt to maintain the existing shoreline if funding is available.

7.6 ECONOMICS OF THE LOCALLY PREFERRED PLAN AND THE NED PLAN

The plan formulation process presented in this report, which includes the development and evaluation of alternative plans, has been based on average annual benefits and costs calculated using a Federal interest rate of 4.00 percent. This interest rate has been replaced by the current interest rate of 3.75 percent. As a reevaluation of the project economics indicates that this change in the interest rate does not change the results of the plan formulation process,the decision was made to update only the average annual benefits and average annual costs for the NED Plan and the Locally Preferred Plan to the current interest rate of 3.75 percent. The following table presents the economics for the Locally Preferred Plan and the NED Plan at the previous interest rate of 4.00 percent and the current rate of 3.75 percent.

Table 29. ECONOMICS OF THE LOCALLY PREFERRED PLAN AND NED PLAN

	LOCALLY PREFERRED PLAN		NED PLAN	
Item	Amount (4.0% Interest Rate) (1)	Amount (3.75% Interest Rate) (2)	Amount (4.0% Interest Rate) (1)	Amount (3.75% Interest Rate) (2)
Average annual benefits	$2,420,000	$2,383,000	$4,570,000	$4,513,000
Average annual costs	$1,830,000	$1,799,000	$2,470,000	$2,393,000
Net benefits	$590,000	$584,000	$2,100,000	$2,120,000
Benefit-to-cost ratio	1.32	1.32	1.85	1.89

(1) Previous Federal interest rate.
(2) Current Federal interest rate.

7.7 SELECTION OF THE TENTATIVELY SELECTED PLAN

It is believed that implementation of the LPP is warranted for the following reasons and is, therefore, designated as the "Tentatively Selected Plan":

- Although clearly of less scope than the NED Plan, the LPP would provide a reasonable and an acceptable degree of protection for the study area if implemented, with average annual benefits estimated at $2,420,000 or 53 percent of the NED Plan benefits;

- Average annual costs of the LPP are substantially less than the average annual costs for the NED Plan;

- It is supported by the non-Federal sponsor because it would provide a reasonable and an acceptable degree of protection for the study area while maintaining the character and aesthetics of the beach and dune environment which are of great importance to the local residents and the City of Norfolk. By designating the maintenance and natural appearance of the existing dune system as continued local responsibilities, the LPP provides the City the flexibility to most effectively address issues regarding dune encroachment and the preservation of the existing view of the Chesapeake Bay from local residences. The LPP would also be less costly to construct and maintain and requires a shorter duration for initial construction.

8.0 THE TENTATIVELY SELECTED PLAN

The preceding section presented in detail the process of selecting a plan for implementation, which is now designated as the "Tentatively Selected Plan," that meets the planning objectives and makes beneficial contributions to the Nation. This section presents a broad description of this plan to include design and construction considerations, HTRW and real estate considerations, plan accomplishments, and economics.

8.1 DESIGN AND CONSTRUCTION CONSIDERATIONS

The Tentatively Selected Plan consists of the initial construction of a beach berm and periodic beach nourishment to provide for an effective coastal storm damage reduction project. The protective berm would have an average width of 60 feet constructed at an elevation of 3.5 feet, NAVD 88, with a foreshore slope of one on 20 extending to the natural bottom. Monitoring and periodic nourishment would ensure that the integrity of the protective berm is maintained. The non-Federal sponsor, the city of Norfolk, would continue to maintain the existing dune system at their expense for the life of the project.

The plan would require the initial placement of approximately 1,200,000 cubic yards of sandy fill along the 7.3 mile shoreline extending from the jetties at Little Creek Inlet west to the terminal groin at the end of Willoughby Spit. Topographic and hydraulic surveys would be performed along the existing beach profiles during the design phase in sufficient detail to develop contract plans and specifications. Specific usable locations within the borrow site would be determined and a layout of the dredging areas would be designed within these locations. The quality and quantity of fill material is a consideration, as well as the avoidance of ordnance and the minimization of impacts on archaeological resources. During project construction, acceptance section surveys would be performed before and after the placement of sandy material on the beach to monitor the contractor's efforts in achieving the beachfill contract requirements.

Material would likely be removed from the Thimble Shoal Auxiliary Channel by cutterhead suction dredge or by trailing suction hopper dredge. The hydraulic dredge would pump the material ashore for dispersal as slurry, through a pipeline deployed on the seabed. The hopper dredge is equipped with drag heads and a hopper which collects the sand. When the hopper is full, material is transported to a pump-out buoy located offshore. The material would then be pumped through a discharge pipeline, which runs along the ocean floor, and up onto the beach where bulldozers and graders would distribute the material along the shoreline.

The beachfill is designed to be sacrificial as the sandy material would erode during storm events. Also, the material would be susceptible to longshore and cross-shore sediment transport on a daily basis. Periodic beach renourishment would be required to maintain the effectiveness of the storm damage reduction and would require that approximately 445,100 cubic yards of sand be placed on the project beach on an average of once every nine years. The actual nourishment requirements would be evaluated on an annual basis. Between each of the beach nourishment cycles, monitoring of the beach and borrow areas would be required. This monitoring would consist of topographic and hydrographic surveys and sampling, as required. Periodic maintenance quantities would vary from one nourishment cycle to the next. Because there is a break point where truck hauling becomes more cost effective than hydraulic dredging, an evaluation of the least cost method of nourishment would be required prior to each maintenance cycle. For instance, upland sources could provide approximately 20,000 cubic yards for less than the cost of mobilizing a large hydraulic pipeline dredge at the Thimble Shoal Auxiliary Channel for the same quantity.

8.2 MONITORING AND ADAPTIVE MANAGEMENT PLAN

A comprehensive monitoring program in accordance with USACE guidance (CEM Part V, Chapter 4 and CHETN II-35) is planned for the Willoughby Spit and Vicinity Project to assess and ensure project functionality throughout its design lifetime. This monitoring supports the design efforts for periodic nourishment and would be cost shared on the same basis as periodic nourishment which WRDA 1986, as amended, establishes as 50 percent Federal and 50 percent non-Federal. The annual monitoring plan, which has an estimated annual cost of $250,000, will consist of semi-annual beach profile surveys, aerial photographs, existing wave gage data retrieval, and an annual monitoring report. Beach profile surveys will allow the assessment of anticipated beachfill performance and determination of renourishment volume and timing requirements. An aerial photographic record of the beach will further facilitate the assessment of the beachfill performance. An annual monitoring report will be prepared that presents the data collected and the corresponding analysis of project performance, including recommendations on renourishment requirements.

8.3 HTRW CONSIDERATIONS

Overall, the potential borrow sites and beach nourishment activities would not be expected to result in the identification and/or disturbance of HTRW. However, the potential for ordnance to be present in the borrow areas does exist. Therefore, it is recommended that the USACE Environmental and Munitions Design Center (EMDC), currently located in Baltimore District, be consulted during the design phase of the project. Specifically, the EMDC should be consulted in order to evaluate the need for screens to be utilized during dredging. The EMDC should also be consulted for guidance on the size, configuration and O&M procedures of the dredge screens if they are required.

8.4 REAL ESTATE CONSIDERATIONS

Real estate rights would be required from the city of Norfolk to access the construction site. The use of several city owned, public vehicle access points would be required to provide the contractor adequate access from public roads to the beach. The access points would provide contractor's equipment, surveyors, etc., adequate right-of-way to transition from the public roads to the beach, and a staging area would be required. The Real Estate Plan (Appendix D) includes an assessment of the non-Federal sponsor's acquisition capabilities, the baseline real estate cost estimate, and real estate mapping. As discussed previously, the shoreline is owned by the city of Norfolk, Virginia.

8.4.1 Public Use

The existing area is currently not a tourist destination nor is it anticipated to be one following project construction. The primary project purpose is coastal storm damage reduction; recreational benefits are not being claimed for the project. Changes in the visitation volume from the existing condition as a result of the project are anticipated to be minimal. Based on the user survey conducted during this study, the heaviest beach use would continue to occur in the central portion. The remaining areas would continue to experience very light usage.

8.4.2 Public Parking and Access

The city of Norfolk now provides parking sufficient for the expected visitation and within a reasonable walking distance of the beach. Public pedestrian access to the beach is provided approximately every one-half mile or less. The city also provides and maintains the parking areas and access ways. The easements required to provide public use, parking, and access, are in addition to those easements required to construct, operate, and maintain the project. These easements are not considered a project cost.

8.5 PLAN ACCOMPLISHMENTS

The Tentatively Selected Plan would make a major contribution in addressing the problems and needs and realizing the opportunities of the study area previously identified. The plan would provide a significant reduction in coastal storm damages for 7.3 miles of coastline extending from Little Creek Inlet north and west to the terminal groin on Willoughby Spit. Substantial reduction in erosion, wave attack, and inundation damages would be realized to residential, commercial, and public structures. Average annual damages and losses due to storms with the plan would be reduced. The plan would also result in reduced damages to improved property and infrastructure and emergency/cleanup operations. Also, the plan would permit a significant reduction in local expenditures currently expended by the city of Norfolk in an attempt to reduce storm, flood, and erosion losses in the study area.

8.6 WHAT THE TSP WOULD NOT ACCOMPLISH

The Tentatively Selected Plan is designed to protect the study area mainly against storm waves and storm-induced erosion, two major categories of storm damage. In major coastal storm events, its implementation would not reduce the threat to human life and safety nor would it prevent damages from back-bay flooding. Any ground level floors of structures, ground level floor contents, vehicles, landscaping, and property stored outdoors on the ground in the Willoughby Spit-Ocean View area would still be subject to saltwater flooding that would flow in from Willoughby Bay, the end of Willoughby Spit beyond the terminal groin, and from Pretty Lake. Structures would also continue to be subject to damage from hurricane winds and windblown debris. Damages from flooding and winds would decrease as older structures are replaced with those that meet floodplain ordinances and wind hazard building construction standards. However, even new construction would not be immune to damage, especially from severe storm events.

The above information regarding the Tentatively Selected Plan, as it relates to the tidal flooding damages and the threat to human life and safety associated with coastal storms, has been discussed with city officials. They clearly understand that the Tentatively Selected Plan is primarily a wave damage and beach erosion control project and will continue to depend on the city's storm warning and evacuation program to address the threat to human life and safety.

8.7 ECONOMICS OF THE TENTATIVELY SELECTED PLAN

8.7.1 Benefits

The Tentatively Selected Plan would provide total quantifiable average annual benefits to the Chesapeake Bay shoreline in the city of Norfolk of $2,420,000 and $2,383,000, respectively, based on the previous interest rate of 4.0 percent and the current interest rate of 3.75 percent as shown in the following table.

Table 30. SUMMARY OF AVERAGE ANNUAL BENEFITS FOR THE TENTATIVELY SELECTED PLAN (1)

Benefit Category	Amount (4.0% Interest Rate)	Amount (3.75% Interest Rate)
Damages	$1,372,000	$1,345,000
Local costs foregone	$1,044,000	$1,038,000
Total	$2,420,000	$2,383,000

(1) Rounding may cause some variations in calculations.

8.7.2 Initial Construction (Fill) and Investment Costs

The following table presents a summary of the estimated initial construction (fill) and investment costs for the Tentatively Selected Plan, including applicable interest during construction costs. Approximately 1,200,000 cubic yards of sand would be placed on the project beach. Details relative to costs are shown in Appendix A. The cost of interest during construction was computed based on a total estimated 33 month installation period for the PED phase (17 months with expenditures would be spread evenly over this period) and the construction phase (16 months with actual project construction would occur over the last five months and the expenditures would be distributed accordingly). The total interest during construction is estimated to be $1,385,000.

Table 31. ESTIMATED INITIAL CONSTRUCTION (FILL) AND INVESTMENT COSTS FOR THE TENTATIVELY SELECTED PLAN(1)

Item			Total Cost
Initial Construction (Fill)			
Mobilization			$1,750,000
Dredging	1,218,000 CY	@ $10.27/CY	$12,509,000
Standby			$100,000
Subtotal 1			$14,359,000
Contingencies	(17.6%)		$2,527,000
Total Construction Cost			$16,886,000
S&A (2)	(5%)		$754,000
Subtotal 2			$17,640,000
PED Costs (3)	(5%)		$754,000
Total Initial Construction (Fill) Costs			$18,394,000
Investment Costs			
Interest During Construction			$1,385,000
Total Investment Costs			$19,779,000

(1) Numbers are rounded from those presented in Appendix A.
(2) Supervision and Administration.
(3) Preconstruction, Engineering, and Design.

8.7.3 Renourishment Costs

The following table presents a summary of the estimated renourishment costs for the Tentatively Selected Plan. The costs are based on the placement of an estimated volume of 445,100 cubic yards of sand for each renourishment cycle, resulting in costs of approximately $7.5 million (rounded) for each renourishment cycle. Costs reflect October 2012 price levels.

Table 32. ESTIMATED RENOURISHMENT COSTS
FOR THE TENTATIVELY SELECTED PLAN (1)

Item			Total Cost
Renourishment			
Mobilization			$800,000
Dredging	445,100 CY	@ $11.16/CY	$4,968,000
Standby			$100,000
Subtotal 1			$5,868,000
Contingencies	(17.1%)		$1,003,000
Total Construction Cost			$6,871,000
S&A (2)	(5%)		$308,000
Subtotal 2			$7,179,000
PED Costs (3)	(5%)		$308,000
Total Renourishment Costs			$7,487,000

(1) Numbers are rounded from those presented in Appendix A.

8.7.4 Average Annual Costs

The following table presents a summary of the estimated average annual costs of the Tentatively Selected Plan. Interest and amortization are based on the previous interest rate of 4.0 percent and the current interest rate of 3.75percent, a 50-year period of analysis, and October 2012 price levels. Cost estimates were compiled over a period of several months and were made consistent at October 2012 price levels to allow proper analysis at a common period of time. Annualized periodic nourishment costs are expected to occur on a 9-year cycle. Engineering During Construction (EDC) costs include appropriate periodic surveys and sampling of the beach and borrow areas, and are estimated at $250,000 on an average annual equivalent basis. There are no operation, maintenance, repair, rehabilitation, or replacement (OMRR&R) costs associated with the project.

Table 33. AVERAGE ANNUAL COSTS FOR
THE TENTATIVELY SELECTED PLAN (1)

Item	Total Cost (4.0% Interest Rate)	Total Cost (3.75% Interest Rate)
Average Annual Costs		
Interest and Amortization for Initial Construction (Fill)	$921,000	$892,000
EDC (2) Costs	$250,000	$250,000
Average Annual Equivalent Renourishment Costs	$659,000	$657,000
Total Average Annual Costs	$1,830,000	$1,799,000

(1) Numbers are rounded from those presented in Appendix A.
(2) Engineering during Construction (Renourishment is continuing construction).

8.7.4 Justification

The following table presents a comparison of the estimated average annual benefits and the annualized costs based on the previous interest rate of 4.0 percent and the current interest rate of 3.75 percent. As indicated, the Tentatively Selected Plan is economically justified with a benefit-to-cost ratio of 1.32 and net annual benefits of $590,000 at the previous interest rate of 4.0 percent and 1.32 and $584,000 at the current interest rate of 3.75 percent.

Table 34. ECONOMICS OF THE TENTATIVELY SELECTED PLAN

Item	Amount (4.0% Interest Rate)	Amount (3.75% Interest Rate)
Average annual benefits	$2,420,000	$2,383,000
Average annual costs	$1,830,000	$1,799,000
Net benefits	$590,000	$584,000
Benefit-to-cost ratio	1.32	1.32

8.7.5 Section 902 Limit (Project Cost Cap)

Section 902 of the Water Resources Development Act of 1986 defines the maximum amount that a project may cost without having to seek additional Congressional authorization through a post-authorization change process. The Section 902 Limit, often referred to as the 902 Limit or Project Cost Cap, is a numerical value specified by law which must be computed in a manner consistent with the guidance contained in Appendix G of Engineering Regulation 1105-2-100, dated April 22, 2000, as amended. The maximum project cost equals the sum of three components: (1) the authorized cost adjusted for inflation; (2) the current cost of any studies, modifications, and action authorized by WRDA 1986 or any later law; and (3) a value equal to 20 percent of the authorized cost without adjustment for inflation. Because periodic nourishments are considered continuing construction on coastal storm damage reduction projects, two 902 limits are computed for these projects, one for initial construction and one for periodic nourishments over the 50-year project life.

The following table shows the comparison of the calculated Section 902 cost limit and current estimated costs for the Tentatively Selected Plan for initial construction and for continuing construction. As indicated in the table, the cost limit is exceeded for both initial construction and continuing construction. This would require that a new cost limit be established for the Tentatively Selected Plan.

Table 35. COMPARISON OF SECTION 902 COST LIMIT AND CURRENT ESTIMATED COSTS FOR THE TENTATIVELY SELECTED PLAN

Item	Authorized Project Costs (1)	Calculated 902 Cost Limit (2)	Current Estimated Costs (3)
Initial Construction Costs	$3,161,000	$8,018,273	$18,394,000
Continuing Construction Costs (4)	$2,529,000	$19,404,130	$38,110,000

(1) In 1983 price levels.
(2) In October 2012 price levels and based on guidance contained in Appendix G of Engineering Regulation 1105-2-100, dated 22 April 2000.
(3) In October 2012 price levels.
(4) Based on periodic nourishment over a 50-year project life.

8.8 ADDITIONAL CONGRESSIONAL AUTHORIZATION

As indicated in Section 8.7.5 Section 902 Limit (Project Cost Cap), the current estimated costs of the Tentatively Selected Plan exceed the Section 902 cost limit computed for the project based on the guidance contained in Appendix G of Engineering Regulation 1105-2-100. Appendix G indicates a number of cases which will "always require authorization by Congress" and this includes a case for projects authorized by WRDA 1986 and subsequent authorizations where there is an increase in the total project costs, exclusive of price level changes, of more than 20 percent of the project costs stated in the authorizing legislation. As the Tentatively Selected Plan was authorized in WRDA 1986 and the costs have increased over 20 percent, the Tentatively Selected Plan will require additional Congressional authorization through a post-authorization change process.

8.9 SUMMARY OF ENVIRONMENTAL AND OTHER SOCIAL EFFECTS

8.9.1 Physical Setting

8.9.1.1 Geology and Soils**.** The TSP would remove approximately 1.2 million cubic yards of sand from Thimble Shoal Auxiliary Channel, while the NED plan would require 2.7 million cubic yards of sand. Removal of this material will not change the geology or sediment quality in the Lower Chesapeake Bay.

The nourishment project may impact the placement site in a number of ways, including alteration of sediment quality, increasing turbidity, and increasing the hardness of the beach. To ensure the project will not alter current sediment characteristics found within the placement site, only sand of similar grain size and composition will be placed in the project area. Dredging will avoid areas of fine sediment present at the borrow site to ensure that the beachfill consists principally of beach quality sand. Avoiding fine sediment will also reduce the amount of turbidity that is created during construction of the project. Material with a large grain size, such as beach quality sand, stays suspended in the water column for relatively short periods of time. Turbidity created by the project should be short lived and spatially limited to the vicinity of the dredge outfall pipe.

The No Action Alternative (NAA) will result in no alteration to the geology of the project area; however, the impact of the NAA on the soils is more difficult to predict. If no future maintenance of the Norfolk shoreline occurs, it is expected that the characteristics of the sand on site will not change. It is more likely that beach maintenance will continue in some form in the future. With each renourishment effort, the character of beach sediment will be altered. Although renourishment is most successful using material that is identical to the existing sand, it is almost impossible to find dredge material that matches exactly and the addition of large quantities of material from another site will slightly change the overall characteristic of the site.

8.9.1.1.2 *Beach Profile* - Both the TSP and NED Plan would result in an alteration of the existing beach profile. The placement activities will create a wider beach profile with a steeper slope. Once construction has been completed, natural processes, including sand supply, sea level change, currents, and wave size, will rework the beach. Over time, the beach will revert to a more natural profile.

The wider beach created by the proposed alternatives will provide significant benefits in the form of storm damage reduction. During storms with elevated water levels and high waves, a wide beach acts as an energy absorber, dissipating wave energy across the surf zone. As a result, the beach is affected by the storm instead of the upland structures.

The impact of the NAA will depend on whether beach restoration efforts continue in the future. If no maintenance efforts occur, it is expected that erosion will continue along most of the beachfront, with some areas of accretion. The project area, however, has been modified through the construction of coastal protection structures and renourishment projects since 1938. Even without the implementation of the Tentatively Selected Plan, it is highly likely that the sponsor or other organizations will continue to maintain the beach. However, these projects are dependent on available funding and usually triggered by coastal storm events, so the frequency and magnitude of future restoration efforts are difficult to predict.

8.9.2 Natural Forces

The two alternatives and the NAA will have no impacts to natural forces.

8.9.3 Terrestrial Wildlife

The impacts due to either of the two alternatives to the terrestrial beach community are expected to be short and insignificant in nature. Some benthic organisms that are not able to move away from renourishment activities and beach plants between the nearshore to the primary beach (Plate 18) in the placement site will be buried under dredged material and will perish. Observations made by the Corps of Engineers and others at previous beach nourishment projects in Hampton (Buckroe Beach, etc.) have shown that these species will re-colonize within a year of sand placement.

Construction may disrupt the natural behavior of terrestrial wildlife that currently utilizes the beach. Terrestrial reptiles, amphibians, and mammals may be temporarily disturbed by the activity and some individuals are expected to leave the area during construction. However, the wildlife is expected to return once nourishment has been completed. Construction is not expected to interfere with nesting, breeding, or migration of any avian species.

The NED plan will have additional impacts on the terrestrial resources within the project area. This plan includes the creation of a dune through the placement of sand and construction will result in the burial of beach flora and fauna. However, dune communities are expected to colonize the area quickly.

Impacts to terrestrial wildlife are predicted to be temporary in nature and it is expected that motile organisms will move back into the placement area once construction has been completed.

The NAA will allow the beach to recede inland and it is expected that the beach community will continue to adjust to the location and configuration beach. If the beach is eventually lost to erosion (e.g., if the beach erodes back to a wall or other permanent structure) the associated community will be lost.

8.9.4 Aquatic Wildlife

Both the TSP and NED plan will result in impacts on aquatic organisms. Recovery time of the benthos within both the dredging area and the seaward surf zone is expected to be relatively rapid, although full recovery of both sites by benthos to a condition resembling pre-project conditions may take several years (Nelson, 1993; Newell et al., 1998).

8.9.4.1 Borrow Site. Aquatic organisms will be lost at the borrow site due to dredging activities. The rate of benthic recovery and degree of diversity at the borrow site following a dredging event depend on a number of factors including: 1) duration and timing of dredging, 2) the type of dredging equipment used to extract the sediment, 3) sediment composition of the mine site, 4) amount of sand removed from the site, 5) the fauna present in the mine pit and surrounding area prior to dredging and their ability to adapt to change, 6) characteristics of the new sediment interface, 7) life history characteristics of fauna that re-colonize, 8) water quality at the site, 9) hydrodynamics of the mine pit and surrounding area, and 10) degree of sedimentation that occurs following dredging.

Motile benthic and pelagic fauna, such as crabs, shrimp, and fish, will be able to avoid the dredging area. In fact, epibenthic organisms, such as crustaceans and burrowing fishes (e.g., flounder) are rarely found in pumped sediments (USACE, 1992). Relatively non-motile benthos, such as worms and mollusks, will be destroyed over much of the dredged area (Parr et al., 1978). The recovery of the aquatic community after dredging has been found to occur relatively quickly and can be accelerated with specific dredging practices. In June 1998 and May 1999, the Virginia Institute of Marine Science and the University of New Hampshire conducted a study of the effects of sand mining on benthic populations forming the bulk of food sources for juvenile finfish in the shallow oceanic waters of Weaver Shoal and Fenwick Shoal, off the coast of Maryland and Delaware. Video sleds, sediment coring, and metered beam trawling were utilized to focus upon areas which provide the most desired sand grain size for commercial sand mining operations. Re-colonization occurred naturally within approximately one year of sand mining. The study concluded that, in order to minimize impacts to finfish food supplies and to promote re-colonization of mined areas as rapidly and efficiently as possible, the total removal of a layer of substrate should be avoided. Instead, small un-dredged areas within an identified borrow area should be left to create refuge patches that will promote rapid re-colonization and serve as habitat for the mobile benthic species. Mining activities ending in time for the spring and summer recruitment would favor crustaceans. Mining operations that begin in the summer and end in time for the fall and winter recruitment season would favor annelids (Diaz, Cutter and Hobbs, 2004).

Dredging by hydraulic or other mechanical methods can cause the suspension of solids into the water column, resulting in some adverse environmental effects at the borrow area, including localized increases in turbidity, slight decreases in DO, and reduction of light penetration. These changes could impact aquatic organisms by interfering with the respiration through gill clogging, temporarily reducing primary production and hampering predators that hunt by sight. Sediments in the Thimble Shoal Auxiliary Channel average approximately 89 percent sands and 11 percent clays and this sandy material would tend to settle rapidly, causing less turbidity and less oxygen demand than finer grained (organic) sediments. It is predicted that water quality will quickly return to pre-project levels once dredging has been completed.

Best management practices will be put in place to reduce the impacts of dredging as possible. USACE will follow all requirements and recommendations of NOAA and the USFWS in order to eliminate impacts to threatened and endangered species that may come in contact with the project site during construction. As a result, the timing of the dredging will be determined by the requirements of sea turtles and other endangered species and not invertebrates. As practicable, areas within an identified borrow area would remain un-dredged in order to create refuge patches that would promote rapid re-colonization and serve as habitat for the mobile benthic species. In addition, only substrate similar to that found on the Norfolk shoreline would be used in the project to avoid alterations to the sediment profile of the beach, which has been shown to slow recolonization after re-nourishment projects.

8.9.4.2 Placement Site. At the placement site, aquatic wildlife that cannot move away from the project site will be buried under the dredged material. However, it is expected that the area will repopulate relatively quickly, with organisms moving in from the surrounding area. Several environmental studies of beach nourishment indicate that there are no detrimental long term changes in the beach fauna as a result of beach nourishment (Burlas et al., 2001). In order to further determine the effects of beach nourishment activities upon key organisms, the Corps of Engineers conducted a study in 1987 along the nearby Virginia Beach shoreline (USACE, 1992). The findings of this study are based upon population changes of the mole crab (*Emerita talpoida*), ghost crab (*Ocypode albicans*), calico crab (*Ovalipes ocellatus*), amphipods (*Haustorius arenarius*), and sand worms (*Clymenella torquata*) in response to deposition of material dredged from offshore sources on the resort beach. This study supported the findings of other separate and independent studies, concluding that the greatest influencing factor on beach fauna populations appears to be the composition of the introduced material and not the introduction of additional material onto the beach. The deposited sediments, when similar in composition (grain size and other physical characteristics) to existing beach material (whether indigenous or introduced by an earlier nourishment or construction event), do not appear to have the potential to reduce the numbers of species or individuals of beach infauna (USACE, 1992).

The overall impact to aquatic organisms for both alternatives is expected to be temporary in nature and not significant. The NAA is expected to have no adverse impacts on the aquatic fauna at the placement or borrow areas.

8.9.5 Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Fishery Management and Conservation Act require Federal action agencies to consult with the NMFS regarding the potential effects of their actions on EFH, which is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity (NMFS, 1998). Step one of the consultation process was accomplished by notifying NMFS that this document was being prepared. Step two is the preparation of an EFH Assessment by the Federal agency proposing the action. The EFH assessment shall include: (1) a description of the proposed action, (2) an analysis of the effects of the action on EFH and associated species, (3) the Federal agency's views regarding the effects of the action on EFH, and (4) a discussion of proposed mitigation, if applicable. Step three of the consultation process is completed after NMFS reviews the Draft EA for which the NMFS provides EFH Conservation Recommendations during the established comment period. The fourth and final step in the consultation process is the Federal agency's response to the EFH Conservation Recommendations within 30 days. This response, in writing, must either describe the measures proposed by the agency to avoid, mitigate, or offset the impacts of the action on EFH pursuant to NMFS recommendations, or must explain its reasons for not following NMFS recommendations.

8.9.5.1 Description of Proposed Action**.** See Section 9.0, The Tentatively Selected Plan, of this document.

8.9.5.2 Analysis of the Effects. Appendix C includes a description of the 14 species in the vicinity of the project and at which life stage the NMFS has determined that those species would come in contact with-project elements. Direct impacts to each finfish species are evaluated on their likelihood of being present, and therefore, potentially physically harmed at either the proposed borrow areas or beachfill placement areas during project construction. Finfish species could potentially be harmed at the borrow area through entrainment in the dredge. Pelagic species, such as bluefish and Atlantic butterfish, should be able to avoid the entrainment into the dredge due to their high mobility. Demersal species such as the windowpane flounder and the summer flounder are mobile and should be able to avoid dredge entrainment as well. However, because of their demersal nature, individuals that may remain on the seafloor of the borrow area during dredging could be entrained and destroyed; demersal eggs may be entrained as well. Juveniles are more vulnerable than adults due to their slower swimming speed. Finfish species that have eggs and larvae in surface waters may be impacted by the hopper dredge making numerous transits through the borrow area; any eggs in the path of the dredge are likely to be destroyed by the ship's propeller. Because eggs and larvae are widely distributed over the continental shelf, egg destruction is not expected to cause significant impacts to fish populations. While some individual finfish will likely be entrained into the dredge and destroyed, no detrimental impacts to populations of any finfish are expected from the proposed project. Dredging may also result in physical alterations to the substrate of EFH which could cause changes to benthic community assemblages after re-colonization or in unsuitable substrate for spawning of some finfish species. However, significant changes in substrate are not expected because dredging depths would be based on vibracore data to minimize dissimilar substrates (MMS, 2006).

Finfish species could also be harmed in the surf zone while sand is being pumped onto the beach. However, most of the fish living nearshore are motile and can easily escape from sand placement. The greatest impacts of sand placement are the initial decrease in fish abundance, potential for gill clogging caused by increased turbidity, and direct burial of demersal fish. These impacts would be short term and would not cause significant impacts to populations of any finfish.

Indirect impacts to each finfish species could occur as a result of several aspects of the project. EFH species can be adversely impacted temporarily due to the formation of a turbidity plume, and decreased dissolved oxygen (DO) content during the dredging and placement. Potential impacts to juvenile and adult fish from turbidity include gill clogging or abrasion. These fish are motile and would most likely leave the area while dredging and sand placement occurs, significantly decreasing their abundance and diversity in the short term. Sessile prey organisms that feed by filtering suspended particles from water are likely to be harmed by turbidity and sedimentation. Abrasion, impaired respiration, and reductions in larvae survival are some of the associated effects. Populations exposed to the increased turbidity are expected to have a drop in productivity. However, no large concentrations of filter feeding organisms are known to exist in the project area. These impacts would subside upon cessation of construction activities. There is only a minor portion of fine-grained sediment within the material to be dredged and placed, and turbidity can be pronounced locally at both sites naturally as a result of wave re-suspension of bottom sediments at any time of year. For these reasons it is assumed that impacts from turbidity will be very minor. In addition, because of the open nature of the sites, turbidity should decrease as the particles in the water column rapidly dissipate into the surrounding coastal ocean waters. Short term beneficial impacts could result from the increase in suspended nutritive material as a food source, creating areas of feeding concentrations.

The sandbar shark (*Charcharinus plumbeus*) is designated as having a Habitat Area of Particular Concern (HAPC), which is described in regulations in a rare subset of EFH as follows: particularly susceptible to human induced degradation, especially ecologically important, or located in an environmentally stressed area. USACE has coordinated with NOAA Fisheries Services regarding this designation. The physical conditions at both the borrow site and the City of Norfolk's Willoughby Spit shoreline do not meet the habitat requirements as pupping or nursery areas for this species. As a result, it is unlikely that the project will have any adverse affects on the sandbar shark HAPC. The correspondence with NOAA can be found in Appendix E.

There will be short term increases in turbidity and settlement associated with dredging and sand placement but they will be localized and temporary. Any minimal turbidity will be very short in duration (i.e., will settle rapidly) and will be generally limited to the vicinity of the dredging and sand placement. It is generally viewed that elevated levels of turbidity generated by trailing suction hopper dredge operations in open ocean waters do not represent a significant ecological impact. Fish can avoid plumes and other organisms can survive short term elevated turbidity. The beach nourishment area (surf zone) and borrow area are not located within nursery or pupping grounds for the sandbar shark. Given that the shark can be found from the intertidal zone to waters more than 655 feet deep and is widely distributed along the East Coast, the borrow area represents a fraction of available forage habitat.

8.9.5.3 Department of the Army's Views Regarding the Action's Effects on EFH. Adverse effects on EFH species, due to dredging and construction activities will largely be temporary and minimal within the dredged footprints and beach nourishment areas in the surf zone. The project is not anticipated to significantly impact EFH species or habitat (including HAPC) that may be in the project area. It was determined, through consultation with NOAA, that dredging operations will not impact the HAPC of the sandbar shark. This species of shark typically pups in shallow, estuarine waters. The depth of the Thimble Shoal Auxiliary Channel is much greater than what the species typically used for nursery areas.

8.9.5.4 Discussion of proposed mitigation. It is the opinion of USACE that no mitigation will be required for this project.

8.9.6 Threatened and Endangered Species

The USFWS and NOAA have been consulted about the impact of the Willoughby Spit project on TES species. The USFWS concluded in the draft Planning Aid Report (PAR) "that there are no federally listed threatened and endangered species that reside in the project area year round."

8.9.6.1 *Birds* **–** The PAR does state that some transient species travel through the area, including piping plovers (*Charadrius melodus*) and roseate terns (*Sterna dougallii dougallii*). The PAR continues to state that "the piping plover is an uncommon summer resident in the lower Chesapeake Bay. They breed and forage in Virginia from March to October. The roseate tern is rare and would only be in the coastal area during the summer. Historically the piping plover nested on the Eastern Shore but nesting has not been documented there since 1927."

It is unlikely that the project will have long-term, negative effects on either species. The piping plover is also an uncommon summer resident in the lower Chesapeake Bay. It breeds and forages in Virginia, mostly on the Eastern Shore, from March to October. The Eastern Shore is a 70-mile long area of the Delmarva Peninsula, which is separated from Virginia Beach by the mouth of the Chesapeake Bay. The most southern point of the Eastern Shore is approximately 16 miles from the project area (Plate 1).

The piping plover both nests and feeds in open beach habitat. Even though there have been no known incidences of plovers nesting within the project area since the 1920's, the placement site will be surveyed for nests before construction begins to ensure that there will be no effect on the piping plover. If nests are found, then the USFWS will be consulted.

Similar to the piping plover, the roseate tern nests on open beaches, but it feeds offshore. The roseate tern is rare visitor to the Mid-Atlantic and would only be in the coastal area of Virginia during the summer. This species has not been known to nest on the Willoughby Spit, so placement of sand will have no impact on the species. Although rare to the borrow site area, roseate terns might be found to forage within or near the borrow site while dredging is taking place.

The proposed action is not likely to affect the roseate tern or the piping plover. If these individuals visit the borrow area or the placement site during the time of construction, it is expected that they will immediately leave the area due to the operation of heavy equipment. This movement will temporarily interrupt their nature behaviors. Once construction has been completed, there will be no impediments that will restrict the birds from returning to project site. Even though there are no know incidence of nesting within the project site, if construction begins during the nesting season, the project area will be surveyed for nests. If nests are found, then the USFWS will be consulted before construction is begun.

8.9.6.2 Sea Turtles. Although the IPaC system did not identify sea turtles as potentially being affected by the proposed project**,** dredging operations can cause the mortality or injury of sea turtles as a result of entrainment, the direct uptake of aquatic organisms by the suction field generated at the draghead or cutterhead. Sea turtle mortalities due to entrainment during hopper dredging operations have been documented since 1980. The Endangered Species Observer Program, established in 1980, required observers to quantify entrainment of turtles by screening dredged material from hopper dredge intake structures or overflows. By species, loggerheads were the most frequently entrained during hopper dredging, accounting for 67.4 percent of the total entrainment (for turtles identified per species). Green sea turtles and Kemp's ridleys accounted for 11.1 and 2.5 percent of entrainment incidents, respectively. Nineteen percent were unidentified as to species, since only fragments were recovered (Reine and Clark, 1998). Over the past 24 years, USACE and the dredging industry have worked to develop protocols, operational methods, and modified dredging equipment to reduce dredging impacts to sea turtles. If dredging occurs from May 1 to November 30, hopper dredges must be equipped with rigid turtle deflectors attached to the drag-head. The deflector is checked throughout every load to ensure that proper installation is maintained.

8.9.6.3 Whales**.** The IPaC system did not list whales as potentially being affected by the proposed action. However, finback, humpback, and right whales are known to exist within the lower Chesapeake Bay. Dredging impacts on marine mammals may result from underwater noise and vessel collisions. Collision with vessels is the leading human caused source of mortality for whales; the most lethal and serious injuries are caused by large, fast-moving ships.

The NMFS has established regulations to implement speed restrictions of no more than ten knots applying to all vessels 65 feet or greater in overall length in certain locations and at certain times of the year along the east coast of the Atlantic Seaboard. The purpose of the regulations is to reduce the likelihood of deaths and serious injuries to endangered North Atlantic right whales that result from collisions with ships (50 CFR, part 224). Since these restrictions are not mandatory for vessels owned or operated by, or under contract to, Federal agencies, the NMFS has requested all Federal agencies to voluntarily observe the conditions of the proposed regulations when and where their missions are not compromised. Should whales happen to occur during dredging operations, USACE will adhere to NMFS' observer/monitoring program to insure that vessel collisions are avoided. The proposed action is not likely to adversely affect any of these whale species.

Coordination with NOAA was completed for marine species, including marine mammals, sea turtle and sturgeon. The activities that are part of the Willoughby Project, both the dredging and sand placement, are included in the programmatic biological opinion released by the National Marine Fisheries Service on October 16, 2012. The entire opinion is included in the Environmental Appendix. The biological opinion states that in order to be exempt from prohibitions of Section 9 if the ESA, USACE must implement the reasonable and prudent measures (RPMs) listed in the document. Section 12.3 of the biological opinion describes the terms and conditions for the implementation of each RPM. Section 13.0 of the biological opinion provides conservation recommendations, which are discretionary activities that USACE can follow to minimize of avoid adverse effected of the proposed actions on listed species or critical habitat. A complete list of RPMs and conservation recommendations can be found in the associated EA.

The NAA has no predicted impact on the threatened and endangered species within the project area.

8.9.7 Submerged Aquatic Vegetation

There would be no effect to submerged aquatic vegetation by either alternative or the NAA.

8.9.8 Wetlands

There would be no effect to wetlands by either plan or the NAA.

8.9.9 Water Quality

8.9.9.1 Borrow Area. Dredging in the borrow area will result in some short term negative effects to water quality, including localized increases in 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. No appreciable 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.

8.9.9.2 Placement Site**.** Both beach nourishment alternatives 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 to 99 percent 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 two 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 beach front. 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 resuspended during storms (USACE, 2001).

Van Dolah et al., 2004, 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. BMP's, such as the containment of sediment during and after construction, will be implemented to order control the increase in turbidity caused by the operation at the placement site.

The NAA will not affect water quality at either the borrow site or placement site.

8.9.10 Cultural and Economic Environment

Effects to socioeconomic conditions would be the result of temporary interruption of beach access to limited areas due to construction and should have a negligible effect to tourism and recreation. As the name implies, the view of the open water is integral to the character of Willoughby Spit - Ocean View. The TSP will not involve the construction of a berm that would block the view of the Chesapeake Bay which could adversely affect property values and incomes for businesses.

Concerns involving Environmental Justice are not apparent in relation to this project; navigation and military operations should not be affected.

Effects to the aesthetic and historic character of Willoughby Spit - Ocean View would not be substantial. Although a berm would be in keeping with the historic character of the landscape where there were natural sand dunes, there is no berm above mean high tide elevation (e.g., 5 feet above mean low water) in the TSP. Historic architectural resources which may be potentially eligible for the National Register of Historic Places would not have their view-sheds adversely affected. This includes the five houses on West Ocean View Avenue (addresses 850, 650, 550, 502, and 450 W. Ocean View Avenue) discussed in Section 2.7. Although the berm in other plans would be consistent with the historic setting in so much as it is similar to sand dunes which may have been the original setting of these buildings, dating between 1895 and 1940, there would be no substantial change in the existing viewshed by widening the beach, the treatment in the TSP. There should be no adverse effects to architectural historic properties or terrestrial archaeological sites resulting from the TSP. The Virginia Department of Historic Resources (VDHR) was consulted and concurs that there would be no adverse effects to above-ground resources (letter Brad MacDonald VDHR to John Haynes USACE Norfolk District, September 4, 2012, VDHR file #2012-4033).

The Phase I and II surveys for submerged archaeological resources cover all of the selected Thimble Shoal Auxiliary Channel borrow areas, having been conducted for a similar beach nourishment project at Cape Henry, VA in 2000. The Phase I survey covers most of the Horseshoe Shoal (Hampton) borrow area, and the Phase I survey of the Willoughby Banks borrow area provides complete coverage of this area. The remote sensing underwater archaeology surveys were fully sufficient to evaluate the alternatives in terms of submerged archaeological resources. The Thimble Shoal Auxiliary Channel has far fewer potential shipwreck sites identified in Phase I, and fewer potential ordnance artifacts. The subsequent Phase II survey found all of the potential shipwreck anomalies are not shipwrecks, but various types of debris jettisoned or lost overboard, and not of archaeological interest. Therefore, dredging in the selected Thimble Shoal Auxiliary Channel borrow areas would not affect significant historic shipwrecks. The Virginia Department of Historic Resources (VDHR) was consulted and concurs that there would be no adverse effects to archaeological resources (letter Brad MacDonald VDHR to John Haynes USACE Norfolk District, September 4, 2012, VDHR file #2012-4033).

A slight chance of historic ordnance in that area was noted, and a number of potential ordnance remote sensing targets were mapped. Protocol for safety and recording historical information of any ordnance encountered during dredging, most likely World War II naval mines, should be developed.

8.9.11 Noise

Both beach renourishment alternatives are anticipated to take approximately 130 days to construct, depending on weather conditions, economic forces, and equipment breakdown. Operations are expected to continue 24 hours per day, seven days per week. Bulldozers will be working on the beach continuously, which would affect the ambient noise level; although the impacts would be restricted to the area immediately surrounding construction and not extend throughout the entire project site. Noise pollution and construction activities will be monitored to ensure minimum disturbance to the surrounding community. The offshore pumps are not expected to impact the ambient noise level as they will be far enough from the beach and not be a nuisance.

Ambient underwater sound levels are an important consideration in assessing the probability of detrimental effects of dredging sounds. Much of the sound produced during filling of the hopper is associated with propeller and engine noise with additional sounds emitted by pumps and generators; these sounds are continuous in nature. Numerous factors contribute to ambient sounds at a given location, including tidal hydrodynamics, meteorological conditions and sea state, the presence or absence of ice, and sounds of biological origin. It should also be recognized that interpreting underwater sound data may be futile without fundamental studies on biological responses to characteristic dredging sounds (Dickerson et al., 2001). Little data exists that adequately characterize sounds emitted by dredge plants to support objective decisions balancing the need to dredge against relative risk to a fishery resource (Dickerson et al., 2001).

The NAA would not involve any construction related noise and would, therefore, have no impact on noise levels in the project area.

8.9.12 Air Quality

The Willoughby project lies within the limits of the independent city of Norfolk, VA. According to the Virginia Department of Environmental Quality's (VDEQ) Air Regulations (Chapter 20, Section 203), the city of Norfolk is included in the Hampton Roads Ozone maintenance area with respect to 8-hour ozone. Air regulations (9 VAC 5-160 – 30), issued by the VDEQ, require Federal agencies to prepare a conformity determination if the total of both direct and indirect emissions produced by a Federal action in a maintenance area is equal to or greater than 100 tons of nitrogen oxides (NOx) or volatile organic compounds (VOC) per year (VDEQ, 2012).

Air pollutant emissions were calculated for both alternatives using estimates of power requirements, duration of operations, and emission factors for the equipment needed to complete the project. Multiplying horsepower ratings, activity rating factor (percent of total power), and operation time yields the energy used. Power requirements and durations for each phase of the proposed hopper dredging and beach placement activities were estimated using previous nourishment projects completed by the USACE.

The horsepower rating of the dredge plant used for each activity are as follows: propulsion (5000 hp), dredging (5000 hp), pumping (4000 hp), and auxiliary (2000 hp). The estimated time to complete each dredge cycle, including idle time, dredging, transit, and pump-out, is roughly four hours per load and on average, approximately 4,000 yd^3 of dredge material will be moved per cycle. Approximately 305 trips would be needed to move 1.2 million yd^3 of sand for the TSP and 676 trips would be required to move 2.7 million yd^3 for the NED plan.

The placement and relocation of the nearshore mooring buoys used during pump-out would require a work barge and a pipeline hauler/crane. The buoy would have to be moved at most five times during the project, with each move taking approximately 12 hours. A work barge (900 hp) and a crane (230 hp) will be needed to relocate the buoy. Buoy placement requirements will be identical for both alternatives. On the beach, the equipment required to move the sand into place will include two bulldozers (300 hp) working 24 hours a day and a front end loader (200 hp) working 18 hours a day. An extra four weeks, two weeks before and after the dredge plant supplies sand to the project, were added to the operational schedule of equipment operated on the beach.

To determine air emission output, emission factors of 0.031(lb/hp*hr) for diesel engines < 600 hp and 0.024031(lb/hp*hr) for engines >600 hp were used to calculate NOx production. VOC emissions were calculated using emission factors of 0.002514031(lb/hp*hr) for diesel engines <600 hp and 0.000705 031(lb/hp*hr) for engines >600 hp. The emission factors were supplied by the USEPA.

Table 36. ESTIMATED EMISSIONS FOR THE PREFERRED ALTERNATIVE (TONS PER YEAR)

Activity	Emissions (tons)				
	TSP			NED Plan	
	NOx	VOC		NOx	VOC
Dredge Vessel (Hopper)					
Dredging	18.8	4.13		25.92	0.76
Transit	36.6	1.08		3.36	0.1
Pump-out	11.52	0.34		40.8	1.2
Idle	1.44	0.04		81	2.38
Relocation of Mooring Buoy	1.51	0.06		1.51	0.06
Beachfill	18.77	1.52		36.18	2.93
Total Emissions	88.64	7.17		188.77	7.43

As shown in the previous table, implementation of the TSP would produce approximately 88 tons of NOx and 7.17 tons of VOC. Projected emissions of NOx and VOC are within 100 tons/year, the standard set for maintenance areas; therefore no conformity determination will be required under 40 CFR Part 93. The TSP would result in small, localized, temporary increases in concentrations of NOx and VOC. Based on the preceding analysis, projected emissions from the Willoughby Spit project would not adversely impact air quality given the relatively low levels of emissions and the prevailing offshore winds.

The NED Plan would have a greater impact to air quality, resulting in the creation of 7.43 tons of VOC and 188.77 tons of NOx. Projected emission of NOx is greater than 100 tons/year, the standard set for maintenance areas; therefore, if the NED Plan is pursued, a conformity determination would be required under 40 CFR Part 93.

The NAA would not involve any construction related air emissions and would, therefore, have no impacts on air quality in the project area.

8.9.13 Cumulative Effects

Cumulative impacts are those impacts on the environment that result from the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions. This section analyzes the proposed action in context of similar and unrelated actions occurring in the vicinity of the action area. In considering potential cumulative impacts, time crowded perturbations, space crowded perturbations, indirect and synergistic impacts, and combinations thereof, were evaluated. Other activities of importance occurring in the vicinity of the project area include beach recreation, coastal development, beach nourishment, navigation channel maintenance, commercial and recreational fishing, and shipping traffic. Both beneficial and adverse cumulative impacts could occur when the impacts of the proposed action are considered in context, but the incremental contributions to impacts on air quality, avian communities, beach habitat, marine mammals and sea turtles, benthic communities, finfish and essential fish habitat, and physical processes from the proposed action are minor.

Sand nourishment of the project area, from Willoughby Spit to the Little Creek Inlet, is projected for approximately every nine years for the next 50 years for the TSP and approximately every 11 years for the next 50 years for the NED Plan. Considered in context of past projects along the Norfolk beachfront, these and similar projects which have taken place in the city, as well as past and future projects that will occur along the shoreline in Norfolk, it is predicted that beachfill activities will continue to be supported in the project area. As a result, the Norfolk beachfront will continue to be subject to the stresses of such activities. The impacted area would not increase, and the nature of impacts would not change. The intervening periods between nourishments generally allow for physical and biological recovery and equilibration of the submerged section of the beach and surf zone. Beach nourishment activities are generally considered beneficial to beach recreation, tourism, and property values, but may encourage disturbance or loss of beach, dune, and overwash habitat owing to human activities associated with coastal development. Trampling, artificial lighting, and beach erosion control (e.g., bulkheading) potentially degrade the full range of seabird and sea turtle nesting habitat and interfere with nesting, foraging, parental care, and hatchling behavior (Defeo et al., 2009).

Beachfill should balance or counter those losses, replacing the dune (NED Plan) and beach habitat that would otherwise be lost to erosion or compromised by more aggressive shoreline protection measures. With the respite between maintenance cycles, sensitive biological resources, including infaunal and epifaunal invertebrates, should substantially recover from disturbances, which include burial, reduced prey availability, and emigration (Burlas et al., 2001; Peterson and Bishop, 2005). Most sandy beach species are adapted to severe physical disturbances, since storms are frequent along the Mid-Atlantic coast. Seabirds should benefit from the long term nesting habitat that would certainly disappear with unmitigated coastal erosion. In general, behavior modifications and displacement from preferred nesting and foraging areas will be temporary.

Not all beach restoration projects in the Hampton Roads region use the same offshore borrow area. Beach quality sand is a finite resource and requires careful resource management. A total of 1.12 million and 2.7 million cubic yards of sand will be needed to implement the TSP and the NED plan, respectively. If dredged to six feet, it is estimated approximately 3.0 million cubic yards of beach grade sand is currently present in the Thimble Shoal Auxiliary Channel. Either alternative will result in the removal of a substantial amount of material from the Thimble Shoal Auxiliary Channel borrow site.

The shoal's function as habitat may be adversely affected, but to date, there has been limited evidence of any sustained disturbance beyond transient and localized impacts to a wide range of benthic and pelagic biota resulting from similar dredging operations that have occurred within the Hampton Roads region (Diaz et al., 2004). Areas of the borrow site where sediment grain size is incompatible with nourishment grain size requirements, as well as other no-dredge areas such as the submarine cable zone, will remain undisturbed, serving as feeder zone for benthic recolonization and natural bottom habitat. Additionally, since borrow areas are not typically dredged perfectly flat relative to the adjacent seafloor, a portion of the dredge areas will remain morphologically intact.

Prominent shoals or broad sand bodies are often the primary target for dredging, but are also considered valuable benthic and fish habitat. The importance of sand shoal habitats to sea turtles and other sensitive biota is largely unknown. The areal extent of seafloor disturbance is governed by dredging cut depth and thickness of available sand deposits. The currently planned project is expected to impact approximately 150-300 acres of seafloor, but no more than 500 acres. These habitats are naturally dynamic and physically-dominated, making resident biota fairly resilient. The proposed action and foreseeable actions will not result in significant effects on sensitive biological resources. It is likely that re-colonization of benthic fauna will occur rapidly by migration and larval recruitment (see EFH Assessment). Cumulative impacts to EFH and finfish occur from a vast array of sources, including neighboring navigation channel dredging, and are discussed in the attached EFH Assessment (Appendix C).

The most influential of impacts on EFH, finfish, and shellfish are regulated recreational and commercial fishing activities that conduct unsustainable fishing practices and policies. Nearly one third of the Nation's marine fisheries have been officially designated as overfished or nearly so; unsustainable harvesting practices reduce recruitment, decrease spawning stock, and decrease overall populations (Defeo et al., 2009). Gillnet fishing may be conducted for fish species such as the spiny dogfish and striped bass. Some by-catch is caught along with the targeted species, and this could potentially reduce the population numbers of non-targeted organisms, sublegal size fish and prey species. Many commercially-caught fish species, such as bluefish and Atlantic croaker, are caught by rod and reel or hand line. Impacts include mortality of catch released because of size limits or species prohibitions. If anchoring takes place, there may be some bottom disturbance as well. Trawl fisheries have targeted bottom fish such as grey seatrout and summer flounder or water column species such as bluefish. Traditional bottom trawls have been shown to remove bottom dwelling organisms such as brittle stars and urchins as well as polychaetes. Colonial epifauna have also been shown to be less abundant in areas disturbed by bottom trawling. This epifauna provides habitat for shrimp, polychaetes and small fish which are potential prey species for commercially desirable fish species. Seafloor areas that have been heavily trawled may bear tracks where trawl doors have gouged into the sediment, changing the sediment surface and in other areas the trawl has flattened the sediment surface reducing habitat for managed species and their prey. Traditional trawl techniques were known to be nonselective in their catch thus having the potential to reduce both prey species and year classes of managed species not yet mature. Longline fishing for species such as some coastal sharks is also expected to occur. Longlining may result in the death of some juvenile and non-target fish species.

Recreational anglers have also caught designated EFH species within the vicinity of the borrow areas (i.e., bluefish, cobia, striped bass, king mackerel) via rod and reel, power trolling, and spear fishing. Mortality of some species is expected from the by-catch of non-target species and sublegal catches. Additionally, disruption of bottom habitat can occur from the anchoring of recreational boats. Benthos and fish caught by the anchor may be destroyed. Repeated anchoring in same location can lead to patches void of benthic organisms. It can reasonably be assumed that Virginia will continue to license and permit recreational vessels and operations, which do not fall under the purview of a Federal agency. If recreational activity increases, the number of mortalities may continue to increase as well.

Vessel activity associated with dredging and fisheries would be added to the existing commercial shipping and naval vessel traffic using the Chesapeake Bay ports.   Air emissions from the construction activities are extremely small in context of the existing point and non-point emissions that contribute to moderate air quality conditions. The impacts on water quality from beach nourishment and channel maintenance activities, including elevated turbidity and reduction of dissolved oxygen and water clarity, are short in duration and limited to the placement and dredging location. The impacts may be influenced by seasonal fluctuations in river and tidal inlet exchange.

Routine discharges from dredge and service vessels are not expected to contribute appreciably to degraded water quality. Oil spills, although non-routine from vessel activity, are potentially the most destructive pollution source impacting sand beaches and biological resources. Runoff from agriculture, stormwater, and other sources carry pathogens, contaminants, and excess nutrients into coastal waters (Defeo et al., 2009). These can lead to reproductive failure, deformations, mortality and contribute to locally anoxic habitats. Impacts from the nonpoint sources of pollution are expected to continue.

Dredge plants and support vessels, such as military, shipping, and fishing activities, may contribute to disrupted feeding, loss of prey, noise disruption, and possible collision and entrainment of finfish and sea turtles. Military activities, including ordnance testing, sonar testing, and operational exercises, may affect listed turtle and marine mammal species. Since sea turtles and pelagic fish are highly migratory, the disturbances discussed above can generally be avoided. The same species are likely to be affected by human activities throughout their geographic range. The mitigation measures considered integral to the project are adopted for the express purpose of reducing these risks.

8.10 SYSTEMS ANALYSIS

Because shoreline processes are dynamic, coastal storm damage reduction measures may generate both beneficial and adverse impacts beyond immediate project sites. Impacts elsewhere may occur as a consequence of the design and implementation of site-specific coastal storm damage reduction projects. These impacts must be evaluated, and this requires expansion of the study area to include reaches adjacent to the project site. Generally, the adjacent reaches are bounded by natural features that interrupt or substantially limit the natural littoral processes (i.e., bays, sounds, inlets, geomorphic features, etc.).

The Tentatively Selected Plan would not significantly impact the shoreline to the south of the project area. Given that the predominate littoral transport is to the north and west along the shoreline, it is anticipated that there would be little or no impact on the shoaling rate at the inlet as a result of the TSP. To the west of the terminal groin, there has been shoaling in the area and some private boat docks have become shoaled in. Recently the city of Norfolk mined these areas as a source for material in their dune restoration project. These areas have begun to shoal in again. It is anticipated that this area will continue to serve as a source area for the city's dune restoration project. The groin system in this area appears to be retaining its functional capacity of material, and little of this material is expected to remain on these beaches. However, any increase that remains on the beaches would have a beneficial impact.

9.0 DIVISION OF PLAN RESPONSIBILITIES

9.1 GENERAL

This section provides the Federal and non-Federal cost sharing requirements for the Tentatively Selected Plan consisting of the estimated costs for initial construction and for periodic nourishment. This information will become part of the local cooperation requirements which will be included in the Project Partnership Agreement (PPA) that will be negotiated and executed between the city of Norfolk and the Department of the Army prior to project construction.

9.2 COST SHARING REQUIREMENTS

Federal and non-Federal participation in coastal storm damage reduction projects is based on the cost sharing requirements contained in Section 103 of WRDA 86, as amended. Section 103(d) specifies that the costs of such projects be assigned to the appropriate purpose(s) specified in Section (c) as normally coastal storm damage reduction and/or separable recreation. In accordance with Section 103(d), the Federal Government and the non-Federal sponsor are responsible for 65 percent and 35 percent, respectively, of the costs for initial construction allocated to coastal storm damage reduction and 50 percent each of the costs for initial construction allocated to recreation. The Federal Government and the non-Federal sponsor are also responsible for 50 percent each of the costs for periodic nourishment, including beach monitoring costs. Costs for Engineering During Construction and project betterments, if any, are entirely the responsibility of the non-Federal sponsor. The following table summarizes the cost sharing requirements.

Table 37. PROJECT COST SHARING REQUIREMENTS

Item	Cost-Sharing (Federal)	Cost Sharing (Non-Federal)
Initial Construction		
Allocated to Storm damage reduction	65%	35%
Allocated to Recreation	50%	50%
Periodic Nourishment	50%	50%
Engineering During Construction	0%	100%
Project Betterments, if any	0%	100%

Cost sharing requirements for coastal storm damage reduction must also consider shore ownership and use. Non-Federal public shores that are dedicated to park and conservation areas are cost shared 50 percent Federal and 50 percent non-Federal. Cost sharing would be 65 percent Federal and 35 percent non-Federal for protection of privately owned lands fronted by publicly owned shores. Protection of undeveloped private lands would be 100 percent non-Federal. The following table shows the applicable construction cost sharing percentages based on shoreline ownership and use.

Table 38. CONSTRUCTION COST-SHARING REQUIREMENTS BY SHORE OWNERSHIP AND USE

Land Use	Federal	Non-Federal
Developed	65%	35%
Undeveloped	0	100%
Public park	50%	50%

9.3 COST SHARING MODIFICATIONS TO REFLECT IMPACT OF FEDERAL NAVIGATION PROJECT ON ADJACENT SHORELINE RECESSION

When it authorized the construction of the Authorized Project (now the Tentatively Selected Plan), Section 501 of WRDA 1986 included a modification to the cost sharing requirements to reflect the impact of the jetties at the Federal navigation project at Little Creek Inlet on the recession of the East Ocean View shoreline. This was the result of an agreement between the city of Norfolk and the Norfolk District to address the inlet issue as part of the then ongoing hurricane protection and beach erosion control feasibility study for the Willoughby Spit and Vicinity shoreline, in lieu of a separate shoreline damage mitigation study conducted under Section 111 of the River and Harbor Act of 1968. At that time, it was estimated that the sand blocking action of the jetties was responsible for the loss of 55 percent of the sand volume nourishing the East Ocean View shoreline.

The cost sharing for the Authorized Project was modified to reflect the different cost sharing requirements for the East Ocean View shoreline and the remainder of the project shoreline. Along the East Ocean View shoreline, 55 percent of the nourishment volume in that segment was allocated to the impact of the jetties and would be a 100 percent Federal responsibility. The remaining 45 percent of the nourishment volume in that segment would be cost shared on the same basis as the remainder of the project shoreline; namely, 65 percent Federal and 35 percent non-Federal. This provides for a cost share breakdown for the entire project shoreline of 70.2 percent Federal and 29.8 percent non-Federal for initial construction.

A similar approach was applied to the periodic nourishment quantities and costs incorporating that periodic renourishment cost sharing would be 50 percent Federal and 50 percent non-Federal except for that portion allocated to the impact of the jetties, which would be a 100 percent Federal responsibility. This provides for a cost share breakdown of 57.4 percent Federal and 42.6 percent non-Federal for periodic renourishment.

9.4 COST APPORTIONMENT FOR THE TENTATIVELY SELECTED PLAN

The Tentatively Selected Plan is justified entirely on benefits associated with storm damage reduction. There are no separable recreation features. The entire length of shoreline in the area protected by the Tentatively Selected Plan is developed and fronted by publicly-owned shores. The area does not include any undeveloped private lands. Part of the shoreline has been developed as a public park containing parking lots, bathhouses, a boardwalk, picnic facilities, bike trails and sidewalks, a pavilion, gazebos, and related park facilities.

Table 39 provides a breakdown of sand placement by shoreline segments and also a breakdown of the sand placement attributable to the jetties for both initial construction and periodic nourishment. Table 40 provides a breakdown of costs and the resulting cost shares based upon the quantities determined in Table 39 for both initial construction and periodic nourishment.

Table 39. CONSTRUCTION AND RENOURISHMENT COST SHARING PERCENTAGES FOR THE TENTATIVELY SELECTED PLAN BASED ON VOLUME OF SAND PLACEMENT AND IMPACT OF LITTLE CREEK FEDERAL NAVIGATION PROJECT

		Initial Construction				Renourishment			
Shoreline Segment	Segment No.	Sand Placement Volume (CY)	Percent of Total Volume (%)	Federal Cost Share (%)	Non-Federal Cost Share (%)	Sand Placement Volume (CY)	Percent of Total Volume (%)	Federal Cost Share (%)	Non-Federal Cost Share (%)
Willoughby Spit	1	410,150	33.7	65	35	149,870	33.7	50	50
Central and West Ocean View	2	478,600	39.3	65	35	174,880	39.3	50	50
East Ocean View Segment not impacted by Little Creek Federal Navigation Project (45%)	3a	148,160	12.1	65	35	54,120	12.1	50	50
Subtotal 1	1, 2, 3a	1,036,910	85.1	65	35	378,870	85.1	50	50
East Ocean View Segment impacted by Little Creek Federal Navigation Project (55%)	3b	181,090	14.9	100	0	66,230	14.9	100	0
Subtotal 2	3b	181,090	14.9	100	0	66,230	14.9	100	0
Total Shoreline	1, 2, 3a, 3b	1,218,000	100.0	**70.2**	**29.8**	445,100	100.0	**57.4**	**42.6**

The following table shows the Federal and non-Federal cost-sharing requirements for the construction, renourishment, and engineering during construction costs for the Tentatively Selected Plan.

Table 40. APPORTIONMENT OF CONSTRUCTION, RENOURISHMENT, AND ENGINEERING DURING CONSTRUCTION COSTS FOR THE TENTATIVELY SELECTED PLAN

Item	Total	Federal Share	Non-Federal Share
Construction First Costs Apportioned to:			
Tentatively Selected Plan (Segments 1, 2, and 3a)	$15,657,000 (85.1%)	$10,177,000 (65.0%)	$5,480,000 (35.0%)
Little Creek Federal Navigation Project (Segment 3b)	$2,737,000 (14.9%)	$2,737,000 (100.0%)	$0 (0.0%)
Total	$18,394,000 (100.00%)	$12,914,000 (70.2%)	$5,480,000 (29.8%)
Beach Renourishment Costs Apportioned to:			
Tentatively Selected Plan (Segments 1, 2, and 3a)	$6,372,000 (85.1%)	$3,186,000 (50.0%)	$3,186,000 (50.0%)
Little Creek Federal Navigation Project (Segment 3b)	$1,115,000 (14.9%)	$1,115,000 (100.0%)	$0 (0.0%)
Total	$7,487,000 (100.0%)	$4,301,000 (57.4%)	$3,186,000 (42.6%)
Engineering During Construction:			
Beach Monitoring (2)	$250,000 (100.0%)	$0 (0.0%)	$250,000 (100.0%)

(1) Beach renourishment costs shown are for one renourishment cycle.
(2) The city of Norfolk would provide 100% of this cost upfront, but would get credit for 50% of this cost toward its 50% share of the renourishment cost.

9.5 FINANCIAL ANALYSIS

A financial analysis is required for any plan being considered for USACE implementation that involves non-Federal cost sharing. The purpose of the financial analysis is to ensure that the non-Federal sponsor understands the financial commitment involved and has reasonable plans for meeting that commitment. The financial analysis includes the non-Federal sponsor's statement of financial capability; the non-Federal sponsor's financing plan; and an assessment of the sponsor's financial capability.

The city of Norfolk has expressed support for a potential project. Their cooperation indicates a strong willingness to proceed with a potential solution to the storm damage problems identified at Willoughby Spit and Vicinity. The city of Norfolk has funding set aside for the design and construction of this project. Funds for periodic nourishment costs, required at estimated nine year intervals, are a relatively small expenditure in view of the city's annual budget requirements and would be incorporated into the city's forecast of expenditures.

The non-Federal sponsor, the city of Norfolk, has provided funds to the Norfolk District Corps of Engineers to cost share studies and projects in the past. The city is committed to protecting its Chesapeake Bay shoreline as demonstrated by the amount of its current and past shoreline expenditures. Over the last thirty years, the city of Norfolk has expended more than $21 million for coastal storm damage reduction projects. This equates to approximately $32.7 million at current price levels. The city of Norfolk has indicated its support for the Tentatively Selected Plan in a letter dated August 28, 2013, a copy of which is included in Appendix E—Pertinent Correspondence.

9.6 PROJECT PARTNERSHIP AGREEMENT

A Project Partnership Agreement (PPA) will be developed, negotiated, and executed with the non-Federal sponsor prior to project implementation. The PPA will define the roles and responsibilities of the Federal Government and the non-Federal sponsor in the initial construction, periodic nourishment, and operation and maintenance of the plan that is ultimately approved for implementation. The PPA will be based on a model agreement developed by Corps Headquarters.

The following are the major steps in the PPA process:

(1) The Norfolk District develops a draft PPA based on a model agreement developed by Corps Headquarters.

(2) The Norfolk District negotiates the draft PPA with the non-Federal sponsor to ensure that the sponsor has a clear understanding of the type of agreement that they would be expected to sign prior to the start of construction. The terms of local cooperation to be required in the PPA are described later in this report.

(3) The Norfolk District prepares a fully coordinated PPA package, including the sponsor's financing plan and letter of intent and reflecting the recommendations of this limited reevaluation study, subsequent to the approval of the limited reevaluation phase.

(4) The Norfolk District submits the draft PPA package to higher authorities for review and approval by the Assistant Secretary of the Army for Civil Works (ASA [CW] after the Environmental Assessment has been coordinated with the public and environmental agencies, resultant comments have been addressed, and the document has been finalized. In addition, the reevaluation report must be approved and the recommended project must be budgeted for construction.

(5) ASA (CW) approves the non-Federal sponsor's financing plan and approves the PPA for execution between the Federal Government and the non-Federal sponsor.

(6) The Federal Government and the non-Federal sponsor execute the approved PPA after the reevaluation report is approved and an Appropriations Bill containing funds for the project is enacted into law.

Federal commitments relating to a construction schedule or specific provisions of the PPA cannot be made to the non-Federal sponsor on any aspect of this project or separable element until:

- A new cost limit is established for the final plan ultimately approved for implementation , possibly through a post-authorization change process;

- Construction funds are added by Congress, apportioned by the Office of Management and Budget, and their allocation is approved by the ASA (CW); and

- The draft PPA has been reviewed and approved by the ASA (CW).

9.7 SUMMARY OF COORDINATION

The Draft Limited Reevaluation Report and Environmental Assessment will be coordinated with the appropriate agencies and groups. Comments from those agencies and groups, along with Corps of Engineers responses, will be included in the Pertinent Correspondence Section and the Comments and Responses Section of the EA. Coordination efforts shall continue through the design and construction phases.

10.0 IMPLEMENTATION CONSIDERATIONS WITH REGARD TO THE DISASTER RELIEF APPROPRIATIONS ACT OF 2013 [Public Law (P.L.) 113-2]

In response to the catastrophic damages to the Atlantic coastline caused by Hurricane Sandy in late October 2012, the Congress passed and President Obama signed into law the Disaster Relief Appropriations Act of 2013 [Public Law (P.L.) 113-2]. In general, P.L. 113-2 provides supplemental funding to the Corps of Engineers for: (1) ongoing studies; (2) rehabilitation, repair, and construction of Corps projects; and (3) operations and maintenance dredging of Federal navigation channels, all in the interest of flood and storm damage reduction within the North Atlantic Division boundaries.

P.L. 113-2 also requires that the Corps provide to Congress two interim reports that assess Corps construction projects and projects under study by the Corps and a Comprehensive Study that addresses the flood risk of vulnerable populations in areas impacted by Hurricane Sandy. The Tentatively Selected Plan is one of several "authorized but unconstructed" projects within the USACE North Atlantic Division boundaries covered by P.L. 113-2. For this category of projects, P.L. 113-2 stipulates specific implementation changes and acknowledgements to the normal Civil Works process as follows:

1. The costs and cost-sharing to support a Project Partnership Agreement (PPA).

2. Acknowledgement of the changes in the applicability of Section 902 of WRDA 1986, as amended.

3. The specific requirements necessary to demonstrate that the project remains economically justified, technically feasible, and environmentally acceptable.

4. The specific requirements necessary to demonstrate resiliency, sustainability, and consistency with the Comprehensive Study.

The following paragraphs will address each of these changes and acknowledgements as related to the Tentatively Selected Plan.

10.1 COSTS AND COST-SHARING IN SUPPORT OF A PROJECT PARTNERSHIP AGREEMENT

As discussed in Section 9.3 of this report, the cost sharing for coastal storm damage reduction projects is based on the requirements contained in Section 103 of WRDA 86, as amended. In accordance with Section 103(d), the Federal Government and the non-Federal sponsor are responsible for 65 percent and 35 percent, respectively, of the costs for initial construction and 50 percent each of the costs for periodic nourishment. In addition, the cost sharing for the Tentatively Selected Plan was modified to reflect the impact of the Little Creek Federal navigation project on the recession of the adjacent project area shoreline resulting in a 70.2 percent Federal ($12,914,000), 29.8 percent non-Federal ($5,480,000) cost sharing for initial construction and a 57.4 percent Federal ($4,301,000), 42.6 percent non-Federal ($3,186,000) cost sharing for renourishment.

The following table presents the cost sharing requirements for the Tentatively Selected Plan in accordance with the provisions of P.L. 113-2.   Title X, Chapter 4 of PL 113-2 states "…*Provided further*, That the non-Federal cash contribution for projects using these funds shall be financed in accordance with the provisions of Section 103(k) of Public Law 99-662 over a period of 30 years from the date of completion of the project or separable element." The initial construction costs are shown at October 2012 price levels, with 100 percent Federal cost allocation, inclusive of real estate costs. The sharing of the renourishment costs remains unchanged by P.L 113-2.

Table 41. COST APPORTIONMENT (INITIAL CONSTRUCTION AND RENOURISHMENT) FOR THE TENTATVIELY SELECTED PLAN IN ACCORDANCE WITH P.L.113-2

Item	Cost Share Percentage	Amount
Initial Construction		
Federal (1)	100	$18,394,000
Non-Federal (1)	0	$0
Total	100	$18,394,000
Renourishment		
Federal	57.4	$4,301,000
Non-Federal	42.6	$3,186,000
Total	100	$7,487,000

(1) The Federal Government will provide upfront funding of the entire cost of initial project construction, with the non-Federal sponsor repaying its share (29.8% or $5,480,000) financed over a period of 30 years from the date of completion of initial construction in accordance with the provisions of Section 103(k) of Public Law 99-662.

10.2 APPLICABILITY OF SECTION 902 OF WRDA 1986, AS AMENDED

As previously discussed in Sections 8.7.5 and 8.8 of this report, the current cost of the Tentatively Selected Plan exceeds the cost limit calculated for the project in accordance with Section 902 of WRDA 1986, as amended, which would indicate that additional Congressional authorization would be required through a post-authorization change process. However, PL 113-2 includes language that changes the applicability of Section 902 to projects funded by its appropriation. Specifically, it states in Title X, Chapter 4, "…*Provided further,* That for these projects, the provisions of Section 902 of the Water Resources Development Act of 1986 shall not apply to these funds…" As such, there are no Section 902 limits associated with the initial construction of the Tentatively Selected Plan, assuming the construction is undertaken in accordance with P.L. 113-2 funding that is applicable to this project.

10.3 DEMONSTRATION OF AN ECONOMICALLY JUSTIFIED, TECHNICALLY FEASIBLE, AND ENVIRONMENTALLY ACCEPTABLE PROJECT

A portion of P.L. 113-2, Chapter 4 of Title X, states that "…*Provided further,* That upon approval of the Committees on Appropriations of the House of Representatives and the Senate these funds may be used to construct any project under study by the Corps for reducing flooding and storm damage risks in areas along the Atlantic Coast within the North Atlantic Division of the Corps that were affected by Hurricane Sandy that the Secretary determines is technically feasible, economically justified, and environmentally acceptable:" Hurricane Sandy resulted in limited impacts to the project area shoreline in October 2012 which does not change the risk assessment, environmental compliance, or economic justification of the Tentatively Selected Plan. Section 7.4 of this report provides a complete assessment of project-related risks which supports the selection of the Tentatively Selected Plan. The economics presented in this Section 8.7.4 of this report demonstrate economic justification over the 50 year project period of analysis. The draft environmental assessment which immediately follows the main report confirms compliance of the Tentatively Selected Plan with environmental laws, regulations, and policies and demonstrates that the Plan has effectively addressed all environmental concerns of the resource and regulatory agencies.

10.4 DEMONSTRATION OF PROJECT RESILIENCY, SUSTAINABILITY AND CONSISTENCY WITH THE COMPREHENSIVE STUDY

Construction funding provided to the Corps in P.L.113-2 (Chapter 4 of Title X) was provided "to reduce future flood risk in ways that will support the long-term sustainability of the coastal ecosystem and communities and reduce the economic costs and risks associated with large-scale flood and storm events in areas along the Atlantic Coast within the boundaries of the North Atlantic Division of the Corps that were affected by Hurricane Sandy." Resiliency is defined as the ability of something to return to its original shape after it has been pulled, stretched, pressed, bent, and sustainability is defined as the ability to last or continue for a long time without being completely used up or destroyed (Merriam-Webster.com).

The Tentatively Selected Plan contributes to the resiliency of the project area shoreline and affects the sustainability of environmental conditions in the project area. The Plan represent a resilient and sustainable solution to the storm damage problems of the project area in that it was formulated to provide a reasonable balance between an acceptable degree of protection and the maintenance of the existing character and aesthetics of the beach and dune environment. It would also allow for the maintenance and appearance of the existing dune system as a continued local responsibility which would afford the non-Federal sponsor greater flexibility in effectively addressing issues regarding dune encroachment and the existing view of the Chesapeake Bay. Additionally, the project would take advantage of the existing and planned offshore breakwaters which are located in the most problematic areas of the project area, thereby increasing the performance and effectiveness of the combined beach fill--breakwater system and reducing renourishment requirements.

While it is acknowledged that the Comprehensive Study will not be completed for some time, the Tentatively Selected Plan has been found to be consistent with the guiding principles established for the Study, thereby making it possible to project that the Plan will be consistent with the Study's findings and recommendations upon its completion. The Plan is a beach fill project which addresses the principle that recognizes the preference for plans that provide protection with the use of sand features, are readily adaptable, and could be modified or terminated based upon the findings of the Comprehensive Study. The overall risk management is to be provided with beachfill and periodic nourishment in combination with an existing storm warning system and temporary evacuation program operated by the non-Federal sponsor that would evacuate residents from the floodplain well in advance of a coastal storm event. The recommended design has accounted for sea level rise. Existing programs by the City of Norfolk would complement the Tentatively Selected Plan in addressing Study's principle emphasizing the need for integrated land-use planning, based upon current understanding of risks. The City has implemented the long term revitalization of the project area through a strategy of slow and progressive public and private redevelopment. 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 regulations. The city of Norfolk is a participant in the National Flood Insurance Program.

10.5 SUMMARY

The Tentatively Selected Plan is one of several "authorized but unconstructed" coastal and storm damage reduction projects within the USACE North Atlantic Division boundaries covered by the provisions of P.L. 113-2. As demonstrated in the above paragraphs, the Plan has been found to address the specific implementation changes and acknowledgements to the normal Civil Works process stipulated by P.L. 113-2. These changes and acknowledgements include the PPA, cost-sharing, Section 902 applicability, risks, sustainability, resiliency, and consistency with the Comprehensive Study. The Tentatively Selected Plan is, therefore, implementable under the provisions of P.L. 113-2.

11.0 PROJECT MANAGEMENT PLAN

A Project Management Plan, through the award of the first construction contract, will be developed for the final plan ultimately approved for implementation and will be printed as a separate document.

12.0 CONCLUSIONS

The coastal storm problems and needs of the study area have been reviewed and evaluated with regard to the overall public interest and with consideration to engineering, economic, environmental, social, and cultural concerns. The conclusions drawn by this study are as follows:

a. The Chesapeake Bay shoreline of the city of Norfolk, between the northern jetty of Little Creek Inlet and the terminal groin at Willoughby Spit, is susceptible to major damage and erosion from coastal storm activity.

b. The Tentatively Selected Plan, which is also the LPP, would consist of the initial construction of a beach berm and periodic beach nourishment along the entire 7.3 mile study area shoreline to provide for an effective coastal storm damage reduction project. The protective berm would have an average width of 60 feet constructed at an elevation of 3.5 feet, NAVD 88, with a foreshore slope of one on 20 extending to the natural bottom. The constructed berm would be monitored and maintained at such time that the berm erodes to a width of 30 feet, resulting in a renourishment cycle of once every nine years on average. The city of Norfolk would continue to maintain the existing dune system at their expense throughout the life of the project. The city would also continue to operate its existing storm warning system and temporary evacuation program which would evacuate residents from the floodplain well in advance of a coastal storm event.

c. The deviation from the NED Plan would result in no additional costs for the non-Federal sponsor, since the Tentatively Selected Plan (LPP) is clearly of less scope and cost.

d. The Tentatively Selected Plan is economically, environmentally, culturally, engineering, and socially feasible and has a benefit-to-cost ratio of 1.32 to 1.

e. The Tentatively Selected Plan is supported by the non-Federal sponsor, the city of Norfolk, which has the capability to provide the necessary non-Federal requirements presented in the "Division of Plan Responsibilities" section of this report.

f. The Tentatively Selected Plan is one of several "authorized but unconstructed" coastal and storm damage reduction projects covered by the provisions of the Disaster Relief Appropriations Act of 2013 (P.L. 113-2) which was enacted in response to the catastrophic damages to the Atlantic coastline caused by Hurricane Sandy in late October 2012. The Plan has been found to address the specific implementation changes and acknowledgements to the normal Civil Works process stipulated by P.L. 113-2 and is deemed implementable under the provisions of P.L. 113-2.

13.0 RECOMMENDATIONS

In view of the conclusions just presented, I recommend the implementation of the Tentatively Selected Plan (also referred to as the LPP) at Norfolk, Virginia, in accordance with the provisions of the Disaster Relief Appropriations Act of 2013 (Public Law 113-2), with such modifications thereof, as in the discretion of the Commander, HQUSACE, may be advisable, at initial construction costs currently estimated at $18,394,000. This recommendation is subject to the cost sharing policies as outlined in this report and is endorsed, provided that, prior to construction, the non-Federal sponsor enters into a written PPA, as required by Section 221 of Public Law 91-161, as amended, to provide local cooperation satisfactory to the Secretary of the Army. All cost sharing requirements as stated in law and regulation will be satisfied prior to initiating project construction and prior to each nourishment cycle. Such local cooperation would include the following non-Federal responsibilities in addition to the responsibility for fulfilling the requirements of law for the selected project:

a. In accordance with the cost sharing provisions of Section 103(d) of WRDA 1986, as amended, and P.L. 113-2 and the modifications to reflect the impact of the Little

Creek Federal navigation project on the recession of the adjacent project area shoreline, repay 29.4 percent of the initial project construction cost through financing over a period of 30 years from the date of completion of initial project construction in accordance with the provisions of Section 103(k) of P. L. 99-662. Also provide 42.6 percent of the renourishment costs for each renourishment cycle over the 50-year life of the project.

b. Provide all lands, easements, and rights-of-way, and perform or ensure the performance of any relocations determined by the Federal Government to be necessary for the initial construction, periodic nourishment, operation, and maintenance of the project;

c. As long as the project elements remain authorized; operate, maintain, repair, replace, and rehabilitate the completed project elements, or functional portion of project elements, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and regulations and any specific directions prescribed by the Federal Government.

d. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor, now or hereafter, owns or controls for access to the project elements for the purpose of inspection, and, if necessary after failure to perform by the non-Federal sponsor, for the purpose of completing, operating, maintaining, repairing, replacing or rehabilitating the project elements. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the non-Federal sponsor of responsibility to meet the non-Federal sponsor's obligations, or to preclude the Federal Government from pursuing any remedy of law or equity to ensure faithful performance.

e. Hold and save the United States free from all damage arising from initial construction, periodic nourishment, operation, maintenance, repair, replacement, and rehabilitation of the project elements and any project related betterments, except for damages due the fault or negligence of the United States or its contractors.

f. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project elements in accordance with the standards of 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.

g. Perform, or cause to be performed, any investigations determined to be necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Public Law 96-510, amended, 422 U.S.C. 9601-9875, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for initial construction, periodic nourishment, operation, and maintenance of the project elements. However, for lands that the Federal Government determines to be subject to navigation servitude, the non-Federal sponsor must obtain prior written instruction from the District Engineer regarding the method of testing and must perform such investigations only in accordance with those instructions. The Government shall have no obligation under the Project Partnership Agreement (PPA) for the costs of any investigations performed under this paragraph.

h. Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor for all necessary cleanup and response cost of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-ways that the Federal Government determines to be necessary for the initial construction, periodic nourishment, operation, or maintenance of the project elements.

i. Agree that the non-Federal sponsor shall be considered the operator of the project elements for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project elements in a manner that will not cause liability to arise under CERCLA.

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970. P. L. 91-646, as amended by the Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, P. L. 100-17, and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the initial construction, periodic nourishment, operation, and maintenance of the project elements, including those necessary for relocations, borrow materials, and dredge or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

k. Comply with all applicable Federal and state laws and regulations, including but not limited to, Section 601 of the Civil Rights Act of 1964, P. L. 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army.

l. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of one percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement.

m. Continue to participate in and comply with applicable Federal flood plain management and flood insurance programs.

n. Not less than once a year inform affected interests of the extent of protection afforded by the project elements.

o. Publicize flood plain management information in the areas of concern 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 protection provided by the project elements.

p. For so long as the project elements remain authorized, the non-Federal sponsor shall ensure continued conditions of public ownership and use of the shore upon which Federal participation is based.

q. Provide and maintain necessary access roads, parking areas, and other public use facilities open and available to all on equal terms.

r. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project elements that would reduce the level of protection it affords or that would hinder operation and maintenance of the project elements.

s. Control water pollution that would endanger the health of bathers.

t. Contribute 100 percent of the incremental first cost and periodic nourishment costs associated with maintaining the existing dunes.

u. Provide all lands, easements, rights-of-way, and relocations necessary for the project free and clear of all environmental hazards, including ordnance and ordnance-related scrap metal.

v. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to have prepared a flood plain management plan within one year after the date of signing a PPA. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by non-Federal interests to preserve the level of flood protection provided by the project. As required by Section 402, as amended, implement the plan not later than one year after completion of construction of the project. Provide an information copy of the plan to the Government upon its preparation.

w. At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal Government.

14.0 NOTE ON THE INFORMATION PRESENTED IN THIS DOCUMENT

The information contained herein reflects the policies governing formulation of individual projects and the information available at this time. It does not necessarily reflect program and budgeting priorities inherent in the local and state program or the formulation of a National Civil Works Construction Program. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsor, the city of Norfolk; interested Federal agencies; and other parties would be advised of any modifications and would be afforded an opportunity to comment further.

PAUL B. OLSEN, P.E.
Colonel, Corps of Engineers
Commanding

15.0 ABBREVIATIONS

ASA (CW) – Assistant Secretary of the Army for Civil Works
CERCLA -- Comprehensive Environmental Response, Compensation, and Liability Act
EA -- Environmental Assessment
EFH -- Essential Fish Habitat
EPA -- U.S. Environmental Protection Agency
ER -- Engineer Regulation
°F -- degrees Fahrenheit
FEMA -- Federal Emergency Management Agency
FIA -- Federal Insurance Administration
FWS – US Fish and Wildlife Service
GIS -- geographic information system
HAPC -- Habitat Area of Particular Concern
HTRW -- hazardous, toxic, and radiological waste
IDC -- interest during construction
IWR -- Institute of Water Resources
LERRD -- lands, easements, rights-of-way, relocations, and disposal areas
LPP -- Locally Preferred Plan
m.h.w. -- mean high water
m.l.w. -- mean low water
m.l.l.w. -- mean lower low water
MSA -- Metropolitan Statistical Area
m.s.l – mean sea level
NAVD -- North American Vertical Datum
NED -- national economic development
NEPA -- National Environmental Policy Act
NER -- national ecosystem restoration
NFIP – National Flood Insurance Program
NGVD -- National Geodetic Vertical Datum
NMFS -- National Marine Fisheries Service
NWI -- National Wetland Inventory
OMRR&R -- operation, maintenance, repair, rehabilitation, and replacement
P. L.—Public Law
PPA -- Project Partnership Agreement
PED – preconstruction engineering and design
SAV -- submerged aquatic vegetation
TSS -- total suspended solids
USACE -- U.S. Army Corps of Engineers
USFWS -- U.S. Fish and Wildlife Service
VDEQ -- Virginia Department of Environmental Quality
VDHR -- Virginia Department of Historic Resources
VDNH -- Virginia Division of Natural Heritage
VIMS -- Virginia Institute of Marine Science
VMRC -- Virginia Marine Resources Commission
WRDA -- Water Resources Development Act

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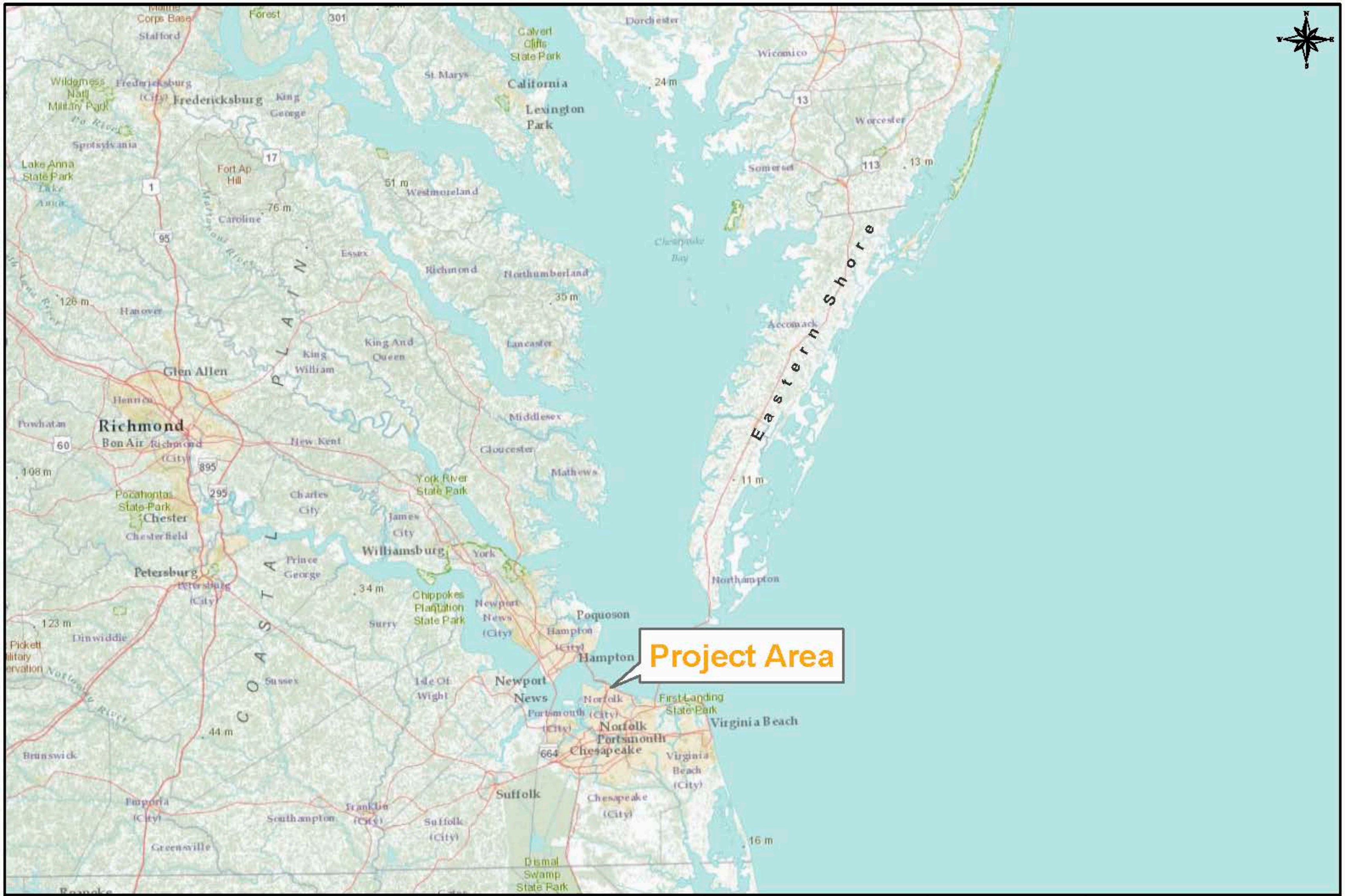


US Army Corps of Engineers
Norfolk District

Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Project Location

January 2013

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI Online Bing Maps Road

Project Manager: Robert Pretlow
E-mail: robert.n.pretlow@usace.army.mil
Phone: (757) 201-7385
Fax: (757) 201-7036

Prepared by: Karin Dridge, Geospatial Section

Map File: SmallProjectOverviewMap.mxd
Map Date: 23 May 2012

Plate 1

Plate 2

US Army Corps of Engineers
Norfolk District

Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Study Area Map

January 2013

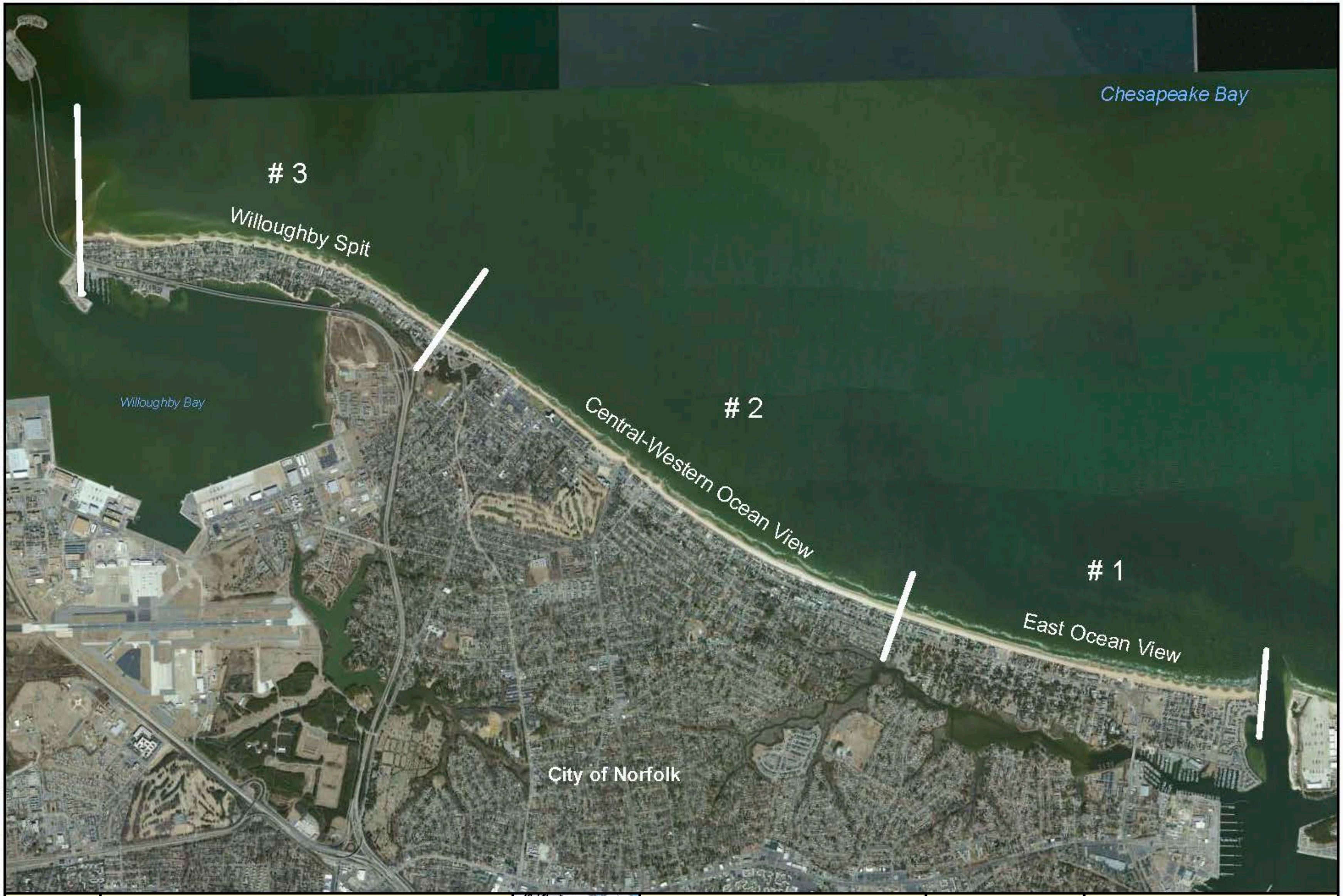
0 0.5 1 1.5 2 Miles

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI Online Bing Maps, Aerial

Project Manager: Robert Pretlow
E-mail: robert.n.pretlow@usace.army.mil
Phone: (757) 201-7385

Prepared by: Karin Dridge, Geospatial Section
Map File: StudyAreaMapPlate2Nov2012.mxd
Map Date: 9 November 2012



US Army Corps of Engineers
Norfolk District

Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Economic Reaches

January 2013

0 0.25 0.5 1 Miles

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI Online Bing Maps Aerial

Project Manager: Robert Pretlow
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Prepared by: Karin Dridge, Geospatial Section

Map File: EconomicReachesPlate3Nov2012.mxd
Map Date: 8 November 2012

Plate 3

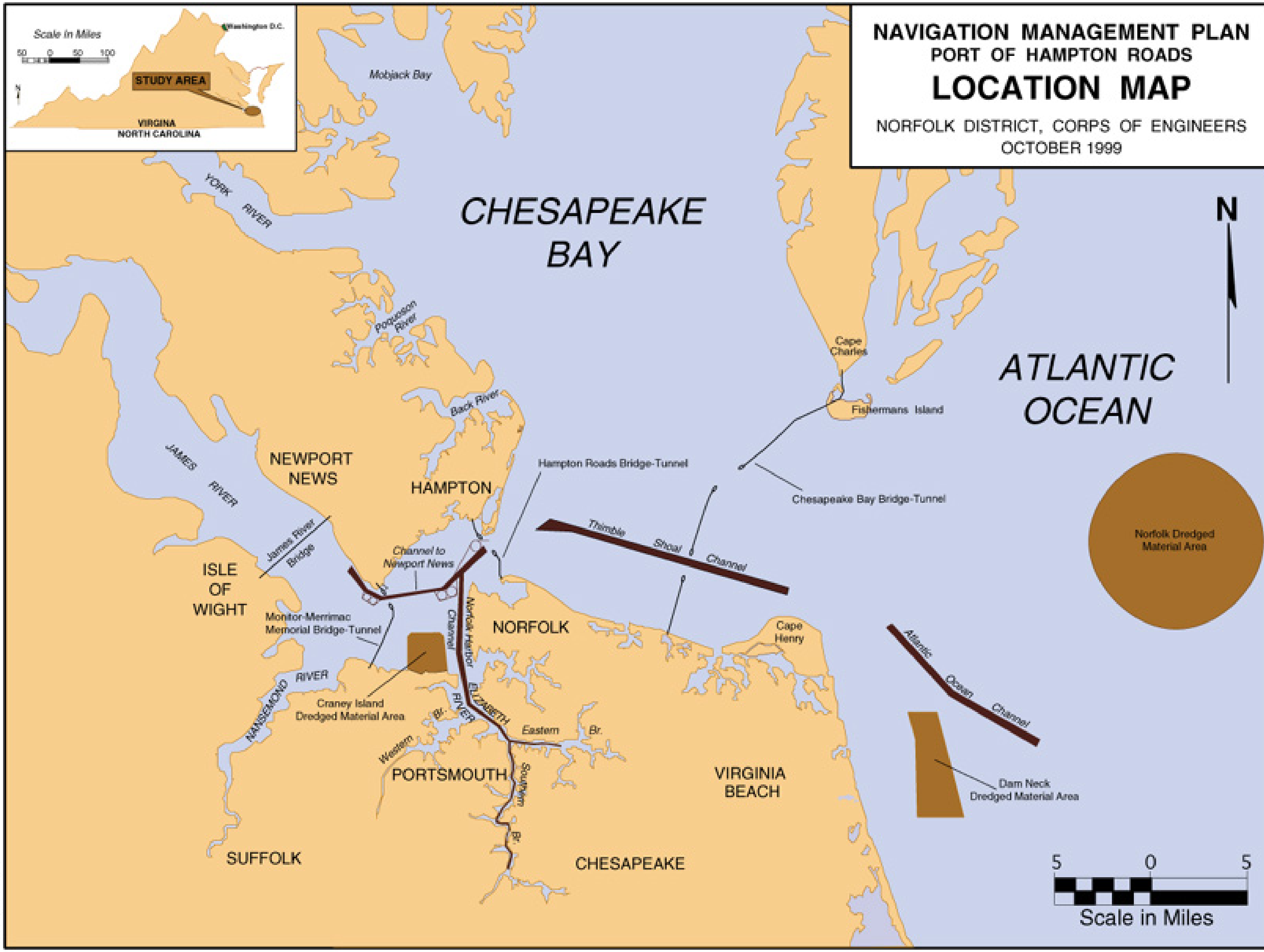
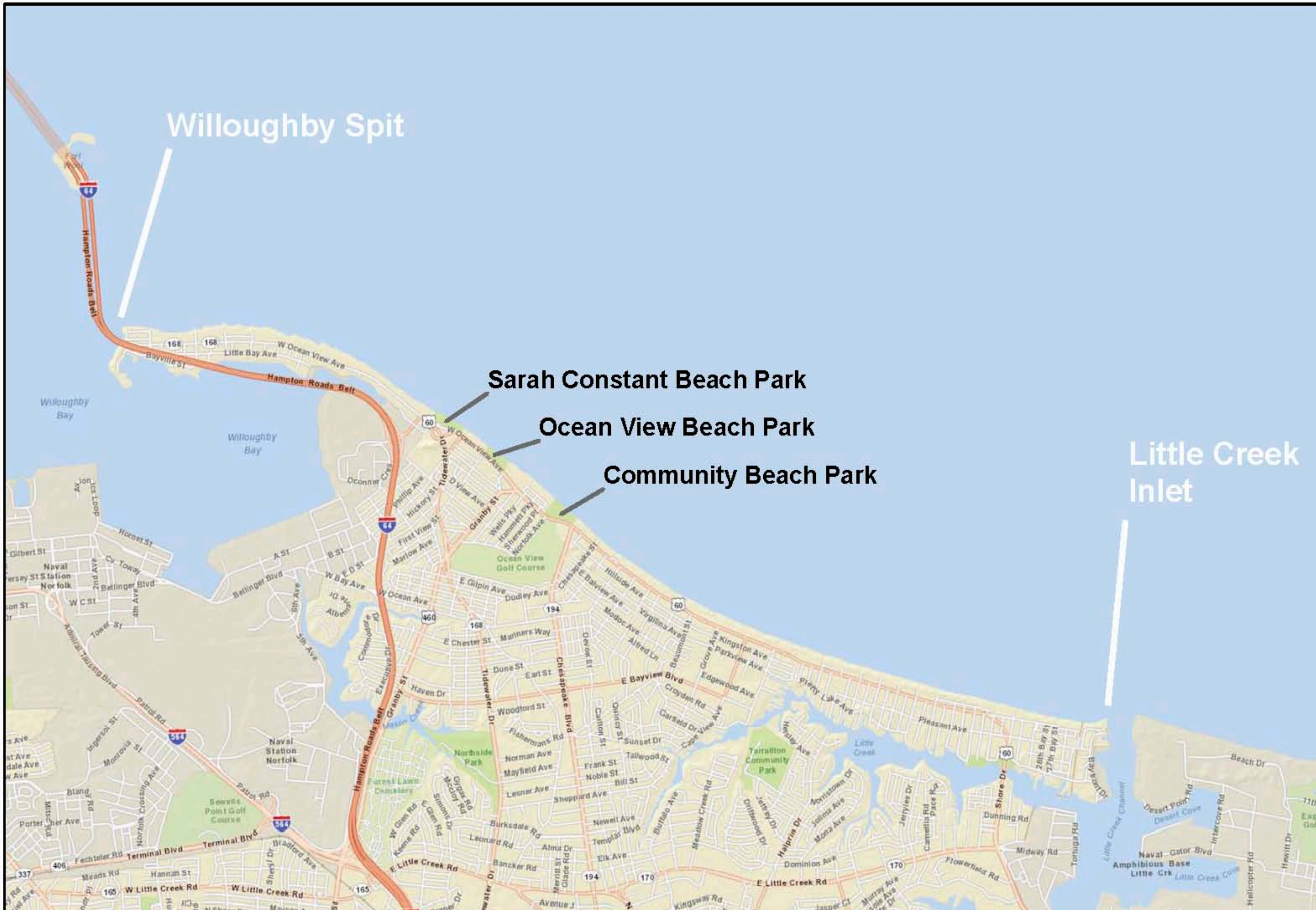

NAVIGATION MANAGEMENT PLAN
PORT OF HAMPTON ROADS
LOCATION MAP
NORFOLK DISTRICT, CORPS OF ENGINEERS
OCTOBER 1999
Scale in Miles
50 0 50 100
Washington D.C.
STUDY AREA
VIRGINIA
NORTH CAROLINA
Mobjack Bay
YORK RIVER
CHESAPEAKE BAY
Poquoson River
Back River
Cape Charles
Fishermans Island
ATLANTIC OCEAN
N
JAMES RIVER
NEWPORT NEWS
HAMPTON
Hampton Roads Bridge-Tunnel
Chesapeake Bay Bridge-Tunnel
Thimble Shoal Channel
Norfolk Dredged Material Area
James River Bridge
Channel to Newport News
ISLE OF WIGHT
Monitor-Merrimac Memorial Bridge-Tunnel
Norfolk Harbor Channel
NORFOLK
Cape Henry
Atlantic Ocean Channel
NANSEMOND RIVER
Craney Island Dredged Material Area
ELIZABETH RIVER
Eastern Br.
Western Br.
Southern Br.
PORTSMOUTH
VIRGINIA BEACH
Dam Neck Dredged Material Area
SUFFOLK
CHESAPEAKE
5 0 5
Scale in Miles

Plate 4



US Army Corps of Engineers
Norfolk District

Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

City of Norfolk Beaches

January 2013

0 0.5 1 1.5 Miles

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI Online Bing Maps, Road

Project Manager: Robert Pretlow
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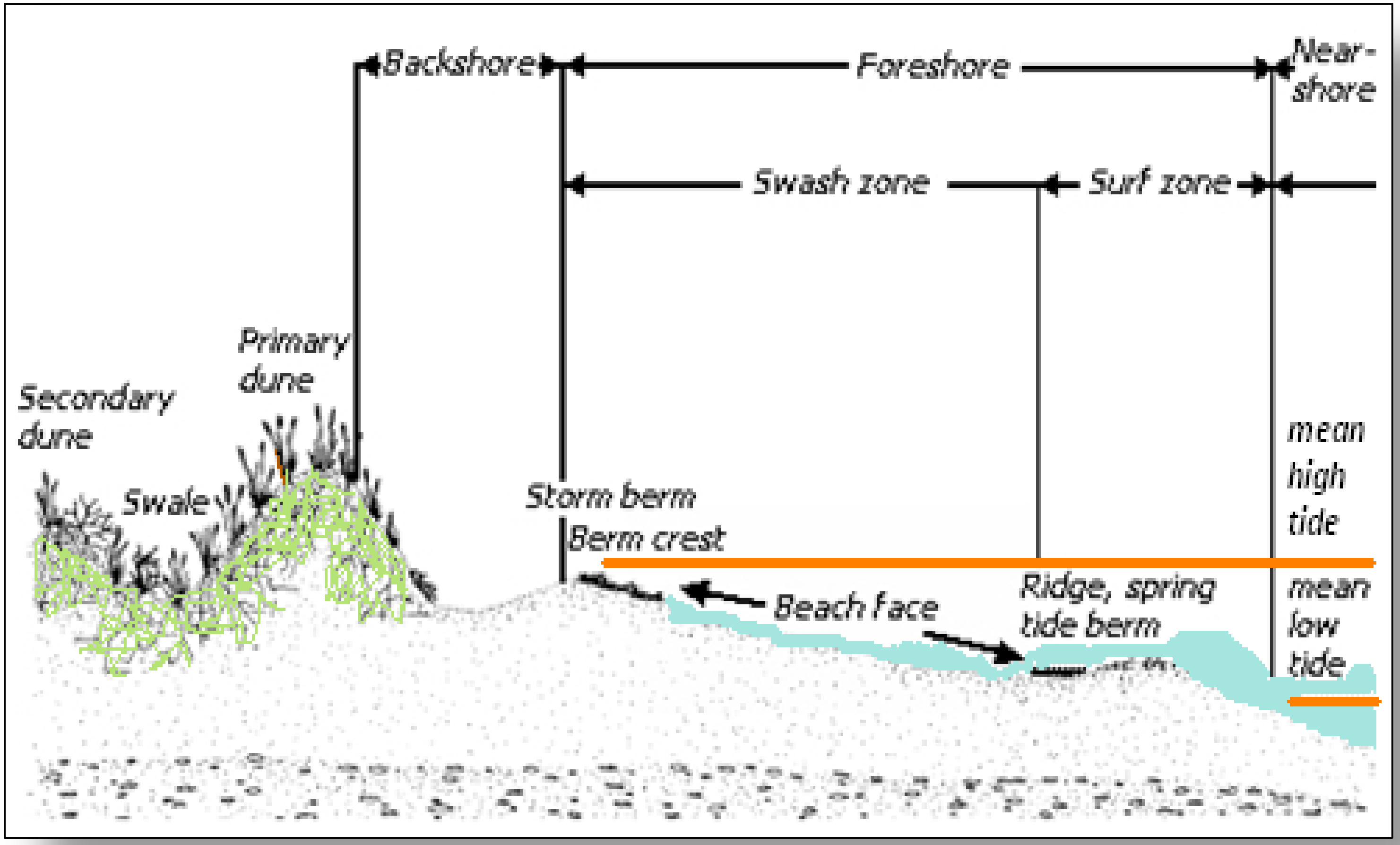
Phone: (757) 201-7385
Fax: (757) 201-7036

Prepared by: Karin Dridge, Geospatial Section

Map File: ProjectRecreationSept21_12.mxd
Map Date: 21 Sept 2012

Plate 5



Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Typical Beach Profile

January 2013
Norfolk District, Corps of Engineers

Plate 6

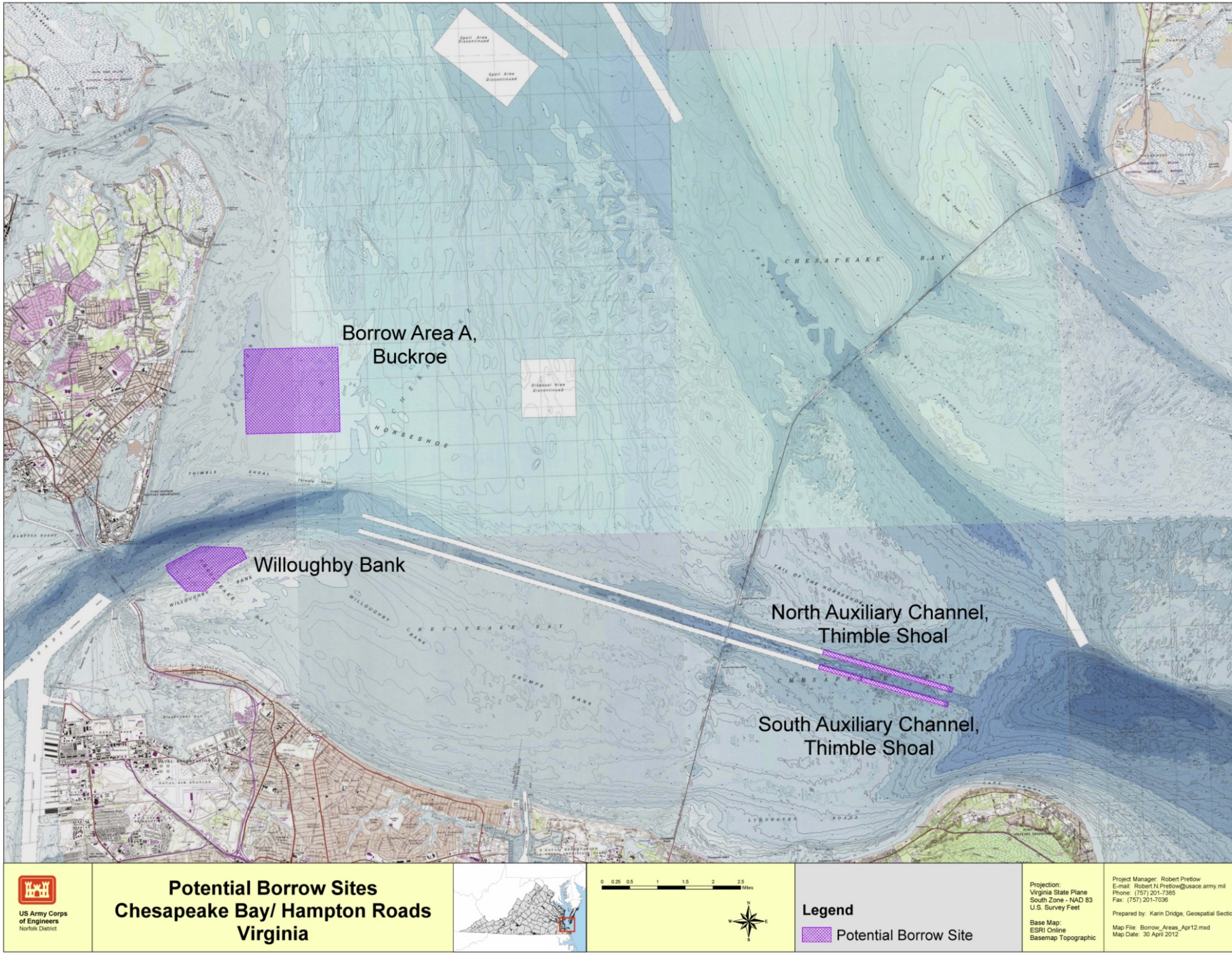
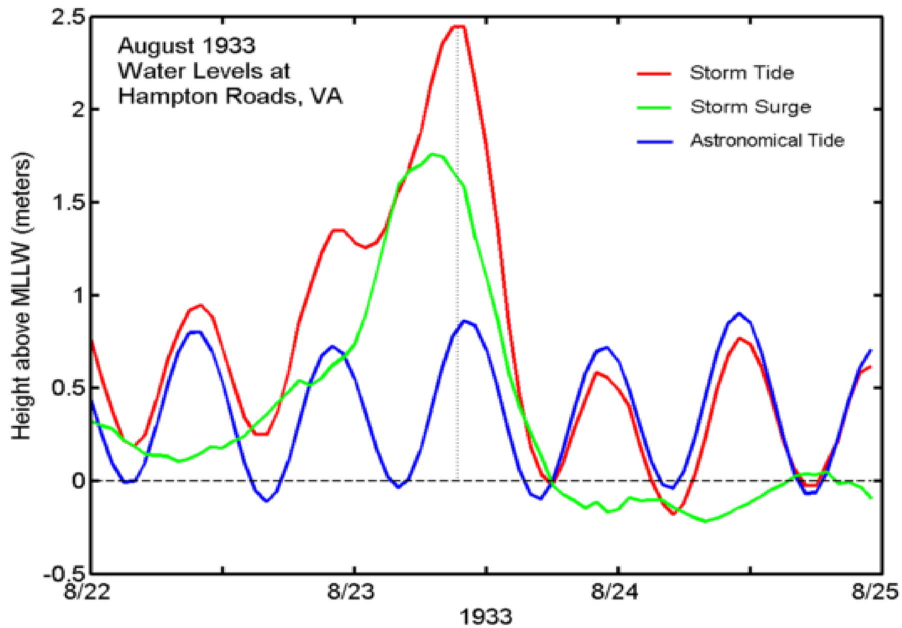
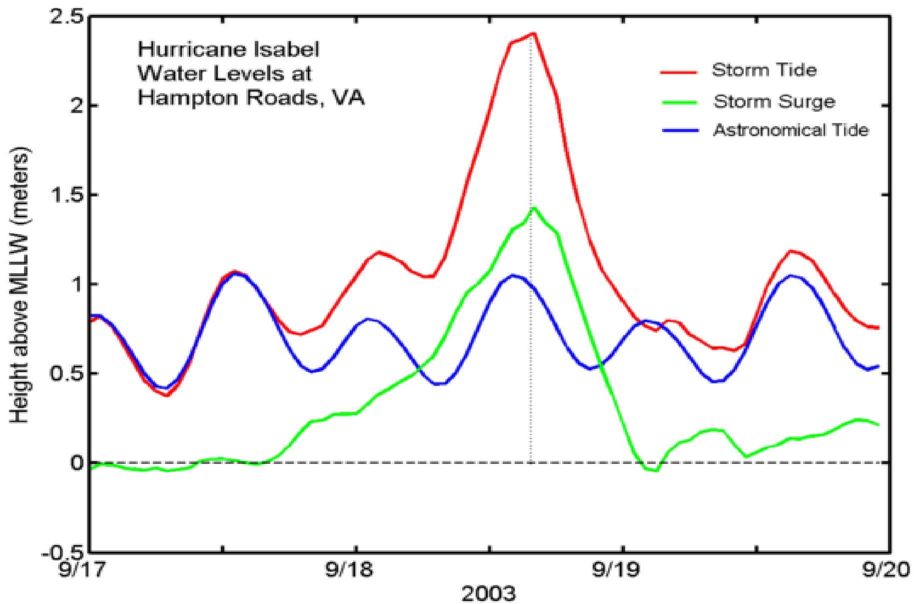

Borrow Area A,
Buckroe
Willoughby Bank
North Auxiliary Channel,
Thimble Shoal
South Auxiliary Channel,
Thimble Shoal
US Army Corps
of Engineers
Norfolk District
Potential Borrow Sites
Chesapeake Bay/ Hampton Roads
Virginia
Legend
Potential Borrow Site
Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet
Base Map:
ESRI Online
Basemap Topographic
Project Manager: Robert Pretlow
E-mail: Robert.N.Pretlow@usace.army.mil
Phone: (757) 201-7385
Fax: (757) 201-7036
Prepared by: Karin Dridge, Geospatial Section
Map File: Borrow_Areas_Apr12.mxd
Map Date: 30 April 2012

Plate 7





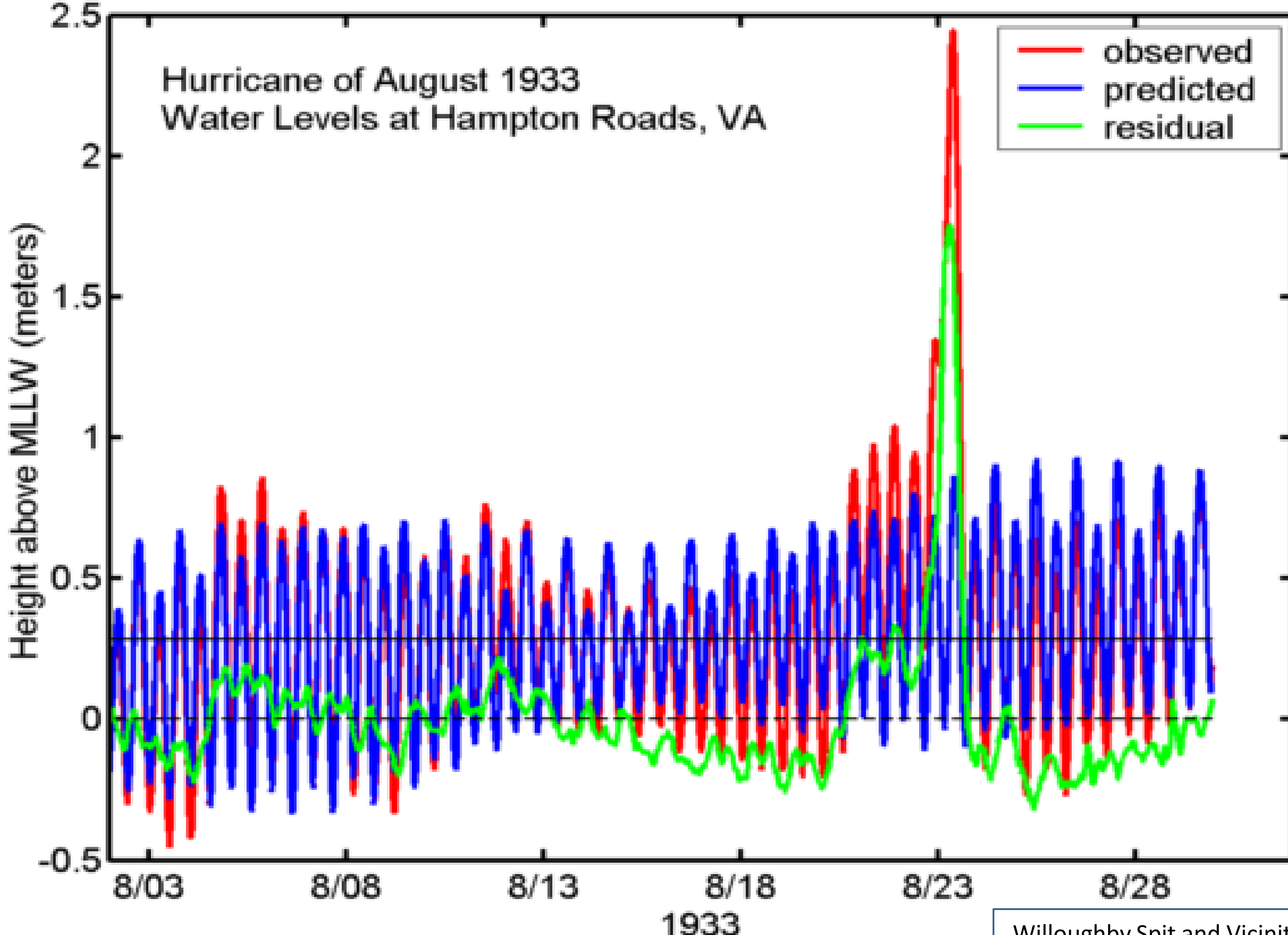
The graph (in meters) on the top shows the peak water level of the 1933 Hurricane and the graph (in meters) on the bottom shows the peak water level from Hurricane Isabel (Images by VIMS).

Willoughby Spit and Vicinity, Norfolk ,Virginia
Hurricane and Storm Damage Reduction

Peak Water Levels

January 2013
Norfolk District, Corps of Engineers

Plate 8



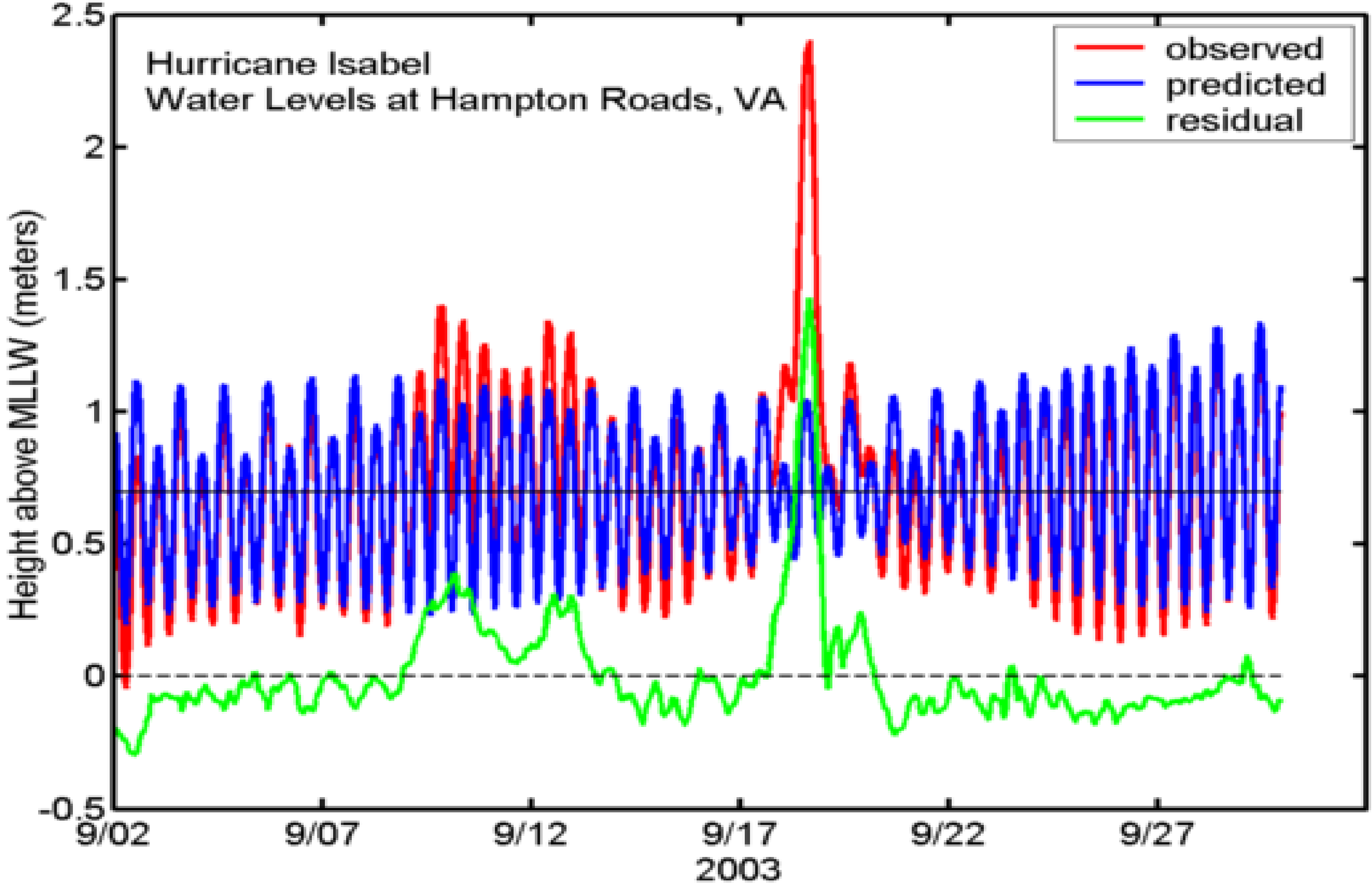
The graph (in meters) is from the 1933 Hurricane (Image by VIMS).

Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Hurricane of August 1933

January 2013
Norfolk District, Corps of Engineers

Plate 9



The graph (in meters) is from Hurricane Isabel (Image by VIMS).

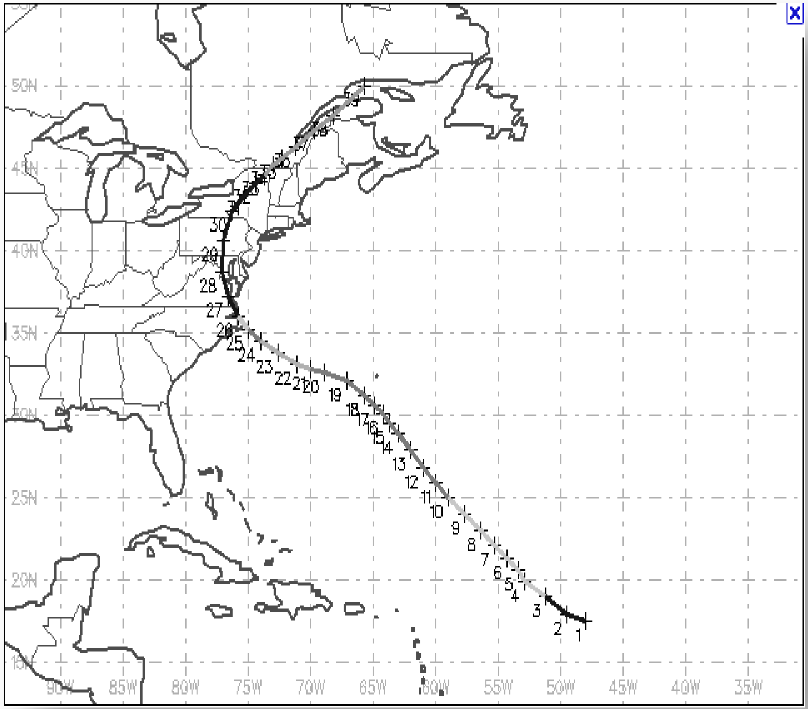
Plates 6 and 7 show the water levels data at Hampton Roads during a three day period, with each plot showing a clear view of the peak height the water level reached when each hurricane was over the area.

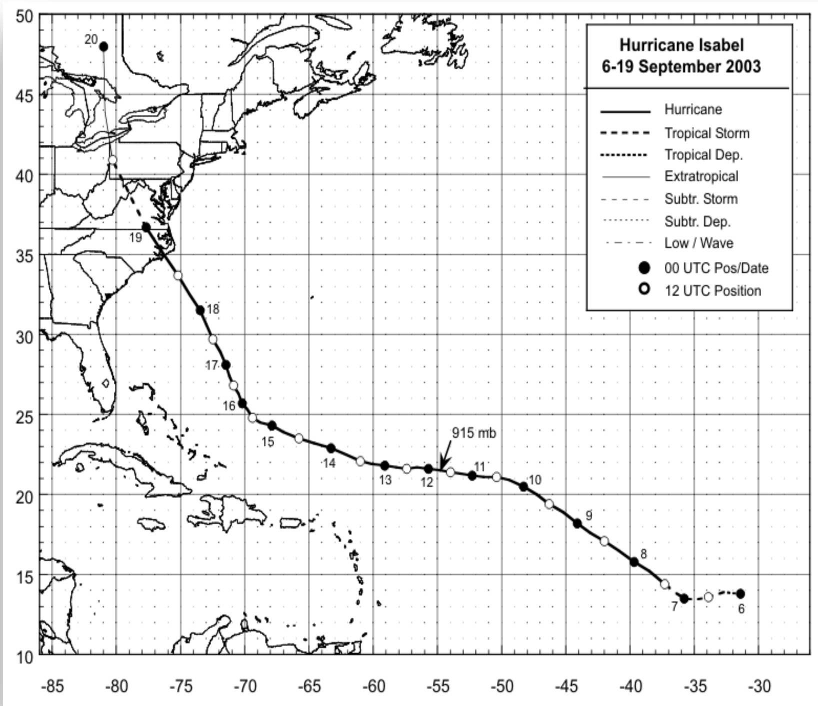
Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Hurricane Isabel

January 2013
Norfolk District, Corps of Engineers

Plate 10





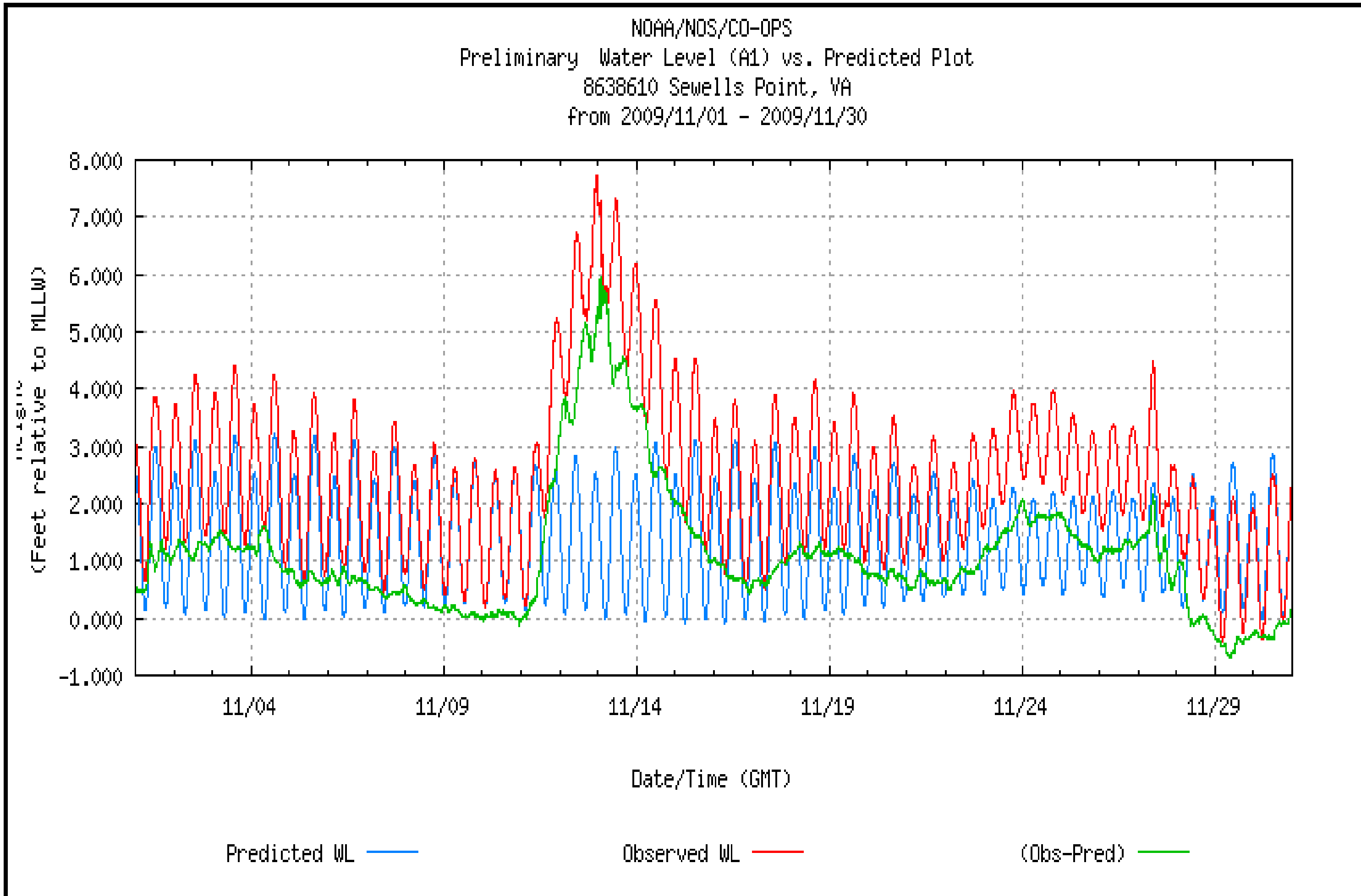
The image on the left shows the track of the 1933 Hurricane and the image to the right shows the track of Hurricane Isabel (Images by NOAA).

Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Storm Tracks

January 2013
Norfolk District, Corps of Engineers

Plate 11



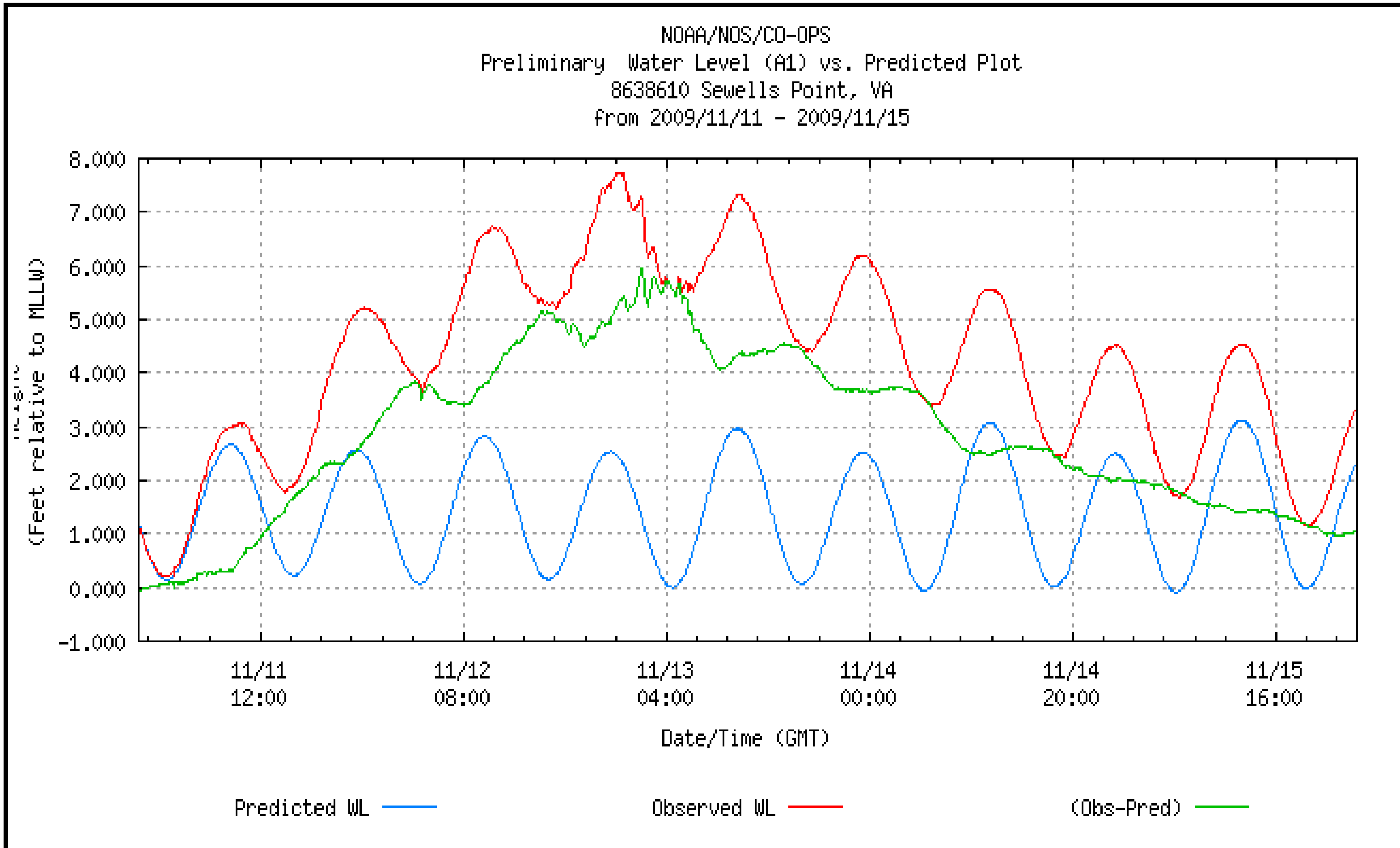
Water level measured at Sewells Point, VA Tidal Gage from November 01, 2009 to November 30, 2009 (Image from NOAA).

Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

November Preliminary vs. Predicted Water Levels

January 2013
Norfolk District, Corps of Engineers

Plate 12



Water level measured at Sewells Point, VA Tidal Gage from November 10, 2009 to November 15, 2009 (Image from NOAA).

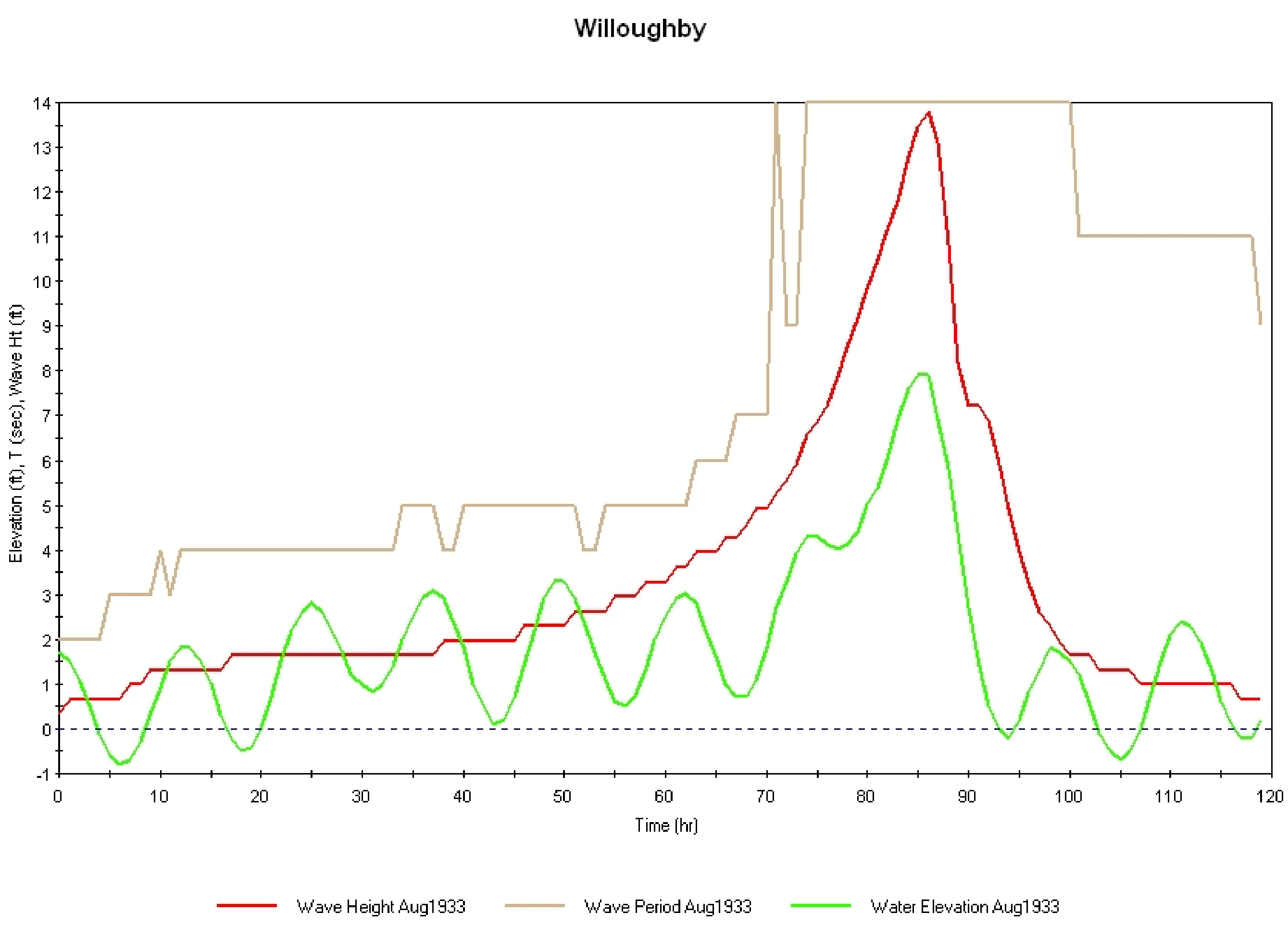
Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

5 Day Preliminary vs. Predicted Water Levels

January 2013
Norfolk District, Corps of Engineers

Plate 13

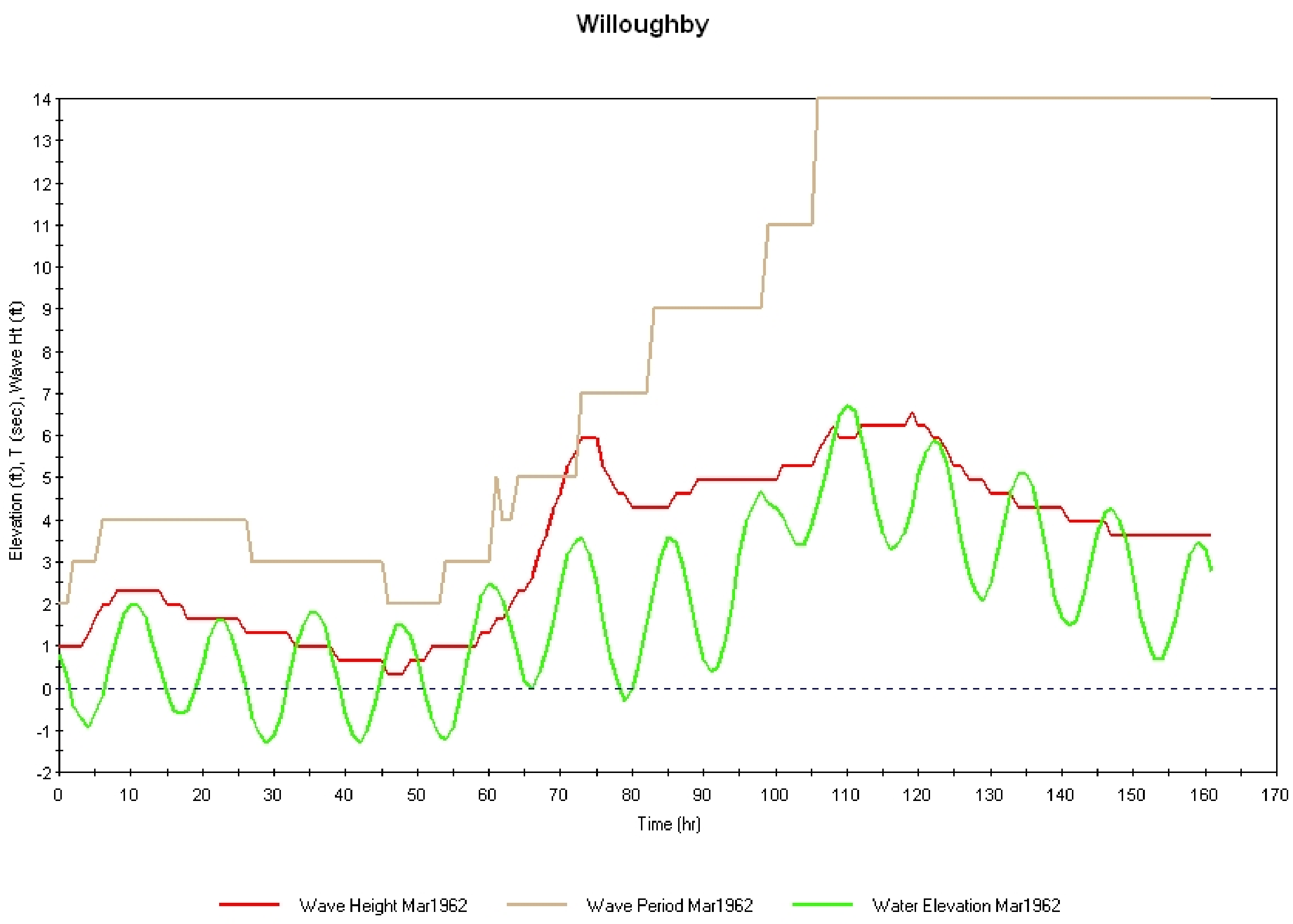
Plate 14



Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Wave Plot August 1933

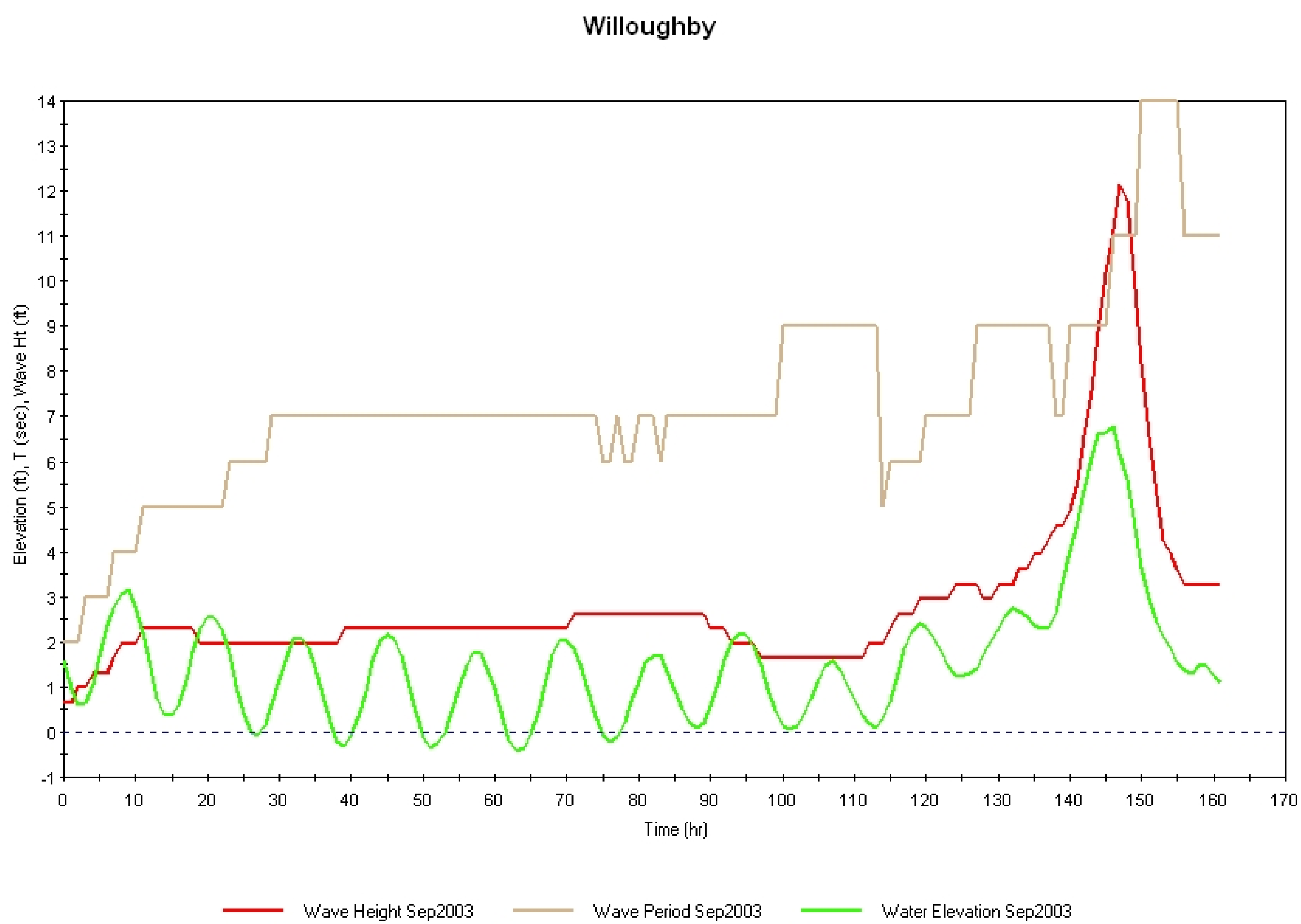
January 2013
Norfolk District, Corps of Engineers



Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Wave Plot March 1962

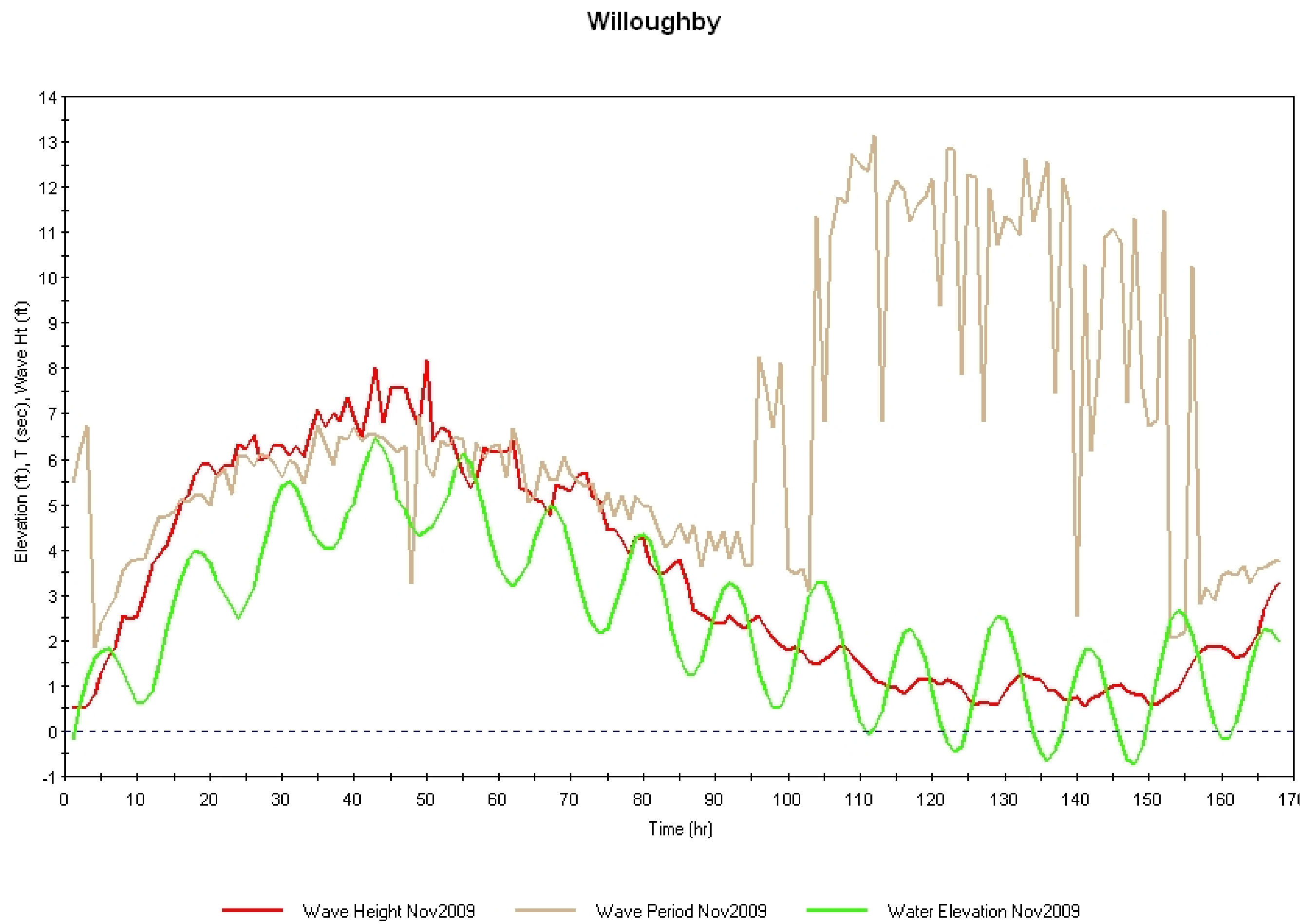
January 2013
Norfolk District, Corps of Engineers



Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Wave Plot September 2003

January 2013
Norfolk District, Corps of Engineers

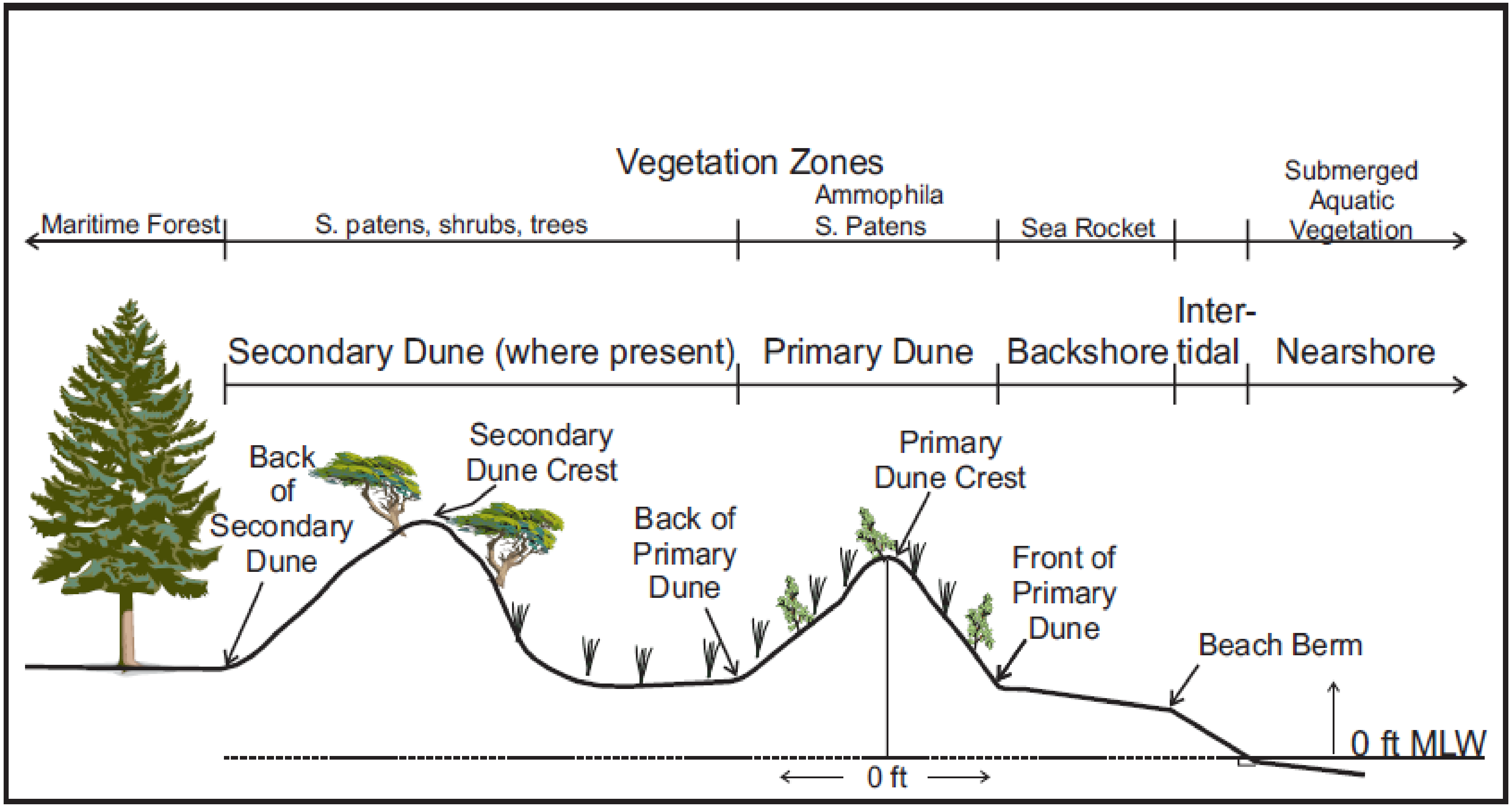


Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Wave Plot November 2009

January 2013
Norfolk District, Corps of Engineers

Plate 17



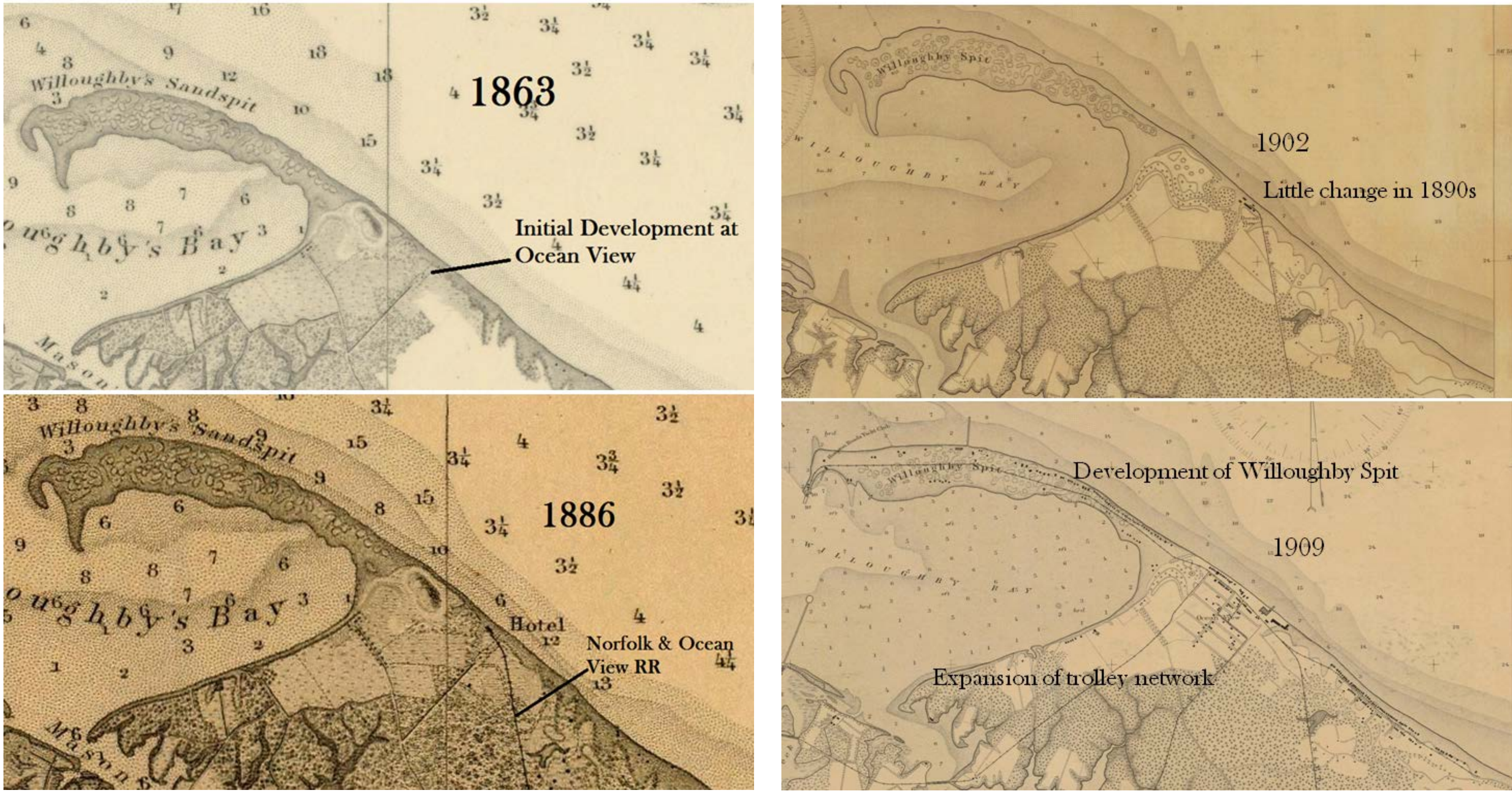
Typical profile of a Chesapeake Bay dune system (from Hardaway *et al.*, 2001). 7

Willoughby Spit and Vicinity, Norfolk ,Virginia
Hurricane and Storm Damage Reduction

Typical Chesapeake Bay Dune Profile

January 2013
Norfolk District, Corps of Engineers

Plate 18

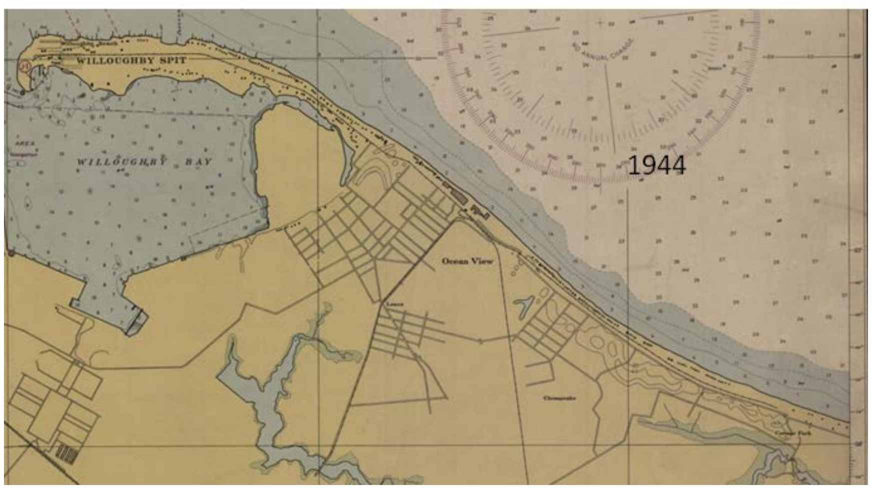


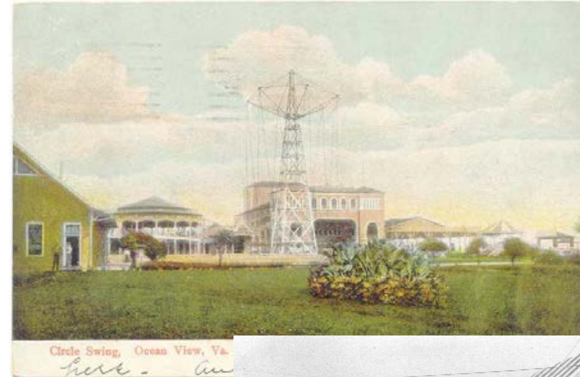
Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

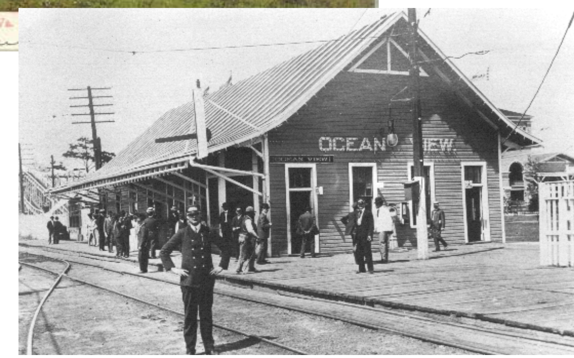
Historic Maps of Willoughby Spit and Ocean View

January 2013
Norfolk District, Corps of Engineers

Plate 19







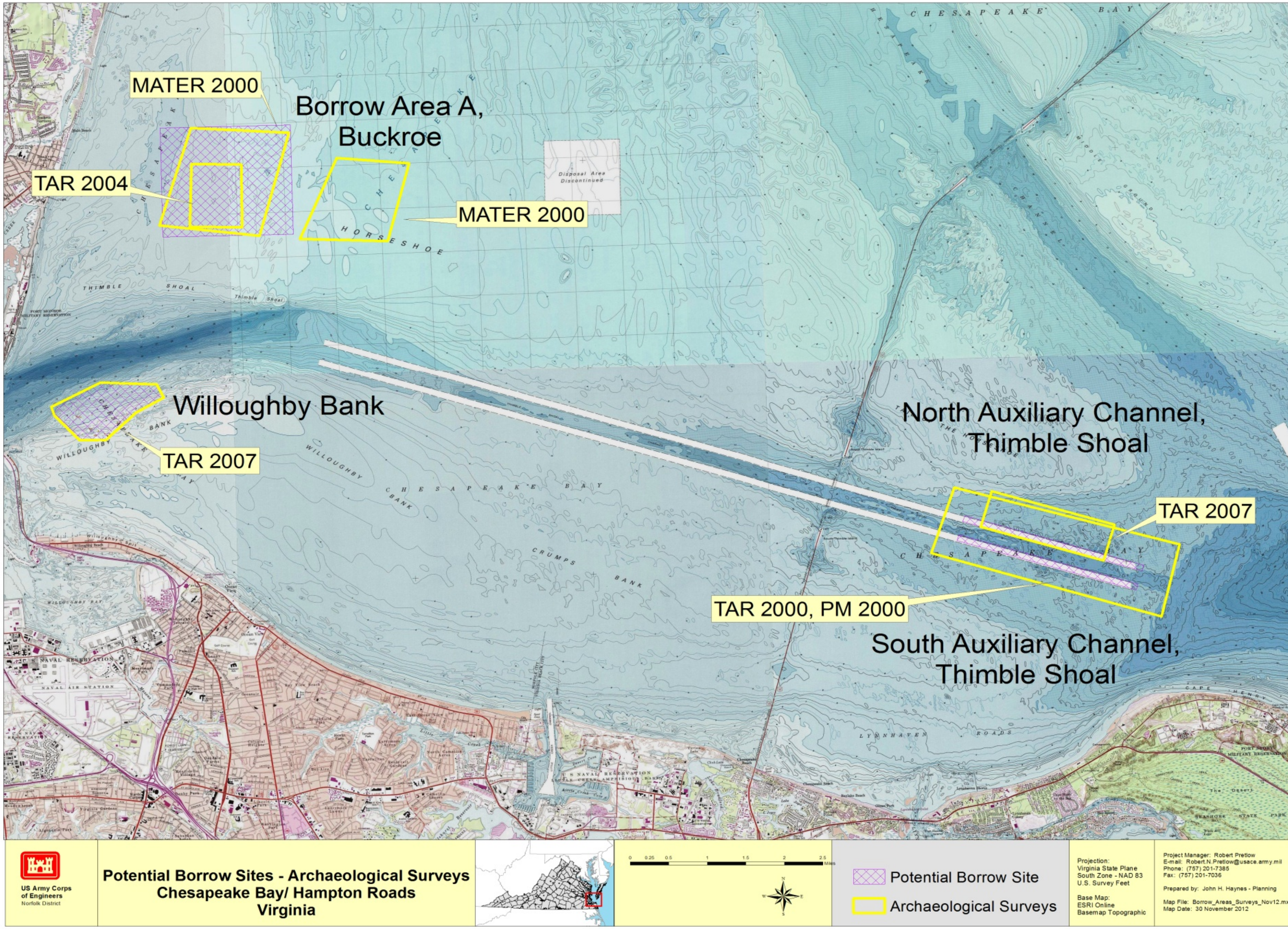
Top right Ocean View Park 1907, middle right Ocean View trolley station 1908, bottom right famous roller-coaster.

Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Historical Maps and Ocean View 20th Century Development

January 2013
Norfolk District, Corps of Engineers

Plate 20



US Army Corps
of Engineers
Norfolk District

Potential Borrow Sites - Archaeological Surveys
Chesapeake Bay/ Hampton Roads
Virginia

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI Online
Basemap Topographic

Project Manager: Robert Pretlow
E-mail: Robert.N.Pretlow@usace.army.mil
Phone: (757) 201-7385
Fax: (757) 201-7036

Prepared by: John H. Haynes - Planning

Map File: Borrow_Areas_Surveys_Nov12.mxd
Map Date: 30 November 2012

Plate 21

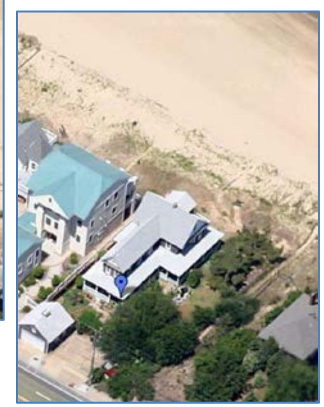
Willoughby and West Ocean View Structures Recored with DHR

17 Chela Avenue   Area

850 W Ocean View Ave.

650 W. Ocean View Ave.

550 W. Ocean View Ave.



502 W. Ocean View Ave.

450 W. Ocean View Ave.

Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Architectural Inventory of Willoughby and Ocean View

January 2013
Norfolk District, Corps of Engineers

Plate 22

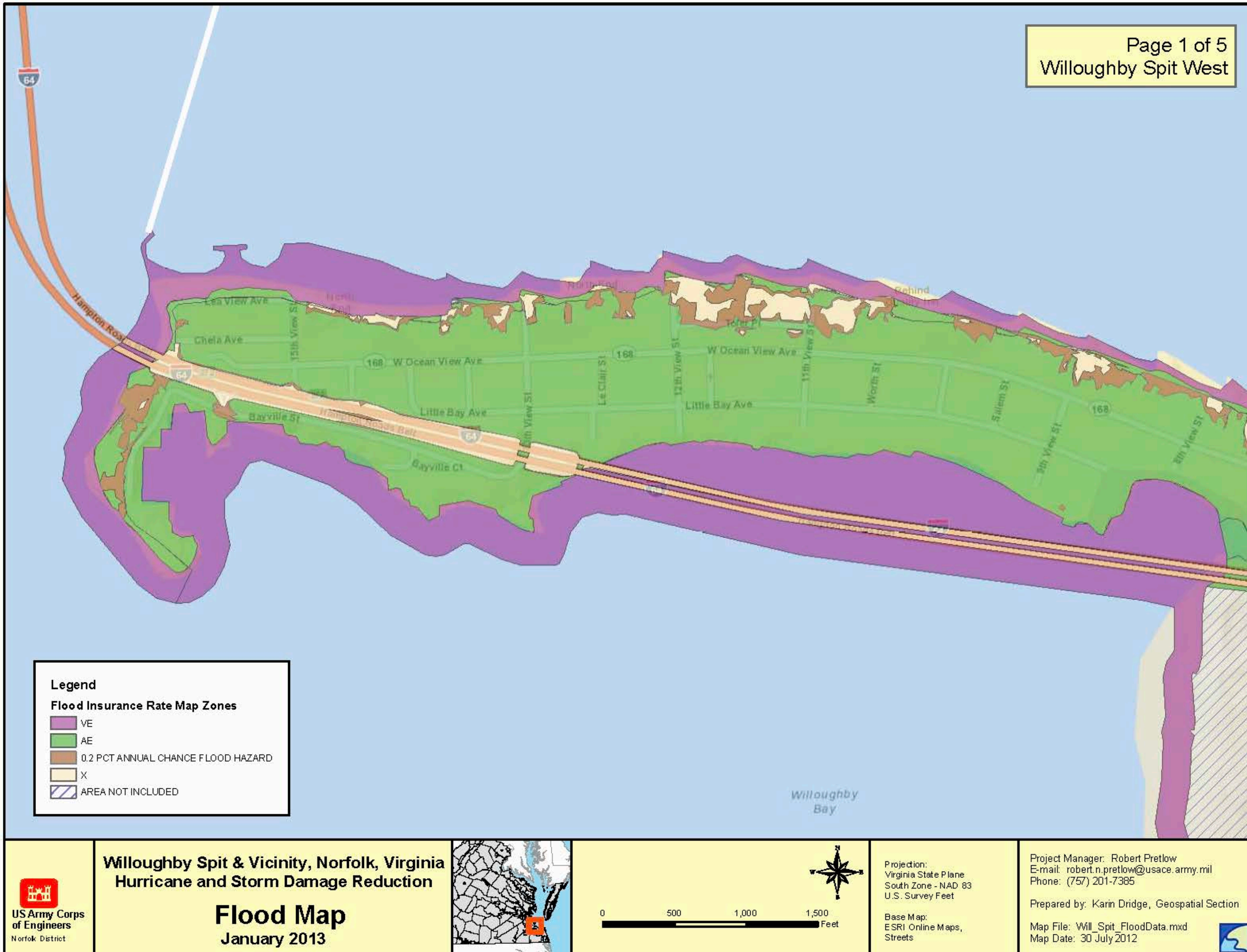

Page 1 of 5
Willoughby Spit West
Hampton Roads
Sea View Ave
Chela Ave
15th View St
W Ocean View Ave
Little Bay Ave
Bayville St
Bayville Ct
Le Clair St
12th View St
11th View St
North St
Salem St
9th View St
8th View St
Willoughby Bay
Legend
Flood Insurance Rate Map Zones
VE
AE
0.2 PCT ANNUAL CHANCE FLOOD HAZARD
X
AREA NOT INCLUDED
US Army Corps of Engineers
Norfolk District
Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction
Flood Map
January 2013
0
500
1,000
1,500
Feet
Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet
Base Map:
ESRI Online Maps,
Streets
Project Manager: Robert Pretlow
E-mail: robert.n.pretlow@usace.army.mil
Phone: (757) 201-7385
Prepared by: Karin Dridge, Geospatial Section
Map File: Will_Spit_FloodData.mxd
Map Date: 30 July 2012

Plate 23

US Army Corps of Engineers
Norfolk District

Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Flood Map

January 2013

0 500 1,000 1,500 Feet

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI Online Maps,
Streets

Project Manager: Robert Pretlow
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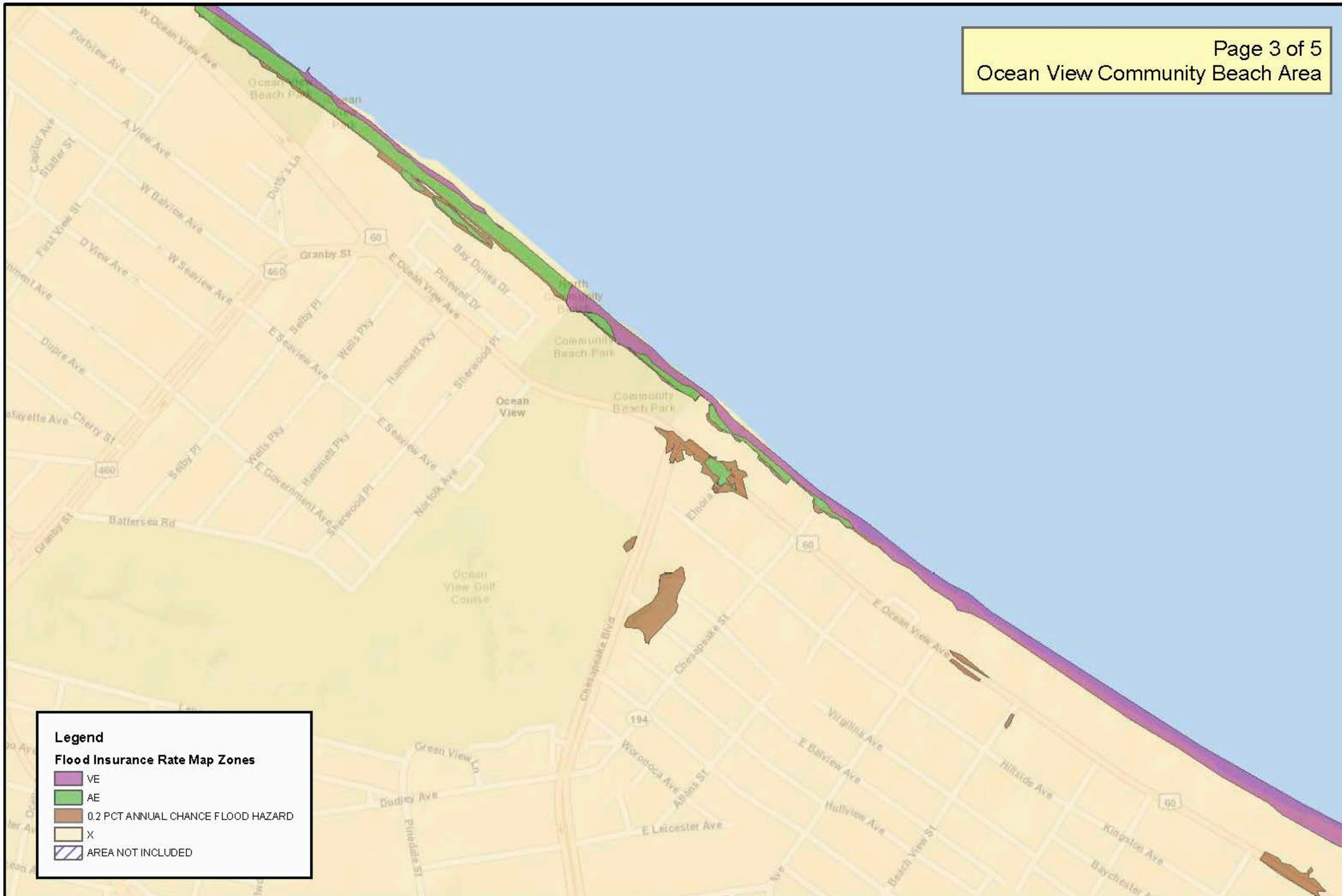
Phone: (757) 201-7385

Prepared by: Karin Dridge, Geospatial Section

Map File: Will_Spit_FloodData.mxd
Map Date: 30 July 2012

Plate 24



Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Flood Map

January 2013

US Army Corps of Engineers
Norfolk District

0 500 1,000 1,500 Feet

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI Online Maps,
Streets

Project Manager: Robert Pretlow
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Phone: (757) 201-7385

Prepared by: Karin Dridge, Geospatial Section

Map File: Will_Spit_FloodData.mxd
Map Date: 30 July 2012

Plate 25

US Army Corps of Engineers
Norfolk District

Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Flood Map

January 2013

0 500 1,000 1,500 Feet

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

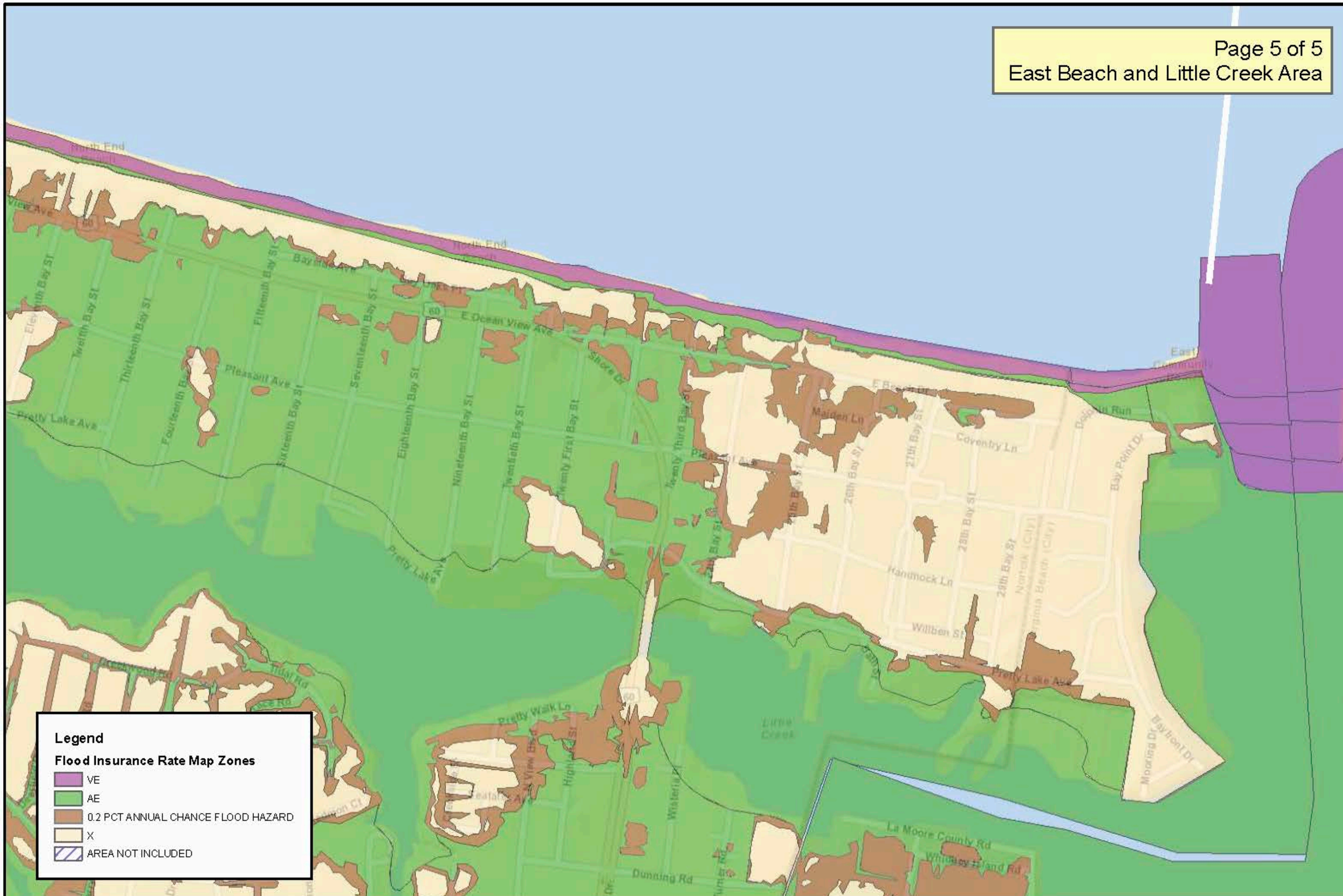
Base Map:
ESRI Online Maps,
Streets

Project Manager: Robert Pretlow
E-mail: robert.n.pretlow@usace.army.mil
Phone: (757) 201-7385

Prepared by: Karin Dridge, Geospatial Section

Map File: Will_Spit_FloodData.mxd
Map Date: 30 July 2012

Plate 26



Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Flood Map

January 2013

US Army Corps of Engineers
Norfolk District

0 | 500 | 1,000 | 1,500 Feet

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

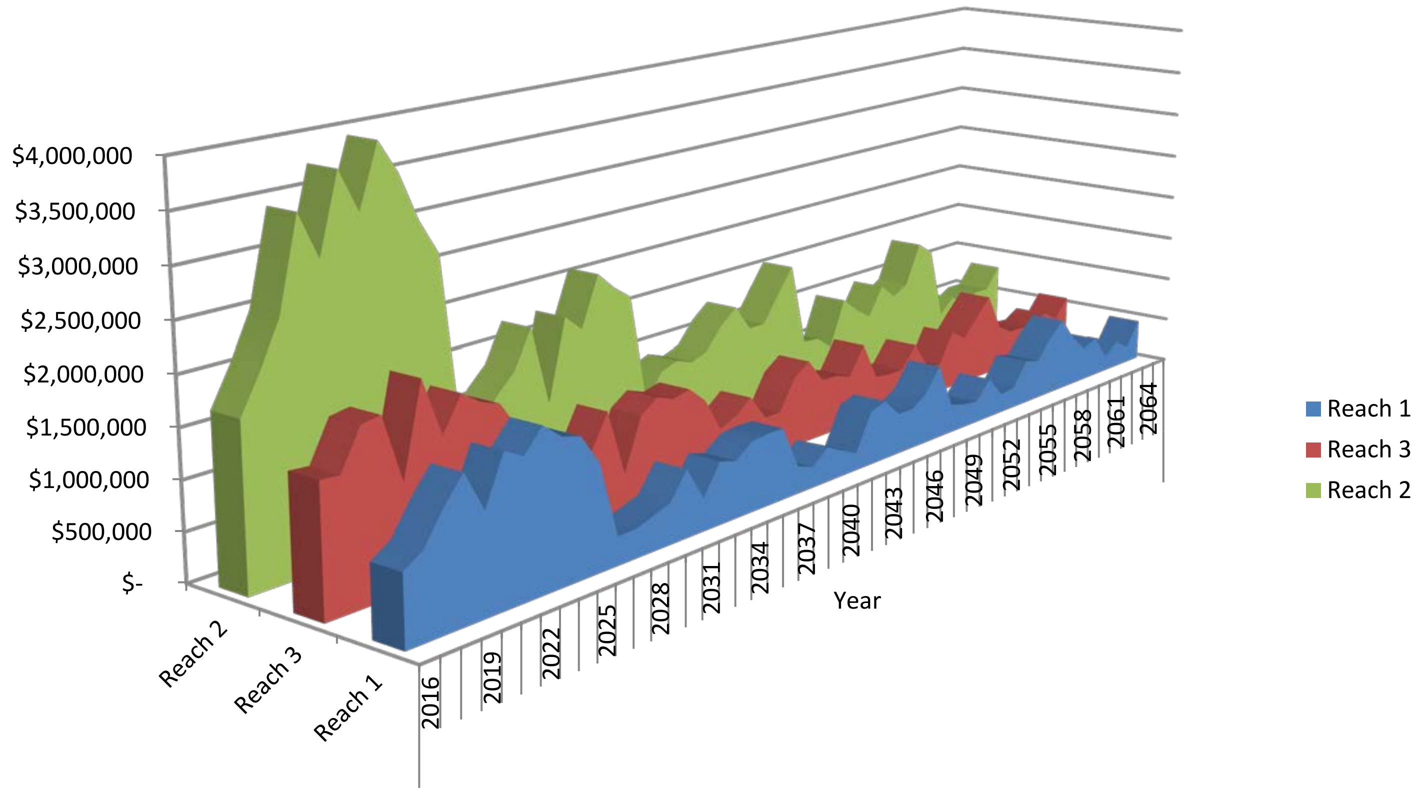
Base Map:
ESRI Online Maps,
Streets

Project Manager: Robert Pretlow
E-mail: robert.n.pretlow@usace.army.mil
Phone: (757) 201-7385

Prepared by: Karin Dridge, Geospatial Section

Map File: Will_Spit_FloodData.mxd
Map Date: 30 July 2012

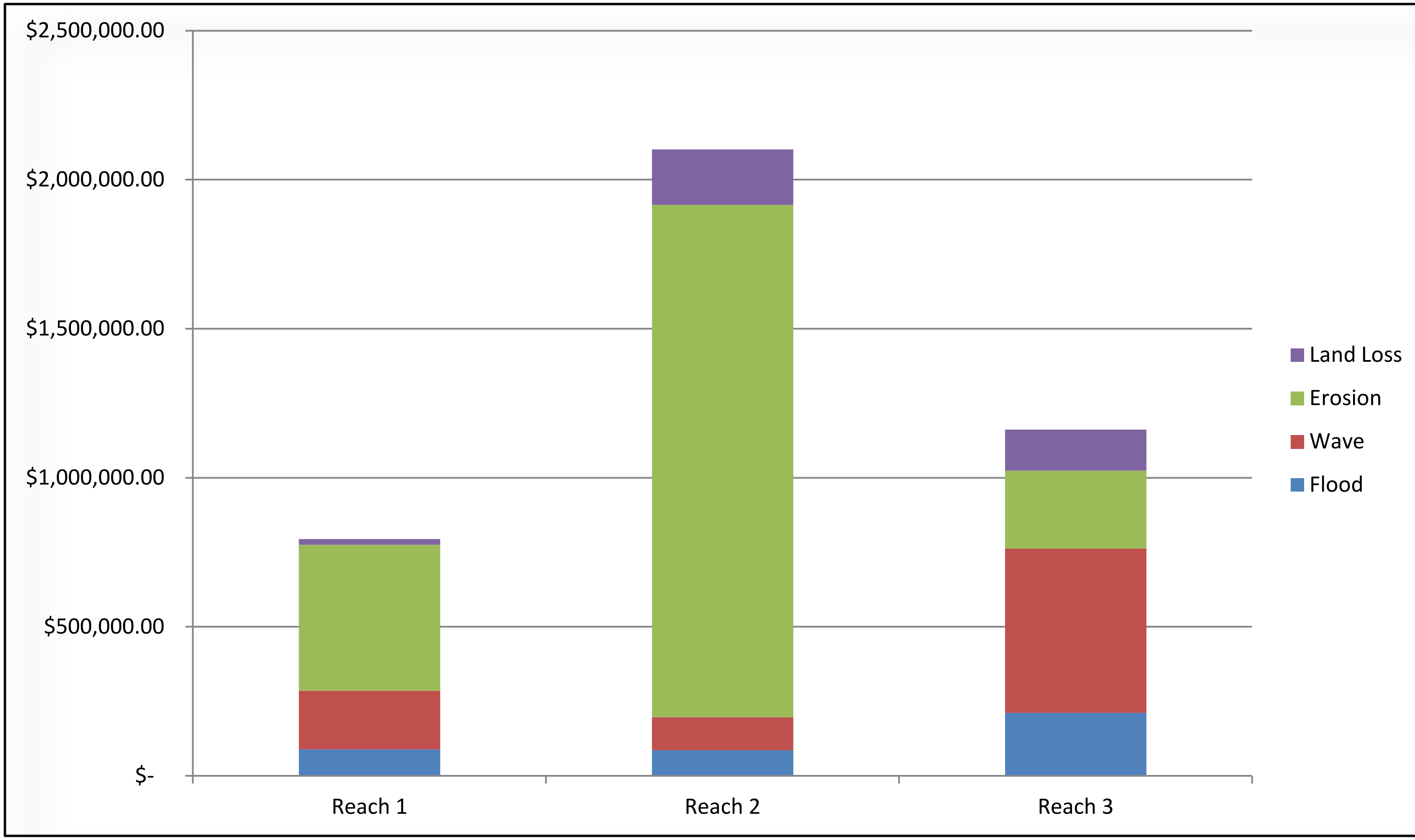
Plate 27



Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Without Project Condition Damages Over Time

January 2013
Norfolk District, Corps of Engineers

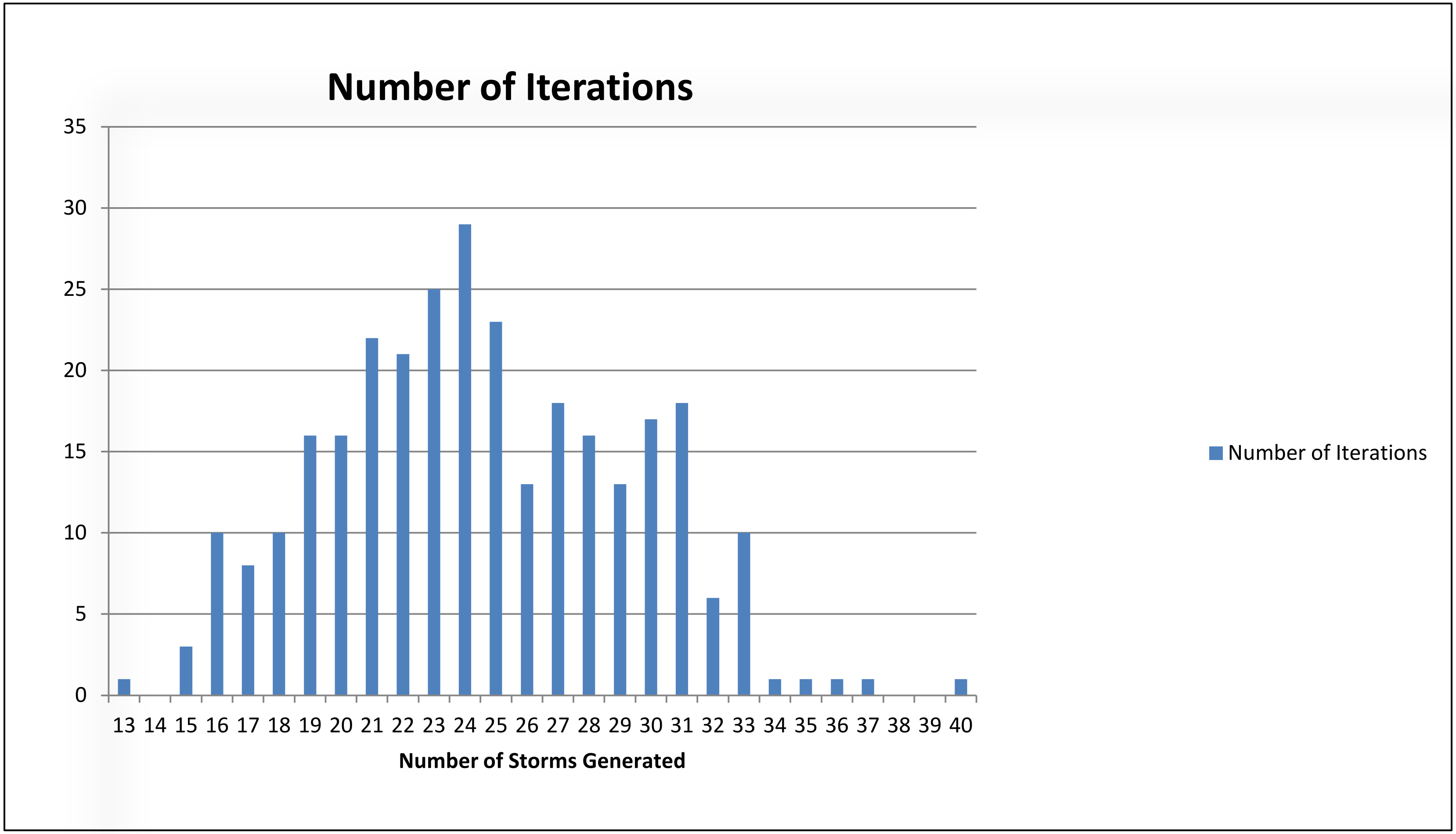


Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Average Annual Damages by Damage Type

January 2013
Norfolk District, Corps of Engineers

Plate 29



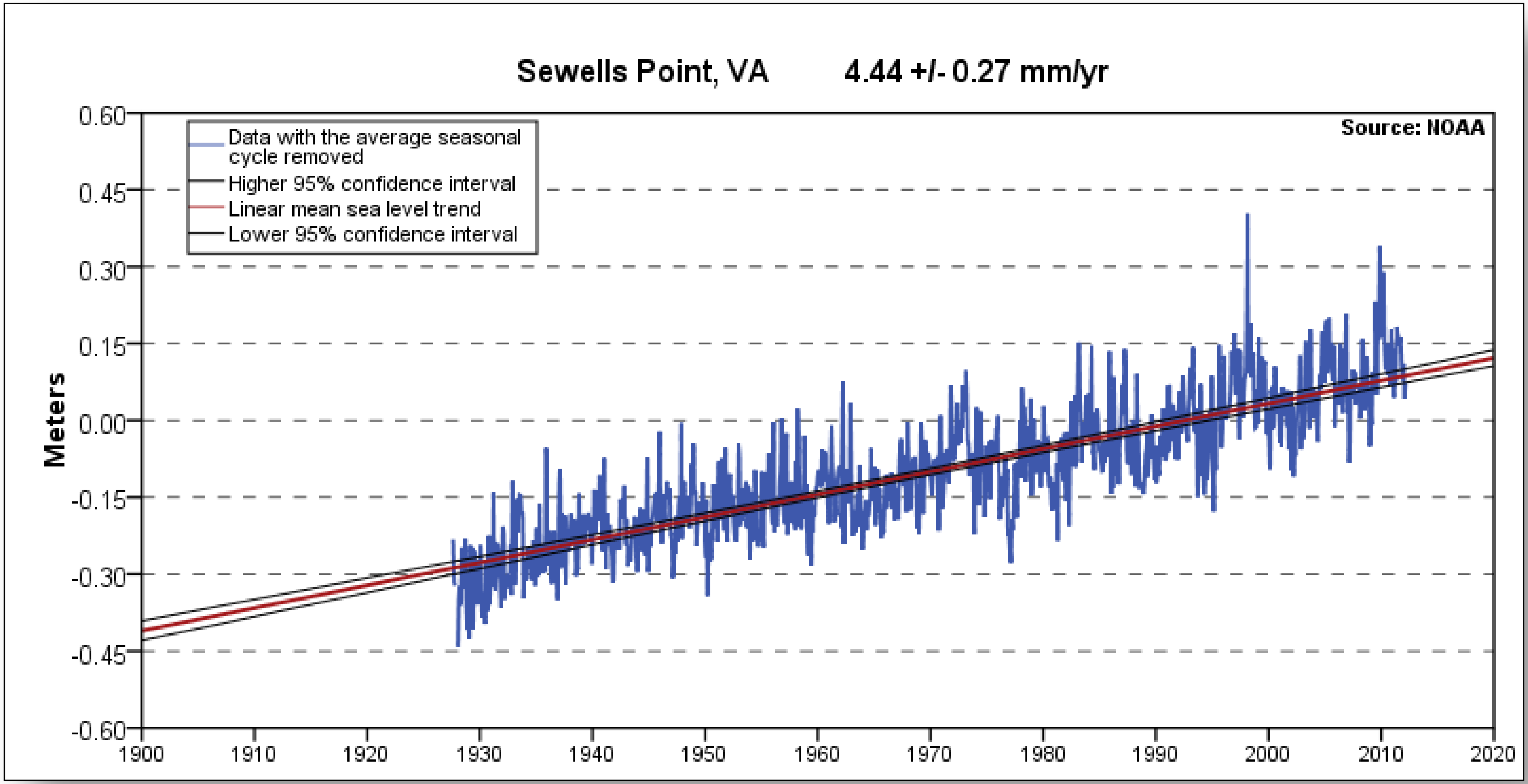
Graph illustrating the range of storm generation in Beach-fx.

Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Beach-fx Range of Storm Generation

January 2013
Norfolk District, Corps of Engineers

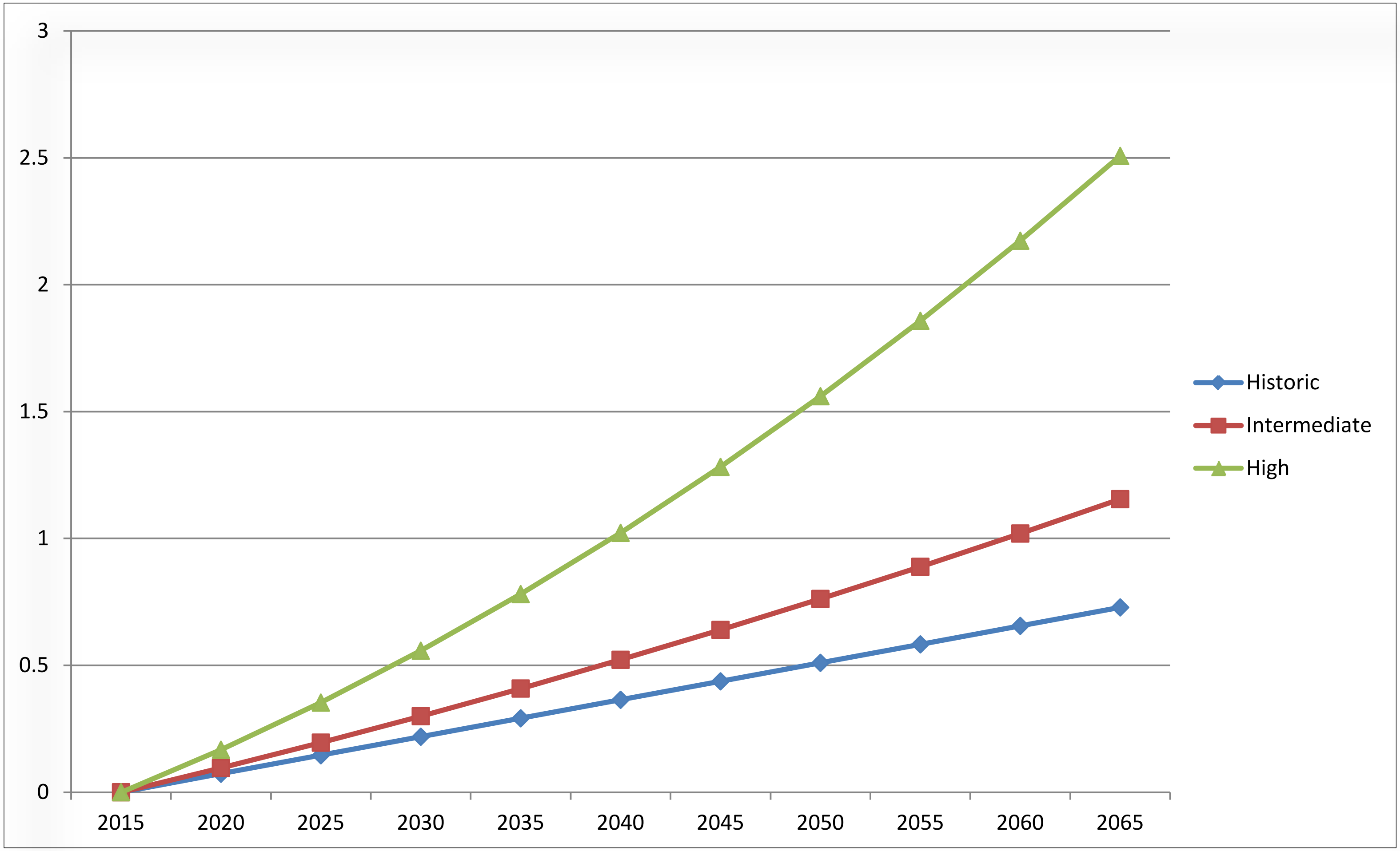
Plate 30



Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

Historical Trends from Tide Gauge

January 2013
Norfolk District, Corps of Engineers



Project SLR in Feet

Willoughby Spit and Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction

January 2013
Norfolk District, Corps of Engineers

Plate 32