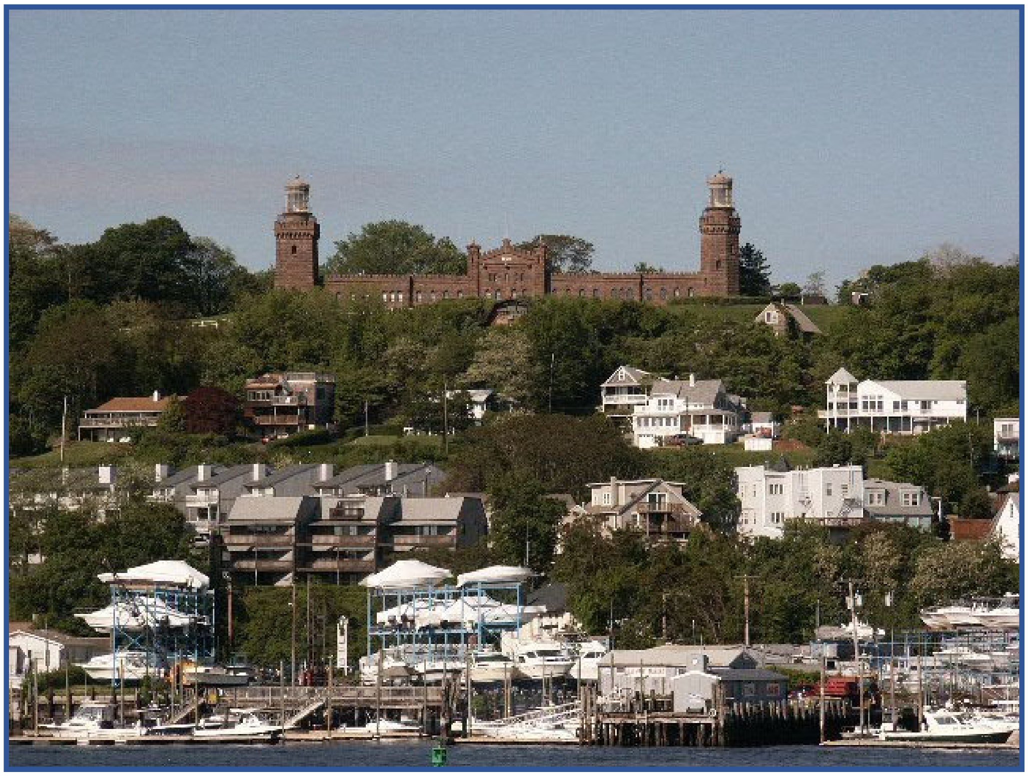
Raritan Bay and Sandy Hook Bay
Highlands, New Jersey
Coastal Storm Risk Management
Feasibility Study



Final Integrated Feasibility Report
and Environmental Assessment
August 2020

New Jersey
Department of
Environmental Protection

U.S. Army Corps of Engineers
North Atlantic Division
New York District

Home damaged by Hurricane Sandy in Highlands, New Jersey (2012).

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PERTINENT DATA

DESCRIPTION

The U.S. Army Corps of Engineers (USACE)'s Recommended Plan for the Coastal Storm Risk Management (CSRM) for Raritan Bay and Sandy Hook Bay, Highlands, New Jersey (Highlands) feasibility study is an alignment of floodwalls at elevation +14 feet (ft) North American Vertical Datum of 1988 (NAVD88).

LOCATION

The Borough of Highlands is located in Monmouth County, NJ, along Sandy Hook Bay and the Shrewsbury River.

CONDITIONS

The existing and future without project conditions at Highlands within the period of analysis (2026-2076) are identified as continued flooding and wave impacts from future storm episodes, and continued maintenance and reconstruction of coastal storm risk management facilities following storm events. Expected annual damages for the without project future condition is estimated at $33,000,000 (Oct. 2019 price levels).

FEATURES

The project spans a geographic distance of approximately 8,000 linear feet along the coast of the Borough of Highlands (Highlands) and ties into high ground (+14 ft NAVD88) at each end. Because the project follows the actual perimeter of the shoreline, its total length is 10,737 linear ft. The project includes a detention pond, diversion culverts, raised ground surfaces, and a pump station for interior drainage. Below highlights project features and dimensions where "lf" represents linear feet and "cfs" represents cubic feet per second.

Project Feature	Dimension
T-Type Floodwall	9,362 lf
I-Type Floodwall	992 lf
Closure Gate (width)	55 lf
Pump Station	300 cfs
Detention Pond	1.6 acres
Pressurized Pipes	1,600 lf
Raised Ground Surfaces	328 lf

REAL ESTATE REQUIREMENTS

The project will require temporary and permanent easements, as well as fee simple purchase for environmental mitigation. The estimated cost for real estate and mitigation is $12,524,400.

Permanent Easements	16.12 acres
Temporary Easements	7.39 acres
Fee Simple Purchase (for mitigation)	0.75 acres

Drainage Ditch Easement	0.7 acres
Fee (for pump station)	0.04 acres
Total	30.2 acres

Project Equivalent Annual Costs and Benefits

The Project Total First Cost is $162,635,000 (October 2019 Price Levels and FY20 discount rate 2.75%). The Fully Funded Project Cost is $179,633,000 (calculated using a construction duration of 42 months, midpoint of construction Q4 2023), to be cost shared 65% Federal and 35% non-Federal. Annual project cost (discounted at 2.75% over a 50 year period of analysis) sum up to $6,520,000. Annual net benefits are in the amount of $19,039,000 (October 2019 P.L.) and the benefit-to-cost ratio is 3.9.

Highlands Equivalent Annual Benefits and Costs

October 2019 Price Levels, 50-year period of analysis, FY20 Discount Rate of 2.75%

Investment Costs	
Total Project Construction Costs	$162,635,000
Interest During Construction	$7,779,000
Total Investment Cost	$170,413,000
Average Annual Costs	
Annualized Investment Costs	$6,312,000
OMRR&R	$208,000
Total Average Annual Costs	$6,520,000
Average Annual Benefits	$25,559,000
Net Benefits	$19,039,000
Benefit-Cost Ratio	3.9

Cost Sharing

The apportionment for the first costs between USACE and the non-federal sponsor are detailed in the table below in accordance with ER 1165-2-131.

Cost Apportionment

October 2019 Price Levels and FY20 Discount Rate of 2.75%

Cost Category	Federal Share	Non-Federal Share	Total
Fully Funded Costs	$ 116,761,000	$ 62,433,000	$ 179,633,000
Project First Costs	$ 105,713,000	$ 56,922,000	$ 162,635,000
LERRD*	0	$ 11,109,000	$ 11,109,000
Cash Contribution	0	$ 45,813,000	$ 45,813,000

***LERRD represents Land, Easements, Rights of Way, Relocations and Disposal costs and are 100% funded at the expense of the non-federal sponsor. Real Estate costs for the project total $12,524,000 and include the nonfederal LERRD and federal administrative obligations.**

EXECUTIVE SUMMARY

This study has determined that periodic coastal storms, such as tropical storms, hurricanes, and nor'easters, pose a severe threat to life and property in the Borough of Highlands, Monmouth County, New Jersey (Highlands). There is an opportunity to manage coastal storm risks in Highlands. In response to these problems and opportunities, plan formulation activities considered a range of structural and nonstructural measures. Through an iterative plan formulation process, potential coastal storm risk management measures were identified, evaluated, and compared in order to achieve the National Economic Development plan that minimizes structural damages caused by water events.

Alternative coastal storm risk management plans that survived the initial screening of alternatives included hard structural (floodwalls and bulkheads) and soft structural / natural / nature-based (beachfill and dune) plans, and a hybrid plan that minimized environmental impacts by matching the existing ground surface (*ie*., elevated bulkheads where the shoreline is already bulkheaded and reinforced dunes consisting of sand-covered seawalls on the existing beaches). The hybrid plan was found to be the most effective and efficient of the three alternatives, and was further developed into five variations to assess various components to maximize water access, such as buoyant swing gates and removable floodwalls. Of the five variations, the alternative that prioritized coastal storm risk management over water access by including stationary components, was found to have the highest net benefits, making it the Tentatively Selected Plan (TSP).

The TSP was released to public and agency review in the Draft Feasibility Report and Environmental Assessment for Highlands from July 2015 to September 2015. Reviews did not alter plan selection. Following reviews, USACE began the process of detailed feasibility analysis on the TSP to identify project dimensions that would maximize net benefits, for what is known as the National Economic Development (NED) Recommended Plan. The project dimensions that optimizes net benefits consist of floodwalls to elevation +14 ft North American Vertical Datum of 1988 (NAVD88) across the entire alignment, and include a detention pond, diversion culverts, and a pump station for interior drainage.

The project spans a geographic distance of approximately 8,000 linear feet along the bayshore of Highlands and ties into high ground (+14 ft North American Vertical Datum of 1988) at each end. Because the project follows the actual perimeter of the shoreline, its total length is 10,737 linear ft. The foundations of the project alignment have been designed to be adaptable to future rising sea levels. Access to Sandy Hook Bay and the Shrewsbury River will be provided as a project feature on publicly owned land. Private property owners will receive compensation if their existing access needs to be removed for the project.

The estimated total first cost for project implementation is $162,635,000 (October 2019 Price Level, FY20 2.75% discount rate), to be cost shared 65% Federal and 35% non-Federal. Annual net benefits are in the amount of $19,039,000 (October 2019 P.L., FY20 2.75% discount rate) and the benefit-to-cost ratio is 3.9. Costs for the value of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD) estimated to be $11,109,000 are 100% the responsibility of the non-federal sponsor.

The non-Federal project partner, New Jersey Department of Environmental Protection (NJDEP), has indicated its support for the NED Recommended Plan and is willing to enter into a Project Partnership Agreement (PPA) with the Federal Government for implementation.

Raritan Bay and Sandy Hook Bay, Highlands, New Jersey

Coastal Storm Risk Management Feasibility Study

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ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Definition
AE zone	Federal Emergency Management Agency (FEMA) 1 percent (also known as base flood) floodplain
ARA	Abbreviated Risk Analysis
ASA (CW)	Assistant Secretary to the Army (Civil Works)
BCR	Benefit to Cost Ratio
BFE	Base Flood Elevation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
CRF	Code of Federal Regulations
CSRM	Coastal Storm Risk Management
D&I	Design & Implementation
EA	Environmental Assessment
ECB	Engineering Construction Bulletin
EFH	Essential Fish Habitat
EO	Executive Order
EQ	Environmental Quality
ER	Engineering Regulation
ETL	Engineering Technical Letter
FCSA	Feasibility Cost Sharing Agreement
FEMA	Federal Emergency Management Agency
FRRS	Flood risk reduction standard
ft	Feet
FY	Fiscal Year
HQUSACE	United States Army Corps of Engineers – Headquarters
Hs	Significant wave height
HTRW	Hazardous, toxic & radioactive waste
HUD	Housing and Urban Development
LERRD	Lands, Easements, Rights of Way, Relocations, & Disposal
lf	Linear feet
MLW	Mean Low Water
NAVD88	North American Vertical Datum of 1988
NED	National Economic Development
NEPA	National Environmental Policy Act of 1970
NFIP	National Flood Insurance Program
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council

Acronym/ Abbreviation	Definition
OMRR&R	Operations, Maintenance, Repair, Rehabilitation & Replacement
OSE	Other Social Effects
P&G	Principles & Guidelines
PED	Pre-Construction Engineering and Design
PFIRM	Preliminary Flood Insurance Rate Map
PL	Price level
PL	Public Law
PMP	Project Management Plan
PPA	Project Partnership Agreement
RED	Regional Economic Development
RONA	Record of Non-Applicability
RSLC	Relative sea level change
SCC	Soil cleanup criteria
SLR	Sea Level Rise
TES	Threatened and Endangered Species
Tp	Peak wave period
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
VE zone	Federal Emergency Management Agency (FEMA) 1 percent (also known as base flood) floodplain that is subject to additional hazards due to storm-induced velocity wave action.
VLM	Vertical land movement

Chapter 1. Introduction

1.1. Study Purpose and Scope

The U.S. Army Corps of Engineers (USACE), New York District prepared this final Integrated Feasibility Report and Environmental Assessment for the Raritan Bay and Sandy Hook Bay, Highlands, New Jersey, Coastal Storm Risk Management Feasibility Study (Highlands study). It includes input from the non-Federal study partner, local governments, natural resource agencies, and the public. This report presents potential solutions to manage coastal storm risk in the Borough of Highlands, Monmouth County, New Jersey (Highlands) (**Error! Reference source not found.**). Sections of the report that are required to fulfill the requirements of National Environmental Policy Act (NEPA) of 1970 are marked with an asterisk (*) in the headings.

Figure 1-1: Highlands, Monmouth County, New Jersey

The Federal objective of water and related land resources project planning is to contribute to national economic development (NED) consistent with managing and reducing risk to the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements (Principles and Guidelines (P&G), 1983). Water and related land resources projects are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective. This feasibility report will: (1) summarize the current and potential water resource problems, needs, and opportunities for coastal storm risk management in Highlands; (2) present and discuss the results of the plan formulation for water resource management solutions; (3) identify specific details of the Recommended Plan for National Economic Development (NED), including inherent risks and (4) determine the extent of Federal interest and local support for the plan.

1.2. Purpose and Need for Action*

Highlands is located on the shoreline of Sandy Hook Bay and the Shrewsbury River approximately 20 miles south of Manhattan, New York. Its "working waterfront" is lined with marinas, docks, piers, and a ferry terminal that serves many businesses throughout the northeast and provides mass transportation for commuters to New York City. Access to the waterfront is critical to the Borough's economy. Large-scale flood risk management structures that could improve use of the waterfront have not been built. Because of this, the Borough is highly susceptible to flooding. Most homes and businesses in Highlands are located in the relatively low-lying downtown area extending from the shoreline to Shore Drive (). The land is generally at an elevation lower than +10 feet (ft) North American Vertical Data of 1988 (NAVD88).

Figure 1-2: Topography of Highlands

Photo Credit: USACE

Highlands experiences moderate to severe flooding from coastal storms like tropical storms, hurricanes, and nor'easters. Flooding is caused by storm surge, which is created when winds push on the ocean's' surface, causing an abnormal rise of water over and above the predicted tide. Residences and businesses have experienced flooding from multiple storm events, the most vivid in recent memory being Hurricane Sandy in October 2012. Highlands was severely impacted by the storm, which was a 0.5 percent flood (190-year event) at the waterfront.[1] Of approximately 1,500 structures in Highlands, about 1,100 were damaged or destroyed by flood waters. Bay Shore Drive and Bay Avenue, the two main roads in the town, were impassable during and after the storm. The downtown business area was submerged during high tide cycles during the storm; many businesses have not reopened. Borough Hall and the Highlands Police Station were flooded; some offices ran operations in temporary trailers for years after the storm. The SeaStreak Ferry, which provides commuter service to Manhattan, was unable to operate for months because the ferry terminal was destroyed by the storm. Residents were displaced for weeks, months, or even years, many lived in temporary trailers or gutted homes as they rebuilt damaged structures. The Borough continues to work towards full recovery.

1.3. Study Authority

The Highlands study was authorized by a resolution of the Committee on Public Works and Transportation of the U.S. House of Representatives adopted August 1, 1990:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors is requested to review the report of the Chief of Engineers on Raritan Bay and Sandy Hook Bay, New Jersey, published as House Document No. 464, Eighty-seventh Congress, Second Session, and other pertinent reports, to determine the advisability of modifications to the recommendations contained therein to provide erosion control and storm damage prevention for the Raritan Bay and Sandy Hook Bay.*

This study authority covered the Raritan Bay and Sandy Hook Bay area, from South Amboy at the western end to Highlands at the eastern end. In response to the study authority, the Raritan Bay and Sandy Hook Bay, New Jersey Combined Flood Control and Shore Protection Reconnaissance Study Report (1993) concluded that within the study area shoreline protection and flood control projects in Highlands and five other communities appeared to be economically viable and were recommended for further investigation.

The Reconnaissance Report recommended that Highlands and the other identified communities could proceed to interim feasibility studies after a "pre-feasibility" study was conducted. It was indicated that such a study was to further demonstrate the extent of Federal interest in a site-specific plan and to provide a better basis for estimating the feasibility phase cost. The pre-feasibility study for Highlands (2000) identified a potential plan that appeared economically and environmentally feasible. The Feasibility Cost Sharing Agreement (FCSA) with the New Jersey Department of Environmental Protection (NJDEP) for the Highlands Coastal Storm Risk Management (CSRM) Study was executed in 2001.

[1] This estimate was developed using historic stage-frequency data from the National Oceanic and Atmospheric Administration (NOAA), which was the typical method used by USACE- New York District prior to Hurricane Sandy.

Prior to Hurricane Sandy, the Highlands CSRM Study was close to completion. The effects of Hurricane Sandy are described in Section 3.1 (Problem Statement) of this report. The Highlands CSRM Study was included in the Second Interim Report in response to Disaster Relief Appropriations Act, Public Law 113-2 (P.L. 113-2), as a project under study to receive $1,500,000 to complete the feasibility study. A FCSA amendment for $1,500,000 to complete the feasibility study at full Federal expense was executed with NJDEP on 23 August 2013.

1.4. The Planning Process

In compliance with the USACE planning process, the draft Feasibility Report was released for concurrent public and agency technical review by USACE of the Tentatively Selected Plan (TSP).[2] For the TSP, the study team evaluated an array of alternatives to arrive at a general description of the TSP (type of treatment - floodwalls vs. beachfill vs. nonstructural treatments such as house elevations, relocations, etc), with the exact details determined during optimization. Optimization of the TSP took place after comments from public review[3] and agency review were received and incorporated into the draft report package. Through optimization, the TSP became the Recommended Plan, documented in this Final Integrated Final Feasibility Report and Environmental Assessment.

1.5. National Environmental Policy Act Requirements

the National Environmental Policy Act (NEPA), the Council on Environmental Quality's (CEQ) Guidance Regarding NEPA Regulations, and the USACE's Procedures for Implementing NEPA (Engineering Regulation [ER]-200-2-2).

An EA is a concise public document prepared by the Federal agency to determine whether the proposed action has the potential to cause significant environmental effects (40 Code of Federal Regulations (CFR) 1508.9(a)). The purposes of an EA are to:

- provide evidence and analysis sufficient to determine whether an Environmental Impact Statement (EIS) is required;
- aid a Federal agency's compliance with NEPA when no EIS is necessary;
- facilitate preparation of an EIS when one is necessary; and
- serve as the basis to justify a finding of no significant impact (FONSI).

The EA must discuss:

- the need for the proposed action;
- the proposed action and alternatives;
- the probable environmental impacts of the proposed action and alternatives;
- and the agencies and persons consulted during preparation of the EA.

[2] http://planning.usace.army.mil/toolbox/smart.cfm?Section=4&Part=0
[3] For information on public involvement comments in Appendix – F "Pertinent Correspondence"

NEPA requires federal agencies to integrate the environmental review into their planning and decision-making process. This integrated report is consistent with NEPA statutory requirements. The report reflects an integrated planning process, which avoids, minimizes, and mitigates adverse project effects associated with coastal storm risk management actions. Sections of the report that are required to implement the environmental assessment requirements of the National Environmental Policy Act (NEPA) of 1970 are marked with an asterisk (*) in the headings.

1.6. Prior Studies, Reports, and Existing Water Projects

Existing reports on the Highlands study area include the 1993 Reconnaissance Report for Raritan Bay and Sandy Hook Bay, and the pre-Feasibility Report conducted on Highlands in 2000, as described in Section 1.3 (Study Authority). This study followed a SMART planning path and a successful Tentatively Selected Plan (TSP) milestone was held on 13 May 2015, where the team received permission to release the draft report. The draft report was logged in for review on 27 August 2015, concurrent with Agency Technical Review and Independent External Peer Review. Due to public access issues, the study was put on hold at the request of the Borough. After the hiatus, the study was revived in August 2019 (again at the request of the Borough). This final report outlines the optimization of the TSP in development of the recommended plan and has undergone vigorous peer, MSC and independent reviews for this final report.

Existing Federal Projects

There are no existing USACE coastal storm risk management projects within the Highlands study area. The closest USACE project is the navigation channel on the Shrewsbury and Navesink Rivers (Figure 1-3 on page 8). The navigation project in the Shrewsbury and Navesink Rivers was authorized by the Rivers and Harbors Act of 1919. It consists of a channel about 2.2 miles long, 12 feet deep Mean Low Water and 300 feet wide, following the westerly shore from deep water in Sandy Hook Bay to near the Route 36 Bridge. The navigation project area is connected to a channel (South Branch) about 6.8 miles long, 9 feet deep Mean Low Water and 150 feet wide, widened at bends, ending at Branchport Avenue in Branchport and to a tributary channel (North Branch) connected to the South Branch channel at Normandie, which extends up the Navesink River approximately 6.1 miles to Red Bank. This channel has a depth of 6 feet Mean Low Water and width of 150 feet. The project is used by the Sea Streak ferry that connects to New York City. P.L. 113-2 funds were used to dredge 100,000 cubic yards (cy) of sand from the Federal navigation channels in the Shrewsbury and Navesink Rivers in 2014.

Other navigation projects include the Federal navigation channels at Atlantic Highlands, Leonardo, and Belford Harbor. Authorized in 1937, the Atlantic Highlands project consists of a 4,000 ft long rubble-mount wave scour stone protection with the area landward of the scour breakwater up to the pierline dredged to a depth of 8 ft. The Leonardo navigation channel in Sandy Hook Bay was authorized by the Rivers and Harbors Acts of 1945 and 1950, and provides for an entrance channel eight ft deep, 150 ft wide, and approximately 2,500 ft long, from the eight ft contour in Sandy Hook Bay to the entrance of the small boat harbor at Leonardo. In addition to provide access to small recreational vessels, the channel is also used to transport distillate fuel oil (approximately 379 tons for the five year average annual commercial tonnage). P.L. 113-2 funds were used to remove approximately 35,000 cy of sand to restore function to the project in 2014. The navigation project at Belford is the Shoal Harbor and Compton Creek Federal Navigation Project, which was authorized by the Rivers and Harbors Act of 1935. The existing project, used for fishing operations, is two miles long from deep water in Sandy Hook Bay up through Compton Creek. It ranges from 8-12 ft deep at Mean Low Water (MLW), narrows from 150 ft wide in the bay to 75 ft wide in Compton Creek. P.L. 113-2 funds were used to dredge 160,000 cy of sand in 2014.

Nearby coastal storm risk management projects to the west of the study include Union Beach; Keansburg, North Middletown and Laurence Harbor (Keansburg); and Port Monmouth. Designs are underway for the Union Beach project, which includes levees and floodwalls, tide gates, pump stations, and a dune and beach-berm with terminal groins. The existing Keansburg coastal storm risk management project encompasses 2.7 miles of shoreline in the Borough of Keansburg and North Middletown (formerly East Keansburg, located in Middletown Township), Monmouth County, and 0.6 miles of shoreline in Laurence Harbor (located in Old Bridge Township), Middlesex County. In 1966, USACE constructed a beach berm and levees at Laurence Harbor. In 1968, USACE completed the construction of a beach berm, groins, levees, pump station, floodwall, and a storm closure gate in Keansburg and North Middletown. The project in Keansburg was damaged by Hurricane Sandy in 2012 and has been repaired and restored pursuant to P.L. 84-99, Flood Control and Coastal Emergencies (33 U.S.C. 701n) and P.L. 113-2. Also, there is a USACE coastal storm risk management project under construction at Port Monmouth between Leonardo and Keansburg. The beachfill portion of Port Monmouth is complete, and the structural components, including levees, floodwalls, a tide gate, pump stations, road closure gates, and environmental mitigation, have been under construction since 2018.

To the east of Highlands is the Sea Bright to Manasquan, NJ Coastal Storm Risk Management and Erosion Control Project. Originally authorized by the Rivers and Harbors Act of 1958, the project consists of 21 miles of Atlantic coast shoreline from the Township of Sea Bright to the Manasquan Inlet in Monmouth County, New Jersey. The beach erosion control project provides beach erosion control protection of the shoreline that protects the highly populated communities and infrastructure located along this area of the New Jersey shoreline. Storm damage reduction is provided by constructing a 100 foot wide beach berm at a total elevation of +12 ft mean low water (MLW), +9.3 ft NAVD88. Construction on part of the project was initiated in 1994 and completed in 2001. The project includes periodic nourishment of the restored beaches on a 6-year cycle for a period of 50 years from the start of initial construction. Some of the constructed portions of the Sea Bright to Manasquan project were damaged by Hurricane Sandy in 2012 and have been repaired and restored pursuant to P.L. 84-99, Flood Control and Coastal Emergencies (33 U.S.C. 701n) and P.L. 113-2 in 2014.

Proposed coastal storm risk management actions for Highlands would not affect or be affected, due to the lack of geographical contiguity, by the Union Beach project, and existing USACE projects at Keansburg, North Middletown, Laurence Harbor, Port Monmouth, Belford, Leonardo, Atlantic Highlands, the Shrewsbury and Navesink Rivers, or along the Atlantic coast of New Jersey from Sea Bright to Manasquan.

Existing Local Structures. There are a number of existing piers, bulkheads, and other revetments in Highlands, including a raised bulkhead constructed by the State of New Jersey between Snug

Harbor Avenue and Sea Drift Avenue. They were built mainly for the purpose of shoreline erosion management and not to prevent flooding from coastal storms. The structures are low enough to allow both inundation and wave damage in landward regions (i.e., lower than elevation +10.7 ft NAVD88). Several of the private bulkheads were undergoing replacement at the time of the inventory, with evidence of several more imminent replacements (stockpiled bulkhead materials).

1.7. Study Area

The **study area** is the area within which significant project benefits and impacts may occur. The study area includes the downtown area of Highlands from Sandy Hook Bay to Shore Drive **Figure 1-4**). Highlands is an established community located on the shoreline of Sandy Hook Bay and the Shrewsbury River in Monmouth County, New Jersey. Within Highlands, the study area is approximately 8000 ft along the bayshore, from Murray Beach at the western end to the Route 36 Bridge at the eastern end (see **Figure 1-4**). Shore Drive serves as the southern boundary.

1.7.1. Planning Reaches

The study area shoreline was divided into four reaches for plan formulation, based on shoreline characteristics and orientation (Figure 1-5). Reaches 1, 2, and 3 are the bay-fronting sections along Sandy Hook Bay, and Reach 4 is the river-fronting section along the Shrewsbury River. Reach 1 and 3 are similar, consisting primarily of beaches and piers, with some private bulkheads. Reach 2 is characterized by a public bulkhead built by the State of New Jersey, and a small, privately owned and operated marina. Reach 4 is primarily bulkheaded with piers.

1.7.2. Project Area

The **project area** is the area in which measures will likely be built. The Recommended Plan is a floodwall alignment along the shoreline, therefore the project area encompasses the areas adjacent to the bay and river shorelines (Figure 1-6).

Figure 1-3: Existing USACE Projects and Studies

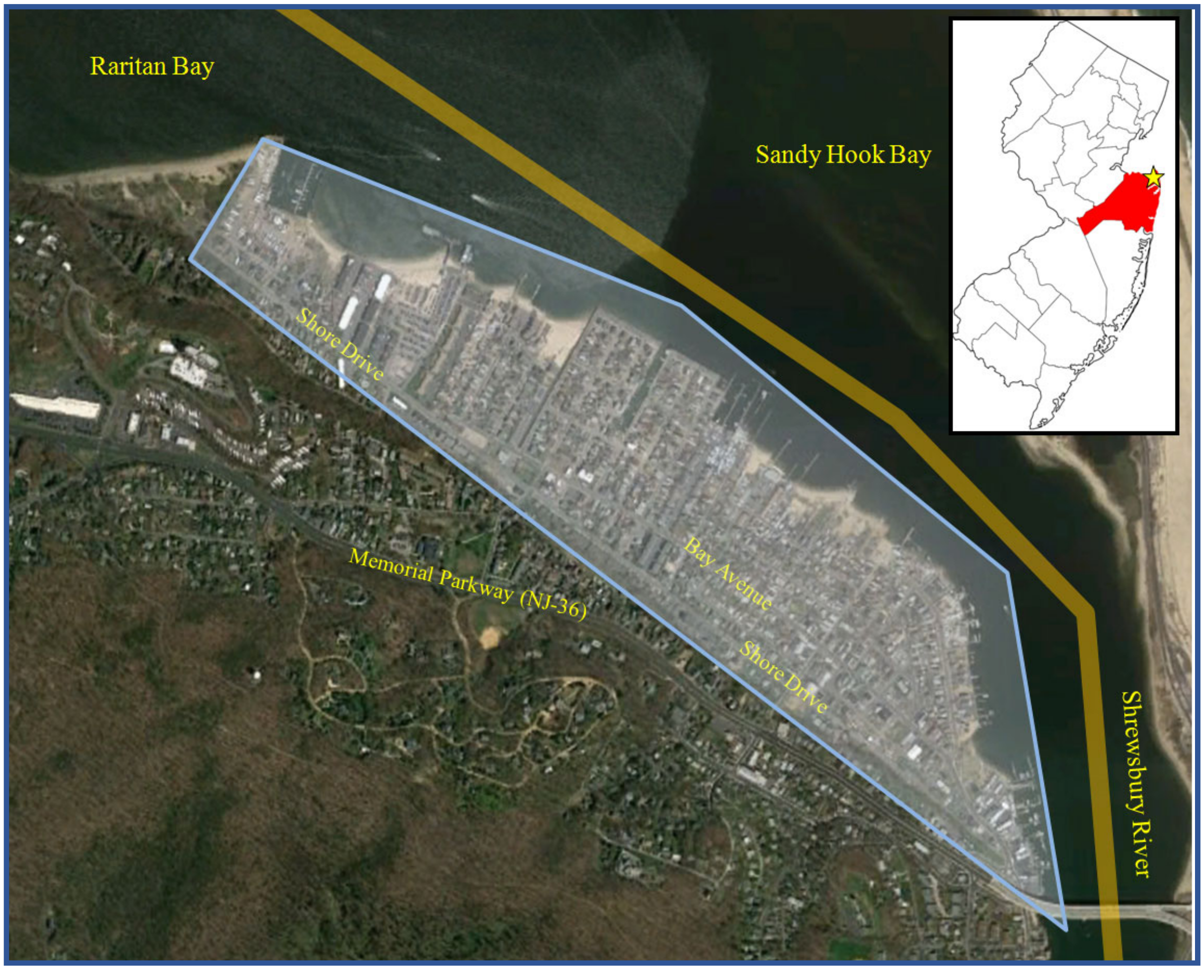

Figure 1-4: Highlands study area.

*The study area is shown shaded in blue. The Shrewsbury River Federal navigation channel is shown in orange.

Figure 1-5: Planning Reaches in Highlands

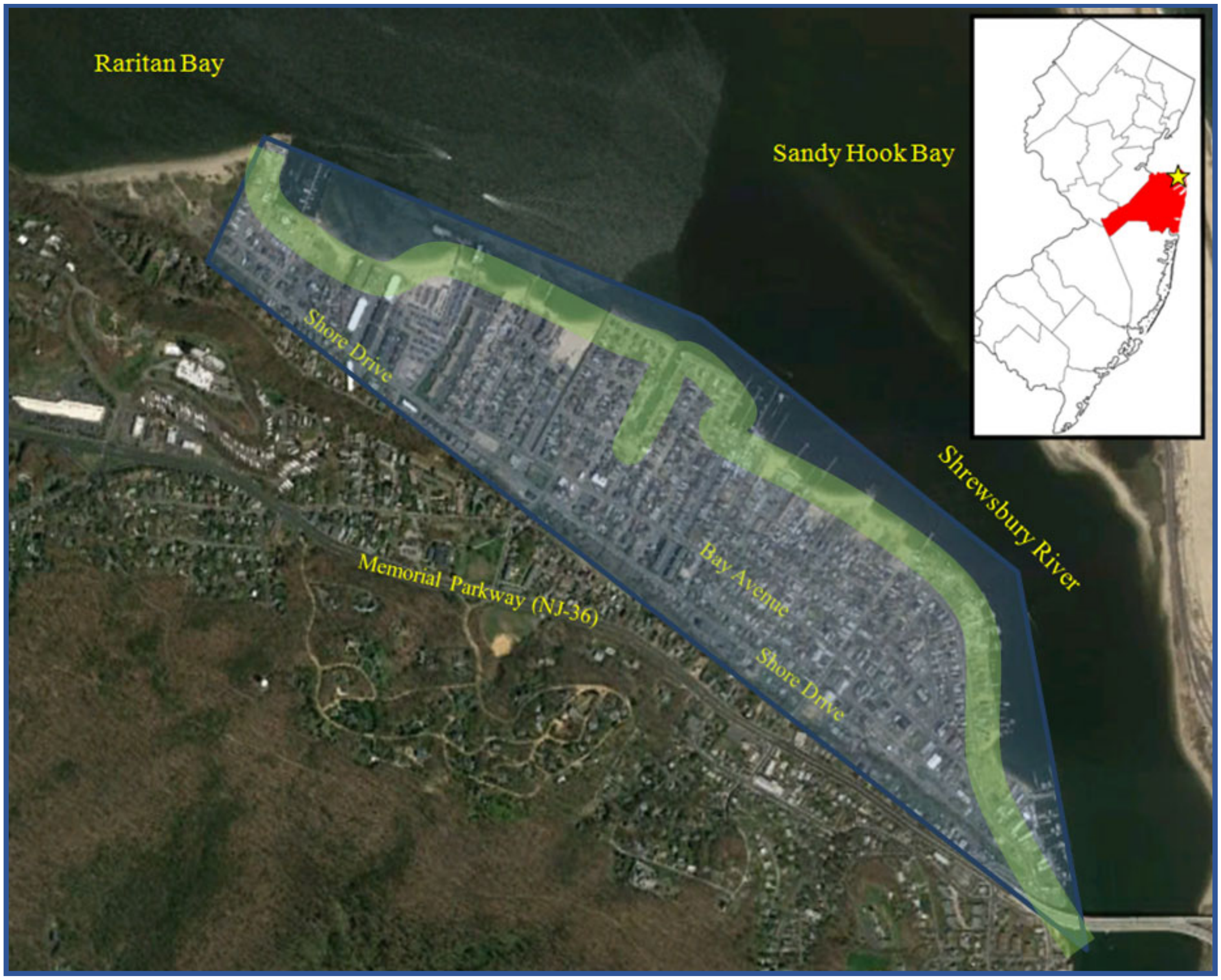

Figure 1-6: Highlands project area.
The study area is shown shaded in blue. The project area is shown highlighted in green.

1.8. Non-Federal Partner*

The non-Federal cost sharing partner is the New Jersey Department of Environmental Protection (NJDEP). In October 2001, the USACE and the NJDEP executed a Feasibility Cost Share Agreement (FCSA) for the study. Though not the study partner, the Highlands governing body is an active participant in the study. Both the NJDEP and the Highlands governing body support the proposed Recommended Plan. The study has been completed with funds authorized by the Disaster Relief Appropriation Act of 2013 (P.L. 113-2) at full Federal expense.

Chapter 2. Existing Conditions*

Existing conditions, which serve as the basis for the characterization of problem identification and projection of future without project conditions, are described in this section. Existing conditions are described through the environmental setting, the built environment, and the human environment. Details from the Highlands Strategic Recovery Planning Report (NJ Future, 2014) informed the existing conditions in this report. For an explanation of how USACE describes storms and flood levels, see Section 2.4 (Describing Storms and Flood Levels).

2.1. Existing Conditions Affected Environment*

This description of the environment to be affected within existing conditions is in accordance with the requirements of National Environmental Policy Act (NEPA), and serves as the baseline for Chapter 5: Environmental Impacts and Chapter 6: Cumulative Impacts of this draft integrated report.

2.1.1. Topography, Geology, and Soils

The relatively low-lying downtown area extends from the shoreline to Shore Drive and is flanked by bluffs to the south (). The land is generally at an elevation lower than 10 ft NAVD88. The flat topography of the waterfront and low existing bulkhead elevations allow tidal inundation during periods of major storm events. Modeling shows that a one percent flood (+11.2 ft NAVD88, including wave setup) would submerge Highlands under five feet of water from shoreline to the base of bluffs, approximately 1,500 feet inland. This largely occurred during Hurricane Sandy, which was a 200 year (0.5 percent) flood event at Highlands in 2012.

The geology in the study area consists of underlying crystalline bedrock composed of Cretaceous sediments. Quaternary deposits are found along the shoreline. The beach sand primarily consists of rounded quartz with lesser amounts of ironstone, sandstone, and argillite.

Sediments in the Sandy Hook Bay estuary are considered part of a Wisconsin glacial outwash plain that overlies an earlier continental drainage system. Silt and clay dominate the western section of the bay and spread from the Raritan River through the deeper part of the bay to Sandy Hook. The remaining bay consists of medium sand (diameter >250 microns) and fine sand (diameter >62 microns and <250 microns).

Soils in the study area primarily consist of the Hooksan Sand (HorBr), Udorthents-Urban Land Complex (UdauB), and, Phalanx (PhbE). The HwB soils occur on 0 to 5% slopes and are rarely flooded. The UdauB soils occur on 0 to 8% slopes and exhibit variable drainage capabilities. The PhbE are on 10 to 25% slopes and are well drained (USDA 2014).

The topography is stable and is not expected to change in the future.

2.1.2. Water Resources

2.1.2.1. Regional Hydrogeology and Groundwater Resources

The study area is located directly above the Northern Atlantic Coastal Plain (NACP) aquifer system, which is a Nationally-Designated Sole Source Aquifer (USEPA 1988). This aquifer system is a complex, multi-layered system underlain by semi-consolidated to unconsolidated sediments that consist of silt, clay, and sand, with some gravel and lignite (Trapp and Horn 1997).

The primary source of groundwater extraction in the study area is from the Potomac-Raritan-Magothy aquifer. The source of recharge for this aquifer is through precipitation and infiltration (Trapp and Horn 1997). Groundwater quality of the Potomac-Raritan-Magothy aquifer is generally good, with a median chloride concentration of 11.6 milligram/liter (mg/L), soft groundwater (0-60 mg/L as calcium carbonate), iron concentrations routinely exceeding the national drinking-water standard of 300 micro-gram/liter (μg/L), and nitrate plus nitrite levels being consistently 0.11 mg/L or less (Moody *et al*. 1988). The predominant ions in most New Jersey groundwater are calcium, magnesium, and bicarbonate (Moody *et al*. 1988).

2.1.2.2. Surface Water

In general, the surface water quality throughout Sandy Hook Bay reflects the close proximity of a highly urbanized and developed population center. The environment of bay has been impacted by a variety of pollutants, including heavy metals, polynucleararomatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), excessive nutrient and organic carbon loading, and pathogenic bacteria and viruses (NJDEP 1983, Bretler 1985, NJDEPE 1993a, 1993b). Other problems documented in the bay include diseased fish, turbid and oily waters, noxious odors, beach and shellfish bed closings, and restricted shellfish harvesting (USDOI 1992).

Phytoplankton blooms have been the most visible, and appear to have had the most substantial impact, of all the water quality problems that have been experienced along the shoreline of the Raritan Bay and Sandy Hook Bay (USACE 2000a). Green, brown, or red tides are common in the Raritan Bay and Sandy Hook Bay during spring and summer seasons creating hypoxic conditions (depletion of dissolved oxygen [DO]) and causing the suffocation of marine fauna (USACE 2000a). The macrobenthic community of the Raritan Bay and Sandy Hook Bay has been described as impoverished because of low concentrations of DO (McGrath 1974).

2.1.2.3. Tidal Influences

Tides at the study area are semi-diurnal. In general, waters in Sandy Hook Bay typically circulate in a counter-clockwise direction. However, long shore currents in the study area transport sediments generally from east to west. Tidal currents along the shore of the area are generally weak except at the eastern end where the Navensink River discharges. The National Oceanic and Atmospheric Administration's (NOAA's) measurement of tidal currents show that maximum flood and ebb tide velocities are 0.6 and 0.4 knots, respectively, in bay (USACE 1996). The mean tide level, mean tidal range, and spring tidal range at the study area are 2.6 ft above mean low water (MLW), 4.9 ft MLW, and 5.9 ft MLW, respectively.

2.1.3. Coastal Processes

Three primary factors shape coastal zone morphology: 1) ocean factors, 2) beach characteristics, and, 3) other natural physical variables. Ocean factors include waves, tidal variations, storm surges, and sea level change. Beach characteristics include beach sediment volume, composition, and grain size. Other natural variables include rainfall runoff, groundwater flow, pore pressures, and existing vegetative cover (Komar 1998). All three factors interact in a dynamic process, which defines the coastal zone area.

Anthropogenic influences often supplement the natural forces, and play significant roles in shaping the coastal zone. As shorelines retreat due to long shore currents, wave and tidal action, and storm events, artificial structures are often constructed to slow down or minimize further erosion. These structures typically modify the coastal zone to increase sediment retention within heavily utilized or populated areas (USACE 2000b). In the bay these processes are less pronounced however, they do impact the shoreline. The majority of the Highlands shoreline is bulkheaded and impacts the natural coastal process by not minimizing how the natural coastal processes impact the shoreline.

2.1.4. Vegetation

2.1.4.1. Upland

Upland vegetation within the study area is limited to maintained areas associated with residential and commercial buildings, narrow beach, and small, undisturbed pockets of trees. The most common vegetated upland areas are typically dominated by shrubs such as northern arrowwood (*Viburnum recognitum*), sweetgum (*Liquidambar styraciflua*), multiflora rose (*Rosa multiflora*), and staghorn sumac (*Rhus typhina*). The beach area is sparsely vegetated with American beachgrass (*Ammophila breviligulata*), sea lavender (*Limonium nashii*), and seaside goldenrod (*Solidago sempervirens*). The small pockets of upland forest scattered throughout the study area consist of sweetgum, black locust (*Robina pseudo-acacia*), oak (*Quercus* spp.), maple (*Acer* spp.), and ash (*Fraxinus* spp.).

2.1.4.2. Wetland

Because of the small area of Highlands and its almost fully developed condition, few wetlands are present. Wetlands mapped in the National Wetlands Inventory for Highlands consist of estuarine and marine wetlands occurring along the western part of the project area (USFWS, 2015). These wetlands contain minimal if any vegetation. Mapping using NJDEP Geo-Web (2012; Figure 2-1) indicates a 1.1 acre vegetated dune communities wetland, between Valley Street and Cedar Avenue. The mapped wetland contains minimal habitat and minimal vegetation. The exact delineation of the wetlands will occur during PED phase.

Figure 2-1: NJDEP Mapped Freshwater Wetland

2.1.5. Fish and Wildlife

2.1.5.1. Finfish

The Sandy Hook Bay is used as a spawning area, nursery area, and part-time residence by many recreational and commercial finfish species of the New York Bight (MacKenzie 1990). Historical data showed a great abundance of finfish in the bay. However, human intervention (*i.e.,* heavy fishing sewage discharge, and dredging, reduction of suitable spawning habitat, and reduction in food supply have contributed to the decline of the diversity and abundance of finfish species in Raritan Bay and Sandy Hook Bay (MacKenzie 1990).

The description below is representative of the bay as a whole and suggests species encountered in the study area though there is no data to suggest that the waters of the study area offer any special or unique values or concentrations of species.

Bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), winter and summer flounders (but that *Pseudopleuronectes americanus* and *Paralichthys dentatus*, respectively), striped bass (*Morone saxatilis*), and scup (*Stenotomus chrysops*) are some of the most sought-after fish by recreational anglers (Figley and McCloy 1988). The bay provides recreational opportunities throughout the year (USFWS 1992). During the spring season, winter flounder, windowpane (*Scophthalmus aquosus*) and anadromous species such as alewife (*Alosa pseudoharengus*), American and hickory shad (*A. sapidissima* and *mediocris*, respectively), and blueback herring (*A. aestivalis*) are abundant throughout the bay. During the summer and fall seasons, summer flounder and weakfish are abundant throughout the bay complex (USFWS 1992, Wilk *et. al.*

1998). Migratory species such as striped bass are found throughout the year (Woodhead 1991). Bay anchovy (*Anchoa mitchilli*), Atlantic silverside (*Menidia menidia*), and Atlantic menhaden (*Brevoortia tyrannus*) are found in the intertidal and nearshore waters.

2.1.5.2. Shellfish

Shellfish throughout the Sandy Hook Bay have been historically important and a major shellfishery existed in the bay (USFWS 1992). However, the increase in population around the New York metropolitan area precipitated an increase in the discharges of sewage effluent, dredging activities, and residential and commercial development thus affecting the shellfish resources of the bay (Figley and McCloy 1988). The NJDEP classifies the Highlands shoreline as "Special Restricted Area" requiring a special permit for commercial shell fishing.

McCloy (1988) found soft-shelled clam (*Mya arenaia*) beds and occurrence of hard-shell clam in the intertidal and nearshore waters. No known blue mussel (*Mytilus edulis*) or oyster (*Crassostrea virginica*) beds are found in vicinity of the study area, and surf clams (*Sapisula solidissima*) are confined to the deep waters of the bay (McCloy 1988). Beach seine surveys conducted by the NJDEP, Bureau of Marine Fisheries in 1982 and 1983, found that grass shrimp (*Palaemonetes pugio*), sand shrimp (*Crangon septemspinosa*), and lady crab (*Ovalipes ocellatus*) were the most abundant shellfish in the intertidal and nearshore waters of the study area (Byrne 1988).

2.1.5.3. Benthic Resources

Benthos is the complex community of plants and animals that live on or in bottom sediments of oceans, bays, streams, and wetlands. The benthic community in the Raritan Bay and Sandy Hook Bay area has historically been rich but unevenly distributed (McCormick et al. 1984), and is characterized as transitional due to changes in water quality and pollution (Steimle and Caracciolo-Ward 1989).

Most studies of Raritan Bay infauna have focused on open-bay waters (Dean, 1975; Dean and Haskin, 1960; Cerrato et al., 1989; Steimle and Caracciolo-Ward, 1989). Benthic invertebrate composition and abundance is highly dependent on sediment type and grain size distribution (Diaz and Boesch 1982, McGrath 1974). McGrath (1974) noted that powerful storms have the ability to shift sediments, thereby causing distributional changes in communities dependent on a specific sediment type. Localized benthic communities can also exhibit large fluctuations between seasons.

As part of a pre-construction effort, intertidal and subtidal benthic samples were taken in 2002 and 2003 along the bay shoreline along Port Monmouth, Keansburg, North Middletown, and Union Beach, NJ (USACE 2004a, 2004b) just west of Highlands. A grand total of 155 taxa and over 42,000 animals were collected; dominant taxa included the gem clam, *Gemma gemma*, which made up 53% of all animals, and the spionid polychaetes *Streblospio benedicti* and *Polydora cornuta* which each accounted for approximately 6% of all animals (USACE 2004a, 2004b; Table 2-1). The oligachaete family Tubificidae and the tubificid species *Tubificoides heterochaetus* together made up an additional 10% of the total collection, while specimens identifiable only to the level of Oligachaete constituted nearly 3%. Ribbon worms (Rhynchocoela) and the sabellariid polychaete *Sabellaria vulgaris* also supplied more than 2% of the total number of animals. Taxa making up approximately 1% of the collection included the snail *Ilynassa (Nassarius) obsoletus)*, the polychaetes *Mediomastus* lowest practical identification level (LPIL), *Heteromastus filiformis*, *Streptosyllis pettiboneae*, and *Protodriloides* LPIL.

Average total abundances within the study area ranged from a low of 2,681 animals/m^2 at Point Comfort to a high of 38,271 animals/m^2 at Port Monmouth. These values are similar to those from previous studies. Ettinger (1996), reported averages of 5,000-6,000 animals/m^2 for Port Monmouth and Keansburg. Ray (2004), computed averages of 15,000-21,000 animals/m^2 for Union and Cliffwood Beaches. Ettinger (1996) who found an average of 25.1 g /m2 at Port Monmouth and 192.0 g /m2 at Keansburg and was highest at subtidal depths has only previously reported biomass for this area. Annelids dominated biomass at MLW and subtidal depths of Port Monmouth, while gastropods (principally *I. obsoleta*) made up most of the biomass at mid-tide depths. At Keansburg, annelids and gastropods dominated upper- and mid-tide levels and bivalves comprised most of subtidal biomass. This same pattern is seen in the present study where annelids were the most important component of biomass at Port Monmouth and Keansburg MLW depths while bivalves constituted the majority of biomass elsewhere.

The sediments and infauna of the three study areas are similar to those previously reported for the Raritan Bay and Sandy Hook Bay shoreline. Species composition, abundance, and biomass differ slightly among the three areas, between depths, and over time but all values are within the degree of variability that is typical of intertidal benthic communities.

2.1.5.4. Reptiles and Amphibians

Site-specific studies or surveys describing the diversity and abundance of amphibians and reptiles within the study area are not available. With the exception of terrestrial woodland salamanders (*Plethodon* spp.) and various toads (*Bufo* spp.), amphibians would be limited to small, isolated freshwater habitats which do not exist in the project footprint. The southern leopard frog (*Rana utricularia*) and spring peeper (*Hyla crucifer*) are possible exceptions because they can tolerate slightly brackish waters (Conant and Collins 1991). No amphibians are expected to inhabit the shoreline project area because of the high salinity resulting from sea spray.

Table 2-1: Relative Total abundances of dominant taxa in the intertidal zone of the Raritan Bay and Sandy Hook Bay.

Taxon	*Total*	*PM*	*KB*	*PC*	*UB*	*MLW*	*MLW-1*
Gemma gemma	53.4	75.8	13.5	3.1	12.2	31.7	58.4
Streblospio benedicti	6.6	2.1	16.9	10.2	9.7	1.9	7.7
Polydora cornuta	6.3	3.6	14.1	4.6	4.7	8.1	5.8
Tubificidae (LPIL)	6.2	4.9	6.5	19.0	12.5	2.0	7.2
Tubificoides heterochaetus	4.1	2.2	5.4	1.1	13.5	1.4	4.7
Enchytraeidae (LPIL)	3.2	*	11.0	10.2	1.5	17.0	*
Oligochaeta (LPIL)	2.9	1.8	6.3	12.2	*	15.4	A
Sabellaria vulgaris	2.2	1.0	6.2	*	1.1	4.7	1.7
Ilyanassa obsoleta	1.4	*	*	3.5	8.9	*	1.6
Mediomastus (LPIL)	1.4	*	2.9	5.3	3.8	*	1.6
Heteromastus filiformis	1.2	*	*	1.4	7.0	*	1.3
Streptosyllis pettiboneae	1.0	*	*	*	7.3	*	1.2
Protodriloides (LPIL)	1.0	1.3	*	1.9	*	5.1	A
Paraonis fulgens	*	*	1.3	*	*	1.9	*
Microphthalmus (LPIL)	*	*	*	3.8	*	1.7	*
Polygordius (LPIL)	*	*	*	2.8	*	1.1	*
Lumbriculidae (LPIL)	*	*	2.1	1.9	*	*	*
Mulinia lateralis	*	*	1.6	3.9	*	*	*
Phyllodocidae (LPIL)	*	*	1.2	*	1.7	*	*
Hypereteone fauchaldi	*	*	1.0	1.1	1.5	*	*
Mediomastus ambiseta	*	*	*	2.4	1.7	*	*
Spionidae (LPIL)	*	*	*	1.1	*	*	*
Leitoscoloplos (LPIL)	*	*	*	1.3	*	*	*

PM: Port Monmouth; KB: Keansburg; UB: Union Beach; MLW: mean low water; MLW-1: I meter below mean low water; LPIL: lowest practical identification level; *: present but not in abundances <1% of total numbers of animals; A: Absent.

Based on historical records, four species of reptiles are known to occur in similar habitat at the nearby Sandy Hook National Park, including diamondback terrapin (*Malaclemys terrapin*), eastern painted turtle (*Chrusemys picta*), northern brown snake (*Storeria dekayi*), and spotted turtle (*Chemmys guttata*) (USDI 1989). Fowler's toad (*Bufo woodhousei*) is the only amphibian known to occur at Sandy Hook National Park; however, it is reported as extirpated (USDI 1989).

2.1.5.5. Birds

No site-specific bird surveys have been conducted in the study area; however, a diversity of bird species is likely to be present due to the variety of habitats in the Raritan Bay and Sandy Hook Bay area. The most abundant species are likely to be habitat generalists that are tolerant of development. Table 2-2. (Padieck *et al*. 2015) provides a list of bird species observed breeding in the Keyport, NJ, a similar town, 20 miles west of Highlands.

Table 2-2: Common Bird Species Likely to Occur in the Study Area.

Common Name	Scientific Name	Common Name	Scientific Name
American Crow	*Corvus brachyrhynchos*	House Sparrow	*Passer domesticus*
American Goldfinch	*Carduelis tristis*	Mallard	*Anas platyrhynchos*
American Robin	*Turdus migratorius*	Mourning Dove	*Zenaida macroura*
Baltimore Oriole	*Icterus galbula*	Northern Cardinal	*Cardinalis cardinalis*
Barn Swallow	*Hirundo rustica*	Northern Mockingbird	*Mimus polyglottos*
Blue Jay	*Cyanocitta cristata*	Ovenbird	*Seiurus*
Brown Headed Cowbird	*Molothrus ater*	Red-bellied Woodpecker	*Melanerpes carolinus*
Canada Goose	*Branta canadensis*	Red-eyed Vireo	*Vireo olivaceus*
Carolina Wren	*Thryothorus ludovicianus*	Red-tailed Hawk	*Buteo jamaicensis*
Cedar Waxwing	*Bombycilla cedrorum*	Red-winged Blackbird	*Agelaius phoeniceus*
Chimney Swift	*Chaetura pelagica*	Ring-necked Pheasant	*Phasianus colchicus*
Chipping Sparrow	*Spizella passerina*	Rock Pigeon	*Columba livia*
Common Grackle	*Quiscalus quiscula*	Scarlet Tanager	*Piranga olivacea*
Common Yellowthroat	*Geothlypis trichas*	Song Sparrow	*Melospiza melodia*
Downy Woodpecker	*Picoides pubescens*	Tufted Titmouse	*Parus bicolor*
Eastern Wood-Pewee	*Contopus virens*	Warbling Vireo	*Vireo gilvus*
European Starling	*Sturnus vulgaris*	White Breasted Nuthatch	*Sitta carolinensis*
Fish Crow	*Corvus ossifragus*	Wild Turkey	*Meleagris gallopavo*
Gray Catbird	*Dumetella carolinensis*	Willow Flycatcher	*Empidonax traillii*
Great Crested Flycatcher	*Myiarchus crinitus*	Yellow Warbler	*Setophaga petechia*
House Finch	*Haemorhous mexicanus*		

2.1.5.6. Mammals

Site-specific studies describing the diversity and abundance of mammals within the study area are not available. The USFWS (1993) reported that several species of whales and dolphins, including the bottlenose dolphin (*Tursiops truncatus*), gray dolphin (*Globicephala macrorhynchus*), and

Atlantic dolphin (*Delphinus delphis*) may occasionally spend time in Raritan Bay and Sandy Hook Bay. Juveniles of several species of whales may also enter the bay, but are generally limited to the deeper portions (USFWS 1993).

Mammals likely to inhabit the study area would be generalist tolerant of development such as muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), gray squirrel (*Sciurus carolinensis*), and opossum (*Didelphis virginiana*; NJAS 1994).

2.1.5.7. Federal Threatened and Endangered Species

The USFWS lists the federally threatened piping plover (*Charadrius melodus*), red knot (*Calidris canutus rufa*), seabeach amaranth (*Amaranthus pumilus*), and northern long-eared bat (*Myotis septentrionalis*) as potentially occurring in the project area. There is no designated critical habitat for any of the listed species in the project area. The USFWS has no records of any of the listed species occurring in the project area.

The NOAA list the federally endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), shortnose sturgeon (*Acipenser brevirostrum*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempii*), and green sea turtle (*Chelonia mydas*).

2.1.5.8. State Threatened and Endangered Species

The NJDEP Division of Fish and Wildlife, manages the state's listed animal species. A review of NJDEP's landscape data project maps threatened and endangered species habitat within the state. The project area is within the Marine and Piedmont Plains Landscape Regions. The state threatened and endangered species for those regions include; endangered black skimmer (*Rynchors niger*), endangered least tern (*Sternula antillarum*), threatened osprey (*Pandion haliaetus*), threatened black-crowned night heron (*Nycticorax nycticorax*), and species of concern common tern (*Sterna hirundo*).

Transient bald eagles (*Haliaeetus leucocephalus*) or peregrine falcons (*Falco peregrinus*), both listed as threatened in New Jersey, may pass through the project area however none are expected to breed in the area.

The NJDEP Division of Parks and Forestry, maintains the state's listed plant species. The Landscape Project lists seabeach amaranth occurring in 2009, within a grid that includes the eastern most section of Highlands; however, the grid also includes part of Sandy Hook on the Atlantic coast, which contains known seabeach amaranth.

Seabeach amaranth occurs on barrier island beaches, where its primary habitat consists of overwash flats at accreting ends of islands and lower foredunes and upper strands of non-eroding beaches. It occasionally establishes small temporary populations in other habitats, including sound-side beaches, blowouts in foredunes, and sand and shell material placed as beach replenishment or dredge spoil. The species appears to need extensive areas of barrier island beaches and inlets, functioning in a relatively natural and dynamic manner. These characteristics allow it to move around in the landscape as a fugitive species, occupying suitable habitat as it becomes available. Beaches in Highlands are very small, in the bay and lack a natural and dynamic process. Highlands's beaches lack the habitat for seabeach amaranth.

2.1.5.9. Essential Fish Habitat

An Essential Fish Habitat (EFH) assessment was prepared and is included in the Environmental Appendix A1. Along the Highlands shoreline, 24 EFH designated species are identified as potentially occurring within the intertidal and nearshore subtidal zones Table 2-3. Of the 22 EFH designated species, five species (Winter Flounder, Window Pane Flounder, Summer Flounder, Hake, and Scup) have been caught as a result of biological monitoring conducted by USACE (2004a, 2004b) in the Raritan Bay and Sandy Hook Bay.

Table 2-3: Essential Fish Habitat Species in the Study Area.

Common Name	Scientific Name	Life Stage Found at Location
Clearnose Skate	*Raja eglanteria*	Adults, Spawning Adults, and Juvenile
Winter Flounder	*Pseudopleuronectes americanus*	Adults, Spawning Adults, Eggs, Larvae, and Juveniles
Windowpane Flounder	*Scopthalmus aquosus*	Adults, Spawning Adults, Eggs, Larvae, and Juveniles
Winter Skate	*Leucoraja ocellata*	Adults, Spawning Adults, and Juveniles
Yellowtail Flounder	*Pleuronectes ferruginea*	Adults, Spawning Adults, Eggs, Larvae, and Juveniles
Smoothhound Shark Complex (Atlantic Stock)	*Mustelus spp*	Adults, Spawning Adults, Eggs, Larvae, and Juveniles
Sandbar Shark	*Charcharinus plumbeus*	Adults, Spawning Adults, and Juveniles
Red Hake	*Urophycis chuss*	Eggs, Larvae, and Juveniles
Silver Hake	*Merluccius bilinearis*	Adults, Spawning Adults, Eggs, and Larvae
Ocean Pout	*Zoarces americanus*	Adults, Spawning Adults, and Eggs
Monkfish	*Lophius spp*	Eggs and Larvae
Smooth Dogfish	*Mustelus canis*	Adults, Spawning Adults, Eggs, Larvae, and Juveniles
Skipjack Tuna	*Katsuwonus pelamis*	Adults and Spawning Adults
Sand Tiger Shark	*Carcharias taurus*	Juveniles
Summer Flounder	*Paralichthys dentatus*	Adults, Spawning Adults, Larvae, and Juveniles
Little Skate	*Leucoraja erinacea*	Adults, Spawning Adults, and Juveniles
Scup	*Stemotomus chrysops*	Adults, Spawning Adults, Eggs, Larvae, and Juveniles
Longfin Inshore Squid	*Doryteuthis pealeii*	Adults, Spawning Adults, Eggs, and Juveniles
Bluefish	*Pomatomus saltatrix*	Adults, Spawning Adults, and Juveniles
Atlantic Butterfish	*Peprilus triacanthus*	Adults, Spawning Adults, Larvae, and Juveniles
Atlantic Cod	*Gadus morhua*	Eggs and Larvae
Atlantic Herring	*Clupea harengus*	Adults, Spawning Adults, Larvae, and Juveniles
Ocean Quahog	*Arctica islandica*	Adults and Spawning Adults
Black Sea Bass	*Centropristis striata*	Adult, Spawning Adult

2.1.6. Socioeconomics

A formal Census update of post-Hurricane Sandy demographic information is not currently available. Because of the extensive damage Highlands sustained after the storm, population and income have likely decreased since 2010. See Section 3.1 (Problem Statement) of this report for a description of a study conducted by Rutgers University on the socioeconomic impact of Hurricane Sandy on Highlands.

2.1.6.1. Demographics

The population in Highlands increased from 2,959 to 5,187 between 1950 and 1980, and decreased to 5,005 in 2010 (U.S. Census, 2010). The 2010 median household income was $75,291, (U.S. Census, 2010). The Highlands SRPR (NJ Future, 2014:2) estimated that the median household income was closer to $53,000 in 2012, compared to the median income of $84,746 for Monmouth County overall in the 2010 census. In the 2010 census, about 93% of the Borough's 5,005 residents identified as Caucasian/white. In summary, the residents of Highlands are less affluent and more vulnerable to income disruptions from weather events compared to Monmouth County overall. Beyond income level, other characteristics that mark socially vulnerable populations are concentrated within the Highlands study area, which correspond roughly to 2010 census block groups 1-4 in Highlands: 143 single parent households, 477 people over the age of 65, and 206 people under the age of 5.

2.1.6.2. Economy and Employment

The economy of Monmouth County has undergone extensive growth in recent years, with much of the development concentrated along major transportation routes. The majority of non-residential development has been for office and research facilities, most likely due to the availability of comparatively inexpensive land with access to the Northern New Jersey - New York City markets. In contrast, there has been little economic development in Highlands. New development has been generally limited to public use projects such as the ferry terminal project, renovations to upgrade existing residential dwellings, and minor land development.

Of the 234 companies in Highlands, 146 were small businesses with four or fewer employees (Highlands Strategic Recovery Planning Report NJ Future, 2014:22), that lack the resources larger businesses have to survive disruptions. Many Highlands businesses were severely damaged by Hurricane Sandy and some have not been in operation since the storm.

2.1.7. Environmental Justice

In accordance with Executive Order 12898 (dated February 11, 1994), Federal agencies are required to identify and address the potential for disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low income populations.

The Highlands community is not a minority community based on race. According to the US

Census' American Community Survey 2013-2017 5-year Estimates data (ACS), 9% of the population considers themselves non-white. The US Environmental Protection Agency provides the Environmental Justice Mapper tool that defines the poverty level for New Jersey as households whose annual income is less than $25,000. The ACS lists the poverty rate for Highlands as 7.2%. The Borough does not have disproportional environmental and health hazards. Borough residents have access to participate in the decision-making process and ensure a healthy environment in which to live, learn, and work.

2.1.8. Cultural Resources

As a Federal agency USACE has certain responsibilities for the identification, protection and preservation of historic properties and cultural resources that may be located within the Area of Potential Effect (APE) associated with a proposed project. Present statutes and regulations governing the identification, protection and preservation of these resources include the National Historic Preservation Act of 1966 (NHPA), as amended; the National Environmental Policy Act of 1969; Executive Order 11593; and the regulations implementing Section 106 of the NHPA (36 CFR Part 800, Protection of Historic Properties, August 2000). NEPA mandates that Federal agencies assess proposed Federal actions' environmental impacts, including impacts on historic and cultural resources.

As established by 36 CFR Part 60, an historical property (generally a property over 50 years of age) is eligible for listing in the National Register if it possesses "integrity of location, design, setting, materials, workmanship, feeling, and association," and it meets at least one of four criteria:

A. It is associated with events that have made a significant contribution to the broad patterns of our history; or
B. It is associated with the lives of persons significant in our past; or
C. It embodies the distinctive characteristics of a type, period, or method of construction, or it represents the work of a master, or it possesses high artistic values, or it represents a significant and distinguishable entity whose components may lack distinction; or
D. It has yielded, or may be likely to yield information important in prehistory or history.

Cultural resources assessments are coordinated with the New Jersey Historic Preservation Office (NJHPO). The Advisory Council on Historic Preservation, Native American Tribes, other interested parties and the public are given opportunities to participate in the process through the NEPA public review process.

Prehistoric Resources

USACE conducted a Phase IA cultural resources survey in 2005 which included a review of existing information pertaining to archaeological discoveries in the study area. Evidence of Paleo-Indian and Archaic period occupation has been found in the Raritan Bay and along the Atlantic shoreline including Clovis-like points found at the Earle Naval Weapons Station, the turkey Swamp Site in Freehold, NJ, and a large Archaic period site on Ivanhoe Creek in Freehold Township. Woodland

Period sites are not as commonly found in the study area but not entirely unknown. Historic records indicate that there were Delaware villages along the coastal areas near Fort Monmouth in the 1600's but no sites have yet been identified. No prehistoric archaeological sites have been identified within the study area or along the extent of Raritan Bay (Davis 2005). Archaeological testing of selected locations along the alignment was recommended however the NJHPO, upon reviewing the report, determined that a Phase IB archaeological testing of the alignment as then proposed was not required.

Historic and Architectural Resources

European settlement of the Raritan Bay region began in 1609 with the landing of Henry Hudson's Half Moon on Sandy Hook. However, the first permanent settlement in the area began in 1678 when an Englishman named Richard Hartshorne built his home on the Navesink River and established a settlement there. Early settlement centered on the Middletown area and on fishing, hunting and farming. In 1812 an Inn called the Cove House was established in the Sandy Hook area by Thomas Martin. From 1827-1828 the Twin Lights were erected above Sandy Hook Harbor to aid ships navigating to the Harbor. In the 1830's the Monmouth County Steamboat Company built and maintained the Highland Dock at the eastern tip of Highlands across from Sandy Hook to carry passengers and shipments between New York City, Sandy Hook, and the Highlands (Davis 2005).

More rapid development occurred in the area in the 1880's when a rail line was constructed to the Atlantic Highlands and later to Sandy Hook. In the late Nineteenth Century seasonal tourism was on the rise and Highlands became an attractive location for summer resorts, bungalows, and tent communities. Development centered around Bay Avenue and Miller Street and along Ocean Boulevard. By the 1920s, private bungalows replaced the tent communities and many of the summer bungalows were converted to permanent residences slowly changing the character of the community from resort to suburban (Davis 2005).

The Phase IA report prepared by USACE identified several extant historic properties in the study area including the Twin Lights of the Navesink Light Station and the Bahr's Landing Restaurant and Marina as well as the Woodward/Schenk Tavern House Archaeological Site. Based on the historical record and the presence of many structures of significant age in the study area the 2005 survey recommended a survey of historic architecture and streetscapes within the APE. In 2007 Panamerican Consultants, Inc, conducted a survey for USACE which identified a number of properties potentially eligible for the National Register of Historic Places (NRHP) (Panamerican Consultants, Inc, 2007).

The report identified the potential Shrewsbury Avenue Historic District comprising five houses on the east side of Shrewsbury Avenue (Numbers 26 - 34). These dwellings were noted as the last of their kind in this area of the New Jersey shore: large, mostly intact, turn-of-the-nineteenth-century residences still standing on sand beaches.

The 2007 study also identified two groups of bungalows as remnants of what was once a larger collection of bungalow/cottage communities within Highlands and the NJ shore in general. Honeysuckle Lodge (between Atlantic and Cedar Street) is a large intact group of bungalows while

58 Fifth Street consists of a small row of bungalows. The authors of the 2007 report noted that there is a lack of context for these middle-class bungalow and cottage communities on the New Jersey shore and they suggest that should a multiple property nomination be prepared these two properties should be included. Bungalow and cottage communities were an important part of summer life on the Jersey Shore, in the Highlands, and for thousands of vacationers, primarily from New Jersey and New York. These communities were an inexpensive answer to the questions of where and how to escape the heat, humidity, and monotony of summer in the big cities of New Jersey and New York. Many of these properties are long gone and those remaining are being lost to storm damage and development. These two properties have not yet received a determination of individual eligibility from NJHPO.

Table 2-4: Identified Properties within the APE and NRHP-eligibility Determinations

Name	Address	NRHP Eligibility
Honeysuckle Lodge	Between Atlantic and Cedar Street	Potentially eligible
58 Fifth Street Bungalows	58 Fifth Street	Potentially eligible
Shrewsbury Avenue District	26 – 34 Shrewsbury Avenue	Potentially eligible Historic District
Clam Shanty	Bay end of Miller Street	Not eligible
Bay Avenue Historic District		Potentially eligible
The following Bay Avenue properties may be found to be contributing elements to the potential Bay Avenue Historic District. Individual eligibility is given below for each structure.		
Creighton Hotel (FLoBar Apartments)	24 Bay Avenue	Potentially eligible
Sculthorpe's Auditorium (the "Purple Building")	78 Bay Avenue	Potentially eligible
Sasha's Boutique Outlet	1 Bay Avenue	Not individually eligible
Bahrs Real Estate	15 Bay Avenue	Not individually eligible
Mewes Bros. Dairy	19 Bay Avenue	Not individually eligible
Sears, Roebuck & Co. kit house	257 Bay Avenue	Not eligible (Demolished)
Dwelling	60 Bay Avenue	Potentially eligible
Bahr's Landing Restaurant and Marina	2 Bay Avenue	Eligible

Two properties in the APE were identified by the Borough of Highlands in its Master Plan as historically interesting; a Sears, Roebuck & Co. kit house at 257 Bay Avenue and the former clam-processing plant (Clam Shanty) at the end of Miller Street. They were both determined by the 2007 survey as too altered and lacking integrity to be individually NRHP-eligible. The Sears, Roebuck &Co. kit house has since been demolished.

The Twin Lights (Navesink Lighthouse) National Historic Landmark (NHL) and the Water Witch Casino, an NRHP-listed property, are on high ground rising above the Borough of Highlands approximately one mile west of the APE. The NRHP-listed Fort Hancock and Sandy Hook Proving Grounds Historic District and the Sandy Hook Lighthouse NHL are located approximately three miles north, across Sandy Hook Bay, from the APE. While well outside the APE, sections of the alignment are within the viewsheds of these historic properties.

2.1.9. Coastal Zone Management

The State of New Jersey administers its federally approved coastal zone program through the Department of Environmental Protection, Land Use Regulation Program (LURP). Pursuant to the Federal CZMA, New Jersey has defined its coastal zone boundaries and developed policies to be utilized to evaluate projects within the designated coastal zone, as set forth in New Jersey's Rules on Coastal Zone Management (CZM) (N.J.A.C. 7:7, dated July 15, 2019). The Waterfront Development Law (N.J.S.A. 12:5-3) and related requirements (N.J.A.C. 7:7-3) provide the authority for issuance of permits for, among other activities the reconstruction (with or without expansion) of single-family homes.

As a Federally funded project within the coastal zone of New Jersey, the Highlands project must be reviewed by the NJDEP for consistency with the policies of the New Jersey State CZM Plan. These applicable policies, along with an impact analysis and consistency determination are discussed within the environmental consequences section of this report as well CZM consistency review that is presented in the Appendix A2.

2.1.10. Floodplains

Highlands has been classified as a "Special Flood Hazard Area" inundated by the 100-year flood (Figure 2-2 on page 49). The topography of Highlands is flat for approximately 1,500 ft inshore to the base of a steep grade. Severe storm events have historically caused extensive flooding and significant damages to the housing, property, and community infrastructure in the Highlands community (USACE 1993).

As previously described, the bay shoreline is subject to frequent storm surges and tidal inundation. It presently provides coastal storm risk management to inland areas against moderate storm surges and serves as a community recreational area. However, these values are diminished by continual erosion of the beach and dune in the small areas where they exist.

2.1.11. Land Use and Zoning

The current land use in the Highlands consists primarily of small beaches, developed residential areas, and public and private access to the bay. Residential areas cover the majority of the study area, including the areas abutting the beach.

The majority of land in the immediate project area contains residential (~70% of Borough area) and commercial and marine development (~30% of Borough area) within the low-lying areas along the Sandy Hook Bayshore (NJ Future, 2014). The local marinas, restaurants, and ferry slips along the shoreline represent an important regional commercial resource. Highlands is a well-developed and densely populated area. Of the 3,039 housing units within the Borough, 2,434 units are occupied year round (Census 2010). The 2010 population of 5,005 and the borough area of 0.77 square miles yield a population density of 6,500 persons per square mile.

2.1.12. Hazardous, Toxic, and Radioactive Waste

A search of Federal and state environmental databases was conducted for a corridor study along the shoreline. The researched area was approximately one mile west, east, north, and south of the proposed shoreline. Governmental agency records were reviewed for information that would be helpful in determining the environmental status, the presence, or potential of hazardous, toxic, or radioactive waste (HTRW) contamination. Because regulated facilities may impact other properties, it was also necessary to review governmental records for the surrounding area.

Skippers Landing at 52 Shrewsbury Avenue, Schupp's Landing at 12 Bay Avenue, a property at 16 Bay Avenue, and Bahr's Landing at 2 Bay Avenue contain underground storage tanks (UST) within 400 ft of the shoreline alignment. None of these sites has violations or is in the maintained database of leaking USTs (LUST). The Dry Dock Café, Inc. at 50-52 Shrewsbury Avenue, Gulf Service Station at 116 Bay Avenue, and Ocean View Apartments at 18 Navesink Avenue are listed in the LUST database. The Dry Dock Café appears to be located within 400 ft of the shoreline. It is listed on the state release and spills databases. The LUST incident occurred in October of 1993 and the removal of the 550-gallon LUST containing oil waste was completed.

On May 30, 2002, USACE personnel along with a driller from Fort Monmouth conducted a series of subsurface sampling along the shoreline of Highlands (Fort Monmouth 2002). Sample points were determined as most likely locations for storm risk reduction measures. The proposed depth of construction for these measures determined the depth of sample collection. Ten samples were collected from depths ranging from 7.5 to 11.5 ft below top of boring. The samples were analyzed for volatile organics (VOAs), pesticides, polychlorinated biphenyls (PCB), and Resource Recovery and Conservation Act (RCRA) metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.

Analytical results for VOAs showed nothing of concern and any results were reported in the parts per-billion-scale (ppb). Two compounds acetone and 2-butanone were detected in all samples but at very low levels. The only other compound detected was methyl tertiary butyl ether (MTBE). The location of the sample that contained this compound previously contained an underground gasoline storage tank. The tank was removed from the site several years before this sampling event took place. The level of MTBE was 0.380 ppb.

The compounds acetone and 2-butanone ranged in quantities of 1.3 and 4.7 ppb. Combining the values of the two compounds on a per sample basis and the total, VOA levels ranged from 6.8 and 2.5 ppb, well below the New Jersey soil clean-up level for VOAs is a combined VOA level of 1,000 ppm1000 ppb.

There were no detections of pesticides or PCBs in any of the samples.

There were no detections exceeding the 20 part per million (ppm) clean-up criteria set by the state of New Jersey, of the RCRA metals in any of the samples. Arsenic did come close at 19.7 ppm. There are geologic formations in this part of New Jersey that have naturally occurring high levels of arsenic that exceed the threshold and could be the cause of the high arsenic levels. The state policy of this issue is on a case-by-case basis.

2.1.13. Aesthetic and Scenic Resources

The shoreline of Highlands is composed primarily of bulkheads, which range in elevation from around +5 ft NAVD88 at low points to approximately +9 ft NAVD88 at the highest point, which provides relatively unobstructed views of Sandy Hook and Shrewsbury River. Small marinas, restaurants, and houses characterize the shoreline. Small beaches with public access are also located in the Borough, and provide for recreational opportunities for residents and visitors.

2.1.14. Recreation

The small beaches provide access to the water for recreation. Recreational fishing charters and sightseeing are available from the local marinas. Many individuals and business have private docks providing access to boating. The Henry Hudson Trail begins along the western section of the study area and links to the Township of Aberdeen.

2.1.15. Air Quality

In accordance with the Clean Air Act of 1977, as amended, the USEPA developed National Ambient Air Quality Standards (NAAQS) to establish the maximum allowable atmospheric concentrations of pollutants that may occur while ensuring protection of public health and welfare, and with a reasonable margin of safety.

The USEPA measures community-wide air quality based on daily measured concentrations of six criteria air pollutants; carbon monoxide, sulfur dioxide, respirable particulate matter, lead, nitrogen dioxide, and ozone. Based on these measurements of air quality, the USEPA designates attainment areas and non-attainment areas nationwide. Non-attainment areas are designated in areas where air pollution levels persistently exceed the national ambient air quality standards.

Based on the NAAQS, Monmouth County is located in the New York, Northern New Jersey, Long Island, Connecticut, nonattainment area, which is currently classified as "marginal" nonattainment for the 2008 8-hour ozone standard. The nonattainment area is part of the Ozone Transport Region. Ozone is controlled through the regulation of its precursor emissions, which include oxides of nitrogen (NOx) and volatile organic compounds (VOCs).

2.1.16. Noise

Noise is defined as unwanted sound. The day-night noise level (Ldn) is widely used to describe noise levels in any given community (USEPA 1978). The unit of measurement for Ldn is the "A"-weighted decibel (dBA), which closely approximates the frequency responses of human hearing. The primary source of noise in the study area is vehicular traffic on local roadways and local construction projects that may be underway. The Seastreak Ferry service to Manhattan also contributes noise. Although noise level measurements have not been obtained in the study area, they can be approximated based on existing land uses. The typical Ldn in residential areas ranges from 39 to 59 dBA (USEPA 1978). It is assumed that the existing sound levels in the study area are roughly within this range.

2.2. The Built Environment

The built environment is the human-made surroundings that provide the setting for human activity such as roads, homes, and businesses. It is the human-made space in which people live, work, and recreate on a day-to-day basis. Humans have greatly influenced the heavily developed Borough.

2.2.1. Shoreline Condition

Historically, the bayshore played the role as a market and distribution center for the agricultural goods produced on the fertile soils of the county's interior. The bayshore’s local commercial resources were developed for these uses. The majority of the study area presently contains mixed-use residential, commercial, and marine development within low-lying areas along the bayshore. Shoreline businesses represent those associated with fishing (clams, finfish), recreational charters, and sightseeing, and include some “dock and dine” restaurants. Commercial fleets use marinas to store boats and equipment, and to access Sandy Hook Bay.

The shoreline of Highlands is composed primarily of bulkheads, which range in elevation from around +5 ft NAVD88 at low points to approximately +9 ft NAVD88 at the highest point, and small beaches with public access. Small marinas, restaurants, and houses characterize the shoreline. The existing beaches and bulkheads are relatively stable, although there is a small portion of deteriorated timber bulkheads, which are in need of repair. Based on the Raritan Bay and Sandy Hook Bay Reconnaissance Report (USACE, 1993) and recent field visual site inspection, the existing shoreline, and beaches are relatively unchanged from 1993 due to the hardened condition of the shoreline.

2.2.2. Structures

The extension of a rail line from Atlantic Highlands through Highlands and along Sandy Hook and Sea Bright to Long Branch in the mid-1800s resulted in the development of Highlands as a summer resort. Throughout the late nineteenth and twentieth century’s, Highlands grew from summer tent colonies and summer bungalows into a year-round residential community with many commercial structures. A number of bungalow neighborhoods still exist in Highlands. Most homes and businesses are still located in the relatively low-lying downtown area. The majority of development within the Borough is more than 50 years old and was constructed prior to the implementation of the National Flood Insurance Program and adoption of the associated Flood Plain Management Regulations.

2.2.3. Access Routes

Access to Sandy Hook across the Shrewsbury River from Highlands was originally via ferry. The first Highlands Bridge was built across the river in 1872 to carry pedestrian and carriage traffic. The Central Railroad purchased the bridge and remodeled it to accommodate trains, vehicles, and pedestrians in the late nineteenth century. Waterfront access remains critical to the Borough’s economy and residents. Commercial and recreational boats use Sandy Hook Bay to access Raritan

Bay, Lower Bay, the Atlantic Ocean, and the Shrewsbury and Navesink Rivers. Residents and visitors use the Sea Streak ferry to travel to and from Manhattan.

Highlands is connected to other areas in the New York metropolitan area through a network of Federal and state highways. The Garden State Parkway and NJ-9 run northward to New York State and southward to Cape May, New Jersey. NJ-287 extends westward beyond Middlesex County, and the New Jersey Turnpike provides additional north-south access. New Jersey-36 is the primary evacuation route. Shore Drive and Bay Avenue are the main downtown roads. They are severely flooded during storm events, as are the local roads that feed into the main roads and evacuation routes.

2.3. The Human Environment (Community Resources)

Community resources refer to the social make-up of a community. Beyond population, housing, demographics, employment, income, community resources also include public services.

2.3.1. Public Services

Public services include schools, local government, police departments, fire departments, and emergency and medical services. Within the study area, there were the Borough Hall with a police station, Emergency Medical Services buildings, the Fire Department, the Department of Public Works facilities, four pump stations, and the Highlands Elementary School and the Henry Hudson Regional High School.

2.3.2. Community Facilities

Community facilities include parks and recreational areas, hospitals, libraries, community centers, and churches. There are two parks within the study area: Veteran's Waterfront Park and Huddy Park. In addition, the Robert D. Wilson Community Center, which also served as the library, is located within the study area.

2.3.3. Community Cohesion

Community cohesion refers to the common vision and sense of belonging within a community that is created and sustained by the extensive development of individual relationships that are social, economic, cultural, and historical in nature. The resilience of a community is directly tied to its degree of community cohesion. Anecdotally, the majority of families in the study area can trace their residence in Highlands back at least three generations. It is a stable, working-class community with churches, schools, and businesses. The Robert D. Wilson Community Center and the Veteran's Waterfront Park serve as a primary community meeting locations. Both locations were heavily damaged by Hurricane Sandy. After the storm, residents of Highlands demonstrated their community cohesion by helping each other and actively participating in coordination of recovery efforts

2.4. Describing Storms and Flood Levels

Floods are often defined according to their likelihood of occurring in any given year at a specific location. The most commonly used definition is the "100-year flood". This refers to a flood level or peak that has a 1 in 100, or 1 percent chance of being equaled or exceeded in any year (i.e., 1 percent "annual exceedance probability"). Therefore, the 100-year flood is also referred to as the "1 percent flood", or as having a "recurrence interval" or "return period" of 100 years.

A common misinterpretation is that a 100-year flood is likely to occur only once in a 100-year period. In fact, a second 100-year flood could occur a year or even a week after the first one. The term means that that the average interval between floods greater than the 100-year flood over a very long period (say 1,000 years) will be 100 years. However, the actual interval between floods greater than this magnitude will vary considerably.

In addition, the probability of a certain flood occurring will increase for a longer period. For example, over the life of an average 30-year mortgage, a home located within the 100-year flood zone has a 26 percent chance of being flooded at least once. Even more significantly, a house in a 10- year flood zone is almost certain to be flooded at least once (96 percent chance) in the same 30-year mortgage cycle. The probability (P) that one or more of a certain-size flood occurring during any period will exceed a given flood threshold can be estimated as

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

Where *T* is the return period of a given flood (e.g., 100 years, 50 years, 25 years) and n is the number of years in the period. The probability of flooding by various return period floods in any given year and over the life of a 30-year mortgage is summarized in Table 2-5.

Table 2-5: Examples of Flooding by Various Return Periods

Return Period (years)	Chance of flooding in any given year	Percent chance of flooding during 30-year mortgage
10	10 in 100 (10%)	96%
50	2 in 100 (2%)	46%
100	1 in 100 (1%)	26%
500	0.2 in 100 (0.2%)	6%

Because of the potential confusion, recent USACE guidance documents and policy letters recommend use of the annual exceedance probability terminology instead of the recurrence interval or return period terminology. For example, one would discuss the "1-percent-annual-exceedance-probability flood" or "1-percent-chance-exceedance flood", which may be shortened to "1 percent flood" as opposed to the "100-year flood". This report uses the short form "1 percent flood".

Flood frequency describes how often a given magnitude of flooding occurs by providing an estimate of the intensity of a flood event. These estimates provide a way to analyze the damage corresponding to specific extreme water levels during flood events. Because of increasing sea levels throughout the project life and the adaptation horizon, the intervals of storms frequencies and flood levels will change over the project timeline. Sea-level rise (SLR), represents a rise in the mean level of the coastal ocean relative to the land. SLR makes coastal cities such as Highlands increasingly vulnerable to flooding. Its impact reduces the intervals between major inundation events so that the likelihood of a coastal city experiencing an extreme water level associated with an event described as a 100 year event at the beginning of the timeline may increase significantly, changing the projected recurrence interval to less than 100 years.

2.4.1. Water Surface Elevation

USACE adapted the ADCIRC model developed for the Fire Island to Montauk Point (FIMP) Reformulation Study in 2005 to use for initial alternative screening on Highlands. Estimated at the 95% confidence interval and are reported for year 1992 which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983–2001, the resulting water surface elevations for Highlands are shown in in Table 2-6. Wave setup was negligible due to the waves arriving in an unbroken state. Project optimization made use of the newly developed USACE stage frequency curves from the North Atlantic Coast Comprehensive Study (NACCS) whose comparison is shown in Table 2-6. In accordance with Engineering Regulation (ER) 1100-2-8162, the NACCS elevations are presented for year 1992 which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983–2001 and estimated using expected values (50% confidence interval). In general, the stage and frequency of water levels change over time. The more years of data available, the more accurate the estimates for the various flood event. The trends identified for the Highlands area show an increase in water levels. During the course of analysis it is expected that these trends would continue in the future so that the water surface elevation level associated with a 1% flood today would occur more frequently than 1% annually by the end of the period of analysis in 2076. Section 2.4.2 details the impact of sea level change.

Table 2-6: ***Comparison of FIMP and NACCS Stage-Frequency at Sandy Hook***

Annual Chance Exceedence	FIMP Still Water Elevation	NACCS Water Surface Elevation
50%	3.7	5.6
20%	5.4	6.7
10%	6.5	7.5
4%	7.5	8.4
2%	8.1	9.7
1%	8.8	11.0
0.50%	9.5	12.6
0.20%	10.1	14.6

*** FIMP Still Water Elevations estimated at the 95% confidence interval without wave effects while NACCS Water Surface Elevations are estimated at the 50% confidence interval with wave effects. Per ER 1100-2-8162 both FIMP and NACCS water levels are reported for year 1992 (which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983–2001).**

2.4.2. Sea Level Change

Sea level change (SLC) is a change in the mean level of the ocean. Relative or "local" sea level change (RSLC) is the locally observed change in sea level relative to a fixed point of a given coast. It is the additive effect of global or eustatic sea level rise if 1.7 millimeters (mm) per year, and the subsidence or uplift rate at a fixed point. RSLC considers the effects of (1) the eustatic, or global, average of the annual increase in water surface elevation due to the global warming trend, and (2) the regional rate of vertical land movement (VLM) that can result from localized geological processes, including the shifting of tectonic plates, the rebounding of Earth's crust in locations previously covered by glaciers, the compaction of sedimentary strata and the withdrawal of subsurface fluids. USACE projects must consider sea level change when planning and designing projects, per Engineering Regulation (ER) 1100-2-8162. Sea level change means that natural forces change in the future; this nonstationarity requires consideration of a future that may be substantially different than the past. There is considerable uncertainty associated with future climate change over the project timeline. Table 2-7 below present the estimates of future water surface elevations for low, intermediate and high scenarios for year 2076 which are expected to change in the future due to nonstationarity.

Table 2-7: Without-Project Existing and Future Conditions Water Surface Elevations

Annual Chance of Exceedence in %	Water Surface Elevation (1983 to 2001 epoch) in ft. NAVD88	Change in Water Surface Elevation between 1992 and 2026 in feet	Existing Condition Water Surface Elevation (in Project Base Year 2026) in ft. NAVD88	Future Condition (2076) Water Surface Elevation with **Low Rate of SLC** in ft. NAVD88	Future Condition (2076) Water Surface Elevation with **Intermediate Rate of SLC** in ft. NAVD88	Future Condition (2076) Water Surface Elevation with **High Rate of SLC** in ft. NAVD88
100%	4.7	0.44	5.2	5.8	6.4	8.4
50%	5.6	0.44	6.0	6.6	7.3	9.3
20%	6.7	0.44	7.2	7.8	8.4	10.4
10%	7.5	0.44	8.0	8.6	9.2	11.2
5%	8.4	0.44	8.8	9.5	10.1	12.1
2%	9.7	0.44	10.1	10.7	11.4	13.4
1.00%	11.0	0.44	11.4	12.1	12.7	14.7
0.50%	12.6	0.44	13.0	13.7	14.3	16.3
0.20%	14.6	0.44	15.0	15.7	16.3	18.3
USACE Curves computed using criteria in ER 1100-2-8162, 31 Dec 13						
Gauge: 8531680, NJ, Sandy Hook: 75 yrs. All values are in feet.						

***Per ER 1100-2-8162 water level is reported in year 1992 (which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983–2001). These NACCS water levels include wave effects and are estimated at the 50% confidence interval. Change in water surface elevation refer to the historic scenario of sea level change.**

The Department of the Army Engineer Regulation ER 1100-2-8162 (15 June 2019) requires that future sea level rise (SLR) projections must be incorporated into the planning, engineering design, construction and operation of all civil works projects. The study team evaluated the proposed alternatives in consideration of the “low,” “intermediate,” and “high” potential rates of future SLR for both “with” and “without project” conditions. This range of potential rates of SLR is based on findings by the National Research Council (NRC, 1987) and the Intergovernmental Panel for Climate Change (IPCC, 2007). The historic rate of future sea-level rise is determined directly from gauge data gathered near the study area. Tide conditions at Sandy Hook (National Oceanic and Atmospheric Administration (NOAA) Station #8531680) best represent the conditions experienced in Highlands. A 75-year record (1932 to 2006) of tide data gathered at Sandy Hook, NJ indicates a mean sea level trend (eustatic SLR + the local rate of VLM) of +3.96 mm/year, or 0.014 ft/year (**Error! Reference source not found.**).

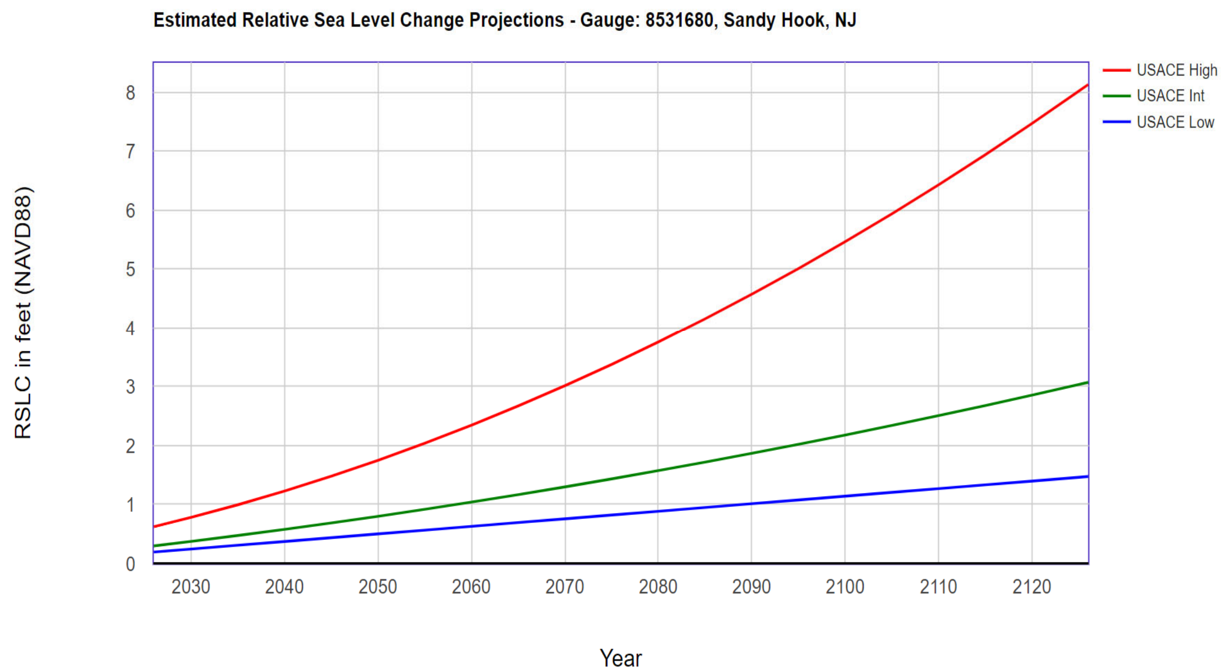

Figure 2-2: Relative Sea Level rise at NOAA Sandy Hook gage

In Figure 2-3 below, the USACE Sea Level Tracker tool shows that the actual sea levels for Sandy Hook between 1992 and 2000 appears to approximately follow the low/historic rate. But following 2000, the recorded sea level varies between the intermediate and high rates. This may be an indication that the low/historic rate of sea level change is too low, and the future may hold sea levels above or below the any of the scenarios. The uncertainty around the trend of relative sea level change prompted incorporation of adaptability into coastal storm risk management measures considered, such that if higher rates than the low/historic rate occurs, adaptive measures may easily and efficiently be applied. Adaptation responses range from building floodwalls with wider bases that can more easily accommodate future height increases;

anticipation of more frequent nourishment cycles for beach projects; and anticipation of future nonstructural actions. The specific type of adaptation measures is described later in this report based on the components of alternative plans that best meet the goals and objectives for this study.

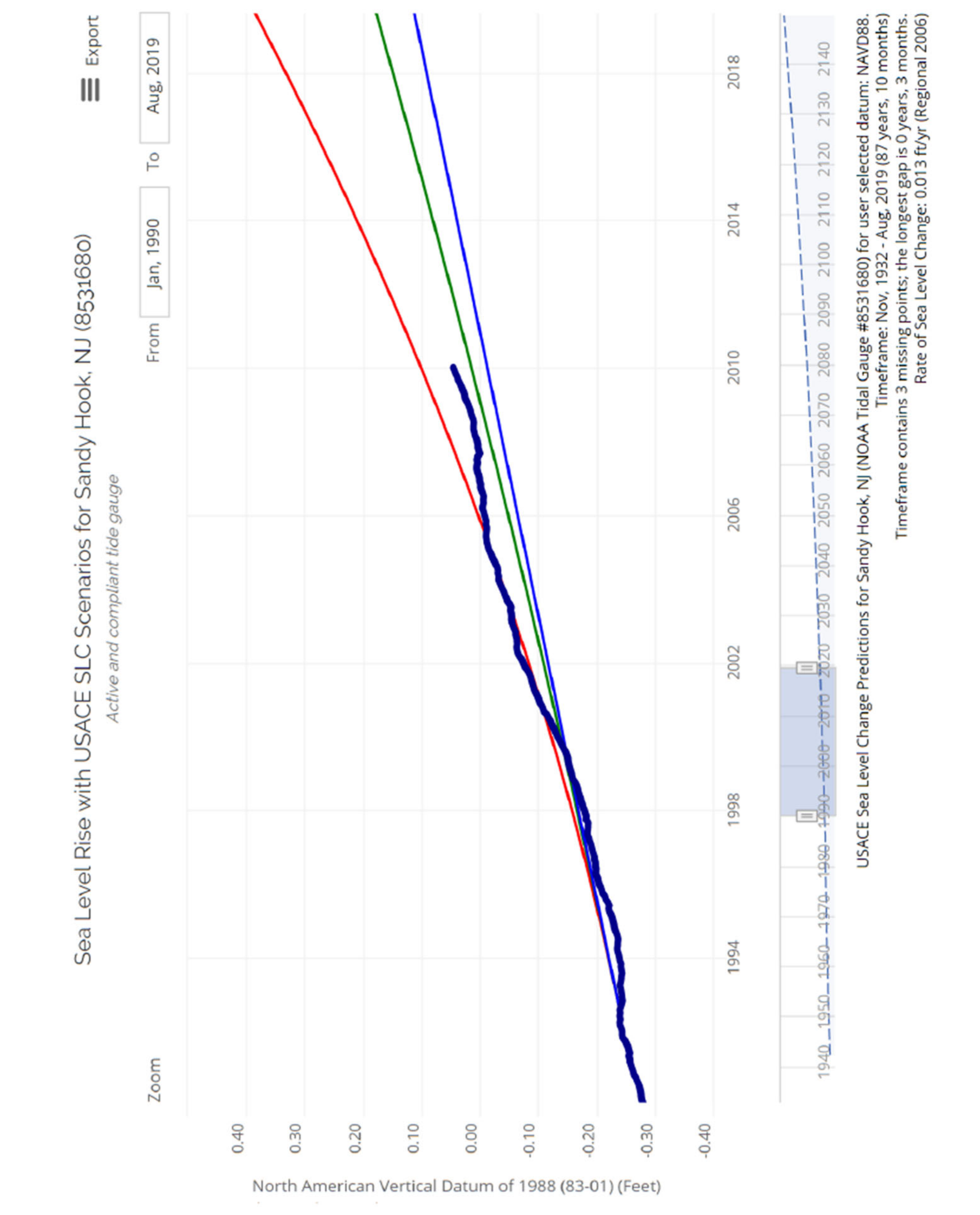

Figure 2-3: Sea Level Tracker for Sandy Hook, NJ (NOAA Station #8531680)

Chapter 3. Plan Formulation

Planning plays a vital role in supporting the USACE Civil Works water resources development mission. Through planning activities, including feasibility studies, USACE study teams help decision-makers identify water resources problems, conceive solutions to them and compare the importance of the inevitable conflicting values inherent in any solution. The 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies (Principles and Guidelines) lay out an iterative 6-step planning process that is used for all USACE Civil Works studies, including the North Atlantic Coast Comprehensive Study (NACCS) CSRM framework (USACE 2015). The study team followed this planning process, as described in this chapter, to choose a Tentatively Selected Plan and conduct detailed feasibility analyses to develop the TSP into the Recommended Plan.

3.1. Problem Statement

Problem definition is the detailed description of a problem. It begins with a problem statement, a simple assertion of the basic problem.

Problem statement: *The community of Highlands experiences damages from flooding due to coastal storms including tropical storms, hurricanes, and nor'easters.*

The primary problem encountered in the study area is coastal flooding associated with water levels. Although nuisance flooding can occur during periods of high astronomical tides or minor storms, severe flooding damage results from tropical storms, hurricanes, and nor'easters. Due to the geographic setting known as the New York Bight and the offshore topography in the NY and NJ region among other meteorological factors, the surge potential is very high in Highlands during extreme coastal storms.

Flood zones are geographic areas that the Federal Emergency Management Agency (FEMA) has defined according to different levels of flood risk. According to the FEMA Flood Insurance Rate Map (FIRM), virtually all of Highlands has been classified as a "Special Flood Hazard Area" inundated by the 100-year or 1 percent chance flood base flood elevation (BFE) (Figure 3-1). The BFE in the AE zone, where the base elevations are defined for the Highlands area, is +11 ft NAVD88, and the BFE in the VE zone, where there is a 1% or greater chance of flooding plus an additional vulnerability to hazards associated with storm waves, ranges from +12 ft NAVD88 to +15 ft NAVD88 in the Borough. The 1 percent chance base flood elevation (BFE) is based on mapping effective date of June 20, 2018, however as sea levels rise, the same flood elevations shall occur more frequently than 1 percent chance of exceedence. To regulate land development in the floodplain, Highlands governing authorities enforce the Highlands Flood Damage Prevention Ordinance (0-99-11 Part 7, Article XXIV of the Zoning Ordinance, adopted August 18, 1999), which has a primary purpose to prevent construction and development from increasing flooding as well as to ensure public safety and reduce property damage. The ordinances and regulations call for elevating buildings one foot above the BFE for new construction projects and substantial improvements to existing structures.[4]

Highlands has a history of devastating flood damages. In general, flooding due to storm surges occurs over a large area of the Borough paralleling the low-lying Sandy Hook Bay shoreline and where flood waters propagate up and restrict flow from tributary storm drainage systems. The Shrewsbury River is a tidal estuary with wide bay-like waterways protected by the Sandy Hook peninsula and nearby barrier beaches is not a separate source of flooding but acts to exacerbate high water from Raritan Bay and Sandy Hook Bay. The river system ultimately drains into the Raritan Bay and Sandy Hook Bay. The low-lying flooded area extends along the entire Borough from the northwest to southeast boundaries and includes a combination of residential and marine-based commercial buildings. Of the 905 structures in the 100-year (1 percent) floodplain, 829 structures are at or below elevation +8 ft NAVD88, subjecting them to severe flood damages.

[4] http://www.highlandsnj.us/docs/Ordinance/2013/O-13-05%20ABFE%20Amended%20Ordinance%20-%20Adoption.pdf

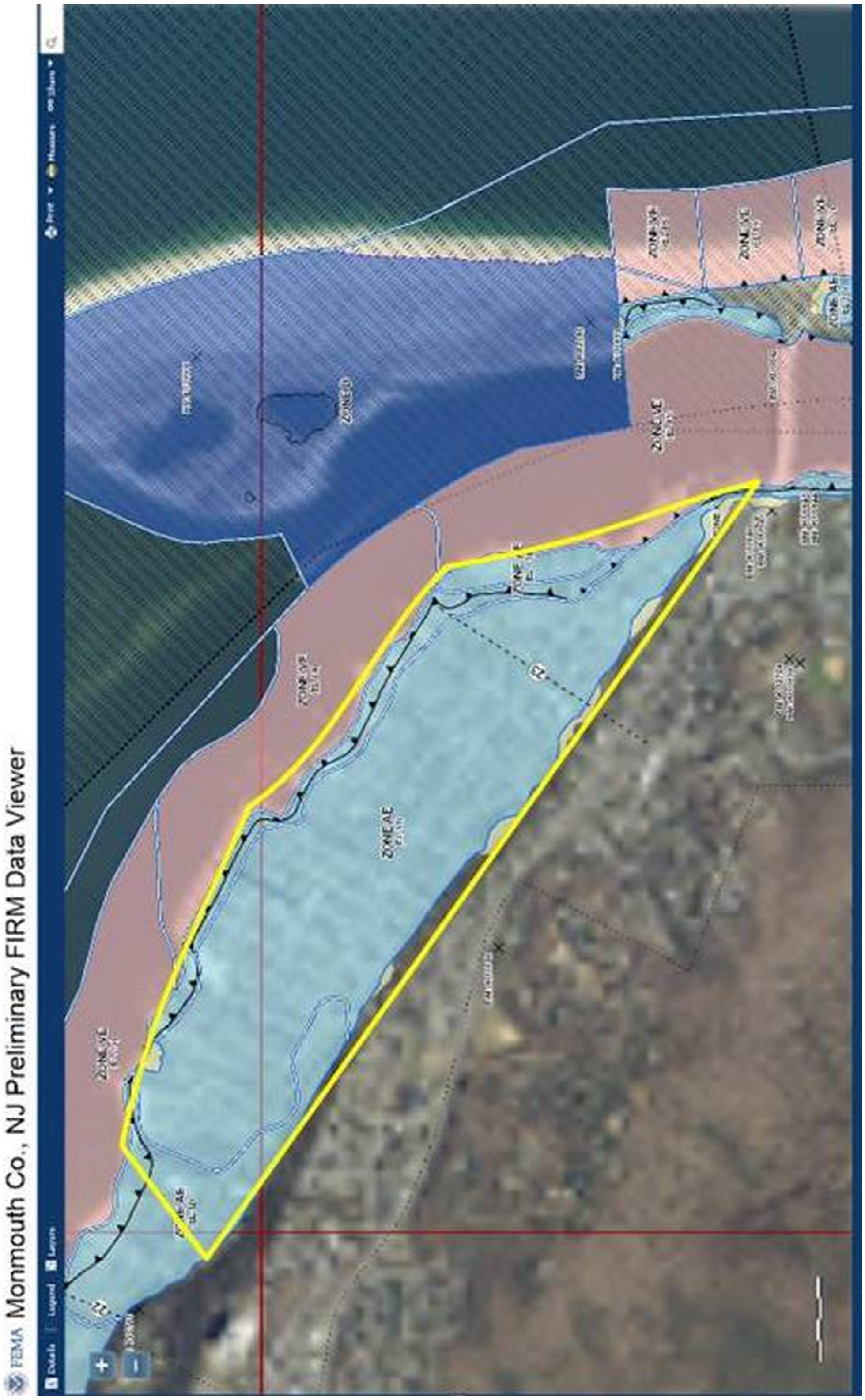

Figure 3-1: FEMA Preliminary Flood Insurance Rate Map (2015) for Highlands

Problems also exist with drainage of storm water through the inland areas of the Borough's storm water systems. Storm water drainage from 260 acres of upland and 240 acres of lower inland tributary areas concentrates by ponding in depressed inland areas. Four pump stations already exist to provide discharge of the storm water pipe systems from these areas into the Bay. Flooding resulting from elevated flood stages further exacerbates this problem. During Hurricane Sandy, four pump stations in Highlands – Waterwitch Avenue, Barberie, South Bay Avenue, and North Street were submerged in six to eight feet of floodwaters and heavy debris (NJ Future, 2014).

Many low-lying roadways are flooded during severe storm events cutting off access to large portions of Highlands. Access through the Borough becomes limited to the upper arterial roadways including Bayside Drive, Linden Avenue, State Highway 36, and Portland Road, as local streets get flooded, cutting off access to evacuation routes. During Hurricane Sandy and other storms, access in and out of the low-lying areas of the Borough was rendered virtually unfeasible. During flood events in general, many residents are unable to leave or evacuate and businesses close down indefinitely. Road closures make post-storm recovery very difficult creating major safety hazards.

Public services in Highlands were curtailed because of the flood damages to the Borough Hall, the Fire Department, and Emergency Medical Services and Department of Public Work facilities. Borough Hall was temporarily relocated to a less central location, which has affected its ability to provide services. The Robert D. Wilson Community Center, which also served as a library, was closed due to flood damages. There are no other community centers/libraries within the study area. The Veteran's Waterfront Park and Huddy Park also sustained severe damages from Hurricane Sandy.

There are significant concentrations of socially vulnerable populations within the study area. This description of Hurricane Sandy's impact on the residents of Highlands is from the Strategic Recovery Planning Report (SRPR) (2014:8):

> *A recently-completed analysis by Rutgers University revealed that Highlands Borough lost power for 12 days and that the amount of lost wages of residents totaled over $17,800,000.*[5] *Moreover, the analysis identified the impact of Sandy on the most vulnerable households (defined as "those working families that do not earn enough to afford a basic household survival budget," or so-called ALICE (Assisted Limited Income Constrained, Employed) households). Highlands was among the top 30 municipalities in the state for Sandy's impact on these households. These households experienced total lost wages in excess of $1,500,000 from the storm. In addition, 70% of these households did not have property insurance, further exacerbating Sandy's impact. According to Rutgers data, these vulnerable households only received an average of $3,770 in FEMA Individual Assistance funds.*

As described in Section 2.1.9 (Socioeconomics) of this report, the Highlands economy had seen little economic growth prior to Hurricane Sandy. The storm left some of its residents even more financially vulnerable by displacing them from their homes or forcing businesses to close, whether

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[5] Halpin, Stephanie Hoopes; The Impact of Hurricane Sandy on New Jersey Towns and Households; Rutgers School of Public Affairs and Administration; n.d

temporarily or permanently.

3.2. Future Without Project Conditions

The Future Without Project Condition (FWOPC) serves as the base conditions for all the alternative analyses. The FWOPC at Highlands within the period of analysis (2026-2076) are identified as continued flooding and wave impacts from future storm episodes, and continued maintenance and reconstruction of coastal storm risk management facilities following storm events. The FWOPC is organized by the environmental setting, the built environment, and the human environment. It is important to note that the structure inventory consists of structures within the 500-year event floodplain. After the Sandy storm, Highlands enforced restrictions on new developments in the flood zone and issued 195 permits for elevations and demolitions of certain structures. The structure inventory was revised accordingly for the analysis of the FWOPC. For each damage category, including residential and commercial structures among others, there remained a total of 905 structures in the 500-year event floodplain which represent approximately $157,000,000 in future damages at that rare event (damages are detailed in the Economics appendix). Future flood events pose additional risk beyond damages to property. Many residents are dependent on present access routes. Shore Drive, Bay Avenue, and other local roads would continue to be at risk of flooding and damage from hurricanes and coastal storms over the 100 year planning horizon, which may cause a life and safety hazard to the community.

3.2.1. Future Without Project Conditions for the Environmental Setting

In the absence of Federal action, the condition of wetlands, air quality, flora & fauna, threatened and endangered species, cultural resources, and Hazardous, Toxic and Radioactive Waste (HTRW) is expected to remain consistent with current conditions. Because Highlands is highly developed, there are few developmental opportunities remaining.

Sea level rise (SLR) is a component of overall damages caused by erosion, inundation and wave attack that exacerbate existing problems well into the future. The predicted "low," "intermediate," and "high" rates of sea level change were calculated for Sandy Hook for 2026 through 2076, the period of analysis as per ER 1100-2-8162. Figure 2-2 presented in section 2.4.2 above, shows the low, intermediate, and high estimates for sea level rise based on the Sandy Hook gauge through the 50-yr period of analysis (years 2026-2076) and beyond to include the planning horizon (years 2026-2126). Under the low scenario, sea level is projected to rise by 1.07 ft. within the period of analysis. Under the intermediate scenario, sea level is projected to rise by 1.70 feet. Finally, under the high scenario, sea level is projected to rise 3.69 feet. Considering a planning horizon from year 2026 to year 2126, SLR is expected to reach 8.37 ft. by year 2126 in the "high" scenario.

3.2.2. Future Without Project Conditions for the Built Environment

Because the downtown area is almost entirely developed, there is little opportunity for new expansion. Homeowners and businesses continue to rebuild or elevate structures flooded by

Hurricane Sandy. Owners of substantially damaged properties, more than 50% damaged,[6] (as defined by the local floodplain manager) are required to rebuild flooded structures one foot above the base flood elevation. Homes and businesses would continue to be at risk of flooding and damage from coastal storms. The Paradise Trailer Park at the western end of the study area was largely destroyed by Hurricane Sandy. It has been redeveloped in coordination with the Borough administration and USACE. The resulting condominium development has an elevated bulkhead (+14 ft NAVD88) that would tie into the USACE project.

Many users are dependent on present access routes. Because of this, street routes and ferry service will likely not change in the future. Shore Drive, Bay Avenue, and other local roads would continue to be at risk of flooding and damage from hurricanes and coastal storms, which may cause a life and safety hazard to the community.

3.2.3. Future Without Project Conditions for the Human Environment

Post-Hurricane Sandy recovery is expected to continue in the immediate future, as laid out in the Highlands Strategic Recovery Planning Report. Local efforts will focus on stormwater drainage and flood mitigation, rigorous zoning and code enforcement, and research into economic viability of local businesses including clamming. Priority actions by the Borough will build redundancy and resiliency into the administration of services and provide long term flood management. It is unclear if the Borough has the resources to undertake all of the initiatives. The current USACE study is complementary to these efforts.

The Borough has three roads that could be considered evacuation routes (Waterwitch Ave., Miller St. and Highland Ave.) all lead to State Route 36. These roads are expected to remain open and in the FWOPC topography. However, it should be noted that access to these roads begin in low lying areas. Once the downtown area flooding increases, for example, during a high tide storm surge, essentially all roads downtown are impassible. There will be periods of time (hours to days, depending on the severity of the storm) where access in and out the downtown area is not possible with automobiles. The risk of loss of life is significant, as the downtown area is densely populated and emergency services would potentially be cut off until floodwaters recede. Though no loss of life has been reported, there have been reports of people who did not evacuate (during Hurricane Sandy and other prior events) and would have been without emergency responders if needed. During a December 1992 Nor'easter, a house fire on Gravely Point Road was inaccessible and spread to a neighboring home. Both homes were left to burn down to the foundation. Fortunately, both homes were unoccupied. The entire downtown area will remain at risk for loss of life in the without project future condition.

3.2.4. Estimate of Future Without Project Damages

In the estimate of damages, the stage versus damage data was combined with stage versus frequency data using the Hydrologic Engineering Center – Flood Damage Analysis (HEC-FDA) program. The HEC-FDA program quantifies uncertainty in discharge-frequency, stage-discharge,

[6] When the value of the repairs exceeds 50% of the market value of the structure

and stage-damage functions and incorporates it into economic and performance analyses of alternatives. The process applies a procedure (Monte Carlo simulation) that computes the expected value of damage while accounting for uncertainty in the basic value. The HEC-FDA program presents results for expected annual damages and equivalent annual damages. Under current USACE guidance, risk and uncertainty must be incorporated into coastal storm risk management studies. The following areas of uncertainty were incorporated into the HEC-FDA program:

- stage frequency
- first floor elevation
- depreciated structure value
- content-to-structure value ratio
- other-to-structure value ratio

The economic analysis includes the existing risk management afforded by high shorefront elevations and bulkheads. Because damages are limited until the storm surge overtops the existing bulkhead or high ground, the analysis of existing conditions considers a levee as part of existing conditions along the shorefront. This levee allows the existing level of risk management to be taken into account when calculating project damages. The high ground elevation along the shorefront varies, but inundation will occur when water overtop the bulkheads at the lowest elevations, identified as +5 ft NAVD88. Under existing conditions, it is assumed that no damages result until water levels exceed the crest of this structure. Once water levels exceed the crest of the bulkheads, however, they are trapped within study area by these same bulkheads, prolonging the duration of the inundation and exacerbating flood damages.

It is expected that storms will continue to occur into the future, causing damage in this area. Tidal inundation is expected to increase gradually over time, in direct relation to the anticipated rise in relative sea level. Based upon long-term trends measured at Sandy Hook, a 0.014-foot per year increase is anticipated, resulting in a 0.7-foot increase over the 50-year period of analysis for the project. In future years this will result in more frequent and higher stages of flooding.

The estimated annual equivalent damages from coastal storm inundation and wave damage are limited to structure, content, and other damages at specific buildings and vehicular damages. Expected annual equivalent damages for the future without project condition are an estimated $29,182,000 (FY20 price level). More details on the identification of future without project damages are in the Economics Appendix.

3.3. Key Uncertainties

Limitations to the quantity and quality of information result in uncertainties. The study team dealt with three major uncertainties.

1. <u>RSLC projections</u>: At Sandy Hook, the Historic (or Low) Rate of SLC, including VLM, accounts for a total of 1.07 ft. in year 2076 (the 50th year of the evaluation period) since 1992. Under the intermediate scenario, sea level is projected to rise by 1.70 feet. Finally, under the high scenario, sea level is projected to rise 3.69 feet. Considering a 100 year planning horizon from year 2026

to year 2126, SLR is expected to reach 8.37 ft. by year 2126 in the "high" scenario. In future years this will result in more frequent and higher stages of flooding. During optimization, formulation accounted for project performance under the intermediate and high rates of projected RSLC, consistent with the ER 1100-2-8162. Analysis of the intermediate and high rates of RSLC showed that a larger height version of the TSP was more effective in light of RSLC considerations.

2. Operations, Maintenance, Repair, Rehabilitation & Replacement (OMRR&R): Some coastal storm risk management measures that preserve waterfront access (removable flood wall, buoyant swing gates) will require intensive operations and maintenance from the non-Federal Partner. It is unclear in this economic climate that the non-Federal partners will have the resources to provide the necessary OMRR&R for some of the measures to reliably meet the objectives of managing flood risk and associated damages. The study team focused its efforts on identifying the full costs of OMRR&R measures needed to avoid failure (personnel and equipment back-ups, pre-emptive project operation, etc.), so that the true OMRR&R costs for these alternatives have informed the plan formulation.

3. Waterfront access: Waterfront access is important for the residents of Highlands. While the public is generally supportive of the features of the TSP, some have expressed concerns about how they will access the water. USACE and NJDEP hosted a series of meetings with the public to discuss public access options in spring 2014. Approximately seven meetings were held for the 107 property owners and businesses from whom easements would be required. To date, local feedback has not led to substantial design alterations.

3.4. Opportunities

Opportunities to solve problems in the study area have been identified by the study team. There are **opportunities** in Highlands to:

1. *Reduce coastal storm risk to residents, property, and infrastructure.*
2. *Reduce damages from wave action.*

The greatest need in the study area is for effective coastal storm risk management that provides acceptable levels of risk reduction from the impacts of storm inundation. Due to the low elevations of the land along the bay front, as well as the dimensions of existing structures, effective damage reduction against high storm surge from Sandy Hook Bay is a necessary component of a complete Coastal Storm Risk Management (CSRM) plan. Many roadways providing access within the study area are subject to frequent flooding, limiting transportation during flood events.

3.5. Federal Action

The Disaster Relief Appropriations Act of 2013, Public Law 113-2 (P.L. 113-2), directed the USACE to address damages caused by Hurricane Sandy and to reduce future flood risk in ways that will support the long-term sustainability of communities such as Highlands. The feasibility study was completed pursuant to this mission.

Per the 1983 Principles and Guidelines, 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) are increases in the net value of the national output of goods and services.

3.6. Planning Goal

A study goal based on problems and opportunities was developed to help create and evaluate alternative plans. The goal reflects the overarching intent of the project.

Goal: Reduce the risk of flooding and associated damages caused by storm surge due to coastal storms that impact Highlands.

3.7. Planning Objectives

Plans are formulated to achieve planning objectives. Planning objectives and constraints are inexorably linked to problems and opportunities. A planning objective states the intended purposes of the planning process. It is a statement of what solutions should try to achieve. Objectives provide a clear statement of the study purpose.

In support of the goal, the planning objectives are to:

1. *Manage the risk of damages from flooding caused by storm surge due to coastal storms that impact Highlands through 2076.*
   Measurement: estimated annual damages, as calculated by the HEC-FDA model. Projects will be formulated to maximize net benefits, rather than to specific historical events such as Hurricane Sandy.
2. *Develop a resilient and sustainable risk management solution for Highlands through 2076.*
   Measurement: qualitative analysis of engineering robustness and rapidity (the speed with which functionality can be restored to a system or project after a disruption)

3.8. Planning Constraints

Constraints are restrictions that limit the extent of the planning process. They can be divided into universal constraints and study-specific constraints. Universal planning constraints are the legal and policy constraints to be included in every planning study. Study-specific planning constraints are statements of things unique to a specific planning study that alternative plans should avoid. Constraints are designed to avoid undesirable changes between without- and with-plan conditions.

Universal planning constraints include:

- Plans should be formulated and evaluated in compliance with USACE regulations and NEPA.

- Plans should avoid and minimize environmental impacts to the maximum degree practicable.
- Plans should not adversely impact threatened or endangered species or their habitat.
- Plans should be compliant with all Federal environmental laws, Executive Orders, and guidance.
- Plans should represent sound, safe, and acceptable engineering solutions.

Study-specific planning considerations include:

- Waterfront Use: Plans should not restrict or significantly change current waterfront use. The bayshore is extensively developed, and is currently employed for many residential, commercial, and recreational uses, outlined in the *Monmouth County Growth Management Plan*. Commercial businesses depend on waterfront access and existing infrastructure. In addition, public access to beaches, marinas, boardwalks, parks, piers, and the Conner's Highlands Sea Streak ferry terminal, as described in the *Bayshore Waterfront Access Plan*, should be maintained. Homeowner's waterfront access will also remain, or be provided to the extent practicable.

- Federal Navigation Project: Plans should minimize disruptions to the operations of the Shrewsbury River Federal navigation project. The project provides depths of 12 ft from Sandy Hook Bay to a point just north of the bridge at Highlands, then 9 ft in Shrewsbury River to the Branchport Avenue Bridge at Long Branch, about 7.4 miles.

3.9. Management Measures

Plans are composed of measures. A measure can be nonstructural (actions to reduce flood damages without significantly alternating the nature or extent of flooding) or structural (a physical modification designed to reduce the frequency of damaging levels of flood inundation by modifying the characteristics of the flood). Natural features are those created through the action of physical, geological, biological and chemical processes overtime. Nature-based features are those created by project intervention to work in concert with natural processes that would occur without the project. Natural and Nature-Based Features (NNBF) were considered consistent with requirements of Water Resources Development Act of 2016, section 1184. Each type of measure can be used individually or combined with other management measures to form alternative plans. Measures were developed to address problems and to capitalize upon opportunities. They were derived from a variety of sources including prior studies, the public scoping process, and the study team's experience.

The following nonstructural, structural, natural and nature-based measures were considered to provide coastal storm risk management and maximize project benefits. All measures were screened for their capability to meet objectives and avoid constraints, for engineering and economic feasibility. Measures that warranted consideration were assembled into alternative plans. Below describes the different types of measures that were considered.

Nonstructural Measures

1. **Buyouts (acquisition) of frequently flooded structures.** This technique includes permanent evacuation of existing areas subject to erosion and/or inundation and involves the acquisition of this land and its structures, either by purchase or by exercising the powers of eminent domain. Following this action, all development in these areas is either demolished or relocated.
2. **Elevation (raising) of frequently flooded structures.** This technique lifts an existing structure. Elevation can be performed on extended foundation walls, or on piers, post, piles, and columns.
3. **Ringwalls/structural peripheral wall.** This technique is applicable on a small-scale basis. As nonstructural measures, berms and floodwalls are intended to reduce the frequency of flooding but not eliminate floodplain management and flood insurance requirements. Within Highlands, ringwalls are mostly likely to be built around individual structures.
4. **Floodproofing of frequently flooded structures.** Floodproofing is a body of techniques for preventing damages due to floods, and requires adjustments both to structures and to building contents. It involves keeping water out of structures, as well as reducing the effects of water entry. Wet floodproofing entails that all construction materials and finishing materials be water resistant, and all utilities must be elevated above the design flood elevation. Dry floodproofing consists of waterproofing structures.

Hard Structural Measures

5. **Seawall/bulkhead with closure gates (raised epoxy coated steel sheet pile bulkhead).** This measure would entail raising or capping existing bulkheads. Raised bulkheads would provide risk reduction from coastal flooding to interior structures.
6. **Offshore closure structure.** During tidal flood events, closure gates placed across waterways can be closed, and high flows pumped across the closure. Such **closure gates and pump stations** could be included in a structural line of risk reduction to ensure access through.
7. **Navigation sector gates.** Gates could be used to allow navigation through a closure structure. They would be designed with consideration of USACE standards.
8. **Removable fabricated floodwall (inland).** A removable floodwall is a temporary structure that is erected prior to a flood event. Post-flooding, the barrier walls are stored offsite.
9. **Setback floodwalls (I-type & T-type floodwall).** Floodwalls are intended to provide risk reduction from coastal flooding to interior structures. While these structures may provide a cost-effective means to prevent flooding of low-lying areas, runoff trapped behind the structure may affect the hydrology and drainage of interior areas. This may alter tidal wetlands and require additional drainage facilities.
10. **Raised road, ground surface, and asphalt areas.** Roads and surfaces would be raised to a level that would provide risk reduction to landward areas. Areas could be raised using fill material.

Soft Structural Measures

11. **Reinforced dune/Buried Floodwall.** Dune construction involves the placement of sand to build the relatively high feature. A buried sheetpile seawall would provide stability.
12. **Beachfill and dune with terminal groins (with buried sheetpile seawall).** Beach nourishment involves the placement of sand on an eroding shoreline to restore its form and to provide adequate risk management. A beach fill typically includes a berm backed by a dune; these elements combine to reduce erosion and inundation damages to leeward areas. A terminal groin would mitigate sand movement via longshore transport.

Measure 11 and 12 above are considered natural and nature based.

3.10. Initial Array of Alternatives

Measures that warranted continued consideration were assembled into **alternative plans**. An alternative plan (also known as, "**plan**" or "**alternative**") is a set of one or more management measures functioning together to address one or more planning objectives. Measures were grouped by theme into the following **design strategies**, which formed the basis of the alternatives. The design strategies were the basis for alternative development and refinement. In general, reinforced dunes and raised ground surfaces/parking areas were used where possible. Raised bulkheads were used to maximize the number of structures to be protected, except where impacts to water views and adjacent property shoreline access would be too extensive.

- **Hard structural strategy.** Based on the pre-feasibility study, a hard structural strategy would include hardening the bayshore to reduce the frequency of damaging levels of flood inundation.
- **Nonstructural strategy.** Instead of trying to reduce the frequency of damaging levels of flood inundation with physical modifications to the bayshore, a nonstructural strategy would consist of actions to reduce flood damages (elevations, buyouts, etc.) without affecting the frequency or intensity of the flooding.
- **Regional strategy - offshore closure.** An offshore closure structure with a navigation sector gate between Highlands and Sandy Hook would remove the need for local structural measures (floodwalls, dunes, etc.) to reduce the frequency of damaging levels of flood inundation and would reduce risk to the entire Shrewsbury and Navesink River Basins.[7]
- **Soft structural strategy.** This strategy focuses on beach fill, dunes, and road raisings to reduce the frequency of damaging levels of flood inundation. These features are also considered Nature and Nature Based Features (NNBFs).
- **Hybrid Strategy.** This strategy tries to match the existing surroundings (hard structures where shoreline is already hardened, beach/dune where there is beach) in developing an alignment to reduce the frequency of damaging levels of flood inundation. It is a hybrid of the hard structural and soft structural strategies.

The design strategies were used to guide the development of alternative plans. Existing risk

[7] This concept is being monitored in the USACE Shrewsbury River and Tributaries, NJ, Coastal Storm Risk Management Feasibility project.

reduction systems, businesses, homes, and other structures were considered when combining features into strategies. Planning constraints, especially to maintain current waterfront uses, were considered as well. For example, raising existing bulkheads was preferable to building new structures.

<u>Descriptions of Alternative Plans</u>

All given quantities in this section are approximate. Storm risk management features are described from west to east. In general, reinforced dunes and raised ground surfaces/parking areas were used where possible as a line of risk reduction. Raised bulkheads were used to maximize the performance of the project, except where impacts to water views and adjacent property shoreline access would be too extensive. Specific details of the connection of the new raised epoxy-coated steel sheet pile bulkheads to existing bulkheads will be determined in future phases of this project.

For comparison purposes, the alternatives were developed for a still water level (SWL) for a 2% flood (50-year return period) storm surge of elevation +8.1 ft NAVD88, plus an anticipated sea level rise[8] of +0.7 ft (over the 50-year period of analysis), for a design storm surge elevation of +8.8 ft NAVD88. A minimum inland crest elevation, where minimal surface wind wave action is anticipated, was set at elevation +10 ft NAVD88, which is the design storm surge elevation of +8.8 ft NAVD88, plus a value of +1.1 ft for the height of small surface, wind generated inland waves.

It should be noted that while the results of the Pre-Feasibility Report (May 2000) were used in the development of the study alternatives, the topographic mapping of the project site has been updated, additional geotechnical information and field observations have been collected, and the cost and wave analyses were updated from what was available in 2010.

- **No Action Alternative:** This plan includes additional Federal actions taken to provide for coastal storm risk management, namely, grants from FEMA to support disaster recovery for homeowners and businesses. This plan fails to meet the USACE study objectives or needs for the majority of the project area. It will, however, provide the base against which project benefits are measured.

- **Alternative 1: Hard Structural Plan (Pre-Feasibility Study Plan)**
The Pre-Feasibility study identified a plan consisting of 13,200 ft of vinyl coated, steel sheet pile floodwall driven in front of the existing bulkhead, tie-ins, three closure gates, 10,032 ft of stone scour protection, 8,448ft of interior storm water diversion pipes, 33 gated interior outlets, and three pump stations with a total capacity of 180 cubic ft per second (cfs) (Figure 3-2).
<u>Measures</u>: I-type floodwall, raised/capped bulkhead, closure gates, pump stations

- **Alternative 2: Nonstructural Plan**. Nonstructural measures are required to be evaluated in all feasibility studies. For each structure, the most cost effective treatment was

[8] In accordance with ER 1100-2-8162, Analysis accounted for sea level rise (SLR) as a component of overall damages using the predicted historic ("low") rates of sea level change which were calculated for Sandy Hook for years 2026 through 2076. A Detailed discussion can be found in section 3.3 Key Uncertainties discussion on RSLC projections.

determined through an assessment of the flood levels at that location, in conjunction with the ground elevation, the main floor elevation, type of construction, and structure condition, details which were obtained from the economic structure inventory or through engineering field surveys. This information was used to consult the flood damage reduction matrix developed by the USACE National Nonstructural Floodproofing Committee.[9] A graphical depiction of this thought process is shown in the Engineering Appendix - Civil of this report. As a brief example, a structure that experiences flooding which does not reach the main floor may be recommended for wet or dry floodproofing. If it experiences some main floor elevation, it would be recommended for elevation. And if floodwaters totally submerge the structure, it would be a likely candidate for buyout or acquisition. Dry floodproofing is appropriate for inundation depths shallower than 3 feet, while wet floodproofing techniques may be used for inundation depths up to 6 feet.

Under this alternative (Figure 3-3), measures include 17 "dry" flood proofings; 65 "wet" flood proofings (for which 50 require barriers to be constructed around the utilities in the basement and 15 require relocation of the utilities in a shed above ground); 861 structure elevations; 13 structures with surface floodwalls; and 35 structures with ringwall/berms. The average height of elevation for buildings is approximately 4.5 ft above existing grade. The total length of ringwall/berms and structure surface floodwalls required is approximately 12,820 ft. After Hurricane Sandy, 160 structures were removed from the calculations of potential damages because they were in the process of being demolished, elevated, or rebuilt to current code.

This alternative does meet the overall project objective of reducing storm damage in the Borough of Highlands. However, as the measures provide risk management to only buildings and structures from flooding, considerable residual damage would remain after a storm (i.e. to the infrastructure, cars, landscaping, and basements of "wet" flood-proofed structures), and significant emergency personnel activity would be required. The nonstructural features will not obstruct any water views, nor will waterfront access need to be modified.

Measures: dry and wet flood proofing, relocations, structure elevation, surface floodwalls, ringwalls/berms.

- **Alternative 3: Offshore Closure Plan**
  This alternative combines structural storm risk management features in Reach 1 with an offshore wave scour stone protection that extends 4,500 linear ft across the Sandy Hook Bay, providing risk management to Reaches 2, 3, and 4 (Figure 3-4). At the western end of Reach 1, existing ground will be raised using impervious fill to create a raised ground surface to elevation +10 ft NAVD88 that will tie into the existing contour near the end of Shore Drive, where approximately 195 ft of concrete I-type floodwall will be constructed at elevation +10 ft NAVD88. A combination of raised ground surface and constructed floodwalls will gradually transition upward to elevation +12.4 ft NAVD88 to meet a reinforced dune constructed along the existing shoreline. The reinforced dune will consist

[9] (http://cdm16021.contentdm.oclc.org/cdm/ref/collection/p16021coll11/id/363 (August 2015))

of a buried sheetpile seawall (1V:1.5H) covered with sand (1V:5H) and with an impervious earthen core installed along the backside of the seawall. The dunes will be planted with native dune grass to provide additional stabilization. The reinforced dune will continue at elevation +12.4 ft NAVD88 for 290 ft to meet a raised bulkhead.

The raised bulkhead, at elevation +12.4 NAVD88, will be located along the set-back high water mark, immediately in front of existing seawalls. The bulkhead will be fronted by protection, constructed at the toe of the bulkhead, to reduce wave overtopping impacts. From the bulkhead proceeding eastward, there will be a series of contiguous reinforced dune interspersed with raised ground surfaces for the rest of Planning Reach 1 up to the existing state bulkhead in Reach 2, which will be raised to +12 ft NAVD88.

At the eastern end of Reach 1, an offshore wave scour stone protection will be tied in to the end of the on-shore dune barrier and run parallel to the existing state bulkhead, continuing across the bay and connecting to high ground on Sandy Hook. The total wave scour stone protection alignment is approximately 4,500 ft, crossing a broad shoal area on the Sandy Hook side. At the location of the existing navigation channel approximately 500 ft from the state bulkhead, a 135-foot wide navigation sector gate will be installed to allow for a 100-foot clear opening for navigation transit when the gate is in the open position. Prior to potential major storm events, the sector gate will be closed during a period of lower tide, sealing the inner basin, providing additional runoff storage leeward of the barrier and providing risk management to Reaches 2, 3, and 4. No additional storm risk management features will be constructed in Reaches 2, 3, and 4.

Mean bay-bottom elevation along the *toe protection alignment* is roughly –4 ft NAVD88 or less, except across the navigation channel where it is an average of –19 to –21 ft NAVD88. The crest of the *toe protection will* be set at elevation +12.4 ft NAVD88. The crest elevation was selected to limit the effect of storm waves, reduce overtopping damage to the leeward side of the *toe protection*, and avoid water buildup from overtopping wave effects. There is insufficient storage leeward of the *toe protection* to store storm water runoff buildup to below elevation +5 ft NAVD88 with the sector gate closed, therefore a pump station will be required. Based on gross approximations, a 4,000 cfs pump station will be necessary to prevent residual damages from the closed gate.

<u>Measures</u>: raised road, ground surface, and asphalt areas; reinforced dune; raised bulkhead; I-type floodwall; navigation sector gate; offshore closure structure; toe protection

- **Alternative 4: Beachfill and Dune Plan**
  The structural storm risk management features in this alternative in Reach 1 are the same as those in Alternative 3—with the substitution of beachfill and dune in a portion of the reach (Figure 3-5). This is the only area where a beachfill and dune section can be accommodated due to the proximity of the existing navigation channel, piers, and shoreline frontage usage.

  In Reach 2, 1,280 linear ft of the existing state bulkhead will be capped to an elevation of +12 ft NAVD88, for an increase in the bulkhead's existing height of approximately 1 foot.

At the center of Reach 2, a buoyant swing gate will be installed at the inlet opening to a marina, tying together the two portions of the capped state bulkhead. The entire gate structure will be 70-ft wide, with a 55-foot wide channel available for navigation transit when the gate is in the open position. Prior to potential major storm events, the swing gate will be closed during a period of lower tide, sealing the existing marina and providing risk management against flood waters. The capped bulkhead will connect to a raised bulkhead in Reach 3.

In Reach 3, a 430-foot transition section of raised bulkhead will be constructed at a crest elevation of +12 ft NAVD88. The raised bulkhead will be located along the set back high water mark, immediately in front of existing seawalls. The associated *toe protection* will only be constructed for 75 ft from the capped state bulkhead, since the remainder of the raised bulkhead runs along the inside perimeter of an existing marina and a *toe protection* would interfere with marina operations. To the east, a raised bulkhead will transition to meet a raised asphalt parking area with a crest elevation of +11 ft NAVD88. From this point, reinforced dunes will alternate with raised bulkhead and associated *toe protection* at elevation +11 ft NAVD88 for the remainder of Reach 3, up to a concrete I-type floodwall in Reach 4. The Windansea Restaurant and its seaside deck will be raised in place and the restaurant entry will be modified to maintain existing water views and access with the alignment to elevation +11 ft NAVD88.

In Reach 4, 140 ft of concrete I-type floodwall will be constructed from the eastern end of the raised bulkhead in Reach 3 southwest along the Windansea Restaurant's property line towards Shrewsbury Street, transitioning from elevation +11 ft NAVD88 to elevation +10 ft NAVD88. The I-type floodwall will connect to the northwestern end of 1,075 ft of removable fabricated floodwall, installed at a crest elevation of +10 ft NAVD88 along the waterside curb of Shrewsbury Street. The removable fabricated floodwall will connect to the northwestern end of another raised ground surface. The crest will continue at elevation +10 ft NAVD88. At the southeastern end of this area, the crest elevation of the raised ground will continue at elevation +10 ft NAVD88 and meet a 415-linear foot raised portion of the existing Bay Avenue to tie into the +11 ft NAVD88 contour along Bay Avenue at the eastern closure of the project. The 415 ft of existing road will be raised to elevation +10 ft NAVD88; regrading will be necessary for access to driveways and walks. To match existing grades of the existing Bay Avenue to the northwest and close the alignment at the eastern end of the project site, a transition road approach will be constructed at a slope of 1V:10H from the northwestern end of the raised road.

Measures: raised road, ground surface, and asphalt areas; beachfill and dune; reinforced dune; raised/capped bulkhead; I-type floodwall; buoyant swing gate; removable floodwall, toe protection

- **Alternative 5: Hybrid Plan**
  Alternative 5 is geared toward matching the existing ground type (Figure 3-6). In Reach 1, it incorporates the measures from Alternative 3 and incorporates the alignment of Alternative 4 for Reaches 2, 3, and 4.

At the western end of Reach 1, existing ground will be raised using impervious fill to create a raised ground surface to elevation +10 ft NAVD88 that will tie into the existing contour near the end of Shore Drive, where approximately 195 ft of concrete I-type floodwall will be constructed at elevation +10 ft NAVD88. A combination of raised ground surface and constructed floodwalls will gradually transition upward to elevation +12.4 ft NAVD88 to meet a reinforced dune constructed along the existing shoreline. The reinforced dune will consist of a buried sheetpile seawall (1V:1.5H) covered with sand (1V:5H) and with an impervious earthen core installed along the backside of the seawall. The dunes will be planted with native dune grass to provide additional stabilization. The reinforced dune will continue at elevation +12.4 ft NAVD88 for 290 ft to meet a raised bulkhead.

The raised bulkhead, at elevation +12.4 NAVD, will be located along the set back high water mark, immediately in front of existing seawalls. The bulkhead will be fronted by a *toe protection*, constructed at the toe of the bulkhead, to reduce wave overtopping impacts. From the bulkhead proceeding eastward, there will be a series of contiguous reinforced dune interspersed with raised ground surfaces for the rest of Planning Reach 1 up to the existing state bulkhead in Reach 2, which will be raised to +12 ft NAVD88.

In Reach 2, 1,280 linear ft of the existing state bulkhead will be capped to an elevation of +12 ft NAVD88, for an increase in the bulkhead's existing height of approximately 1 foot. At the center of Reach 2, a buoyant swing gate will be installed at the inlet opening to a marina, tying together the two portions of the capped state bulkhead. The entire gate structure will be 70-ft wide, with a 55-foot wide channel available for navigation transit when the gate is in the open position. Prior to potential major storm events, the swing gate will be closed during a period of lower tide, sealing the existing marina and providing risk management against flood waters. The capped bulkhead will connect to a raised bulkhead in Reach 3.

In Reach 3, a 430-foot transition section of raised bulkhead will be constructed at a crest elevation of +12 ft NAVD88. The raised bulkhead will be located along the set back high water mark, immediately in front of existing seawalls. The associated *toe protection* will only be constructed for 75 ft from the capped state bulkhead, since the remainder of the raised bulkhead runs along the inside perimeter of an existing marina and a *toe protection* would interfere with marina operations. To the east, a raised bulkhead will transition to meet a raised asphalt parking area with a crest elevation of +11 ft NAVD88. From this point, reinforced dunes will alternate with raised bulkhead and associated *toe protection* at elevation +11 ft NAVD88 for the remainder of Reach 3, up to a concrete I-type floodwall in Reach 4. The Windansea Restaurant and its seaside deck will be raised in place and the restaurant entry will be modified to maintain existing water views and access with the alignment to elevation +11 ft NAVD88.

In Reach 4, 140 ft of concrete I-type floodwall will be constructed from the eastern end of the raised bulkhead in Reach 3 southwest along the Windansea Restaurant's property line towards Shrewsbury Street, transitioning from elevation +11 ft NAVD88 to elevation +10 ft NAVD88. The I-type floodwall will connect to the northwestern end of 1,075 ft of removable fabricated floodwall, installed at a crest elevation of +10 ft NAVD88 along the waterside curb of Shrewsbury Street. The removable fabricated floodwall will connect to the northwestern end of another raised ground surface. The crest will continue at elevation +10 ft NAVD88. At the southeastern end of this area, the crest elevation of the raised ground will continue at elevation +10 ft NAVD88 and meet a 415-linear foot raised portion of the existing Bay Avenue to tie into the +11 ft NAVD88 contour along Bay Avenue at the eastern closure of the project. The 415 ft of existing road will be raised to elevation +10 ft NAVD88; regrading will be necessary for access to driveways and walks. To match existing grades of the existing Bay Avenue to the northwest and close the alignment at the eastern end of the project site, a transition road approach will be constructed at a slope of 1V:10H from the northwestern end of the raised road.

Measures: raised road, ground surface, and asphalt areas; beachfill and dune; reinforced dune; raised/capped bulkhead; I-type floodwall; buoyant swing gate; removable floodwall, toe protection

Figure 3-2 to Figure 3-6 show the layouts of Alternatives 1 to 5. The full layouts can be found in the Engineering Appendix.

Table 3-1: Summary of Measures for Highlands Alternatives

WEST *EAST*

<table>
<tr><th></th><th colspan="8">[Reach 1]</th><th colspan="2">[Reach 2]</th><th colspan="3">[Reach 3]</th><th colspan="6">[Reach 4]</th></tr>
<tr><td>Hard Structural Alternative[1]</td><td colspan="2">I-Type Floodwall</td><td colspan="6">Raised Bulkhead[5]</td><td>Raised Bulkhead[5]</td><td>Capped Existing State Bulkhead</td><td colspan="3">Raised Bulkhead[5]</td><td colspan="2">Raised Bulkhead[5]</td><td colspan="2">Fabricated Floodwall</td><td colspan="2">I-Type Floodwall</td></tr>
<tr><td>Nonstructural Alternative</td><td colspan="18">Nonstructural Measures</td></tr>
<tr><td>Regional Alternative - Offshore Closure [2]</td><td>Raised Ground Surface</td><td colspan="2">Raised Roadway</td><td colspan="2">Reinforced dune</td><td>Raised Bulkhead</td><td>I-Type Floodwall</td><td>Raised Asphalt Area</td><td>Navigation Sector Gate</td><td colspan="9">Offshore Closure Structure</td></tr>
<tr><td>Beachfill and dune Alternative[3]</td><td>Raised Ground Surface</td><td colspan="2">Raised Roadway</td><td>Beachfill and dune</td><td>Reinforced dune</td><td>Raised Bulkhead</td><td>I-Type Floodwall</td><td>Raised Asphalt Area</td><td>Buoyant Swing Gate</td><td>Capped Existing State Bulkhead</td><td>Reinforced dune</td><td>Raised Bulkhead</td><td>Raised Asphalt Area</td><td>I-Type Floodwall</td><td colspan="2">Fabricated Floodwall</td><td colspan="2">Raised Ground Surface</td><td>Raised Roadway</td></tr>
<tr><td>Hybrid Alternative[4]</td><td>Raised Ground Surface</td><td colspan="2">Raised Roadway</td><td colspan="2">Reinforced dune</td><td>Raised Bulkhead</td><td>I-Type Floodwall</td><td>Raised Asphalt Area</td><td>Buoyant Swing Gate</td><td>Capped Existing State Bulkhead</td><td>Reinforced dune</td><td>Raised Bulkhead</td><td>Raised Asphalt Area</td><td>I-Type Floodwall</td><td colspan="2">Fabricated Floodwall</td><td colspan="2">Raised Ground Surface</td><td>Raised Roadway</td></tr>
</table>

Notes:

1. Includes 4 closure gates, the replacement of 10 existing outlets with 10 new tide gates, and 27 timber stair walkovers.
2. Includes 2 closure gates, the replacement of 1 existing outlet with 1 new tide gate, 5 earthen dune walkovers, and 1 timber stair walkover.
3. Includes 3 closure gates, the replacement of 4 existing outlets with 4 new tide gates, 8 earthen dune walkovers, 9 timber stair walkovers, and 1 modified timber stair walkover for the dune fill.
4. Includes 3 closure gates, the replacement of 3 existing outlets with 3 new tide gates, 10 earthen dune walkovers, and 10 timber stair walkovers.
5. The raised bulkhead feature includes a *toe protection* along the seaward side of the bulkhead, except in the inside perimeter of marina areas.

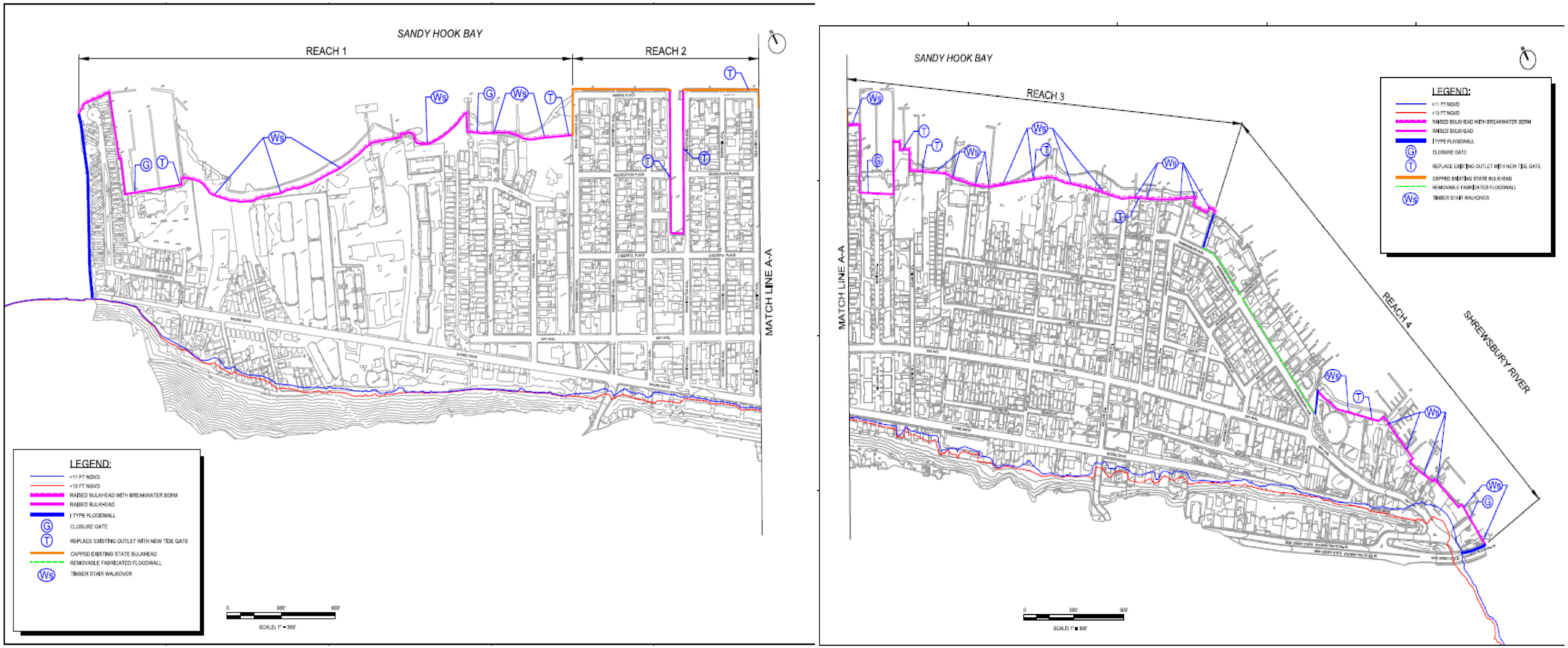

Figure 3-2: Alternative 1 – Hard Structural Plan*

*A higher resolution version of these images can be found in the Engineering Appendix of this report.

Figure 3-3: Alternative 2 – Nonstructural Plan*

*A higher resolution version of these images can be found in the Engineering Appendix of this report.

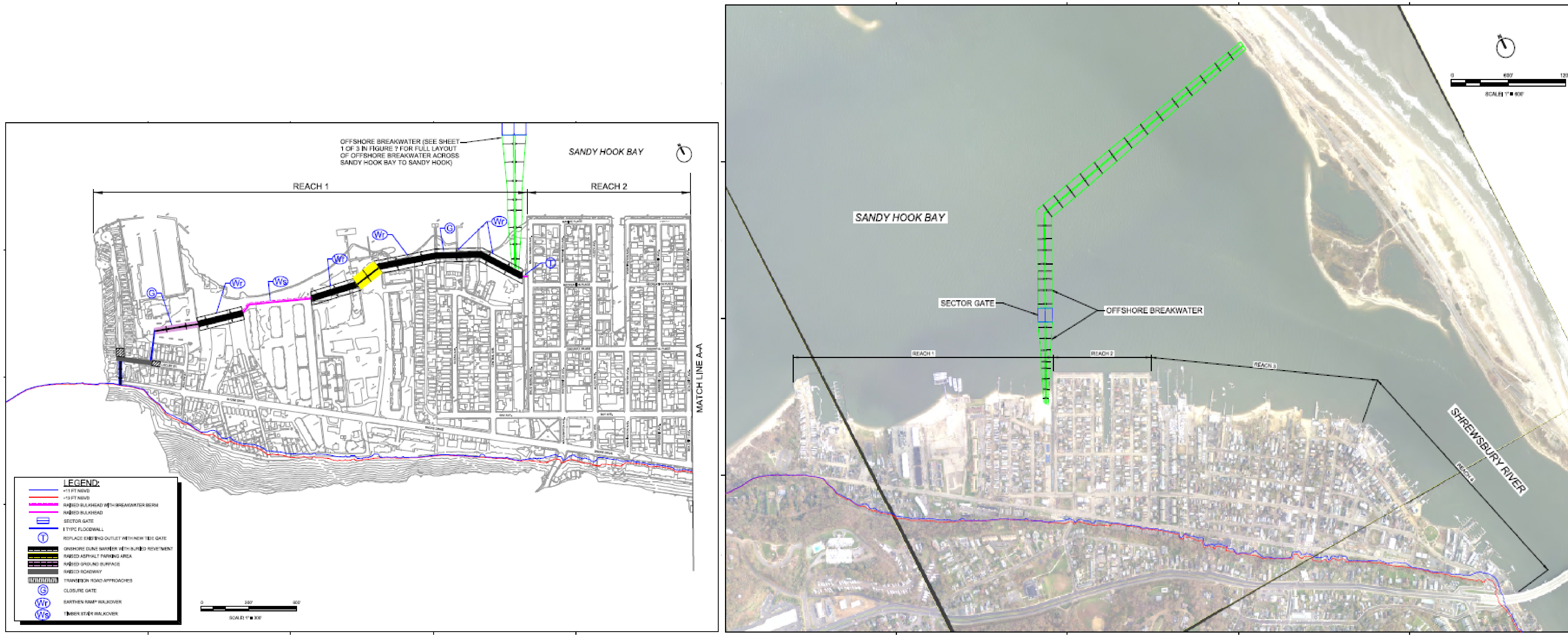

Figure 3-4: Alternative 3 – Offshore Closure Plan*

*A higher resolution version of these images can be found in the Engineering Appendix of this report.

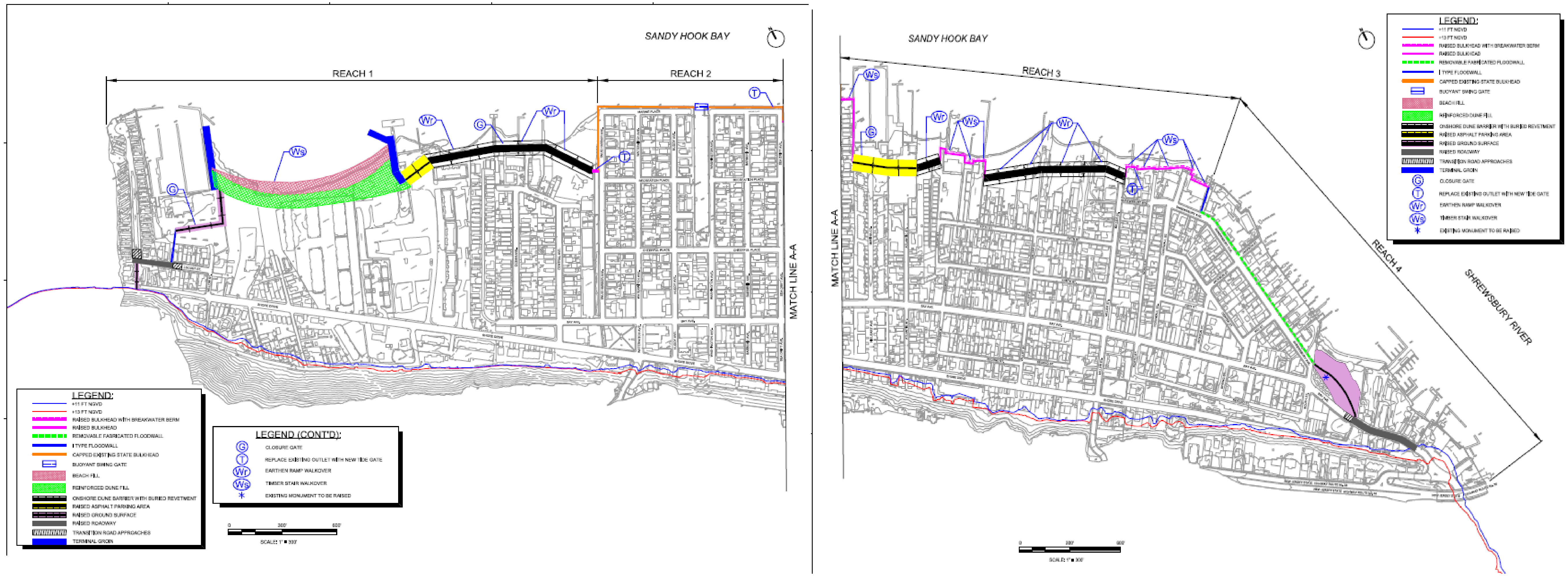

Figure 3-5: Alternative 4 – Beach and Dunefill Plan*

*A higher resolution version of these images can be found in the Engineering Appendix of this report.

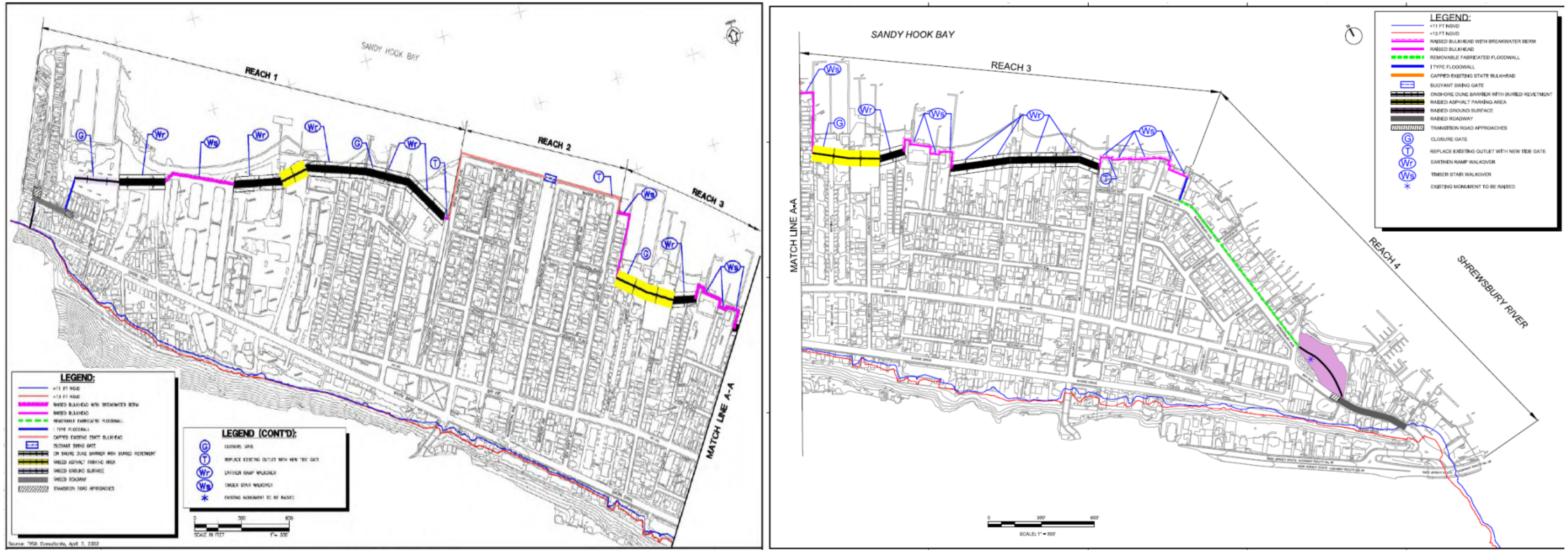

*Figure 3-6: Alternative 5 - Hybrid Plan**

*A higher resolution version of these images can be found in the Engineering Appendix of this report.

3.11. Evaluation of Initial Array of Alternatives

The purpose of the evaluation step is to carefully examine each alternative and determine if it is worthy of additional consideration. Criteria used to evaluate a plan and to determine if it qualifies for further consideration include all significant resources, outputs, and plan effects. Significant plan effects must include contributions to planning objectives and constraints. They also include the Federal Objective, environmental compliance requirements, the 1983 Principles and Guidelines Criteria four evaluation criteria, and other impacts important to the study team and stakeholders.

3.11.1. The Federal Objective

Per the 1983 Principles and Guidelines, 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." Table 3-2 shows the estimated cost for construction of each alternative. Through a sensitivity analysis, it was determined that the update to existing conditions would not affect the results of the plan formulation, because changes in construction costs would be proportional across the alternatives. Consequently, costs and benefits are presented in October 2010 price level to reflect when these numbers were derived.

Table 3-2: First Cost and Annual Cost Summary For Highlands Alternatives

(October 2010 price level – Discount Rate of 4.125%)					
	Alternative #1	**Alternative #2**	**Alternative #3**	**Alternative #4**	**Alternative #5**
Total First Cost	**$50,077,000**	**$127,770,000**	**$139,757,000**	**$44,638,000**	**$38,788,000**
Interest During Construction	$2,030,000	$5,181,000	$5,667,000	$1,810,000	$1,573,000
Total Investment Cost	$52,107,000	$132,950,000	$145,424,000	$46,448,000	$40,360,000
Annualized Total Investment Cost *	$2,478,000	$6,322,000	$6,915,000	$2,209,000	$1,919,000
Annualized Periodic Nourishment Cost	$0	$0	$0	$70,000	$0
Annualized OMRR&R Cost	$202,000	$154,000	$270,000	$163,000	$161,000
Total Annual Cost	**$2,679,000**	**$6,476,000**	**$7,185,000**	**$2,442,000**	**$2,080,000**

3.11.2. 1983 Principles and Guidelines Criteria

The 1983 Principles and Guidelines require that plans are formulated in consideration of four criteria: **completeness**, **effectiveness**, **efficiency**, and **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. For the Highlands study, an alternative had to provide risk management along the entire length of the alignment (8,000 ft) to be considered complete. Any "holes in the fence" would threaten the success of the entire project.
- **Effectiveness** is the extent to which the alternative plans contribute to achieve the planning objectives. Effectiveness of the alternatives was measured by the reduced damages in the with-project condition against a 2 percent flood (50 year event). Alternatives that have a Benefit to Cost Ratio (BCR) lower than one were eliminated from consideration.
- **Efficiency** is the extent to which an alternative plan is the most cost effective means of achieving the objectives. Efficiency will be measured through a comparison of BCRs and reduced damages. Plans that provide the same level of performance, but at higher cost, will be eliminated from consideration.
- **Acceptability** is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies. The alternatives were formulated to be in accord with applicable laws and regulations.

It is necessary to know the preliminary benefits and costs of the alternatives in order to assess their effectiveness and efficiency. Accordingly, the annual costs and benefits for Alternatives 1 to 5 are presented in Table 3-3:

Table 3-3: Highlands Alternatives Annual Costs and Annual Benefits

Net Benefit and Benefit to Cost Ratio (October 2010 P.L.)				
Alternative	**Cost**	**Benefit**	**Net Benefit**	**B/C ratio**
1	$2,679,355	$3,142,600	$463,200	1.2
2	$6,475,535	$4,791,770	-$1,683,765	0.7
3	$7,185,426	$3,123,530	-$4,061,426	0.4
4	$2,441,555	$3,121,230	$679,675	1.3
5	$2,080,378	$3,121,230	$1,040,492	1.5

With BCRs in hand, Table 3-4 shows alternatives screening using the P&G criteria. Based on the Benefit to Cost Ratios below one, Alternative 2 (Nonstructural) and Alternative 3 (Off-Shore Barrier with Navigation Sector Gate) were removed from further consideration. This screening resulted in Alternatives 1 (the Pre-Feasibility Alternative), 4 (the Dune and Beachfill Alternative), and 5 (the Hybrid Alternative) remaining for consideration.

Table 3-4: Summary of Consideration of P&G Criteria.

Alternative	Completeness	Effectiveness	Efficiency	Acceptability
No Action	N	N	N	N
Alternative 1	Y	Y	N	Y
Alternative 2	Y	N	N	Y
Alternative 3	Y	N	N	Y
Alternative 4	Y	Y	N	Y
Alternative 5	Y	Y	Y	Y

Shaded alternatives eliminated from consideration.

Table 3-4 above compares each remaining alternative on P&G criteria for evaluation purposes. Each plan remaining in consideration perform equally well for completeness, effectiveness and acceptability. Plans were formulated according to applicable regulations and achieve damage reduction. Having the lowest cost, Alternative 5 emerged as the most efficient plan.

Table 3-5: Summary of Consideration of the Four Accounts

Alternative	National Economic Development	Regional Economic Development	Environmental Quality	Other Social Effects
No Action	-	-	0	-
Alternative 1	+	0	-	+
Alternative 4	+	0	+	+
Alternative 5	+	0	+	+

Of the three alternatives, Alternative 5 had the highest net benefits and aligned the most with P& G criteria. Accordingly, Alternative 5 was developed further with five (5) variants, 5A to 5E.

3.12. Final Array of Alternative Plans

Alternative 5 was further developed in the next round of planning into 5 variants, 5A to 5E, which involved different elevations, and substitution of higher floodwall for buoyant swing gates, removable floodwalls, and concrete floodwalls & bulkheads. Table 3-6 below shows that the elements for the five variants were the same in Reaches 1 and 3 comprised of a combination of raised bulkheads and reinforced dunes to match the existing ground cover. [10] All five variants include the same assumption of three pump stations for three interior drainage areas of Highlands, to be refined during plan optimization.

Table 3-6: Summary of 5A to 5E Features

<table>
<tr><th>Alt</th><th>Reach 1</th><th>Reach 2</th><th>Reach 3</th><th colspan="2">Reach 4</th></tr>
<tr><td>5A</td><td rowspan="5">Combination of raised bulkheads and reinforced dunes</td><td>Raised bulkhead</td><td rowspan="5">Combination of raised bulkheads and reinforced dunes</td><td>Removable floodwalls</td><td rowspan="5">Combination of reinforced dunes and floodwall</td></tr>
<tr><td>5B</td><td rowspan="3">Buoyant swing gate</td><td>Nonstructural and raised bulkhead +10.9ft NAVD88</td></tr>
<tr><td>5C</td><td>Nonstructural and raised bulkhead +12.1ft NAVD88</td></tr>
<tr><td>5D</td><td rowspan="2">Raised bulkhead +12.4ft NAVD88</td></tr>
<tr><td>5E</td><td>Raised bulkhead</td></tr>
</table>

[10] The alignments for Alternatives 5A to 5E are shorter than Alternatives 1 to 5. After Hurricane Sandy, the trailer park at the eastern end of the proposed alignment is being turned into condominiums by a local developer. 5A to 5E begin at the eastern end of the condominium development.

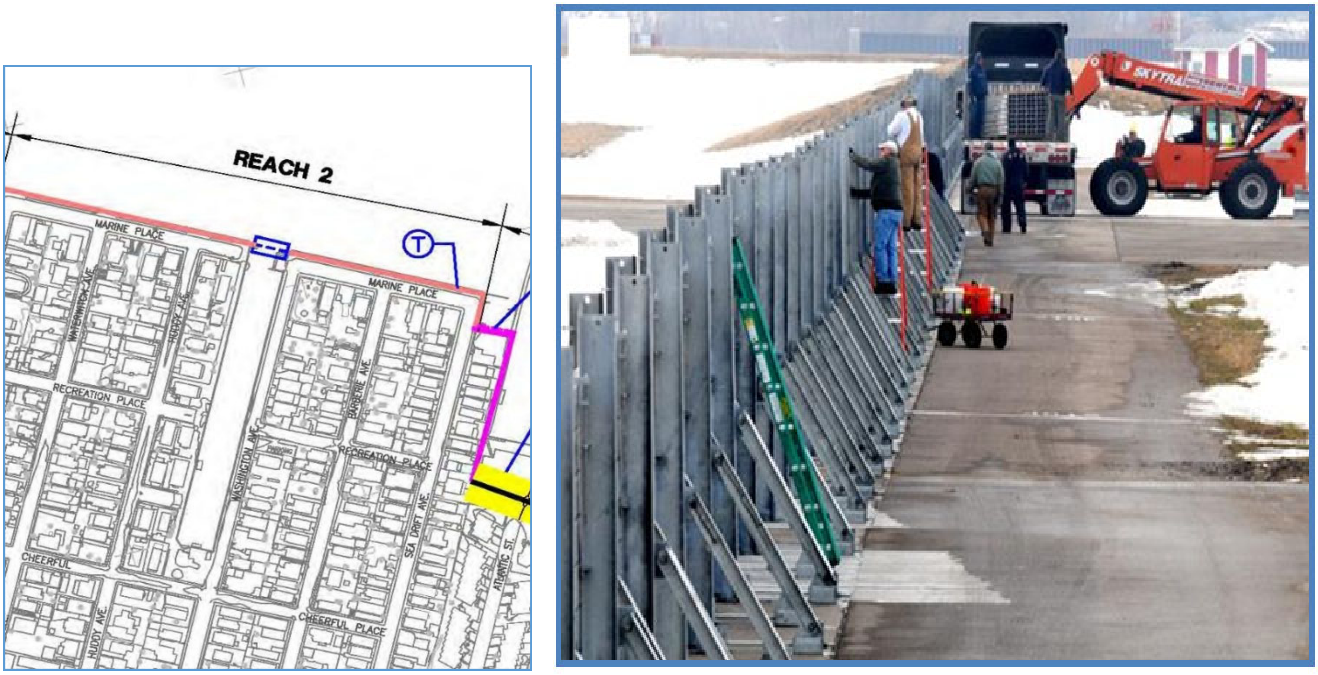

Figure 3-7: Installation of removable floodwall
Photo credit: AP Photo/Pioneer Press, John Doman

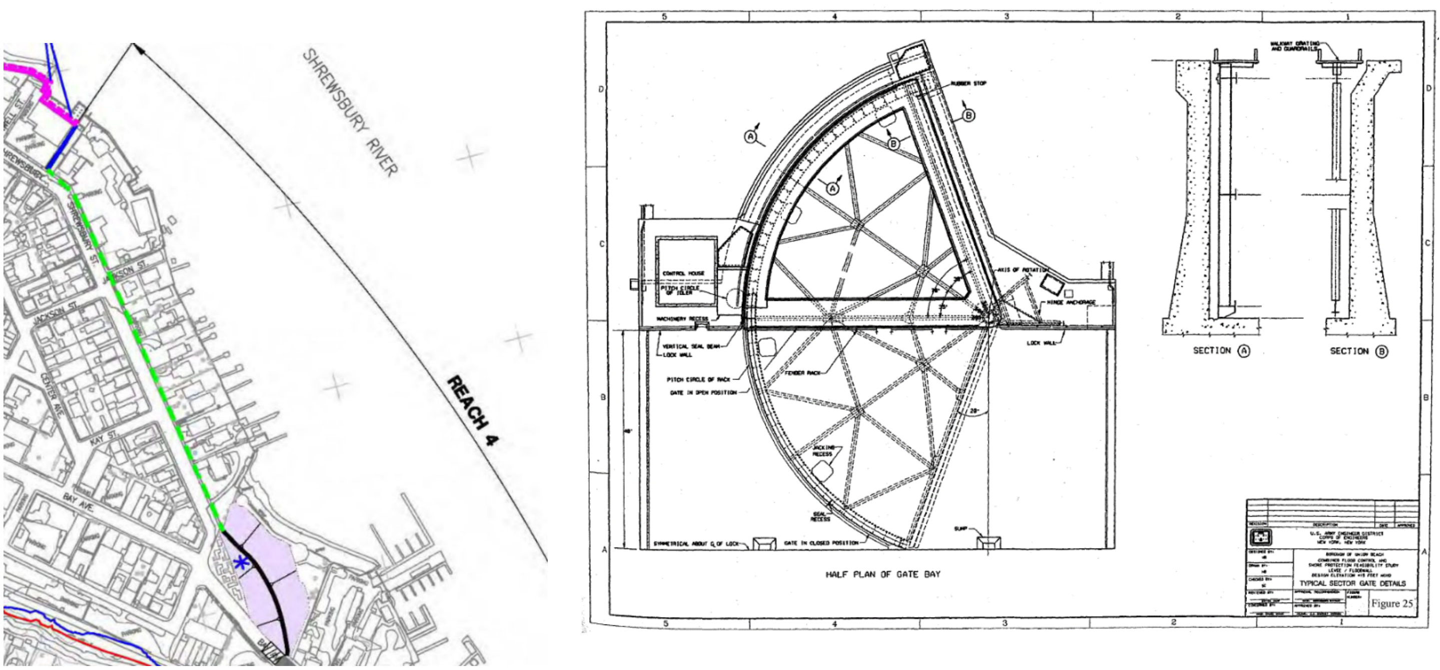

Figure 3-8: Schematic of buoyant swing gate

Figure 3-9: Example of floodwall
Photo Credit: USACE

Figure 3-10: Example of bulkhead
Photo credit: http://www.landandseamarine.com/rbk.htm

The costs for Alternatives 5A to 5E are presented in Table 3-7 in October 2014 price levels reflecting the period of evaluation. The level of detail provided on operations, maintenance, repair, rehabilitation and replacement (OMRR&R) costs is greater than typically provided for this level of alternative analysis. The OMRR&R costs were developed to this level of detail because it is a specific issue of concern for NJDEP, particularly with regard to the operations of projects with movable components, such as removable floodwalls or buoyant swing gates. Typically it is assumed that the project would be operated when needed, based on USACE projections about future storm events. The Non-Federal partner advised, based on its past experience with built USACE projects, that there is uncertainty in predicting whether a given storm would require project operation. At that time and as a precaution, the Non-Federal partner was operating the projects much more frequently than was assumed, and the projected OMRR&R costs were far exceeded by the reality for some projects.

Incorporating feedback from the Non-Federal partner, the study team used the frequency of warnings for coastal storm warnings issued by the National Oceanic and Atmospheric Administration from 2003 and 2013 as a proxy for how often the Highlands project would have to be operated.[11] Regardless of whether the warning would lead to flooding and damages, the project would have to be operated as a precaution. Between 2003 and 2013, there were 41 such warnings issued by NOAA, which is an average of four times per year. It was assumed that projects would be operated four times per year over the period of analysis for OMRR&R costs.

This adjustment had a greater effect upon the alternatives with removable floodwalls and buoyant swing gates than alternatives that were stationary (Alternative 5E). All of the alternatives carry the same level of annual maintenance and inspections - mowing, resealing, recoating, *etc*. The OMRR&R costs was important in the identification of the TSP because the first project cost for alternatives with removable floodwalls and buoyant swing gates were lower than the first costs for stationary alternatives, but require more intensive OMRR&R in the long run. The true cost of these alternatives is reflected in the annual equivalent costs with OMRR&R.

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[11] http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=34%2CNEW+JERSEY

Table 3-7: First Cost and Annual Cost Summary for Highlands Alternatives 5A to 5E

October 2014 price level, FY15 Discount rate 3.375%, over a 50 year period of analysis					
	Alternative 5A	***Alternative 5B***	***Alternative 5C***	***Alternative 5D***	***Alternative 5E***
Total First Cost	***$78,628,000***	***$84,824,000***	***$81,978,000***	***$80,454,000***	***$78,905,000***
Interest During Construction	***$2,596,000***	***$2,801,000***	***$2,707,000***	***$2,657,000***	***$2,605,000***
Total Investment Cost	***$81,224,000***	***$87,625,000***	***$84,685,000***	***$83,111,000***	***$81,509,000***
Annualized Total Investment Cost*	***$3,385,000***	***$3,652,000***	***$3,529,000***	***$3,464,000***	***$3,397,000***
Annualized OMRR&R Cost*	***$319,000***	***$207,000***	***$211,000***	***$213,000***	***$92,000***
Total Annual Cost	***$3,705,000***	***$3,859,000***	***$3,740,000***	***$3,677,000***	***$3,489,000***

3.13. Trade-Off Analysis

The annual costs of alternatives 5A to 5E have a relatively small range – from $3,489,000 for 5E to $3,859,000 for 5B. This observation prompts the question of whether it is worthwhile for the non-Federal partner to pursue one of the slightly more expensive alternatives as a Locally Preferred Plan.[12] The trade-off is that the additional cost would buy more convenient water access through the construction of removable floodwalls and buoyant swing gates, in addition to providing CSRM benefits.

A key factor in this consideration is that the removable floodwalls and buoyant swing gate would not be operated until needed, to preserve easy water access the rest of the time. Consequently, if just one of these elements is not operated in time, the project alignment would be incomplete. Given the topography of Highlands, an incomplete alignment would lead to flooding of the entire study area, just as if there were not project at all - there is no intermediate level of flooding with part of the project in place.

The hazards inherent with the buoyant swing gate include the following, many of which were experienced in New Orleans, LA during Hurricane Katrina in 2005:

1) No commercial power
2) Backup generator failure
3) Lack of fuel for generator
4) Mechanical failure of components
5) Operator unavailability

[12] An alternative that does not have the highest net benefits (the NED plan) may be pursued as a Locally Preferred Plan (LPP), assuming 1) the alternative has a benefit to cost ratio above one; 2) the alternative meets USACE policy on residual risk and uncertainty; and 3) the Non-Federal partner is willing and able to pay for 100% of the difference between the NED plan and the LPP, should the LPP be more expensive than the NED plan.

6) Operator error
7) Debris blocking gate seal
8) Shoaled sediment blocking gate seal

The hazards associated with the removable floodwall are:

1) Short storm warning time, preventing full erection of the wall
2) Inaccessibility of the storage facility
3) Structural failure of components
4) Debris blocking placement site
5) Operator unavailability
6) Operator error
7) Lack of fuel or mechanical failure of the vehicle transporting the components from the storage facility to the placement site.

The operation and maintenance (O&M) costs provided for 5A to 5E assume that the buoyant swing gate and removable floodwalls will be properly deployed, whenever needed, and in time to reduce flood damages. As previously listed, there are many factors that could interfere with this proper, timely deployment, resulting in what would essentially be the without project condition. In light of the inherent risks and uncertainty associated with these features, NJDEP is not pursuing any of the alternatives within 5A to 5D as a Locally Preferred Plan.

3.14. Identification of the Tentatively Selected Plan

Alternative plans 5A to 5E could provide risk management to a water surface elevation of +9.9 ft NAVD88, including the historic rate of sea level change, over the 50 year period of analysis. Average annual damages are shown in Table 3-8 for the without project condition and for Alternatives 5A to 5E. The benefits were calculated at October 2014 price levels at a discount rate of 3.375%. Post Hurricane Sandy, a structure inventory update was conducted using 10% of the 1000+ structures in the study area. The analysis of the updated information included identification of properties that received rebuilding permits and confirmation of rebuilding requirements. The approximate cost of annual equivalent damages for the future without project conditions for the Highland study estimated to be $11,450,000 (October 2014 P.L.).

Table 3-8: Highlands Equivalent Annual Damages

Equivalent Annual Damages (Oct. 2014 P.L.)			
Alternatives	Without Project Damages	With Project Damages	Damages Reduced
No Action	$11,450,000	$11,450,000	$ -
Alternative 5A	$11,450,000	$2,074,000	$9,376,000
Alternative 5B	$11,450,000	$2,074,000	$9,376,000
Alternative 5C	$11,450,000	$2,074,000	$9,376,000
Alternative 5D	$11,450,000	$2,074,000	$9,376,000
Alternative 5E	$11,450,000	$2,074,000	$9,376,000

This table shows that Alternatives 5A to 5E each provides the same level of performance. Any differentiation would be achieved through examination of annual costs against the annual benefits (Table 3-9), with the lowest annual cost determining the Tentatively Selected Plan.

Table 3-9: Net Benefit and Benefit to Cost Ratio

Highlands Alternatives 5A to 5E				
(Oct. 2014 P.L.)				
Alternative	Cost	Benefit	Net Benefit	B/C ratio
5A	$3,705,000	$9,376,000	$5,671,000	2.5
5B	$3,859,000	$9,376,000	$5,517,000	2.4
5C	$3,740,000	$9,376,000	$5,636,000	2.5
5D	$3,677,000	$9,376,000	$5,699,000	2.5
5E	**$3,489,000**	**$9,376,000**	**$5,887,000**	**2.7**

Based on having the highest annual net benefits ($5,887,000), Alternative 5E is the Tentatively Selected Plan. This alternative consists of approximately 10,600 linear ft of raised bulkheads, raised ground surfaces, floodwalls, and reinforced dunes. Beyond being the most efficient and effective plan, 5E also best meets the P&G criteria by being the most sustainable and resilient plan, as it requires minimal human intervention to be operational during storm events and has the fewest OMRR&R requirements.

Alternatives 5A through 5E were formulated using the historic rate of sea level change. It is possible that sea levels may increase to greater levels, such as the Corps Intermediate or High estimates. Should higher rates of sea level change occur, each of the alternatives (5A through 5E) shall perform similarly, as they are all perimeter solutions.

Reach 1, 3 and part of 4 measures are identical for 5A through 5E. Reach 2 uses a buoyant swing gate at the canal opening instead of perimeter measures along the canal. Increased sea level changes shall affect both of these similarly in that they shall be exceeded at the same sea level. The remainder of Reach 4 varies the protection type from removable floodwalls behind the row of structures at the shoreline, to varying elevations of bulkheads in front of the structures in combination with nonstructural protective measures performed on the structures (houses) themselves. Alternative 5A with the removable floodwall allows damage the shorefront row of houses. Damage would be of the same nature with increased sea level changes. Alternatives 5B through 5E with shorefront barriers would function the same with increased sea level changes. The lowest wall elevation considered precludes inundation for design conditions. Waves would overtop this wall and damage the houses but for the nonstructural reinforcements. The higher wall elevations simply lower the wave overtopping thus reducing the need for nonstructural reinforcements. However in ALL these 5A through 5E Reach 4 area of shorefront structures, the damage would be similar in nature with increased sea level changes, as it is limited to the shorefront structures, which comprise a very small portion of the structural inventory.

So, increased levels of sea level change do not change to functionality of any of the alternatives, or in other words, 5A through 5E are equally susceptible to increased sea level changes. Hence there is no sea level change reason to prioritize another alternative over 5E.

However, as sea levels rise, the frequency of inundation shall increase. As an example, a 0.02 Annual Chance of Exceedence water surface elevation of +8.8 ft. NAVD88 in 2076, may have an annual chance of exceedence significantly more than 0.02, or in other words large magnitude rare events with low sea level change shall become more frequent events with higher rates of sea level change.

Chapter 4. Development of the NED/Recommended Plan*

This section of the report describes how the Tentatively Selected Plan (TSP) that was developed after agency and public reviews for the optimal project dimensions, to arrive at the National Economic Development (NED)/Recommended Plan.

4.1. Tentatively Selected Plan Components

Alternative 5E was documented in the Draft Feasibility Report and Environmental Assessment as the TSP, consisting of approximately 10,636 linear ft of raised bulkheads, raised ground surfaces, floodwalls, and reinforced dunes, tying into high ground (+10 ft NAVD 88 to +12.4 ft NAVD88) at each end (Table 4-1). For each segment of the project, features were chosen to match the existing surroundings, *ie*., elevated bulkheads where the shoreline is already bulkheaded and reinforced dunes consisting of sand-covered seawalls on the existing beaches. It was noted in the draft report that the final dimensions would be determined during project optimization.

Table 4-1: Highlands TSP components

Project Feature	Length (lf)
Raised Bulkheads	7,289
Capped Existing Bulkheads	1,395
Floodwall	375
Reinforced dune	1,194
Raised Ground Surfaces	328
Closure Gate (width)	55
Total Length	10,636

4.2. Public and Agency Review of the Tentatively Selected Plan

Documentation of the TSP in the Draft Feasibility Report and Environmental Assessment for Highlands was released to public and agency review for comments from July 2015 to September 2015. Comments did not alter the plan selection and are documented in the Pertinent Correspondence Appendix of this report. Following comment reviews, USACE began the process of detailed feasibility analysis on the TSP to identify project dimensions that would maximize net benefits, for what is known as the Recommended Plan.

4.3. Identification of the Recommended Plan

The TSP was released for reviews and comments as early as possible in the planning process (hence the "Tentative") to foster transparency and collaboration. The level of detail in the draft report was sufficient to support plan selection, but not enough to proceed to plans and specifications for construction. Following receipt of comments on the draft report, feasibility level analyses were needed to determine the optimal project dimensions to maximize net benefits, also known as optimization. Primary tasks in optimization included:

1. Incorporation of latest stage-frequency data

2. Optimization (to maximize net benefits)
3. Incorporation of latest design standards and value engineering
4. Identification of interior drainage requirements
5. Evaluation against relative sea level change scenarios

These tasks are described in further details in sections 4.3.1 to 4.3.5.

4.3.1. Incorporation of the latest stage-frequency data

Identification of the TSP in the draft Feasibility Report was made with 2005 stage-frequency data developed for the Fire Island to Montauk Point study, adapted for the Highlands area. USACE released updated stage-frequency data through the North Atlantic Coast Comprehensive Study in 2015. The NACCS water surface elevations are higher than those from the 2005 modeling (see table 4-2). At that point in time, the study team determined that use of updated NACCS data would not change the identification of the TSP, and the decision was made to use the NACCS data to optimize the TSP during feasibility level analysis. The first task of the detailed feasibility analysis was to incorporate the NACCS data into the TSP and any other alternatives to be evaluated during this phase of the study.

Table 4-2: Comparison of FIMP and NACCS Stage-Frequency at Sandy Hook

Annual Chance Exceedence	FIMP Still Water Elevation	NACCS Water Surface Elevation
50%	3.7	5.6
20%	5.4	6.7
10%	6.5	7.5
4%	7.5	8.4
2%	8.1	9.7
1%	8.8	11
0.50%	9.5	12.6
0.20%	10.1	14.6

*** FIMP Still Water Elevations estimated at the 95% confidence interval without wave effects while NACCS Water Surface Elevations are estimated at the 50% confidence interval with wave effects. Per ER 1100-2-8162 both FIMP and NACCS water levels are reported for year 1992 (which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983–2001).**

The water surface elevation of 6.5 ft. NAVD88 corresponded to 10% annual chance of exceedence in the 2005 modeling and slightly more than 20% in the NACCS data. One factor in the difference may be wave setup for both models. In the 2005 FIMP model, linear wave theory estimated non-breaking waves for Highlands in which wave setup is negligible; whereas the NACCS data incorporated wave set up in the development of water surface elevations (see Coastal Appendix).

As described in Section 3.14 of this report, increased water surface elevations do not change plan selection of a perimeter plan for Highlands. The latest stage-frequency data from NACCS do affect the sizing and performance of the TSP perimeter plan, as described in the following sections on optimization and sea level change adaptations.

4.3.2. Optimization

In the process of optimization, different project sizes are considered to find the optimal dimensions that maximize net benefits. Using the TSP as a starting point, two additional versions of the project were developed: one smaller than the TSP and one larger than the TSP. For analysis purposes, the performance of the three versions were measured based on stillwater design elevations (see Economics Appendix). **Error! Reference source not found.**3 shows the elevation heights of the optimized alternatives in relation to the stillwater design elevations evaluated in HEC-FDA.

Table 4-3: Height of Alternatives for Optimization

Size	Project Height	Stillwater Design Elevation
Small	+11 ft. NAVD88	+8.7 ft. NAVD88
Medium (TSP)	+12.5 ft. NAVD88	+9.7 ft. NAVD88
Large	+14 ft. NAVD88	+11 ft. NAVD88

The project height of +11 ft NAVD88 was chosen for the small plan because it is the elevation of the existing bulkhead built by the State in Reach 2 of the study area. Building a project lower than +11 ft NAVD88 would not fully leverage the benefits of the existing State bulkhead.

The project height of +14 ft NAVD88 was chosen for the large plan because it is the ground elevation of the new condominium development (Harborside at Hudson's Ferry) at the western end of the project. Project heights above +14 ft NAVD88 were not considered because the additional height requires additional length (approximately 2,000 linear feet) to circumvent the edge of the condominium development to tie into high ground. Evaluation of the extension cannot include benefits to the development because it was constructed after 1991, in accordance with Section 308 of the Water Resources Development Act of 1990.[13] In this situation, only the cost of the extension could be counted, which would lead only to a decrease in the net benefits.

All three heights would have the same effect upon interior drainage, that is, rain or snow run-off on the landward side of the project. Consequently, interior drainage requirements can be identified independently of project optimization to address exterior flooding.

4.3.2.1. Adaptation for Sea Level Change

The Highlands Project was designed to function with a design water surface elevation of +11 ft NAVD88. The top height of the structure is +14 ft NAVD88, which accounts for 3 feet of wave effects, based upon an acceptable level of overtopping of 50 l/s/m. The critical threshold is when the recurrence interval associated with a water surface of +11 ft NAVD88 results in an unacceptable level of risk to the community. Given the large amount of infrastructure and critical

[13] https://www.epw.senate.gov/wrda90.pdf

infrastructure at risk within the community, it is assumed that adaptation would need to be implemented when the +11 ft NAVD88 water elevation is reached. This threshold is established based upon the community's stated desire to balance project performance with the visual effects associated with the project.

An analysis of the Sandy Hook gauge data was conducted using the Corps Sea Level Curve Calculator to identify when the threshold above would be met. This analysis is shown in Figure 4-1. Based upon the historic, low sea level scenario and NACCS curves, the 2% storm with 50% confidence corresponds to a water surface elevation of 10.2 ft NAVD88, at the 2026 Project Base Year. Figure 4-1 depicts the change in the 2% water elevation, over time, associated with the three different RSLC scenarios. The figure also illustrates the 11 ft. NAVD88 threshold used to identify when the recommended adaptation would be implemented (shown as implementation threshold). Given that a project reevaluation would be required, prior to implementing the adaptation, an analysis threshold has been identified, which would be the trigger when a reevaluation would need to be initiated. This threshold accounts for 0.2 ft of RSLC, to provide sufficient time to conduct the reanalysis, and results in a reevaluation threshold of 10.8 ft NAVD88.

This figure shows when the project alignment would require adaptation for the increased sea level changes. Project adaptation would be required in 2090 under the Low RSLC scenario, 2063 under the intermediate rate of RSLC, and 2044 under the high rate of RSLC. The threshold for undertaking the reevaluation is estimated to be 2055 under the intermediate rate of RSLC, and 2039 under the high rate of RSLC.

Measured water-level information provides an assessment of the state of sea-level change rates and will help determine if reassessment of the project is needed before the project period of analysis ends in the year 2076.

The information presented in Figure 4-1 represents a trigger elevation of 0.6 ft of RSLC increase measured from the project base year of 2026. In order to assess if this threshold is met, the District would track the five month moving average mean sea level for the Sandy Hook, NOAA tide gauge to determine if the threshold for a reevaluation study has been met. In order to determine the 0.6 ft threshold has been met, a 0.15 foot buffer for natural variability would be included that is based on the 90 percentile five month moving average inter-annual variability record at the Sandy Hook tide gauge. Therefore the criteria to trigger the reevaluation study is 6 sequential months of the 5 month moving monthly average of mean sea level elevations above 0.75 feet at the Sandy Hook, NJ NOAA tide gauge, relative to the 2026 base condition.

The majority of the alignment that is suitable for Highlands is concrete T-wall. Given that the likely adaptation is increasing the height of the structure, the recommended plan that would be constructed in 2026 includes a larger foundation that would accommodate up to a three foot increase in wall height above the +14 NAVD88 crest elevation. Including the larger foundation now, would allow for a concrete cap of the required elevation to be added to the top of the T-wall, leaving the foundation in place. This is the most likely method for future sea level change adaptations. The challenge for sea level rise adaptation is that the western end of the project ties into an existing private bulkhead at elevation +14 ft NAVD88. Any future reevaluation would consider the condition of this bulkhead. It is possible that the private development to the west of alignment would increase the height of its ground elevation in the future so that the project alignment does not need to be extended spatially, otherwise consideration would need to be given for an alternate tie-in on the west end.

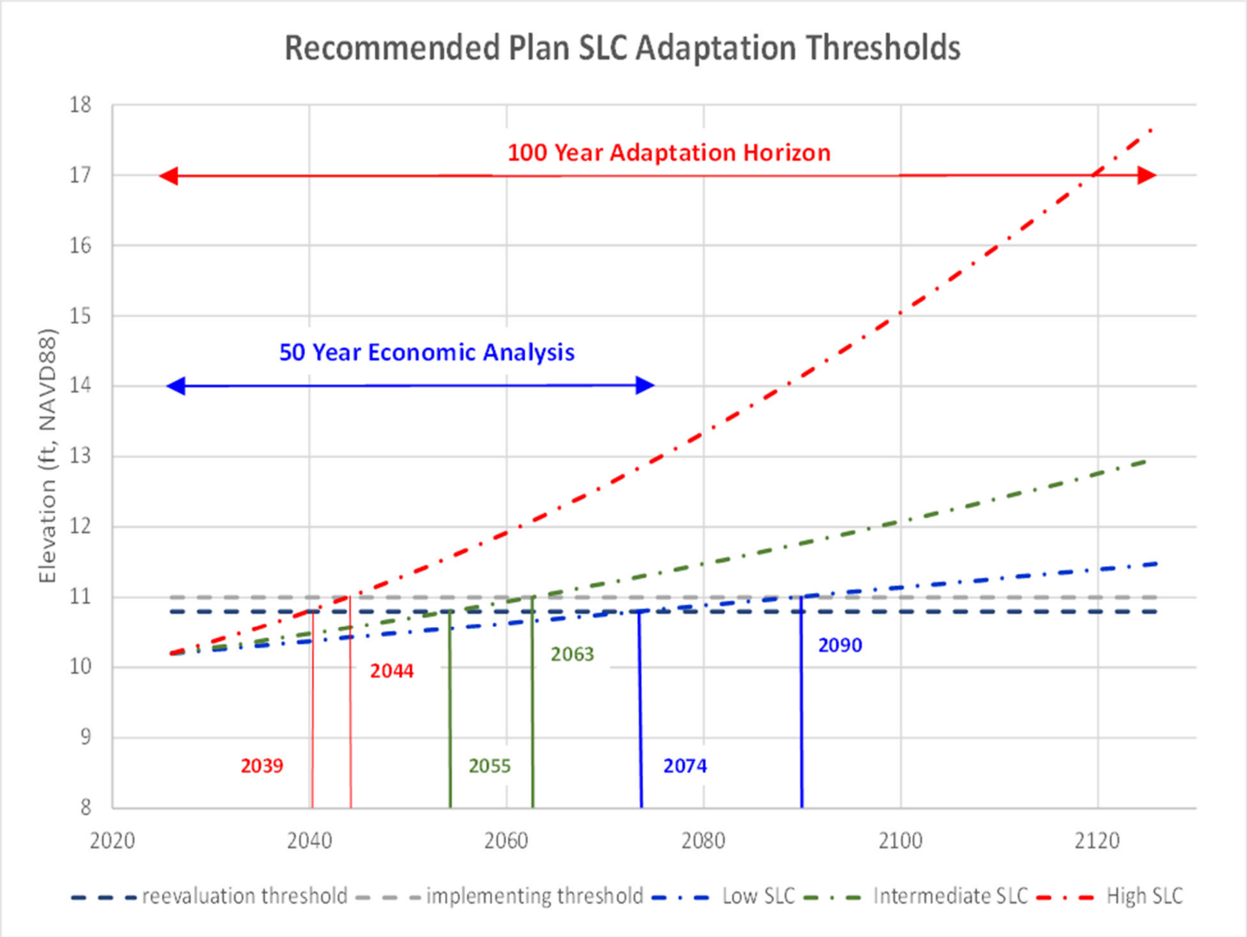

Figure 4-1: Recommended Plan Sea Level Change Adaptation Thresholds

4.3.3. Incorporation of latest design standards and value engineering

In keeping with USACE regulations and the requirements for using funds from the Hurricane Sandy Disaster Relief Appropriations Act, our analyses must incorporate the most recent available data (such as the stage-frequency data) and the latest science and design standards. The latest design standards required changes to the TSP, so that some of the raised or capped bulkheads in the TSP were changed to more substantial floodwalls, either I-wall or T-wall.[14] I-type floodwalls have the profile of a vertical slab driven into the ground, while T-type floodwalls have an underground horizontal base so that its profile resembles an inverted T. In general, I-walls are

[14] Standards are detailed in Engineering Circular (EC) 1110-2-6066, Engineering Technical Letter (ETL) 1110-2-575, and Engineering Construction Bulletin (No. 2014-18)

considered when the height of the project above grade is no more than six feet and if the soil type is appropriate. If both conditions are not met, T-type floodwalls are required.

Alternative designs were also updated based upon value engineering recommendations provided at a workshop in summer 2016 to identify cost-saving measures. The workshop resulted in three recommendations:

1. Replace buried floodwalls with I-type and T-type floodwalls. The sand had been proposed as a cosmetic measure to match the project to its immediate surroundings. It does not affect project performance. Removing the sand would decrease upfront construction costs and maintenance costs over the period of analysis.

2. Use fiber-reinforced polymer (FRP) in lieu of steel sheet pile under concrete encasement. FRP is a more cost effective way to cut off seepage, but more geotechnical data is needed to determine if it is appropriate for Highlands.

3. Replace rolling closure gate at Bay Avenue with buoyant flood gate. Rather than a roller gate that has to be manually closed, a buoyant flood gate is triggered by rising water levels. The buoyant flood gate is less expensive to install and does not require human intervention to activate. However, it is vulnerable to debris jams, and it is difficult to increase the height in the future if needed.

Value engineering recommendation 1, to replace buried floodwalls with I-type and T-type floodwalls, was adopted for final report analysis. The other two value engineering recommendations will be investigated in detail during the Preconstruction Engineering and Design phase after approval of the final report.

The comparison of project features in the original TSP and the three updated alternatives, incorporating design updates and VE recommendations, is shown in **Error! Reference source not found.**.

Table 4-4: Comparison of Project Features in Optimization Process

	TSP*	Small	Medium	Large
Project Feature	**Length (lf)**	**Length (lf)**	**Length (lf)**	**Length (lf)**
Raised Bulkheads	7,289	0	0	0
Capped Existing Bulkheads	1,395	0	0	0
I-type Floodwall	375	4,020	1,777	992
T-type Floodwall	0	6,290	8,559	9,362
Buried floodwall	1,194	0	0	0
Raised Ground Surfaces	328	328	328	328
Closure Gate (width)	55	55	55	55
Total Length	**10,636**	**10,693**	**10,719**	**10,737**

The TSP represents the pre-Value engineering plan. It is included here as a reference for the optimal dimensions of features being considered. The Small, Medium and Large plans are the refinements of floodwall types of the TSP.

The three alternatives, Small, Medium and Large, have the same alignment as the TSP, although the overall length changes slightly with the height of the project, as higher projects require a little more length to achieve the specified performance. The primary difference among the three alternatives is that different heights require different features to maintain project performance – *i.e.,* certain heights require either I-type floodwalls or T-type floodwalls. Buried floodwalls were removed from the project features based upon value engineering recommendations.

<u>Small Alternative</u>

The small plan is designed to the height of the existing NJ state bulkhead in Reach 2 (+11 ft. NAVD 88) along the entire alignment. The alternative assumes replacement of the existing bulkhead upfront rather than waiting to midway through the period of analysis to minimize uncertainty about project performance. The small alternative includes 4,020 lf of I-type floodwalls and 6,290 lf of T-type floodwalls.

<u>Medium Alternative</u>

The medium alternative is the updated TSP. The design heights (which vary throughout the alignment in response to wave action) are unchanged, but the project components have been changed from raised or capped bulkheads to a combination of I-type (1,777 lf) and T-type (8,559 lf) floodwalls.

<u>Large Alternative</u>

The large alternative is designed to the height of the planned floodwall/bulkhead/raised ground surfaces under construction at the Harborside at Hudson's Ferry development at the western end of the alignment (+14 ft NAVD88). The developer chose the height after consulting the FEMA FIRMs. The elevation of +14ft ft NAVD88 is along the entire alignment, and is achieved mostly through the construction of T-type floodwalls (9,362 lf) and I-type (992 lf) floodwalls where possible.

4.3.4. Interior drainage requirements

Interior drainage requirements are the same for all heights being considered and were formulated independently. The first step was to identify the minimum facilities, which are "the measures required to provide interior drainage relief such that during low exterior stages (gravity conditions), the local storm drainage system will function essentially as it did without the [project] in place to accommodate the flows from the storm water system design storm."[15] Minimum facility was established and residual risk identified to determine the optimal hydraulic measure. It was determined that the most cost effective feature was the pump station. The cost at the time of analysis, of minimum facilities was approximately $1,780,000 (FY17 P.L.) and included gravity outlets of two concrete box culverts at 4-foot square, leaving residual damages of $5,281,000 (FY17 PL) annually. This represents the amount of damages from interior flooding that exists in the without project condition, which can be partially attributed to existing local bulkheads at

[15] USACE Policy Guidance Letter No. 37, Cost Sharing of Interior Drainage Facilities. At http://planning.usace.army.mil/toolbox/library/PGL/pgl37.pdf

Highlands that can trap stormwater.

The next step was to identify alternatives for reducing the residual damages, which can be cost shared as project features if they are incrementally justified. For the purpose of interior drainage, the study area was divided into three basins: A, B, and C, and up to two alternatives were identified per basin (Figure 4-2).

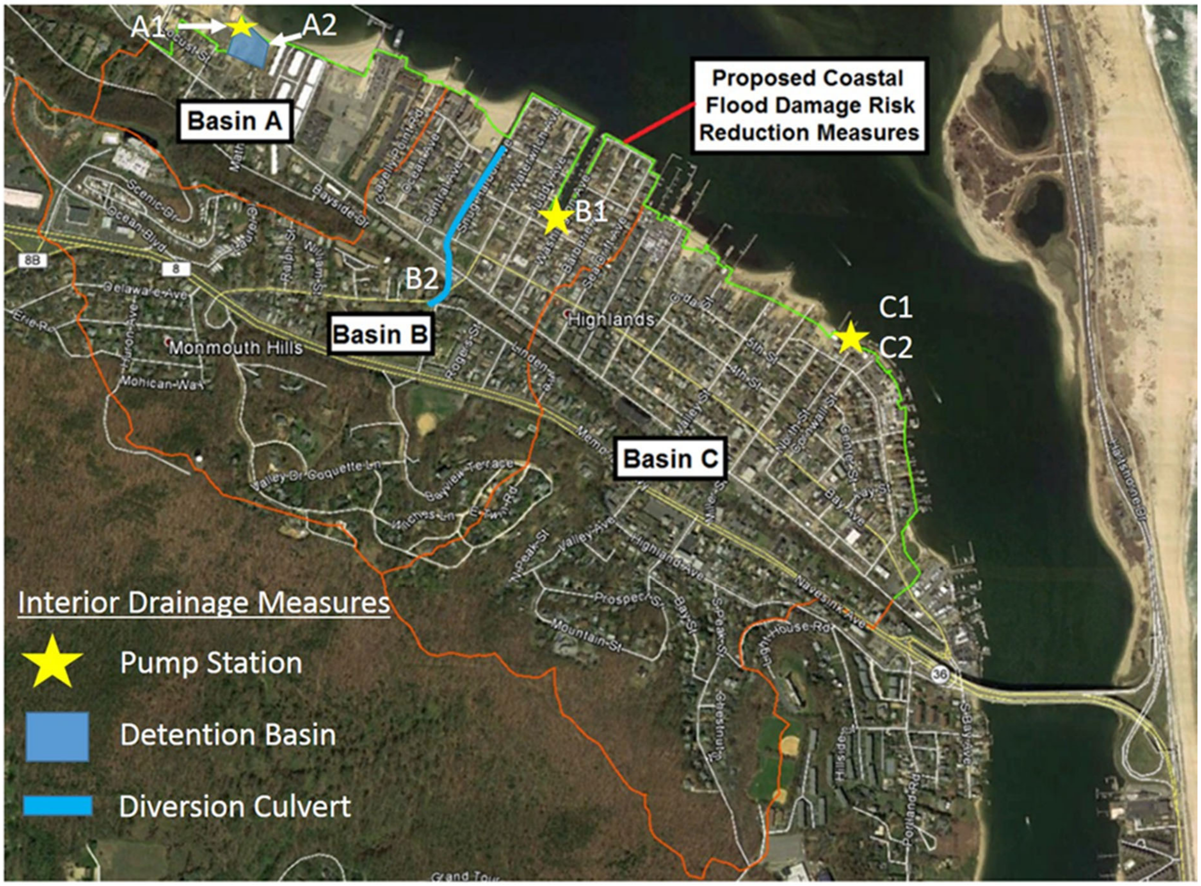

Figure 4-2: Highlands Interior Drainage Basins and Alternatives

Basin A has a drainage area of 0.083 square miles and significant damages from interior flooding begins when surface water elevations reach +5.5 ft. NAVD88. Two alternatives were developed for low spots within Basin A:

1. A single pump with a capacity of 160 cfs, to be situated in a vacant lot near the of Neil's Original Oyster Beacon the Bay Parking Lot (Near Willow Street).
2. Detention pond with 8 acre-foot volume capacity within an approximate area of 1.6 acres with a connecting outfall in the Bay Parking Lot, northeast of the corner of Shore Drive and Willow Street. The top of the ponding area is elevation +7 ft. NAVD88 and the bottom is elevation 0 ft. NAVD88, with an average depth of five feet.

Basin B has a drainage area of 0.32 square miles and significant damages from interior flooding begins when surface water elevations reach +3.9 ft. NAVD88. The Basin B alternatives are:

1. 600 cfs capacity pump station: one pump at 450 cfs capacity, and one pump at 150 cfs capacity in a vacant lot near the intersection of Cheerful Place and Washington Avenue. The location was chosen because it is a low spot within Basin B.
2. Upper-B Basin diversion into pressurized pipe: From the intersection of Waterwich Avenue and South Linden Street, the new pressurized line will consist of two five feet by five feet box culverts spanning a distance of 1600 lf in place of the existing drainage ditch along Snug Harbor Avenue to the bay. The culverts will be covered and access will be provided through sealed manholes at selected locations. This configuration was chosen to leverage existing infrastructure and to divert drainage from Upper B Basin before it reaches lower B Basin.

Basin C has a drainage area of 0.34 square miles, and significant damages from interior flooding begins when surface water elevations reach +3.9 ft. NAVD88. The Basin C alternatives are:

1. 300 cfs capacity Pump Station; one pump at 250 cfs capacity, and one pump at 50 cfs capacity. The pump station is located on North Street next to the project alignment.
2. 150 cfs capacity Pump Station; one pump at 100 cfs, one pump at 50 cfs, plus 4 extra outlets. This pump station is located on North Street next to the project alignment, and compensates for the smaller pump capacity with extra outlets (36 inch RCP each).

The performance of the interior drainage alternatives were compared against minimum facility in **Error! Reference source not found.** to identify and select the most effective Basin-to-feature combination that maximizes net benefits.

Table 4-5: Highlands Interior Drainage Alternatives (October 2016 PL)

	First Cost*	Annualized Cost*	Annualized Benefit	Annualized Net Benefit	BCR
Basin A					
1- 160 cfs pump station	$7,534,000	$379,000	$164,000	($215,000)	0.4
2- 1.6 acre detention basin	$1,030,000	$52,000	$117,000	$66,000	2.1
Basin B					
1- 600 cfs pump station (450 cfs+150 cfs)	$18,588,000	$936,000	$1,296,000	$360,000	1.3
2- Diversion into pressurized pipes (1,600 lf)	$2,933,000	$147,000	$989,000	$842,000	6.3
Basin C					
1- 300 cfs pump station (250 cfs + 50 cfs)	$12,213,000	$615,000	$3,493,000	$2,878,000	5.5
2- 150 cfs pump station (100 cfs + 50 cfs) & 4 extra pipe outlets (36" RCP each)	$10,214,000	$514,000	$3,143,000	$2,628,000	5.9
* Costs based on a 50 year period of analysis at a 3.125% interest rate, and includes					

operations and maintenance costs.	

Based on the producing the most net benefits, the optimal configuration for interior drainage includes a ponding area in Basin A, diversion into pressurized pipes in Basin B, and the 300 cfs pump station in Basin C for a total first cost of $16,176,000, an annual cost of $813,000, (cost escalated from FY17 to FY20 according to Civil Works Construction Cost Index System) annual net benefits of $3,610,000 (October 2019 P.L.), and a BCR of 5.4.

Interior drainage costs for the Small, Medium, and Large alternatives are independent of the project alignment and are thus the same for each height. **Error! Reference source not found.**6 provides the total costs, including the exterior alignment and the interior drainage features, and are presented in October 2019 price levels.

Table 4-6: Costs of Small, Medium, and Large Plans (October 2019 P.L.)

	Small Plan	Medium Plan	Large Plan
Total First Cost	**$120,225,000**	**$130,688,000**	**$133,162,000**
Total Annualized Cost	**$4,919,000**	**$5,325,000**	**$5,376,000**

4.3.5. Performance evaluated against relative sea level change scenarios

The three sizes were evaluated against projections of relative sea level change over the period of analysis (2026-2076) (**Error! Reference source not found.**). The sea level change analysis within the period of analysis encompassed the water surface elevations for the "low" and "intermediate" sea level change scenarios. Over the planning horizon, from project study completion to year 2126, water surface elevations are projected to increase 8.37 ft NAVD88 with respect to the "high" scenario by 2126. Under the more aggressive rates of RSLC, the damages to be prevented by the project increase, which in turn increase the benefits. Cost increases are minimal because the three sizes were designed with more substantial bases underground so that their heights could be increased if required in the future in response to climate change. The project can withstand storm events having water surface elevations with respect to the 1986-2001 epoch of 11 ft. NAVD88. This accounts for 50 years of historic sea level change. Should sea level changes exceed the historic rate, each measure is able to be adapted accordingly.

Table 4-7: Performance Evaluated Against RSLC Scenarios

Performance of Optimized Alternatives Against RSLC			
	Small	Medium	Large
Annual Cost	$4,919,000	$5,325,000	$5,376,000
Historic SLR			
Annual Benefits	$21,521,000	$23,908,000	$25,559,000
Net Benefits	$16,602,000	$18,583,000	$20,183,000

BCR	4.4	4.5	4.8
Intermediate SLR			
Annual Benefits	$23,096,000	$26,085,000	$28,133,000
Net Benefits	$18,177,000	$20,760,000	$22,757,000
BCR	4.7	4.9	5.2
High SLR			
Annual Benefits	$25,694,000	$34,806,000	$40,459,000
Net Benefits	$20,775,000	$29,481,000	$35,083,000
BCR	5.2	6.5	7.5

** October 2019 price levels and FY20 discount rate of 2.75%.*

Economic justification in this USACE study is based upon the historic or low rate of RSLC to be conservative on the estimate of benefits. Upon the historic rate of RSLC, the large alternative (+14 ft. NAVD88) provides the most net benefits, and shares similar susceptibility and adaptability to increased levels of RSLC in the Small and Medium Plans, and is therefore identified as the NED plan, or the Recommended Plan. Under the intermediate and high scenarios of RSLC, the large alternative still has the highest net benefits, confirming its identification as the Recommended Plan.

4.4. Recommended Plan Components

Based on having the highest annual net benefits ($25,559,000 October 2019 P.L.), the large alternative (floodwalls to elevation +14 ft NAVD88) was identified as the NED/Recommended Plan. The project spans a geographic distance of approximately 8,000 linear ft along the bay shoreline of Highlands and ties into high ground at each end. Because the project follows the actual perimeter of the shore, its total length is 10,737 linear ft (**Error! Reference source not found.**8).

Table 4-8: Highlands NED/Recommended Plan Project Features

Project Feature	Dimension
T-Type Floodwall	9,362 lf
I-Type Floodwall	992 lf
Closure Gate (width)	55 lf
Pump Station	300 cfs
Detention Pond	1.6 acres
Pressurized Pipes	1,600 lf
Raised Ground Surfaces	328 lf

The reach-by-reach description of the proposed Highlands projects begins with Reach 1 to the west and ends at Reach 4 on the Shrewsbury River to the east.

Reach 1

At the western end of Reach 1, a private developer has initiated construction of a new multi-use development (approximately 600 linear ft). The preliminary plan includes a multi-use development consisting of 49 residential units located in 11 buildings, a 5,735 square foot restaurant, a 590 square foot office space and reconstructs the existing marina to include 129 slips. This area, referred to as the Harborside at Hudson's Ferry, will include a combination of raised ground surfaces and new bulkheads that will tie into the proposed USACE project at elevation +14 ft NAVD88. The Hudson's Ferry property will need to be reexamined during the USACE Preconstruction, Engineering, and Design phase to ensure that a continuous and complete alignment is provided at the western tie-in.

The design elevation of +14 ft NAVD88 is achieved through a combination of I-type (456 lf) and T-type (1,767 lf) floodwalls, based upon the soil type and height of the wall above grade. To reduce wave forces, Reach 1 includes a rubble toe up to elevation +14 ft NAVD88 to reduce wave action and level out induced flood elevations at an assumed angle of 1V:1.5H, founded on approximately 1 ft of bedding stone with bottom elevation at -3 ft at NAVD88. The range of project height above existing grade is 3.5 ft to 10.5 ft.

For interior drainage purposes, Reach 1 includes a detention pond with an approximate area of 1.6 acres with a connecting outfall in the Bay Parking Lot, northeast of the corner of Shore Drive and Willow Street. The top of the ponding area is elevation +7 ft NAVD88 and the bottom is elevation 0 ft NAVD88, with an average depth of five feet.

<u>Reach 2</u>

In Reach 2, the existing state bulkhead and private bulkheads will be replaced with T-walls (3,230 lf) and I-walls (17 lf) For comparison purposes, the existing state bulkhead, which will be replaced, is at elevation +11 ft NAVD88, so the proposed project is three feet higher at +14 ft NAVD88. No rubble toe is anticipated for Reach 2.

For interior drainage purpose, Reach 2 includes two upland diversion culverts in place of the existing storm sewer line along Waterwich Avenue. From the intersection of Waterwich Avenue and South Linden Street, the new pressurized line will consist of two five feet by feet box culverts over a distance of 1600 lf in place of the existing drainage ditch along Snug Harbor Avenue to the bay. The culverts will be covered and access will be provided through sealed manholes at selected locations.

<u>Reach 3</u>

The characteristics of Reach 3 are similar to that of Reach 1, but Reach 3 is longer, requiring 2,539 lf of T-type floodwalls and 334 lf of I-type floodwalls at elevation +14 ft NAVD88. Wave forces are present, but not as strong as in Reach 1. Reach 3 includes rubble toe up to elevation +6 ft NAVD88 to reduce wave action and level out induced flood elevations at an assumed angle of 1V:1.5H, founded on approximately 1 ft of bedding stone with bottom elevation at -3 ft at NAVD88. The range of project height above existing grade is 3.5 ft to 10.5 ft.

Reach 3 contains a number of bayside restaurants and marinas for whom water access will be affected through construction of the project. Access to the water will be addressed through severance damages to be developed as part of the real estate requirements for the project. The Engineering Appendix describes some possible ways that property owners could reestablish water access.

For interior drainage purposes, Reach 3 includes a pump station consisting of two pumps, one with a capacity of 250 cfs, and another pump with a capacity of 50 cfs, for a total capacity of 300 cfs. The pump station is located on North Street next to the project alignment. The pumps will be triggered when the water surface elevation reaches heights that will be determined during the project design phase.

Reach 4

Reach 4 is where the alignment shifts from bayside to riverside, along the Shrewsbury River. This section of the project, includes 1,826 lf of T-type floodwalls and 184 lf of I-type floodwalls to +14 ft NAVD88. Of the 2,010 lf of floodwalls, 238 lf will be covered by raised ground surface in the existing Veteran's Memorial Park located to the north of Bay Avenue. The footprint of this raised ground covers 50,850 sq ft and the raised surface will be consistent with the existing park surface through capping with topsoil and plantings with native vegetation. A monument at the entrance to the park will be elevated as part of the raised ground surface construction.

The eastern tie-in will consist of an epoxy-coated sheet pile sea wall from the alignment along the center of Veteran's Memorial Park to high ground at the bluff. A steel and reinforced concrete closure structure and hydraulic gate or gates, 55 ft wide, will be required to allow access along Bay Avenue while maintaining the alignment. This tie-in was selected as the most economical option and reduced the number of conflicts with landowners, including the Twin Lights and Gateway Marinas.

The layout for the NED/Recommended Plan is shown in **Error! Reference source not found.**3 to **Error! Reference source not found.**6.

4.5. Benefits of the Plan

Benefits were calculated as the difference in damages between Without and With Project conditions. Benefits were then amortized over a 50-year period to identify equivalent annual benefits using October 2019 price levels and an interest rate of 2.75%. The without project annual damages are $29,182,000. The proposed project would reduce $25,559,000 worth of annual damages, leaving $3,623,000 in annual damages. The project dimensions correspond to approximately 1% flood design.

4.6. Cost Estimate*

A summary of the costs of the Highlands TSP is presented in **Error! Reference source not found.** below.

Table 4-9: Total Firsts Costs for Highlands (October 2019 P.L.)

Account/Feature	Amount
01 – Lands and Damages	$12,524,000
02 - Relocations	$67,000

11 – Levees & Floodwalls	$79,816,000
13 – Pumping Plant	$23,586,000
15 – Floodway Control & Diversion Structure	$8,677,000
18 – Cultural Resource Preservation	$3,325,000
30 – Planning, Engineering, & Design	$23,093,000
31 – Construction Management	$11,547,000
Total	**$162,635,000**

The initial project first cost is $162,635,000 (October 2019 P.L.) and the fully funded cost is $179,633,000, assuming mid-point of construction in the 4th quarter year 2023 and price escalation through construction. These costs include construction, lands and damages, design, supervision and associated administration costs. The material costs were based on a combination of MII database, RSMeans, quotes, and some historical information. Equipment rates were obtained from region 1, and Davis Bacon Wage Rates for Monmouth County, NJ were utilized for labor costs. The contingencies were developed using Cost and Schedule Risk Analysis (CSRA). The summary of the results of this risk analysis, and more detail on the cost estimate, can be viewed in the Cost Appendix.

The layout for the NED/Recommended Plan is shown in **Error! Reference source not found.**3 to **Error! Reference source not found.**6.

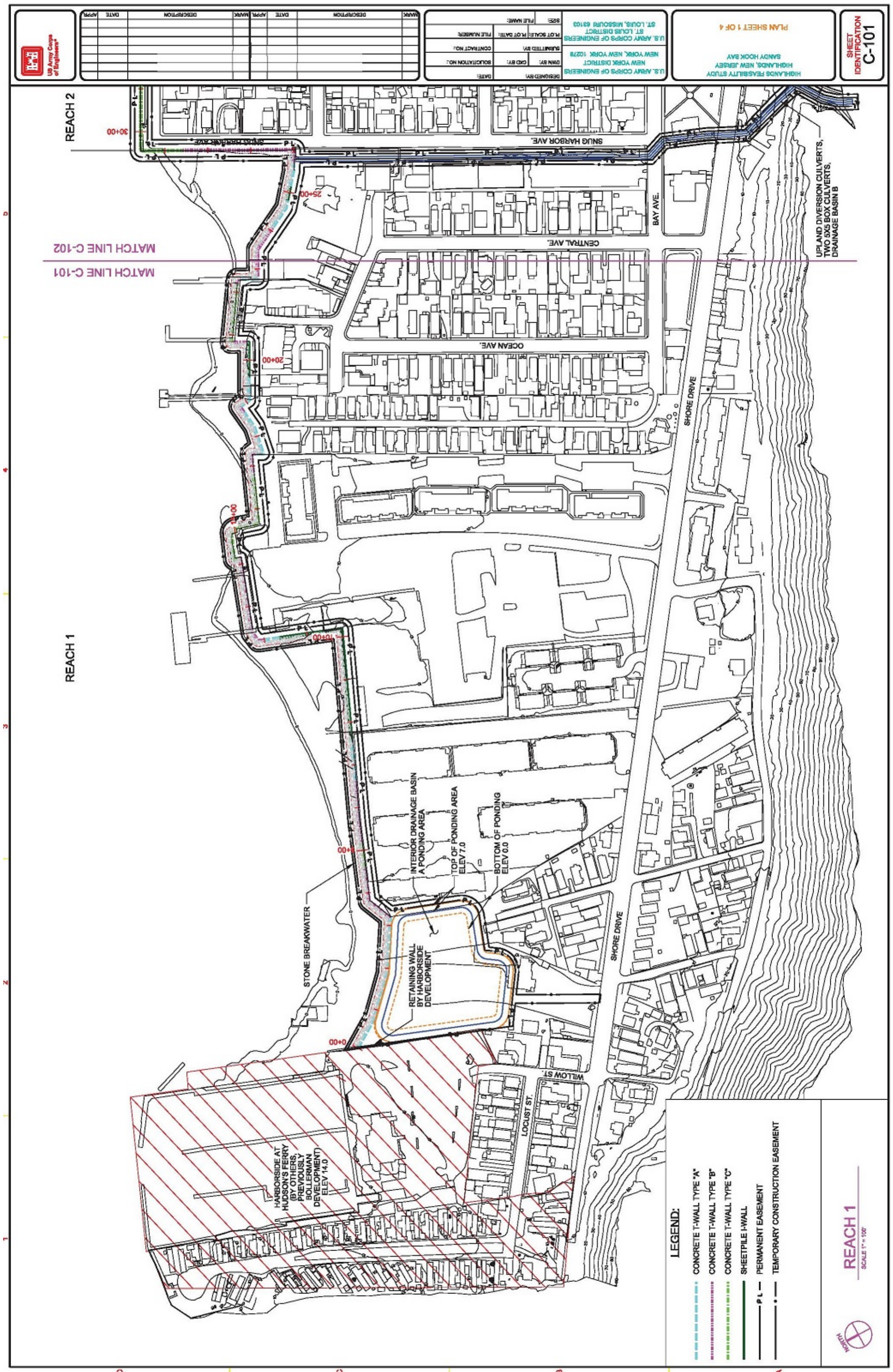

Figure 4-3: Highlands Recommended Plan Reach 1

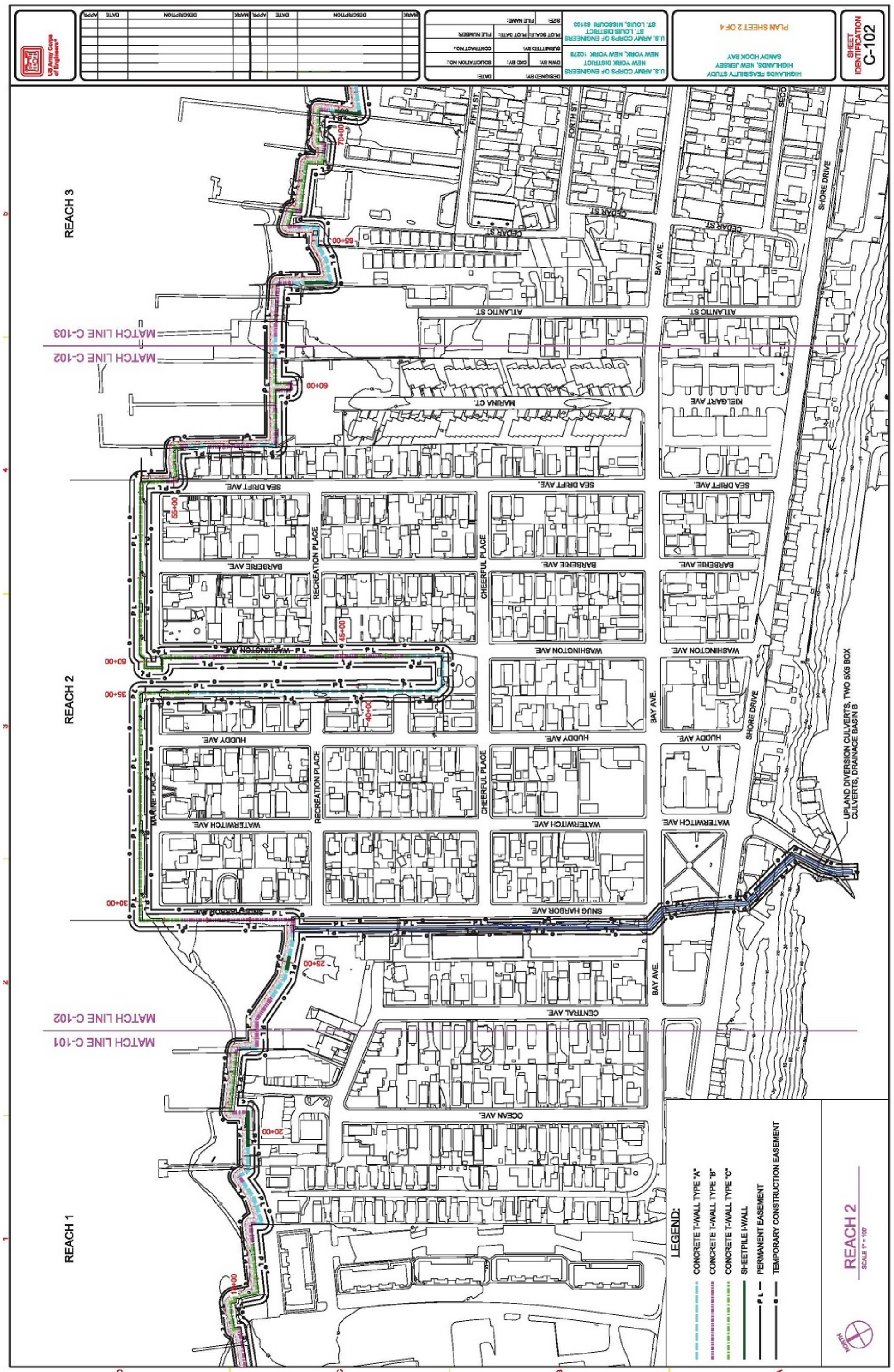

Figure 4-4: Highlands Recommended Plan Reach 2

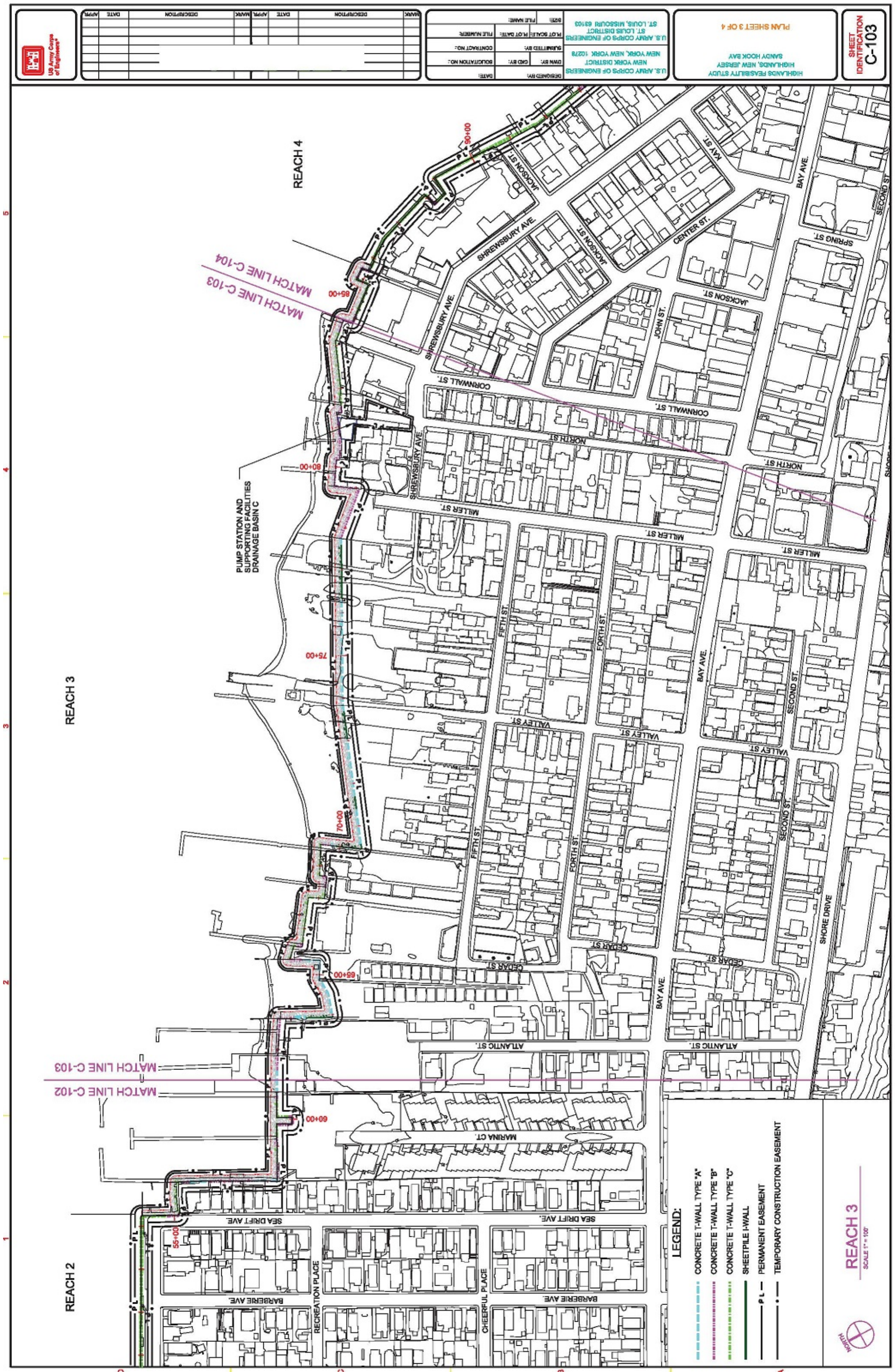

Figure 4-5: Highlands Recommended Plan Reach 3

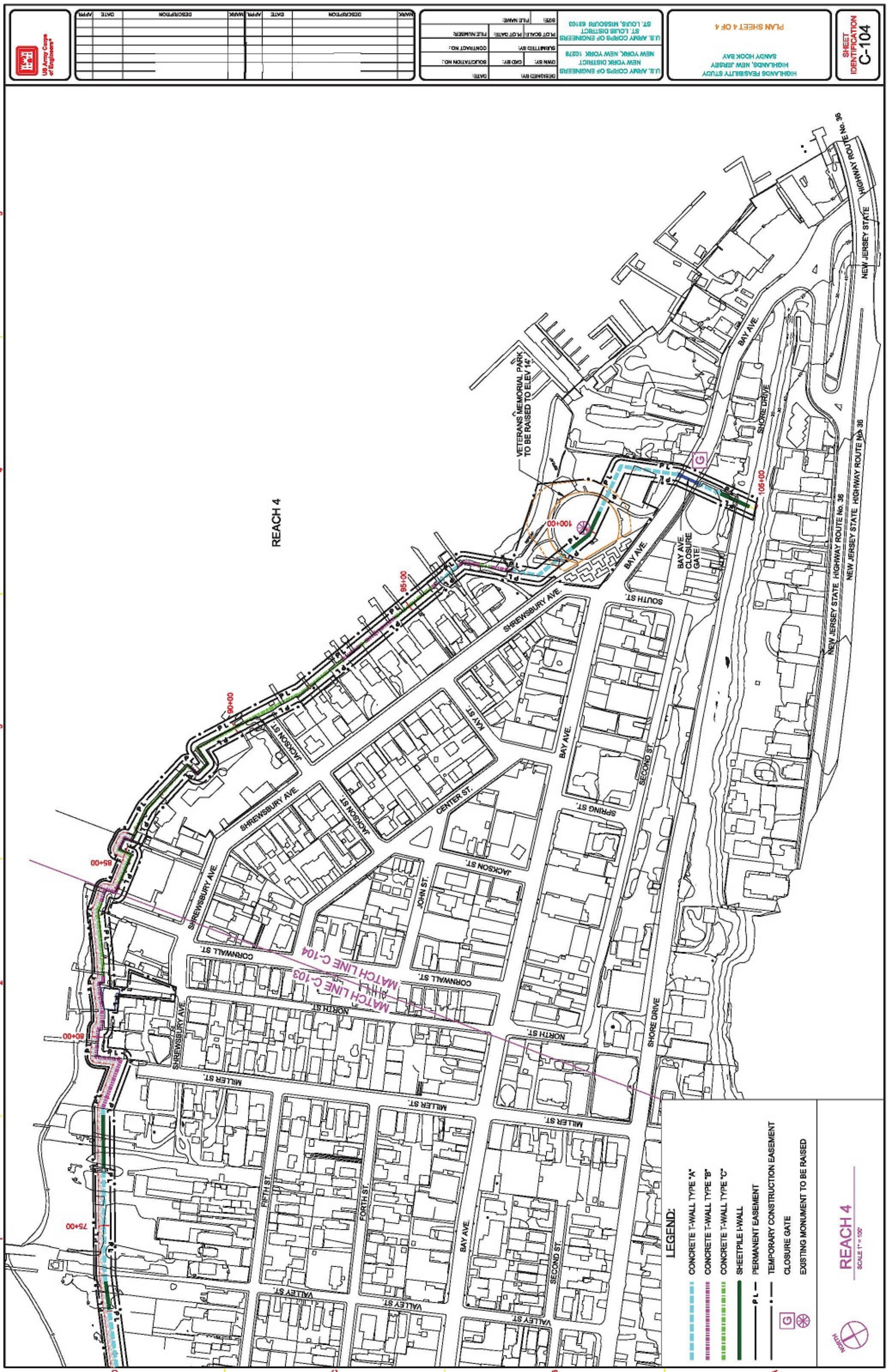

Figure 4-6: Highlands Recommended Plan Reach 4

4.7. Operations, Maintenance, Repair, Replacement, & Rehabilitation Considerations*

Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) actions will be minimal for the exterior alignment of the Recommended Plan because the project does not contain movable parts in the water. Aside from the major repair of a closure gate halfway through the period of analysis, most of the OMRR&R consists of minor repairs (recoating the bulkhead, resurfacing the raised roadway, *etc*.) and inspections, at an estimated annual cost of $208,000. The interior drainage features require inspections and clearing of the detention pond and pressurized outlet, and inspections and maintenance of the pump station, which is automated, for an estimated annual cost of $115,000.

4.8. Interior Drainage and Minimum Facilities

Exterior storm events were computed using the North Atlantic Coast Comprehensive Study (NACCS), and are discussed in Appendix B2 covering Coastal Hydraulics and exterior stage-frequencies. This analysis evaluated the normal tide conditions, and coastal storm frequencies ranging from the 50% Annual Exceedance Probability (AEP) to the 2% AEP (or the 2 to 50-year) flood events. These events were evaluated for the present conditions (based on construction completion date of 2025) and future conditions (end of 50-year period of analysis, in 2076). Minimum Facility Analysis included updates of the 2007 computations of interior water surface elevations at all three lower Drainage Basins (A, B, and C), for a series of combinations of exterior and interior storm events to determine facility requirements.

There have been local plans for interior drainage work that might reduce the required capacity, but the status of this local project is still being coordinated (NJ Future, 2014) and no definitive updates were received during ongoing coordination after review of the draft report. Feasibility level analyses resulted in the finding that the cost of minimum facilities was $1,957,000 (FY20 P.L.) and included gravity outlets of two concrete box culverts at 4-foot square, leaving residual damages of $5,508,000 (FY20 P.L.) annually. Alternatives to reduce the residual damages were considered, including detention basins and pump stations. Based on producing the most net benefits, the optimal configuration for interior drainage includes a ponding area in Basin A, diversion into pressurized pipes in Basin B, and the 300 cfs pump station in Basin C for a total first cost of $23,061,000, an annual cost of $973,000, annual net benefits of $3,785,000, and a BCR of 4.7.

4.9. Risk and Uncertainty Analysis

ER 1105-2-101 "Risk Assessment for Flood Risk Management Studies" (USACE, 15 July 2019) stipulates that the risk analysis for a flood risk reduction project should quantify the performance of the plan and evaluate the residual risk, including the consequences of exceedance of the project's capacity. The guidance specifically stipulates, along with the basic economic performance of a project, the engineering performance of the project is to be reported in terms of:

- The annual exceedance probability
- The long-term risk of exceedance
- The conditional non-exceedance probability

The overall economic performance (expected and probabilistic values of damages and benefits) of all the evaluated alternatives under the low sea level rise condition has been computed by HEC-FDA and the results are presented in **Error! Reference source not found.**. Additional detail is in the Economics Appendix.

Table 4-10: Expected and Probabilistic Values of Structure/Contents Damage Reduced

Alternative	Equivalent Annual Damage **(Line of Risk Reduction Only)**			Probability that Damage Reduced Exceeds the Indicated Values		
	Without Project	With Project	Damage Reduced	75%	50%	25%
Small	$29,182,390	$6,751,950	$22,430,450	$21,070,040	$21,908,660	$22,812,770
Medium	$29,182,390	$4,366,150	$24,816,240	$23,020,780	$24,234,280	$25,561,580
Large	$29,182,390	$2,715,190	$26,467,200	$23,823,620	$25,872,280	$27,747,840

October 2019 price levels and FY20 Discount Rate of 2.75%

4.10. Residual Risk and Life Safety

Residual risk is the flood risk that remains after a proposed flood risk management project is implemented. This may occur by one or more of either of the following scenarios: 1) breach prior to overtopping, 2) overtopping with breach, 3) malfunction or improper operation of floodwall system components, and 4) floodwall overtopping without breach. Of concern with respect to floodwalls, the effectiveness of the project will cease abruptly if a flood such as that for an unusually large storm, should overtop it. Flood waters would inundate the community behind by the floodwall which would pose a risk to life loss.

Sea level change as described in section 2.4.2 poses a threat to the effectiveness of the project. The NED plan is designed to exclude flood waters from the protected area up to a height of +14 ft NAVD88. A floodwall, however, can trap stormwater landward of the floodwall, on the interior side, resulting in either nuisance flooding or more intense inundation in a short time frame in the case of a rare event. The pump stations, detention pond and pressurized pipes components of the NED manage the risk of interior flooding from stormwater run-off.

While no structure provides full protection from flooding, only 10% of the entire USACE floodwall portfolio are expected to have poor performance due to instability according to the 2018 USACE

Levee Portfolio Report. The proposed system for Highlands Borough would not be within this 10%. The recommended plan floodwall will be constructed pursuant to Engineering Manual 1110-2-1913 and other up-to-date engineering best practice, which reduces the probability of seepage caused by risk drivers (USACE 2000b).

Project performance statistics present the likelihood of seepage for the floodwall. Annual exceedence probability (AEP) represents the probability of any event equaling or exceeding a specified stage in any given year. AEP represents the probability of water getting into the interior area of the floodwall in any given year. With the project in place AEP is 1.5% for 2076 at the low scenario. The long term exceedence probability (LTEP) is the likelihood of exceedance at least once in the specified period. With the NED plan, LTEP estimates there is a 1 in 2.9 chance of flooding in a 30 year period. While no structure provides full protection from flooding, only 10% of the entire USACE floodwall portfolio are expected to have poor performance due to instability according to the 2018 USACE Levee Portfolio Report. The proposed system for Highlands Borough would not be within this 10%. Conditional nonexceedance probability (CNP) or assurance, describes the likelihood that the project can prevent damage given the occurrence of an event of the specified exceedance probability. Assurance for the NED project alignment at the 2% event provides a 75% probability that a target stage will not be exceeded.

Life Safety

Planning Bulletin 2019-04 defines four considerations of risk communication as 1) Understanding the risk 2) Building risk awareness 3) Fulfilling daily requirements and 4) Actions to reduce risk as the Tolerable Risk Guidelines (TRGs) framework (USACE, 2019c). Pursuant to PB 2019-04, at a minimum, the alternative that addresses TRG 1 and TRG 4 must be identified. TRGs 2 and 3 are met through USACE levee safety program activities and sponsor activities which include public engagement, media stories or maintaining a community website.

TRG 1 (Understanding the risk) answers the question, are the risks commensurate with the benefits through a life safety assessment. The assessment of the life safety risk, societal life risk, individual life risk, and economic risk are informed by the Life Risk Matrix, reprinted here as Figure 4-7 (USACE, 2019c). Observe that life safety risks generally meet Tolerable Risk Guideline 1 when the annual exceedance probability of life loss with respect to individual life and societal life are both below 1.E − 04. Typically a determination of the project's location on the life risk matrix would require separate quantitative modeling to identify the respective annual exceedance probabilities.

The population at risk (PAR) is defined as the percentage of the population of 65 years or older. Based on the Census Bureau's 2018 American Community Survey 5-year estimates, approximately 18% of Highlands's residents fit the description. The PAR will need access to evacuation routes and emergency responders. Reaches 6 and 7 have been identified as areas where access to evacuation routes and critical infrastructure such as the police and fire departments and on ramps to major Route 36 are located. With the project in place, equivalent annual residual damages in reaches 6 and 7 are estimated to be $1,025,000 – a $16,208,000 reduction from the $17,234,000 in equivalent annual without-project damages over the 50 year period of analysis. This 94% damage reduction with the project alignment in place implies that risks to access routes and impacts to PAR are similarly reduced.

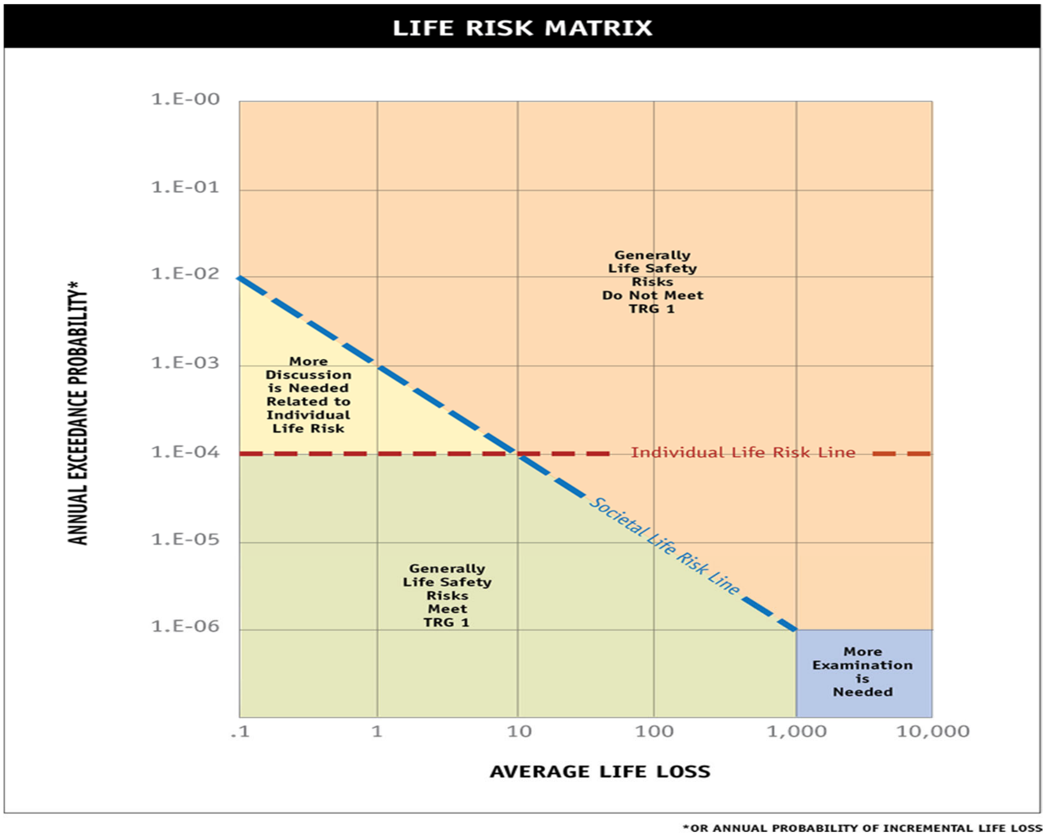

Figure 4-7: Life Risk Matrix

The effect of incremental risk of the proposed floodwall on the annual exceedance probability of life loss can however be assessed without quantitative modeling. Water levels are not predicted to be higher in the floodplain in the event of overtopping than they would have been without the floodwall. This means that the effect of incremental risk with respect to floodwall overtopping on the annual exceedance probability of life loss is null and that the proposed floodwall generally meets Tolerable Risk Guideline 1. There are other modes of floodwall failure that effect incremental risk and the project's ability to meet Tolerable Risk Guideline 1, such as floodwall breach. However, this floodwall will be built according to the latest USACE guidelines and regulations, minimizing this risk. As such, the perceivable effect of the incremental risk of the floodwall on the annual exceedance probability of life loss suggests that the project meets Tolerable Risk Guideline 1.

Tolerable Risk Guideline 4 (Actions to reduce risk) must also be assessed. Tolerable Risk Guideline 4 requires determination of cost-effective, socially acceptable, or environmentally acceptable ways to reduce risk from an individual or societal risk perspective. It should be considered whether appropriate actions have been taken to reduce risks, could any actions reasonably be taken that would reduce risks further, what would be the cost of reducing risk and how much would the risk be reduced, if the actions should be detailed in further study, and if there is demonstrated progress toward implementing risk reduction measures. An appropriate action that has been taken to reduce risks includes the adaptability in the design to sea level rise. As the floodwall is expected to overtop in the case of extremely rare events, it can be expected that this scenario of floodwall non-performance would by exacerbated if the rate of sea level change accelerates. The recommended plan proposed for construction in 2026 includes a larger foundation that would accommodate up to a three foot increase in wall height above the +14 NAVD88 crest elevation. Including the larger foundation allows for a more nimble response to the risk of changing sea levels.

4.11. Economic, Environmental, and Other Social Effects

Four accounts have been established to facilitate evaluation of alternative plans:

1. National Economic Development (NED) – changes in the economic value of the national output of goods and services
2. Environmental Quality (EQ) – non-monetary effects on significant natural and cultural resources
3. Regional Economic Development (RED) – changes in the distribution of regional economic activity that result from each alternative plan
4. Other Social Effects (OSE) – effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

In reducing damages from future storm and flood events, the Highlands Recommended Plan contributes to National Economic Development. In addition to reducing property damage, implementation of the Recommended Plan would serve to keep critical facilities, such as police and emergency services, operational during storm events by reducing the intensity and frequency of flooding. It would also reduce flooding on evacuation routes, access routes for emergency vehicles, and the local roads that feed into these major roads. It neither contributes nor detracts from the RED account. As identified in the Environmental Assessment, there would be minimal environmental impacts because of the highly developed nature of the project area and the relatively tight footprint of the project.

As for the OSE account, this project will affect the community's water views or water access along some portions of the alignment. The height of the project above the existing ground surfaces ranges from 5.0 to 12.5 feet. Waterfront access will be maintained in the form of timber walkovers, and the benefits of the CSRM project will outweigh the water access issues for the community overall.

4.12. Plan Costs and Benefits

The benefits of implementing coastal storm risk management measures represent flood damages avoided by the project. Benefits were calculated as the difference in damages before and after project implementation. Benefits were then amortized over a 50-year period to identify equivalent annual benefits using October 2019 price levels and an interest rate of 2.75%. **Error! Reference source not found.**11 provides a summary of the annual costs and benefits of the plan.

Table 4-11: Performance of Highlands Recommended Plan (Oct. 2019 P.L.)

Annual Project Cost (Discounted at 2.75% over a 50-year period)	$6,520,000
Average Annual Benefits (Discounted at 2.75% over a 50-year period)	$25,559,000
Average Annual Net Benefits	$19,039,000
Benefit-Cost Ratio	3.9

4.13. Executive Order (EO) 11988

Executive Order 11988 requires that Federal agencies avoid, to the extent possible, adverse impacts associated with the occupancy and modification of flood plains and to avoid support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

In accordance with Section 202(c) of the Water Resources Development Act of 1996, "Floodplain Management Plans", the non-Federal sponsor will prepare a floodplain management plan within 1 year after the date of signing a project partnership agreement for construction of the project. The floodplain management plan will be designed to reduce the impacts of future flood events in the project area. Such plan shall be implemented by the non-Federal sponsor not later than 1 year after completion of construction of the project. WRDA Section 202(c) also requires the non-Federal interest to participate in flood insurance programs. The Borough of Highlands currently participates in the National Flood Insurance Program. More information can be found at https://www.nj.gov/dep/landuse/lu_bfm.html and http://www.highlandsborough.org/hnj/Flood%20Information/.

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized in **Error! Reference source not found.**.

Table 4-12: Highlands Study Compliance with E.O. 11988

EO 11988 Step	Project-Specific Response
Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).	The proposed action is within the base floodplain. However, the project is designed to reduce damages to existing infrastructure located landward of the proposed project.
If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.	Practicable measures and alternatives were formulated and evaluated against USACE of Engineers guidance, including nonstructural measures such as retreat, demolition and land acquisition.
If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.	The draft Feasibility Report and Environmental Assessment was released to public review in July 2015, and public hearings have been held throughout the study.
Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.	The anticipated impacts associated with the Selected Plan are summarized in Chapters 4 and 5 of this report. The project would not alter or impact the natural or beneficial flood plain values.
If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.	The project will not encourage development in the floodplain because the project area frontage is 100% developed. The project provides benefits solely for existing development.
As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.	The project would not induce development in the flood plain and the project has minimal mitigation. Chapter 3 of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.
If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.	The draft Feasibility Report and Environmental Assessment was released to public review in July 2015, and public hearings have been held throughout the study.
Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.	The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

Chapter 5. Environmental Impacts*

5.1. Topography, Geology, and Soils

No- Action Alternative: Under the No-Action alternative, topography may change due continued soil erosion and degradation. Geology will not change and soils will continue to erode and degrade as flooding continues. Soils will continue to erode during the flooding with no action.

Proposed Action: No significant impacts to topography, geology, and soils will result from the implementation of the proposed action. Topography along the Highlands shoreline would be permanently impacted by the installation of higher bulkheads. Bulkheads will be raised to +14 ft NAVD88.

No impacts will occur to the geology of the Highlands with the implementation of the proposed action.

Soils behind the bulkheads will be stabilized with the proposed action, as floodwaters eroding the soils will be reduced. The dynamic coastal processes that presently influence the soils on the beach will continue, such that the beach elevations and width will continue to fluctuate as it has in the past.

5.2. Water Resources

5.2.1. Regional Hydrogeology and Groundwater Resources

No Action Alternative: The no action alternative will have no effect on hydrogeology and groundwater as natural processes will continue.

Proposed Action: The implementation of the proposed action will have neither short nor long-term impacts to regional hydrology and groundwater resources.

5.2.2. Surface Water

No Action Alternative: The no action alternative will allow natural flood processes to continue and will allow seawater to impact and flood the Borough.

Proposed Action: During construction of the proposed action, there will be minor short-term impacts to the surface water with an increase in suspended sediments in the water. This will be localized to the immediate area and will dissipate quickly. Additionally the implementation of best management practices (BMP) such as silt fencing during construction will minimize the impacts.

There will be long-term impacts to surface water in that surface water will less frequently inundate the Borough of Highlands.

5.2.3. Tidal Influences

No Action Alternative: The no action alternative will have no impacts to tidal influences.

Proposed Action: Implementation of the proposed action will not have short-term impacts to tidal influences, as most of the shoreline is currently bulkheaded. Long-term impacts will be minor as the whole shoreline will now be bulkheaded impacting the ability of the tides to flow freely into the Borough of Highlands.

5.2.4. Coastal Processes

No Action Alternative: The no action alternative will have neither short nor long-term impacts to coastal processes.

Proposed Action: The construction of the bulkheads would not change the nature of, or the rate of, existing coastal processes. However, the proposed action will reduce the influence of the existing coastal processes on the land-based structures. In particular, the beach plan will provide long-term coastal storm risk management to residences, roads, and other structures and properties.

5.3. Vegetation

5.3.1. Upland

No Action Alternative: The no action alternative will have minor short-term impacts to upland vegetation as flooding may destroy ornamental vegetation and lawns.

Proposed action: Implementation of the proposed action will have minor short-term impacts to upland vegetation, as minimal amounts of vegetation will be removed. There will be positive long-term impacts, as ornamental vegetation, lawns, and other upland vegetation will not flood as often with salt water.

5.3.2. Wetlands

No Action Alternative: Under the no action alternative wetlands may decrease with the rise in sea level permanently flooding some of the existing wetlands.

Proposed Action: Under the proposed action, the estuarine and marine wetlands will have minor short-term impacts to the benthos within the sand. The estuarine and marine wetlands are lacking vegetation and would not be delineated as a wetland. The construction of the floodwall is expected to cover benthic organisms and cause some mortality. Benthic resources would begin to recolonize along the floodwall immediately following the completion of each construction reach, and populations are expected to revert to pre-construction levels (Wilber and Clarke, 1998). There will be no long-term impacts to the estuarine and marine wetlands as the benthos are expected to return to pre-construction levels (USACE, 2014).

5.3.2.1. Mitigation Guidelines

Federal Mitigation Guidelines

The following documents provide distinct USACE policy and guidance pertinent to developing this monitoring and adaptive management plan:

- CECW-P 6 Nov 2008 Memo: Implementation Guidance for the Water Resources Development Act of 2007- Section 2036(c) Wetlands Mitigation – directs the Secretary, where appropriate, to first consider the use of a mitigation bank to compensate for wetland impacts that occur within the service area of an existing, approved mitigation bank.
- CECW-PC 31 August 2009 Memo: Implementation Guidance for Section 2036(a) of the Water Resources Development Act of 2007 (WRDA 07) – Mitigation for Fish and Wildlife and Wetlands Losses" – requires: 1) monitoring until successful, 2) criteria for determining ecological success, 3) a description of available lands for mitigation and the basis for the determination of availability, 4) the development of contingency plans/adaptive management plans, 5) identification of the entity responsible for monitoring; and 6) establish a consultation process with appropriate Federal and State agencies in determining the success of mitigation.
- ER 1105-2-100 dated 22 April 2000, Planning Guidance Notebook
- Compensatory Mitigation for Losses of Aquatic Resources; Final Rule; Federal Register, Volume 73, No. 70, April 10, 2008.

USACE regulations stipulate that the recommended plan must contain sufficient mitigation measures to ensure that the plan selected will have no more than negligible net adverse impacts on fish and wildlife resources, including impacts of the mitigation measures themselves. Regarding wetlands, however, the guidance contains very specific requirements that the District "ensure that adverse impacts to wetland resources are fully mitigated...as required to clearly demonstrate efforts made to meet the Administration's goal of no net loss of wetlands" as determined by a habitat functional assessment method.

Federal Mitigation Hierarchy

The Mitigation Rules' preference hierarchy for types of wetland mitigation is as follows:

- The purchase of wetland credits from an approved wetland mitigation bank
- In-Lieu fee program credits (monetary contribution)
- On-site and in-kind restoration, enhancement, establishment, or preservation.
- Off-site and/or out of kind restoration, enhancement, establishment or preservation.

Under the USACE Civil Works guidance and Mitigation Rule, restoration should be the first method considered for an on-site and in-kind mitigation. The Corps does not apply a mitigation hierarchy to non-wetland habitats (e.g. upland forest).

State Mitigation Guidelines

The following documents provide New Jersey policy and guidance that are pertinent to developing this monitoring and adaptive management plan:

- New Jersey Freshwater Wetlands Protection Act, N.J.S.A. 13:9B; Freshwater Protection Act Rules N.J.A.C. 7:7A: Outlines requirements for compliance with Sections 401 and 404 of Clean Water Act.

- N.J.A.C. Coastal Zone Management Rules: Establishes compliance and mitigation requirements related to Sections 401 and 404 of the Clean Water Act for tidal wetland and open water resources.

State Mitigation Hierarchy

Mitigation hierarchy for intertidal and subtidal shallows and tidal water as outlined in Subchapter 17 of the Coastal Zone Management Rules is as follows:

1. Creation of intertidal, subtidal or tidal waters on site where filling occurred;
2. Off-site creation within same estuary as site or through purchase of in-kind credits from a mitigation bank;
3. Restoration, creation, or enhancement of a wetland within same estuary as site of filling or through purchase of out-of kind credits from a mitigation bank in service area;
4. Upland preservation;
5. In-lieu fee payment via monetary contribution to the New Jersey Mitigation Council/Wetland Mitigation Fund; and
6. Land donation in accordance with Freshwater Wetland Act Rules.

Subchapter 17 of the CZM Rules requires a 1:1 ratio for the on site creation of intertidal, subtidal or tidal waters. It also requires a 1:1 mitigation ratio for the off-site creation of intertidal, subtidal, or tidal waters.

Mitigation hierarchy for freshwater wetland impacts less than 1.5 acres as outlined in the Freshwater Wetlands Act Rules is as follows:

1. Purchase from a NJDEP approved wetland mitigation bank in the same Hydrologic Unit Code 11 (HUC-11) as the disturbance;
2. Purchase credits from a bank in an adjacent HUC-11 as disturbance and within same watershed management area as disturbance;
3. Purchase of credits in same watershed management area as the disturbance ;
4. On-site or off-site creation, restoration or enhancement;
5. In-lieu fee payment via monetary contribution to the Mitigation Council/Wetland Mitigation Fund;
6. Upland preservation; and
7. Land donation.

The proposed alignment is located within the 150 feet wetland buffer area. The majority of the wetland buffer area has already been modified by development. However, temporary impacted wetlands and buffers will be restored. The NJDEP Freshwater Wetlands Protection Act Rules require a mitigation ratio of 2:1 for wetland restoration or creation, and a minimum mitigation ratio of a 3:1 for wetland enhancement. The purchase of wetland mitigation credits is based on a 1:1 mitigation ratio.

The freshwater wetland between Valley Street and Cedar Avenue will have major and minor impacts. Approximately 0.75 acres will be permanently impacted with the construction of the floodwall. During the PED phase, the reinforced dune will be placed as far inland to minimize impacts to the wetland. Impacts to the wetland will be mitigated through the purchase of credits at an approved NJDEP wetland bank. There are three wetland banks within the Wetland Management Area 12, which have credits available for purchase.

5.4. Fish and Wildlife

5.4.1. Finfish

No Action Alternative: The no action alternative will have neither short nor long-term impacts on fish and wildlife.

Proposed Action: The proposed action is expected to have an indirect, short-term impact on fish species in the immediate construction area. Motile species would likely avoid burial during the construction of the bulkheads by relocating outside of the area. However, the potential for some fish mortality does exist. Demersal fishes that may reside just offshore of the construction footprint (*e.g.*, winter flounder, windowpane, summer flounder, etc.) would be temporarily displaced until appropriate invertebrate species return to the area. Resident fish are expected to feed in surrounding areas, and therefore be relatively unaffected by temporary, localized, reductions in available benthic food sources (USACE, 2000a).

There will be no long-term adverse impacts on fish.

5.4.2. Shellfish

No Action Alternative: The no action alternative will have neither short nor long-term impacts on fish and wildlife.

Proposed Action: The proposed action is expected to have a direct, short-term, impact on shellfish. Sessile shellfish that are present in the immediate construction area such as the razor clam and blue mussel are likely to be buried. However, no shellfish with significant commercial or recreational importance were identified. Motile shellfish would avoid the study area during construction and therefore would not be impacted. Upon construction completion, any shellfish that moved can return (Wilber and Clarke 1998).

There will be no long-term impacts on shellfish.

5.4.3. Benthic Resources

No Action Alternative: The no action alternative will have no long-term impacts on benthic resources as they are expected to return to preconstruction levels (USACE 2014).

Proposed Action: The implementation of the proposed action is expected to have a direct, short-term impact on benthic resources. The construction of the bulkheads is expected to cover benthic organisms and cause some mortality. Benthic resources would begin to recolonize along the bulkheads immediately following the completion of each construction reach, and populations are expected to revert to pre-construction levels within a year or two (Wilber and Clarke, 1998).

5.4.4. Reptiles and Amphibians

No Action Alternative: The no action alternative will have neither short nor long-term impacts on reptiles and amphibians.

Proposed Action: The implementation of the proposed action is expected to have neither short nor long-term impacts on reptiles and amphibians. As stated in section 2.5.4, there are low numbers if any reptiles and amphibians in the construction area. Any reptiles in the bay would be able to move and avoid construction of the bulkheads.

5.4.5. Birds

No Action Alternative: The no action alternative will have neither short nor long-term impacts on birds.

Proposed Action: Birds that currently use the area may have indirect short-term impacts. Increased noise and heavy machine activity could cause their displacement or disruption in foraging within the immediate vicinity of the construction. To avoid nesting birds the District will remove trees and shrubs during the nonbreeding season. However, it is anticipated that low amount of trees will need to be removed. If trees are to be removed during the bird-breeding season, surveys will be conducted for nesting migratory birds. Avian species are highly mobile and are expected to avoid the construction area and return after completion of the construction.

There will be no long-term impacts on bird species.

5.4.6. Mammals

No Action Alternative: The no action alternative will have neither short nor long-term impacts on mammals.

Proposed Action: Mammals in the construction area may have short-term impacts during construction activities. During construction, heavy machinery activity and increased noise levels may indirectly cause displacement of individuals near construction activities. Mammals are mobile species and will move and avoid the construction areas minimizing their impacts. Most mammals inhabiting the study area are accustomed to human activities and would likely return after completion of construction. It is anticipated that any muskrat, raccoon, striped skunk, gray squirrel, and opossum in the area would return to areas after construction.

There will be no long-term impacts on mammals.

5.5. Federal Threatened and Endangered Species

No Action Alternative: The no action alternative will have neither short nor long-term impacts on federal threatened and endangered species as there are no records of their occurrence in the study area.

Proposed Action: The District has determined there is “No effect” on the federally threatened northern long-eared bat, a “May affect, but is not likely to adversely affect” on the federally threatened piping plover, a “May affect, but is not likely to adversely affect” on the federally threatened red knot, and a "May affect, but is not likely to adversely affect" on the federally threatened seabeach amaranth.

To mitigate potential impacts to piping plovers, the District will:

1. Investigate the use of noise muffling devises on pile drivers and demolition equipment between March 15 and August 15.
2. In order to mitigate any impacts, noise at piping plover nest will not exceed 10 dBA higher
than ambient level.
3. Alternatively, demolition and pile driving activities will occur outside the March 15 - August 31 nesting season.

To avoid potential impacts to seabeach amaranth The District will conduct seabeach amaranth surveys prior to the start of Project construction. Surveys in suitable habitat will continue weekly. The District will establish exclusion fencing according to Service protocol, if any seabeach amaranth is identified within the project area.

A detailed discussion of the District's effects determination can be found in Appendix A8. Concurrence with USFWS was received on March 2, 2020.

The District has determined there is "Not Likely to Adversely Affect" on the federally endangered Atlantic sturgeon, leatherback sea turtle, loggerhead sea turtle, Kemp's ridley sea turtle, and green sea turtle. A detailed discussion of the District's effects determination can be found in Appendix A8. Concurrence with NOAA was received on February 11, 2020.

5.6. State Threatened and Endangered Species

No Action Alternative: The no action alternative will have neither short nor long-term impacts on state threatened and endangered species as there are no records of their occurrence in the study area.

Proposed Action: There will be no short-or long-term impacts on state threatened and endangered species as there are no records of any occurring in the study area.

5.7. Essential Fish Habitat

No Action Alternative: The no action alternative will have neither short nor long-term impacts on essential fish habitat.

Proposed Action: The proposed action is expected to have an indirect, short-term impact on food availability for benthic-feeding EFH designated species in the immediate placement area. The construction of the bulkheads may cause mortality of benthic infaunal organisms. However, resident fish are expected to feed in surrounding areas, and therefore be relatively unaffected by temporary, localized, reductions in available benthic food sources (USACE 2004a). A detailed EFH assessment is provided in environmental Appendix A1. The conclusion of this assessment indicates that implementation of the proposed action will have short-term, minimal effects to EFH species, their habitat, and no long-term impacts. NMFS provided EFH Conservation Recommendations based on this EA and the associated EFH worksheet on January 14, 2020. The District concurred with the Recommendations on January 23, 2020 (see Appendix A).

5.8. Socioeconomics

No Action Alternative: The no action alternative may have short- or long-term impacts on socioeconomics as continued flooding may deter businesses and industry from developing or rebuilding. With a lack of industry and businesses, the community may have a difficult time supporting themselves having to travel for work, goods, and services. Households may not rebuild and leave empty lots or unrepaired homes with continued flooding.

Proposed Action: The implementation of the proposed action should have positive short- and long-term socioeconomic impacts to existing business in the Highlands area because of the reduction of future storm damages and improved accessibility to businesses during storm events. There may also be a minor, indirect economic benefit on the local economy during initial construction. The introduction of construction workers should result in their purchasing of supplies and food during the initial construction phase and the additional phases. Construction work along the beaches will not occur during the months of June-August to avoid impact to the beaches. The implementation of the plan is expected have a direct positive impact on housing and structures due to a reduction in future storm damage to existing properties, and the subsequent reduction in associated costs to repair such damages. An indirect benefit to residential property values in Highlands is the expected increase due to the added coastal storm risk management of storm damages.

5.9. Environmental Justice

No Action Alternative: The no action alternative will have neither short nor long-term impacts to environmental justice communities. According to the United States Environmental Protection Agency (EPA), environmental justice means no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies.

There are six demographic indicators that the EPA uses to identify a community's potential susceptibility to environmental factors: percent low income (less than $25,000 annual), percent minority (non-white), percent of over 25 year olds with less than high school education, linguistic isolation, individuals under five and individuals over 65. The EPA Environmental Justice Mapper tool compiles US Census Bureau's 2013-2017 American Community Survey estimates. The population of Highlands is 5,005 people. In general, Highlands is not a minority community by race, only 9% of the population consider themselves non-White. Further, only 2% of the population speak English less than "very well" and ten percent of adults over 25 have less than a high school diploma. However, those residents in the Highlands' ALICE community facing the no action alternative would see even more financial vulnerability by displacing them from their homes or forcing businesses to close, whether temporarily or permanently.

Proposed Action: The implementation of the proposed action will have no short-or long-term impacts to environmental justice communities. The community, including those households that are low income will benefit through the allocation of Federal/public funds to this coastal storm risk management project.

5.10. Cultural Resources

The APE for this undertaking includes all areas directly impacted by activities required to construct project features as well as construction access and staging areas and, as required, environmental mitigation measures. The APE also includes viewsheds and landscapes in the vicinity of the alignment.

No Action Alternative: The no action alternative has the potential to lead to additional loss of historic properties within the study area as a result of continued exposure to future storm and flooding events.

Proposed Action: The NJHPO has previously indicated that no archaeological testing is required for the project as proposed in 2007. The alignment has remained largely as originally proposed but now ties into high ground along Bay Avenue on the eastern end and includes two interior drainage features, a detention pond and a diversion culvert along Snug Harbor Avenue, that have not been evaluated. As per the NJHPO opinion USACE will not undertake archaeological testing along the shoreline where the project alignment remains unchanged. The western end of the alignment has been modified since 2007 to tie into a new development project. That development is being constructed by others and USACE will not undertake testing. The eastern end of the alignment has been modified to tie into high ground along Bay Avenue. An archaeological assessment, followed as needed by testing, will be undertaken of newly proposed project features and for any future project changes.

The project will have no effect on 2 Bay Avenue, Bahrs Restaurant and Marina, due to the distance of the property from the project alignment. The NRHP eligibility of Honeysuckle Lodge and 58 Fifth St., both identified previously as potentially eligible as part of a thematic bungalow/cottage communities of the New Jersey shore, will need to be re-assessed following impacts from Hurricane Sandy and recovery measures. As the alignment is now proposed to cross Bay Avenue the eligibility of Bay Avenue, previously noted as a potentially eligible historic district before Hurricane Sandy, will also need to be evaluated. The FloBar Apartments, determined to be a potential individually eligible property, is just three parcels from the now proposed closure gate. Sculthorpe's Auditorium and 60 Bay Street would be included in the overall Bay Street evaluation but will also be evaluated for individual eligibility. It is clear that no above ground resources, if determined eligible, will be directly impacted by the proposed plan however indirect impacts to any properties determined significant will need to be evaluated.

Sections of the alignment are visible from the Sandy Hook Lighthouse NHL, the Twin Lights (Navesink Lighthouse) NHL, the Water Witch Casino and Fort Hancock Historic District. The project will have no adverse effect on the viewsheds from these properties as the views from them are focused out to sea. Also, the proposed project will match existing shoreline features so when viewed from these distant historic properties there will be little change from existing conditions.

The Borough of Highlands has a Master Plan which contains a Design Manual for the Central Business District. While the proposed closure structure across Bay Avenue is just outside the designated Central Business District as per the Borough's zoning map, the streetscape improvement suggestions therein should be considered for the design of the line of protection in the vicinity of Bay Avenue (Borough of Highlands 2004).

Section 106 Coordination. All previous USACE cultural resources studies for this study were coordinated with the NJHPO (see Appendix A4). On 10 January 2017, a Programmatic Agreement (PA) between the USACE and the NJSHPO was executed (Appendix A5) which stipulates the actions the USACE will take with regard to cultural resources as the project proceeds. The PA will be used to ensure that the USACE satisfies its responsibilities under Section 106 of the NHPA and addresses impacts to historic and cultural resources under NEPA. The Draft PA was provided to the NJHPO, the Advisory Council on Historic Preservation (ACHP), the Delaware Nation, the Delaware Tribe of Indians, the Shawnee Tribe of Oklahoma and the Historical Society of Highlands for review and to invite their participation. The ACHP has opted not to participate in the agreement at this time. No comments were received from the other parties contacted. The draft PA was available for public review in the Draft EA which served as the USACE Section 106 and NEPA public coordination. No comments were received regarding the cultural resources component of the project or the PA.

5.11. Coastal Zone Management

No Action Alternative: The no action alternative will have neither short nor long-term impacts to the Coastal Zone Management policies.

Proposed action: In conformance with the established policies of New Jersey's Coastal Zone Management Program, USACE has determined that the proposed action is consistent with New Jersey's Rules on Coastal Zone Management. For further discussion, see Appendix A2. NJDEP regulatory protocol is to process Federal Consistency Determinations and Water Quality Certification on final selected project designs during the Pre-construction, Engineering and Design (PED) Phase. A letter dated April 16, 2020 has been provided by NJDEP.

5.12. Floodplains

No Action Alternative: The no action alternative will have negative short and long-term impacts to the floodplains Highlands. Flooding will continue eroding soils, damaging property, roads, and infrastructure.

Proposed Action: The construction of the project will result in both short-and long-term impacts to floodplain values. Temporary indirect effects, which are associated with construction activities, include the displacement of aquatic and terrestrial resources, loss of recreational opportunities, and an increase in suspended sediments should a severe storm event occur during construction. Public access to the beaches and park would be temporarily impeded during construction. Because the floodplain is almost completely developed, there will be no long-term impacts to the floodplain

5.13. Land Use and Zoning

No Action Alternative: The no action alternative may have short- and long-term impacts as flooding will continue and possibly necessitating changes in land use a zoning as property is destroyed and land lost.

Proposed Action: Implementation of the proposed action will have no negative short- or long-term impacts to land use and zoning. The resulting increase in coastal storm risk management is not expected to significantly induce future development in the adjacent residential areas, because most, if not all, of the developable areas are developed.

5.14. Hazardous, Toxic, and Radioactive Waste

No Action Alternative: The no action alternative will have neither short nor long-term impacts from HTRW.

Proposed Action: There will be neither short nor long-term impacts from HTRW. As stated in section 2.12.15, only MTBE was detected and that was from a deep sample from a former gasoline station. Environmental impacts from the MTBE would be minimal, at most because of the soil depth it was detected at and the limited quantity present at that location. There may be small potential for the MTBE to migrate via ground water flow. The potential for this occurring is low. First because the area the compound is located in is paved, preventing direct infiltration. Second, it is located at a soil depth that is above the ground water table, further reducing the potential for migration. The remaining soil samples contained no detection of NJDEP listed compounds. The reminder of the proposed line of construction is viewed as clear of possible environmental impacts from sub-surface contaminants.

5.15. Aesthetic and Scenic Resources

No Action Alternative: The no action alternative may have negative short- and long-term impacts as flooding will continue, damaging houses, business, and personal property.

Proposed Action: Implementation of the proposed action will have negative and positive short-term impacts to aesthetics and scenic resources. Construction equipment and vehicles will be in the community during the implementation of the plan generally not considered visually appealing. Positively, the plan will provide flood management to segments completed reducing damage to property.

Long-term impacts of the proposed action will also have negative and positive impacts. The view shed toward the water will be altered, as the existing bulkheads will be raised up to 14 ft NAVD88. The bulkheads on the beaches will also raise the horizon of the view toward the bay. Positively, the plan will reduce damage to property resulting in less destruction, construction, and rebuilding of the community by managing flood risk.

5.16. Recreation

No Action Alternative: The no action alternative may have negative short-and long-term impacts as beaches, access to docks, and businesses will continue to flood and not be accessible.

Proposed Action: Implementation of the proposed action will have negative short-term impacts to recreation as beaches and docks will be temporarily inaccessible during construction. Long-term impacts will be positive as future risks of flooding of Veterans Park, and residents will be able to utilize the park after storms.

5.17. Air Quality

No Action Alternative: The no action alternative may have negative short-term impacts to air quality as construction may occur more often repairing property from continued floods. There will be no long-term impacts.

Proposed action: The Proposed Action was evaluated to determine the applicability of the General Conformity regulations pursuant to Section 176 of the Clean Air Act. The assessment determined that the requirements of this rule due not apply because the total direct and indirect emissions from the project would be significantly less than the threshold that triggers applicability. In a Record of Non-Applicability (RONA), the District determined that the project presumes to conform with the General Conformity requirements and is also exempted from Subpart B under 40 CFR§93.153(c)(1). The RONA is provided in Appendix 6 of the Integrated Feasibility Report and Environmental Assessment for the project. Post construction, the Project would not noticeably increase air emissions above existing levels.

5.18. Noise

No Action Alternative: The no action alternative may have negative short-term impacts to noise as construction may occur more often than repairing property from continued floods. There will be no long-term impacts.

Proposed action: Implementation of the proposed action will have minor negative short-term impacts to noise as construction vehicles and actions will increase the noise levels temporarily up to 100 dBA immediately at the construction site. Long-term impacts may be positive as continued construction and repair noise from repeated flooding will be reduced.

Chapter 6. Cumulative Impacts*

Cumulative impacts refer to one or more individual impacts which, when considered together, are considerable or which compound or increase the other's impacts. The cumulative impact from several projects is the change in the environment that results from the incremental impact of the proposed action when added to other closely related past, present, or reasonably foreseeable future projects. Highlands Borough conducts ongoing nonstructural flood risk damage management through elevations, buyouts and demolitions which does not adversely change the environment or interacts with the proposed plan. USACE currently has two other projects in study; Leonardo, a nonstructural CSRM project in Middletown Township, and Shrewsbury River, a CSRM study in Sea Bright; and two authorized projects along the Raritan Bay and Sandy Hook Bay shoreline, Union Beach and Port Monmouth. Union Beach is a structural project in design phase, consisting of structural floodwalls, levees, and beach nourishment. Port Monmouth is in construction and consists of structural floodwalls, levees, and beach nourishment. Implementation of the Highlands project is not anticipated with overlap with other projects in construction within Raritan Bay and Sandy Hook Bay.

There will be positive cumulative impacts to upland vegetation as all projects will replace removed vegetation with native vegetation. There will be a cumulative loss to wetlands; however all wetlands impacts will be mitigated according to NJDEP regulations resulting in the creation or restoration of the impacted wetlands.

There are potential cumulative impacts to the benthic communities resulting from the combined USACE projects. Intertidal and subtidal benthic communities are expected to recolonize within a few months after construction. Following this type of disturbance, the species composition of the reestablished community might be slightly different from the pre-construction composition. This effect, along with this project is a potential cumulative effect. However based on projected schedules, funding, and the distances between each project this is not a likely occurrence.

There are no anticipated cumulative impacts to fish and wildlife and Federal and state threatened and endangered species. All of the projects anticipate no long-term or major impacts to fish and wildlife and Federal and state threatened and endangered species.

Several low-income and lower-than-average-income communities would benefit through the allocation of Federal/public funds to USACE proposed coastal storm risk management projects along the Raritan Bay and -Sandy Hook Bay coast. Specifically, construction will have a positive benefit to the lowest income population of the area by reducing costs resulting from storm and water damage as well as costs incurred from temporary relocation during and after storm events.

The implementation of numerous beach erosion projects along the Raritan Bay and Sandy Hook Bay will involve the conversion of subtidal habitat to sandy beach, resulting in an overall loss of subtidal habitat and an extension of the intertidal zone. However, the loss of this habitat is minute when compared to the expanses of subtidal habitat along the Raritan Bay and Sandy Hook Bay shoreline.

The implementation of the USACE project would result in increased levees, floodwalls, and bulkheads altering the parts of the view shed in and along the Raritan Bay and Sandy Hook Bay. However, the local communities support all the projects and they understand and accept the impacts in exchange for flood control.

Chapter 7. Coordination & Compliance with Environmental Requirements*

Table 7-1. Summary of Primary Federal Laws and Regulations Applicable to the Proposed Project

Legislative Title U.S. Code/Other		Compliance
Clean Air Act	42 U.S.C. §§ 7401 7671g	Compliant. RONA - Project in non-attainment area, Appendix A5
Clean Water Act	33 U.S.C. §§ 1251 et seq.	USACE produced an evaluation complying with the Clean Water Act in Appendix A3. NJDEP regulatory protocol is to process Federal Consistency Determinations and Water Quality Certification on final selected project designs during the PED Phase. Wetlands will be mitigated through a wetland bank as described in Section 5.3.2
Coastal Zone Management Act	16 U.S.C. §§ 1451-1464 N.J.A.C. 7:7 and N.J.A.C. 7:7E	A CZM Determination was prepared and is located in Appendix A2. NJDEP regulatory protocol is to process Federal Consistency Determinations and Water Quality Certification on final selected project designs during the PED Phase.
Endangered Species Act of 1973	16 U.S.C. §§ 1531 et seq.	Coordination is complete with USFWS and NOAA. See Appendix A8.
Environmental Justice in Minority and Low Income Populations	Executive Order 12898	USACE performed an analysis and has determined that a disproportionate negative impact on minority or low-income groups in the community is not anticipated; a full evaluation of Environmental Justice issues is not required.
Fish and Wildlife Coordination Act	16 U.S.C. § 661 et seq.	Final FWCAR received. Coordination is complete
Magnuson-Stevens Act Fishery Conservation and Management Act	Section 305(b)(2) 1996 Amendments	EFH Assessment was prepared, Conservation Recommendations provided by NMFS and concurred by the District. The EFH Assessments are located in Appendix A.
National Environmental Policy Act of 1969	42 U.S.C. §§ 4321-4347	The circulation of the Draft EA with Draft FONSI fulfills requirements of this act.
National Historic Preservation Act of 1966	16 U.S.C. §§ 470 et seq.	The final executed PA fulfills this requirement and is included in Appendix A5.
Executive Order 11990, Protection of Wetlands	May 24, 1977	Circulation of this report for public and agency review fulfills the requirements of this order.
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	April 21, 1997	Implementation of this project will reduce environmental health risks. Circulation of this report for public and agency review fulfills the requirements of this order.
Migratory Bird Treaty Act of 1918, as amended	16 U.S.C. 703-712	The District will avoid and minimize impacts to migratory birds and their nests from construction and operation of the project.
Bald and Golden Eagle Protection Act of 1940, as amended	16 U.S.C. 668-668d	The District will avoid and minimize impacts to bald and golden eagles from construction and operation of this project.

Table 7-2. List of Report Preparers

Individual	**Responsibility**
Matthew Voisine	Biologist; NEPA
Carissa Scarpa	Archeologist: NEPA, SEC. 106
Richard Dabal	Physical Scientist: HTRW, NEPA
Jenine Gallo	Biologist: Clean Air Act, NEPA
Christina Rasmussen	Coastal Hydraulics
Rebecca Augustin	Planner

Chapter 8. Plan Implementation

As non-Federal partner, the NJDEP must sign a Project Partnership Agreement (PPA) that will carry the project through the Preconstruction Engineering and Design (PED) phase to project construction. This process is described in more detail in Section 8.4. A Project Management Plan (PMP) will be prepared to identify tasks, responsibilities, and financial requirements of the Federal Government and the non-Federal partner during PED and construction. A project schedule has been estimated to serve as the basis of the cost estimate based on reasonable assumptions for the detailed design and construction schedules. It will be refined as more data are available in subsequent phases of the project.

8.1. Institutional Requirements

NJDEP has indicated its intent to implement this project through a strong record of involvement and coordination in the feasibility study, and a letter of support (Pertinent Correspondence Appendix).

A fully coordinated PPA package, which will include the non-Federal partner's financing plan, will be prepared subsequent to the approval of the feasibility phase to initiate design and construction. It will be based on the recommendations of the feasibility study. NJDEP has agreed to comply with all applicable Federal laws and policies and other requirements that include, but are not limited to:

a. Provide a minimum of 35 percent of initial project costs assigned to coastal and storm damage reduction as further defined below:

    (1) Provide, during design, 35 percent of design costs allocated to coastal and storm damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

    (2) Provide all lands, easements, rights-of-way, including suitable borrow areas, and perform or assure performance of all relocations, including utility relocations, as determined by the Federal government to be necessary for the initial construction, periodic nourishment or operation and maintenance of the project;

    (3) Provide, during construction, any additional amounts necessary to make its total contribution equal to 35 percent of initial project costs assigned to coastal and storm damage reduction;

b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

c. Participate in and comply with applicable Federal floodplain management and flood insurance programs; comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12); and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood risk management features;

d. Operate, maintain, repair, replace, and rehabilitate the completed project, or function portion of the project, 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;

e. For so long as the project remains authorized, ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

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

g. At least twice annually and after storm events, perform surveillance of the beach to determine damages to the project and provide the results of such surveillance to the Federal government;

h. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

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

j. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

k. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the initial construction, periodic nourishment, operation and maintenance of the project;

l. Assume, as between the Federal government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way required for the initial construction, periodic nourishment, or operation and maintenance of the project;

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

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

p. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)); and

q. Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

In an effort to keep the non-Federal project partner involved and the local government informed, meetings were held throughout the feasibility phase. Coordination efforts will continue, including coordination of this study with other State and Federal agencies. A public meeting on the draft feasibility report was held on July 22, 2015, at the Borough of Highlands. Comments on the draft report are documented in Appendix F.

8.2. Financial Analysis

For purposes of executing the PPA, NJDEP has a dedicated source of funding for coastal storm risk management projects and has indicated its intent to enter into a PPA at the conclusion of the study. The Letter of Support from NJDEP is included in the Pertinent Correspondence Appendix.

8.3. Real Estate Requirements

The total lands and easements required in support of the project is approximately 23.51 acres; 16.12 acres required in permanent easements, 7.39 acres required in temporary easements, and 5 acres of fee simple purchase for environmental mitigation purposes. The project impacts approximately 119 parcels, affecting approximately 105 private owners and 14 public owners (15 parcels). In some instances, more than one estate is required to be obtained over the lands of an owner.

Access to Sandy Hook Bay will be provided as a project feature on publicly owned land either in the form of an earthen ramp or timber stair walkover. Private property owners will receive compensation if their existing access needs to be removed for construction. The compensation estimate is the amount that the Federal government has estimated to build either a timber stair walkover or an earthen ramp, similar to the type identified for the public property, as part of the real estate easements. The cost for these components (severance) are included in the LERRD account as a non-federal obligation.

The appraisal cost estimate was completed by the New York District Corps of Engineers in October 2019. The total estimated cost for the required lands and easements is $12,524,000. Publicly owned lands within the project impact area are not valued, or acquisition costs are nominal, and not considered in the cost estimate.[16]

8.4. Preconstruction Engineering and Design

In order for Preconstruction Engineering and Design (PED) and construction to be initiated, the Administration must approve a new phase investment decision and USACE must sign a Design Agreement with the non-federal sponsor to cost share PED. There is a possibility that Public Law 113-2 investigation funds could be used for Preconstruction Engineering and Design, contingent upon availability of remaining funds. For the Highlands project, PED costs are estimated at $23,093,000 (Oct. 2019 P.L.) to cover detailed field surveys, geotechnical data collection, easements, and construction contract award. Implementation would then occur, provided that sufficient funds are appropriated to design the project. This project would ultimately require congressional authorization, a new start construction decision by the Administration, and execution of a Project Partnership Agreement in order to proceed to a follow-on construction phase.

[16] In accordance with Section 5.a. of USACE North Atlantic Division memorandum dated 16 October 2013, subject: Regional Real Estate Policy Guidance – Hurricane Sandy Coastal Restoration Program Easement Valuation.

8.5. Construction Schedule

The project assumes a construction period of 42 months. The estimated construction duration of 42 months was calculated using crew hours from the MCACES MII Estimate for this project. The crew hours for each construction activity include labor, equipment, and material delivery. For this project, the construction of the levees and floodwalls amounts to the longest duration. Based on MII, this construction feature would take 10 years to construct assuming one crew. IT was assumed that this activity would be performed by 3 crews working simultaneously which reduces the construction duration to approximately 42 months. Other construction features of this projects such as the pump station, closure gate, and drainage structures would be constructed concurrently with the levees and floodwalls using additional crews.

8.6. Cost Sharing and Non-Federal Partner Responsibilities

The breakdown of cost sharing for the initial total project first cost of implementing the Recommended Plan are shown in Table 8-1, and the implementation schedule is shown in Table 8-2. The Federal share is 65 percent of the total project first cost. The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of non-Federal interests. The non-Federal share of the estimated total first cost of the proposed project is 35 percent of the total. The non-Federal share includes LERRD in the estimated amount of $11,109,000, which are credited against the Non-Federal share, reducing the non-Federal cash contribution to $45,813,000.

Table 8-1: Cost Apportionment (Oct. 2019 Price level)

Initial Project First Cost *	
Federal (65%)	$ 105,713,000
Non-Federal (35%)	$ 56,922,000
Total	**$162,635,000**

8.7. Views of the Non-Federal Partner and Other Agencies

The proposed action has received strong support from the non-Federal project partner, NJDEP and the affected local government in Highlands. This support is expressed through the Letter of Support (Pertinent Correspondence Appendix). Through project planning and National Environmental Policy Act (NEPA) scoping in 2003, a variety of other Federal agencies have been involved in this investigation and support the project goals.

Table 8-2: Implementation Schedule for Highlands Recommended Plan

Highlands Recommended Plan Implementation Schedule	
Milestone	**Date**
Final Report Transmittal to HQ	Feb-20
S&A Briefing for HQUSACE P&P Chief	Apr-20
S&A Start	June-20
S&A End	July-20
Chief's Report	Aug-20
Pre-Construction Engineering & Design Start	Jan-21
Project Partnering Agreement Execution	Jan-22
Construction Contract Award	Aug-22
Construction Completion	Feb-26

8.8. Consistency with Public Law 113-2

This feasibility report has been prepared in accordance with the Disaster Relief Appropriations Act of 2013, Public Law 113-2. Specifically, this section of the report addresses:

1. The specific requirements necessary to demonstrate that the project is economically justified, technically feasible, and environmentally acceptable, and
2. The specific requirements necessary to demonstrate resiliency, sustainability, and consistency with the North Atlantic Coast Comprehensive Study (NACCS).

8.8.1. Economics Justification, Technical Feasibility and Environmental Compliance

The prior sections of this report demonstrate how the NED/Recommended Plan manages coastal storm risk. It also identifies the NED/Recommended Plan to be economically justified for the authorized period of Federal participation. The Environmental Assessment sections of this integrated report have been prepared to meet the requirements of NEPA and demonstrate that the NED/Recommended Plan is compliant with environmental laws, regulations, and policies and has effectively addressed any environmental concerns of resource and regulatory agencies.

8.8.2. Resiliency, Sustainability, and Consistency with the NACCS

This section describes how the Highlands feasibility study is consistent with the findings and recommendations of the North Atlantic Coast Comprehensive Study (NACCS). Resiliency is defined as the ability to adapt to changing conditions and withstand, and rapidly recover from disruption due to emergencies.[17] Sustainability is defined as the ability to continue (in existence or a certain state, or in force or intensity), without interruption or diminution.

The North Atlantic Coast Comprehensive Study (NACCS) was released in January 2015 and provides a risk management framework designed to help local communities better understand changing flood risks associated with climate change, and to provide tools to help those communities better prepare for future flood risks. In particular, it encourages planning for resilient coastal communities that incorporates wherever possible sustainable coastal landscape systems that takes into account, future sea level and climate change scenarios (USACE, 2015).

The process used to identify the Recommended Plan used the NACCS Risk Management framework that included evaluating alternative solutions and also considering future sea level change and climate change. A local OMRR&R plan will be put in place with periodic USACE inspections to sustain a continuous level of risk management for the period of analysis.

The Highlands Recommended Plan is a resilient, sustainable, and a robust solution. It consists of raised and capped bulkheads, floodwalls, and reinforced dunes. Compared to beach and dunefill systems, this plan has the advantage of not requiring renourishment to maintain its authorized dimensions (renourishment requires future, additional congressional authorization). Following an

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[17] in the February 2013 USACE-NOAA Infrastructures Systems Rebuilding Principles white paper

analysis of project performance under intermediate and high rates of sea level change, in accord with ETL 1100-2-1, the cost estimate for the project includes larger footings for the floodwalls to allow for extending the height of the project if needed in the future. Cost increases are minimal because the three sizes were designed with more substantial bases underground so that their heights could be increased up to three feet if required in the future in response to climate change.

8.9. Major Conclusions and Findings

This study has determined that periodic coastal storms, including tropical storms, hurricanes, and nor'easters pose a severe threat to life and property in Highlands, Monmouth County, New Jersey. There is potential to manage coastal storm risks in Highlands. In response to these problems and opportunities, plan formulation activities considered a range of structural and nonstructural measures. Through an iterative plan formulation process, potential coastal storm risk management measures were identified, evaluated, and compared.

Alternative coastal storm risk management plans that survived the initial screening of alternatives included hard structural (floodwalls and bulkheads) and soft structural (beachfill and dune) plans, and a hybrid plan that minimized environmental impacts by matching the existing ground surface (ie., elevated bulkheads where the shoreline is already bulkheaded and reinforced dunes consisting of sand-covered seawalls on the existing beaches). The hybrid plan was found to be the most effective and efficient of the three alternatives, and was further developed into five variations to assess various components to maximize water access, such as buoyant swing gates and removable floodwalls. Of the five variations, the alternative that prioritized coastal storm risk management over water access by including stationary components, was found to have the highest net benefits, making it the Tentatively Selected Plan (TSP).

The TSP was released to public and agency review in the Draft Feasibility Report and Environmental Assessment for Highlands from July 2015 to September 2015. Reviews did not alter the plan selection. Following reviews, USACE began the process of detailed feasibility analysis on the TSP to identify project dimensions that would maximize net benefits, for what is known as the National Economic Development (NED) Recommended Plan. The project dimensions that optimized net benefits consists of floodwalls to elevation +14 ft NAVD88 across the entire alignment, and includes a detention pond, diversion culverts, raised ground surfaces, and a pump station for interior drainage.

The project spans a geographic distance of approximately 8,000 linear feet along the bayshore of Highlands and ties into high ground (+14 ft NAVD 88) at each end. Because the project follows the actual perimeter of the shoreline, its total length is 10,737 linear ft. Access to Sandy Hook Bay and the Shrewsbury River will be provided as a project feature on publicly owned land. Private property owners will receive compensation if their existing access needs to be removed for the project.

Chapter 9. Recommendations

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental, social and economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of New Jersey and other non-Federal interests.

I recommend that the selected National Economic Development plan for coastal storm risk management at Raritan Bay and Sandy Hook Bay, Highlands, New Jersey, as fully detailed in this Final Feasibility Report and Environmental Assessment, be authorized for construction as a Federal project, subject to such modifications as may be prescribed by the Chief of Engineers.

I recommend authorization of the coastal storm risk management project for Highlands, NJ, subject to such modifications as may be prescribed by the Chief of Engineers.

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

Matthew W. Luzzatto
Colonel, U.S. Army
Commander and District Engineer

Chapter 10. References*

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Raritan Bay and Sandy Hook Bay
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Coastal Storm Risk Management
Feasibility Study

Appendix A

Environmental Documentation

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Appendix B

Engineering

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Appendix C

Economics

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Appendix D

Cost Engineering

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Appendix E

Real Estate Plan

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Appendix F

Pertinent Correspondence

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