NCBB

Nassau County Back Bays Study

Nassau County Back Bays Coastal Storm Risk Management Feasibility Study

STATUS REPORT

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US Army Corps of Engineers®
Philadelphia District

DEPARTMENT OF ENVIRONMENTAL CONSERVATION · NEW YORK STATE ·

NASSAU COUNTY STATE OF NEW YORK

Table of Contents

List of Figures

List of Tables

1. INTRODUCTION

1.1. Purpose and Scope of this Report

The purpose of this Status Report is to provide an update on the Nassau County Back Bays (NCBB) coastal storm risk management (CSRM) study to residents, stakeholders, local government officials, Federal and non-Federal agencies, the non-Federal study sponsor, and other interested parties and to present the projected timetable for attaining the remaining study milestones. All interested parties are invited to provide review comments to the study team.

It should be noted that this report is not a "decision document" in the formal sense for U.S. Army Corps of Engineers (USACE) reports. Decision documents typically are presented to USACE decision makers (higher authority within USACE) for review and approval, after which most are submitted to Congress for authorization and subsequent funds appropriations in order to implement the recommendations presented in the decision document. This status report is a product that is not specifically called for by USACE planning and reporting guidance and policies. Rather, it is provided as an interim report on the present status of the study and the proposed path toward a recommended plan and final report to Congress.

The report is presented in four sections. The first section (INTRODUCTION) provides background on the impacts of coastal storms including Hurricane Sandy in October 2012, the directive from Congress for USACE to perform the North Atlantic Coast Comprehensive Study (NACCS) and ultimately this study, and related additional information regarding the overall study area, purpose, study sponsor, and related topics.

The report then presents PLANNING CONSIDERATIONS, which outlines the standard planning principles and practices uniformly employed by USACE in water resource investigations, including this study. The third section summarizes WORK COMPLETED TO DATE, and the fourth section presents the proposed PATH FORWARD including the scope and schedule of work required to complete the study process and make a final recommendation to Congress to implement a selected plan.

This report does not make recommendations or present conclusions regarding a preferred plan to address flood risk in the study area. Instead it describes the planning, engineering, economic, and environmental analyses and public input to date that are critical to develop the tentatively selected plan (TSP) and ultimately release a Draft Feasibility Report and Environmental Impact Statement (EIS) in the summer of 2020. The Final Feasibility Report and EIS are scheduled for completion in January 2022.

1.2. Hurricane Sandy

Hurricane Sandy originated in the Caribbean on 22 October 2012 and strengthened to a Category 1 hurricane as it moved northward in the Atlantic Ocean parallel to the coast of the southeastern United States. It continued to increase in size to a diameter of more than 1,000 nautical miles, making it the largest diameter storm recorded in the Atlantic basin. On the evening of 29 October 2012, Hurricane Sandy made landfall near Brigantine, NJ at about the same time as predicted high tide in the NY-NJ metropolitan area.

The highest storm surge and greatest inundation of land occurred in New Jersey and New York, especially in and around New York City. In many of these locations, including the coastline of Nassau County, the surge was accompanied by powerful damaging waves. In Nassau County, a high-water mark of 4.6 ft above ground level was observed in Freeport in the Town of Hempstead. The four U.S. Geological Survey (USGS) tide gages in the Nassau County portion of the study area recorded high water elevations during Sandy that ranged between +8.6 and +9.7 feet relative to the North American Vertical Datum of 1988 (NAVD88). The USGS tide gage at Lindenhurst in Suffolk County attained a water level maximum of +6.5 feet NAVD88.

Because of its tremendous size and timing during high tide, the storm drove a catastrophic surge of water into densely developed areas of New Jersey and New York. As a result, there was considerable loss of life, extensive damage to development, and massive disruption to communities. With estimated damages of $65 billion, Hurricane Sandy was one of the costliest hurricanes in the Nation's history and the largest storm of its kind to hit the U.S. east coast.

1.3. Public Law 113-2

As a result of Hurricane Sandy, Congress passed the Disaster Relief Appropriations Act of 2013 (Public Law [PL] 113-2) in January 2013 to assist with the recovery in the aftermath of the storm. The Act authorized supplemental appropriations to Federal agencies for expenses related to the consequences of Hurricane Sandy. Chapter 4 of PL 113-2 identified those actions that Congress assigned specifically to USACE, including preparation of two interim reports to Congress, a project performance evaluation report, and a comprehensive study (the NACCS) to address the flood risks of vulnerable coastal populations in areas affected by Hurricane Sandy within the boundaries of the North Atlantic Division (CENAD) of USACE.

1.4. North Atlantic Coast Comprehensive Study (NACCS)

The goals of the NACCS were to provide a risk management framework, consistent with the National Oceanic and Atmospheric Administration (NOAA) and USACE Infrastructure Systems Rebuilding Principles, and support resilient coastal communities and robust, sustainable coastal landscape systems, considering future sea level and climate change scenarios, to reduce risk to vulnerable populations, property, ecosystems, and infrastructure.

The January 2015 NACCS final report identified nine high-risk focus areas in the North Atlantic region that were deemed to warrant additional analyses to address coastal flood risk, including the development of strategies to manage risk associated with relative sea level change (RSLC). One of the nine focus areas is the NCBB. PL 113-2 did not provide direct authority for USACE to complete the additional analysis required to achieve a Chief of Engineers' Report for the focus area studies. However, the study is authorized by Chapter 140 of Public Law 71, which follows.

1.5. Study Authority

Chapter 140, Public Law 71, 84th Congress (15 June 1955):

> *That in view of the severe damage to the coastal and tidal areas of the eastern and southern United States from the occurrence of hurricanes, particularly the hurricanes of August 31, 1954, and September 11, 1954, in the New England, New York, and New*

Jersey coastal and tidal areas . . . the Secretary of the Army . . . is hereby authorized and directed to cause an examination and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.

1.6. Study Purpose

The purpose of the study is to determine the feasibility of a project to reduce the risk of coastal storm damage in the back bays of Nassau County, while contributing to the resilience of communities, important infrastructure, and the natural environment. Implementation of any Federal CSRM plan recommended by the study will ultimately require further authorization and appropriations by Congress.

1.7. Study Sponsor

The non-Federal study sponsor is the New York State Department of Environmental Conservation (NYSDEC) in partnership with Nassau County, NY. A Feasibility Cost Sharing Agreement (FCSA) between USACE and NYSDEC was executed on 30 September 2016.

1.8. Federal Interest

CSRM is one of the primary civil works mission areas of USACE, and the study area is highly vulnerable to coastal storm events. This feasibility study is investigating a range of approaches that have the potential to reduce coastal storm flood risk and at the same time be economically justified, environmentally acceptable, and consistent with USACE operating principles.

Coastal flooding has caused significant economic, environmental, and community impacts in Nassau County. The study area is affected by flooding due to relatively more frequent high tides as well as from less frequent but major coastal storms. Flood impacts can range from street closures to massive destruction from hurricane surge inundation, as occurred as a result of Hurricane Sandy in 2012. The storm flooded homes, businesses, and critical infrastructure, rendered roads and Long Island Rail Road stations and infrastructure unusable, and caused school and business closures and gasoline shortages. Some communities in Nassau County are still recovering from the effects of Sandy. USACE, Federal Emergency Management Agency (FEMA), U.S. Department of Housing and Urban Development (HUD), U.S. Department of Transportation (USDOT), and other Federal agencies have invested billions of dollars in recovery and resilience missions.

As with all USACE feasibility studies, potential water resource solutions are being formulated to support the Federal objective to contribute to National Economic Development (NED) consistent with protecting the nation's environment, in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements. Alternative plans are formulated to alleviate problems and take advantage of opportunities that contribute to study planning objectives and, consequently, to the Federal objective. Contributions to NED outputs will be quantified using standard economic analysis procedures and these benefits will be used during plan formulation and documented in the feasibility report.

1.9. Study Management

The study area falls within the area of responsibility of the New York District (CENAN) of USACE. CENAN executed the FCSA in September 2016 to begin the study. CENAN was responsible for all activities of the study from its inception to its eventual transition and assignment to Philadelphia District (CENAP) in February 2019. The Corps made this transition in the interest of balancing and more efficiently executing the Corps' workload in the North Atlantic Division area of responsibility. This regional approach will also be used to transition design and construction work back to CENAN after the planning study is complete.

From the outset of the study it was obvious that an exemption to study management policy would be needed. The standard USACE policy is to complete all studies in three years and within a total cost of $3 million. An exemption is needed due to the large size of the study area and its associated complex hydraulic, environmental and economic characteristics. The primary cost and schedule drivers include complexity, size, scope, and potential project cost; the need for additional engineering analyses; and the requirement for additional environmental analyses and extensive agency coordination to comply with the Coastal Barrier Improvement Act of 1990; and a change to the USACE study process that necessitates development of additional planning products such as the TSP in progress review (TSP IPR) and preparation of a draft interim planning document, neither of which was envisioned at the time the original project management plan (PMP) was developed.

If USACE determines it appropriate, the exemption would enable a revised schedule and scope based on the additional time needed to conduct technical analyses as the project is further analyzed and designed, both before and after the Agency Decision Milestone (ADM). These analyses will include, but are not limited to, detailed design and cost analyses, environmental impact/mitigation analysis, hydrodynamic circulation and water quality modeling, geotechnical data collection, environmental compliance coordination, nonstructural plan development, operation and maintenance plan development, real estate plan development, vertical team coordination, and additional public outreach meetings.

1.10. Study Area

Nassau County is located on Long Island, NY, between Queens County to the west and Suffolk County to the east. Nassau County has a population of 1.3 million people, a land area of 287 square miles, and 166 square miles of water. Southern Nassau County is typified by dense, low elevation mixed-use development (residential and commercial), a highly developed shoreline, and many roads, rail roads, and critical facilities that serve Long Island and parts of New York City. Beaches and back bay wetland areas provide habitat for many regionally and nationally important aquatic and terrestrial species. It is assumed that future land use will be similar to current land use. It is further assumed that the location and use of major infrastructure such as roads, rail roads, wastewater treatment plans, fire departments, and police departments will not significantly change in the future.

The study area (**Figure 1**) extends approximately 30 miles in the east-west direction, primarily in Nassau County, but also in adjacent portions of Queens and Suffolk Counties. The study area includes all of the tidally influenced bays and estuaries hydraulically connected to the south shore of Nassau County on the Atlantic Ocean. The regular rise and fall of tide in the ocean leads to tidal flow through East Rockaway, Jones, and Fire Island Inlets that causes a corresponding rise and fall of water levels in the back bays. The study area is thus subject to tidal impacts under non-storm conditions, as well as to more widespread inundation during coastal storm events. The study area limits were established using the following principles and assumptions.

Northern Boundary. The mainland of Long Island was established using NACCS water level statistics for the 500-year return period (0.2% annual exceedance probability, or “AEP”) at 13 locations. The vertical datum used in the NACCS water level calculations is local mean sea level (LMSL) in meters. The NACCS water surface elevations were converted to units of feet relative to NAVD88 using the application known as VDatum, developed and maintained by NOAA. This conversion was necessary because NAVD88 is the standard vertical datum used for topographic (elevation) surveying and mapping. Three feet was added to the NACCS water surface elevations to account for potential future relative sea level change (RSLC), then each value was rounded to the nearest whole foot. The resulting elevation contour selected as the northern study area boundary was thus +19 feet NAVD88. The boundary line was smoothed using engineering judgment so that it did not cut through real estate parcels. The typical distance from the northern study area boundary to the ocean shoreline of Long Beach, Jones, and Fire Islands is between 5 and 7 miles.

Southern Boundary. Corresponds to the Atlantic Ocean offshore of Long Beach, Jones, and Fire Islands.

U.S. Geological Survey (USGS) hydrologic units were used to identify and select the east and west boundaries of the study area. USGS Hydrologic Unit Code (HUC) 12-digit sub-watersheds were adopted as the appropriate level of geographic detail for this study.

Western Boundary. Hook and Motts Creeks are hydraulically connected to Jamaica Bay at Head of Bay south of John F. Kennedy International Airport and act as conduits for storm surge that floods portions of eastern Queens and western Nassau Counties. The Hook Creek-Head of Bay watershed is included in both the NCBB and New York – New Jersey Harbor and Tributaries Study (NYNJHATS) areas at present. There is a risk that the economic benefits of a project that reduces flood risk in this area may not be captured if they are only investigated in one study. For example, if the area is included only in the NYNJHATS and a storm surge barrier at Jamaica Bay is subsequently screened from further consideration in that study, then the Project Delivery Teams (PDTs) may miss the opportunity to investigate different measures as part of the study. In addition, Nassau County has invested in CSRM infrastructure in the watershed and has stated that this is an important area for investigation. The NCBB and NYNJHATS PDTs will continue to coordinate about this matter throughout plan formulation and selection.

Eastern Boundary. The study is evaluating the potential for ocean storm surge to enter the back bays through East Rockaway, Jones, and Fire Island Inlets. Structural measures, such as a storm surge barrier at Fire Island Inlet or a cross-bay barrier, would also have the potential to affect storm water elevations in the portion of western Suffolk County that adjoins Nassau County. Consequently the PDT adopted the eastern extent of the West Channel-Dickerson Channel watershed as the eastern study area boundary.

Communities in the study area include villages and unincorporated municipalities in the towns of Hempstead and Oyster Bay that border Hewlett Bay, Middle Bay, Jones Bay, South Oyster Bay, and connected creeks, channels, and minor water bodies, as well as the City of Long Beach. Also included are the Suffolk County towns of Babylon and Islip that border Great South Bay.

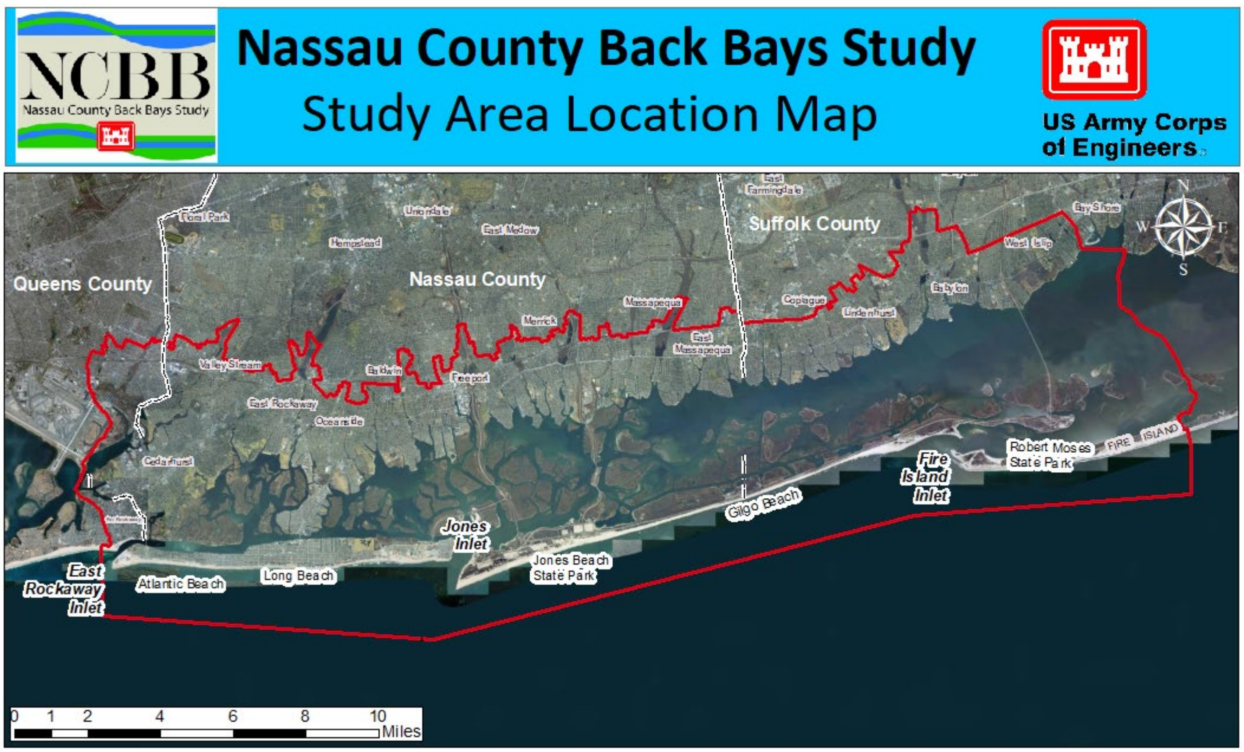

Figure 1: Study Area

1.11. Congressional Interests

The study area is represented by NY Senators Charles Schumer and Kirsten Gillibrand, Representative Peter King (NY-02), Representative Kathleen Rice (NY-04), and Representative Gregory Meeks (NY-05).

1.12. Prior Reports and Existing Water Resource Projects

There are a number of existing water resource projects in the study area, which will be factored into the formulation of the future without project (FWOP) conditions discussed later in this report, including:

- Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet (Long Beach, NY) CSRM project
- Fire Island Inlet and Shores Westerly to Jones Inlet, NY (Gilgo Beach) navigation/CSRM project
- East Rockaway Inlet, New York Federal Navigation Channel

- Jones Inlet, New York Federal Navigation Channel
- Fire Island, New York Federal Navigation Channel
- Great South Bay, New York Federal Navigation Channel
- Long Island Intracoastal Waterway, New York Federal Navigation Channel
- New York State Department of Transportation repair and resilience work for bridges over multiple water bodies
- Back bay shoreline bulk-heading, Long Beach, NY (planned, funded for construction)

In addition, there are other ongoing or completed Federal, state, and local CSRM studies and hazard mitigation plans. They include:

- East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Hurricane Sandy Reformulation Study (Rockaway Reformulation)
- Nassau County Multi-Jurisdictional Natural Hazard Mitigation Plan (completed 2014)
- Nassau County Public Housing Resilience Study (ongoing)
- Baldwin-East Baldwin Road Raising Study (ongoing)
- Seaford Road Raising Study (ongoing)
- Lido Beach-Point Lookout Revetment Study (ongoing)
- Rebuild by Design Living with the Bay Study (ongoing)
- The Path to the Park - Shoreline Improvements in South Valley Stream Study (ongoing)
- Baldwin Park Water Esplanade Study (ongoing)
- Meadowbrook Corridor Stormwater System Pilot Study (ongoing)
- South of Merrick Road, Bellmore-Merrick and Seaford-Wantagh Outfall, Bulkhead and Stormwater Drainage and Bulk-heading Survey (ongoing)
- Multiple local drainage improvement studies (ongoing)

2. PLANNING CONSIDERATIONS

2.1. Introduction

This section of the NCBB status report provides an overview of the USACE planning process and the principal concepts and tasks that are common to all USACE water resource investigations. The application of these planning considerations specifically to the study area and its problems is presented in greater detail in the subsequent section of this report, "Work Completed to Date."

2.2. Six Step Planning Process

The USACE planning process is a structured and iterative approach to problem solving. USACE uses the six-step planning process in water resource development studies, including this study. The six steps are:

1. Identify water resources problems in the study area
2. Collect data on the problems identified
3. Develop alternatives to solve the problems
4. Evaluate the effects of the alternatives
5. Compare alternatives
6. Select a plan for recommendation or decide to take no action. The alternative plan with the greatest net economic benefits consistent with protecting the nation's environment is normally selected.

2.3. Problems, Opportunities, and Constraints

The following problems and opportunities were identified based on public coordination and an examination of existing and FWOP conditions.

Problems are existing negative conditions.

- Frequent flooding from high tides, spring tides, sunny day flooding, and coastal storms
- High risk of coastal storm flooding and threat to life safety
- Ecosystem degradation in the back bays
- RSLC

Opportunities are desired future conditions that improve on the present.

- Manage coastal storm flood risk
- Better communicate coastal storm risk to communities
- Improve recreation and restore natural systems in ways that may provide CSRM benefits
- Contribute to community rebuilding and resilience

Constraints are actions to avoid, or conditions that cannot be changed while trying to meet study objectives.

- Avoid impact to Federal navigation channels
- Avoid impact to constructed and planned resilience projects
- Avoid induced coastal flooding in adjacent communities, and flooding from rainfall or overwhelming of existing interior drainage systems
- Avoid impacts to critical infrastructure

- Minimize or avoid impacts to the environment and public access
- Avoid CBRA impacts

2.4. Planning Objectives

- Reduce the risk of coastal storm damage to communities, public infrastructure, important societal resources, and the environment in southern Nassau County through 2075. (USACE studies typically utilize a 50-year period of economic analysis. Assuming 2025 as the base year for a potential NCBB project results in a period of analysis through 2075.)
- Contribute to the long-term sustainability and resilience of coastal communities in southern Nassau County through 2075
- Contribute to the long-term sustainability and resilience of the back bay environment in southern Nassau County through 2075

2.5. Risk-Informed Decision Framework

Engineer Regulation (ER) 1105-2-100 Planning Guidance Notebook states "planners shall identify areas of risk and uncertainty in their analysis and describe them clearly, so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans." Consequently the study has included risk-informed decision making in all aspects of the study. This includes:

- Utilizing SMART (Specific, Measurable, Attainable, Risk Informed, Timely) Planning principles such as balancing the level of uncertainty and risk with the level of detail of analysis of the study
- Ensuring transparent and early vertical team engagement of decision makers as the study process progresses
- Identifying the Federal role in resolving a problem up front
- Recognizing there is no single best plan and that there are quantitative and qualitative methods of alternative comparison and analysis
- Iterative incorporation of the six-step planning process.

In addition, the consideration of risk and uncertainty is built into technical analyses including economic Monte Carlo simulation; inclusion of a large number of storm events and scenarios in hydrodynamic modeling to determine water levels with various statistical confidence levels; and consideration of water level/wave crest height analyses in floodwall design height analyses.

In risk-informed planning, the PDT continually asks critical questions about the appropriate level of detail necessary to make decisions. Throughout the study process, the team makes choices about what data are considered necessary to make planning decisions and the appropriate level of detail for the phase of the study. The PDT progressively and deliberately determines the level of detail needed to make the next planning decision. The PDT must balance its choice for additional detail with the funds and time available against the risk and uncertainty of decision outcome. Using these tools in conjunction with clear communication of decisions and understanding of the risks helps achieve the integration with all members of the PDT, as well as project reviewers from CENAD and USACE Headquarters (HQUSACE). The first step in any planning study is to identify the problem to be solved.

2.6. Plan Formulation – Measures and Alternative Plans

Measures are features or actions that meet some or all of the study objectives and avoid study constraints. Measures that are being considered in the NCBB study include structural measures, nonstructural measures, and natural and nature-based features (NNBFs). Alternative plans are made up of multiple measures. A description of CSRM measures under consideration is included in the section, "Work Completed to Date."

2.7. Plan Formulation – Strategy

The general plan formulation strategy is to maximize National Economic Development (NED) benefits while considering technical feasibility, environmental impacts, economic implications, social consequences, and technical criteria. This includes an evaluation of four accounts specified in the 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, more commonly known as the "P&G." The four P&G accounts include NED, regional economic development (RED), other social effects (OSE), and environmental quality (EQ). The PDT is using the following overarching goals as part of the plan formulation strategy:

- Maximize reduction of flood damage to homes and business
- Contribute to the resilience of communities and critical infrastructure
- Contribute to ecosystem resilience
- Be acceptable to community stakeholders
- Use existing data and tools – NACCS Tier 2 evaluation, Coastal Hazard System (CHS) wave and water level statistics, state and local datasets
- Integrate public outreach
- Synergistic with Federal, state, and local resilience projects
- The four Planning Criteria - effectiveness, efficiency, acceptability, and completeness - identified in the P&G will also be considered in plan formulation.

2.8. National Environmental Policy Act (NEPA) of 1969

NEPA requires Federal agency decision makers to consider how proposed actions could impact the human and natural environment. The NEPA process includes both decision making and public involvement aspects. During the NEPA process, the USACE, NYSDEC, and Nassau County will assess whether or not the project's environmental impacts are significant. The NEPA process must be completed before any decision is made by a Federal agency.

As part of the NEPA process, federal agencies prepare an Environmental Impact Statement (EIS) for proposed major federal actions. A draft integrated feasibility report and EIS will be prepared for the NCBB study. There will be a series of public meetings to present the draft report and EIS, and the public will have the opportunity to review and provide comments on the draft report and EIS.

3. WORK COMPLETED TO DATE

3.1. Introduction

This section of the NCBB status report presents an overview of the work that has been accomplished to date by applying the previously-discussed USACE planning considerations specifically to the study area. This section includes a recap of the NCBB coastal flooding problem, public and agency involvement in the study process, the range of potential measures that have been formulated into preliminary plans, and summary discussions of how the principal economic, coastal engineering, and environmental analyses have been conducted to date.

3.2. The Coastal Storm Flooding Problem

The purpose of the study is to determine the feasibility of a project to reduce the risk of coastal storm damage in the back bays of Nassau County. Because the study is authorized principally for purposes of CSRM, any recommended plan of improvement at a minimum must demonstrate average annual benefits that exceed average annual costs; i.e., the benefit-to-cost ratio (BCR) must exceed 1.0. There are other factors, including engineering, economic, environmental, and social considerations, that can influence the ultimate plan selection and recommendation, including RED, OSE, and EQ.

The principal damage mechanism in the study area is inundation of developed low-lying areas caused by Atlantic Ocean storm surge that enters the back bays through East Rockaway, Jones, and Fire Island Inlets. Additional contributors to back bay flooding may include the action of wind over the back bays, causing water to "pile up" in the direction toward which the wind is blowing, and the overwash or breaching of the barrier islands on the Atlantic Ocean. Historic sea level change has exacerbated the flood probability over the past century, and potential accelerated sea level change in the future will only increase the magnitude and frequency of the problem.

Conceptually, the simplest approach to reduce flood risk in the back bays would be to prevent storm surge in the Atlantic Ocean from entering the back bays. This can be accomplished with structures at each inlet that can be closed when needed to reduce back bay flooding, but remain open to tidal exchange in non-storm conditions. Such structures are referred to as "storm surge barriers", and examples of this type of structure exist at a number of locations around the world, including several in the US. Although storm surge barriers can be effective in reducing back bay flooding during more intense, less frequent coastal storm events, it is necessary that storm surge barriers remain open most of the time in the interests of navigation and back bay environmental and water quality. Consequently, storm surge barriers cannot be operated in a manner that significantly reduces impacts from more frequent but less intense storm events, nor can storm surge barriers reduce the impacts of RSLC.

If storm surge is not prevented from entering the back bays in the first place, it is then necessary to reduce the risk of coastal storm inundation locally within the back bay region. There are two principal means by which to accomplish this. The first is termed the "perimeter" structural approach, by which low elevation areas at risk of inundation are isolated from water in the back bay by means of structures such as a floodwalls, bulkheads, or levees with sufficiently high crest elevations to avoid being overtopped. This approach creates a perimeter barrier within the back bays that prevents elevated water levels from encroaching on low elevation developed areas.

The second general approach is termed "nonstructural." Nonstructural measures reduce risk by removing vulnerable people and property from the flood threat, rather than by altering the nature of the hazard (back bay flooding) itself. Nonstructural measures include raising structures in place, flood proofing, flood warning, relocations of properties, etc. Except for flood warning systems, nonstructural measures are generally applied on privately-owned property and require that the non-Federal sponsor take an active role in implementation. Both structural and nonstructural measures and approaches to reducing back bay flood risk are discussed in greater detail in the following sections of this report.

While NNBF is not considered an approach on its own, it should be noted that NNBF measures will be considered in all approaches

3.3. Public and Agency Coordination

Coordination with the public, resource agencies, elected officials, and the study sponsors is an integral and critical component of the study. Public coordination is critical to the first two steps of the six-step planning process, and continues throughout the study. Early input from the public provides an opportunity for the PDT to hear first-hand the problems experienced by those who live and work in the study area. Continued engagement throughout the study insures that the PDT receives ongoing public input, and provides the public with information on the study progress and findings. This in turn allows further public feedback to the PDT. To date the PDT has hosted the following public coordination meetings:

- 3 February 2017. Agency and public kickoff meeting with NYSDEC, Nassau County, and local government leaders, Mineola, NY
- 2 and 3 May 2017. NEPA scoping meetings with the public, Seaford and Freeport, NY
- 14 June 2017. Coordination meeting with Governor's Office of Storm Recovery (GOSR), Farmingdale, NY
- 18 and 19 September 2017. Public meetings in Long Beach and Hewlett, NY
- Webinar for elected officials on 18 April 2019
- Additional public coordination meetings will be held in May and June 2019

In addition to the open public meetings there have also been several project briefings held with elected representatives at the state, county, and municipal level. The principal findings from stakeholder coordination include:

- There is great interest in studying the feasibility of storm surge barriers at East Rockaway, Jones Inlet, and Fire Island Inlets
- There is a flooding risk to people, businesses, critical infrastructure, and important resources
- The study needs to consider and complement work done by other agencies and groups
- The potential environmental impacts and benefits of alternatives should be investigated and documented

- There is a concern that operation and maintenance (O&M) of a large or expensive project will be a fiscal burden on municipalities
- All must recognize the limits of flood risk management that a project could provide
- This status report is also a form of coordination with the public, and will be followed by additional public meetings in May 2019.

3.4. Future Without Project Conditions

Projecting the "future without project" (FWOP) condition is a critical step in evaluating and comparing plans that contribute to the study objectives. The FWOP condition is analogous to the "no action" plan, and presents a vision of the future for the study area in the absence of any intervention as a result of the study. The FWOP includes no additional measures beyond those that exist under existing conditions, plus any CSRM actions that are currently under construction to manage coastal storm risk. The FWOP is a baseline against which any potential plan of improvement is compared, in order to identify and quantify economic and environmental impacts of the alternative plan. The FWOP (i.e., "no action") plan is also the baseline used in NEPA analysis of any proposed project.

3.5. Plan Formulation

Plan formulation is the third step ("develop alternatives to solve the problems") in the six-step planning process. The structural and nonstructural measures being considered in the study are presented first, followed by a discussion of how these measures have been combined into a group of initial plans for further analysis.

3.6. Measures Being Considered

Measures are structure types or actions that have the potential to meet the study objective to reduce flood risk. The four principal measure types identified for the study include:

1. Storm surge barriers at inlets and cross-bay barriers
2. Perimeter barriers within the back bays (levees, floodwalls, etc.)
3. Nonstructural measures, such as building retrofits, structure raising, and relocation
4. Natural and Nature Based Features (NNBFs), such as vegetation and reefs

3.6.1. Structural Measures

Structural CSRM measures are engineering solutions to manage flood risk and reduce damage from coastal storms. Typical structural solutions include levees, floodwalls, beaches, and dunes, which are intended to physically prevent flood water inundation from causing damage. The types of structural measures being considered in the NCBB study include the following:

3.6.1.1. Inlet Storm Surge Barriers

Storm surge barriers reduce risk from storm surge for back bay communities and environments. Storm surge barriers typically consist of a series of movable gates that stay open under normal conditions to allow navigation and tidal flow, but can be closed during storm events. Storm surge barriers range in scale from small, local gates that reduce risk at relatively small coastal inlets to very large barrier "systems" that reduce risk to a large estuary or bay and may include a series of coastal dikes and gates. One recent example of a storm surge barrier in the U.S. is the Seabrook Floodgate complex in New Orleans, LA, which includes a navigable sector gate and two vertical lift gates (**Figure 2**).

Figure 2: Seabrook Floodgate complex in New Orleans, LA.

3.6.1.2. Cross-bay Storm Surge Barriers

Cross-bay storm surge barriers are constructed across the interior of the bay, rather than across an inlet. These barriers may be appropriate at locations where feasible and acceptable. They could be constructed adjacent to existing roads, bridges, and causeways with gates across navigable channels and additional auxiliary flow gates to allow tidal flow to pass under normal conditions. As with inlet storm surge barriers, interior bay closures remain open to tidal flow during non-storm conditions, but can be closed during storm events.

3.6.1.3. Raised Roads and Rails

Existing road and rail networks can be raised to function as levees and reduce risk to storm surge flooding. Raised roads and rails can also enhance local evacuation plans and public safety by providing safer evacuation routes out of the area.

3.6.1.4. Levees

Levees are earthen embankments with an impervious core constructed along a waterfront to reduce risk to flooding. Levees may be constructed in urban areas or coastal areas. If a levee is located in an erosive shoreline environment, armoring may be needed.

3.6.1.5. Floodwalls (Permanent)

Floodwalls are vertical structures constructed with steel or concrete that are used to reduce risk of flooding. Floodwalls are most commonly used in urban and industrial areas where smaller structure footprints are desired and there is limited space for large flood protection measures. Two of the most common types of floodwalls are cantilevered I-walls and pile-supported T-walls, and both of these and other floodwall types will be considered in the study.

3.6.1.6. Floodwalls (Deployable)

Deployable floodwalls are vertical structures that can be rapidly deployed during a storm event to reduce the risk of flooding. Deployable floodwalls are particularly useful for flood risk management in smaller areas, and are usually considered for high value facilities with access to the waterfront.

3.6.1.7. Crown Walls

Crown walls are relatively small reinforced concrete walls constructed on top of a new or existing vertical structure (bulkhead, seawall, curb, or gravity wall) to reduce the risk of flooding. Crown walls are relatively small structures, 1 to 3 feet high, which are drilled and grouted to connect to an existing concrete surface.

3.6.1.8. Beach Restoration

Beach restoration, commonly referred to as beach nourishment or beachfill, typically includes the placement of sand to either replace eroded sand or increase the width and/or height of an existing beach. Beach restoration is most applicable to areas with an existing beach, and can be considered both a structural measure as well as a natural and nature-based feature (NNBF); see Section 3.6.3 below. Additional erosion control measures such as groins or breakwaters may be included in a beach restoration project to reduce erosion and increase the longevity of the project and reduce future renourishment requirements.

3.6.1.9. Bulkheads

Bulkheads are vertical structures with the primary purpose of retaining land that adjoins a water body. Bulkheads are normally constructed in the form of a vertical wall of concrete, steel or timber. The concrete, steel or timber walls can be piled and anchored walls, whereas the concrete and stone walls can also be constructed as gravity walls. Their use is limited to those areas where wave action can be resisted by such materials. In areas of intense wave action, massive concrete seawalls are generally required. Bulkheads, unlike floodwalls and levees, are generally constructed at or near the existing grade and flood risk management is of secondary importance.

3.6.1.10. Seawalls

Seawalls are typically massive structures constructed along a shoreline where the primary purpose is interception of waves, prevention of upland erosion and reduction of wave-induced overtopping and flooding. If constructed with impermeable materials, seawalls may also reduce flood risk to low-lying coastal areas.

3.6.1.11. Revetments

Revetments are sloped structures with the principal function of protecting the shoreline from erosion. Revetments are typically constructed with stone, concrete, or asphalt to armor sloping natural shoreline profiles. Existing revetments may be retrofitted with an impermeable concrete wall at the top to increase the elevation of the structure by 1 to 3 feet and reduce flood risk.

3.6.1.12. Storm Water Drainage Improvements

Storm water system and drainage improvements carry water away from a developed area during times of heavy rainfall or high tidal water. Conveyance systems utilize measures such as pump stations, culverts, drains, and inlets to remove water from a site quickly and send it to larger water bodies. Improvements may also include retrofitting existing culverts and outfalls with tide valves to prevent back flow during storm surge events.

3.6.2. Nonstructural Measures

Section 73 of the Water Resources Development Act of 1974 requires consideration of nonstructural measures in all flood risk management studies. Nonstructural measures can be considered independently or in combination with structural measures, and reduce human exposure to a flood hazard without altering the nature or extent of the hazard.

Nonstructural management measures in general are intended to reduce the consequences that flooding would have on assets exposed to flood risk, as opposed to a structural measures that alter the characteristics or the probability of occurrence of the flood risk. Operation and maintenance costs of nonstructural measures are typically low, and are usually sustainable over long-term planning horizons.

The following is a list of potential nonstructural measures being considered in the NCBB study.

- Building retrofit
- Acquisition/buyouts
- Floodproofing
- Relocating utilities and critical infrastructure
- Design/redesign and location of services and utilities
- Retreat
- Increased storage
- Resilience standards
- Emergency response systems
- Stormwater management
- Building codes/zoning
- Hazard mitigation plans
- Coastal zone management
- Early warning systems

Building retrofit measures provide flood risk management to individual buildings and include:

- Elevation - raising the existing structure on fill or foundation elements such as solid perimeter walls, piers, posts, columns, or pilings.
- Dry flood proofing - strengthening of existing foundations, floors, and walls to withstand flood forces while making the structure watertight.
- Wet flood proofing - making utilities, structural components, and contents flood- and water resistant during periods of flooding within the structure.
- Ringwall - construction of a floodwall around an individual structure.

- Replace building - demolition of the structure and subsequent building of an equivalent structure within the same property boundary to the design elevation.

3.6.3. Natural and Nature-Based Features (NNBF)

Natural features are created and evolve over time through the actions of physical, biological, geologic, and chemical processes operating in nature. Natural coastal features take a variety of forms, including reefs, barrier islands, dunes, beaches, wetlands, and maritime forests. The relationships and interactions among the natural and built features comprising the coastal system are important variables determining coastal vulnerability, reliability, risk, and resilience. Conversely, “nature-based” features are those that mimic characteristics of natural features, but are created by human design, engineering, and construction to provide specific services such as coastal risk reduction. The built components of the system include nature-based and other structures that support a range of objectives, including erosion control and storm risk management (e.g., seawalls, levees), as well as infrastructure providing economic and social functions (e.g., navigation channels, ports, harbors, residential housing). An integrated approach to coastal resilience and risk management will employ the full array of measures, in combination, to support coastal systems and communities. NNBFs potentially appropriate for the NCBB study area include the following features.

3.6.3.1. Living Shorelines

Open and exposed shorelines are prone to erosion due to waves. Living shorelines are essentially tidal wetlands constructed along a shoreline to reduce coastal erosion. Living shorelines maintain dynamic shoreline processes, and provide habitat for organisms such as fish, crabs, and turtles. An common component of a living shoreline is constructing a rock structure (breakwater/sill) offshore and parallel to the shoreline to serve as protection from wave energy that would impact the wetland area and cause erosion and damage or removal of the tidal plants. Alternatively, such protective structures have also been built with coir logs or “oyster castles”.

3.6.3.2. Reefs

The development of artificial reefs in bays provides a means to reestablish and enhance reef communities. Artificial reefs provide shoreline erosion protection through the attenuation of wave energy. Artificial reefs are established for various reasons, including: restore degraded or damaged natural reefs, provide three dimensional habitat structure above the bottom, and provide fishing and scuba diving opportunities. The study is also considering modifications that can be made to structural measures that can increase their habitat value including habitat benches to restore more natural slopes along shorelines, and textured concrete to support colonization of algae and invertebrates.

3.6.3.3. Wetland Restoration

Wetlands may contribute to coastal flood risk management, wave attenuation and sediment stabilization/accretion. The dense vegetation and shallow waters within wetlands can slow the advance of storm surge somewhat and slightly reduce the surge landward of the wetland. Wetlands can also dissipate wave energy. The magnitude of these effects depends on the specific characteristics of the wetlands, including the type of vegetation, its rigidity and structure, as well as the extent of the wetlands and their position relative to the storm track. Functionally restored wetlands act in the same manner as natural wetlands, though design features may be included to enhance risk management or account for adaptive capacity considering future conditions (e.g., by allowing for migration due to changing sea levels).

3.6.3.4. Submerged Aquatic Vegetation (SAV) Restoration

Submerged aquatic vegetation (SAV) consists of grasses that grow to the surface of shallow water, but do not emerge from the water surface. SAV performs many important functions, including wave attenuation, buffering shorelines by stabilizing sediments with plant roots, water quality improvement, primary production, food web support for secondary consumers, and provision of critical nursery and refuge habitat for fisheries species.

3.7. Alternative Plans

3.7.1. Plan Formulation Rationale

The PDT utilized information compiled to date in the study to develop a plan formulation strategy that combines measures and evaluates plans. It is guided by the following overarching values identified during NEPA scoping meetings and through outreach to local community leaders. The values are as follows:

- Maximize reduction of flood damage to homes and business
- Contribute to the resilience of critical infrastructure
- Contribute to community resilience
- Contribute to ecosystem resilience
- Be acceptable to community stakeholders

The PDT will:

- Use existing data and tools as applicable. This includes the NACCS Tier 2 evaluation, Coastal Hazards System, and state and local datasets
- Integrate public outreach efforts with other Federal and state agencies
- Coordinate with and improve synergy with Federal and state resilience projects

3.7.2. Screening of Management Measures

After completion of a detailed survey of shoreline features, measures are selected and combined within each study reach based on their performance relative to the following screening criteria:

- Does the measure meet the planning objectives?
- Does the measure avoid planning constraints?
- Does the measure contribute to the P&G criteria of completeness, effectiveness, efficiency, and acceptability?
- Does the measure contribute to the P&G accounts of NED, Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE)?

Note that planning reaches are defined based on USGS watershed delineations and the results of hydrodynamic modeling. Measures will be screened for each reach using these criteria. Measures not included in the section below were screened out based on their inability to meet the planning problems/opportunities/objectives

3.7.3. Focused Array of Alternatives

Four alternatives in addition to the "no action" alternative have been identified as the focused array. They include:

- No Action Alternative
- Alternative 1A: Oceanfront Strategy
- Alternative 1B: Oceanfront/Back Bay Strategy
- Alternative 2: Back Bay Shoreline Strategy
- Alternative 3: Nonstructural Focused Strategy

3.7.4. Alternative 1A: Oceanfront Strategy

Alternative 1A (**Figure 3**) includes storm surge barriers at East Rockaway Inlet, Jones Inlet, and Fire Island Inlet that would prevent storm surge in the Atlantic Ocean from entering the back bays. An oceanfront alignment of structural improvements or NNBFs (e.g., beach nourishment, dunes, wetlands, and living shorelines) on Long Beach Island, Jones Island, and/or Fire Island could reduce the impacts of overwash of the barrier islands that contributes to flooding in the back bays. The locations of potential nonstructural measures and NNBFs will be determined during a detailed analysis into the performance of measures within each planning reach. The alternative may include modifications to the following authorized USACE projects:

- Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet (Long Beach) CSRM project (under construction in April 2019)
- Fire Island Inlet and Shores Westerly to Jones Inlet, NY (Gilgo Beach) navigation/CSRM project
- East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Hurricane Sandy Reformulation
- East Rockaway Inlet, New York Federal Navigation Channel
- Jones Inlet, New York Federal Navigation Channel
- Fire Island, New York Federal Navigation Channel

Plan Features:

- Barriers across three inlets
- Oceanfront alignment improvements
- Nonstructural measures
- Natural and nature-based features

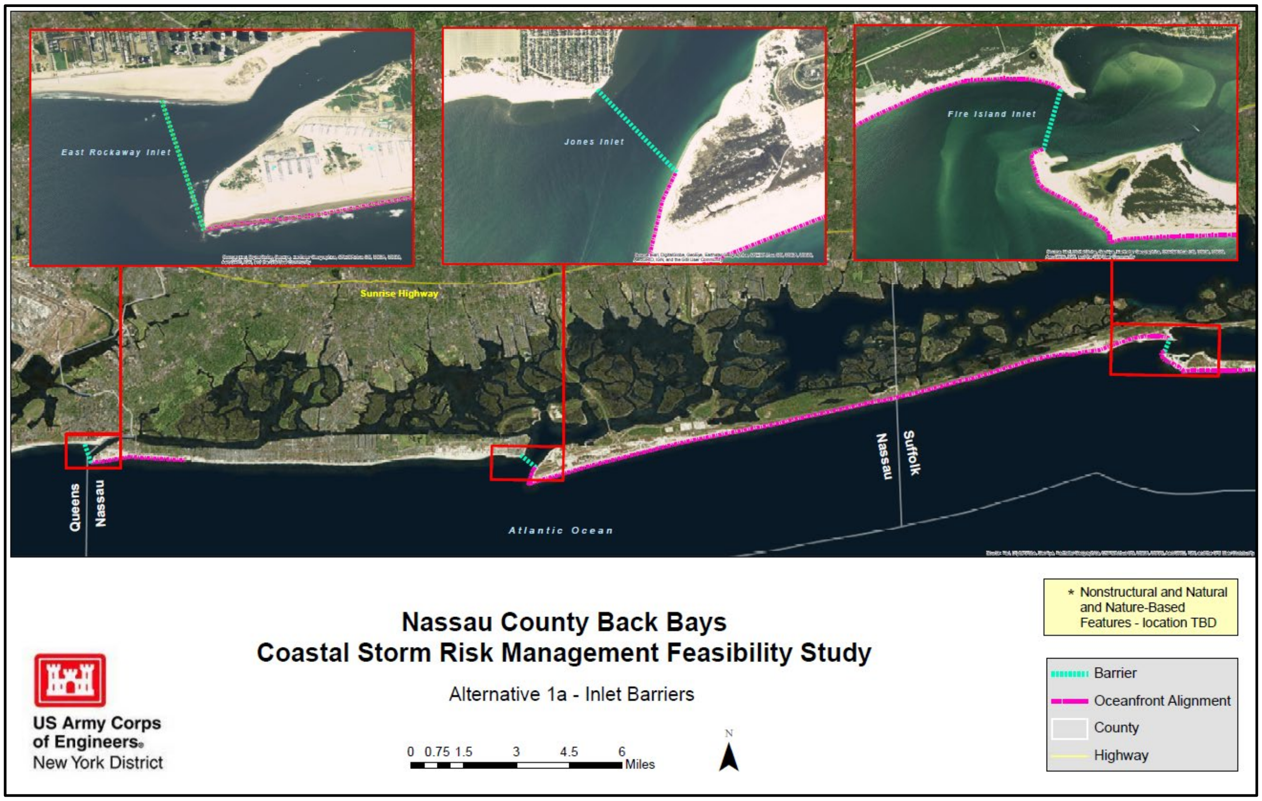

Figure 3: Alternative 1A, Oceanfront Strategy

3.7.5. Alternative 1B: Oceanfront/Back Bay Strategy

Alternative 1B (**Figure 4**) includes storm surge barriers at East Rockaway and Jones Inlets and a cross-bay barrier along the Jones Beach Causeway. Note that the location of the cross-bay barrier at the Jones Beach causeway is tentative at this time; the location was selected to inform the investigation of other cross-bay barrier locations. The cross-bay barrier connecting Jones Island to the mainland would prevent water within the Great South Bay from inundating the western shore of the back bay area. An oceanfront alignment of structural measures or NNBFs on Long Beach Island and/or Jones Island would prevent overwash flooding. The locations of potential nonstructural measures and NNBFs will be determined during a detailed analysis into the performance of measures within each planning reach. The alternative may include modifications to the following maintained USACE projects:

- Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet (Long Beach, NY) CSRM project (under construction)
- Fire Island Inlet and Shores Westerly to Jones Inlet, NY (Gilgo Beach) navigation/CSRM project
- East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Hurricane Sandy Reformulation
- East Rockaway Inlet, New York Federal Navigation Channel
- Jones Inlet, New York Federal Navigation Channel
- Fire Island, New York Federal Navigation Channel
- Great South Bay, New York Federal Navigation Channel
- Long Island Intracoastal Waterway, New York Federal Navigation Channel

Although Alternative 1B is similar to Alternative 1A, it is important to differentiate the two because the alternatives will affect hydraulic and environment conditions in significantly different ways due to the proposed barrier near Jones Beach Causeway.

Plan Features:

- Barriers across East Rockaway and Jones Inlets
- Cross-bay barrier along the Jones Beach Causeway
- Associated pumps, operator stations, etc.
- Oceanfront alignment improvements
- Nonstructural measures
- Natural and nature-based features

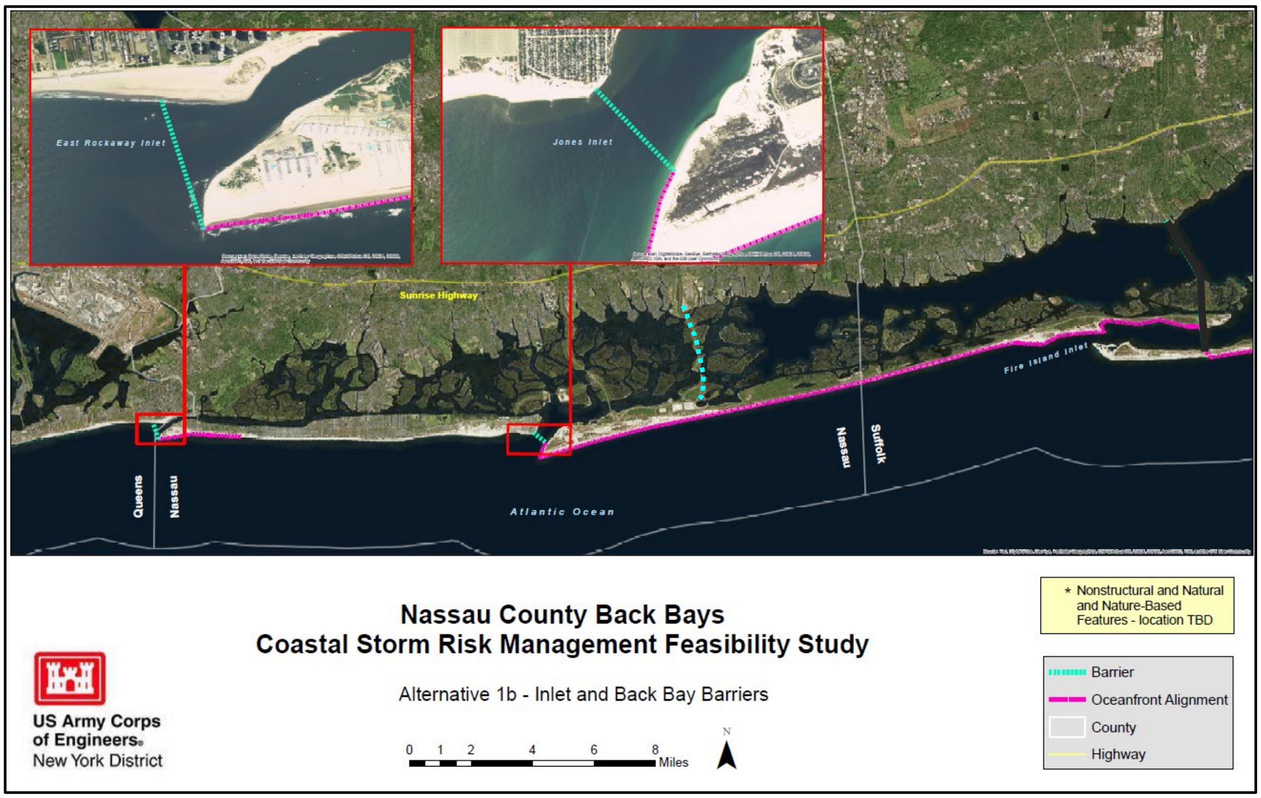

Figure 4: Alternative 1B: Oceanfront/Back Bay Strategy

3.7.6. Alternative 2: Back Bay Shoreline Strategy

Alternative 2 (**Figure 5**) does not include any storm surge barriers, but instead reduces flood risk to developed upland areas with an interior perimeter approach that may include a combination of structural and nonstructural measures and NNBFs.

Plan Features:

- Length of shoreline (northern side of back bays) = 191 miles
- Length of shoreline (on north side of barrier islands) = 16 miles

- Structural measures will likely include those typically found in the area (bulkheads, flood walls, raised recreational areas, etc.)
- Nonstructural measures
- Natural and nature-based features

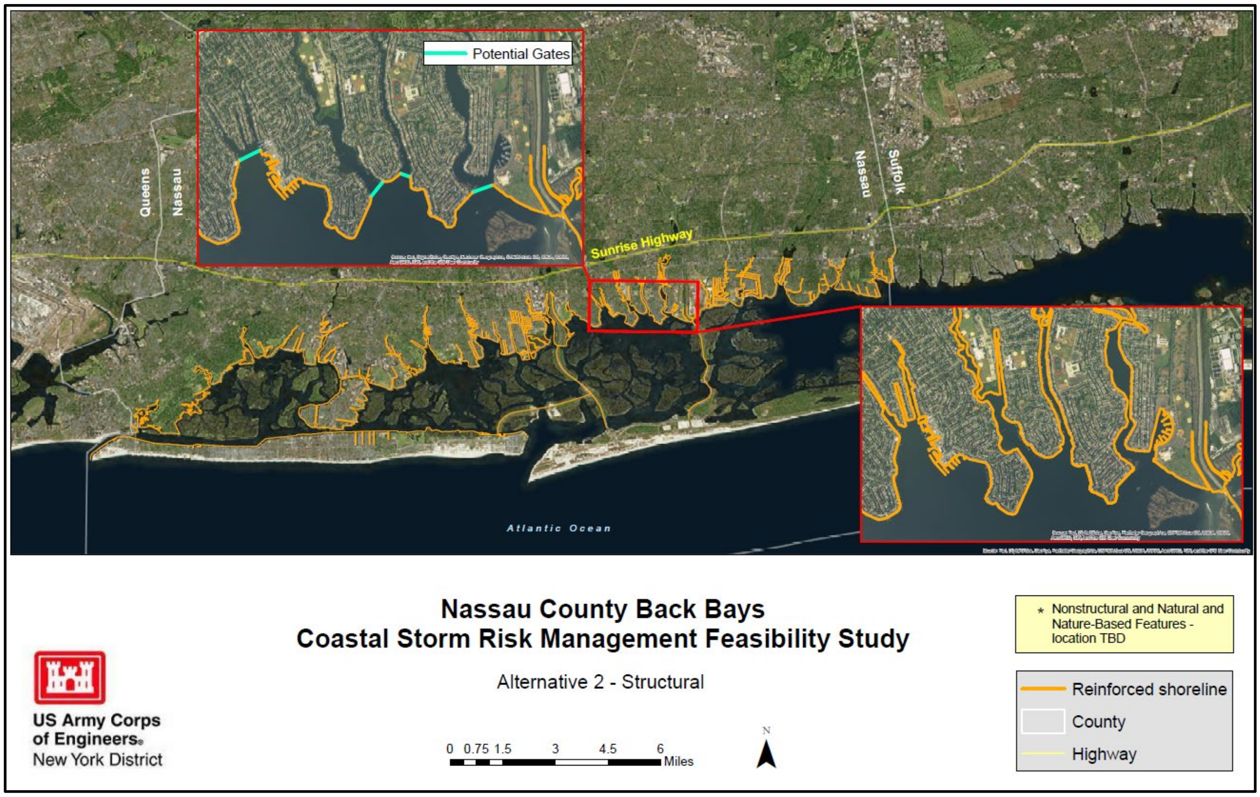

Figure 5: Alternative 2, Back Bay Shoreline Strategy

3.7.7. Alternative 3: Nonstructural Focused Strategy

Alternative 3 (**Figure 6**) focuses on reducing economic damages to structures within the floodplain primarily with nonstructural measures. However, structural measures and NNBFs will be considered for inclusion in the plan; the locations of these measures will be determined during a detailed analysis into the performance of measures within each planning reach. All nonstructural measures presented above will be considered.

Plan Features:

- Nonstructural measures
- Hydrologic modeling and real estate data will be used to determine the number of structures in different floodplains.
- Natural and nature-based features
- Localized, small-scale structural measures

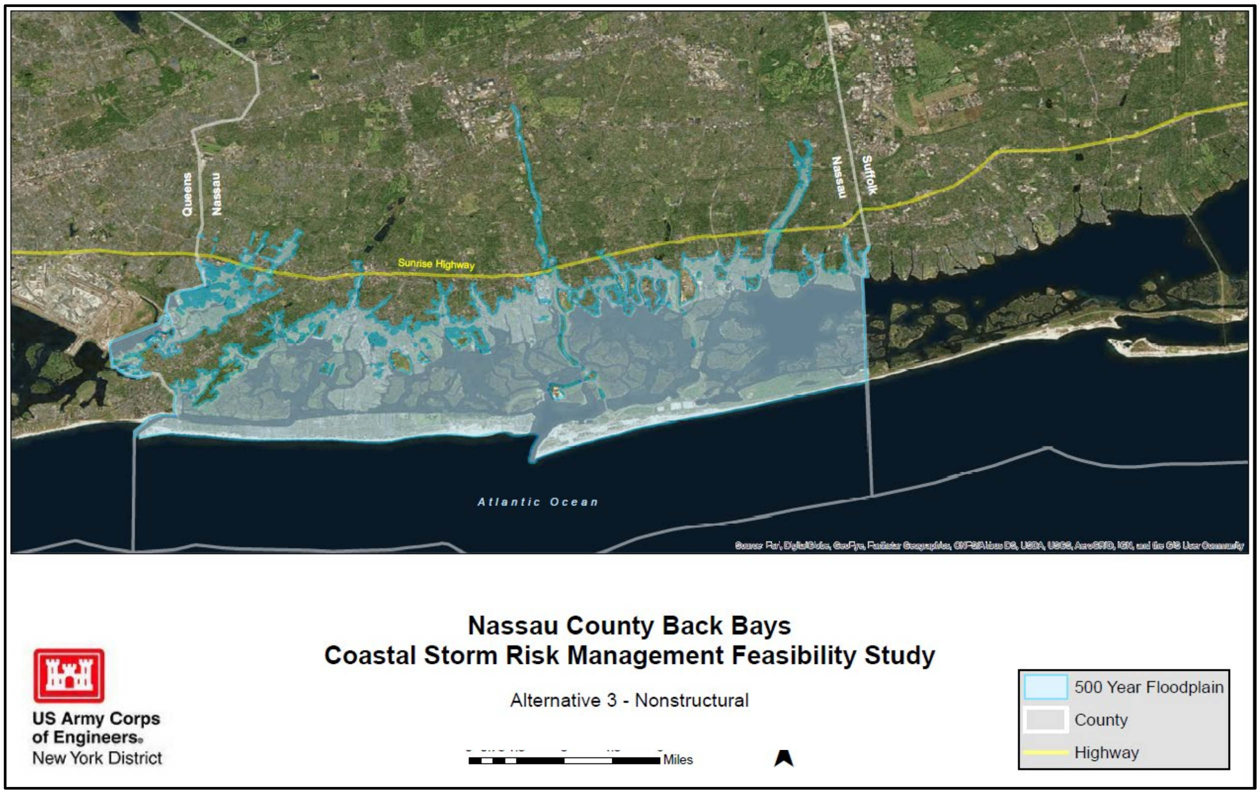

Figure 6: Alternative 3, Nonstructural Focused Strategy

3.8. Economic Analysis

3.8.1. Introduction

The study area spans three counties and six municipalities including Queens County in New York City; Oyster Bay, Long Beach, and Hempstead in Nassau County; and Babylon and Islip in Suffolk County. In total, the study area spans approximately 170 square miles of densely populated communities encompassing residential, commercial, industrial, public, and multi-use properties as well as a significant number of vehicles, roads, railroad lines, utilities, critical infrastructure, and other damageable assets. **Figure 7** shows the full extent of the study area.

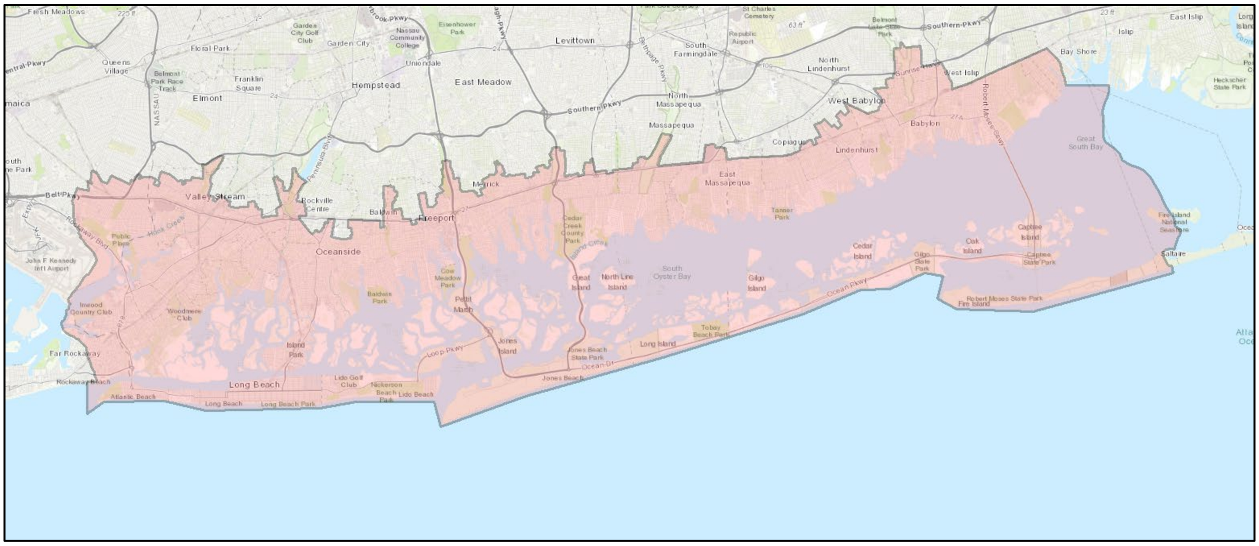

Figure 7: Nassau County Back Bay (NCBB) Inventory Study Area

3.8.2. Structure Inventory

A structure inventory is an accounting of all residential, commercial, and industrial facilities. It is completed to define what is at risk to coastal storm flooding. The information provided in this section is preliminary and will change as more information is made available. It was used to identify major damage mechanisms and geographic areas.

Though the total study area extends across three counties, detailed structure inventory assessments are currently only available for Nassau County. Further investigation on the structure inventory in Queens County and Suffolk County is ongoing and will be used when calculating total storm-induced damage estimates. **Table 1** below shows the total study area within each county.

Table 1: Inventory Study Area by County

County	Municipalities	Area (Sq. Miles)	Percent Total
Queens County	Queens (Borough of NYC)	6.4	3.8%
Nassau County	Oyster Bay, Long Beach, Hempstead	96.8	57.6%
Suffolk County	Babylon, Islip	65.0	38.6%
Total	**-**	**168.2**	**100.0%**

As **Table 1** illustrates, only a small portion of Queens County is included in the inventory study area with over 96% of the total area in Nassau and Suffolk counties. As mentioned earlier, detailed structure inventory data is only currently available for Nassau County with assessment efforts ongoing for Queens County and Suffolk County. The inventory for Nassau County includes identification and valuation of structures, contents, and vehicles, but does not yet include critical infrastructure, utilities, waste water treatment plants, communication centers, power generating plants, and transportation network evaluation. Work to better quantify damages to infrastructure is ongoing.

Within the Nassau County portion of the study area, there are 102,526 structures with an average total depreciated replacement value (DRV) of $539,582. DRV includes both structure and content value. The inventory is split among residential, commercial, industrial, public, and multi-use properties. There were 92,483 vehicles identified as potentially damageable with an average DRV of $21,574. **Figure 8** shows the point file (markers) database for the Nassau County structures and **Table 2** displays the inventory valuation data for Nassau County.

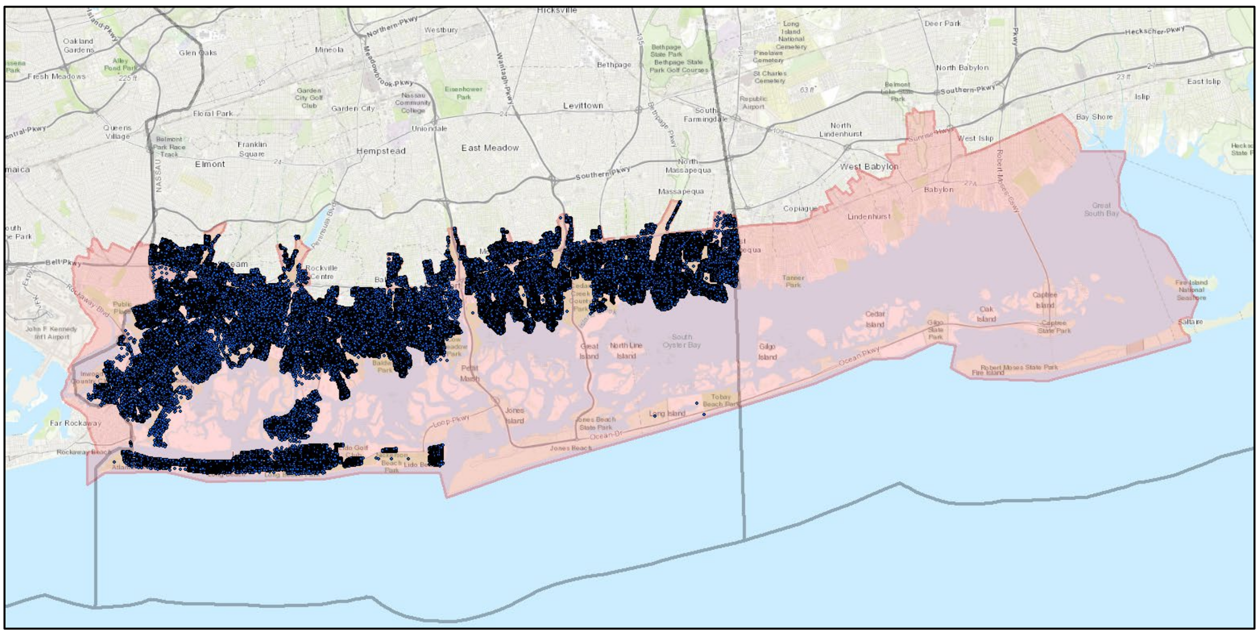

Figure 8: Nassau County Inventory Markers

As **Figure 8** shows, Nassau County has a significant density of structures along the northern shoreline of the back bay and on the back bay side of Long Beach Island, between East Rockaway and Jones Inlets. Structure DRVs are based on data from the 2016/2017 Final Assessment Rolls for Nassau County and updated to an FY2018 price level using the RS Means Square Foot Costs catalog in compliance with EM 1110-2-1619 *Risk-Based Analysis for Flood Damage Reduction Studies*.

Content DRV is based on a generic Content-to-Structure Value Ratio (CSVR) and will be updated to a structure category specific ratio during future investigation. Vehicle DRVs are based on the stated average in Edmund's Used Car Report and updated to an FY2018 price level using the Manheim Used Vehicle Index.

Table 2: Nassau County Inventory Distribution

Category	Count	Percent Count	Total DRV	Percent DRV	Average DRV
Residential	90,529	88.3%	$35,459,152,834	64.1%	$391,688
Commercial	6,640	6.5%	$9,890,165,616	17.9%	$1,489,483
Industrial	2,477	2.4%	$4,560,455,619	8.2%	$1,841,121
Public	926	0.9%	$2,055,691,792	3.7%	$2,219,970
Multi-Use	1,954	1.9%	$3,355,734,968	6.1%	$1,717,367
Total	**102,526**	**100.0%**	**$55,321,200,830**	**100.0%**	**$539,582**
Vehicle	**92,483**	**-**	**$1,995,195,600**	**-**	**$21,574**

Residential structures in Nassau County comprise over 88% of the total inventory by volume, but only 64% of the total inventory by value. This is evidenced by the higher average DRVs for commercial, industrial, public, and multi-use structures. In total, Nassau County structures and contents account for over $55 billion in total value with a further $2 billion in value from assessed vehicles.

With further refinement of the Queens County and Suffolk County inventories, the total study area inventory is expected to approach 150,000 total structures with over $100 billion in total damageable assets. This includes direct physical damages to infrastructure, structures, contents, and vehicles as well as indirect damages from emergency costs, transportation delays, and non-transferable income losses. **Figure 9** provides a view of the total study inventory although the red markers (Queens County) and yellow markers (Suffolk County) are preliminary.

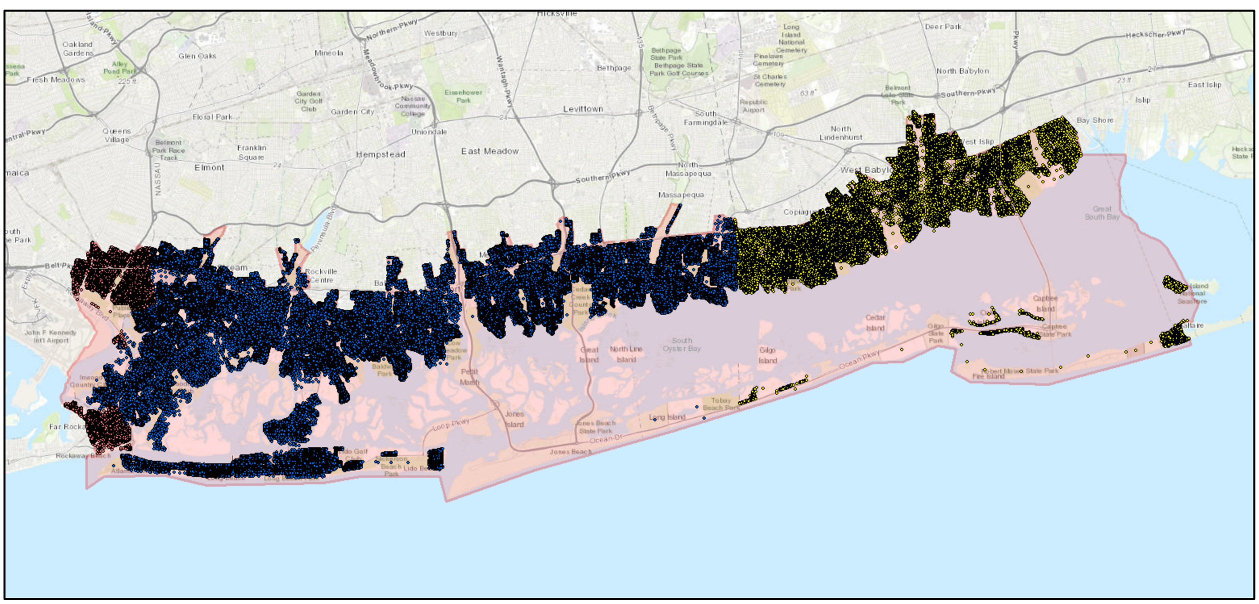

Figure 9: Total Inventory Study Area (Preliminary)

3.8.3. Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) Modeling

Future without-project condition (FWOP) and Future with-project condition (FWP) scenarios will be modeled using the Hydrologic Engineering Center – Flood Damage Reduction Analysis (HEC-FDA) software version 1.4.2. This model provides integrated hydrologic engineering and economic risk analysis during the formulation and evaluation of flood damage reduction plans in compliance with policy regulations ER 1105-2-100 *Planning Guidance Notebook* and ER 1105-2-101 *Risk Analysis for Flood Damage Reduction Studies*. Uncertainty in stage-damage probability and stage-frequency are quantified and incorporated into economic and engineering performance analyses of alternatives. The process applies Monte Carlo simulation, a numerical-analysis procedure that computes the expected value of damage while explicitly accounting for uncertainty in the basic parameters used to determine flood inundation damage.

Data on historic storms, water surface profiles, depth-percent damage functions, and structure inventory details within the study area will be used as input for the HEC-FDA software. In conjunction with hydrologic modeling, HEC-FDA will also incorporate Historic (Low), Intermediate, and High Relative Sea Level Change (RSLC) analysis in compliance with ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs* and EM 1110-2-1619 *Risk-Based Analysis for Flood Damage Reduction Studies.*

FWOP conditions are used as the base condition over the 50-year period of analysis and are compared against potential alternatives to determine potential with-project NED benefits. The model will use the FY2019 Project Evaluation and Formulation Rate (Discount Rate) of 2.875% and all inputs will be updated to the FY2019 price level.

HEC-FDA requires a significant amount of data to properly project damages over a 50 year period of analysis. These data are acquired or created from a variety of sources and are used to create the potential damage pool (structure inventory) and integrate that inventory with a range of potential storm events to calculate Average Annual Damages for each individual structure for each With- and Without-Project Condition scenario. In addition to the variables explained in the above structure inventory section, HEC-FDA also requires inputs for structure ground elevation, structure foundation height, depth-percent damage functions, and refined reach delineations.

3.9. Hydrodynamic Analyses

3.9.1. Vertical Datum

In accordance with ER 1110-2-8160, *Policies for Referencing Project Elevation Grades to Nationwide Vertical Datums*, elevation data in the NCBB Feasibility Study is referenced to NAVD88, the current orthometric vertical reference datum within the National Spatial Reference System (NSRS) in the continental United States (CONUS). The study area is subject to tidal influence and is directly referenced to National Water Level Observation Network (NWLON) tidal gauges and coastal hydrodynamic tidal models established and maintained by the NOAA. The current NWLON National Tidal Datum Epoch (NTDE) is 1983-2001.

More than one NWLON tidal gauge is required to reference tidal water levels to NAVD88 due to the size of the study area. The local NAVD88-MSL relationship at locations between gauges is estimated using NOAA VDatum models of the project region (EM 1110-2-6056). Hydrodynamic modeling completed for this study was performed in meters, MSL in the current NTDE. Water elevations are converted to ft., NAVD88 using NOAA VDatum.

3.9.2. RSLC

3.9.2.1. Sea Level Change Guidance

Global sea level change (SLC) is caused by the global change in the volume of water in the world’s oceans in response to three climatological processes: 1) ocean mass change associated with long-term forcing of the ice ages ultimately caused by small variations in the orbit of the earth around the sun; 2) density changes from total salinity; and most recently, 3) changes in the heat content of the world’s ocean, which recent literature suggests may be accelerating due to global warming. Global SLC can also be caused by oceanic basin changes through such processes as seafloor spreading. Thus, global sea level, also referred to as global mean sea level, is the average height of all the world’s oceans.

RSLC is the local change in sea level relative to the elevation of the land at a specific point on the coast. RSLC is a combination of both global and local SLC caused by changes in estuarine and shelf hydrodynamics, regional oceanographic circulation patterns (often caused by changes in regional atmospheric patterns), hydrologic cycles (river flow), and local and/or regional vertical land motion (subsidence or uplift). RSLC in the study area is higher than mean global SLC.

In accordance with ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*, potential effects of RSLC were analyzed over a 50-yr economic analysis period and a 100-yr planning horizon. ER 1100-2-8162 requires planning studies and engineering designs to consider three future sea level change scenarios (low, intermediate, and high) and consider how sensitive and adaptable the alternatives are to the range of RSLC scenarios. The historic rate of RSLC represents the “low” rate. The “intermediate” rate of RSLC is estimated using the modified National Research Council (NRC) Curve I. The “high” rate of RSLC is estimated using the modified NRC Curve III. The “high” rate exceeds the upper bounds of IPCC estimates from both 2001 and 2007 to accommodate the potential rapid loss of ice from Antarctica and Greenland, but it is within the range of values published in peer-reviewed articles since that time.

3.9.2.2. Historical and Projected RSLC

Historical RSLC for this study (a rise of 1.3 ft. per century) is based on NOAA tidal records at Sandy Hook, NJ. USACE low, intermediate, and high RLC scenarios over the 100-yr planning horizon at Sandy Hook, NJ are presented in **Table 3** and **Figure 10**. Water level elevations at year 2030 are expected to be between 0.49 and 1.02 ft. higher than the current NTDE. Water elevations at year 2080 are expected to be between 1.13 and 4.00 ft. higher than the current NTDE.

Hydrodynamic modeling performed for this study was completed in the current NTDE. Therefore, the modeled water levels represent MSL in 1992. Future water levels are determined by adding the RSLC values in **Table 3**. For example, a water level elevation of 10 ft. NAVD88 based on the current NTDE (1983-2001) will have an elevation in the year 2080 of 11.13, 11.82, and 14.00 ft. NAVD88 under the USACE low, intermediate, and high RSLC scenarios, respectively.

Table 3: Relative Sea Level Change Projections for Study Area

Year	USACE – Low (ft., MSL[1])	USACE – Int. (ft., MSL[1])	USACE – High (ft., MSL[1])
1992	0.00	0.00	0.00
2000	0.10	0.11	0.13
2019	0.35	0.41	0.62
2025	0.42	0.52	0.83
2050	0.74	1.04	1.99
2075	1.06	1.68	3.62
2100	1.38	2.42	5.71
2125	1.70	3.28	8.26

[1]Mean Sea Level based on National Tidal Datum Epoch (NTDE) of 1983-2001

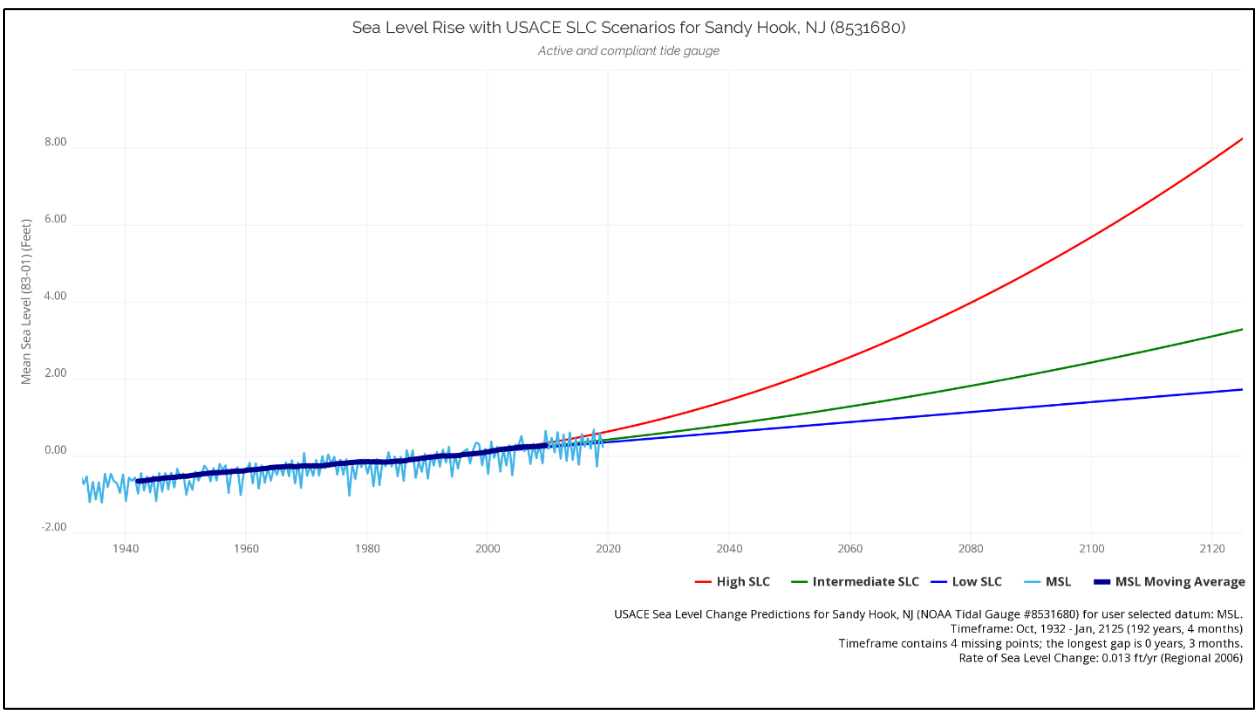

Figure 10: Relative Sea Level Change Projections for Study Area

3.9.3. High Frequency Flooding

High-frequency flooding, also known as nuisance flooding, recurrent flooding, or sunny-day flooding, are flood events caused by tides and/or minor storm surge that occur more than once per year. High-frequency flooding mostly affects low-lying and exposed assets or infrastructure, such as roads, public storm-, waste- and fresh-water systems (Sweet et. al 2018) and is more disruptive (a nuisance) than damaging. However, the cumulative effects of high-frequency flooding may be a serious problem to residents who live and work in these low-lying areas. The number of high-frequency flood days is accelerating in the study area in response to RSLC.

Flooding from rainfall and inadequate storm water systems are closely related to high-frequency flooding but are treated separated in this study. It is common for municipalities in the study area to have gravity based storm water systems that are unable to drain water when tidal level exceeds the elevation of the storm drain. When this happens, water starts ponding around the drain and may flood many of the same low-lying areas as high-frequency flooding. The frequency and impact of rainfall flooding will increase as the probability of the tide level exceeding storm drains increases in response to RSLC.

The primary focus of the study is managing risk from severe storm surge events (i.e. Hurricane Sandy), not flooding associated with inadequate storm sewer systems and/or high-frequency flooding. It is USACE policy per ER 1165-2-21 *Flood Damage Reduction Measures in Urban Areas* that storm water systems are a non-Federal responsibility. While flooding from high frequency flooding and inadequate storm water systems is not the focus of the NCBB study, it is acknowledged that nonstructural and storm surge barrier measures may not provide any relief from these problems. Therefore, complementary measures to address these problems will likely be investigated and may be recommended for implementation at the local/non-Federal level.

3.9.4. Storm Surge Modeling

3.9.4.1. NACCS

As part of the NACCS, the U.S. Army Engineer Research and Development Center (ERDC) completed a coastal storm wave and water level modeling effort for the U.S. North Atlantic Coast. This modeling study provides nearshore wind, wave, and water level estimates and the associated marginal and joint probabilities critical for effective CSRM. This modeling effort involved the application of a suite of high-fidelity numerical models within the Coastal Storm Modeling System (CSTORM-MS) to 1050 synthetic tropical storms and 100 historical extra-tropical storms. Documentation of the numerical modeling effort is provided in Cialone et al. 2015 and documentation of the statistical evaluation is proved in Nadal-Caraballo et al. 2015. Products of the study are available for viewing and download on the Coastal Hazards System (CHS) website: https://chs.erdc.dren.mil.

3.9.4.2. Modification for NCBB

The ERDC Coastal and Hydraulics Lab (ERDC-CHL) conducted a numerical modeling study to evaluate the effectiveness of storm surge barriers in reducing water levels in the study area. ERDC-CHL leveraged the existing NACCS CSTORM-MS to complete the numerical modeling study. As part of this numerical modeling study the existing condition water levels in the study area were updated from NACCS to ensure that the existing and with-project water levels were consistent and derived from a common model, set of storms, and statistical evaluation.

A total of 1,050 synthetic tropical cyclones were designed and simulated in the NACCS. However, not all of these storms affect the NCBB region. Using Gaussian Process Metamodeling (GPM) and a design of experiments (DoE) approach, CHL selected a subset of the NACCS synthetic tropical cyclones to maximize coverage of the storm parameter and probability spaces and produce storm surges across the NCBB region while reducing the hydrodynamic modeling requirements. A set of 25 tropical cyclones (**Figure 11**) was selected for modeling in order to complete the frequency distributions of response for both the with- and without-project conditions. Although the subset of storms does not include extratropical storms (nor'easters) the combined frequency distributions for both tropical and extratropical storms is generated by CHL using GPM.

The ERDC-CHL numerical modeling study reused the CSTORM-MS developed for NACCS. While the original mesh boundary was maintained, Chesapeake Bay in the NACCS grid were subject to a "de-refining" procedure, which locally reduces a mesh resolution in areas that are distant from the area of interest. The model bathymetry was updated to capture recently constructed dune elevations along Long Beach and updated based on a 2014 LIDAR survey to capture ground elevations at some of the small islands and causeways in the study area.

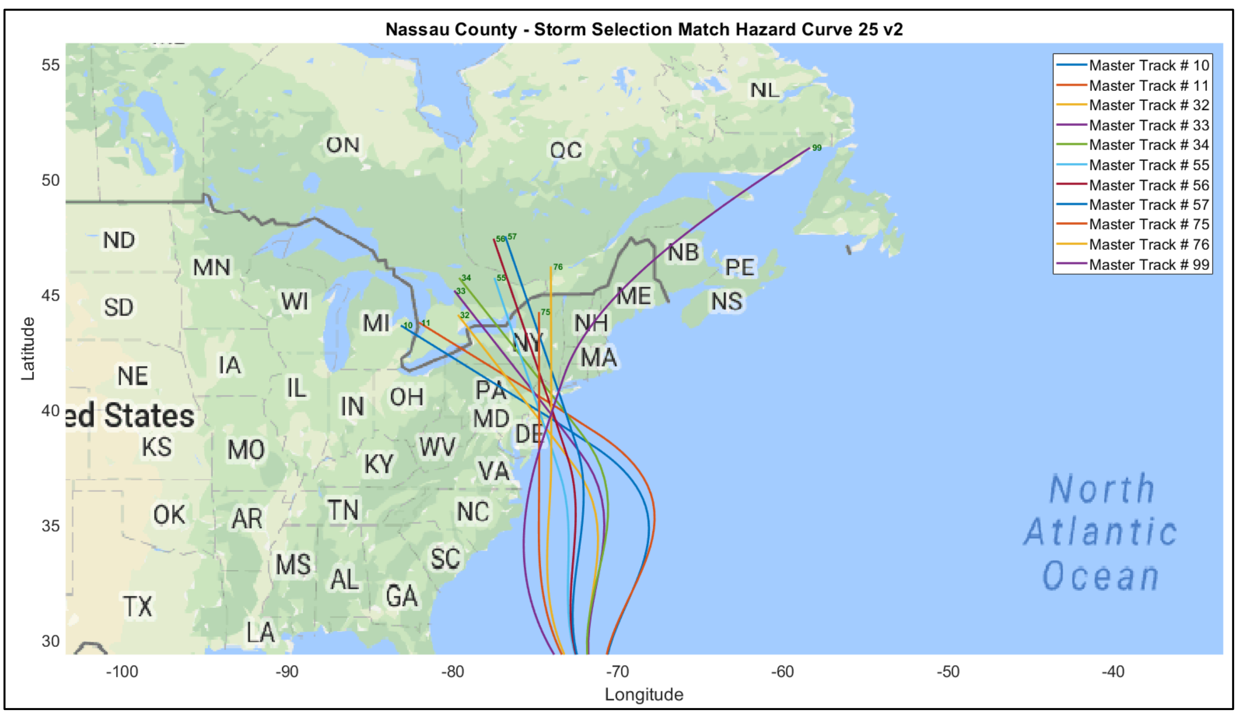

Figure 11: Subset of 25 Tropical Cyclones

3.9.5. Model Validation

The NACCS model validation procedure, documented in Cialone et al. (2015), included a harmonic analysis to ensure that the model is responding correctly to astronomical forcing at 143 NOAA gage locations, two of which are near the study area: Sandy Hook, NJ and The Battery, NY. In addition a comparison of model to measurements for seven storm conditions was conducted to ensure that the model is responding to meteorological forcing. The seven storms are Hurricanes Sandy, Irene, Isabel, Josephine, and Gloria and extratropical storms ET070 (North American Blizzard of 1996) and ET073. Cialone et al. (2015) concluded that "consistency in the model's ability to predict water levels for the seven validation storm events provided a level of confidence in what can be expected from the model", and "from the harmonic analysis conducted for the long-term simulation, it was determined that the model accurately predicts response to tidal forcing."

Since model validation conducted for the NACCS study focused on the available NOAA gage locations, which are located in the Atlantic Ocean, ERDC-CHL performed an additional analyses for USGS gages located in the study area. The additional model validation analyses compared observed water levels to modeled (ADCRIC) water levels for Hurricane Sandy at five USGS gages (**Figure 12**) that were active during the storm events. **Figure 13** compares the observed and modeled peak water levels at one of the USGS stations (USGS 01311145, East Rockaway Inlet Atlantic Beach, NY). Model validation results at the five stations showed similar trends, the modeled (red line) and observed (green line) peak water level during Hurricane Sandy are in excellent agreement. However, the observed water levels 6 hours before and 6 hours after the peak of the storm are under-predicted by the model.

Figure 12: USGS Tidal Gages used in Model validation

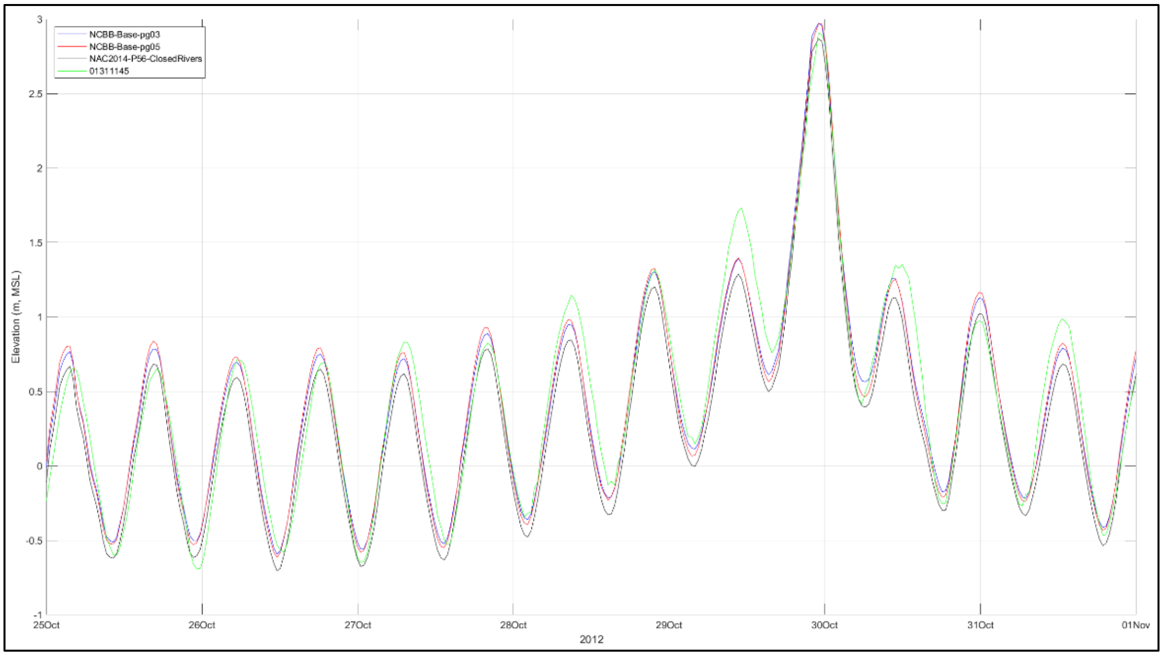

Figure 13: Model validation during Hurricane Sand at USGS 01311145 - Atlantic Beach, NY

3.9.6. With-Project Configurations

Three alternatives were modeled in addition to the existing/baseline condition.
The three alternatives are:

1. Alternative 1A
2. Alternative 1B
3. Alternative 2

Alternative 1A includes storm surge barriers at East Rockaway, Jones, and Fire Island inlets. Alternative 1B includes storm surge barriers at East Rockaway and Jones Inlet and a cross-bay storm surge barrier along the Jones Beach Causeway. Alternative 2 includes floodwalls and levee along the bay shoreline for much of the study area. An overview of the three alternatives and baseline conditions is provided in **Figure 14**. Alternative 3 has not yet been modeled because the location of CSRM measures has not yet been selscted.

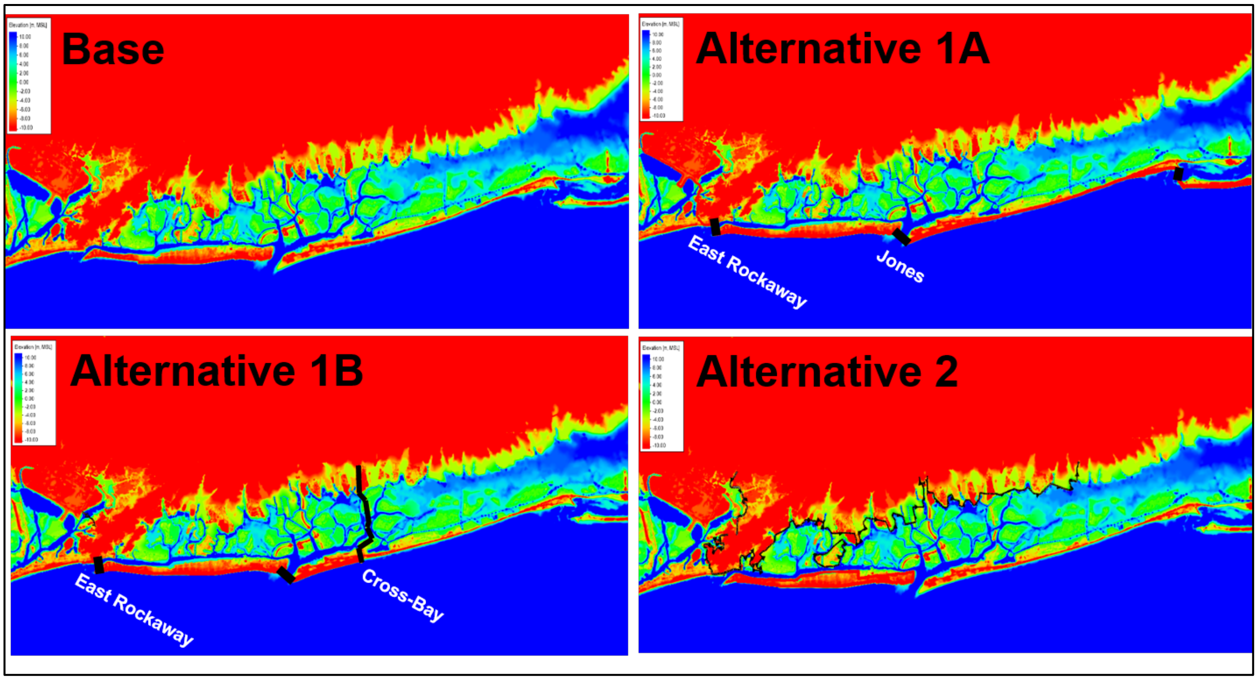

Figure 14: ADCIRC MESH Configurations for Baseline and Alternatives

The process of the mesh modification to implement a proposed storm surge barrier or floodwall/levee was the same for all structures, that is, the Base Grid was altered in the vicinity of the structure by adding "weir-pairs" to represent a structure. This local modification of the Base Grid minimized the mesh changes between the different alternatives. All weir-pair structures were set to +20 ft MSL. Implementing weir-pairs in ADCIRC improves the stability of the model since sub-grid scale formulation for weir-pairs prevents the model from transitioning from sub to supercritical flows during the course of the simulation in the event that the water elevation is high enough to overtop the structure. **Figure 15** show the same region of the ADCIRC mesh before and after implementation of the weir-pairs, respectively.

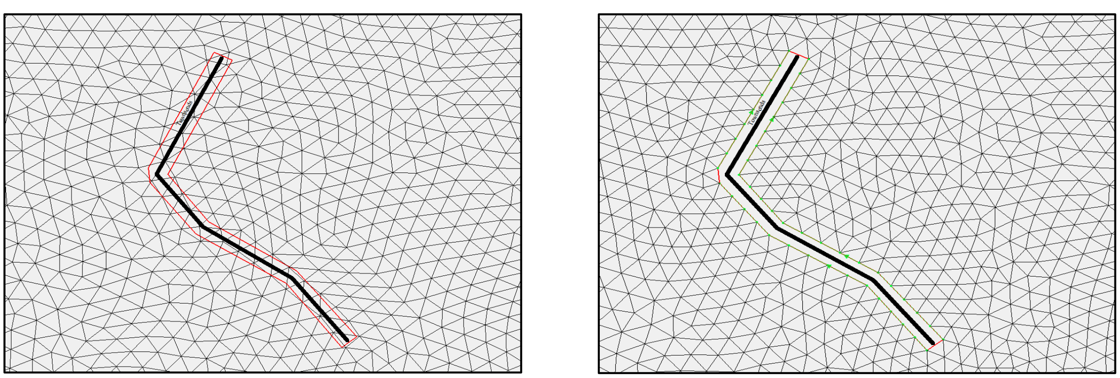

Figure 15: Left: Base Grid before implementing closure. Right: ADCIRC MESH implementing closure. The black line is the centerline of the closure structure

3.9.7. Preliminary Model Results

Although preliminary modeling has been completed, it is important to note that the work is being updated. The PDT recnognizes that changes to modeling results will provide more information about existing and future conditions, which may affect alternative development. The preliminary modeling results of the base conditions and three alternatives show that the performance (reduction in peak water elevations) of the alternatives is dependent on the storm track and storm characteristics. Model results for four different sample storm events are presented in this section highlighting the variability and sensitivity of the model results to the storm characteristics. The With-project still water level (SWL) hazard curves will capture the relative likelihood of each storm and its storm characteristics providing a more complete picture of the With-project performance. The With-project SWL hazard curves are still under development at the time of this report.

In general the model results show that there are three principal processes for storm surge entering the back bays:

- Storm surge propagation through the three tidal inlets
- Local wind-driven storm surge along the east-west bay axis
- Overwash across the barrier islands

It is difficult to assess the relative importance of each process from the base condition results; however combining the base condition results with the results from Alternative 1A and Alternative 1B provides insight into the three processes. Alternative 1A and Alternative 1B have storm surge barriers at the tidal inlets, stopping storm surge propagation through the tidal inlets, as well as elevated dunes along the barrier island ocean shoreline, stopping overwash. The primary difference between the two alternatives is the cross-bay storm surge barrier in Alternative 1B that stops local wind-driven storm surge along the bay-axis.

Preliminary model results for Alternative 1A indicate that local wind-driven storm surge along the bay axis is a significant process for storm surge entering the study area and for a storm surge barrier alternatives to be effective it must stop or slow this process. Model results presented here for Alternative 1A show that there is little reduction in the SWLs in the study area relative the base conditions for two of the four storms (**Figure 16** and **Figure 17**).

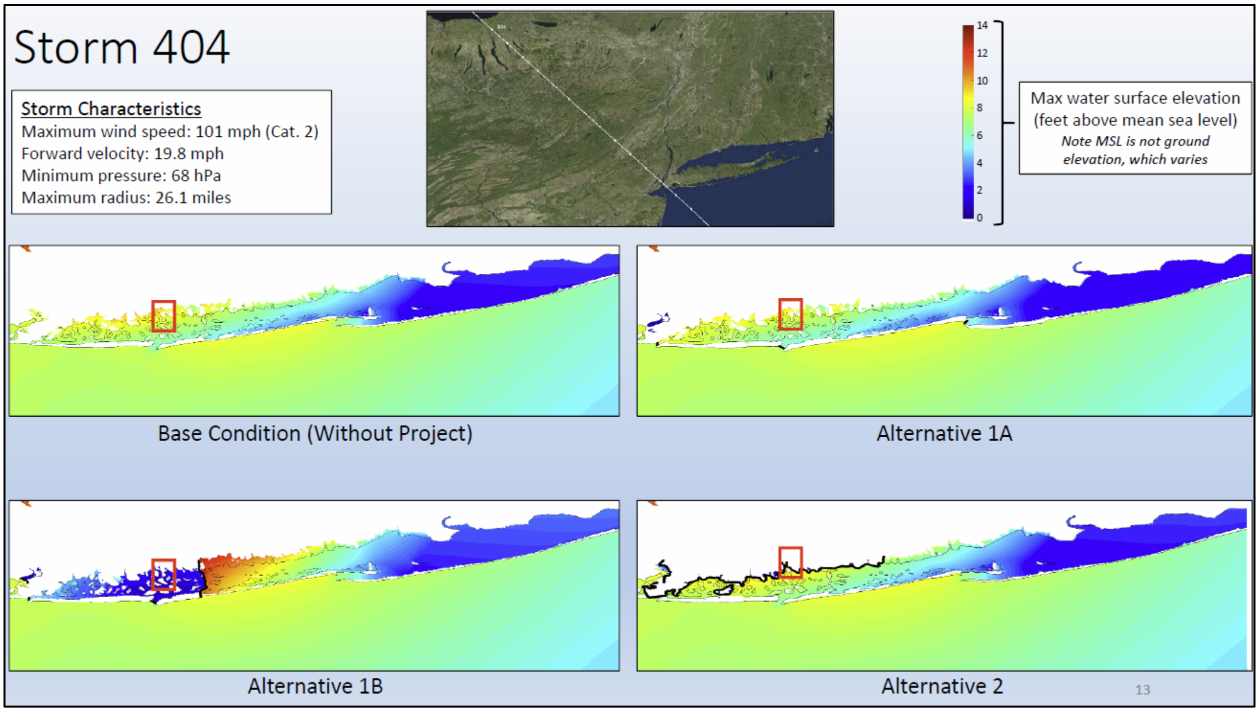

Figure 16: ADCIRC Model Results for Storm 404

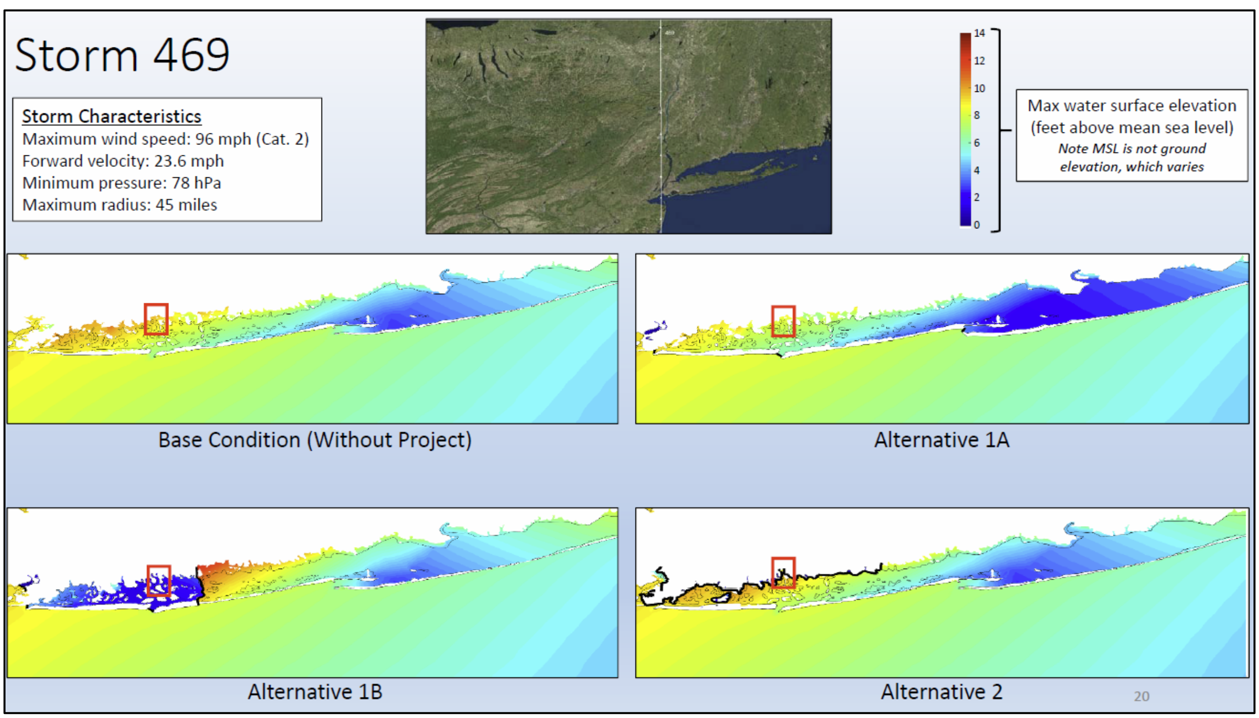

Figure 17: ADCIRC Model Results for Storm 469

However, preliminary model results for Alternative 1A show that the alternative is effective at reducing peak SWLs for the other two storms (**Figure 18** and **Figure 19**). The results for these four storm highlight the variability and sensitivity of the model results to the storm characteristics, especially the storm track and forward velocity. Storms that pass west and south of the study area are more likely to generate wind directions oriented along the bay-axis (east winds) that result in local wind-driven storm surge into the study area. It is also observed from the preliminary model results that slow moving storms (low forward velocity) are more likely to generate strong local wind-driven surges in the study area.

The preliminary findings for Alternative 1A may seem counterintuitive since it is more common to associate storm surge in the back bay from storm surge propagation through the inlet. However, the preliminary findings are consistent with Bennett et al. (2018) that also found that during Hurricane Sandy strong local wind-driven storm surge along the bay axis had the largest influence on the total water level fluctuations during the hurricane. Bennett et al. (2018) found similar results using a completely separate modeling suite (Delft3D-SWAN) providing confidence in the NACCS model results.

Preliminary model results for Alternative 1B reinforce the importance of local wind-driven storm surge. Model results for Alternative 1B show that the cross-bay storm surge barrier is effective at blocking this process and significantly reducing peak SWLs “behind the storm surge barriers.” However, the local wind-driven storm surge piles up against the cross-bay storm surge barrier resulting in substantial increases in peak SWLs in some storm events.

Preliminary model results for Alternative 2 show that an extensive system of floodwalls along bay shoreline has the potential to cause a small increase in peak SWLs in the bays. The With-project hazard curves will provide a more complete picture of the relative impact.

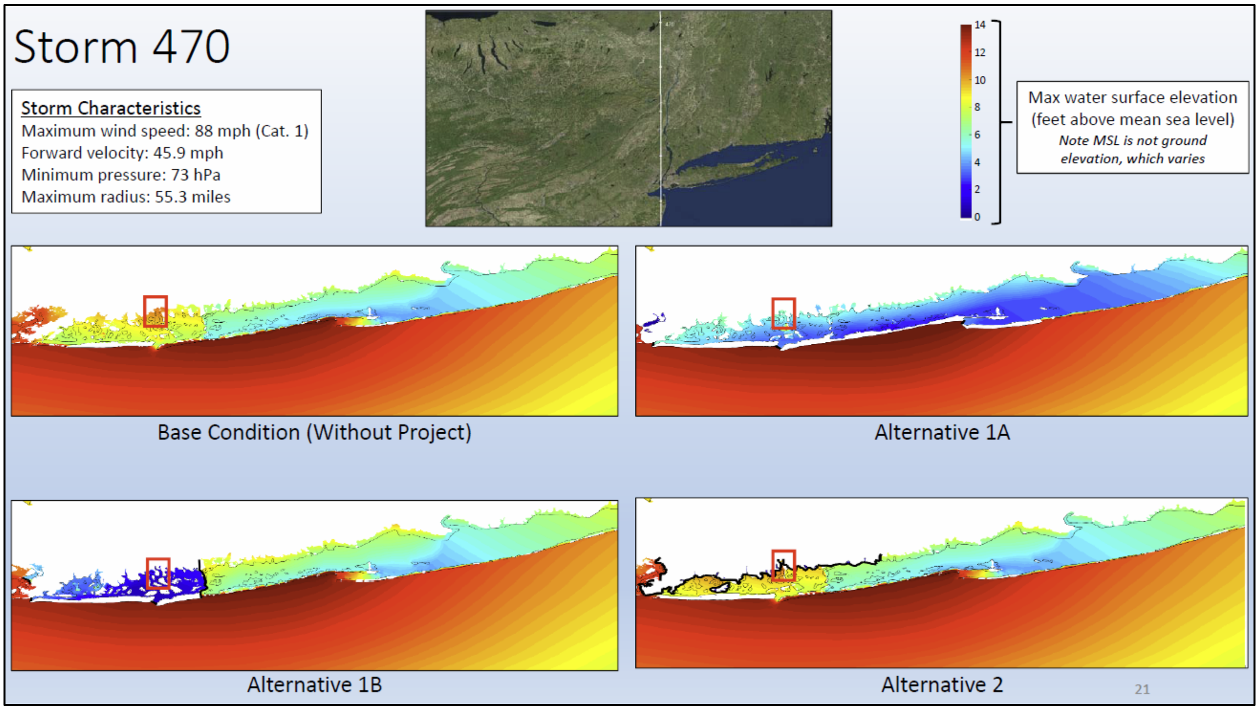

Figure 18: ADCIRC Model Results for Storm 470

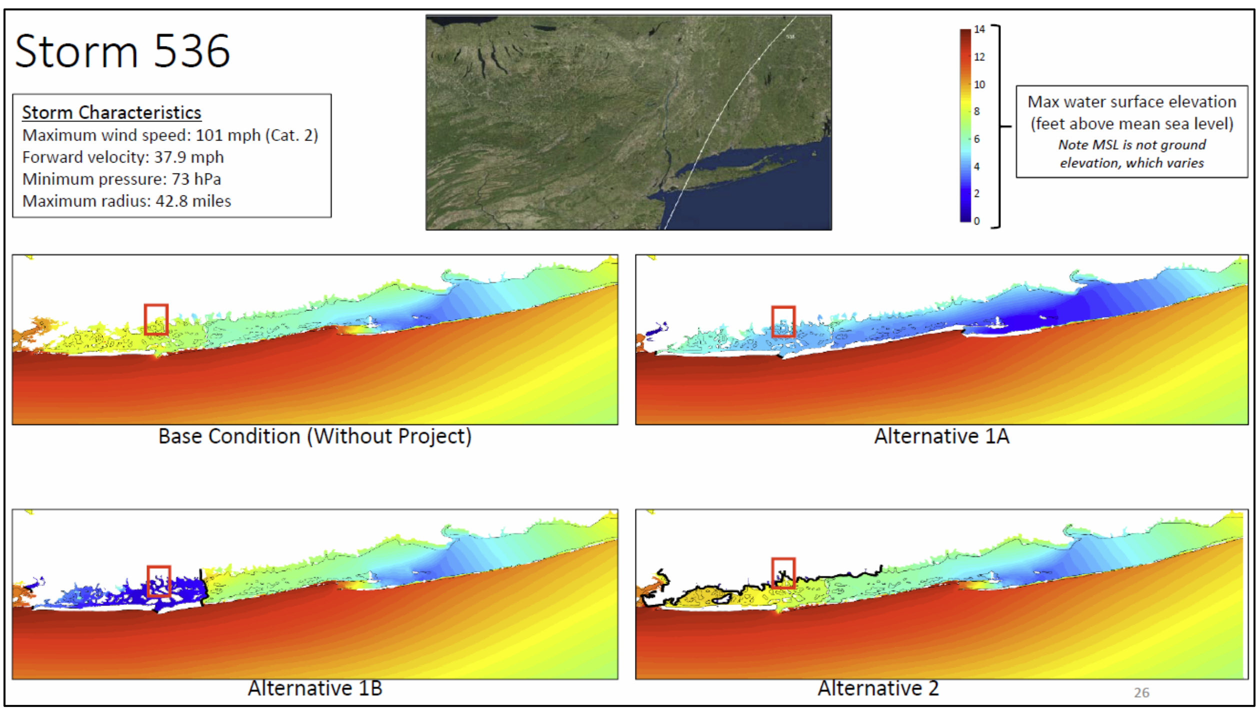

Figure 19: ADCIRC Model Result for Storm 536

3.10. Preliminary Conceptual Design Analyses

In addition to the hydrodynamic modeling discussed in the preceding paragraphs, conceptual design for the storm surge barriers and for the interior perimeter plan were prepared.

3.10.1. Conceptual Design of Storm Surge Barriers

Design criteria and initial conceptual design features were developed for the East Rockaway Inlet, Jones Inlet, and Fire Island Inlet storm surge barriers, and the cross-bay barrier at the Jones Beach Causeway. The conceptual designs focus on the minimum practical dimensions of the storm surge barrier openings and a preliminary selection of gate types for the openings. The openings consist of one navigable passage and multiple auxiliary flow openings per inlet.

The following functional requirements have been identified for the conceptual design of the storm surge barriers consistent with the overall objectives of the study. The storm surge barriers may provide a reliable structural function as part of Alternatives 1A and 1B to reduce the risk of coastal storm damage to the study area. The storm surge barriers will minimize impact to navigation and waterborne commerce. The storm surge barriers will minimize impact on the water exchange through the opening during normal operation (non-storm conditions) in order to minimize impacts on back bay environmental conditions. The storm surge barriers will minimize the impact on bay water levels during normal operation.

As a result of the above requirements, the storm surge barrier gate concept will at its simplest consist of two principle parts: moveable gates and a supporting static substructure and tie-in structure. For any system of gates there are three primary functional requirements:

1. The moveable gates of the storm surge barrier will be able to open and close with a high degree of reliability
2. The gates will be sized and provide a range of motion suitable for purpose (e.g. navigation, flow conveyance)
3. The moveable gates of the storm surge barrier will be an integral part of the overall structure and be designed such that they impede the coastal storm surge water levels and minimize the risk of coastal storm damage to the study area

The general design criteria identified above are not complete and many design criteria are yet to be specified. Such criteria may include but are not limited to the following:

- Constructability Criteria
- Geotechnical and Foundation Criteria
- Structural Loading Criteria (e.g. concrete design and steel gate design criteria)
- Mechanical Design Criteria
- Electrical Design Criteria
- Civil Design Criteria
- Dredging and Earthwork Design Criteria
- Infrastructure and Transportation Criteria
- Materials
- Aesthetics

- Risk (assessments would occur across a broad range of structures, environmental, and operations evaluations)
- Extreme event loadings (seismic, vessel collision, force protection)

Environmental criteria other than those identified in the preceding sections will be further evaluated during subsequent design phases. Such criteria, among others, include the following:

- Criteria related to the impacts on bed morphology and sediment transport
- Criteria related to water quality
- Criteria related to marine habitats, flora and fauna (e.g. fish passage) - ecology
- Criteria related to environmental impacts during construction and upon completion of the project)

Significant additional study will be required to substantiate the conceptual design of the storm surge barriers for East Rockaway Inlet, Jones Inlet and Fire Island Inlet. This work will evaluate the width, location, and configuration of the navigable passages and auxiliary flow gates, including a full evaluation of navigation, environmental, ecological, and cost considerations, among others. Technical topics that will be addressed if one or more of the storm surge barriers is ultimately considered as part of a TSP include wave and wind climate, geotechnical information, inlet bathymetry, and gate type selection.

3.10.2. Conceptual Design of Perimeter Risk Management Features

General design criteria and conceptual design for structural CSRM measures were also developed. The structural CSRM measures under consideration include levee, floodwall, seawall, operable floodgates, road raising, composite seawall with beach and dune, and small navigable gates that reduce the risk of flood damages for the areas behind them. In general, these are considered shoreline based measures (SBMs), which are located along or inward of a shoreline. Small navigable gates are distinguished from storm surge barriers by having a much smaller span and allowing for passage of small boats and water craft only. The completion of the conceptual designs will allow for an inventory of SBMs (total length and number of measures) per study alternative and for a quantity take-off per SBM. This data set will be used by USACE as input to complete initial cost estimates for the alternatives and allow for a relative comparison among the alternatives.

Publicly-available data and aerial images were used to categorize the existing shoreline typology (e.g. natural shoreline, urban waterfront development, etc.) associated with each alignment. Based on the existing shoreline typologies that prevail throughout the study area, a reasonable but limited number of prototypical SBMs and small navigable gates were developed. The goal is to develop conceptual SBMs and small navigable gates that are not site-specific but can be applicable as CRSM measures throughout the study area as part of any of the alternatives.

The conceptual structural designs are comprehensive enough to be applicable for the range of conditions found throughout the study area, yet not so detailed or site specific that they can only be applied at one location. Due to the large area covered by the study, generalized assumptions were made about existing conditions such as site topography, bathymetry, and soil parameters. No site specific topographic survey, bathymetric survey, site condition survey and/or geotechnical analyses have been completed. Instead, publicly-available qualitative data and results from desktop analyses were used to develop conceptual structural CSRM measure designs, which can be used as the basis of a quantity take-off. A quantity per linear foot for each CSRM measure was determined, and subsequently an inventory of CSRM measures for each alternative was calculated. This information will be used to perform additional analyses and as the basis for initial cost estimates of the alternatives.

3.10.2.1. Functional Requirements and Design Limitations

The following functional requirements have been identified for the conceptual design of the structural CSRM measures consistent with the overall objectives of the study:

- The measures shall provide a reliable structural approach to reduce the risk of coastal storm damage to the coastal area it is intended to protect
- The measures shall minimize adverse effect on existing infrastructure in the study area
- The measures shall minimize adverse effect on existing access and egress, such as access to existing private and public space
- The measures shall seek to minimize footprint and impact to the environment

The list of structural CSRM measures includes:

Floodwalls: Due to a relatively small footprint, a floodwall is deemed suitable for flood-prone urban waterfront areas, both directly at the shoreline and farther inland, where there are no existing structures and viewshed impacts are of lesser concern. It should be noted that flood-prone waterfront areas are likely to have poor soil conditions and require excavation and backfilling prior to construction.

Levees: Whereas floodwalls are made of materials such as reinforced concrete and steel, levees are made of compacted soil with grassy vegetation on top. Levees are commonly used along rivers, coastlines and bodies of water to prevent inland flooding in the case of rising water levels. Levees are typically constructed by placing engineering fill on a cleared and leveled surface; soil is compacted in layers into a large earthen structure that is wide at the base and tapers toward the top. The interior of the levee is a core composed of impervious material, usually a firm clay, to form a watertight barrier to prevent or minimize seepage, either through or beneath the section. Grass or some other type of non-woody vegetation is planted on the levee to add stability and protection from erosion. The vegetation on the levee also increases its aesthetic appeal. Relatively large tracts of real estate are typically required due to the levee width, required setbacks, and space needed for smooth grade changes. For this reason, levees are best used as flood risk management measures along natural shorelines, or parallel to the course of streams, and set away some distance from developed areas.

Bulkhead with King Pile: A bulkhead is typically comprised of a steel pile wall with or without a pile cap. The steel pile wall is a row of vertical interlocking steel piles driven to form an integrated straight wall. For this study, the bulkhead with king piles consists of steel king piles with intermediate sheet piles and a reinforced concrete pile cap. Self-compacting, cementitious flowable fill would be placed to fill in the gap between the new king pile wall and the existing bulkhead/shoreline. Soil behind the sheet piling was assumed to be backfilled up to existing ground elevation. Two different existing mudline elevations, -7 feet and -12 feet, were used to establish the design of the prototypical shallow and deep bulkhead, respectively. The relatively small footprint of a bulkhead renders it a preferred solution to residential shorefront with high density that is subjected to flooding. The conceptual design of the bulkhead with king piles is generic in nature and not site specific. The construction of this measure along a high-density residential shorefront typically requires removing, temporarily relocating, and replacing a large number of piles and the associated floating boat docks, stairs, ramps and various other structures that interfere with construction.

Road Raising: Road raising consists of raising the elevation of an existing road in order to use the road itself as a levee-like feature and reduce the risk of flooding on one side of the road. A road width of 32 feet with a top elevation at +16 feet is proposed as a two-lane traffic roadway. In order to raise the road surface, connecting infrastructure may need to be raised and ramped to meet the raised road. Also, the various construction activities required to complete a road raising project often necessitate relocating and/or raising buried utilities and adding drainage inlets and pipes. Due to the relatively large width and height of the road, large tracts of real estate are typically required. Also, to minimize the need to raise or modify connecting infrastructure, road raising is best used as flood risk management measures in rural or less densely populated areas.

Seawall: A rubble mound seawall is effective at dissipating wave energy but does not prevent coastal flooding from elevated storm surges because it is porous. However, a seawall that includes a pile supported reinforced concrete floodwall with a vertical sheet pile cut-off wall can be impervious to storm surge. The prototypical design for the seawall is composed of a rubble mound structure on the seaward side and a pile supported concrete floodwall on the landward side. One of the more important variables of the rubble mound design is the seaward side slope which, together with the crest height, is generally dictated by soil conditions and construction methods. For the purposes of this study, it was assumed that the rubble mound was founded on soils that are of moderate quality which is common in the study area.

Composite Seawall with Beach and Dune: A composite seawall in combination with beach and dune is included as an SBM to provide a reduction in flood risk. Two variations of this measure were developed, namely the composite seawall with beach and dune (urban application) and the composite seawall with beach and dune (NNBF application). The urban variation is proposed to be applied in more developed beach areas where spatial constraints are more apparent. The NNBF variation of this SBM has a structural core, is completely covered in sand and has a larger footprint.

Deployable Floodgate – Vehicular/Pedestrian/Railroad Gates: Deployable floodgates are measures that allow for unimpeded access across the alignment during normal day-to-day conditions. Deployable floodgates can be either manually or automatically operated. The prototypical deployable floodgate developed for this study is designed to be manually operated. Manually operated gates require operation personnel to physically go to the location of the gate and close it prior to storm conditions. The gate would then be locked into place to prevent tampering and access to the flood side of the gate would be impeded.

Both swing gates and roller gates are being considered, the choice of gate depending on the orientation and space available. In general, a roller gate can slide into place along a track whereas a swing gate is supported on one side by top and bottom hinges attached to a support structure. Both gates have the advantage of being simple, with quick operation and no special skill or equipment required. However, swing gates require a relatively large right-of-way area for operating while roller gates will require a level track surface.

The floodgates are assumed to be supported on piles. Pile design depends on design loads and soil parameters. Since flood-prone waterfront areas are likely to have poor soil conditions, excavation and backfilling prior to construction may be required. Gate widths of 30 feet and 60 feet were assumed. At this stage of the study no preferred floodgate type has been selected and only an inventory of total number of gates will be completed. Floodgate type evaluation and associated detailed design would be completed during the next phases of the study when site specific parameters are available.

Tide Gates (non-navigable): Tide gates are CSRM management measures that stay open under normal conditions to let tidal flow pass but are closed when water levels are expected to exceed a certain level. Tide gates do not allow for navigation or passage of vessels. A tide gate is typically a reinforced concrete superstructure supported on steel pipe piles, with a steel sheet pile cut-off wall as a seepage control measure. At present a gate width of 50 feet is assumed. The prototypical tide gate developed for this study is designed to be provided with an electric winch and to be manually operated remotely. Tide gates are assumed to be supported on piles. Pile design depends on design loads and soil parameters. Since flood-prone waterfront areas are likely to have poor soil conditions, excavation and backfilling prior to construction may be required. At this stage of the study no preferred tide gate type has been selected and only an inventory of total number of gates will be completed. Tide gate type evaluation and associated detailed design would be completed during the next phases of the study when site specific parameters are available.

Small Navigable Gates: Small navigabable gates are CSRM measures that that stay open under normal conditions to let boats and tidal flow pass but are closed when water levels are expected to exceed a certain level. They are similar in structure to non-navigable tide gates. Navigable gate type evaluation and associated detailed design would be completed during the next phases of the study when site specific parameters are available..

In general, when further refinements to the alignments of the study alternatives are made additional data and studies are recommended to be incorporated. Such studies and data include:

- Site topographic survey
- Existing structure condition survey
- Site-specific geotechnical data
- Bathymetric survey for alignments following existing bulkhead lines
- Wetland survey and mapping
- Comprehensive interior drainage modeling, including combined probability analysis of storm surge and rainfall events
- Site use and traffic studies
- Continuation and furthering stakeholder and public outreach such that input and comments from stakeholders including local, state agencies and the public can further inform alignment alternatives to be evaluated
- An analysis of easement delineation and real estate studies such that impacts beyond the footprint of the measures can be preliminarily made assessed
- Utility investigations and as-needed service diversions or relocations studies,
- Cost estimates and impact assessments for alignment alternatives

3.11. Environmental Resource Considerations

The environmental effort to date for the study has focused on documenting existing conditions in the study area. However, the documentation of existing conditions is not complete at this time. Work will continue to complete that effort in the near-term. Topics include but are not limited to land use, geology, soils, topography, water resources, water quality, wildlife, vegetation, infrastructure, hazardous, toxic, and radioactive waste, cultural and recreational resources, noise, and aesthetics. Once alternatives are formulated and screened, impacts to all these resources will be accessed. Based on initial evaluations completed for the study, primary areas of concern from implementation of coastal storm damage reduction measures with respect to environmental and socioeconomic resources are likely to be potential impacts to Coastal Barrier Resources System units; Essential Fish Habitat; wetlands and the estuarine ecosystem; rare, threatened, and endangered species; wildlife; recreational resources including parks; and aesthetics.

3.12. Summary of Existing Conditions Likely to be Impacted by the Proposed Project

3.12.1. Coastal Barrier Improvement Act (CBIA) of 1990/Coastal Barrier Resource System (CBRS)

The CBIA is a reauthorization of the Coastal Barrier Resources Act (CBRA) of 1982. This act is intended to protect fish and wildlife resources and habitat, prevent loss of human life, and preclude the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. The CBRA established the CBRS, which consists of mapping of those undeveloped coastal barriers and other areas located on the coasts of the U.S. that were made ineligible for most Federal expenditures and financial assistance. The CBIA of 1990 expanded the CBRS and created a new category of lands known as otherwise protected areas (OPAs). The only Federal funding prohibition within OPAs is Federal flood insurance. Other restrictions to Federal funding that apply to CBRS units do not apply to OPAs. Within the NCBB study area, there is one existing CBRS unit (NY-59) that extends from the western end of Long Beach to the western end of Fire Island. There are also small pockets of OPAs (NY-59P) within NY-59. The U.S. Fish and Wildlife Service prepared "Draft Revised" CBRA maps as part of the Hurricane Sandy Remapping Project, which include a number of proposed changes to existing CBRS units and OPAs within the study area; however, these changes require Congressional authorization. The proposed changes have undergone public review and are slated to be submitted to Congress in 2020 for adoption. Maps of the existing CBRA areas and "Draft Revised" areas are provided in **Figure 20** and **Figure 21**, respectively.

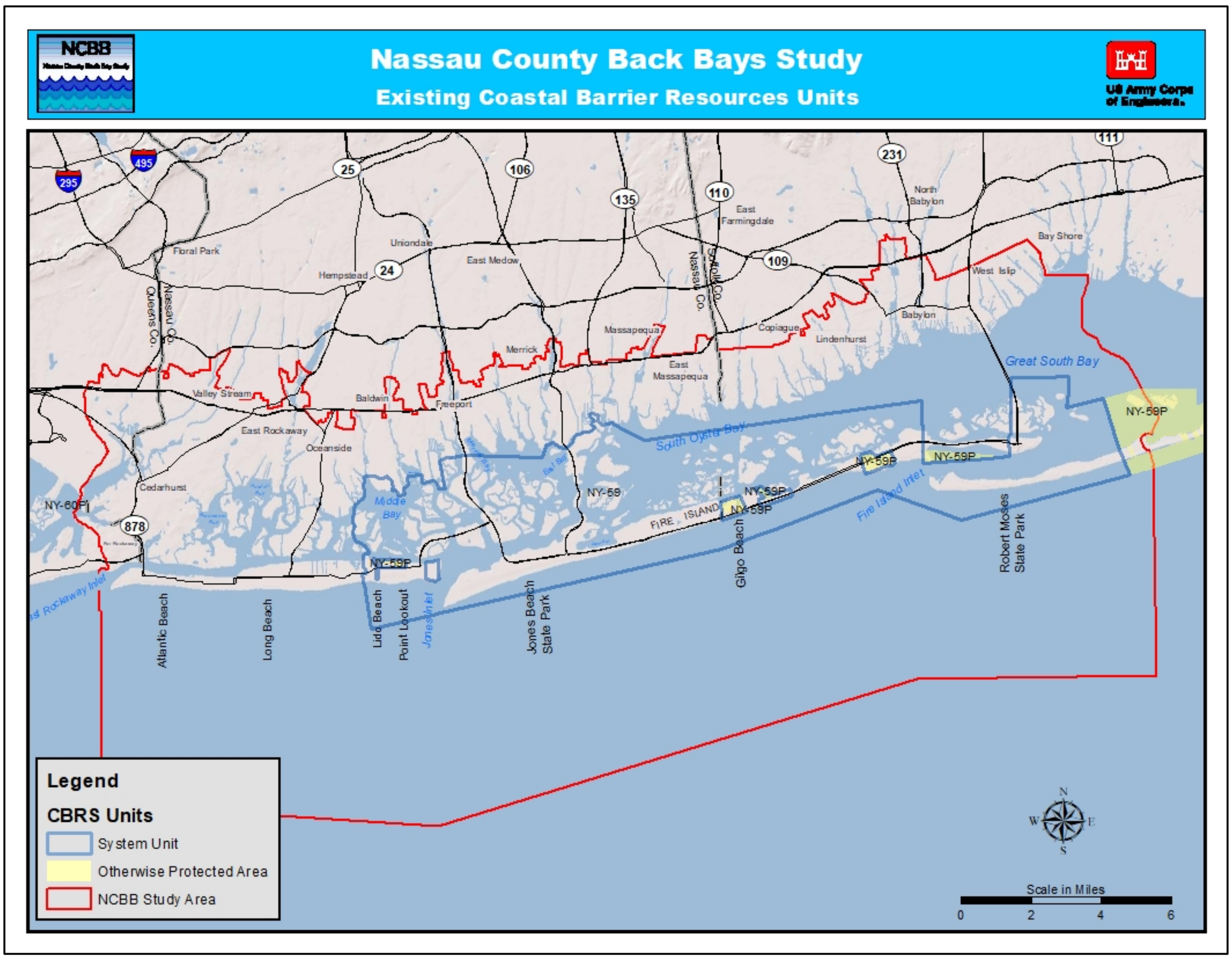

Figure 20: Existing CBRS Units and OPAs

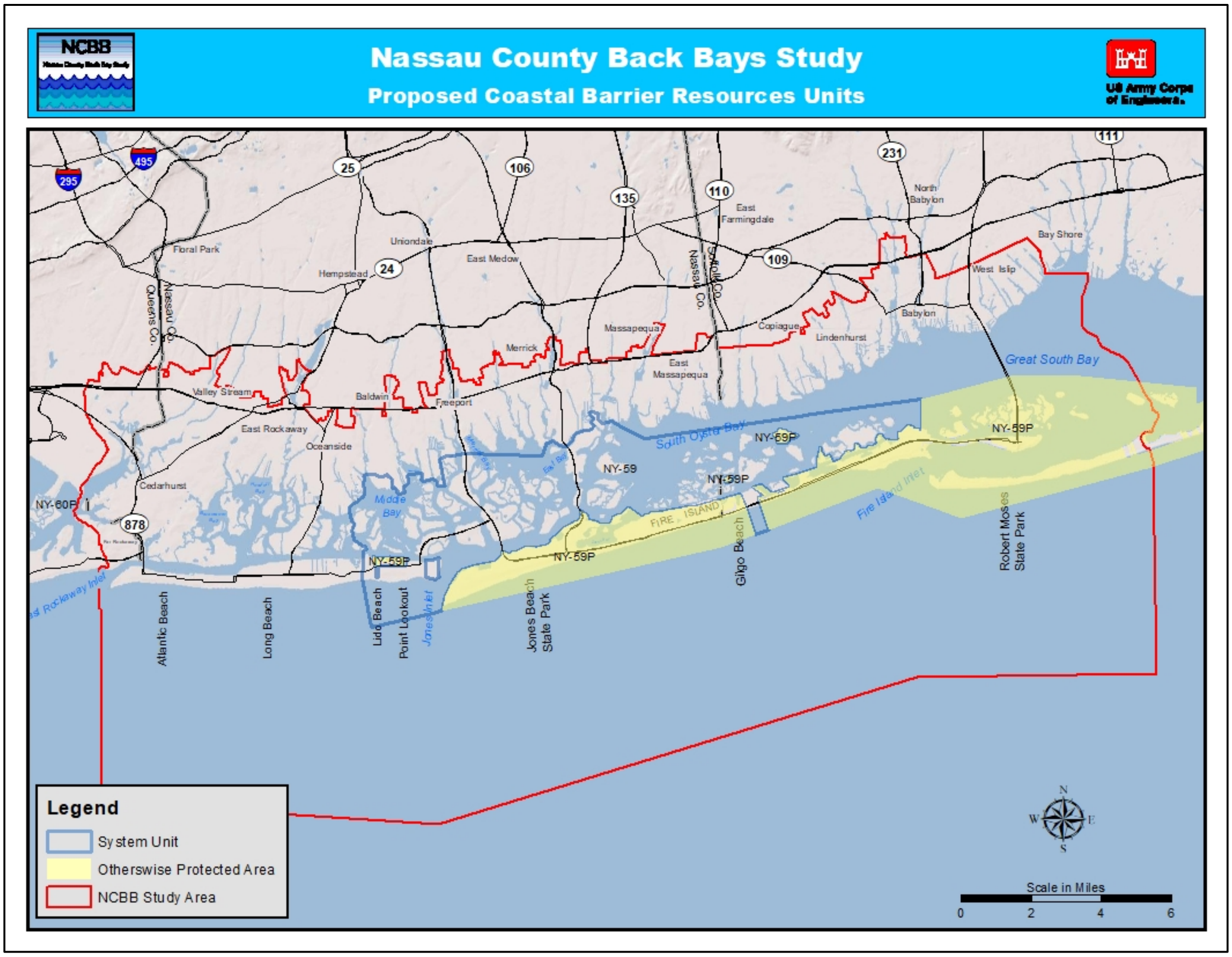

Figure 21: Proposed CBRS Units and OPAs

3.12.2. Estuarine Ecosystems

The back bays of southern Nassau County are characterized by an extensive network of marshlands that serve as a natural defense against coastal storm surge. The back bay environment behind the barrier islands supports biologically diverse estuarine ecosystems where freshwater and marine environments meet. These estuarine habitat complexes are characterized by intertidal wetlands and salt pannes, shallow bays, tidal flats, numerous tidal ditches, submerged aquatic vegetation, and salt ponds. The study area includes numerous embayments including Bannister Bay, Brosewere Bay, Hewlett Bay, Middle Bay, Baldwin Bay, Jones Bay, Zachs Bay, Merrick Bay, East Bay, South Oyster Bay, and the Great South Bay (as far east as approximately Saltaire), and connected creeks, channels, and minor water bodies. The boundary of the habitat complex follows the high tide line from Edgemere on the Rockaway Peninsula in the west along the north shore of the bays into Suffolk County, then south along the Gilgo Cut Boat Channel that separates South Oyster Bay from the Great South Bay, and across Jones Island; the southern boundary extends about 400 meters or 1/4 mile offshore of the barrier islands from this point west to East Rockaway Inlet.

The environmental and economic importance of the study area was recognized by the State of New York in 1993 when it established the Long Island South Shore Estuary Reserve (SSER) to protect and manage the resource as a single integrated estuary and maritime region of statewide importance. The SSER extends 75 miles east from the Nassau County/New York City line to the Village of Southampton in Suffolk County, and includes the entire study area. The SSER was established in recognition of the highly productive habitats that support the largest concentration of water-dependent businesses in New York; and the critical need to maintain water quality in the estuary in support of commercial and recreational fishing and shellfishing industries. A SSER Comprehensive Management Plan was prepared with recommended implementation actions for partners across a broad range of entities (State, Federal, and local governments; NGOs; the private sector; and academic institutions). The five outlined goals are to:

- improve and maintain water quality
- protect and restore living resources
- expand public use and enjoyment
- sustain and expand the estuary economy
- increase education, outreach, and stewardship

Wetlands are categorized as special aquatic sites by the U.S. Environmental Protection Agency (USEPA). In addition to wetlands, other special aquatic sites defined by the USEPA include areas such as vegetated shallows (e.g., SAV) and areas that may be unvegetated, including sand flats and mud flats. Within the study area, intertidal wetlands are the predominant wetland resource. **Figure 22** depicts the wetland resources in the area as mapped by the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory. There are 17,331 acres of wetlands within the study area by this inventory. Estuarine and marine wetlands (intertidal) are the dominant wetland type, comprising over 15,600 acres. **Table 4** provides the composition of wetland resources in the study area.

Table 4: Wetland Resources

NWI Wetland Type	Acres
Estuarine and Marine Wetland	15624
Freshwater Emergent Wetland	280
Freshwater Forested/Shrub Wetland	923
Freshwater Pond	340
Lake	163
Riverine	1
Total	**17331**

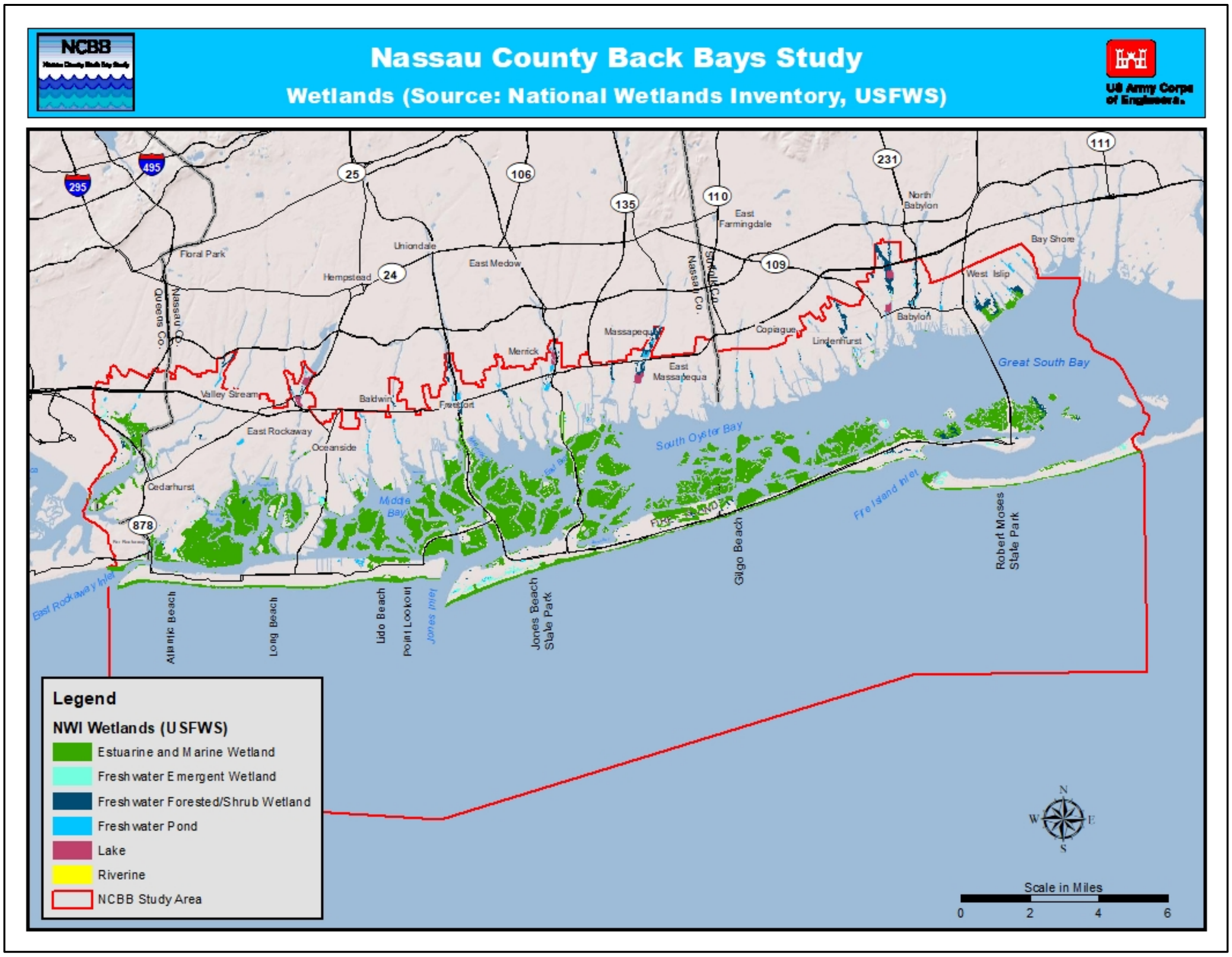

Figure 22: National Wetlands Inventory within the Study Area

Intertidal wetlands are vegetated areas tidally influenced and connected to open waters that are inundated or saturated by surface- or ground-water frequently enough to support vegetation that thrives in wet soil conditions. Intertidal wetlands in the back bay estuaries are some of the most important habitats for wintering waterfowl, migratory and resident shorebirds, waterbirds, wading birds, passerines, raptors, and songbirds; and provide nursery grounds and refuge for numerous fish and invertebrates. The substrate of most bays and sounds are exposed at low tide and the invertebrates present are heavily utilized by shorebirds, wading birds, gulls, terns, and waterfowl. Vegetation assemblages characteristic the estuarine intertidal subsystem include high and low salt marshes and salt pannes dominated by smooth cordgrass (*Spartina alterniflora*), common glasswort (*Salicornia europea*), salt hay grass (*Spartina patens*), spike grass (*Distichlis spicata*), and perennial salt marsh aster (*Aster tenuifolius*). The predominant vegetation in these wetlands is salt marsh cordgrass, an important species for the production of food chain organisms for fish, shellfish, birds, and other wildlife.

Additionally, wetlands within the terrestrial upland habitat are nontidal, freshwater wetlands that support forested, scrub-shrub, and emergent communities. These wetlands occur primarily in small, isolated depressions within the greater upland terrestrial community. Freshwater forested wetlands are not common in the study area but can be found in the upland interior of the barrier island ecosystem.

SAV and/or seagrass beds exist in localized areas of the back bay estuarine system. SAV are rooted vascular flowering plants that exist within the photic zone of shallow bays, ponds, and rivers. SAV are an essential food for a number of waterfowl species; provide habitat for finfish, shellfish and a number of other invertebrates; and improve water quality and clarity. Further, SAV beds help absorb wave energy, stabilize sediment to reduce erosion, and support shoreline resilience. Eelgrass (*Zostera marina*) is the dominant seagrass within the study area. Widgeongrass (*Ruppia maritime*) can also be found to a lesser extent in some brackish and estuarine waters. **Figure 23** depicts SAV in the study area from the NYSDEC Statewide Seagrass Map. Western Great South Bay supports significant SAV beds near the border of Suffolk and Nassau Counties. In prior surveys, South Oyster Bay SAV habitat covered 2,544 acres and the western half of the Great South Bay supported 10,818 acres of SAV habitat (DOS 2008).

Figure 23: NYSDEC Statewide Seagrass Map portraying the Study Area

There are three inlets in the study area: East Rockaway Inlet, Jones Inlet, and Fire Island Inlet. All three are Federal navigation projects and play an important role in nearshore processes that affect the back bay environment. Inlets are the openings in coastal barriers through which water, sediments, nutrients, animals, planktonic organisms, and pollutants are exchanged between the open sea and the protected embayments behind the barriers. Inlets serve as critical corridors for fish migration and are concentrated areas for feeding by fish and wildlife. Jetties and dredged navigation channels have been constructed to stabilize the inlets and make them navigable. This stability has led to an increase of bay flushing relative to pre-stabilization conditions because the maintained inlets permit the continual exchange of bay and ocean waters. The jetties have also profoundly affected sand bypassing and other natural processes at the inlets and adjacent shorelines.

3.12.3. Wildlife

The extensive wildlife resources in the study area are primarily avian and aquatic. NYSDEC has designated a number of areas as Significant Coastal Fish and Wildlife Habitats (SCFWH). The SSER supports more designated SCFWH areas than any other region of the State including Democrat Point, Hempstead Bay (East, Middle, and West), Jones Beach (East and West), Tobay Sanctuary, South Oyster Bay, and the Great South Bay (DOS 2008). Many of these areas are significant for their undeveloped salt marsh complex, tidal flats, and open water.

The marine offshore and nearshore ecosystems, inlets, bayside intertidal saltmarsh, mudflats, beach, and sand shoals are utilized by a diverse group of birds for various activities, including foraging, nesting, and resting; and fish, shellfish, and marine mammals. The study area is part of the Atlantic Flyway, a route used by a wide array of avifauna during migrations, and is home to a host of pelagic avifauna species (birds that spend most of their time on the ocean; petrels, shearwaters, gannetts, cormorants, sea ducks, etc.) during certain portions of the year. The area provides invertebrate-rich feeding grounds for nesting birds and many migratory shorebirds. Colonial wading and water birds use the island network within the back bays for rookeries, and maritime shrublands support a diverse assemblage of migratory land birds such as warblers, vireos, and thrushes. The following species are a sampling of the avian resources supported by the back bay estuarine habitat: *colonial water birds* - common terns, Forster’s tern, least tern, roseate terns, gull-billed terns, and black skimmer; *shorebirds* – piping plovers, sanderling, dowitchers, willet, red knot, ruddy turnstone, marbled godwit, sandpipers, herring gulls, great black-backed gull, whimbrel, yellowlegs, black-bellied plover, and American oystercatcher; *colonial wading birds* – snowy egret, great egret, little blue heron, black-crowned night heron, yellow-crowned night herons, tri-colored heron, glossy ibis, and green-back heron; *raptors* – Northern harrier, Cooper’s hawk, short-eared owl, peregrine falcon, and osprey; *passerines* – marsh wren, sharp-tailed sparrow and seaside sparrow; and *waterfowl* – American black duck, greater and/or lesser scaup, brants, geese, canvasback, American coot, mergansers, mallards, common goldeneye, bufflehead, ruddy duck, long-tailed duck, blue-winged teal, green-winged teal, northern shoveler, and American widgeon. South Oyster Bay is a primary waterfowl wintering area on Long Island. The National Audubon Society of New York State has recognized nearly the entire study area as Important Bird Areas within two priority areas: West Hempstead/Jones Beach West or Captree Island vicinity.

In addition to supporting an extensive and diverse bird assemblage, the back bays are a productive area for marine finfish, shellfish, and other wildlife. The back bays are critical nurseries for yearling striped bass, summer flounder, and bluefish; and reef-associated species such as tautog, cunner, and black sea bass; and important spawning ground for winter flounder, Atlantic menhaden, Atlantic silverside, bay anchovy, weakfish, American sandlance, pipefish, sticklebacks, and killifish. Important bivalves (mollusks) and crustaceans in the study area include soft clam, hard clam, scallop, ribbed mussel, blue mussel, and blue crabs. American eel, Atlantic croaker, northern kingfish, and northern puffer are other examples of fish found in the area. Diamondback terrapins and four species of sea turtles are the primary reptiles within the study area. Horseshoe crabs are also an important component of the ecosystem, and harbor seals are among the marine mammals using the area for feeding and resting.

The back bay estuarine environments are sensitive to activities that would degrade water quality, destroy habitat, increase turbidity, increase sedimentation, or alter flows, tidal patterns, temperature, or water depths (DOS 2008).

3.12.4. Rare, Threatened and Endangered Species

The Endangered Species Act (ESA) of 1973 describes several categories of Federal status for plants and animals and their critical habitat, as designated by the USFWS or the National Marine Fisheries Service (NMFS). The regulations for the designations are contained in 50 Code of Federal Regulations Section 17. An "endangered species" is defined as any species in danger of extinction throughout all or a large portion of its range. A "threatened species" is defined as any species likely to become an endangered species in the foreseeable future. The USFWS has jurisdiction over terrestrial and freshwater species; NMFS is responsible for any endangered or threatened marine species found in the study area. Under Section 7 of the ESA, any Federal agency that is sponsoring or assisting a project must coordinate with the DOI and/or NOAA for a determination of impacts on protected plants and animals.

Federal and state agencies independently list species based on the ESA. Each state's endangered and threatened species program is subject to approval by the U.S. Secretary of the Interior. Under New York State Environmental Conservation Law, the NYSDEC maintains a list of plant and animal species that are considered rare, threatened, endangered, or of special concern in the state of New York.

Information on threatened, endangered, or otherwise protected species was compiled from USFWS, NMFS, and NYSDEC. Additionally, a literature search was conducted to determine which of these species would likely occur in the study area.

A total of 12 Federally-listed species occur in the study area, and one species is proposed for listing (**Table 5**). Federally-listed species include birds, mammals, reptiles, fish, and plants. There are no critical habitats identified under Section 7 of ESA in the study area.

In addition to Federally-listed species, there are 54 species listed by the state of New York as endangered, threatened, or of special concern: 2 amphibians, 25 birds, 1 insect, 18 plants, 6 reptiles, and 2 mammals. Potential impacts to these species will be considered as alternative plans are screened.

Table 5: Federal Threatened, Endangered, and Candidate Species of the Nassau County Back Bays CSRM Study Area

Common Name	Scientific Name	Federal Status
BIRDS		
Piping plover	*Charadrius melodus*	Threatened
Roseate tern	*Sterna dougallii dougallii*	Endangered
Red knot	*Calidris canutus rufa*	Threatened
Bald eagle	*Haliaeetus leucocephalus*	Protected
PLANTS		
Sandplain gerardia	*Agalinis acuta*	Endangered
Seabeach amaranth	*Amaranthus pumilus*	Threatened
MAMMALS		
Northern long-eared bat	*Myotis septentrionalis*	Threatened
REPTILES		
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Green sea turtle	*Chelonia mydas*	Endangered
FISH		
Alewife	*Alosa pseudoharengus*	Candidate
Atlantic Sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
Shortnose Sturgeon	*Acipenser brevirostrum*	Endangered

3.12.5. Essential Fish Habitat

In accordance with the Magnuson-Stevens Fishery Conservation and Management Act, the back bays and coastal waters of New York have been designated as Essential Fish Habitat (EFH) for a variety of life stages of fish managed under the New England and Mid-Atlantic Fishery Management Councils and the NMFS. Thirty-five species are listed including Mid-Atlantic species, New England species, coastal migratory pelagic species, highly migratory species and shark species (**Table 6**). No habitat areas of particular concern (HAPC) are identified in the study area. Potential impacts to these species will be considered as alternative plans are screened.

Table 6: Essential Fish Habitat Species and Lifestages Present

Species	Lifestage Present
Black Sea Bass	Eggs, Larvae, Juvenile, Adult
Longfin Inshore Squid	Eggs, Juvenile
Atlantic Mackerel	Eggs, Larvae, Juvenile, Adult
Bluefish	Juvenile. Adult
Atlantic Butterfish	Eggs, Larvae, Juvenile, Adult
Spiny Dogfish	Sub- Female, Adult Male
Atlantic Surfclam	Juvenile, Adult
Ocean Quahog	Juvenile, Adult

Scup	Juvenile, Adult
Summer Flounder	Juvenile, Adult
Bluefin Tuna	Juvenile
Sandbar Shark	Neonate, Juvenile, Adult
Common Thresher Shark	Neonate, Juvenile, Adult
Skipjack Tuna	Adult
Dusky Shark	Neonate
White Shark	Neonate, Juvenile, Adult
Smoothhound Shark Complex (Atlantic Stock)	Neonate, Juvenile, Adult
Sand Tiger Shark	Neonate, Juvenile
Winter Flounder	Eggs, Larvae, Juvenile, Adult
Little Skate	Juvenile, Adult
Ocean Pout	Eggs, Adult
Atlantic Herring	Juvenile, Adult
Atlantic Cod	Eggs, Larvae, Adult
Pollock	Eggs, Larvae, Juvenile
Red Hake	Eggs, Larvae, Juvenile, Adult
Silver Hake	Eggs / Larvae
Yellowtail Flounder	Eggs, Adult
Monkfish	Eggs, Larvae, Adult
Windowpane Flounder	Eggs, Larvae, Juvenile, Adult
Winter Skate	Juvenile, Adult
Atlantic Salmon	Adult
American plaice	Juvenile, Adult
King mackerel	Eggs, Larvae, Juvenile, Adult
Spanish mackerel	Eggs, Larvae, Juvenile, Adult
Cobia	Eggs, Larvae, Juvenile, Adult

3.12.6. Recreational Resources

Extensive recreational resources exist in the study area for swimming, fishing, boating, surfing, hiking, biking, running/walking, kayaking/canoeing, camping, bird watching, etc. These include beaches, and national, state, and county parks. Those parks located within the study area in proximity to shorelines that would likely be at highest exposure to storm risks include: Idlewild Park, North Woodmere Park, Rockaway Community Park, Rockaway Beach, Silver Point County Park, Hewlett Point Park, Bay Park, Ocean Beach Park, Shell Creek Park, Oceanside Park, Baldwin Park, Waterfront Park, Cow Meadow Park, Lido Beach Town Park, Nickerson Beach Park, Town Park at Point Lookout, Malibu Town Park, Norman J. Levy Park and Preserve, Newbridge Road Park, Wantagh Park, Jones Beach State Park, Gilgo State Park, Robert Moses State Park, Captree State Park, Seamans Neck Park, John J. Burns Park, James Caples Memorial Park, Copiague Neck County Park, Shore Road Park, Venetian Shores Park, Bergen Point County Park, West Islip Town Beach and Marine Park, and Fire Island National Seashore. Other recreational resources include fishing piers, docks and marinas, boating clubs, golf and country clubs, hunting, and seal watching excursions. The major beaches in the study area include Rockaway Beach, East Atlantic Beach, Ocean Beach Park, Lido Beach, Nickerson Beach, Jones Beach State Park, Gilgo Beach, Cedar Beach, and Fire Island. A full compilation and review of recreational resources will be completed as work continues on the study.

3.12.7. Aesthetics

Aesthetics refer to the sensory quality of the resources (sight, sound, smell, taste, and touch) and especially with respect to judgment about their pleasurable qualities (Canter, 1993; Smardon et al. 1986). The aesthetic quality of the study area is influenced by the natural and developed environment. The NCBB contain extensive natural tidal marshlands and islands, beaches, tidal creeks, and open-water embayments. Likewise, the study area also contains heavily urbanized areas consisting of developed shorelines composed of homes, condominiums, businesses, marinas, boat ramps, industrial activities, and infrastructure. Many of these developed shorelines include docks, wharves, and hardened shorelines with bulkheads, concrete revetments, and riprap.

Visual resources are the natural and man-made features that comprise the visual qualities of a given area, or “viewshed.” These features form the overall impression that an observer receives of an area or its landscape character. Topography, water, vegetation, man-made features, and the degree of panoramic view available are examples of visual characteristics of an area. The views of open water bays and saltmarsh landscapes are an important component of the viewshed within the study area.

3.12.8. Climate Change

Climate change and RSLC are significant issues affecting coastal areas in New York. Climate change has potentially devastating ecological, economic and public health impacts in New York (IPCC, 2007). Executive Order (EO) 13653 on Preparing the United States for the Impacts of Climate Change was released 1 Nov 2013. Executive Order (E.O.) 13653 contains specific language, goals, and objectives to prepare the Nation for the impacts of climate change by undertaking actions to enhance climate preparedness and resilience. In response to this and other related EOs, USACE has developed a comprehensive policy on climate change (USACE, 2015). It states in this document that: “It is the policy of USACE to integrate climate change preparedness and resilience planning and actions in all activities for the purpose of enhancing the resilience of our built and natural water-resource infrastructure and the effectiveness of our military support mission, and to reduce the potential vulnerabilities of that infrastructure and those missions to the effects of climate change and variability.”

Climate change and its impacts to the proposed project and surrounding area is a primary concern for the study. A climate change assessment will be completed for the study for a period of 100 years. The purpose of the climate assessment is to reduce vulnerabilities and enhance the resilience of the proposed project. Climate change will be evaluated extensively as the study continues.

3.13. Environmental Compliance

All Federal projects must comply with existing environmental laws and EOs. Those potentially applicable to this study are listed in **Table 7**. The alternative plans will require a rigorous examination of compliance with these environmental protection statutes and EOs.

Table 7: Environmental Laws and Executive Orders

Federal Statutes
Archaeological Resource Protection Act
Bald and Golden Eagle Protection Act
Clean Air Act
Clean Water Act
Coastal Barrier Resources Act/Coastal Barrier Improvement Act
Coastal Zone Management Act
Comprehensive Environmental Response, Compensation and Liability Act
Endangered Species Act
Estuary Protection Act
Farmland Protection Policy Act
Fish and Wildlife Coordination Act
Magnuson-Stevens Fishery Conservation and Management Act
Marine Mammal Protection Act
Marine Protection Research and Sanctuaries Act
Migratory Bird Treaty Act
National Environmental Policy Act
National Historic Preservation Act
North American Wetlands Conservation Act
Resource Conservation and Recovery Act
Rivers and Harbors Act
Water Resources Planning Act
Wild and Scenic Rivers Act
Executive Orders (EO), Memoranda, etc.
Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
Protection and Enhancement of Environmental Quality (E.O. 11514)
Protection and Enhancement of Cultural Environment (E.O. 11593)
Exotic Organisms (E.O. 11987)
Floodplain Management (E.O. 11988)
Protection of Wetlands (E.O. 11990)
Relating to Protection and Enhancement of Environmental Quality (E.O. 11991)
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)
Invasive Species (E.O. 13112)
Protection of Children from Environmental and Safety Risks (E.O. 13045)
Prime and Unique Farmlands (CEQ Memorandum, 11 August 1980)
Establishing Discipline and Accountability in the Environmental Review and Permitting Process for Infrastructure Projects (E.O. 13807)

4. PATH FORWARD

4.1. Introduction

The study is being performed in accordance with USACE SMART Planning and Civil Works Modernization guidance and milestones. Planning, engineering, and environmental efforts will be conducted in accordance with all applicable USACE guidance, including Engineer Regulations, Engineer Manuals, Engineering Circulars, Planning Bulletins, and memoranda. The study will be completed in the following five major segments:

1. PMP Development to the Alternatives Milestone
2. Alternatives Milestone to the Tentatively Selected Plan (TSP) Milestone
3. TSP Milestone to the Agency Decision Milestone (ADM)
4. ADM to the Final Feasibility Report
5. Final Feasibility Report to the Chief of Engineers' Report

The study is presently in segment 2, leading up to the TSP milestone.

4.2. Segment 1 – PMP Development to the Alternatives Milestone

This segment was initiated with the signing of the Feasibility Cost Sharing Agreement (FCSA) on 30 September 2016 and included the development of the PMP, and initial efforts to identify the focused array of alternatives that has been carried forward for analysis. This was accomplished using data and analyses from the NACCS, and other studies and reports. Existing and future without project conditions were reviewed to determine which should be part of this study's existing conditions. Major tasks described in Section 3 included:

- Identification of problems, opportunities, needs, objectives, constraints, and considerations
- Development of a plan formulation rationale
- Formulation of alternatives based upon screening of measures
- Characterization of the existing and future-without project conditions
- Identification of management measures
- Development of screening criteria
- Refinement of parametric costs
- Identification of a focused array of alternatives
- The segment concluded at the 16 August 2017 Alternatives Milestone meeting

4.3. Segment 2 – Alternatives Milestone to the TSP Milestone

The study is currently in this phase. Based on current HH&C and HEC-FDA modeling results, the PDT has determined that additional analysis is necessary to re-evaluate the without project conditions and the array of alternatives to be considered. For the without project conditions, the PDT will prepare a narrative to document existing conditions in the study area. This information will be used to refine the problem identification process as well as to serve as the baseline existing conditions narrative to be included as part of the feasibility report.

Note that no cultural, geotechnical (i.e. borings, borrow areas delineation/suitability analysis/field data collection) or real estate analyses or surveys will be performed during this phase of the study; however, existing data sources and information will eventually be updated with data collected during field investigations in later phases of the study.

A particular emphasis will be placed on managing the level of detail throughout the study to balance the technical analyses with appropriate risk. The PDT plans to conduct a screening level analysis to include hydrodynamic modeling of the entire study area as well as a comparison of NACCS Tier 3-like exposure, risk and vulnerability assessments with parametric costs to identify areas for additional detailed study. This will be corroborated with a preliminary economics analysis of the potential magnitude of damage reduction covering a range of potential categories (structures, contents, infrastructure, emergency costs, detour impacts, etc.) to tie in with the hydrodynamic modeling screening analysis to offer preliminary BCRs for the focused array of alternatives. The screening will allow the identification of potentially viable plans at a relatively early study stage in the formulation process. This screening level analysis will be performed in association with environmental evaluations to inform the selection of a TSP. The TSP Milestone meeting ensures vertical team concurrence on the TSP that will be released as part of the EIS for public and agency review in a draft feasibility report 30 – 60 days after the scheduled TSP meeting. This EIS will be an iterative document and will be vetted with Federal and State environmental agencies prior to and during release.

The overall study scope will consider a level of detail needed to make a decision regarding the NED Plan. To accomplish this decision, a likely path forward will include a cycled approach where the perimeter plan and nonstructural plan formulation analyses will be performed while hydrodynamic modeling for the storm surge barrier with project condition is conducted. Comprehensive storm surge barrier structural plan formulation analyses will subsequently be performed. NNBF will be considered in addition to the aforementioned analyses during economic/NED analyses.

An economic analysis will be conducted for flood risk management alternatives consistent with the requirements of ER 1105-2-100 *Planning Guidance Notebook*, ER 1105-2-101 *Risk Analysis for Flood Damage Reduction Studies*, and Engineering Manual (EM) 1110-2-1619 *Risk-Based Analysis for Flood Damage Reduction Studies*. The National Economic Development Procedures Manual for Flood Risk Management and Coastal Storm Risk Management, prepared by the Institute for Water Resources, will also be used as references along with the User's Manual for the HEC-FDA model. Economic/NED analyses will undergo a cycled approach as well based upon completion of the aforementioned analyses.

HEC-FDA version 1.4.2 is a USACE-certified model that provides integrated hydrologic engineering and economic risk analysis during the formulation and evaluation of flood damage reduction plans in compliance with policy regulations ER 1105-2-100 and ER 1105-2-101. Uncertainty in stage-frequency, stage-damage, and damage-frequency curves are quantified and incorporated into economic and engineering performance analyses of alternatives. The process applies Monte Carlo simulation, a numerical-analysis procedure that computes the expected value of damage while explicitly accounting for uncertainty in the basic parameters used to determine flood inundation damage.

This draft status report is being released for public review (April 2019) to provide an update on work completed to date and the path forward, prior to the TSP Milestone and the subsequent release of the draft feasibility report and EIS. This status report includes information on analyses completed prior to its release and is based largely on existing data sets. Comments received on the status report will help inform the PDT as the level of detail in the feasibility-level analysis increases during formulation of the TSP and ultimately the optimized recommended plan. This report contains a status update of the existing work done from the FCSA to the AMM and the additional work done on preliminary plan formulation, benefit calculations, designs, CBRA coordination and the remaining management measures that will be part of the plan formulation process in the future. It also contains the rationale for plan formulation, a schedule of future report release dates and general dates for future coordination with resource agencies, the general public and the vertical team.

Concurrently and in conjunction with the status report review, the PDT will continue to forecast future with project conditions, refining details of the alternatives, and will ultimately select a TSP. Major tasks include:

- Initiation of hydrodynamic, economic, and environmental modeling
- Evaluation of Composite Exposure Index (CEI), as defined by the NACCS, in study reaches
- Economic analysis of secondary and tertiary impacts from coastal storm flooding to avoid and/or minimize induced flooding necessitating mitigating measures
- Evaluation and comparison of the costs and benefits of alternatives
- Development of a final array of concepts or alternatives,
- Release of a Status Report to the public and USACE reviewer teams
- Facilitate Risk-Informed Workshop to incorporate comments on status report
- Risk analysis of the proposed alternative (TSP)
- Relative ranking of alternatives based on screening criteria
- Selection of a TSP and execution of TSP Milestone

The PDT will investigate in detail and conduct plan formulation for structural (including storm surge barrier), nonstructural, NNBF and policy/programmatic measures as strategies to reduce coastal flooding risk towards the development of a conceptual alternative design for presentation at the TSP milestone meeting.

In coordination with NYSDEC and Nassau County, the USACE team will refine the conceptual alternative designs for the plan formulation screening process. Criteria will be developed to assist in the identification of alternative plans, including the no action alternative. The specific number of conceptual alternative plans has not yet been determined. The evaluation of alternative plans will consider geographic and coastline characterization (vulnerability, shoreline type etc.) criteria. An individual alternative plan may be applicable to a regional area characterized by similar conditions. Furthermore, alternative plans may be developed for both regional and local applications.

The development of the alternative designs will include a literature search and investigation to identify the appropriate management measures for the different risk management philosophies, techniques, or practices based upon site conditions. This was performed largely during the conduct of the NACCS. A suite of guidelines and constraints that considers means to maximize benefits, minimize costs, and avoid/minimize unacceptable impacts will be developed to guide concept design development.

The conceptual alternative designs will be developed in GIS format. The study manager will generate a template format for figure creation for a unified look across report sections and presentation media. Conceptual alternative plans will be included in the feasibility project geodatabase.

The alternative designs will be developed for with project conditions, which will be compared to both the existing conditions and the future-without project conditions to identify any increases or decreases in water surface elevations, specifically as it relates to flood-prone areas and adjacent structures, if applicable.

The conceptual alternative plan design cost estimates will be developed using unit costs from similar CSRM projects or other reference conditions. Initial conceptual costs will include a minimum 40 percent contingency to account for using parametric unit costs and potential error in calculating quantities; however, alternative-specific contingencies will be developed and refined as the level of design is increased and improved. Cost estimates will be developed for each individual conceptual project site by economy of scale savings that would be produced by undertaking multiple projects at different localities will be determined.

4.4. Segment 3 – TSP Milestone to the Agency Decision Milestone (ADM)

This segment will begin with the 45-day public review of the draft feasibility report and EIS that will be released within 30 days of the TSP milestone. One of the major risk drivers includes the conduct and level of hydrodynamic and circulation modeling of environmental impacts. Coordination with the vertical team has indicated that these resource agencies do understand that decisions need to be made based on a decreased level of detail and increased level of risk. However, it is understood that not all levels of resource agencies are fully engaged in SMART Planning tenets, and may require additional detail and time to complete their review. In addition, note that SMART Planning is Corps Policy and not the policy of other resource agencies, which may affect their flexibility on the topic.

The study scope includes the preparation of a single Feasibility Report and Draft EIS (DEIS) approximately 45-60 days after the TSP milestone. This DEIS will be integrated into the Feasibility Report. The DEIS will be immediately released for public and resource agency review. NEPA compliance will follow the tenets of SMART planning where there are assumed risks resulting from less detail in TSP project plan components and reduced environmental and cultural resource data collection. It is recognized that a low level of detail for environmental impact analysis may significantly affect the ability to acquire resource agency approvals, and provide a legally sufficient NEPA document (DEIS) necessary to complete to a Final EIS and Record of Decision (ROD). A consequence of this risk could be a need to prepare a supplemental EIS and additional support studies to be compliant with NEPA and to obtain resource agency approvals including a Federal Coastal Zone Consistency Determination, Section 401 Water Quality Certification, Clean Air Act Compliance, Fish and Wildlife Coordination Act, Endangered

Species Act, Essential Fish Habitat Conservation Recommendations (Magnuson-Stevens Act), Section 106 National Historic Preservation Act, etc. prior to the Agency Decision Milestone, which would result in significant impacts to study schedule and budget. Because of the scope of the study, complexity of potential FRM measures, and potential level of controversy with the public and resource agencies, the development of a DEIS 30 days following a TSP milestone introduces high risk for not adequately assessing environmental impacts in the DEIS.

Comments received from reviewers, stakeholders, agencies, and the public will help the PDT determine what investigations and/or analyses would be necessary to recommend a plan. Major tasks include:

- Completion of concurrent public, Agency Technical Review (ATR), Independent External Peer Review (IEPR), and policy reviews for the draft feasibility report and EIS
- Hosting of public meetings
- Consideration of all reviewer comments
- Refining the TSP as necessary

The segment will conclude at the ADM meeting, which will be attended by HQUSACE and CENAD decision makers and reviewers. The meeting marks corporate endorsement of the recommended plan and proposed way forward to complete feasibility-level design and the feasibility study report package.

4.5. Segment 4 – ADM to the Final Feasibility Report

During this segment the PDT will optimize the TSP to be sure that the plan with the highest net benefits is recommended as the NED plan. All comments received during the previous segment will be addressed, and the draft feasibility report and EIS will be revised as needed to address comments. Major tasks include:

- Commencement of feasibility-level design of the TSP
- Completion of RSLC sensitivity analysis
- Preparation of the final feasibility report and EIS

The segment will conclude at a Senior Leaders Panel meeting. The meeting will mark the corporate checkpoint to determine if the final feasibility report and EIS, and the proposed Chief of Engineers report, are ready to be released for State and Agency review.

4.6. Segment 5 – Final Feasibility Report to the Chief of Engineers' Report

During this segment the PDT will ensure that all outstanding comments received are addressed and the final feasibility report and EIS are prepared for the 30-day State and Agency review. A draft Chief of Engineers' Report will also be prepared for inclusion in the State and Agency review. Upon completion of State and Agency review, comments will be collated and addressed. Major tasks include:

- Submittal of the final feasibility report and EIS to HQUSACE
- Production of a draft Chief of Engineers' Report
- State and Agency Review

This segment will conclude with the execution of a ROD and a Chief of Engineers' Report.

4.7. Study Schedule

A summary of the study schedule is provided in **Table 8**. The total study timeframe is approximately 5 years, 7 months from the execution of the FCSA on 30 September 2016 to the signature of the Chief of Engineers' Report in April of 2022.

Table 8: Study Schedule

Milestone	Date
FCSA	30 September 2016 (A)*
Alternative Milestone	16 August 2017 (A)*
Study Status Report	April 2019
TSP Milestone	May 2020
Draft Feasibility Report/EIS	July 2020
ADM	January 2021
Final Feasibility Report/EIS	January 2022
Chief of Engineers' Report	April 2022

(A)* Actual date of milestone achieved

Ongoing & Upcoming Work:

- Hydrodynamic (ADCIRC) modeling. ADCIRC (ADvanced CIRCulation) is a hydrodynamic model for coastal oceans, inlets, rivers and floodplains.
- Environmental impact and benefit analysis
- Selection and combination of site-specific measures
- Survey of site conditions and land use
- Coordination with sponsor and stakeholders

Major environmental factors that will be considered include:

- Changes in hydrology and sediment transport
- Changes in benthic communities
- Changes in the extent and type of habitat on the shoreline and within the back bay system; this includes cross island transport accretion of sediment on wetlands, wetland migration, and breach formation
- Benefits or impacts to threatened and endangered species, and their habitat
- Impacts to historic structures and other sites of cultural significance
- Climate change and relative sea level change

The period of analysis for the economic analysis is 2025 – 2075. The period of analysis for the climate change and RSLC analysis is 2025 – 2125.

4.7.1. Screening of Alternatives

Alternative plans will be compared based on their performance relative to following screening criteria:

- Does the alternative meet the planning objectives?
- Does the alternative avoid planning constraints?
- Does the alternative contribute to the P&G criteria of completeness, effectiveness, efficiency, and acceptability?
- Does the alternative contribute to the P&G accounts of NED, EQ, RED, and OSE?
- Does the alternative function well in a systems context?

4.7.2. Key Assumptions

Important assumptions used during plan formulation and evaluation include:

- All data, model outputs, and analyses collected and performed as part of the NACCS planning effort accurately portray the study area and its risk of coastal storm damage.
- Planned CSRM and resilience projects that are funded for construction will be constructed according schedule.
- The East Rockaway Inlet, Jones Inlet, Fire Island Inlet, and other Federal navigation channels will continue to be maintained and utilized in a similar manner in the future as they are today.

4.7.3. Recommended Plan

A summary of the features, costs, benefits, and impacts of the recommended plan will be included in the draft feasibility report and DEIS.

4.7.4. Environmental Operating Principles

A summary of how the recommended plan is consistent with and supports the USACE Environmental Operating Principles will be included in a future version of this document.

4.7.5. Peer Review

The draft and final feasibility reports will undergo District Quality Control (DQC), ATR, and IEPR. A summary of comments received during the reviews will be included in a future version of this document.

4.8. Expected Project Performance

4.8.1. Project Costs

Estimated project costs for each alternative will be refined based on a detailed engineering analysis. They will be summarized in the draft feasibility report and DEIS.

4.8.2. Equivalent Annual Costs and Benefits

Estimated project equivalent annual costs and benefits for each alternative will be refined based on a detailed economic analysis. They will be summarized in the draft feasibility report and DEIS.

4.8.3. Cost Sharing

Construction will be cost-shared by the USACE and non-Federal construction sponsor, in accordance with applicable USACE guidance and the Project Partnership Agreement.

4.8.4. Project Implementation

The project will be implemented in accordance with all applicable engineering and construction guidance, best practices, and environmental laws and policies.

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

OMRR&R will be the responsibility of the non-Federal construction sponsor. Estimated OMRR&R costs and requirements for each alternative will be developed based on a detailed engineering analysis. They will be summarized in the draft feasibility report and DEIS.

4.8.6. Key Social and Environmental Factors

- Changes in hydrology and sediment transport
- Changes in benthic communities
- Changes in the extent and type of habitat on the shoreline and within the back bay system; this includes cross island transport accretion of sediment on wetlands, wetland migration, and breach formation
- Benefits or impacts to threatened and endangered species, and their habitat
- Impacts to historic structures and other sites of cultural significance
- Climate change and relative sea level change

A stand-alone NEPA scoping document associated with the Preliminary Draft Feasibility Study will be completed, followed by an Integrated Draft Environmental Impact Statement/Draft Feasibility Study.

For Alternatives 1A, 1B, 2, and 3, the PDT will consider both temporary impacts of construction as well as impacts to tidal exchange in the bays and creeks, salinity gradients, interior drainage, wetlands, dunes and beaches, benthic communities, finfish and shell fish as well as viewsheds.

The PDT seeks to enhance natural storm surge buffers as well as natural coastal features in and around the project area. Resource agency input for scoping of alternatives has not yet been received or fully considered.

The PDT anticipates the following coordination:

- EFH coordination with NOAA
- Plover/Sea beach amaranth/ESA compliance with USFWS
- ESA coordination with NOAA (Atlantic sturgeon, marine turtles, marine mammals, and their habitats, as designated)
- Potential wetland impacts/FWCAR with USFWS
- NHPA compliance (coordination with SHPO, Tribes and other interested parties)
- Clean Air Act compliance (NOx, PM and GHG)
- Coastal Zone Management coordination with NYSDOS

- CBRA compliance or exemption with USFWS

Compliance with Section 106 of the National Historic Preservation Act (NHPA) will be achieved through cultural resources investigations and coordination with the New York State Historic Preservation Office (SHPO), Tribes, and other interested parties. Coordination will be carried out in tandem with the NEPA process. An agreement document will be prepared to address the need for additional cultural resources surveys in the Project Engineering and Design (PED) phase of the project.

4.8.7. State and Agency Review

State and Agency Review of the final feasibility report will commence after a Senior Leaders Panel meeting. A summary of comments received during the review will be included in the draft feasibility report and DEIS.

4.8.8. Certification of Peer and Legal Review

Certification of peer and legal review of the draft and final feasibility reports will be included or referenced in the draft feasibility report and DEIS. A summary of comments received during the reviews will be included in the draft feasibility report and DEIS.

4.8.9. Policy Compliance Review

The draft and final feasibility reports will undergo policy compliance reviews by North Atlantic Division and Office of Water Project Review. A summary of comments received during the reviews will be included in the draft feasibility report and DEIS.

5. ACRONYMS

ADCIRC: Advanced Circulation
ADM: Agency Decision Milestone
AMM: Alternatives Milestone Meeting
ATR: Agency Technical Review
BCR: Benefit to Cost Ratio
CENAD: USACE North Atlantic Division
CENAN: Corps of Engineers North Atlantic New York
CENAP: Corps of Engineers North Atlantic Philadelphia
CHL: Coastal Hydraulics Laboratory
CHS: Coastal Hazard System
CONUS: Continental United States
CSRM: Coastal Storm Risk Management
CSTORM-MS: Coastal Storm Modeling System
DOE: Department of Energy
DQC: District Quality Control
DRV: Depreciated Replacement Value
EFH: Essential Fish Habitat
EIS: Environmental Impact Statement
E.O.: Executive Order
EQ: Environmental Quality
ERDC: USACE Engineer Research and Development Center
ERDC-CHL: USACE Engineer Research and Development Center Coastal Hydraulics Laboratory
FCSA: Federal Cost Sharing Agreement
FEMA: Federal Emergency Management Agency
FWCAR: Fish and Wildlife Coordination Act Report
FWOP: Future Without Project
FWP: Future With Project
GHG: Green House Gas
GIS: Geographic Information System
GPM: Gaussian Process Metamodeling
HAPC: Habitat Area of Particular Concern
HEC-FDA: Hydrologic Engineering Center-Flood Damage Reduction Analysis
HH&C: Hydrology, Hydraulics, and Coastal Engineering Section
HQUSACE: USACE Headquarters
HUD: Housing and Urban Development
IEPR: Independent External Peer Review
NACCS: North Atlantic Coast Comprehensive Study
NCBB: Nassau County Back Bay
NED: National Economic Development
NEPA: National Environmental Policy Act
NHPA: National Historic Preservation Act
NMFS: National Marine Fisheries Service

NGO: Non Government Organization
NNBF: Natural and Nature-Based Feature
NOAA: National Oceanic and Atmospheric Administration
NOx: Nitrous Oxide
NRC: National Resource Counsel
NTDE: National Tidal Datum Epoch
NWLON: National Water Level Observation Network
NYNJHATS: New York and New Jersey Harbor & Tributaries Study
NYSDEC: New York State Department of Environmental Conservation
NYSDOS: New York State Department of State
O&M: Operations & Maintenance
OSE: Other Social Effects
PDT: Project Delivery Team
PED: Preconstruction Engineering and Design
P&G: 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
P.L.: Public Law
PM: Project Manager
PMP: Project Management Plan
RED: Regional Economic Development
ROD: Record of Decision
RSLC: Relative Sea Level Change
SBM: Shoreline Based Measure
SCFWH: Significant Coastal Fish and Wildlife Habitats
SHPO: State Historic Preservation Office
SLC: Sea Level Change
SLC: Sea Level Change
SMART: Specific, Measurable, Attainable, Risk Informed, Timely
SSER: South Shore Estuaries Reserve
SWLS: Surface Water Elevations
TSP: Tentatively Selected Plan
TSP IPR: Tentatively Selected Plan In Progress Review
USACE: U.S. Army Corps of Engineers
USDOT: United States Department of Transportation
USEPA: United States Environmental Protection Agency
USFWS: United States Fish and Wildlife Service
USGS: United States Geological Survey
VT: Vertical Team

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