RHODE ISLAND COASTLINE
COAST STORM RISK MANAGEMENT
Final Integrated Feasibility Report & Environmental Assessment

Appendix F: Plan Formulation

January 2023

US Army Corps of Engineers®
New England District

RHODE ISLAND COASTLINE
COASTAL STORM RISK MANAGEMENT

DRAFT FEASIBILITY REPORT
APPENDIX F: PLAN FORMULATION

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LIST OF ACRONYMS AND ABBREVIATIONS

AEP	Annual Exceedance Probabilities
BCR	Benefit Cost Ratio
CAP	Continuing Authorities Program
CDC	Center of Disease Control
CSO	Combined Sewer Overflow
CSRM	Coastal Storm Risk Management
EO	Executive Order
EQ	Environmental Quality
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation
FWOP	Future Without Project
FWP	Future With Project
FY	Fiscal Year
G2CRM	Generation 2 Coastal Risk Model
HTRW	Hazardous, Toxic, and Radiological Waste
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
IDC	Interest During Construction
IEBC	International Existing Building Code
IFR/EA	Integrated Feasibility Report and Environmental Assessment
IRC	International Residential Code
LERs	Lands, easements, and rights-of-way
LF	Linear Feet
NAA	No Action Alternative
NACCS	North Atlantic Coast Comprehensive Study
NED	National Economic Development
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NFS	Non-Federal Sponsor
NNBF	Natural and nature-based features
OSE	Other Social Effects
P&G	Principles and Guidelines, 1983
PED	Preconstruction Engineering and Design
PDT	Project Delivery Team
PL	Public Law
RECONS	Regional Economic System
RED	Regional Economic Development
RIC	Rhode Island Coastline
SLC	Sea Level Change
SVI	Social Vulnerability Index
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers
WRDA	Water Resources Development Act
WWTF	Wastewater Treatment Facility

SECTION 1.0 INTRODUCTION

Rhode Island is the smallest state in the union, being only 37 miles wide and 48 miles long. Although small in size, the state is highly industrialized and is the 2nd most densely populated state in the union, with slightly less than 1.1 million people residing in the state as of 2020. Approximately 75 percent of the state's population resides in a 40-mile long urban/suburban corridor along the shores of Narragansett Bay.

As a result of Hurricane Sandy, Congress authorized the U.S. Army Corps of Engineers (USACE) to undertake the North Atlantic Coast Comprehensive Study (NACCS) to address flood risks of vulnerable coastal populations in areas affected by the storm. This culminated in the January 2015 completion of the NACCS final report, which identified high-risk focus areas in the North Atlantic region for additional analyses to address coastal storm risk, including the development of strategies to manage risk associated with relative sea level change. The NACCS identified nine (9) high-risk, focus areas; two (2) of which are located in Rhode Island. The first included the Rhode Island coastline from Point Judith eastward to the Massachusetts border, and the second included the Rhode Island coastline from Point Judith westward to the Connecticut border. This study investigates the first focus area, with the inclusion of Block Island. The second study area was investigated by the USACE in the Pawcatuck River Coastal Storm Risk Management (CSRM) study.

The study area for the Rhode Island Coastline (RIC) Project runs from Point Judith eastward to the Massachusetts State line, including the majority of Narragansett Bay, which is a major feature of the state's topography (**Figure 1-1**). The RIC study area also includes Block Island, which is not located in Narraganset Bay. The study area covers more than 457 miles of coastline as shown in **Figure 1-2**. All or part of 19 municipalities across all five (5) counties within Rhode Island are included in the study area, with more than 650,000 people currently residing within the boundaries of the study.

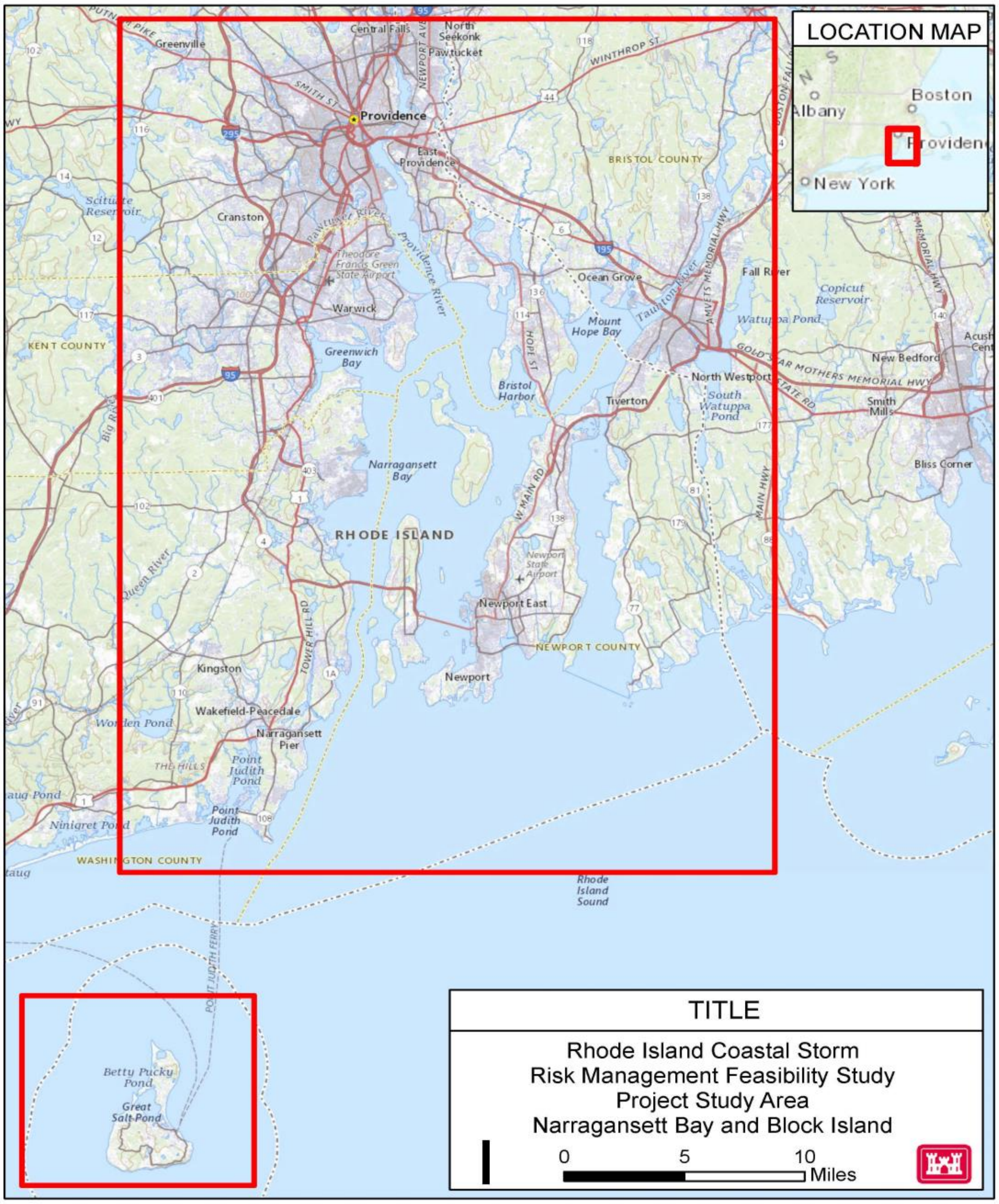

Figure 1-1: The Rhode Island Coastline CRMS project study area

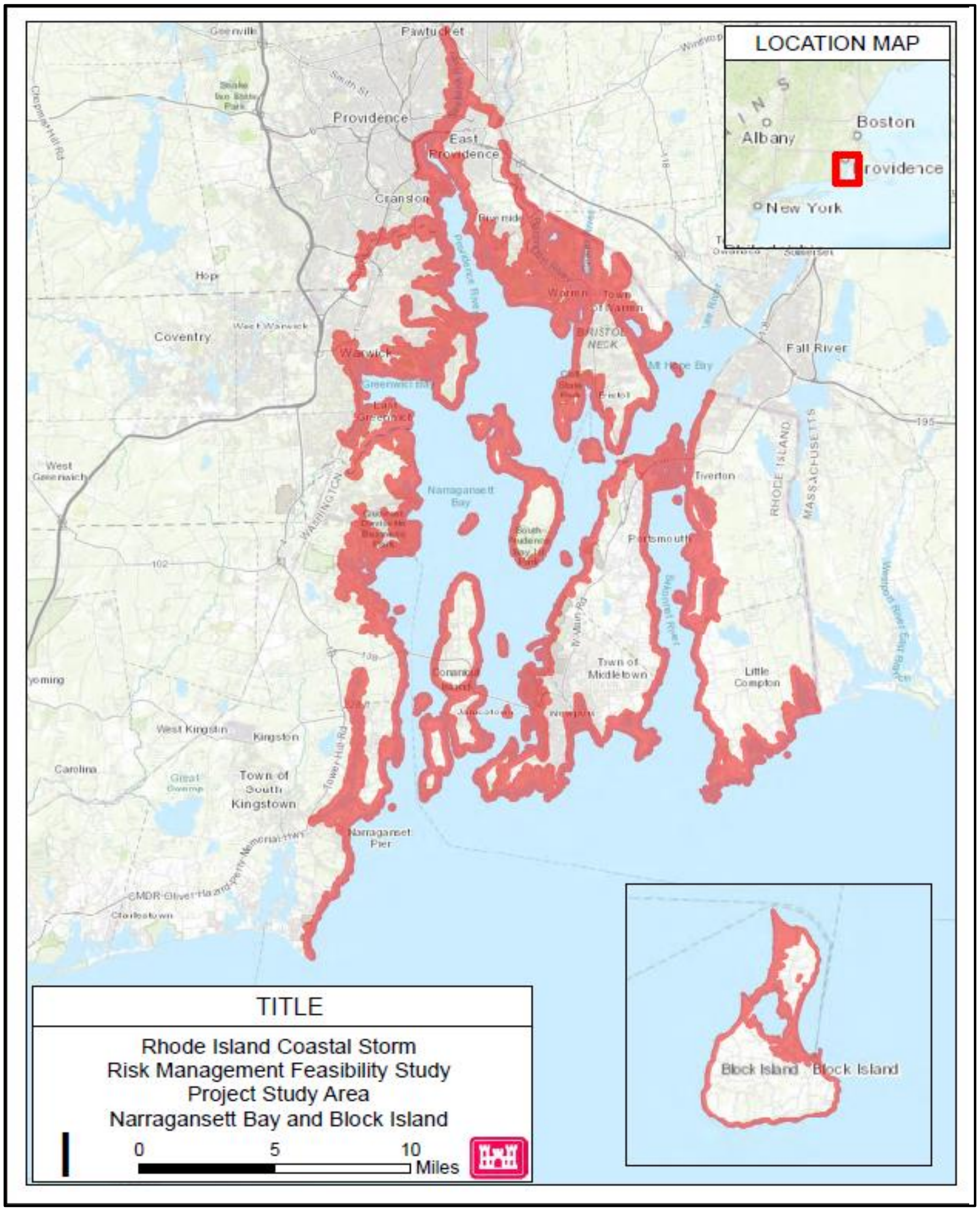

Figure 1-2: The coastline included in the study area

The RIC study focused on specifically on the 100-year floodplain within the study area. The maps (**Figure 1-3** through **1-9**) included below show the location of floodplains in relation to the surrounding land cover. Providence, Bristol County, and Newport all have dense urban and residential development located in these floodplains. The Narrow River area also has residential development located in 100-year floodplains along the river. Block Island has both commercial and residential development in the 100-year floodplains along New Harbor and Harbor Pond.

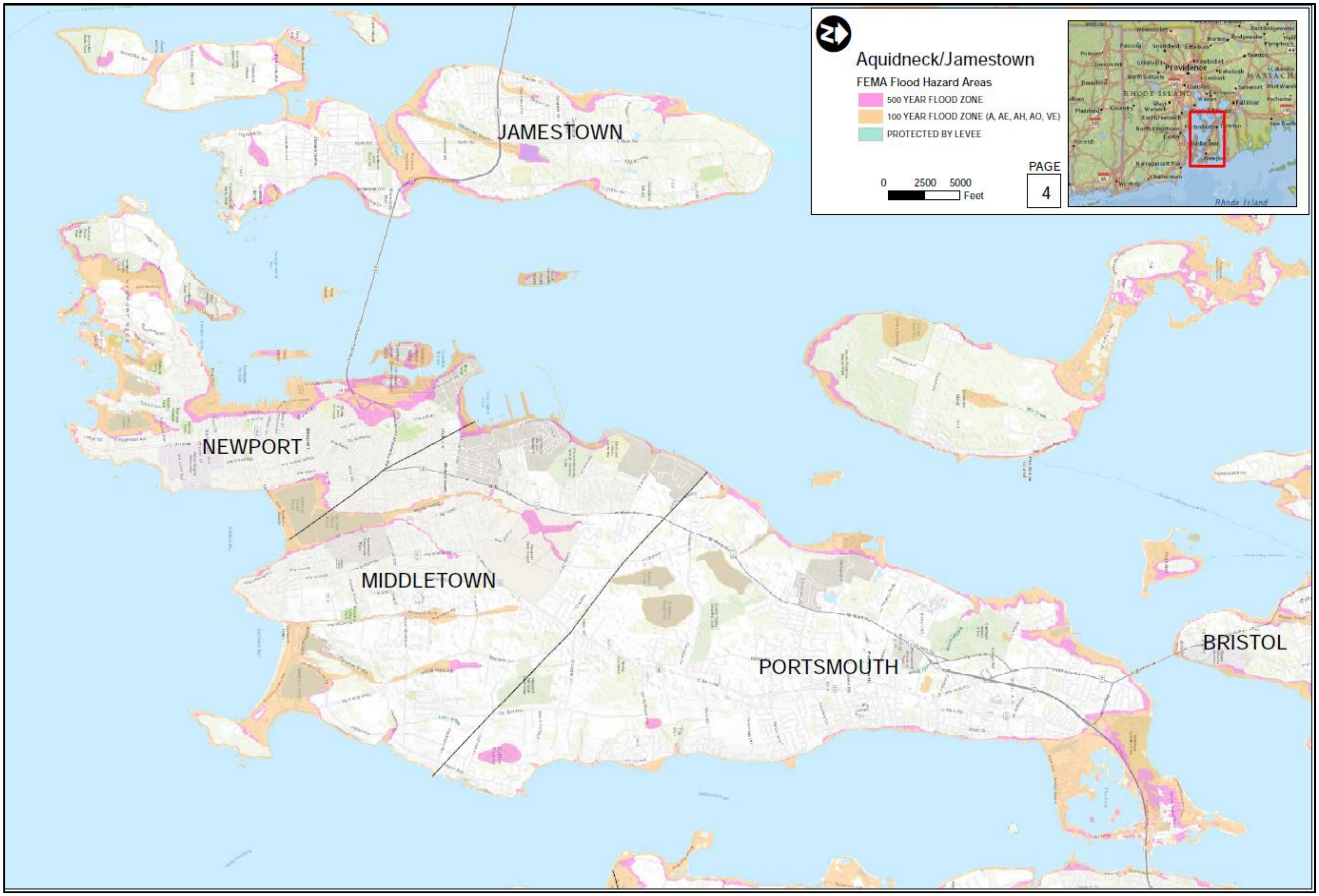

Figure 1-3: FEMA Flood Hazard Areas in Jamestown, Newport, Middletown and Portsmouth

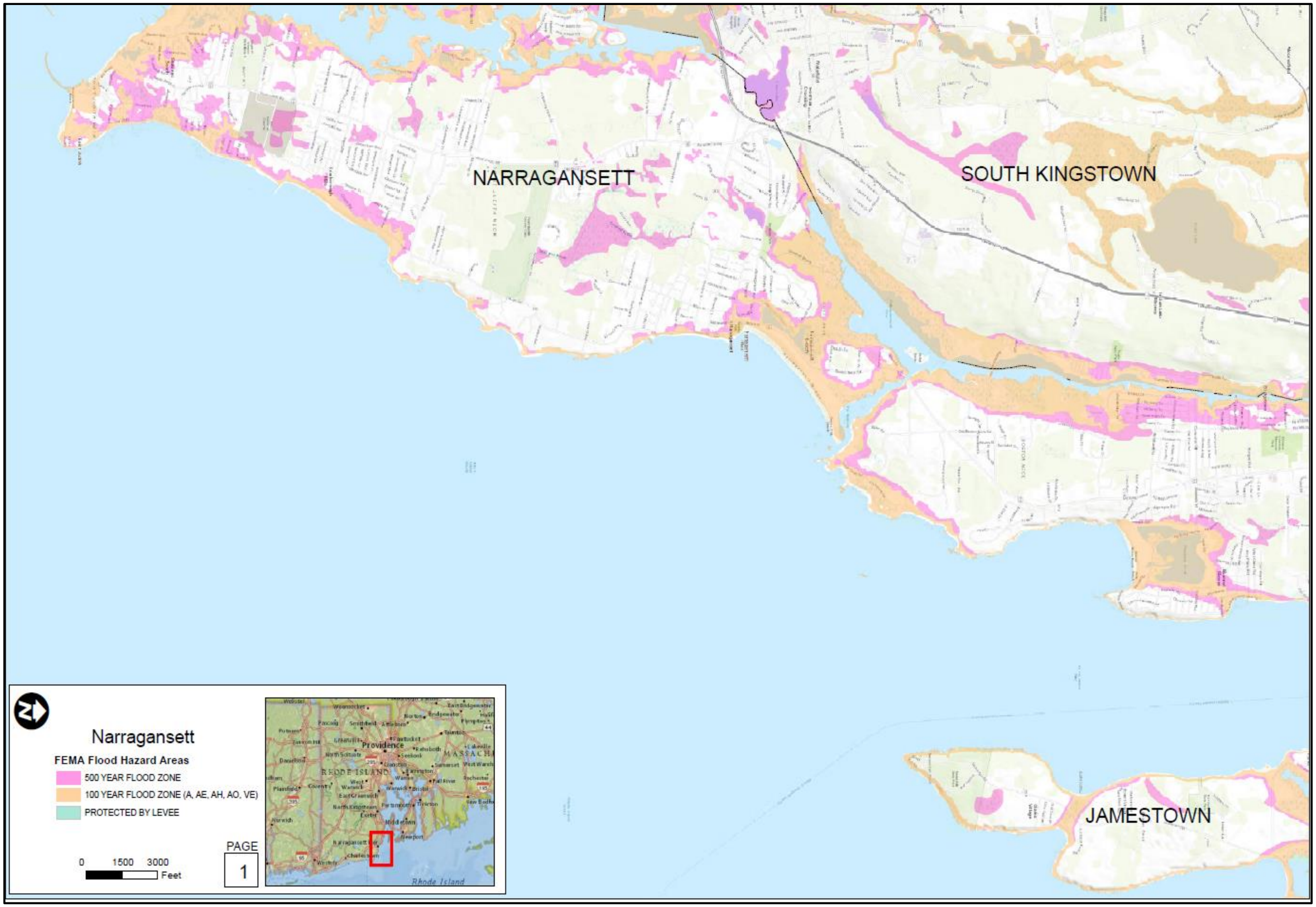

Figure 1-4: FEMA Flood Hazard Areas in Narragansett, Jamestown and South Kingstown

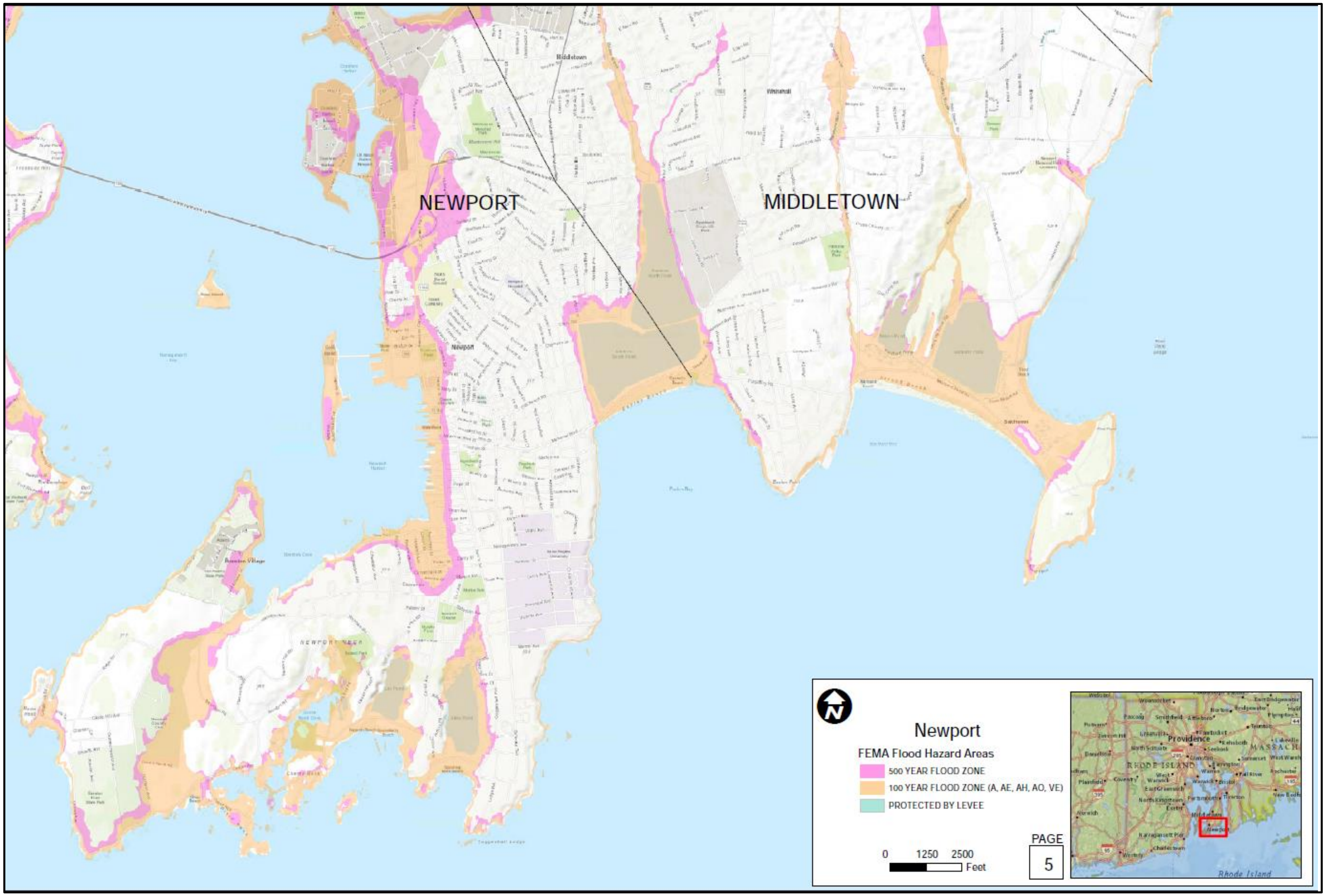

Figure 1-5: FEMA Flood Hazard Areas in Newport and Middletown

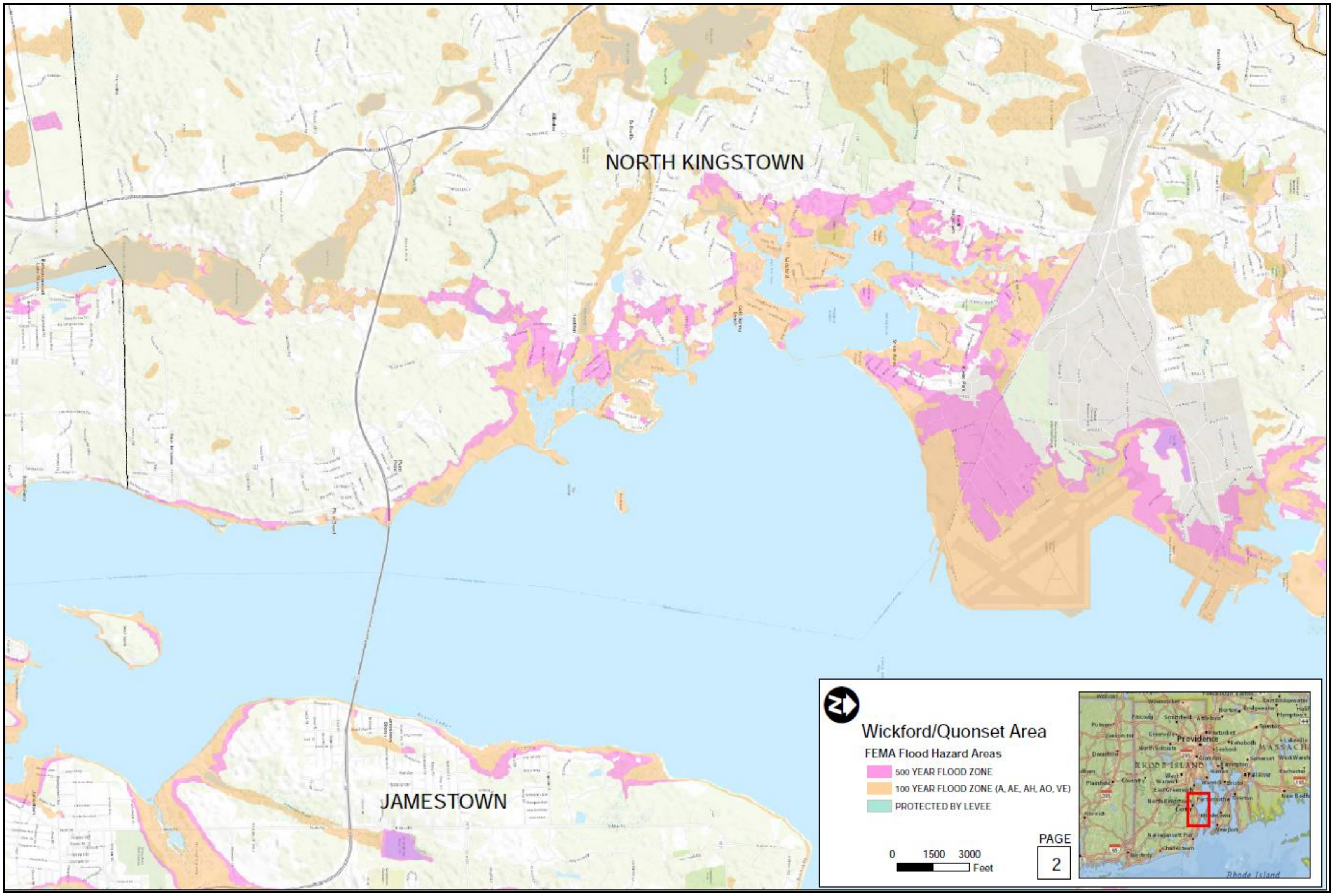

Figure 1-6: FEMA Flood Hazard Areas in North Kingstown and Jamestown

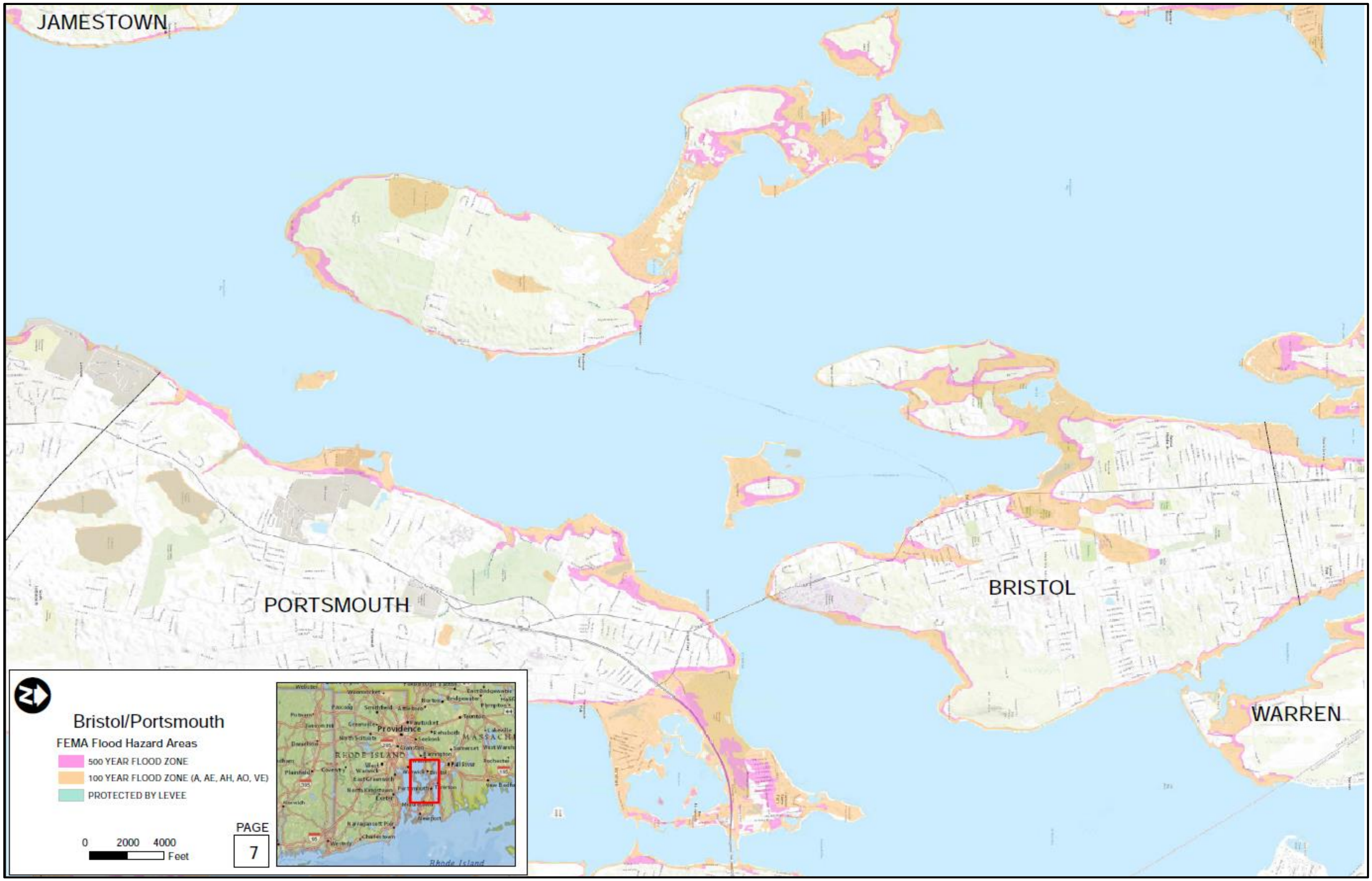

Figure 1-7: FEMA Flood Hazard Areas in Portsmouth and Bristol

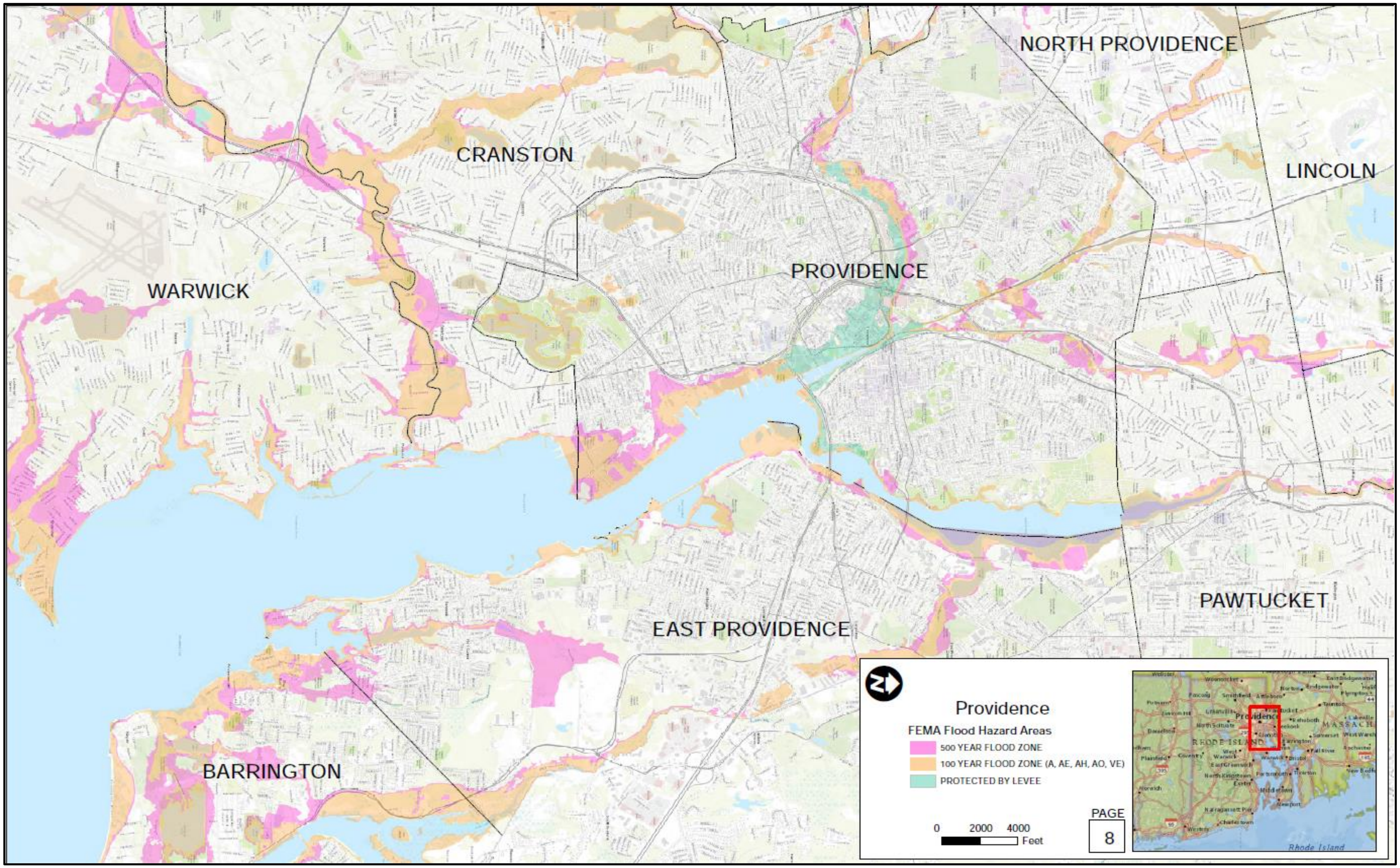

Figure 1-8: FEMA Flood Hazard Areas in Warwick, Barrington, Cranston and Providence

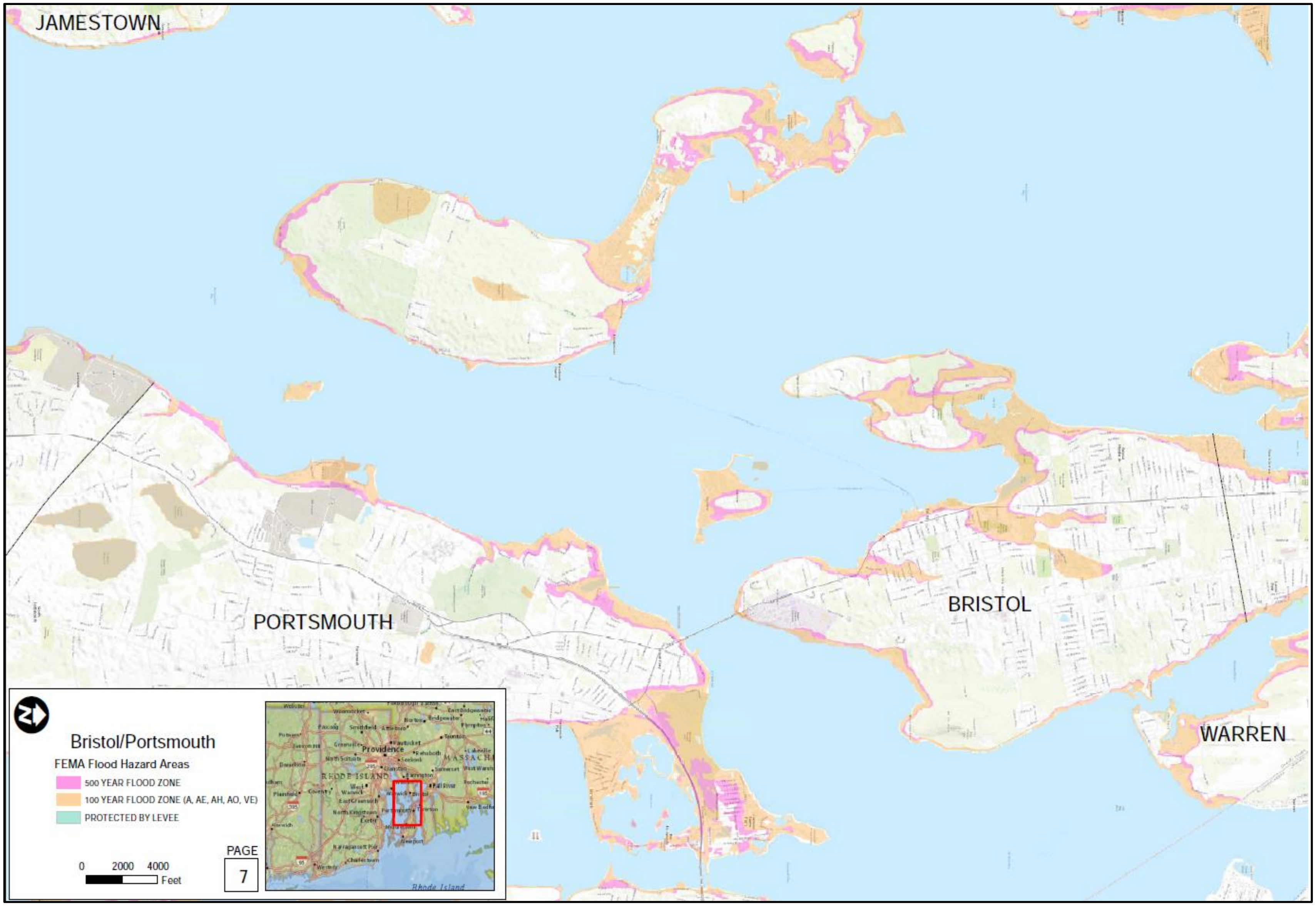

Figure 1-9: FEMA Flood Hazard Areas in Portsmouth, Bristol and Warren

SECTION 2.0 PROBLEMS AND OPPORTUNITIES

Problems are undesirable conditions to be changed through the implementation of an alternative plan. A problem statement was developed at the start of the study and led to the identification of the study objectives. The problem to be addressed in this study is:

> The shoreline and coastal tributaries of southeastern Rhode Island, from Narragansett Bay to the Massachusetts border and Block Island, experience recurring and significant coastal flooding during storm events. This flooding contributes to the risk to public safety and causes property damage within the region. Flood damage caused by storm events is expected to increase due to future sea levels rise.

CSRM is a growing concern along the entire Rhode Island coastline. Coastal storms can cause damage through a number of different processes, including storm surge, erosion and wave attack. As waves hit the shoreline, they can cause flooding and erosion. However, for much of the study area waves are limited in height due to the shallow water within Narragansett Bay, which induces dissipation and wave breaking. Block Island and south facing coastlines are typically exposed to the largest wave heights. Erosion caused by wave attack has the potential to allow water to penetrate farther inland. Storm surge is the coastal phenomenon of rising water commonly associated with low-pressure waters systems, when water levels rise above the normal tidal level. Storm surges can cause significant flooding. In addition to storm surge, coastal storms can also cause riverine flooding, when large amounts of rain fill streams and rivers and water overflows their banks. While inflows from tributaries to Narragansett Bay are relatively low, compound coastal and riverine flooding can exacerbate flooding. Non-storm tidal flooding will be an issue in certain locations in time due to sea level change. This study focused on coastal flooding, with modeling also taking into account wave contributions to flooding. Erosion and riverine flooding compound overall flooding, but these elements were not a focus of the investigation.

The coastal Rhode Island region experiences extensive inundation (flooding) from coastal storms due to the combination of low-lying topography, extensive low-lying infrastructure, and degraded coastal ecosystems. The region is almost entirely developed, with billions of dollars of largely fixed public, private, and commercial investment. The coastline within the study area is also densely populated. These factors, when considered with continued sea level change (SLC) and a general increase in storm frequency and intensity, present a challenge for many coastal communities in terms of how to manage the land sea interface with respect to property damage, coastal resiliency and life safety.

Rising sea levels causes numerous, significant water resource problems such as: increased, widespread flooding along the coast; changes in salinity gradients in estuarine areas that impact ecosystems; increased inundation at high tide; decreased capacity for storm water drainage; and declining reliability of critical infrastructure services, such as transportation, power, and communications. Addressing these problems requires a paradigm shift in how

Rhode Island residents work, live, travel, and play in a sustainable manner because a large extent of the area is at a very high risk of coastal storm damage given into the future of SLC.

The Federal Government investigates prospective projects from a national point of view. When determining the need for Federal investment in a project, the primary analysis centers on the significance of the problem and the benefits provided by possible solutions. In the RIC study, the primary goal is focused on CSRM benefits. It is also in the Federal and non-Federal sponsor's interest to select a cost-efficient plan, specifically one in which the benefits exceed the costs. It is important to note that benefits can include non-monetary benefits such as reducing life-safety issues and improving the environmental quality. In addition, the plan must be consistent with protecting the nation's environment pursuant to national and state environmental statues, with applicable Executive Orders (EO) and with other federal and state planning requirements.

Opportunities are instances in which the implementation of a plan has the potential to create a desirable future condition and provides ways to address the specific problems within the study area. The opportunities identified for the study area are:

- Manage the threat of damages to existing residential structures, commercial properties and infrastructure caused by coastal storms.
- Improve the overall resiliency of communities and manage flood risk in the future along the Rhode Island coastline (project area) in the wake of coastal storms.
- Incorporate other social effects that are affected by coastal storms, including improve community cohesion, protecting socially vulnerable communities and reducing post-storm displacement
- Manage the risk of flooding and economic damages due to sea level change through formulation analyses.

SECTION 3.0 OBJECTIVES AND CONSTRAINTS

As part of the USACE planning process, the project development team (PDT) and the stakeholders identified planning objectives and constraints.

3.1 STUDY OBJECTIVES

The planning objectives and constraints describe what a successful plan will accomplish. Planning objectives are specific statements that describe the desired measurable results of the planning process. The objective and constraint statements are used to guide the planning efforts to formulate solutions that solve the identified problems and attain the identified opportunities. The objectives for the study area over the period of analysis, from 2030 through 2079, are:

- Reduce damages to residences, business, and critical infrastructure caused by flooding resulting from coastal storms within vulnerable coastal communities adjacent to the Narragansett Bay and on Block Island through 2079.

- Reduce potential life loss related to flooding caused by coastal storms within vulnerable coastal communities adjacent to the Narragansett Bay and on Block Island through 2079.

3.2 STUDY CONSTRAINTS

Planning constraints represent restrictions that limit the extent of the planning process and potential solutions. Plans should be formulated to meet the objectives and avoid violating the constraints. Constraints can be divided into two categories: general and study specific. General planning constraints are the technical, legal, and policy constraints that are included in every planning study. Study specific planning constraints are statements unique to a specific study.

3.2.1 General Constraints

General constraint statements that alternative plans should avoid, over the period of analysis, from 2030 through 2079, are listed below.

- Plans should not increase or induce flooding elsewhere within the Rhode Island coastline.
- Plans should avoid and minimize environmental impacts within the project area to the maximum degree practicable.
- Plans should not adversely impact threatened or endangered species, and their habitat within the Rhode Island coastline.
- Plans should avoid or minimize negative impacts to commercial fisheries and Essential Fish Habitat offshore of the Rhode Island coastline.
- Plans should avoid or minimize impacts that negatively affect authorized navigation projects along the Rhode Island coastline.
- Plans should avoid or minimize impacts that contribute to poor water quality along the Rhode Island coastline.
- Plans should minimize effects on cultural resources and historic structures, sites, and features within the project area.
- Plans should fall within the USACE Flood Risk Management Business Line.

3.2.2 Study Specific Planning Constraints

Study specific considerations were also identified by the PDT. These items were considered in the plan formulation process and include:

- Due to the large project area, the plan will have to be adaptive and expansive enough to address problems of the diverse study area.
- Some communities and stakeholders may not be interested in participation in the study.
- Communities may not have the ability to support the operation and maintenance of large flood control structures.
- Non-structural plans may have low participation rates due to homeowner’s inability to support/fund nonstructural measures, which could impact the effectiveness of the plan.

SECTION 4.0 THE USACE PLANNING PROCESS

The 1983 "Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies" (P&G) and Engineering Regulation 1105-2-100, Planning Guidance Notebook, (USACE 2000), as amended, provides an iterative six (6) step planning process for USACE teams to use in developing and evaluating alternatives. The steps are:

Step 1: Specification of problems and opportunities, along with identification of objectives and constraints
Step 2: Inventory, forecast, and analysis of relevant conditions within the planning area
Step 3: Formulation of alternative plans
Step 4: Evaluation of the effects of the alternative plans
Step 5: Comparison of alternative plans
Step 6: Selection of a plan based upon the comparison of alternative plans

This process is iterative and was repeated as the team focused on the alternatives, bringing in new data, information, and stakeholder input as the study progressed. Risk analysis was incorporated in the process by acknowledging uncertainty and developing only the level of detail needed to make a risk-informed decision at each stage of the study.

The Integrated Feasibility Report and Environmental Assessment (IFR/EA) was prepared in compliance with the National Environmental Policy Act (NEPA), the Council on Environmental Quality's NEPA Regulations, and USACE's Procedures for Implementing NEPA (33 Code of Federal Regulations part 230). NEPA requires Federal agencies to integrate the environmental review into their planning and decision-making process. The IFR/EA is consistent with NEPA statutory requirements. The report reflects an integrated planning process

4.1 PLANNING FRAMEWORK

Plan formulation is the process of creating plans that meet objectives and, thereby, solve problems and realize opportunities for gain (**Figure 4-1**). Formulation has four (4) basic phases: scoping and identify measures that meet planning objectives, combine these measures into alternatives to build plans, analysis of the selected plan as necessary and review of the plan.

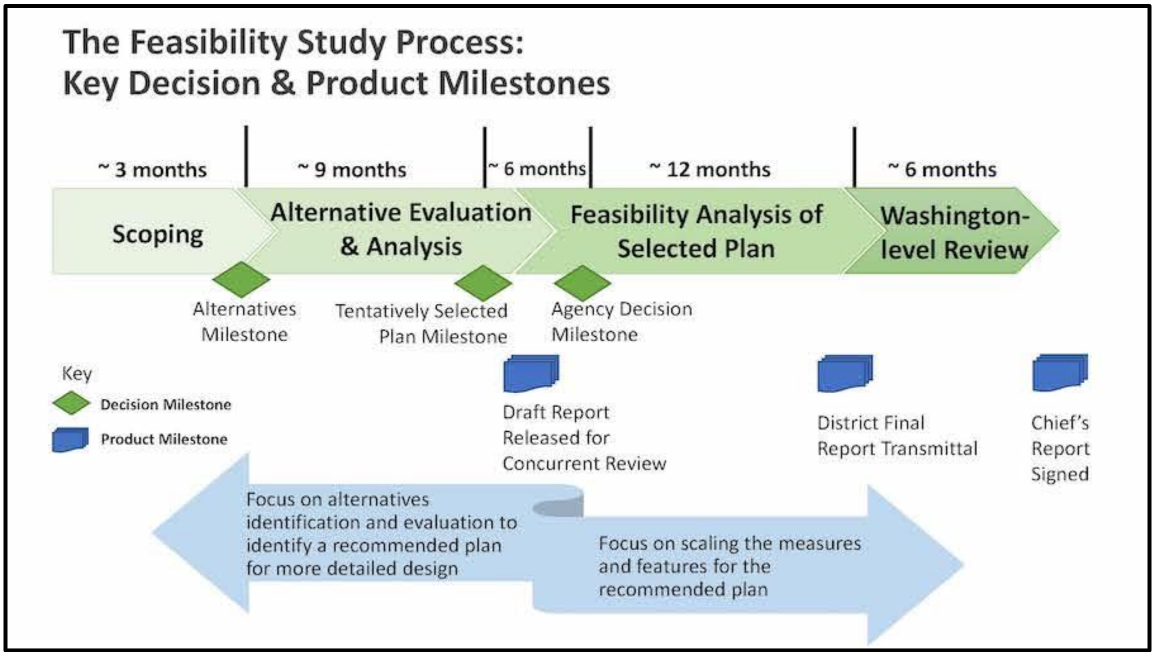

Figure 4-1: The USACE planning process

4.2 ASSUMPTIONS

4.2.1 Future Without Project Conditions Assumptions

For the Future Without Project (FWOP) conditions and the Future with Project (FWP) conditions, the structure inventory and assigned values are considered static throughout the 50-year period of analysis. Though this approach may ignore future condemnations of repeatedly damaged structures or, conversely, increases in the number or value of structures in the inventory due to future development, the variability and limitations of projecting future inventory changes over 50 years across such a wide study area are too significant to assign any reasonable level of certainty to the predicted inventory alterations. FWOP damages are used as the base condition and the reduction in damages due to implementation of project alternatives is measured against this base to evaluate the project effectiveness and cost efficiency. The FWOP modeling results are based on estimated structure damages, content damages, and vehicle damages.

4.2.2 Economic Assumptions

The Generation 2 Coastal Risk Model (G2CRM) was used to model protective system elements and evaluate damages along the coastline and inland bay areas. The structure inventory was developed based on the best available data, which may not always be complete or reliable. While steps were taken to verify data inputs, assumptions based on the foundation types assigned to each structure were applied to develop First Floor Elevation (FFE) estimates for structures used in the analysis. Another critical input used in the economic analysis was the depth-damage functions applied within the models to estimate damages associated with various occupancy types. The depth-damage functions established within the NACCS *Physical Depth Damage Function Summary Report* were specifically developed for this geographic region and determined to be the most appropriate for use on the study.

In addition, all structures within the provided parcel database were assumed to be compliant with Section 308 of the Water Resources Development Act (WRDA) of 1990. Section 308 states that structures built in the 100-year floodplain with a FFE (first floor elevations are the same as finished floor elevation, as defined by Federal Emergency Management Agency (FEMA) of less than the 100-year flood elevation after July 1, 1991, or, in the case of a county substantially located within the 100-year floodplain, any new structure built in the 10-year floodplain after July 1, 1991 shall not be included in the benefit base for justifying Federal flood damage reduction projects. The structures were assumed to be compliant since, as of October 2017, Rhode Island has ten (10) communities that have entered the FEMA Community Rating System. The application process for the Community Rating System Program can take a significant amount of time and includes a verification visit with FEMA or its contractor. It is, therefore, assumed that structures within Rhode Island conform to the Base Flood Elevation in effect when each structure was built.

4.2.3 Cost Estimating Assumptions

For the nonstructural alternatives, it is important to note that nonstructural implementation is applied on a house-by-house basis; thus, a true building retrofit (elevation and flood proofing) cost would also be developed for each structure individually based on its characteristics such as foundation type, wall type, size, condition, and available workspace. Individually surveying each structure to capture this data, however, is prohibitively time and resource intensive.

Elevation was considered for single family residences. The elevation design height was determined separately for each structure based on the 1% Annual Exceedance Probabilities (AEP) NACCS water level + wave contribution + sea level change. Costs for elevation were estimated based on structure type and foundation heights, height of raising, as well as square footage.

Floodproofing was considered for non-residential structures and large multi-family structures not in a designated VE Zone and without a basement. For floodproofing, a three (3) feet height was assumed for all measures. However, this assumes a watertight barrier of three (3) feet around the structure. It should be noted that, where applicable, additional measures, such as closures for windows and doors, may be appropriate and may provide a higher-level protection than evaluated in this analysis. Costs for floodproofing were estimated based on various ranges of structure square footage. More information on nonstructural cost estimation can be found in **Appendix E**, *Cost Engineering* and **Appendix C**, *Economic and Social Considerations*.

For aggregated cost summaries, current analysis assumes a 100% participation rate in the nonstructural alternative. In compliance with USACE's National Nonstructural Committee Best Practice Guide 2020-02 "*Considerations for Estimating Participation Rates in Voluntary Nonstructural Measures"*, further analysis will be conducted to estimate the participation rate of the study area. Identifying structures eligible for elevation and flood proofing focused on isolating structures with the highest coastal storm damage risk levels. Residential and non-residential structures with high vulnerability to coastal storm damage, whether due to geographic conditions or FFE, are considered prime candidates for such building retrofits.

4.3 MANAGEMENT MEASURES

A management measure is a feature or activity at a site, which addresses one or more of the study objectives. Coastal storm risk management measures consist of three (3) basic types: structural, nonstructural, and natural or nature-based features, and the initial array of alternatives consists of a variety of each type. Following USACE planning methodology, the construction and performance qualities of management measures and the dependencies and interactions among these measures are considered over both the short- and long-term.

4.3.1 Structural Measures Considered

Structural measures have historically been the technique most desired by the general public, as they modify flood patterns and "move floods away from people." Structural coastal storm risk management measures are man-made, constructed features that counteract a flood event by reducing the hazard or influencing the course or probability of occurrence of the event. Structural measures are features such as levees, flood walls, and gates that are implemented to reduce risk to people and property. During the initial stages of the study, the following structural measures were considered.

Storm Surge Barriers - Storm surge barriers consist of a series of movable gates that stay open under normal conditions to let navigation and flow pass but are closed when storm surges are predicted to exceed a specific water level.

Shoreline Stabilization – Shoreline stabilization includes a wide range of alternatives to control erosion. Stabilization generally uses hardened structures, built parallel to the shoreline, to protect soils and unstable banks from currents and waves. Other methods of shoreline stabilization methods include revetments, bulkheads, seawalls, and coastal wetlands. Coastal wetlands, which is described in further detail in **Section 4.3.3**, are a green infrastructure technique using native vegetation alone or in combination with low sills to stabilize the shoreline.

Breakwaters/Groins – Breakwaters are structures that are built offshore to protect the shoreline, while groins are long narrow structures that originate on a beach and extend into the water. These structures are used to reduce coastal erosion and the intensity of wave action. They trap and accumulate sediment in the areas of low energy that are created by the structures. However, these structures can also disrupt the longshore currents and result in sediment starvation downstream.

Levees, Floodwalls, Seawalls – These are structures made of stone and other materials that are built to prevent floodwaters and storm surge from reaching at risk areas. These structures are typically built parallel to the water way.

Tide Gates - Tide gates or flap gates are structures which control tidal flow such that water may flow freely when the tide sets in one direction, but which closes automatically and prevents the water from flowing in the other direction. Alternatively, a self-regulating tide gate will allow flow through the gate in both directions up to a specified water level at which point it automatically closes preventing inundation of the interior.

4.3.2 Nonstructural Measures Considered

Nonstructural management measures basically “remove people from floods,” leaving flood waters to pass unmodified. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding, instead of focusing on reducing the probability of flooding. Nonstructural coastal storm risk management measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Relocation, floodproofing, home elevation, and flood warning systems are examples of nonstructural measures. The nonstructural measures that were considered during this study include residential structure elevation, wet floodproofing, dry floodproofing, buyouts/acquisitions, and relocations. In addition, the USACE considered non-physical nonstructural measures, such as flood warning systems, land use regulations emergency response plan and low-impact development / green infrastructure.

Elevate Structures - This nonstructural technique lifts an existing structure to an elevation that is at least equal to or greater than the 1% annual exceedance probability flood elevation to limit floodwaters from reaching living areas. In many elevation scenarios, the cost of elevating a structure an extra foot or two is less expensive than the first foot, due to the cost incurred for mobilizing equipment. Elevation can be performed using fill material, on extended foundation walls, on piers, post, piles, and columns. Elevation is also a very successful technique for slab on grade structures.

Wet Floodproofing - Wet floodproofing is a nonstructural technique that allows floodwaters to enter an enclosed area of a structure without damaging the structure or its contents. This measure is applicable as either a stand-alone measure or as a measure combined with other measures such as elevation. As a stand-alone measure, all construction materials and finishing materials need to be water resistant and all utilities must be elevated above the design flood elevation. Wet floodproofing is applicable to commercial and industrial structures when combined with a flood warning system.

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

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

Buy-out / Acquisition - This nonstructural technique consists of buying the structure and the land. The structure is demolished, and the land is allowed to return to its natural state. Property owners would be relocated in accordance with the Uniform Relocation Assistance and Real Property Acquisitions Act of 1970 as amended, (42 U.S.C. 4601 et seq.).

Flood Warning System - A flood warning system is a way of detecting threatening events in advance to warn the public to take actions to reduce the adverse effects of the event. As such, the primary objective of a flood warning system is to reduce exposure to coastal flooding or remove people from the flood. Local flood warning systems are the responsibility of the local government.

Emergency Response Plan - An emergency response plan is a set of written procedures for dealing with emergencies that minimize the impact of the event and facilitate recovery from the event. The objective of an emergency response plan is to prevent fatalities and injuries, reduce damage to structures and content, and accelerate the resumption of normal activities.

Land Use Regulations - Land use and zoning laws involve the regulation of the use and development of real estate. The basics principles of these tools are based nationally in the NFIP, which requires minimum standards of floodplain regulation for those communities that participate in the NFIP. For example, land use regulations may identify where development can or cannot occur, or to what elevation structures should locate their lowest habitable floor.

4.3.3 Natural or Nature-Based Features Considered

Natural or Nature-Based Features (NNBF) refer to those features that define natural coastal landscapes and are either naturally occurring or have been engineered to mimic natural conditions. Examples of NNBF include beaches and dunes; vegetated environments such as maritime forests, salt marshes, freshwater wetlands, and seagrass beds; coral and oyster reefs, and barrier islands. For this study, three (3) NNBFs that attenuate waves and or slow and store tidal flooding, were considered. These included living shorelines and reefs.

Coastal Wetlands – This technique uses vegetation, with or without low sills and reefs, to stabilize the shoreline. Coastal wetlands "provide a natural alternative to 'hard' shoreline stabilization methods like rip rap or bulkheads, and provide numerous benefits nutrient pollution remediation, essential fish habitat structure, and buffering of shorelines from waves and storms." NOAA research indicates that coastal wetlands are more resilient than bulkheads in protecting against the effects of hurricanes. (National Oceanic and Atmospheric Administration 2021b)

Reefs – The construction of reefs can protect the shoreline against the impacts of coastal storms. These structures stabilize bottom sediments, reduce wave energy and prevent erosion.

Beach Nourishment – This is a "soft armoring" technique where large qualities of sand are added to a beach to combat erosion. The sand increases the width of the beach. This is not a permanent solution, as waves, storms, and rising sea level continues to erode the beach. Therefore, renourishment is typical required after a certain amount of time.

4.3.4 Initial Screening of Measures

The list of measures that would address coastal storm risk was developed and applied to each of the eleven (11) focus areas. Each measure was assessed on whether it would meet a series of criteria. First the measures were compared against the two (2) study objectives. In order for a measure to be carried forward for further analysis it had to meet both study objectives. Next, the feasibility of each measure was considered. A measure was carried forward only if it was determined to be constructable and if, without completing a full economic analysis, it was estimated to be economically justified. Finally, a measure was eliminated from consideration if it would have a significant negative impact on coastal access or use, the environment or existing storm protection measures. The questions that were considered during the initial screening iteration are listed below.

1. Did the alternative address study objectives?
    a. Would the measure reduce coastal storm hazard damages?
    b. Does the measure provide protection for health/safety?

2. Is the measure feasible?
    a. Is the measure constructable?
    b. Is the measure economically justified?

3. Will the measure cause adverse impacts?
    a. Will the measure restrict or significantly alter current coastal access or use?
    b. Will the measure have significant impacts on the environment?
    c. Will the measure adversely impact existing storm protection measures?

The tables that include (**Tables 4-1 through 4-11**) below are the complete initial screening analysis for all management measures considered in each problem area. This initial screening, not including the No Action Alternative (NAA), resulted in 28 management measures, shown in **Table 4-12** of the Main Report that were kept for additional study.

Table 4-1: Management measures considered for the Barrington/Warren focus project area

Barrington Measures Screening										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversley impacts existing storm protection measures?		
Structural	Storm Surge Barrier	Yes	Yes	Yes	Potentially	Yes	Yes	No	YES	
	Beach Nourishment	No	No	No	No	No	No	No	NO	
	Breakwater	No	No	Yes	No	No	Yes	No	NO	
	Groins	No	No	Yes	No	No	Yes	No	NO	
	Shoreline Stabilization	Yes	Yes	Yes	Potentially	No	No	No	YES	
	Levees/Floodwalls	Yes	Yes	Yes	Yes	No	Yes	No	YES	
	Seawall	No	No	No	No	No	No	No	NO	
	Tide Gates	Yes	Yes	Yes	No	No	No	No	YES	
NNBF	Reefs	No	No	No	No	Potentially	No	No	NO	
	Coastal Wetlands	No	No	No	No	Potentially	No	No	NO	
Non-Structural	Acquisition/ Relocation	Yes	Yes	Yes	Yes	No	No	No	YES	
	Road Elevation	Yes	Yes	Not likely	Potentially	No	No	No	YES	
	Floodproofing	Yes	Yes	Yes	Yes	No	No	No	YES	
	Structure Raising	Yes	Yes	Yes	Yes	No	No	No	YES	
	Land Use Development Regulations	No	No	No	No	Yes	No	No	NO	

Table 4-2: Management measures considered for the Block Island focus project area

Block Island – Initial Management Measures									
Measures		Objectives		Feasibility		Impacts			
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?	Retained for Further Evaluation?
Structural	**Storm Surge Barrier**	No	No	No	No	Yes	Yes	No	**NO**
	Beach Nourishment	Yes	Yes	Yes	Yes	No	No	No	**YES**
	Breakwater	Yes	Yes	Yes	No	No	Yes	No	**NO**
	Groins	No	No	Yes	No	No	Yes	No	**NO**
	Shoreline Stabilization	Yes	Yes	Yes	Yes	No	No	No	**YES**
	Levees/Floodwalls	Yes	Yes	Potentially	Not Likely	No	Yes	No	**NO**
	Seawall	Yes	Yes	Yes	Not Likely	No	Yes	No	**NO**
	Tide Gates	No	No	No	No	No	No	No	**NO**
NNBF	**Reefs**	Not Likely	Not Likely	Yes	Potentially	Potentially	No	No	**NO**
	Coastal Wetlands	Not Likely	Not Likely	Yes	Potentially	Potentially	No	No	**NO**
Non-Structural	**Acquisition/ Relocation**	No	No	No	No	No	No	No	**NO**
	Road Elevation	Yes	Yes	Yes	Potentially	No	Unlikely	No	**YES**
	Floodproofing	No	No	No	No	No	No	No	**NO**
	Structure Raising	No	No	No	No	No	No	No	**NO**
	Land Use Development Regulations	No	No	No	No	Yes	No	No	**NO**

Table 4-3: Management measures considered for the Bristol focus project area

Bristol – Initial Management Measures										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversley impacts existing storm protection measures?		
Structural	**Storm Surge Barrier**	Yes	Yes	Yes	Potentially	Yes	Yes	No	**NO**	Surge Barrier being considered for entire study area, not just Newport.
	Beach Nourishment	No	No	No	No	No	No	No	**NO**	
	Breakwater	No	No	Yes	No	No	Yes	No	**NO**	
	Groins	No	No	Yes	No	No	Yes	No	**NO**	
	Shoreline Stabilization	No	No	Yes	No	No	No	No	**NO**	
	Levees/Floodwalls	Yes	Yes	Yes	Yes	No	Yes	No	**YES**	
	Seawall	Yes	No	Potentially	Potentially	No	No	No	**YES**	
	Tide Gates	Yes	Yes	Yes	No	No	No	No	**YES**	Tide gates may need to be a part of a complete project, but do not provide any standalone value.

Bristol – Initial Management Measures										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversley impacts existing storm protection measures?		
NNBF	Reefs	No	No	No	No	Potentially	No	No	NO	
	Coastal Wetlands	No	No	No	No	Potentially	No	No	NO	
Non-Structural	Acquisition/Relocation	Yes	Yes	Yes	Yes	No	No	No	YES	
	Road Elevation	Yes	Yes	Not likely	Not likely	No	No	No	NO	
	Floodproofing	Yes	Yes	Yes	Yes	No	No	No	YES	
	Structure Raising	Yes	Yes	Yes	Yes	No	No	No	YES	
	Land Use Development Regulations	No	No	No	No	Yes	No	No	NO	

Table 4-4: Management measures considered for the Jamestown focus project area

Jamestown – Initial Management Measures										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?		
Structural	Storm Surge Barrier	No	No	No	No	No	No	No	NO	
	Beach Nourishment	No	No	Yes	No	No	No	No	NO	
	Breakwater	No	No	Yes	No	No	Yes	No	NO	
	Groins	No	No	Yes	No	No	Yes	No	NO	
	Shoreline Stabilization	No	No	Yes	No	No	No	No	NO	
	Levees/ Floodwalls	Yes	Yes	Yes	Yes	No	Yes	No	YES	Only potentially viable option
	Seawall	No	No	Yes	No	No	No	No	NO	
	Tide Gates	No	No	No	No	No	No	No	NO	
NNBF	Reefs	No	No	Yes	No	Potentially	No	No	NO	
	Coastal Wetlands	No	No	Yes	No	Potentially	No	No	NO	
Non-Structural	Acquisition/Relocation	No	No	No	No	No	No	No	NO	
	Road Elevation	Yes	Yes	No	No	No	No	No	NO	
	Floodproofing	No	No	No	No	No	No	No	NO	
	Structure Raising	No	No	No	No	No	No	No	NO	
	Land Use Development Regulations	No	No	No	No	No	No	No	NO	

Table 4-5: Management measures considered for the Newport Downtown focus project area

Newport Downtown – Initial Management Measures										
Measures		Objectives		Feasibility		Impacts				
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?	Retained for Further Evaluation?	Notes
Structural	**Storm Surge Barrier**	Yes	Yes	Yes	Yes	Yes	Yes	No	**NO**	Surge Barrier being considered for entire study area, not just Newport.
	Beach Nourishment	No	No	Yes	No	No	No	No	**NO**	
	Breakwater	No	No	Yes	No	No	Yes	No	**NO**	
	Groins	No	No	Yes	No	No	Yes	No	**NO**	
	Shoreline Stabilization	No	No	Yes	No	No	No	No	**NO**	
	Road Raisings	Yes	Yes	Not Likely	Not Likely	No	No	No	**NO**	
	Levees/floodwalls	Yes	Yes	Yes	Yes	No	No	No	**YES**	
	Seawall	Yes	Yes	Yes	Yes	No	Yes	No	**YES**	

Newport Downtown – Initial Management Measures											
Measures		Objectives		Feasibility		Impacts					
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?	Retained for Further Evaluation?	Notes
	Tide Gates	Yes	Yes	Y- es	No	No	No	No	**YES**	Tide gates could be considered as supplemental features. Not enough information at this time.
NNBF	**Coastal Wetlands**	No	No	Yes	No	Yes	No	No	**NO**	
	Reefs	No	No	Yes	No	Yes	No	No	**NO**	
Non-Structural	**Acquisition/Relocation**	No	No	No	No	No	No	No	**NO**	
	Floodproofing	Yes	Yes	Yes	Potentially	No	No	No	**YES**	
	Structure Raising	Yes	Yes	Yes	Potentially	No	No	No	**YES**	
	Land Use Development Regulations	No	No	No	No	Yes	No	No	**NO**	

Table 4-6: Management measures considered for the Newport Reservoir focus project area

Newport Reservoir – Initial Management Measure										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?		
Structural	Storm Surge Barrier	No	No	No	No	No	No	No	NO	
	Beach Nourishment	No	No	Yes	No	No	No	No	NO	
	Breakwater	No	No	Yes	No	No	Yes	No	NO	
	Groins	No	No	Yes	No	No	Yes	No	NO	
	Shoreline Stabilization	No	No	Yes	No	No	No	No	NO	
	Reoad Raisings	Yes	Yes	Not Likely	Not Likely	No	No	No	NO	
	Levees/floodwalls	Yes	Yes	Yes	Yes	No	No	No	YES	
	Seawall	Yes	Yes	Yes	Yes	No	Yes	No	YES	
	Tide Gates	No	No	Yes	No	No	No	No	NO	
NNBF	Coastal Wetlands	No	No	Yes	No	Yes	No	No	NO	
	Reefs	No	No	Yes	No	Yes	No	No	NO	
Non-Structural	Acquisition/Relocation	No	No	No	No	No	No	No	NO	
	Floodproofing	No	No	No	No	No	No	No	NO	
	Structure Raising	No	No	No	No	No	No	No	NO	
	Land Use Development Regulations	No	No	No	No	Yes	No	No	NO	

Table 4-7: Management measures considered for the Narragansett focus project area

Narragansett- Initial Management Measures									
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures	
Structural	**Storm Surge Barrier**	No	No	No	No	Yes	Yes	No	**NO**
	Beach Nourishment	No	No	Yes	No	No	No	No	**NO**
	Breakwater	No	No	Yes	No	No	Yes	No	**NO**
	Groins	No	No	Yes	No	No	Yes	No	**NO**
	Shoreline Stabilization	Yes	Yes	Yes	Yes	No	No	No	**YES**
	Levees/Floodwalls	Yes	Yes	Yes	Yes	No	Yes	No	**YES**
	Seawall	Yes	Yes	Yes	Yes	No	No	No	**YES**
	Tide Gates	Yes	Yes	Yes	Yes	No	No	No	**YES**
NNBF	**Reefs**	No	No	No	No	Potentially	No	No	**NO**
	Coastal Wetlands	No	No	No	No	Potentially	No	No	**NO**
Non-Structural	**Acquisition/Relocation**	Yes	Yes	Yes	Yes	No	No	No	**YES**
	Road Elevation	Yes	Yes	No	No	No	No	No	**NO**
	Floodproofing	Yes	Yes	Yes	Yes	No	No	No	**YES**
	Structure Raising	Yes	Yes	Yes	Yes	No	No	No	**YES**
	Land Use Development Regulations	No	No	No	No	Yes	No	No	**NO**

Table 4-8: Management measures considered for the North Kingstown focus project area

North Kingstown – Initial Management Measures									
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?	
Structural	Storm Surge Barrier	Yes	Yes	Yes	Potentially	Yes	Yes	No	NO
	Beach Nourishment	No	No	No	No	No	No	No	NO
	Breakwater	No	No	Yes	No	No	Yes	No	NO
	Groins	No	No	Yes	No	No	Yes	No	NO
	Shoreline Stabilization	No	No	Yes	No	No	No	No	NO
	Levees/Floodwalls	Yes	Yes	Yes	Yes	No	Yes	No	YES
	Seawall	Yes	No	Potentially	Potentially	No	No	No	YES
	Tide Gates	Yes	Yes	Yes	No	No	No	No	YES
NNBF	Reefs	No	No	No	No	Potentially	No	No	NO
	Coastal Wetlands	No	No	No	No	Potentially	No	No	NO
Non-Structural	Acquisition/Relocation	Yes	Yes	Yes	Yes	No	No	No	YES
	Road Elevation	Yes	Yes	Not likely	Not likely	No	No	No	NO
	Floodproofing	Yes	Yes	Yes	Yes	No	No	No	YES
	Structure Raising	Yes	Yes	Yes	Yes	No	No	No	YES
	Land Use Development Regulations	No	No	No	No	Yes	No	No	NO

Table 4-9: Management measures considered for the Portsmouth focus project area

Portsmouth– Initial Management Measures										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?		
Structural	Storm Surge Barrier	Yes	Yes	Yes	Yes	Yes	Yes	No	NO	Surge Barrier being considered for entire study area, not just Portsmouth
	Beach Nourishment	No	No	Yes	No	No	No	No	NO	
	Breakwater	No	No	Yes	No	No	Yes	No	NO	
	Groins	No	No	Yes	No	No	Yes	No	NO	
	Shoreline Stabilization	No	No	Yes	No	No	No	No	NO	
	Levees/Floodwalls	Yes	Yes	No	No	No	Yes	No	NO	
	Seawall	Yes	Yes	Yes	Not Likely	No	No	No	NO	In order for a seawall to provide value it would need to be built in conjunction with another perimeter type protection measure, which do not appear to be constructible/economically justified in this area. Improvements to the

Portsmouth– Initial Management Measures

Measures		Objectives: Reduce coastal storm hazards & damages?	Objectives: Provide protection for health/safety?	Feasibility: Constructible?	Feasibility: Economically Justifiable?	Impacts: Restrict or significantly alter current coastal access & use?	Impacts: Potentially significant impacts to the environment?	Impacts: Adversely impacts existing storm protection measures?	Retained for Further Evaluation?	Notes
										existing seawall could be a part of a regional surge barrier project
	Tide Gates	Yes	Yes	Yes	No	No	No	No	**NO**	Tide gates may help with moving floodwaters out of the problem area, but would not provide any standalone value
NNBF	**Reefs**	No	No	Yes	No	Potentially	No	No	**NO**	
	Coastal Wetlands	No	No	Yes	No	Potentially	No	No	**NO**	
Non-Structural	**Acquisition/Relocation**	Yes	Yes	Yes	Yes	No	No	No	**YES**	
	Road Elevation	No	No	Not likely	No	No	No	No	**NO**	
	Floodproofing	Yes	Yes	Yes	Yes	No	No	No	**YES**	
	Structure Raising	Yes	Yes	Yes	Yes	No	No	No	**YES**	
	Land Use Development Regulations	No	No	No	No	Yes	No	No	**NO**	

Table 4-10: Management measures considered for the Providence focus project area

Providence – Initial Management Measures										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?		
Structural	Storm Surge Barrier	Yes	Yes	Yes	Potentially	Yes	Yes	No	NO	Surge Barrier being considered for entire study area, not just Providence
	Beach Nourishment	No	No	No	No	No	No	No	NO	
	Breakwater	No	No	Yes	No	No	Yes	No	NO	
	Groins	No	No	Yes	No	No	Yes	No	NO	
	Shoreline Stabilization	No	No	Yes	No	No	No	No	NO	
	Levees/Floodwalls	Yes	Yes	Yes	Yes	No	Yes	No	YES	
	Seawall	Yes	Yes	Yes	Yes	No	No	No	YES	
	Tide Gates	No	No	Yes	No	No	No	No	NO	
NNBF	Reefs	No	No	No	No	Potentially	No	No	NO	

Providence – Initial Management Measures

Measures		Objectives: Reduce coastal storm hazards & damages?	Objectives: Provide protection for health/safety?	Feasibility: Constructible?	Feasibility: Economically Justifiable?	Impacts: Restrict or significantly alter current coastal access & use?	Impacts: Potentially significant impacts to the environment?	Impacts: Adversely impacts existing storm protection measures?	Retained for Further Evaluation?	Notes
	Coastal Wetlands	No	No	No	No	Potentially	No	No	**NO**	
Non-Structural	**Acquisition/ Relocation**	Yes	Yes	Yes	Yes	No	No	No	**YES**	
	Road Elevation	No	No	No	No	No	No	No	**NO**	
	Floodproofing	Yes	Yes	Yes	Yes	No	No	No	**YES**	
	Structure Raising	Yes	Yes	Yes	Yes	No	No	No	**YES**	
	Land Use Development Regulations	No	No	No	No	Yes	No	No	**NO**	

Table 4-11: Management measures considered for the Warwick focus project area

Warwick – Initial Management Measures										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?		
Structural	Storm Surge Barrier	Yes	Yes	Yes	Potentially	Yes	Yes	No	NO	Surge Barrier being considered for entire study area, not just Newport.
	Beach Nourishment	No	No	Yes	No	No	No	No	NO	
	Breakwater	No	No	Yes	No	No	Yes	No	NO	
	Groins	No	No	Yes	No	No	Yes	No	NO	
	Shoreline Stabilization	No	No	Yes	No	No	No	No	NO	
	Levees/Floodwalls	Yes	Yes	Yes	Yes	No	Yes	No	YES	
	Seawall	No	No	No	No	No	No	No	NO	
	Tide Gates	Yes	Yes	Yes	No	No	No	No	YES	Tide gates may need to be a part of a complete project, but do not provide any standalone value.

Warwick – Initial Management Measures										
Measures		Objectives		Feasibility		Impacts			Retained for Further Evaluation?	Notes
		Reduce coastal storm hazards & damages?	Provide protection for health/safety?	Constructible?	Economically Justifiable?	Restrict or significantly alter current coastal access & use?	Potentially significant impacts to the environment?	Adversely impacts existing storm protection measures?		
NNBF	Reefs	No	No	No	No	Potentially	No	No	NO	
	Coastal Wetlands	No	No	No	No	Potentially	No	No	NO	
Non-Structural	Acquisition/Relocation	Yes	Yes	Yes	Yes	No	No	No	YES	
	Road Elevation	Yes	Yes	Not likely	Not likely	No	No	No	NO	
	Floodproofing	Yes	Yes	Yes	Yes	No	No	No	YES	
	Structure Raising	Yes	Yes	Yes	Yes	No	No	No	YES	
	Land Use Development Regulations	No	No	No	No	Yes	No	No	NO	

Table 4-12: Array of management measures after the first screening iteration

Initial Array of Measures			
ID #	**Description**	**Location**	**Management Measure**
NAA	No Action	Entire Study Area	N/A
NS	Nonstructural	Entire Study Area	Structure Raising/Floodproofing
R3	3-Segment Narragansett Bay Barrier	Entire Study Area	Storm Surge Barrier
R4	2-Segment Narragansett Bay Barrier	Entire Study Area	Storm Surge Barrier
J1	No Action	Jamestown	N/A
J2	Newport Bridge Approach Protection	Jamestown	Levee/Floodwall
ND1	No Action	Newport Downtown	N/A
ND2	Nonstructural	Newport Downtown	Structure Raising/Floodproofing
ND3	Point Area Perimeter	Newport Downtown	Point Area Floodwall
ND4	Wellington Perimeter	Newport Downtown	Wellington Area Floodwall/Levee
NR1	No Action	Newport Reservoirs	N/A
NR2	Easton Pond Perimeter Only	Newport Reservoirs	Easton Pond Perimeter Levee
NR3	Memorial Boulevard Barrier Only	Newport Reservoirs	Memorial Boulevard Barrier Levee
NR4	Gardner Pond Barrier only	Newport Reservoirs	Gardner Pond Perimeter Levee
NR5	Sachuest Road	Newport Reservoirs	Sachuest Road Floodwall/Dune
BI1	No Action	Block Island	No Action
BI2	Corn Neck Road Raising	Block Island	Elevation of Corn Neck Road
BI3	Corn Neck Road Beach Nourishment	Block Island	Beach Nourishment
BI4	Corn Neck Road Stabilization (Hard)	Block Island	Rock Revetment
BI5	Corn Neck Road Stabilization (NNBF)	Block Island	Sill/Reef-based coastal wetlands
BI6	Corn Neck Road Stabilization & NNBF	Block Island	Combination of Revetment & NNBF
PO1	No Action	Portsmouth	N/A
PO2	Nonstructural	Portsmouth	Structure Raising/Floodproofing
PO3	Common Fence Perimeter	Portsmouth	Floodwall/Levee
PO4	Island Park Perimeter	Portsmouth	Floodwall/Levee
BW1	No Action	Barrington/Warren	N/A
BW2	Nonstructural	Barrington/Warren	Structure Raising/Floodproofing
BW3	Warren River Surge Barrier (Upper)	Barrington/Warren	Surge Barrier
BW4	Warren River Surge Barrier (Lower)	Barrington/Warren	Surge Barrier
BW5	Mathewson Road Protection	Barrington/Warren	Rock Revetment
BW6	Belchers Cove Perimeter	Barrington/Warren	Belchers Cove Levee/Floodwall
BW7	Route 114 Floodproofing	Barrington/Warren	Route 114 Levee/Floodwall
BR1	No Action	Bristol	N/A
BR2	Nonstructural	Bristol	Structure Raising/Floodproofing
BR3	Bike Path Levee	Bristol	Raise Existing Bike Path
PR1	No Action	Providence	N/A
PR2	Nonstructural	Providence	Structure Raising/Floodproofing

Initial Array of Measures			
ID #	Description	Location	Management Measure
PR3	Providence Harbor Bulkhead	Providence	Bulkhead
PR4	Fields Point Levee/Bulkhead	Providence	Levee/Floodwall
WA1	No Action	Warwick	N/A
WA2	Nonstructural	Warwick	Structure Raising/Floodproofing
WA3	West Shore Road Barrier	Warwick	Bulkhead/Floodwall/Levee
NA1	No Action	Narragansett	N/A
NA2	Nonstructural	Narragansett	Structure Raising/Floodproofing
NA3	Pier Area Protection	Narragansett	Floodwall/Levee/Revetment
NA4	Middle Bridge Protection	Narragansett	Middle Bridge Barrier

4.4 ARRAY OF ALTERNATIVES

4.4.1 Second Screening Iteration

The second screening iteration involved a quantitative analysis. During this screening iteration, measures were combined into a basic initial array of alternatives. For most alternatives that were brought forward from the initial screening, rough costs and benefits were developed. NACCS parametric costs were used to develop project costs and National Structure Inventory structure data was used to develop rough Benefit/Cost Ratios (BCRs). These alternatives fell into three categories. The first group were alternatives, identified in dark grey in **Table 4-13**, that were removed from further consideration, because they had a BCR significantly lower than 1.0. The next group of alternatives (highlighted in white in **Table 4-13**) had BCRs greater than 1.0 and were carried forward to the next round of screenings. For the remaining alternatives (identified in light gray in **Table 4-13**), the PDT did not have sufficient information to develop accurate BCRs at that point in the study. These alternatives were also carried forward into the next screening iteration, allowing the PDT to continue to develop the designs, costs and benefits of each alternative.

There were a number of alternatives that were removed from consideration during this iteration without the development of a BCR. All alternatives that involving the Newport Reservoirs were removed from consideration. The facility staff indicated that they did not want to participate in the project and declined to provide data necessary to complete the analysis. NNBFs were also removed from consideration. In compliance with WRDA of 2016, Section 1184(b), the PDT considered three (3) NNBFs (coastal wetlands, beach nourishment and reefs) as management measures for the RIC study. The main coastal hazard within the RIC study area is storm surge. Both reefs and coastal wetlands are more effective at dissipating wave energy, and less effective at decreasing storm surge. While coastal wetlands such as marshes have been shown to decrease storm surge in some settings, they require large areas on the order of miles, to be effective. No opportunities for such a large-scale project were located within the study area.

Table 4-13: Initial array of alternatives after the second screening iteration

Alternative		Location	Measures	Project Cost ($)	Annual Cost ($)	Annual Damage Reduced ($)	BCR	Carried Forward?
NAA	No Action	Entire Study Area	No Action	N/A	N/A	N/A	N/A	YES
NS	Non-Structural	Entire Study Area	Structure Raising/Floodproofing	848,200,000	32,189,190	111,498,877	3.46	YES
R3	3-Segment Narragansett Bay Barrier	Entire Study Area	Storm Surge Barrier	23,175,000,000	879,491,250	200,697,978	0.23	NO
R4	2-Segment Narragansett Bay Barrier	Entire Study Area	Storm Surge Barrier	55,575,000,000	2,109,071,250	200,697,977	0.10	NO
J1	No Action	Jamestown	No Action	N/A	N/A	N/A	N/A	YES
J2	Newport Bridge-Approach Protection	Jamestown	Levee/Floodwall	33,120,000	1,256,904			YES
ND1	No Action	Newport Downtown	No Action	N/A	N/A	N/A	N/A	YES
ND2	Non-Structural	Newport Downtown	Structure Raising/Floodproofing	75,200,000	2,853,840	4,288,786	1.50	YES
ND3	Point Area Perimeter Only	Newport Downtown	Point Area Floodwall	28,885,000	1,096,186	2,143,367	1.96	YES
ND4	Wellington Perimeter Only	Newport Downtown	Wellington Area Floodwall/Levee	11,289,411	428,433	565,108	1.32	YES
ND5	Point and Wellington Area Perimeter Protection	Newport Downtown	Combination	40,174,411	1,524,619	2,708,475	1.78	YES
NR1	No Action	Newport Reservoirs	No Action	N/A	N/A	N/A	N/A	NO
NR2	Easton Pond Perimeter Only	Newport Reservoirs[1]	Easton Pond Perimeter Levee	28,800,000	1,092,960	N/A	N/A	NO
NR3	Memorial Blvd Barrier Only	Newport Reservoirs[1]	Memorial Blvd Floodwall	19,240,000	730,158	N/A	N/A	NO
NR4	Gardner Pond Barrier Only	Newport Reservoirs[1]	Gardner Pond Perimeter Levee	13,440,000	510,048	N/A	N/A	NO
NR5	Sachuest Rd Barrier Only	Newport Reservoirs[1]	Sachuest Rd Floodwall/Dune	25,875,000	981,956	N/A	N/A	NO
NR6	Easton Pond and Gardner Pond Barrier	Newport Reservoirs[1]	Combination	42,240,000	1,603,008	N/A	N/A	NO
NR7	Memorial Blvd and Gardner Pond Barrier	Newport Reservoirs[1]	Combination	32,680,000	1,240,206	N/A	N/A	NO
NR8	Easton Pond and Sachuest Rd Barrier	Newport Reservoirs[1]	Combination	54,675,000	2,074,916	N/A	N/A	NO
NR9	Memorial Blvd and Sachuest Rd Barrier	Newport Reservoirs[1]	Combination	45,115,000	1,712,114	N/A	N/A	NO
BI1	No Action	Block Island	No Action	N/A	N/A	N/A	N/A	YES
BI2	Corn Neck Road Raising	Block Island	Elevate Corn Neck Road	25,875,000	981,956			YES

Alternative		Location	Measures	Project Cost ($)	Annual Cost ($)	Annual Damage Reduced ($)	BCR	Carried Forward?
BI3	Corn Neck Road Beach Nourishment	Block Island	Beach Nourishment	28,800,000	1,092,960			YES
BI4	Corn Neck Road Stabilization (Hard)	Block Island	Rock Revetment	3,000,000	113,850			YES
BI5	Corn Neck Road Stabilization (NNBF)	Block Island	Sill/Reef-based Living Shoreline[2]	2,700,000	102,465	N/A	N/A	NO
BI6	Corn Neck Road Stabilization and (NNBF)	Block Island	Combination[2]	5,700,000	216,315	N/A	N/A	NO
PO1	No Action	Portsmouth	No Action	N/A	N/A	N/A	N/A	YES
PO2	Non-Structural	Portsmouth	Structure Raising/Floodproofing	34,600,000	1,313,070	395,724	0.30	YES
PO3	Common Fence Perimeter	Portsmouth	Floodwall/Levee	79,005,000	2,998,240	207,580	0.07	NO
PO4	Island Park Perimeter	Portsmouth	Floodwall/Levee	70,380,000	2,670,921	476,897	0.18	NO
PO5	Common Fence and Island Park Barrier	Portsmouth	Combination	149,385,000	5,669,161	684,477	0.12	NO
BW1	No Action	Barrington/Warren	No Action	N/A	N/A	N/A	N/A	YES
BW2	Non-Structural	Barrington/Warren	Structure Raising/Floodproofing	207,400,000	7,870,830	7,666,354	0.97	YES
BW3	Warren River Surge Barrier (upper)	Barrington/Warren	Surge Barrier	9,600,000	364,320	12,156,303	33.37	YES
BW4	Warren River Surge Barrier (lower)	Barrington/Warren	Surge Barrier	1,128,200,000	42,815,190	13,507,004	0.32	YES
BW5	Mathewson Road Protection	Barrington/Warren	Rock Revetment	3,900,000	148,005	110,892	0.75	NO
BW6	Belchers Cove Perimeter	Barrington/Warren	Belchers Cove Levee/Floodwall	31,050,000	1,178,348	3,500,953	2.97	YES
BW7	Route 114 Floodproofing	Barrington/Warren	Route 114 Levee/Floodwall	67,333,333	2,555,300			YES
BW8	Belchers Cove and Route 114 Protection	Barrington/Warren	Combination	98,383,333	3,733,648			YES
BR1	No Action	Bristol	No Action	N/A	N/A	N/A	N/A	YES
BR2	Non-Structural	Bristol	Structure Raising/Floodproofing	14,200,000	538,890	556,846	1.03	YES
BR3	Bike Path Levee	Bristol	Raise Existing Bike Path	8,320,000	315,744	501,161	1.59	YES
PR1	No Action	Providence	No Action	N/A	N/A	N/A	N/A	YES
PR2	Non-Structural	Providence	Structure Raising/Floodproofing	10,600,000	402,270	517,004	1.29	YES
PR3	Providence Harbor Bulkhead	Providence	Bulkhead	46,080,000	1,748,736	568,704	0.33	YES

Alternative		Location	Measures	Project Cost ($)	Annual Cost ($)	Annual Damage Reduced ($)	BCR	Carried Forward?
PR4	Fields Point Levee/Bulkhead	Providence	Levee/Bulkhead	43,750,000	1,660,313	568,704	0.34	NO
PR5	Providence Harbor/Fields Point Combo	Providence	Combination	90,080,000	3,418,536	930,606	0.27	NO
WA1	No Action	Warwick	No Action	N/A	N/A	N/A	N/A	YES
WA2	Non-Structural	Warwick	Structure Raising/Floodproofing	101,200,000	3,840,540	2,060,341	0.54	YES
WA3	West Shore Road Barrier	Warwick	Levee/Floodwall	42,780,000	1,623,501	80,177	0.05	NO
NK1	No Action	North Kingstown	N/A	N/A	N/A	N/A	N/A	YES
NK2	Non-Structural	North Kingstown	Structure Raising/Floodproofing	50,400,000	1,912,680	2,130,424	1.11	YES
NK3	Wickford Village Perimeter	North Kingstown	Bulkhead/Floodwall/Levee	49,920,000	1,894,464	2,789,058	1.47	YES
NA1	No Action	Narragansett	No Action	N/A	N/A	N/A	N/A	YES
NA2	Non-Structural	Narragansett	Structure Raising/Floodproofing	39,400,000	1,495,230	2,015,123	1.35	YES
NA3	Pier Area Protection	Narragansett	Floodwall/Levee/Revetment	27,440,000	1,041,348	80,790	0.08	NO
NA4	Middle Bridge Protection	Narragansett	Middle Bridge Surge Barrier	5,520,000	209,484	3,022,684	14.43	YES
NA5	Pier Area and Middle Bridge	Narragansett	Combination	32,957,200	1,250,726	3,103,474	2.48	NO

1 – All Newport Reservoirs alternatives were removed from consideration due to disinterest from Reservoir managers.
2 – NNBF were eliminated because they were determined not to be effective at decreasing storm surge

Row Legend

White – Alternatives with BCRs greater than 1.0 and were kept for further analysis
Light Gray – Alternatives that didn't have enough information to develop an accurate BCR and were carried forward to the next screening.
Dark Gray – Alternatives removed from consideration because their BCR was lower than 1.0.

4.4.2 Third Screening Iteration

During the third screening iteration, all alternatives carried through from the previous screening iterations and the NAA were evaluated against the P&G criteria of completeness, effectiveness, efficiency, and acceptability. Additionally, the PDT conducted an in-depth analysis of the remaining alternatives; again, considering constructability, design, and environmental impacts. The PDT reached out to the municipalities and stakeholders an additional time to assess interest in the alternatives that had been developed to date. The results of third screening iteration results of third screening iteration are found in **Table 4-14**.

Principles and Guidelines Criteria – The Federal P&G established four (4) criteria for evaluation of water resources projects (USACE 1983). These are completeness, effectiveness, efficiency, and acceptability. These criteria and their definitions are listed below. Alternatives considered in the study must meet minimum subjective standards for all four (4) criteria to qualify for further consideration and be carried forward to compare with other plans.

> Completeness **-** Completeness is defined as the "extent to which an alternative provides and accounts for all features, investments, and/or other actions necessary to realize the planned effects, including any necessary actions by others". It does not necessarily mean that alternative actions need to be large in scope or scale. This criterion asks the question "Does the plan include all the necessary parts and actions to produce the desired results?"
>
> Effectiveness **-** Effectiveness is defined as the "extent to which an alternative alleviates the specified problems and achieves the specified opportunities." This criterion addresses two (2) questions. 1. Does the plan meet the objectives? 2. How does the plan address constraints?
>
> Efficiency - Efficiency is the extent to which an alternative plan is a cost-effective means of alleviating the specified problems and realizing the specified opportunities. To address this criterion, one asks if the plan minimize costs. Is it cost effective? And does it provide net benefits?
>
> Acceptability - Acceptability has been defined in a number of ways. The 1983 P&G defines the terms as "the viability and appropriateness of an alternative from the perspective of the Nation's general public and consistency with existing Federal laws, authorities, and public policies". Appendix E of the ER 1105-2-100, *The Planning Guidance Notebook*, (USACE 2000 as amended in Section E-38(a.)) describes acceptability as "an ecosystem restoration plan should be acceptable to State and Federal resource agencies, and local government. There should be evidence of broad-based public consensus and support for the plan. A Recommended Plan must be acceptable to the non-Federal cost-sharing partner. However,

Table 4-14: The results of third screening iteration

Alternative		Location	Measures	Completeness	Effectiveness	Efficiency	Acceptability	Notes
NAA	No Action	Entire Study Area	No Action	N/A	N/A	N/A	N/A	
NS	Nonstructural	Entire Study Area	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Carried forward to the focused array
J1	No Action	Jamestown	No Action	N/A	N/A	N/A	N/A	
J2	Newport Bridge Approach Protection	Jamestown	Levee/ Floodwall	Yes	Yes	No	Yes	Only provides traffic benefits, the state is studying this area in a separate effort to completely redesign this site.
ND1	No Action	Newport Downtown	No Action	N/A	N/A	N/A	N/A	
ND2	Nonstructural	Newport Downtown	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.
ND3	Point Area Perimeter	Newport Downtown	Floodwall	No	Yes	Yes	Yes	Not constructable, could not determine an alignment for the floodwall without adversely affecting significant historic resources.
ND4	Wellington Perimeter	Newport Downtown	Levee/ Floodwall	Yes	Yes	Yes	Yes	Carried forward to the focused array
ND5	Point and Wellington Area Perimeter Protection	Newport Downtown	Levee/Floodwall	No	Yes	Yes	Yes	The Wellington Area Alternative was not constructable, could not determine an alignment for the floodwall without adversely affecting significant historic resources.
BI1	No Action	Block Island	No Action	N/A	N/A	N/A	N/A	
B12	Corn Neck Road Raising	Block Island	Elevate Corn Neck Road	No	Yes	Yes	Yes	More appropriate to pursue the project in Continuing Authorities Program (CAP), Section 103, which provides authority to construct small hurricane and storm damage reduction projects.
BI3	Corn Neck Road Beach Nourishment	Block Island	Beach Nourishment	No	Yes	Yes	Yes	More appropriate to pursue the project in CAP, Section 103
BI4	Corn Neck Road Stabilization	Block Island	Rock Revetment	No	Yes	Yes	Yes	More appropriate to pursue the project in CAP, Section 103
PO1	No Action	Portsmouth	No Action	N/A	N/A	N/A	N/A	
PO2	Nonstructural	Portsmouth	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.
BW1	No Action	Barrington/ Warren	No Action	N/A	N/A	N/A	N/A	
BW2	Nonstructural	Barrington/ Warren	Elevations/ Acquisitions/	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.

Alternative		Location	Measures	Completeness	Effectiveness	Efficiency	Acceptability	Notes
			Floodproofing					
BW3	Warren River Surge Barrier (Upper)	Barrington/ Warren	Surge Barrier	Yes	Yes	Yes	Yes	Carried forward to the focused array
BW4	Warren River Surge Barrier (Lower)	Barrington/ 'Warren	Surge Barrier	Yes	Yes	Yes	Yes	Carried forward to the focused array
BW6	Belcher's Cove Perimeter	Barrington/ Warren	Levee/ Floodwall	No	No	Yes	No	No acceptable location for tie-ins, Significant environmental impacts (salt marsh), HTRW concerns, Stakeholder (town) did not show interest in this measure.
BW7	Route 114 Floodproofing	Barrington/ Warren	Levee/ Floodwall	No	Yes	Yes	Yes	No acceptable location for a tie-in on the East side of the area due to the densely developed neighborhood. Only provides transportation benefits.
BW8	Belcher's Cove Perimeter and Route 114 Floodproofing	Barrington/ Warren	Levee/ Floodwall	No	No	Yes	No	See the notes in the previous two alternatives.
BR3	Bike Path Levee	Bristol	Raise existing path	Yes	No	Yes	Yes	Only provides traffic benefits.
PR1	No Action	Providence	No Action	N/A	N/A	N/A	N/A	
PR2	Nonstructural	Providence	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.
PR3	Providence Harbor Bulkhead	Providence	Bulkhead	Yes	Yes	Yes	Yes	Carried forward to the focused array
WA1	No Action	Warwick	No Action	N/A	N/A	N/A	N/A	
WA2	Nonstructural	Warwick	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.
NK1	No Action	North Kingstown	No Action	N/A	N/A	N/A	N/A	
NK2	Nonstructural	North Kingstown	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.
NK3	Wickford Village Perimeter	North Kingston	Bulkhead/ Levee/ Floodwall	Yes	No	Yes	No	Significant impacts to cultural resources, view shed etc. Difficult to find an acceptable alignment. Require a large river crossing.
NA1	No Action	Narragansett	No Action	N/A	N/A	N/A	N/A	
NA2	Nonstructural	Narragansett	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.
NA4	Middle Bridge Protection	Narragansett	Surge Barrier	Yes	Yes	Yes	Yes	Carried forward to the focused array

this does not mean that the Recommended Plan must be the locally preferred plan."

The Route 114 floodproofing alternative (BW7) was developed early in the study t address the concerns of the state and locality regarding flooding of Roue 114. Upon further assessment of the alternative during the third screening iteration, the PDT found that the alternative did not meet the criteria for constructability and completeness as well as limited life-safety risks. Specifically, the length of the project would need to extend from Barrington all the way to Bristol in order to constitute a complete project, and due to the current elevation of the bridges crossing the Warren River, amendments to the bridges themselves would likely be necessary. These factors both would increase the costs well above what was originally prepared for an estimate.

4.4.3 Focused Array of Alternatives

Preliminary crest elevations for storm surge barriers are based on the 0.2% AEP with 50% assurance provided in the NACCS hazard curves for the year 2080 under intermediate SLC. Selection of the 0.2% AEP was based on the assumption that storm surge barriers with gates would be costly to construct, difficult to adapt, and in service longer than the 50-year economic period of analysis. Therefore, higher crest elevations (lower AEPs) were initially selected for design of storm surge barriers. Preliminary crest elevations for other structural measures, such as floodwalls and levees, and nonstructural measures, such as structure elevations, are based on the 1% AEP with 50% assurance provided in the NACCS hazard curves for the year 2080 under intermediate SLC. It is emphasized that there is no policy requirement that USACE projects be designed to the 1% AEP water level or any minimum performance standard. The optimization of design heights is discussed in **Appendix C**, *Economic and Social Considerations*.

The base level of performance used for each alternative was chosen based on factors specific to each type of design and project location. The nonstructural alternatives provide protection throughout the entire study area, whereas the structural alternatives provide protection at specific areas within the study area. As such, the comparison of the alternative evaluated at Warren-Barrington is not directly comparable to the non-structural alternatives regardless of the design level of performance. Even so, when considering the cost of the Warren-Barrington surge barrier designed using the 1% AEP, the project would not be economically justified, even assuming a higher level of benefits associate with the 500-year level of performance. Therefore, the 100-year level of performance design would not be justified and would not alter the selected Recommended Plan.

The following alternatives were included in the focused array of alternatives:

No Action Alternative - The NAA assumes that no actions would be taken by the Federal Government to address the problems identified by the study. Consequently, the NAA would not reduce damages from storm surge inundation (flooding). Although this alternative would not accomplish the purpose of this study, it must always be included in the analysis and can serve several purposes. The NAA will be used as a benchmark, enabling decision makers to compare the magnitude of economic, environmental, and social effects of the actionable alternatives. The NAA will lead to the FWOP condition in this study.

Structural Alternatives **-** Structural alternatives included in the final array were located throughout the project area **(Figure 4-2).**

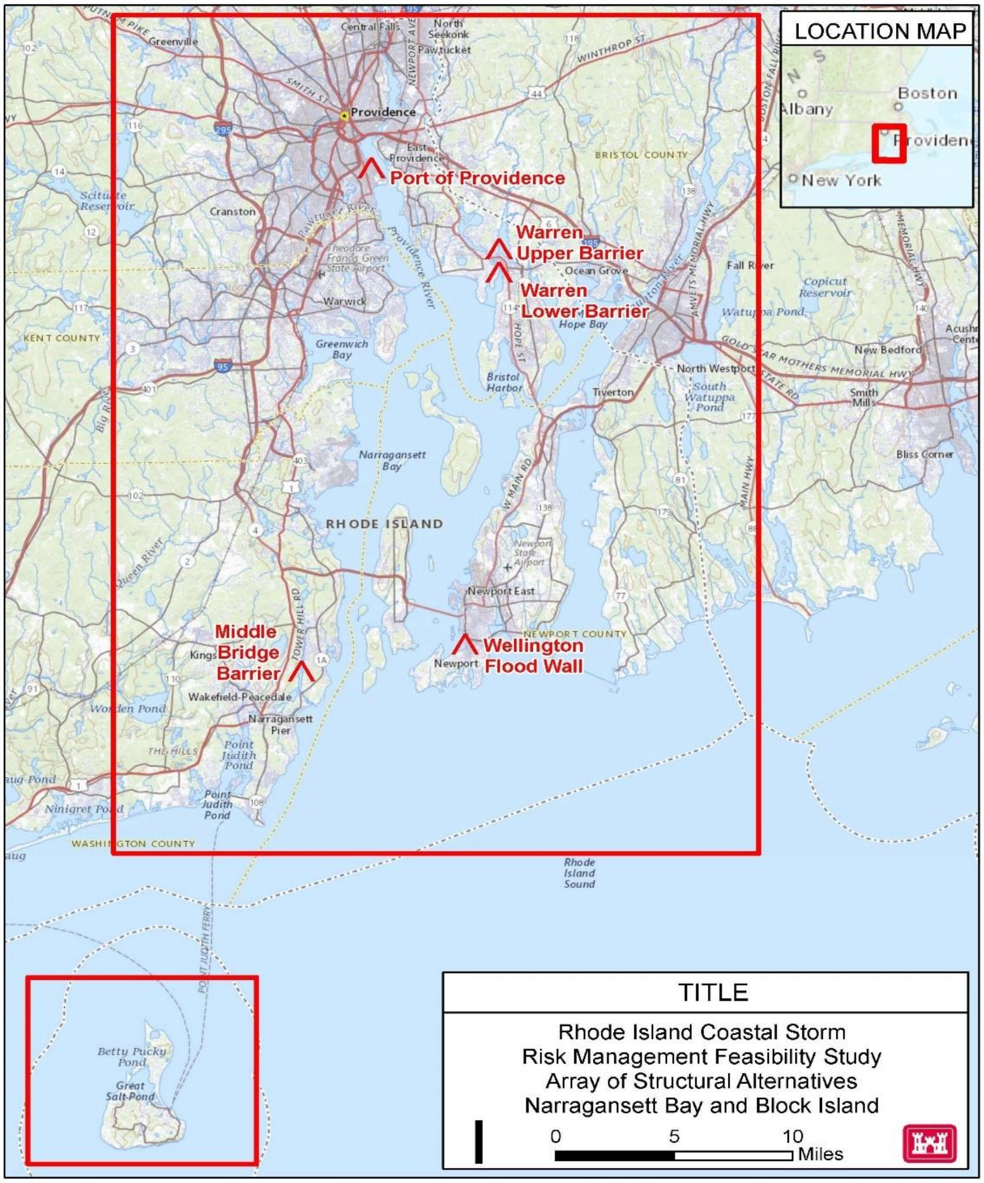

Figure 4-2: Locations of the structural measures included in the final array of alternatives

<u>Barrington/Warren – Lower Surge Barrier and Upper Surge Barrier</u> – This area of high exposure was particularly striking as it encompasses a significant portion of the towns of

Warren and Barrington and extends into the backshore areas of the Warren and Barrington Rivers. Hundreds of residential and commercial properties are in this area of high exposure, including all associated municipal and State infrastructure (**Figure 4-3**).

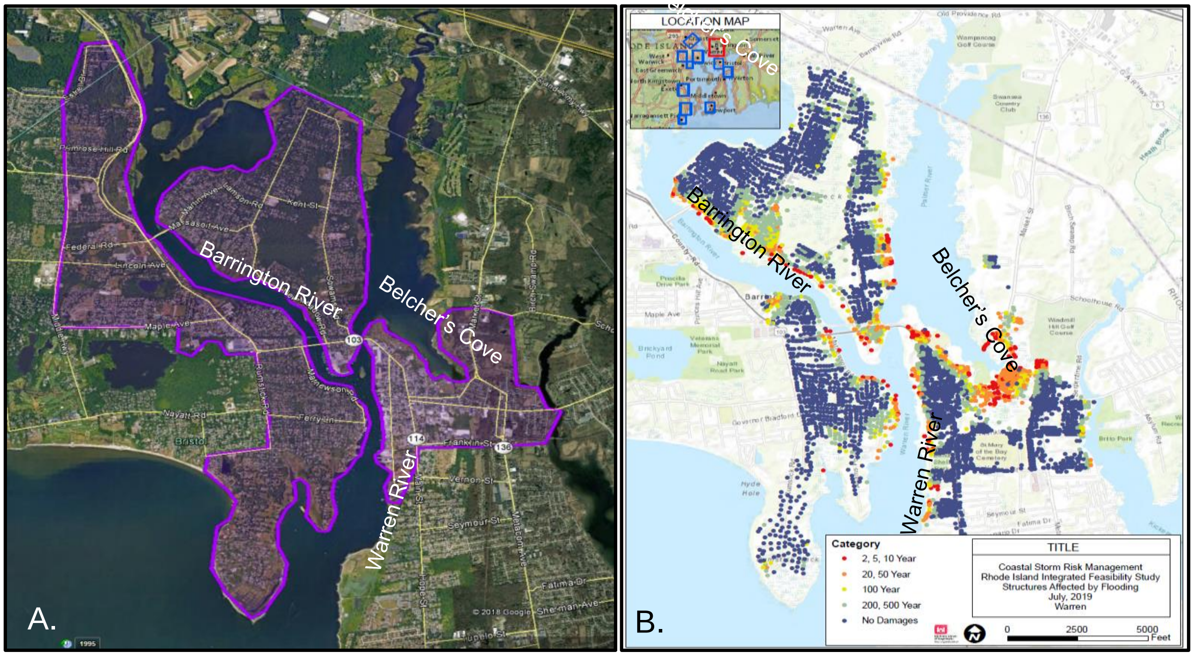

Figure 4-3: **A.** The 100-year floodplain in the Barrington/Warren focused study area. **B.** Structures affected by flooding in the Barrington/Warren focused study area

Route 114 is the primary infrastructure of concern as this serves as an evacuation route and major thruway for the community. Significant portions of the road located in Warren and Barrington experience inundation during storm events and requires persistent maintenance due to flooding. The area is also thickly settled with both residential and commercial properties. Overflow from the Warren River and Belcher Cove are the main sources for flooding in the area during storm events.

The design elevation selected for both the upper and lower alignments was the 0.2-percent AEP NACCS water level for the year 2080 under the intermediate SLC scenario. The 0.2-percent AEP was selected due to the density of structures within the Warren-Barrington area and the lower adaptability of a storm surge barrier system that would be expected to be in service longer than the 50-year economic period of analysis. Further, moving from the 1-percent AEP to the 0.2-percent AEP required only lengthening the tie-ins to higher ground by 250 feet, a small fraction of the total lengths of 6,386 feet for the upper barrier alignment and 3,449 feet for the lower barrier alignment.

A hurricane barrier system was considered for the upper reach of the Warren River (**Figure 4-4)**. This system, utilizing a combination of existing infrastructure and the construction of new structures, would result in a structure that would extend for 6,350 feet (1.2 miles) between Barrington and Warren. Overall, the hurricane barrier system would consist of elevating the existing East Bay Bike Path, installing operable flood gates on the two (2) existing pedestrian bridges, and constructing a flood wall along the Warren River front. Structure heights would range between 10 and 16 feet above ground. The closure structure built in the waterway channel would be composed of steel bulkhead roller gates and concrete T- walls. One section of the barrier would utilize heavy steel tube sections. This is the portion that would allow the daily passing of recreational vessels. When protection is needed, a barge would install the stoplog sections to provide storm protection, while the steel bulkhead roller gates would be operated by a mobile crane.

A lower surge barrier was also considered to protect the Warren/Barrington study area. This barrier would include 1,000 linear feet (LF) of in-water structures and a 2,000 LF approach levee (**Figure 4-4**). As with the upper surge barrier, the alignment design was analyzed for a 500-yr storm event. The west wingwall would utilize Bourne Lane in Barrington and the east wingwall for the hurricane barrier would run along Water Street and then turn onto Campbell Street in Warren. The barrier would extend across the Warren River and include a 150 foot-wide double-leaf steel sector gates that, when opened, would provide minimal obstructions to the waterway, allowing commercial and recreational navigation. Earth fill levees would be constructed within the river to either side of the gate and then tie into floodwalls built upon the landsides of the river. Vehicle barriers, which would be closed only during storm events, would be integrated into each floodwall in Barrington and Warren. A tide gate would be built into the floodwall along Bourne Lane to maintain tidal flows to the surrounding wetlands and a maintenance road along the crest of the levees out to the gates would be required in order for crews to maintain and operate the hurricane barrier.

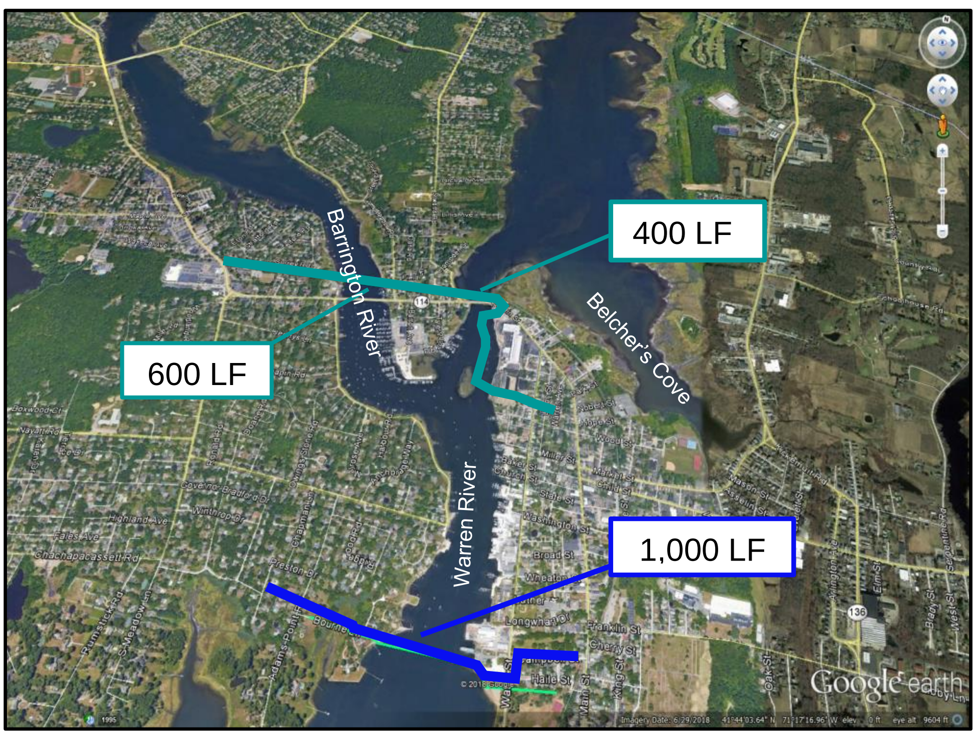

Figure 4-4: The placement of the lower and upper surge barriers on the Warren River

The lower surge barrier would provide a larger area of protection as compared to the upper barrier. This additional protection includes several riverfront properties, as well as Route 114 (**Figure 4-5**).

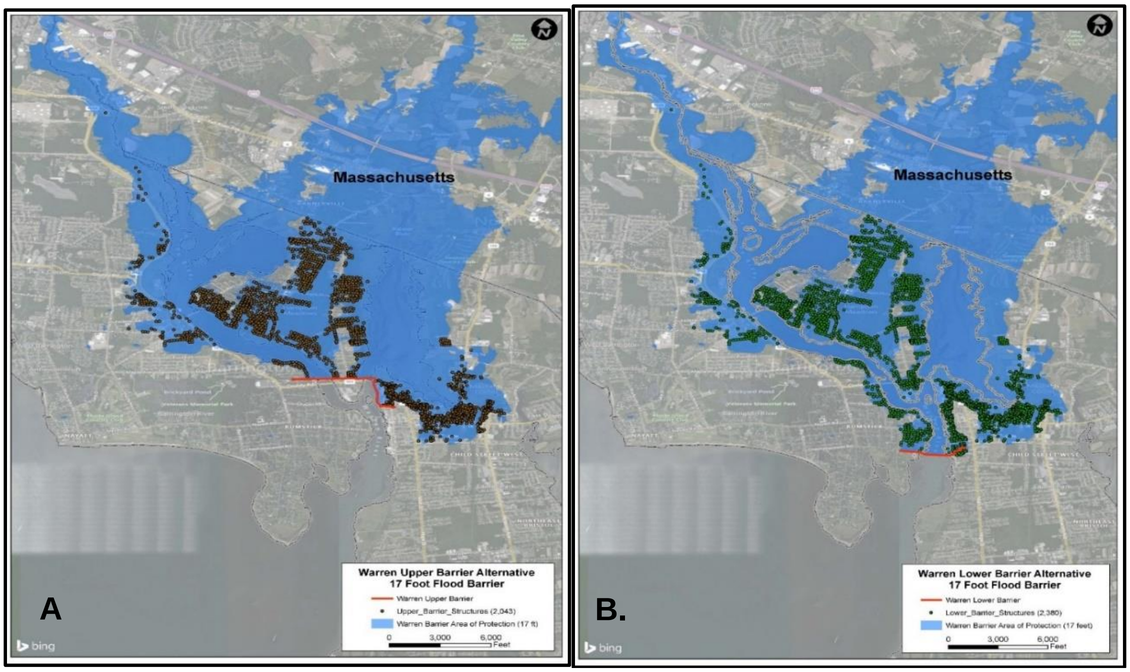

Figure 4-5: Areas of protection and structures that would be protected by **A.** the upper surge barrier and **B.** the lower surge barrier on the Warren River

Narragansett – Middle Bridge Surge Barrier - The Narragansett study area includes communities that lie along the Narrow River (**Figure 4-6**). This waterway is classified as a tidal inlet, which is fed by the waters of Narragansett Bay and forms a natural boundary between the towns of Narragansett, South Kingston and North Kingstown. The study area

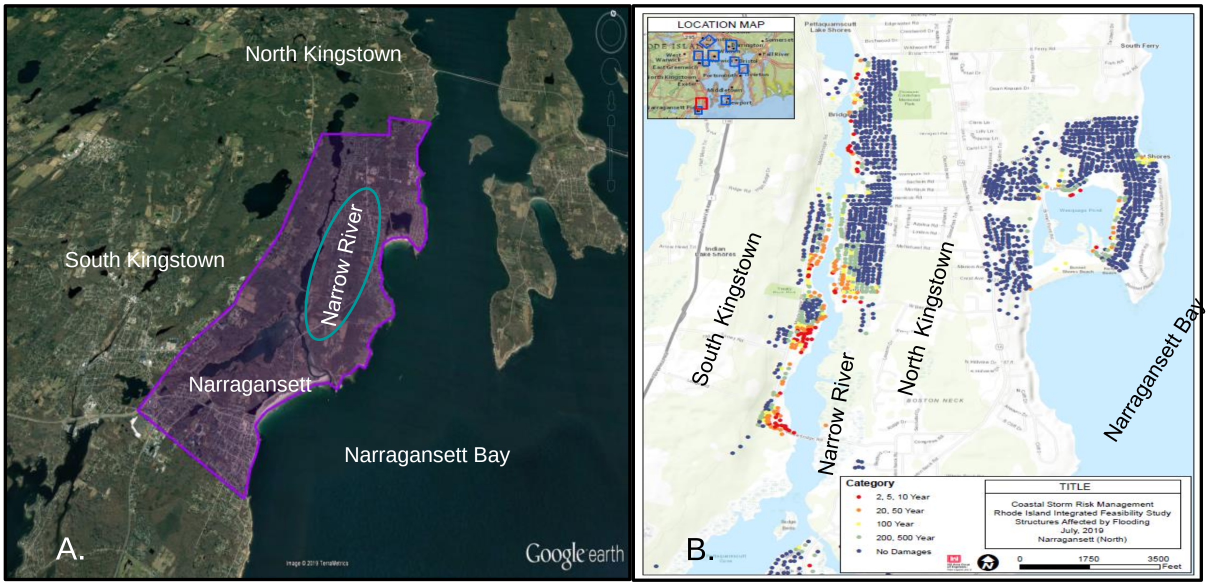

Figure 4-6: A. The 100-year floodplain in the Narragansett study area. **B.** Structures affected by flooding in the Narragansett study area

lays north of Middlebridge Road, where it crosses the Narrow River. This study area consists of densely populated, low lying residential neighborhoods that have experienced flooding and inundations during storm events.

A flood protection system for the area would consist of a floodwall to either side of the Narrow River Bridge and a stop log structure underneath the existing bridge. The in-water structure would be approximately 500 LF in length, with 2,000 LF of on-land approach levees (**Figure 4-7**). The structure would be built into the existing bridge and contain slots to install stop logs during storm events. The width of the opening would be approximately 30 feet in order to maintain marine traffic. The west wingwall would utilize an existing cleared pathway along the shoulder of Middlebridge Road in South Kingstown and the east wingwall would be constructed along the shoulder of Middlebridge Road in Narragansett.

Figure 4-7: The placement of the surge barrier in Middle Bridge on the Narrow River

<u>Newport - Wellington Levee/Floodwall</u>: Wellington Avenue is located in the Fifth Ward neighborhood in Newport, Rhode Island. This densely developed residential neighborhood is within walking distance to downtown Newport Area (**Figure 4-8**). Though many properties along Wellington Avenue are vulnerable to both storm induced flooding and sunny day flooding due to SLC, historical records and models indicate the most significant flooding concern in the Fifth Ward neighborhood is due to coastal storms.

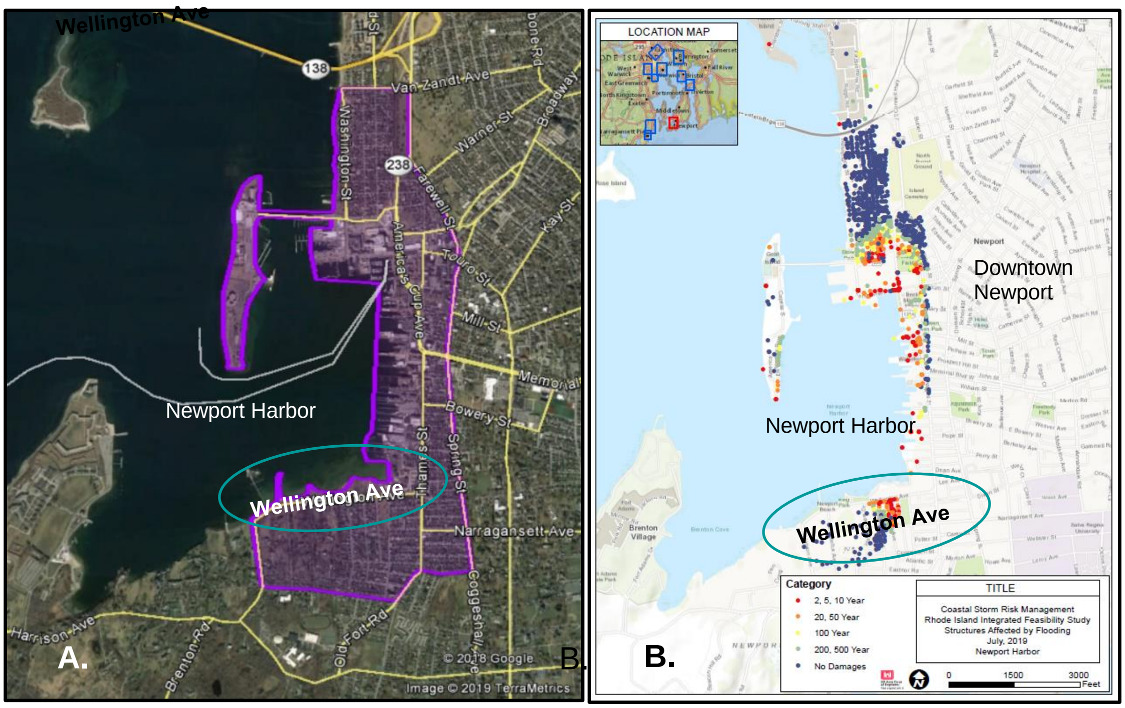

Figure 4-8: **A.** The 100-year floodplain in the Newport Downtown – Wellington Avenue study area. **B.** Structures affected by flooding in the Newport Downtown - Wellington Avenue study area

Models showed that flood waters come in from Newport Harbor and inundate the area to the south of Wellington Avenue.

The structural measure designed to reduce coastal storm risk in this area consisted of a 2100 LF concrete floodwall and earthen levee system located along the westbound side of Wellington Avenue (**Figure 4-9**). The was designed to the 100-year water level and includes storm surge and SLC for the end of the 50-year period of economic analysis (i.e., through year 2079). The structure would extend from Thames Street on the east to Columbus Avenue on the west. The concrete floodwall would range in height of five (5) to eight (8) feet. above ground, with the majority of the earthen levee having a crest height of eight (8) feet above ground.

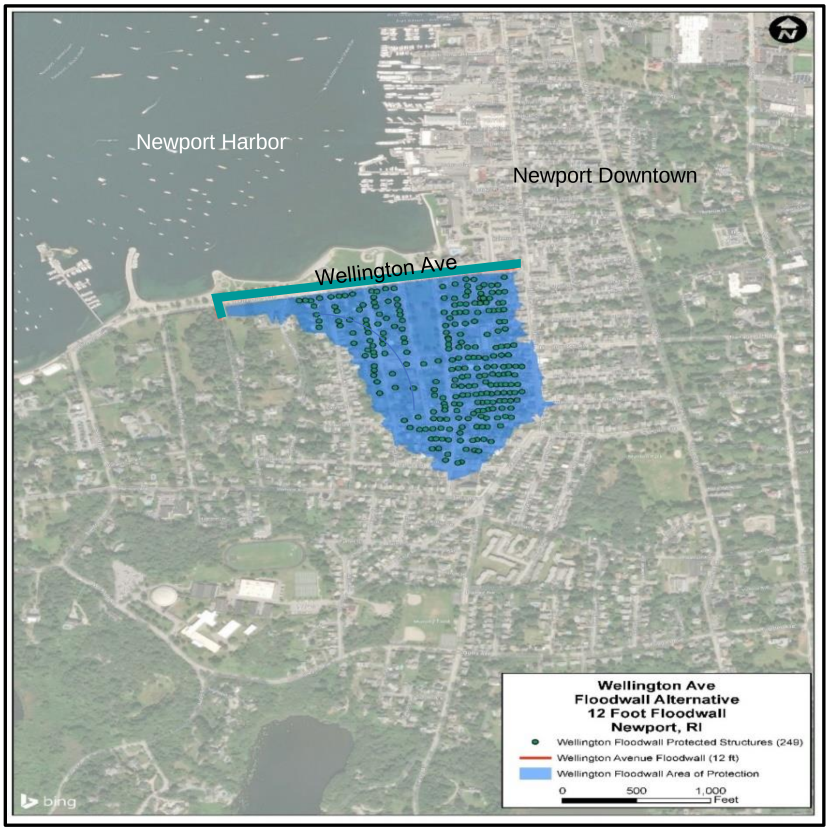

Figure 4-9: The placement of the floodwall in the Newport Downtown Wellington Avenue and the area and structures that would be protected by the wall

In addition to the structure, there will be various personnel and vehicle access points. A vehicle barrier crossing at Wellington Avenue will consist of a 40-foot-wide span with a deployable steel flood gate that would be manually installed ahead of a storm. The structure would also include two (2) pedestrian access points integrated into the levee. A five (5) foot wide paved walking path will be located at the crest of the levee and serve as a recreational walkway for views of Newport Harbor. In order to maintain access for service vehicles to the Newport Combined Sewer Overflow (CSO) building, a 15-foot-wide stop-log barrier would be integrated into the floodwall structure. Similar stop-log barriers would be integrated into the floodwall, crossing driveways for two (2) private properties along the east end of the structure.

In order to remove rainwater that would accumulate behind the wall (dry side) during a storm event with all barriers closed, a pump station would be integrated into the flood protection system. Based upon the existing topography of the Wellington Avenue area, the pump station would be located underground at a localized low point at Spencer Park. Existing stormwater drainage piping would require modifications and relocations. There are currently two (2) stormwater outfalls located within the project area and both flow into Newport Harbor near the CSO building. Installation of a box culvert leading to the pump station might be required in order to maintain flow as well as capacity requirements during a storm event.

Providence – Port of Providence - The Port of Providence is one (1) of the largest and busiest deep-water ports in New England and is strategically located as a distribution center to move goods and materials throughout the region (**Figure 4-10**). The facility is managed by ProvPort, Inc., which was created in 1994 to hold and manage the port. The port facilities include 6 berths, 3,500 LF of berthing space, plus 700 additional feet of non-contiguous berthing. On land, the facility is 115 acres in size, with 20 acres of open laydown and 40 feet alongside water depth. Ships from all over the world utilize the port. The primary imports include petroleum, asphalt, cement, liquid petroleum gas, coal, aluminum oxide and road salts. The primary exports from the port are scrap metals, automobiles and project equipment and materials. This port is part of an intermodal transportation system in Rhode Island that includes two major highways (Interstates 95 and 195) that are less than one (1) mile away from the port, railway capable of supporting double stack service, and the deep-water port itself.

The Port of Providence study area includes land within the two (2) cities of Providence and East Providence. The area extends from Watchemoket Cove in East Providence, north into the City of Providence, west into the Olneyville area, then south to the area in Providence known as Washington Park. Significant commercial development is located in this area, including bulk cargo facilities, as well as ship servicing facilities and water treatment facilities. The area also includes downtown Providence, the capital of the State. The area is protected by the Fox Point Hurricane Barrier up to a Category 3 hurricane. The barrier protects about 280 acres of downtown Providence, including the commercial and industrial center of the city, transportation facilities, public utilities, and many homes. Storms greater than that classification could cause catastrophic damage to the city's commercial and residential properties. The area also includes critical infrastructure including rail line, several important State (e.g., Route 6) and local roads, and major highways. A small industrial area in Cranston, just south, is included in this risk area.

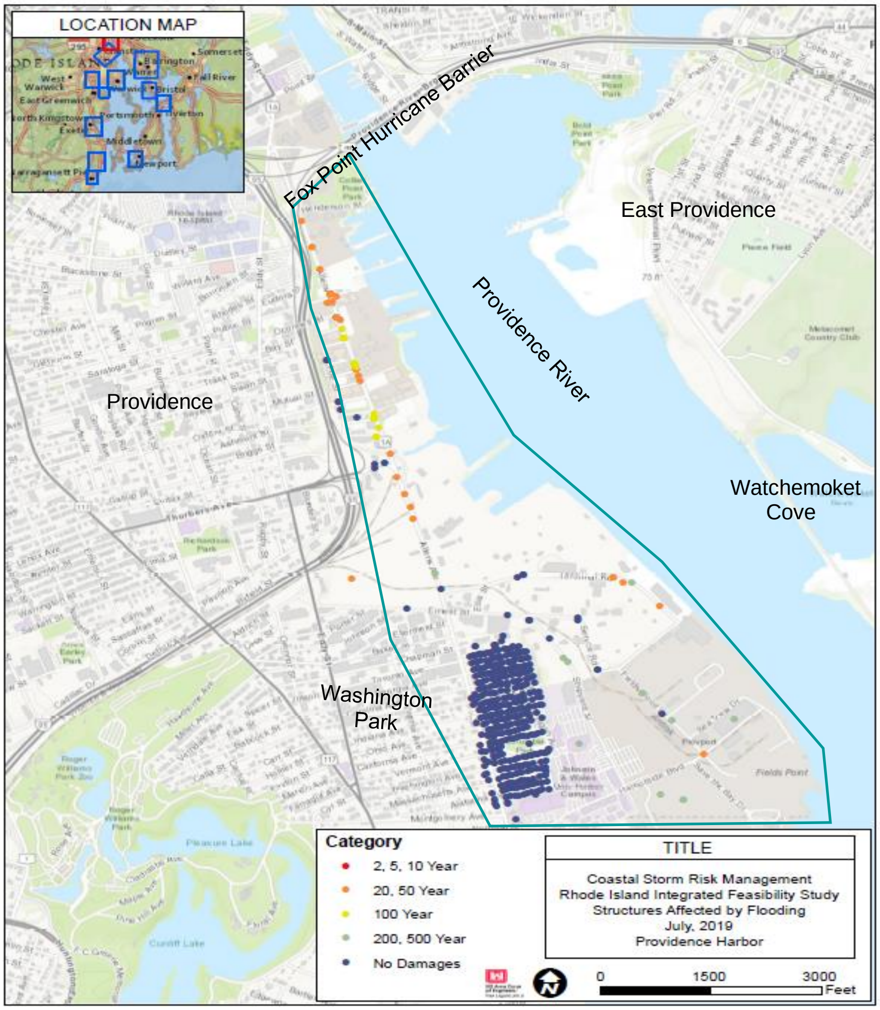

Figure 4-10: The Port of Providence study area and the structures that would be affected by flooding in the Port

The PDT began the planning process but discovered early in the process that the port area is an extremely complicated system with diverse facilities and stakeholders. Many challenges were discovered, including:

- Limited detailed information regarding vulnerability of facilities,
- Unknown level of protection provided by the spill containment barriers against flooding,
- Unknown information about storage tanks management,
- Unknown data regarding storage tanks and wastewater treatment facility (WWTF) durability and limits that would result in catastrophic failure,
- Limited detailed information regarding replacement costs,
- No detailed cost information on value of contents at WWTF,
- Limited understanding of regional economic impacts,
- No detailed cost information on the value of goods and materials to determine

damages resulting from flooding,

- Limited interest/participation from some of the facilities owners, and
- The northern area of the port is significantly different from the southern area (WWTF and tank farm).

Due to the complexity and challenges outlined above, alternatives to reduce coastal storm risk at the Port were not able to be developed during this study, however, it is a recommendation of this study that the Port of Providence should be the subject of its own study.

<u>Nonstructural Alternatives</u> - Nonstructural measures include modifying homes, businesses, and other facilities to reduce flood damages. Private homes can be elevated or removed from the floodplain. Once private structures have been relocated, the land remains undeveloped and can be used for ecosystem restoration, outdoor recreation, or natural open space. Non-residential structures can undergo floodproofing. Flood warning systems are also considered nonstructural measures.

Nonstructural alternatives were developed in compliance with Planning Bulletin 2019-03 *Further Clarification of Existing Policy for USACE Participation in Nonstructural Flood Risk Management and Coastal Storm Risk Management Measures, December 13, 2018.* The bulletin directs that "nonstructural analyses will formulate and then evaluate measures and plans using a logical aggregation method." Aggregations refers to the grouping of structures by specific characteristics, such as FFE, common flood consequences, shared demographic or socioeconomic characteristics, census block or tract boundaries; neighborhood or communities sharing common infrastructure, etc. By aggregating or grouping structures, these groups will share common characteristics, instead of being randomly scattered throughout a watershed or study area, being subject to multiple different flood sources. The PDT's considers a range of attributes and criteria to combine structures into coherent groups and also selects reasonable combinations of those attribute and criteria as part of a logical aggregation methodology to combine structures into coherent groups. Then a range of nonstructural alternatives, which were developed using the aggregation methodology, should be formulated, evaluated, and compared. In this study, the initial structure inventory was aggregated and three separate nonstructural plans were developed.

The investigation of nonstructural measures included the entire study area and was not limited to the eleven focused study areas. Initially the structures located within the 100-year floodplain were aggregated into an initial inventory, which included approximately 12,000 buildings.

Because the initial inventory was so large, the PDT chose to further aggregate these structures by considering "Common Flood Consequences" to identify structures that experience relatively high flood damages. Structures that had experienced $125,000 or more overall damages were used as a threshold to determine if a property would be considered for inclusion in the investigation or would be removed from consideration. This value was a considered a very conservative estimate since it was based on half of the lowest cost estimated for floodproofing in order to focus on structures receiving significant enough damage to warrant protection out of the over 12,000 structures under consideration. The threshold resulted in the inclusion of structures with first floors that experience frequent flood damages. The $125,000 threshold resulted in exclusion of structures due to the following reasons:

- Structures with no damages in the FWOP,
- Structures with First Floor Elevation (FFE) above Base Elevation Design Height,
- Structures with current FFE within 1 foot of Base Elevation Design Height, and
- Structures considered for floodproofing, but in a VE zone (areas that are inundated at 1 percent AEP with additional hazards associated with storm-induced waves) or have a basement.

This aggregation resulted in a Baseline Inventory of 1033 structures; 757 that are residential and 276 which are non-residential (**Table 4-15**). Non-residential structures include commercial properties and multi-family housing, such as apartment buildings. **Figure 4-12** shows the location of the Baseline Inventory.

Table 4-15: Baseline Inventory

Baseline Inventory	Structures
Residential	757
Non-Residential	276

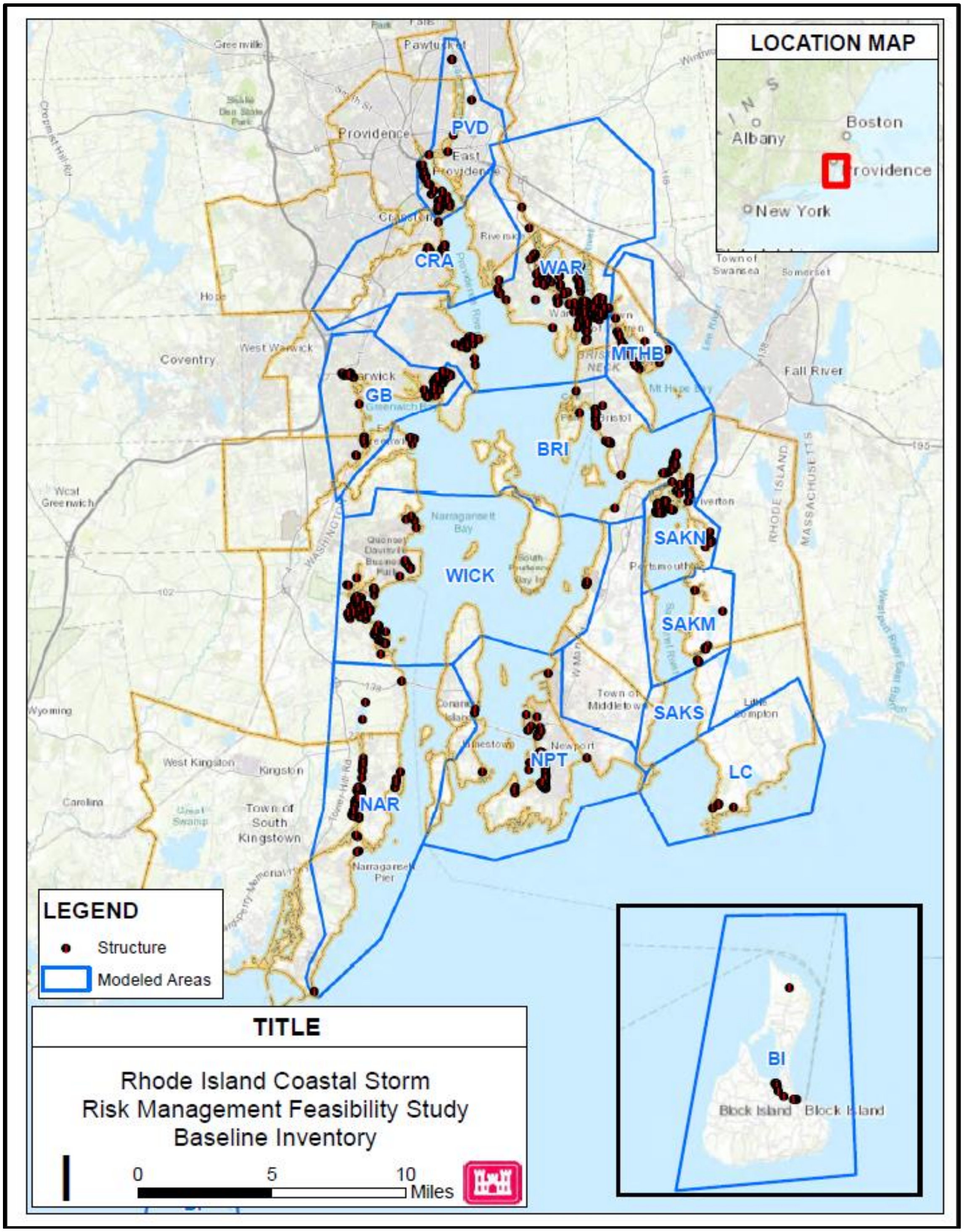

Figure 4-11: Structures include in the baseline inventory, with modeling areas illustrated in solid, blue lines and town boundaries shown in the dashed yellow lines

Structures included in the baseline inventory were divided into community groups using three (3) criteria (**Table 4-16**). These were:

Town Boundaries - All but two (2) community groups were located within a single town and did not cross a town boundary. Town boundaries were considered important because structures within the same town share the same infrastructure, community identity and town government.

Modeling Areas - Areas that experienced similar water levels during storm events were developed for modeling purposes. Water levels can vary greatly depending on where a site is located within the study area for a particular storm event, so it was necessary to delineate the community groups by areas of similar water levels. Each community group is in a single modeling area so that structures within a group experience the same damaging water levels. Modeling areas are illustrated in **Figure 4-11.**

Structure Groups – Community groups were made up of structures that are located in proximity to other structures (i.e., buildings that were grouped together). Community groups consisted of anywhere from five (5) to 153 structures and included both residential and non-residential buildings. 74 structures were not located near any other structures, so were not part of any community group. These were identified as “outliers” and were initially removed from consideration (**Table 4-16**).

Thirty-one community groups were developed from the baseline structure inventory and are shown in **Figure 4-12**. These groups were used to create three (3) Nonstructural plans for this analysis. For each plan, the estimated present value damages for the FWP condition were subtracted from the estimated present value damages for the FWOP to determine the total present value benefits for each community group. These were compared to the total estimated costs for each community group for the corresponding plan. Typically, a benefit-to-cost ratio is a comparison of average annual values, including the cost of interest during construction (IDC). However, since nonstructural cost estimates only include first costs and minimal IDC, the total present value compared to total costs results in a comparable BCR for decision making at the community group level. The present value benefits and total cost information presented in this section is later aggregated for the community groups chosen to be included in each nonstructural plan, then annualized for evaluation and comparison of each alternative.

Table 4-16: Community groups

Community Group Name	Town	Residential	Non-Residential
Barrington	Barrington	66	11
Block Island	Block Island	2	10
Bristol Downtown	Bristol	14	8
Common Fence Point	Portsmouth	25	0
Cranston Mall	Cranston	0	5
Downtown Warwick	Warwick	5	12
East Greenwich	East Greenwich	0	10
Fort Ave	Cranston	9	3
Island Park	Portsmouth	50	0
Laurel Park	Warren/Bristol	37	0
Little Tree Point	North Kingstown	24	0
Nannaquaket Pond	Tiverton	13	1
Narragansett	Narragansett	26	3
Newport Downtown	Newport	85	38
Newport North	Newport	3	8
Oakland Beach	Warwick	28	2
Potowomut	Warwick	5	0
Port of Providence 1	Providence	0	35
Quonset Airport	North Kingstown	0	9
Sakonnet	Little Compton	3	2
Sakonnet North	Tiverton	8	0
Sakonnet South	Tiverton	10	0
Shawomet	Warwick	21	3
Shore Acres	North Kingstown	7	0
South Kingstown	South Kingstown	38	0
The Hummocks	Portsmouth	7	0
Tiverton/Little Compton	Tiverton/Little Compton	9	0
Warren	Warren	64	49
Warwick Neck	Warwick	29	0
West Passage	North Kingstown	9	0
Wickford	North Kingstown	113	40
Outliers		47	27

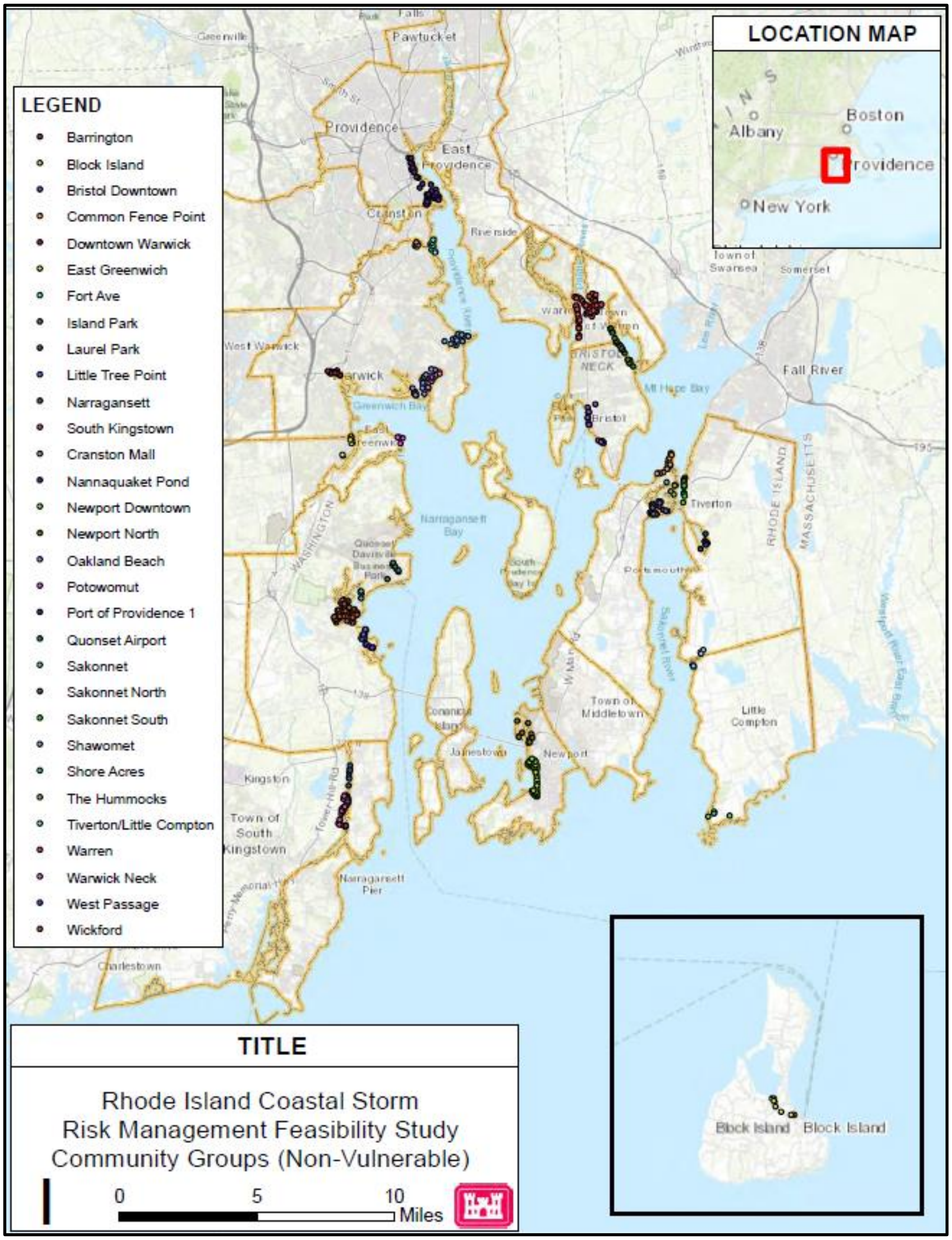

Figure 4-12: Community Groups developed from the baseline inventory

Application of Measures - Elevation was considered for single family residences. The elevation design height was determined separately for each structure based on the 1% AEP NACCS water level + wave contribution + sea level change (intermediate through 2080). Costs for elevation were estimated based on structure type and foundation heights, height of raising, as well as square footage. It is assumed there will be no fill added to the basements of structures being elevated. And, as such, no associated costs for fill are included for this measure.

Floodproofing was considered for non-residential structures and large multi-family structures not in a designated VE Zone and without a basement. For floodproofing, a three (3) feet height was assumed for all measures. However, this assumes a watertight barrier of three (3) feet around the structure. It should be noted that, where applicable, additional measures, such as closures for windows and doors, may be appropriate and may provide a higher-level protection than evaluated in this analysis. For the FWP, depth damage functions were adjusted to remove damage if the inundation depth is lower than 3 feet. Costs for floodproofing were estimated based on various ranges of structure square footage.

Acquisition was considered for single family residences expected to be inundated at the highest annual tide with the 2080 USACE Intermediate SLC scenario or have access roads which would be cut off from utility access at this flood level. Acquisition benefits would alleviate the full estimated FWOP damages. The cost of acquisition was developed based on available city tax assessment data adjusted as necessary and included various cost components. More details on the methodology used to develop acquisition costs can be found in the **Appendix G**, *Real Estate Plan*.

<u>Plan Nonstructural (NS)-A</u> - For the first plan, costs and benefits for elevations for residential properties and dry floodproofing for non-residential structures were developed for each community group. A contingency of 30 percent was used for this analysis. Twelve community groups had a BCR >1.0, while the remaining community groups had a BCR <1.0 (**Table 4-17**). Three (3) community groups had a BCR of 0.9. There was a large amount of uncertainty when the initial economic analysis was completed due to large contingency and the preliminary nature of the cost analysis. For that reason, the three (3) community groups with a BCR of 0.9 were included with the 12 groups that had a BCR above 1.0 to create Plan NS-A. In **Table 4-17**, community groups that are highlighted in blue were part of Plan NS-A, while grayed-out groups were removed from the plan. This plan included 494 total structures: 313 residential recommended for elevation and 181 non-residential recommended for floodproofing (**Figure 4-13**).

Table 4-17: Economic analysis for the Plan NS-A
(October 2020 price levels and 2.5% discount rate)

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR
Barrington	19,926,663	27,249,240	0.7
Block Island	13,981,081	4,384,340	3.2
Bristol Downtown	6,175,878	8,097,265	0.8
Common Fence Point	4,997,412	9,282,420	0.5
Cranston Mall	999,216	2,246,801	0.4
Downtown Warwick	9,047,754	6,467,902	1.4
East Greenwich	16,110,150	3,737,150	4.3
Fort Ave	5,665,512	4,113,303	1.4
Island Park	8,820,825	16,892,371	0.5
Laurel Park	7,051,756	12,265,738	0.6
Little Tree Point	6,073,631	7,504,134	0.8
Nannaquaket Pond	2,053,799	4,492,056	0.5
Narragansett	7531400	9,379,882	0.8
Newport Downtown	123,300,197	47,593,332	2.6
Newport North	5,519,085	4,678,317	1.2
Oakland Beach	5,241,542	9,572,737	0.5
Potowomut	1,617,807	1,591,669	1.0
Port of Providence 1	12,095,014	19,758,065	0.6
Quonset Airport	11,033,142	4,498,113	2.5
Sakonnet	1,837,250	1,747,901	1.1
Sakonnet North	2,413,607	2,775,778	0.9
Sakonnet South	2,124,147	3,690,453	0.6
Shawomet	4,804,555	7,974,676	0.6
Shore Acres	2,163,717	2,542,409	0.9
South Kingstown	7,282,201	12,138,881	0.6
The Hummocks	1,284,553	2,596,478	0.5
Tiverton/Little Compton	1,796,627	3,040,647	0.6
Warren	44,663,135	42,055,525	1.1
Warwick Neck	4,972,011	9,626,549	0.5
West Passage	2,797,581	3,187,718	0.9
Wickford	50,053,164	51,653,408	1.0

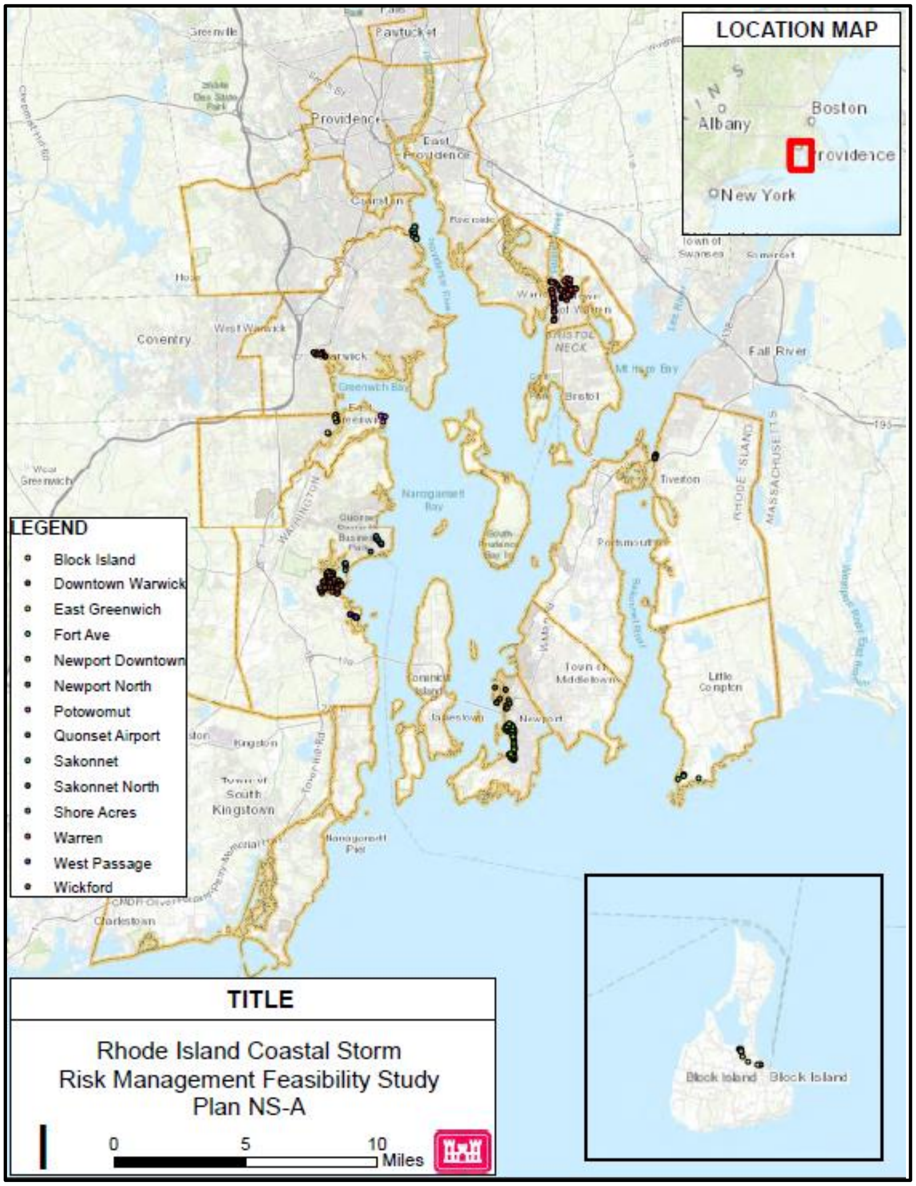

Figure 4-13: Elements of Plan NS-A

Plan NS-B – Vulnerable Communities - Plan NS-B addresses socially vulnerable populations within the RIC project area using the tool, the Social Vulnerability Index (SVI), that was developed by the Centers for Disease Control (CDC) to identify social vulnerability within communities (CDC 2021). The CDC defines social vulnerability as "the potential negative effects on communities caused by external stresses on human health. Such stresses include natural or human-caused disasters, or disease outbreaks. Reducing social vulnerability can decrease both human suffering and economic loss." The index uses U.S. Census data to determine the vulnerability of every census tract. The CDC SVI ranks each tract on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes. These themes include Socioeconomic status, Household Composition, Race/Ethnicity/Language and

Housing and Transportation. A numerical ranking is assigned to each tract for each of the themes, in addition to an overall ranking. For the RIC Study, the overall ranking was used to identify socially vulnerable communities.

Plan NS-A was used as the baseline for Plan NS-B. First, social vulnerability community groups were identified using the CDC SVI (**Figure 4-14**). Four (4) community group are located in vulnerable communities. Two (2) of these communities (Quonset Airport & Fort Ave – highlighted in blue in **Table 4-18**) had a BCR greater than 0.9 and were already included in Plan NS-A. However, the other two (2) communities (Oakland Beach & Port of Providence 1 – highlighted in gray in **Table 4-18**) were not included in the Plan NS-A because their BCR was below 0.9. Oakland Beach and Port of Providence 1 were included in the Plan NS-B, adding 28 residential properties and 37 non-residential properties into the plan.

Table 4-18: Socially vulnerable communities included in Plan NS-B
(October 2020 price levels and 2.5% discount rate)

Baseline Inventory			
Community Group	**Total Present Value Benefits ($)**	**Total Costs ($)**	**BCR**
Oakland Beach	5,241,542	9,572,737	0.5
Port of Providence 1	12,095,014	19,758,065	0.6
Quonset Airport	11,033,142	4,876,113	2.5
Fort Ave	5,665,512	4,113,303	1.4
Initial Inventory			
Community Group	**Total Present Value Benefits ($)**	**Total Costs ($)**	**BCR**
Newport NE	365,414	3,485,150	0.10
Port of Providence 2	765,212	9,574,358	0.08
Quonset Airport 2	406,691	5,542,725	0.07

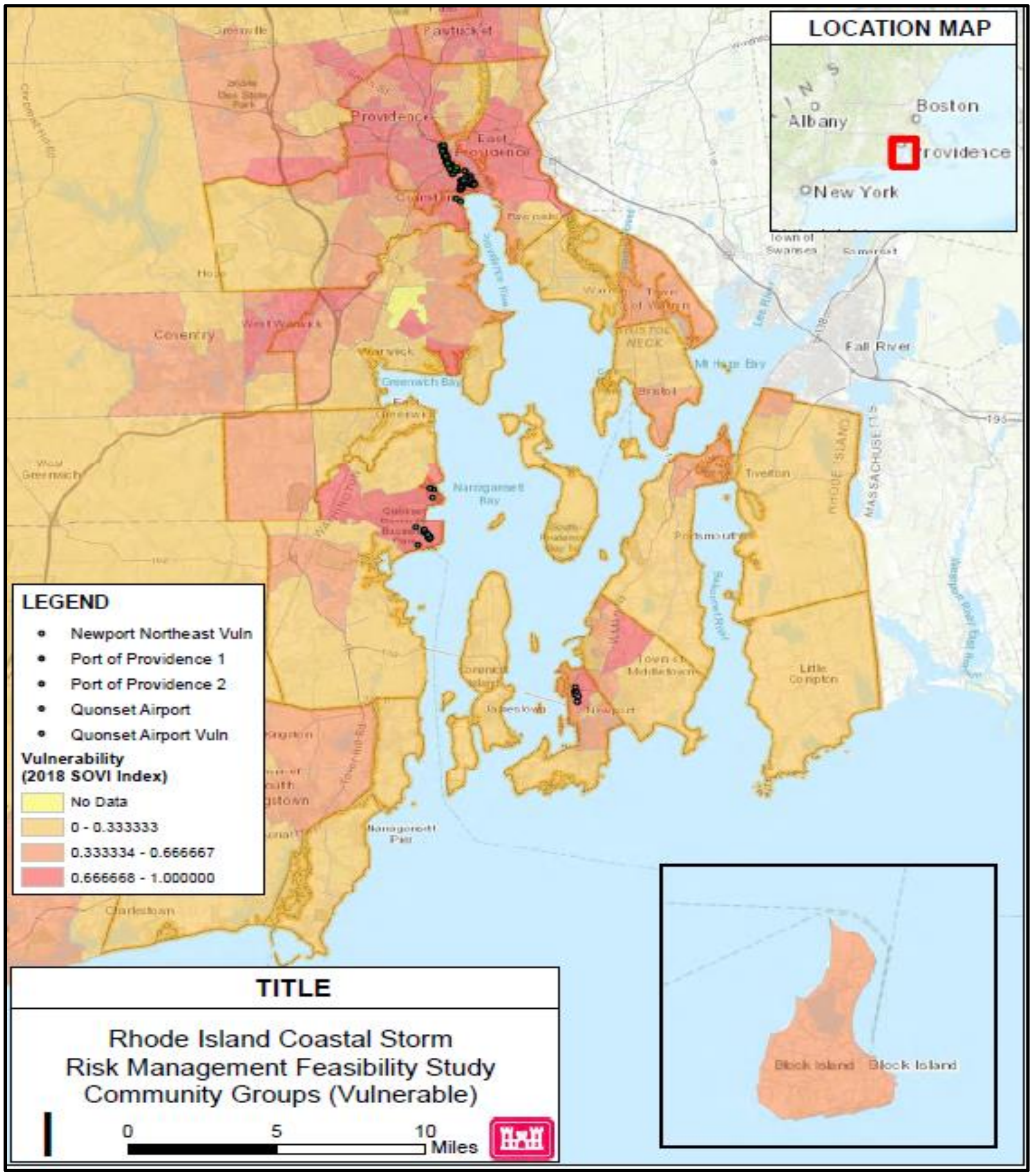

Figure 4-14: Community groups located in socially vulnerable communities

The second step in the creation of Plan NS-B involved a reassessment of the Initial Inventory. The PDT reevaluated the approximate 12,000 structures included in the Initial Inventory to identify structures in vulnerable communities that weren't included in the Baseline Inventory. Only areas identified by the CDC SVI over .75 (i.e., communities with high social vulnerability) were considered. 51 additional structures, not included in the community groups, were found. These properties were divided into three (3) additional community groups (Port of Providence 2, Newport NE & Quonset Airport 2) and added into the plan (**Table 4-18**).

Ultimately, Plan NS-B included 348 residential properties that would be recommended for elevations and 262 non-residential properties that will be recommended for floodproofing (**Figure 4-15**).

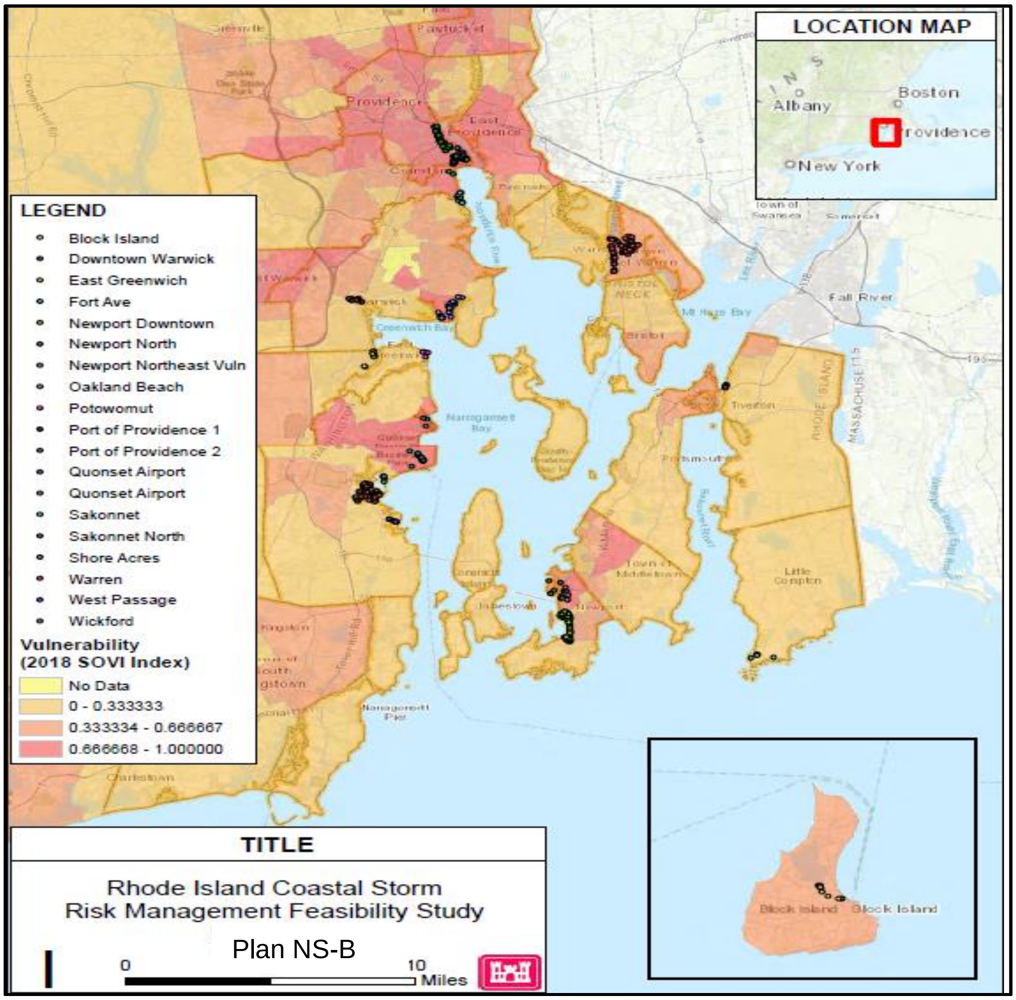

Figure 4-15: Elements of Plan NS-B

Plan NS-C – Flooded and Isolated Structures - Plan NS-C considered Health and Safety of the residents living within the study area by assessing structures that would be cut off from essential services and utilities due to future flooding caused by SLC and storm flooding. This was done by mapping the inundation of the highest annual tide with the 2080 USACE Intermediate SLC scenario. Residential structures that were predicted to be inundated at this future flood level were recommended for acquisition, instead of elevations (**Figure 4-16**). Additionally, there are residential properties that would be cut off from essential services and utilities because all access (i.e., roads and bridges) would be inundated at this future flood level. The structures on these properties were also included for buy-outs. This element of Plan NS-C's rationale was that private properties experiencing consistent flooding would no longer be safe to inhabit because they would be cut off from essential services and utilities. Therefore, moving the buildings out of the floodplain, instead of elevating them, would reduce repetitive flooding, promote safety and increase community resiliency. The final element of Plan NS-C addressed non-residential structures. All non-residential structures that would be inundated at this future flood level would not be included in the plan. Because these properties would regularly experience flooding (at the highest annual tide), floodproofing measures would be insufficient to stop property damage. The state and property owners would have to consider other measures to address these properties.

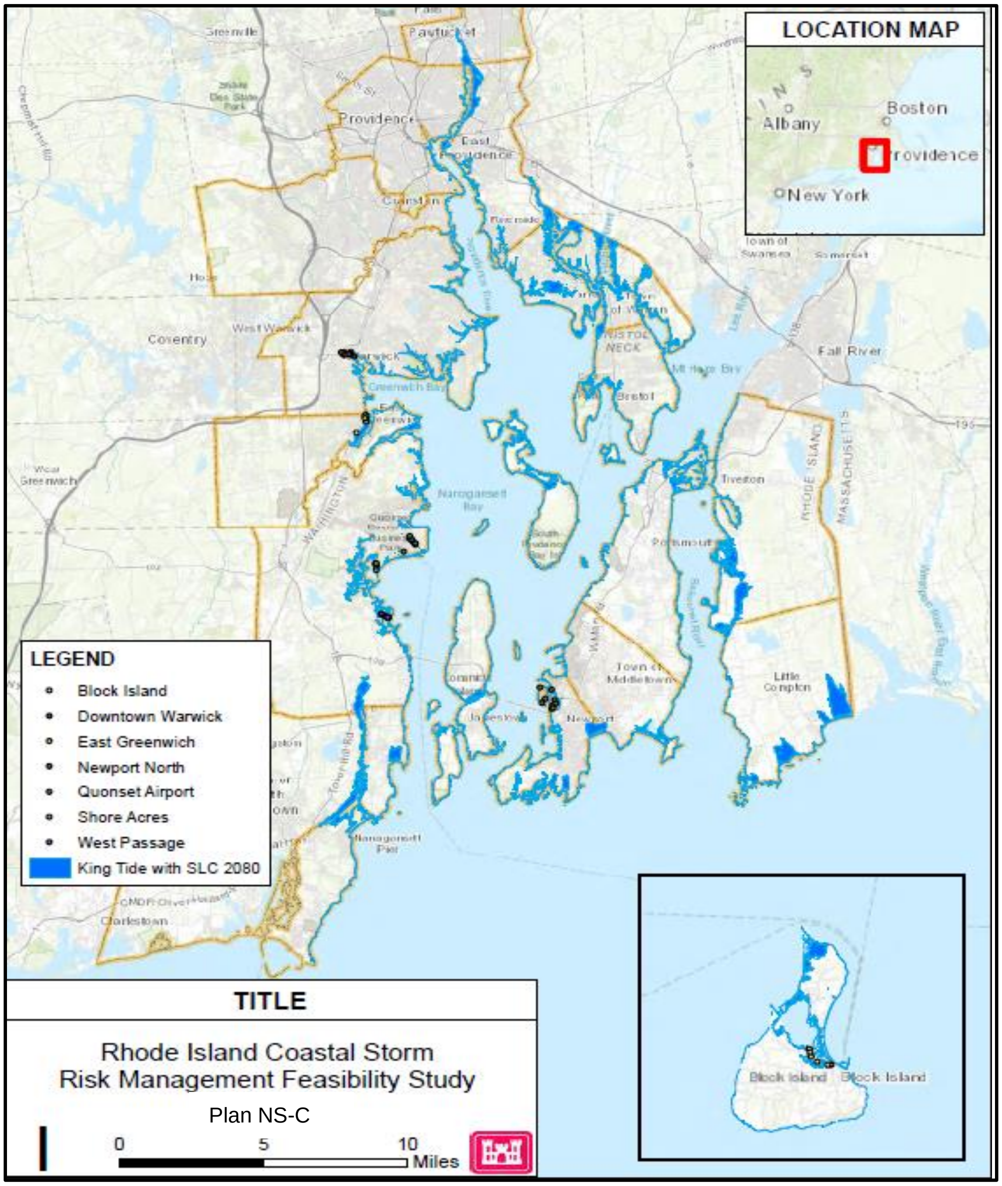

Figure 4-16: Elements of Plan NS-C

This plan was developed using the community groups formulated in Plan NS-A. An economic analysis as completed, which included three (3) elements:

1. Acquisitions for residential properties that would be consistently flooded at the future flood level (i.e., Mean Higher High Water plus 1.5ft using the USACE intermediate SLC model),
2. Elevations for residential properties that would be flooded at the future flood level,
3. Floodproofing for non-residential properties that would not be consistently flooded at the future flood level.

Because the cost of acquisition is so much higher than the cost of elevations, only seven (7) community groups had a BCR greater than 0.9 (highlighted in blue in **Table 4-19**). Twenty-five (highlighted in gray in **Table 4-19**) had a BCR less than 0.9, so were not included in the plan. As a result, Plan NS-C is a much smaller plan. Plan NS-C includes 21 elevations, five (5) acquisitions and 41 floodproofings (highlighted in blue in **Table 4-19**).

Table 4-19: Economic analysis for Plan NS-C
(October 2020 price levels and 2.5% discount rate)

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR	Acquisition	Elevation	Floodproof
Barrington	22,287,407	47,457,131	0.5	29	37	11
Block Island	3,326,145	2,889,480	1.2	0	2	6
Bristol Downtown	6,175,878	8,097,265	0.8	0	14	8
Common Fence Point	5,872,950	17,207,321	0.3	12	13	0
Cranston Mall	999,216	2,246,801	0.4	0	0	5
Downtown Warwick	8,532,124	8,635,518	1.0	3	2	11
East Greenwich	3,003,178	2,989,720	1.0	0	0	8
Fort Ave	2,524,052	4,510,793	0.6	1	8	1
Island Park	9,894,835	21,442,490	0.5	16	34	0
Laurel Park	8,349,363	19,069,709	0.4	11	26	0
Little Tree Point	8,106,434	25,060,387	0.3	24	0	0
Narragansett	8,525,624	18,972,983	0.4	17	9	3
MB South Kingstown	8,607,544	20,430,822	0.4	18	20	0
Nannaquaket Pond	2,731,614	7,498,215	0.4	11	2	1
Newport Downtown	71,911,010	88,566,890	0.8	54	31	29
Newport North	3,717,798	3,823,460	1.0	1	2	7
Oakland Beach	6,224,850	11,583,918	0.5	5	23	2
Potowomut	2,128,178	4,521,580	0.5	3	2	0
Provport 1	12,095,014	19,758,065	0.6			35
Quonset Airport	11,033,142	4,498,113	2.5	0	0	9
Sakonnet	1,891,846	2,248,749	0.8	1	2	2
Sakonnet North	3,583,277	8,458,327	0.4	7	1	0

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR	Acquisition	Elevation	Floodproof
Sakonnet South	3,378,462	6,790,561	0.5	6	4	0
Shawomet	5,150,644	10,831,255	0.5	6	15	3
Shore Acres	2,163,717	2,542,409	0.9	0	7	0
South Kingstown	8,607,544	20,430,822	0.4	18	20	0
The Hummocks	1,622,946	4,594,010	0.4	4	3	0
Tiverton/Little Compton	2,513,143	7,450,163	0.3	9	0	0
Warren	27,616,489	43,935,846	0.6	20	44	36
Warwick Neck	6,267,922	16,081,207	0.4	17	12	0
West Passage	3,011,609	3,502,615	0.9	1	8	0
Wickford	46,539,575	62,298,473	0.7	16	97	35

Table 4-20 provides a summary of the three (3) nonstructural plans that were developed for the RIC study.

Table 4-20: Summary of measures for the nonstructural plans

Plan	Elevations	Floodproofings	Acquistions	Total Structures
NS-A	313	181	0	494
NS-B	348	262	0	610
NS-C	21	41	5	67

5.0 CRITICAL INFRASTRUCTURE

5.1 CRITICAL INFRATRUCTURE ANALYSIS

Flood risk management measures for critical infrastructure (CI) were analyzed as part of this study. FEMA identifies CI as being “those assets, systems, networks, and functions—physical or virtual—so vital to the United States that their incapacitation or destruction would have a debilitating impact on security, national economic security, public health or safety, or any combination of those matters. Key resources are publicly or privately controlled resources essential to minimal operation of the economy and the government.” (FEMA 2008).

The formulation strategy for the CI analysis was to provide flood risk management measures for CI as part of the nonstructural component of the alternative plan selected for recommendation, regardless of whether or not the CI is located in a community group that is otherwise economically justified. As such, CI could be incorporated throughout the study area, including those areas where no other nonstructural action is recommended.

A list of facilities, initially developed from the Rhode Island Emergency Management Office, the Department of the Interior, as well as various Rhode Island localities, were preliminarily identified as CI. The list was also provided to the Non-Federal Sponsor (NFS) for their concurrence. This list included airports, communication sites, electrical substations, emergency facilities (EMS and fire stations, hospitals, police stations), hazardous material facilities (e.g., wastewater treatment plants), nursing homes, assisted living facilities, and schools. There were over 800 CI facilties located within the study area, however, the project development team (PDT) focused the investigation primarily on the 73 facilities that were identified as critical and were located within the designated 100-year floodplain. The list was refined down to 55 facilties (**Table 5.1**), by removing certain categories of structures, including:

- Federal facilities, which can not be part of a USACE project,
- Duplicate listings of the same structures,
- Structures that were not to be located in the 100-year floodplain, but were mistakenly inlcuded in the list, and
- Structures that were not truly critical infrastructure, such as bus stops.

Table 5-1: Critical Infrastructure facilities located in the 100-year floodplain

Type of Critical Infrastructure	Number of Sites	Number & Type of Structure
Airport	1	Multiple
Electrical Power Station	9	7 Buildings/ 8 Substations
Energy Production	1	1 Building
Fire/police	4	5 Buildings
FP - Chemical/Single Building	3	3 Buildings
Nursing Home/ Assisted Living	4	4 Buildings
School	6	9 Buildings
Sewer	24	21 Buildings/ 10 Underground Facilities
Structural - WWTF	1	1
Tank Farm	2	2
Total	**55**	**53 Buildings** **10 Underground Facilities** **8 Substations**

Using the refined list of CI facilties, the PDT then identifed a point of contact (POC), such as the site managers, property owners, town planner or other personel who have an understanding of the management and history of each site, to determine if they were interested in participating in the study and if the facilty had already been hardened to flooding caused by coastal storms. If the POC was interested in participating and the facility had not been floodproofed, the faciltiy was added to the Recommended Plan and the PDT continued coordination efforts with the POC to obtain information about each site. Ultimately, 36 sites were included in the Recommended Plan.

5.2 FACILITIES INCLUDED IN THE RECOMMENDED PLAN

This section provides a brief description of each CI facility that was included in the Recommended Plan.

5.2.1 Schools

Barrington High School (Barrington) - Barrington High School is a public high school in Barrington, RI and is the singular high school in the Barrington Public Schools district, enrolling approximately 1,200 students in grades 9-12. The high school is located in Barrington's "Evacuation Zone A" and does not function as an emergency shelter for the community as a result of its high likelihood of flooding. It is also located along a prime evacuation route should Barrington ever experience severe weather, such as a hurricane. This risk of future flooding is why the Town of Barrington is extremely interested in floodproofing the building. Although the school is not used as a shelter, its used for other purposes in addition to education. For example, elections are held at the High School and low cost, or free lunches are served to low-income children.

Barrington High School was included in the Recommended Plan as part of the Barrington community group.

International Yacht Restoration School (Newport) - The International Yacht Restoration School, now known as the IYRS School of Technology & Trades, is a private nonprofit school with a 3-acre campus on Thames Street in Newport, RI. The school owns several large buildings, including the 1831 stone Newport Steam Factory building listed on the National Register of Historic Places. Part of the student curriculum includes building and restoring boats, such as the iconic Beetle Cat, to be sold to the public each year. IYRS also holds an annual race called the Annual Newport Classic Yacht Regatta, which is open to anyone wishing to race their yachts. Additionally, they hold public workshops that last anywhere from 1-day to 5-weeks such as their "Build a Wood Charcuterie Board" (1-day), "Rhino 7 Workshop" (4 sessions), and their summer "Youth Boatbuilding Program" (5-weeks). The school is also open to the public to tour and learn more about the history of boat building and restoration.

The International Yacht Restoration School was included in the Recommended Plan as part of the Newport community group.

5.2.2 Nursing Homes and Assisted Living Facilities

East Bay Manor (Riverside) - East Bay Manor, now known as Anchor Bay at East Providence, is a retirement community in East Providence, RI. It is run by Elegance Living, which owns and operates 26 properties across ten (10) states. It is located near One Hundred Acre Cove Nature Reserve and provides a variety of amenities, such as a beauty salon and daily community activities, for its residents. Living situations here vary from basic Assisted Living to Memory Support depending on each individual resident's needs. The facility provides utilities, housekeeping, meals, laundry services, among other services to their residents.

Anchor Bay at East Providence is an outlier, meaning that it is not located in any community group developed for the Rhode Island Coastline CSRM study. The Benefit/Cost ratio of protecting this facility was less than 1.0. Therefore, the facility cannot be included in the plan using National Economic Development (NED) benefits. Instead, the facility provides Other Social (OSE) benefits to the community, such as providing safe housing, specialized on-site medical and nursing care and a sense of community for the elderly, which are often the most vulnerable members of a community. **Table 9-2**, found in this appendix provides a full list of OSE benefits that support the inclusion of this CI facility in the Recommended Plan.

Grace Baker Nursing Center (Warren) - Grace Barker Nursing Center is a family-owned care facility in Warren, RI that has been in operation since 1966. Many patients come from the communities of Warren, Bristol, Barrington, Riverside, East Providence, Rumford, Portsmouth, and Tiverton as well as the nearby Massachusetts communities of Swansea, Seekonk, Somerset, and Rehoboth. The family owns two facilities: The Willows and The Cove. The Willows focuses on adult day health and assisted living services while The Cove, which is located closest to the water, specializes in skilled nursing and short-term rehabilitation.

Similar to Anchor Bay at East Providence, Grace Barker Nursing Center is an outlier and does not have a BCR above 1.0. It was included in the Recommended Plan due to the OSE benefits that the CI facility provides to the community (**Table 9-2**).

5.2.3 Fire and Police Stations

Quonset Fire Department (North Kingstown) - The Quonset Fire Station is a newly open facility located at the Quonset Airport in North Kingstown, Rhode Island. The 15,000 square foot facility was opened in 2020, replacing the original fire station which was built in 1981. The station provides 24 -hour fire and emergency services for the Quonset Point Air National Guard base and the Quonset airport as a whole, as well as the Quonset Business Park. The fire station can also provide assistance to the North Kingstown Fire Department with mutual aid when called upon. The Quonset Point Air National Guard base is home to the 143rd Airlift Wing, whose mission is to provide airlift and combat support forces to the U.S. Airforce and to provide resources to protect life, property and public safety for Rhode Island and the local community.

The New England district had its Office of Counsel investigate whether this specific National Guard facility could be including in the Recommended Plan. After an investigation into the ownership of the underlying property, it was determined that the State of RI, not the Federal Government owns the land. The property is owned in fee by RI, acting through its Department of Transportation, and is leased to the Rhode Island

Airport Corporation (RIAC). The RIAC in turn leased the property to the United States Government. The property was then licensed to the State of RI for the Air National Guard. The RI Air National Guard is a state agency. Therefore, there are no Economy Act issues presented. The Economy Act does not apply to the National Guard, except possibly when the Guard is called into federal service, because it is not an agency or instrumentality of the United States Government. *See* GOA, Principles of Federal Appropriations Law, 3rd Ed., Volume III, ch. 12, §B.1.b., GAO-08-978SP (Washington, D.C.: Sep. 2008); B-152420, Oct. 3, 1963, aff'd on reconsideration, B-152420, Feb. 25, 1964. It was the opinion of the Office of Counsel that this facility could be included in the plan.

The North Kingstown Fire Department was included in this study because it is part of the Quonset Airport Community Group.

Fire Department – Station 1 (Newport) - The Newport Fire Department offers Firefighting, ALS Emergency Medical Services, and Fire Prevention Services to over 24,000 citizens. The Fire Department is comprised of 95 personnel divided into three (3) branches: Administration, Fire Prevention, and Fire Suppression/EMS Personnel. The mission of the Newport Fire Department is to preserve lives and property within the community by providing services directed at the prevention and control of fires, accidents, and other emergencies, while maintaining the highest standards of professionalism, efficiency, and effectiveness.

The Newport Fire Department has three (3) stations throughout the community. Station 1, which serves as the Department's Headquarters, is located at 21 W. Marlborough Street and was built in 1934. In June 2019, Newport launches the "Safe Stations Program" aimed at aiding anyone battling addiction. All three (3) fire stations serve as Safe Stations where those battling addiction can go to receive medical attention and be connected with a Certified Peer Recovery Specialist from the Hope Recovery Center.

Station 1 was included in the Recommended Plan as part of the Newport community group

5.2.4 Electric Power Stations

National Grid Newport West Howard Substation (Newport) - The West Howard Substation directly feeds distribution load in Newport and directly supplies other substations in Newport (Harrison substation) and Jamestown, acting as backup feed for the Eldred and Clarke Street substations. The West Howard substation serves 2,526 customers, while the Harrison substation serves 2,060 customers.

Although the Newport Substation has ties to other substations, there is not enough capacity to energize all of the customers from those two substations. If a flood were to happen when the system load was off-peak, then approximately 50% of customers could be energized from other substations. However, that number drops drastically if an event were to occur during a peak loading timeframe.

The Newport Substation was included in the Recommended Plan as part of the Newport community group.

Block Island Power Station (New Shoreham) - The town of New Shoreham purchased the majority of shares for the Block Island Power Company in 2016 and sponsored the effort to create a non-profit utility district. For 92 years, the Island's electricity was produces by diesel generators. A year after the town of New Shoreham purchased a majority share of the company, the facility was connected to the mainland power grid through the National Grid's Sea2Shore submarine cable. This transition resulted in stabilized supply prices, reduced carbon emissions and noise pollution and provided access to clean power.

The main campus of the Block Island Power Company is located on Ocean Avenue. The site includes one (1) electric substation and four (4) buildings. The company has plans to reinvest in the buildings on site and is interested in participating in the Rhode Island Coastline project in conjunction with their ongoing efforts. Only the substation and three (3) of the buildings are included in the Recommended Plan, as the company has plans to tear down and rebuild one of the buildings onsite to create employee housing. The new building will be constructed to withstand flooding.

All main campus of the Block Island Power Company is located in New Shoreham and were included in the Recommended Plan as part of the Block Island community group.

5.2.5 Sewer Systems

Newport Sewer System - The city of Newport has a single WWTF that serves 41,600 customers throughout Newport, Middletown, the U.S. Naval Station Newport, and a portion of Portsmouth. Pumping stations throughout the city help move wastewater from homes and businesses to the treatment facility.

From 2010-2014, the WWTF experienced Extreme Weather Related SSO Events 21 out of 85 events for a total of 25%. As a whole, the city is being proactive with how they tackle the challenges rising sea levels and increased extreme weather events will have on their sewage treatment systems. They recently upgraded the WWTF, the two (2) combined sewer overflow facilities in the town and some of the pump stations. To continue this effort, Newport is interest in participating in the Rhode Island Coastline CSRM study to harden the Bliss Mine Road Pump Station, Dyres Street Pump Station, the Lee's Wharf Pump Station and the Sakonnet Pump station. The Sakonnet Pump station also has a small electric substation located on the site.

The Lee's Wharf pump station is located in downtown Newport and was included in the Recommended Plan as part of the Newport community group. Whereas, the Bliss Mine Road Pump Station, the Dyres Street Pump Station and the Sakonnet pump station and electrical substation are not located in any of the community groups that were included in the Recommended Plan using NED benefits. These sites were included in the Recommended Plan due to the OSE and environmental quality (EQ) benefits that these facilities provide to the community. The sewer systems collect and transport sewage away from residences and commercial builds to a treatment facility. If these pump stations are inundated with flood water, untreated sewage can back up into basements, which creates a health hazard to residents and damages private property. In some cases, the untreated sewage will flow into local waterways, again resulting in a health hazard for the community and damaging the environment. A complete list of OSE and EQ benefits provided by the pump stations is included in **Table 9-2**.

Block Island Wastewater Treatment System - The New Shoreham WWTF on Block Island is located at 252 Spring Street. It serves approximately 300-700 customers in the winter and approximately 4,000 customers during the summer. Being an island off the coast of Rhode Island, Block Island is highly susceptible to flooding from storms and hurricanes. A climate vulnerability assessment was done for the WWTF and its subsequent pump stations on Block Island which shows how susceptible their infrastructure is to 100-year flood events. The town of New Shoreham is currently hardening its wastewater treatment system to withstand future flooding. They are interested in participating in the current study and would like to harden the three (3) pump stations that have not yet been floodproofed. These are the Old Harbor Pump Station, Boat Basin Pump Station and the Champlin's Pump Station.

All three (3) sites are located in New Shoreham and were included in the Recommended Plan as part of the Block Island community group.

Barrington Sewer System - Barrington is a suburban town located seven (7) miles southeast of Providence, with a population of approximately 17,000 people. Barrington maintains a public sewer system that serves approximately 14,700 residents of the town. The system includes a series of pump, ejector and lift stations that transport wastewater to a centralized WWTF in East Providence. The town has just recently considered floodproofing the sewer system and is interested in participating in the Rhode Island Coastline study. They have suggested 13 different sites throughout the town, including:

Bay Spring Ave Pump Station
Riverview Street Ejector Station
Wampanoag Ejector Station
Mussachuck Creek Pump Station
Freemont Avenue Pump Station
Walnut Road Pump Station
Adam's Point Rd Ejector Station
Police Cove Pump Station
Rumstick Rd Ejector Station
Brickyard Pond Pumping Station
Nayatt Rd Grinder Station
Elm Lane Ejector Station
Pheasant Lane Pump Station

Many of these facilities are located in the FEMA Coastal A or X zone or they are entirely underground. These sites will be wet floodproofed instead of dry floodproofed.

The all of these sites were included in the Recommended Plan as part of the Barrington community group.

SECTION 6.0 PLAN EVALUATION

6.1 FEDERAL OBJECTIVE

The Federal objective of water and related land resources project planning is to contribute to the economic development of the nation consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable EOs, treaties, and other Federal planning requirements. This Federal objective is captured in the National Economic Development (NED) Account discussed below in **Section 6.3.1**. The NED account helps the PDT to compare the risk reduction (damages reduced) for each alternative. Alternatives that provide NED benefits are consistent with the coastal risk management purpose of this study.

6.2 P&G CONSTRAINTS

The third screening iteration found in **Section 4.4.2** of this report addressed the P&G Criteria of Effectiveness, Efficiency, Acceptance, and Completeness. Alternatives carried forward to this step for comparison amongst the plans meet minimum standards of these criteria.

6.3 SYSTEM OF ACCOUNTS

The P&G established four (4) accounts for comparison of the alternatives. These are the NED, environmental quality/impacts (EQ), regional economic development (RED), and other social effects accounts (OSE). The 1983 P&G for Water and Related Resources Planning dictates that the NED benefit account be the primary decision criteria for selecting a solution. This criterion is based on an estimate of costs and benefits for each alternative and selection of the alternative plan with that reasonably maximized the net economic benefit consistent with protecting the Nation's environment (the NED plan). A USACE Policy Directive *Comprehensive Documentation of Benefits in Decision Documents* dated January 5th, 2021, requires that the PDT identify and analyze benefits in total and equally across a full array of benefit categories, including RED, OSE and EQ benefits. A description of each benefit type is provided below, while a quantitative analysis of benefits for the proposed plans is provided later in the report.

6.3.1 National Economic Development

The NED account documents the economic value of the national output of goods and services produced by the proposed investment. Planning guidance requires identification of the plan, from among the focused array of alternatives, that would produce the greatest contribution to NED. The NED plan is the plan with a positive BCR that most reasonably maximizes net annual benefits. The net annual benefits of a plan are equal to its annual benefits minus its annual costs. An economic analysis of NED benefits was completed for all structural alternatives that were included in the final array (**Table 6-1**). However, none of these alternatives had BCRs above 1.0 and they were all ultimately eliminated from consideration as they were not economically justified. All of the nonstructural plans have a BCR above 1.0. Plan NS-A maximizes Net Benefits and is therefore the NED Plan.

Table 6-1: NED Net Benefit Comparison of the Final Array of Alternatives
(October 2020 price levels and 2.5% discount rate)

Plan	Structure Count	Total First Cost ($)	Average Annual Benefit ($)	Average Annual Cost ($)	Average Annual Net Benefits ($)	BCR
Wellington Perimeter (Newport)	N/A	$36,640,000	$633,000	$1,305,000	-$672,000	0.5
Warren River Surge Barrier (Upper)	N/A	$614,631,000	$13,246,000	$27,276,000	-$14,030,000	0.5
Warren River Surge Barrier (Lower)	N/A	$568,211,000	$14,977,000	$24,142,000	-$9,165,000	0.6
Middle Bridge Protection (Narragansett)	N/A	$130,966,000	$954,000	$5,138,000	-$4,184,000	0.2
NS- A	494	181,000,000	9,730,000	6,500,000	3,220,000	1.5
NS-B	610	229,000,000	10,360,000	8,230,000	2,130,000	1.3
NS-C	67	29,000,000	1,170,000	1,040,000	130,000	1.1

For additional information on the cost and economic analysis, please refer to **Appendix C**, *Economics and Social Considerations* and **Appendix E**, *Cost Engineering*.

6.3.2 Environmental Quality

The EQ account displays non-monetary effects on significant natural and cultural resources. The alternatives included in the focused array would have varying impacts on the environment. Nonstructural alternatives, including residential elevations, buy-outs and nonresidential floodproofing would have relatively minor, negative and positive environmental impacts. Negative impacts would include temporary soil and vegetation disturbance during construction. The environmental benefits resulting from the construction of any of the nonstructural plans would include the reduction of the release of hazardous materials into the environment during a flooding event. Structures that would either be elevated or floodproofed would remain in the floodplain, however, the treatments would result in the reduction of hazardous chemical from being washed out of damaged structures into the local waterways. Structures that would be acquired would be removed from the watershed, which would also result in smaller amounts of hazardous materials entering the ecosystem due to coastal flooding events. Socioeconomics, economy and employment would improve due to each nonstructural plan because implementation of these alternatives would increase flood resilience. Structural alternatives would have a far greater negative environmental impact. For example, closure structures would permanently modify the river ecosystem and have long term negative impacts on environmental resources. The structural alternatives were not found to be technically, economically, or environmentally feasible, thus an assessment of the environmental impacts of the proposed nonstructural plans is provided in **Section 4.0** of the main report.

Prior to selection of the final Recommended Plan, non-residential buildings in the 100-year floodplain that generate/store/transport hazardous materials will be reviewed to determine if the EQ benefits associated with floodproofing these structures warrant inclusion in the Recommended Plan. Floodproofing these structures would benefit the environment by preventing the potential release of hazardous materials to the environment.

6.3.3 Other Social Effects

The OSE account includes urban and community impacts and effects on life, health and safety, and relevant effects not reflected in other accounts. The OSE categories that were considered during the RIC Study include Social Connectedness & Identity, Health and Safety and Social Vulnerability.

Social Connectedness & Identity – The social connectedness dimension of OSE relates to the sustained sense of connection that people feel to their community and neighbors. Recurring storm and flooding events can disrupt the interpersonal networks in the community and the vision of the future held by community members when people and businesses are displaced. Social identity is the feeling of pride in the community, which can be destroyed when flooding causes significant property damage and community members must leave the area of impact.

In this study, social connectedness and identity were taken into account in all of the nonstructural plans when community groups were developed using town boundaries, storm level impacts and physical clusters of buildings. Structural alternatives were developed with the intention to keep communities intact, so that connectedness and identify remained unimpaired during future flooding events

Health and Safety – The life, security, health and safety of the people living within the project area was also considered during the development of each alternative. Structural measures would protect the health and safety of residents from the direct impact of coastal storms by keeping flood waters away from property and eliminating future damages. The non-structural plans addressed health and safety in a number of ways.

Critical infrastructure facilities located in the 100-year floodplain were identified. Preliminary costs and benefits for providing flood risk management measures for critical infrastructure were developed as part of this study. The PDT will continue to investigate the inclusion of critical infrastructure protection into the Recommended Plan. Additionally, Plan NS-C was designed to assess the possible acquisition of private properties that are predicted to be consistently inundated if SLC continues throughout the study area.

Social Vulnerability Index – Social vulnerability communities are those that would most likely need additional support before, during, and after hazardous or severe events. The CDC's SVI was used to identify socially vulnerable communities. This database uses 15 social factors such as socioeconomic status, age, minority status, disabilities, crowded housing, primary first language, poverty, and lack of vehicle access to aggregate and rank the social vulnerability of communities using census tracts. The ranking system is on a scale from 0 (lowest vulnerability) to 1 (highest vulnerability). The Rhode Island coastline has a ranking of 0.35 on this scale, indicating a low to moderate level of vulnerability. The following figure (**Figure 6-1**) shows the SVI across the study area.

Plan NS-B was specifically developed, using the CDC's SVI, to identify and address recurring flooding in vulnerable populations within the project area.

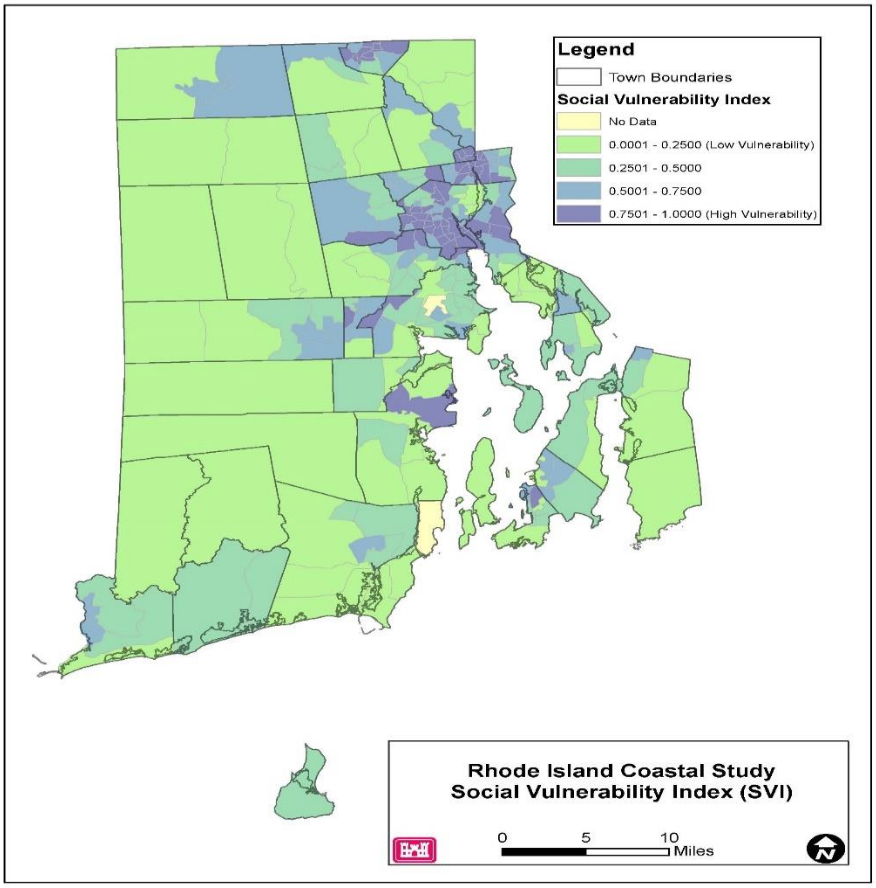

Figure 6-1: Social Vulnerability Index for the Rhode Island coastline

6.3.4 Regional Economic Development

The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan, including the regional incidence of NED effects, income transfers, and employment effects. The impacts of project spending on the employment, income, and output of the regional economy are considered part of the RED account. These regional impacts associated with construction spending for the plan are calculated using the USACE Regional Economic System (RECONS) certified regional economic model. The model is based on data collected by the U. S. Department of Commerce, the U.S. Bureau of Labor Statistics, and other federal and state government agencies. Nationally developed input-output tables represent the relationships between the many different sectors of the economy to allow an estimate of changes in economic activity on the larger economy as a whole, brought about by spending in the study area.

There are two (2) types of effects estimated by the RECONS model—direct and secondary effects. These effects, or impacts, are described as follows:

- Direct effects are the change in dollars or number of jobs that are created because of the direct construction spending made through payroll and direct purchases from businesses for goods and services.
- Secondary impacts measure the change in dollars or employment caused by the next round of spending as businesses make further purchases and pay their employees—these are often called the multiplier effect.

6.3.5 System of Accounts Assessment

Table 6-2 provides a quantitative analysis for the focused array of alternatives for the system of accounts. The NED account displays the average annual net benefit estimated for each alternative. Structural alternatives are not economically justified with negative net NED benefits. Non-structural plans have positive net NED benefits and are economically justified.

The RED account shows the total output associated with each alternative. "Output" is the sum total of transactions that take place as a result of the construction project, including both value added and intermediate goods purchased in the economy. Additional information on how RED benefits were estimated can be found in Section 8 of the **Appendix C**, *Economic and Social Consideration*.

The scale used to evaluate the OSE account was between 3 (positive impacts) and 1 (negative impacts), while the scale used to evaluate the EQ account was between 3 (positive impacts) and -3 (negative impacts). The Pros and Cons of the OSE and EQ accounts for each alternative were also included in **Table 6-2**. These qualitative benefit assessments were used to develop a scaled rating to compare alternatives. Qualitative assessment was determined to be suitable for this comparison of alternatives since the only NED justified alternatives are all nonstructural. It is reasonable to conclude that any positive quantitative assessment of EQ and/or OSE would not outweigh the value of the NED benefits attained by the nonstructural alternatives as compared to the structural alternatives for this study. Likewise, it is not anticipated that the difference in EQ or OSE benefits would be substantial enough to warrant quantitative assessment of these accounts.

Plan NS-A provides the most average annual benefits and is identified as the NED plan. The other alternatives do not provide as many NED benefits. Not only did the structural alternatives provide less NED benefits, but none of these alternatives were also economically justified. Plan NS-A, along with the Providence Harbor Bulkhead and Plan NS-B, also provided the highest level of OSE benefits.

By choosing a non-structural plan, some OSE and RED benefits, which would have been provided by the structural alternatives, will not be realized. The structural alternatives included in the final array of alternatives would have reduced coastal storm risk for entire communities upstream of the Warren River Surge Barrier, upstream of the Middle Bridge Protection structure and areas behind the Wellington Perimeter Flood Wall. While the non-structural plans only reduce risk to individual properties. Additionally, the two (2) Warren River Surge Barriers would have provided a much greater number of RED benefits. Although they would provide more RED benefits and coastal storm risk reduction on a community level, these structural alternatives would have resulted in significant negative environmental impacts upstream of the structures. Some of these impacts (e.g., destruction of Native American burial sites and impacts to an Audubon Sanctuary) were anticipated to be so extreme that they would not be acceptable to the community and to resource agencies. These negative environmental impacts would be avoided by Plan NS-A or the Recommended Plan.

The Providence Harbor Bulkhead would have provided OSE benefits to the entire area that is protected by the bulkhead and localized environmental benefit. Although these benefits will not be gained through the Recommended Plan for the RIC study, this report does include a recommendation that the New England District should study the Port of Providence in a separate study effort. A future study would assess and develop OSE and environmental benefits gained in reducing coastal storm risk in and around the port.

Plan NS-B would provide OSE and RED benefits that are not included in Plan NS-A. Plan NS-B protects socially vulnerable communities and communities located in environmental justice areas. Plan NS-B also is anticipated to provide more RED benefits than Plan NS-A. These additional benefits are not anticipated to lost because, as described later in the report, socially vulnerable/environmental justice communities were added to Plan NS-A while the Recommended Plan was developed. With the inclusion of socially vulnerable/environmental justice communities to the Recommended Plan, its anticipated that additional RED benefits would be gain from implementation of the plan.

Although Plan NS-C would provide the reduction of coastal storm risk on a regional scale, it was a much smaller plan, providing risk reduction to a smaller population and elements of the plan (i.e., property acquisition) were not acceptable to the NFS or the community.

Table 6-2: System of accounts analysis

Alternative	NED[1] ($)	RED[2] ($)	OSE			EQ		
			Value	Pros	Cons	Value	Pros	Cons
Wellington Perimeter (Newport)	-672,000	122M	1	•Maintains communities, local roads and utilities.	•Localized Benefits •Does not protect socially vulnerable communities.	1	No Significant Beneficial Impacts	•Effects to aesthetics
Warren River Surge Barrier (Upper)	-14,030,000	2B	1	•Maintains communities, local roads and utilities.	•Localized Benefits •Does not protect socially vulnerable communities.	-3	No Significant Beneficial Impacts	•Effects to wetlands and fish passage.
Warren River Surge Barrier (Lower)	-9,165,000	1.9B	1	•Maintains communities, local roads and utilities.	•Localized Benefits •Does not protect socially vulnerable communities.	-3	No Significant Beneficial Impacts	•Effects to wetlands and fish passage •Located adjacent to an Audubon Sanctuary •Impacts to Native American burial site.
Providence Harbor Bulkhead	N/A	N/A	2	•Maintains communities, local roads and utilities. •Located in a vulnerable community	•Localized Benefits •Does not protect socially vulnerable communities.	2	•Minimizes HTRW releases to Providence River	No Significant Detrimental Impacts
Middle Bridge Protection (Narragansett)	-4,184,000	437M	1	•Maintains Communities	•Localized Benefits •Does not protect socially vulnerable communities.	-3	No Significant Beneficial Impacts	•Effects to wetlands, eelgrass, and fish passage. •Located near a wildlife sanctuary.
NS - Plan A	3,220,000	473M	2	•Benefits on regional scale •Maintain communities •Includes some vulnerable communities	•Does not reduce risk for local roads and utilities.	1	No Significant Beneficial Impacts	No Significant Detrimental Impacts
NS - Plan B	2,130,000	599M	2	•Benefits on regional scale •Maintain communities •Includes all vulnerable communities	•Does not reduce risk for local roads and utilities.	1	No Significant Beneficial Impacts	No Significant Detrimental Impacts
NS - Plan C	130,000	79M	1	•Benefits on regional scale •Maintain communities •Considers future access to critical services and utilities	•Highest residual risk of NS plans. •Does not reduce risk for local roads and utilities. plans	1	No Significant Beneficial Impacts	No Significant Detrimental Impacts

NED account displays average annual net benefits
RED account displays total economic output estimated to result from project implementation expenditures

6.4 FINAL ARRAY OF ALTERNATIVES

The comparison of the focused array resulted in the elimination of all five (5) structural alternatives. The floodwall in Newport and all three (3) surge barriers (two on the Warren River and one on the Narrow River) could not be economically justified (i.e., the BCR calculated for each alternative was below 1.0). While the initial evaluation of the Port of Providence led the PDT to determine that this complex system required a separate planning effort to adequately address the area. Therefore, only the NAA and the non-structural plans will be moved forward, and their environmental effects will be assessed.

While plan formulation and evaluation to this stage was based on the intermediate SLC curve, it is unlikely that the structural alternatives would have been carried forward under a lower or higher SLC scenario. Under a lower SLC scenario, damages are expected to be reduced. Therefore, the benefits of implementing a structural alternative would also be reduced. Under a higher SLC scenario, while damages and benefits might increase, additional costs associated with lengthening floodwalls to tie into higher ground, increased operations and maintenance, increased pumping to evacuate water from inland areas, and costs for environmental mitigation, would also be incurred. Further, to maintain the same level or risk reduction, higher floodwalls would have greater impacts on the viewshed and be less favorable to communities.

SECTION 7.0 PLAN COMPARISON AND SELECTION

7.1 PLAN COMPARISON

As discussed in **Section 3.5.3**, "*System of Accounts*" of this report, there are four (4) accounts to facilitate and display the effects of alternative plans in the formulation of water resource projects while recognizing the importance of maximizing potential benefits relative to project costs. These accounts are National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE).

The results from the "System of Accounts Analysis are provided in **Table 6-2**. No one plan maximized the benefits of all four (4) accounts. Plan NS-A maximized NED benefits, while the Warren River Upper Surge Barrier maximized RED benefits. The Providence Harbor structural alternative and nonstructural plans NS-A, and NS-C all received the highest scores for OSE benefits. The Providence Harbor structural alternative also received the highest score for EQ benefit. However, it was difficult to compare a localized plan, such as the Providence Harbor alternative, with the regional nonstructural plans. Although the Providence Harbor plan would provide environmental benefits, these benefits would only be experienced in the immediate vicinity of the Port. The nonstructural plans would produce minor environmental benefits throughout the entire region.

All structural alternatives were not economically justified and fell out of consideration, which left the three (3) nonstructural plans.

7.2 IDENTIFICATION OF THE NED PLAN

The NED plan is Plan NS-A.

7.3 PLAN SELECTION

Nonstructural Plan A has the highest Average Annual Net Benefit of the plans under consideration and is the NED plan. This is the plan that maximizes net benefits consistent with the study purpose.

Nonstructural Plan A would also be the selected plan under a higher SLC curve, as the values shown in **Table 6-2**, "System of Accounts Analysis," are expected to remain consistent across SLC scenarios for the nonstructural alternatives. Under the high SLC scenario, however, there would most likely be more elevations included in the plan as more damages would be protected by elevations under the high curve, supporting justification for more elevations.

SECTION 8.0 PLAN REFINEMENTS

8.1 REFINEMENTS INCLUDED IN THE TENTATIVELY SELECTED PLAN

After the Plan NS-A was selected as the Tentatively Selected Plan (TSP), two (2) refinements were made in order to be as inclusive as possible and reduce the greatest amount of flood risk in the study area. These refinements resulted in the inclusion of an additional 39 structures to the TSP and were carried forward into the Recommended Plan. This plan will be referred to as NS-A.1.

The first refinement added non-residential structures from four (4) community groups (Barrington, Bristol Downtown, Narragansett and Shawomet). Although these groups had an overall BCR less than 1.0 when both elevations and floodproofing were considered, the BCR for non-residential floodproofing alone was greater than 1.0. **Table 8-1** shows the economic analysist for the four (4) community groups. The rows highlighted in blue include the costs and benefits of non-residential floodproofing. As a result of this refinement, twenty-five non-residential properties were added in Plan NS-A.1.

Table 8-1: Community groups with BCRs above 1.0 for the non-residential floodproofing included in the TSP

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR
Barrington	19,926,663	27,249,240	0.7
Elevation	14,108,403	21,794,889	0.6
Floodproof	5,818,260	5,454,351	1.1
Bristol Downtown	6,175,878	8,097,265	0.7
Elevation	2,545,806	5,107,545	0.5
Floodproof	3,630,072	2,989,720	1.2

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR
Narragansett	7,531,400	9,379,882	0.8
Elevation	5,945,377	8,258,737	0.7
Floodproof	1,586,023	1,121,145	1.4
Shawomet	4,804,555	7,974,676	0.6
Elevation	3,487,028	6,853,531	0.5
Floodproof	1,317,527	1,121,145	1.2

After the TSP milestone, the project costs were reassessed as described in **Section 8.2** of this report. Eight (8) community groups, which included 91 non-residential properties, fell into this category and were added to the Recommended Plan. These properties were supported by NED benefits.

The second refinement includes the outlier properties. As described previously in this report, 74 structures were not located near any other structures, so were not part of any community group. These were identified as "outliers" and were initially removed from consideration. However, after coordination with the North Atlantic Division and USACE Headquarters, it was determined that USACE policy allows the analysis and inclusion of individual properties in a non-structural plan. Of the 74 structures, six (6) were justified, with BCR's greater than 1.0. These structures were added to the Recommended Plan.

8.2 ACTIONS COMPLETED BETWEEN THE TSP MILESTONE AND FINAL REPORT

After the completion of the TSP milestone, the PDT completed a number of actions. These included:

Quality Control of the Structural Inventory – Errors were found in the structure inventory dataset. To ensure the accuracy of the study, a quality control (QC) review of the baseline inventory dataset, with a focus on foundation type and first floor elevations, was completed. Additionally, structures were removed from the baseline inventory if they were either federal owned or if they were non-residential properties located in the Coastal A Zone. FEMA regulations forbids dry floodproofing of properties in the Coastal A Zone, which is defined as the area landward of a V Zone or landward of an ocean cost without mapped V Zones. Likewise, if residential structures were found to have first floor elevations higher than the base elevation height, these were removed from consideration. The revised baseline inventory is shown in **Table 8-2**.

Table 8-2: Revised baseline inventory

Structure Type	# of Structures
Residential	722
Non-Residential	216

Rerun G2CRM model – Once the QC review of the baseline data set had been completed, the G2CRM model was rerun.

Cultural Resources and the Programmatic Agreement - For the communities included in the Recommended Plan, additional research was required to identify known archaeological sites and determine historic and archaeological sensitivity. This research and assessment continued throughout the feasibility phase and will continue during the (Preconstruction Engineering and Design) PED phase, when further identification, assessment, and evaluation will take place in coordination with the Rhode Island Historic Preservation Officer and consulting parties. The programmatic agreement was developed and is currently under review by the Rhode Island Historic Preservation Officer and will be completed prior to the conclusion of this study.

Sea Level Change Analysis - The benefits were further evaluated using the USACE SLC scenarios, low and high. The benefits were then compared to the project costs for the Recommended Plan.

Hazardous Materials Analysis – To further increase EQ benefits provided by the Recommended Plan, the non-residential structure inventory was investigated to find properties located in the 100-yr floodplain that store, generate, treat, or dispose of large amounts of hazardous material. Three (3) properties were identified using Resource Conservation and Recovery Act data and spill records and were included in the Recommended Plan, in order to reduce the potential environmental damage caused by hazardous materials released due to coastal storm events and related flooding.

Optimization of FFE - The elevation design height modeled for the Recommended Plan was determined separately for each structure based on the 1% AEP NACCS water level + wave contribution + sea level change (intermediate through 2080). From the G2CRM User's Manual (USACE, 2018b) and per FEMA guidance, the wave contribution was computed as 0.705* (the smaller of the 1% wave height or 0.78* water depth). For optimization of the plan, costs were updated and damages were modeled in G2CRM for an elevation of plus one foot (if possible based on an engineering constraints of 12 feet maximum elevation) and minus one foot to the base elevation used for the Recommended Plan. Net benefits were then compared for each to determine where benefits would be maximized, which will determine the optimized design elevation to be used in the Recommended Plan. More information about this optimization can be found in **Appendix C**, *Economic and Social Considerations*.

Refinement Real Estate Information – Addition work was completed to refine real estate information included in this report and to calculate accurate real estate costs.

Reassessment of Project Costs – Project costs were revised to reflect contractual and construction management realities associated with the Pawcatuck CSRM study. The Pawcatuck CSRM study is currently in PED phase and costs associated with elevations have been found to be significantly higher than anticipated, due to supply chain issues, labor costs and fuel prices. The foundation type played the largest role in determining the true cost of elevating the structure.

- 59% cost increase for houses with basements/crawlspaces to be converted to pile foundations,
- 62% cost increase for houses with basements/crawlspaces to be converted to extended walls, and
- 98% cost increase for houses on slabs to be converted to pile foundations

These cost increases were incorporated into the project data. which ultimately resulted in a significant decrease of plan elements that could be included in the plan using NED benefits. Other benefit types (OSE and EQ benefits) were used instead to support the inclusion of many Recommended Plan elements.

Critical Infrastructure Analysis – The analysis of CI facilities was completed, and structures were included in the Recommended Plan.

Project Performance - Project performance is discussed in **Appendix B**, *Coastal Engineering.* This analysis was refined as the Recommended Plan was optimized, and project performance across all three (3) USACE SLC scenarios is reported in this report.

Updating of Price Levels - Both costs and depreciated replacement values used to derive inundation damages were updated to October 2021 price levels for comparison at the current price level.

8.3 REFINEMENT OF THE RECOMMENDED PLAN

The PDT incorporated further refinements into Plan NS-A.1 to incorporate appropriate modeling updates and revisions to structure inventory based on a quality check of the entire baseline inventory. The updated G2CRM modeling results were used along with updated cost estimates to reevaluate inclusion of each community group in the plan based on NED benefits and the plan was adjusted accordingly. The refined estimated damages and costs are shown in the following table for each community group. If a community group had a BCR greater than 1.0, all structures (both residential and non-residential) were included in the Recommended Plan. Due to increases in the project cost and increases associated with residential elevations, a smaller number of whole community groups were included in the Recommended Plan as compared to the initial analysis of Plan NS-A, which is shown earlier in this report in **Table 4-17**. The revised economic analysis of the community groups is shown in **Table 8-3**. Groups highlighted in blue are included in Plan NS-A, the base plan for the Recommended Plan.

Table 8-3: Revised economic analysis of recommended plan community groups

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR
Block Island	5,084,853	2,276,000	2.2
Cranston Mall	19,628,559	3,683,000	5.3
Downtown Warwick	249,356,085	73,796,000	3.4
East Greenwich	7,075,514	5,135,000	1.4
*Newport Downtown	7,075,514	5,135,000	1.4
*Quonset Airport	19,628,559	3,683,000	5.3
Sakonnet	249,356,085	73,796,000	3.4

***Includes Critical Infrastructure in Community Group Benefits and Costs

8.3.1 Additional Non-Residential Floodproofing

As with the TSP, some community groups had a BCR that was too low to be part of the Recommended Plan when both elevations and floodproofing were considered. However, when only considering non-residential floodproofing, these community groups did have a BCR greater than 1.0. As shown previously in Table 7-1, the TSP included four (4) community groups that fell into this category. After completing the analysis described in **Section 8.2**, the number of community groups increased to eight (8) (**Table 8-4**). As a result, 91 non-residential properties were added to the Recommended

Table 8-4: Economic analysis for recommended plan floodproofing groups

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR
*Barrington	9,991,468	9,748,000	1.0
*Bristol Downtown	1,898,677	1,842,000	1.0
Fort Ave	2,246,692	1,105,000	2.0
Nannaquaket Pond	409,799	368,000	1.1
Narragansett	785,395	737,000	1.1
Shawomet	348,316	337,000	1.0
Warren	24,680,711	16,369,000	1.5
Wickford	19,989,396	12,891,000	1.6

***Includes Critical Infrastructure in Community Group Benefits and Costs

8.3.2 Individual Structures with BCRs Greater than 1.0

Individual structures within community groups not included in the plan were reviewed and added to the plan if their estimated BCR was over 1.0. There were 454 structures located within community groups that were not justified as a group. Of these individual structures, 14 were justified, with BCR's greater than 1.0. These structures were added to the Recommended Plan, similar to individually justified outliers.

8.3.3 Socially Vulnerable and Environmental Justice Communities

During the concurrent review of the draft report, the PDT received many comments about socially vulnerable and environmental justice communities. The concerns ranged from not including these communities in the plan to whether the three (3) community groups developed from the initial inventory were eliminated due to low property values. Due to these comments, the PDT reassess socially vulnerable and environmental justice communities.

As described previously, four (4) community group from the Baseline Inventory were found to be located in socially vulnerable communities as defined by the CDC Social Vulnerability Index (**Figure 8-1**). After the new G2CRM Model runs, only one (1) community (Quonset Airport) had a BCR high enough to be included in the base plan (Plan NS-A). Three (3) communities (Oakland Beach, Port of Providence 1 and Fort Ave.) were not included in Plan NS-A due to a low BCR. The Port of Providence community group is located in the Port of Providence. This report includes a recommendation for the Port of Providence to be investigated in a separate study effort. As for the Fort Ave. community group, the non-residential structures, when considered alone, have a BCR greater than 1.0 and were included in the Recommended Plan (**Table 8-4**) No part of the Oakland Beach community group could be included in the Recommended Plan using NED benefits.

To address the concern that the three (3) community groups (Port of Providence 2, Newport NE and Quonset Airport 2) develop from the Initial Inventory were eliminated from consideration due to low property values, the PDT reassessed these groups and determined that the extremely low BCRs were due to lack of flood damages, not low property values. Therefore, the PDT is confident that protection of these three (3) areas wouldn't reduce future flood risk in the study area.

Finally, environmental justice was reconsidered as the Rhode Island Department of Environmental Management updated the environmental justice maps for Rhode Island in June 2022, between the TSP milestone and the completion of the final report. New environmental justice areas were add to the state. One of the new areas encompassed the Warren community group (**Figure 8-1**). When considered as a whole (both residential and non-residential properties) the Warren community group does not have a BCR high enough to be included in the Recommended Plan using NED benefits; however, this community group does have a BCR > 1.0 when only considering non-residential structures (**Table 8-4**). Therefore, the non-residential structures were included in the Recommended Plan.

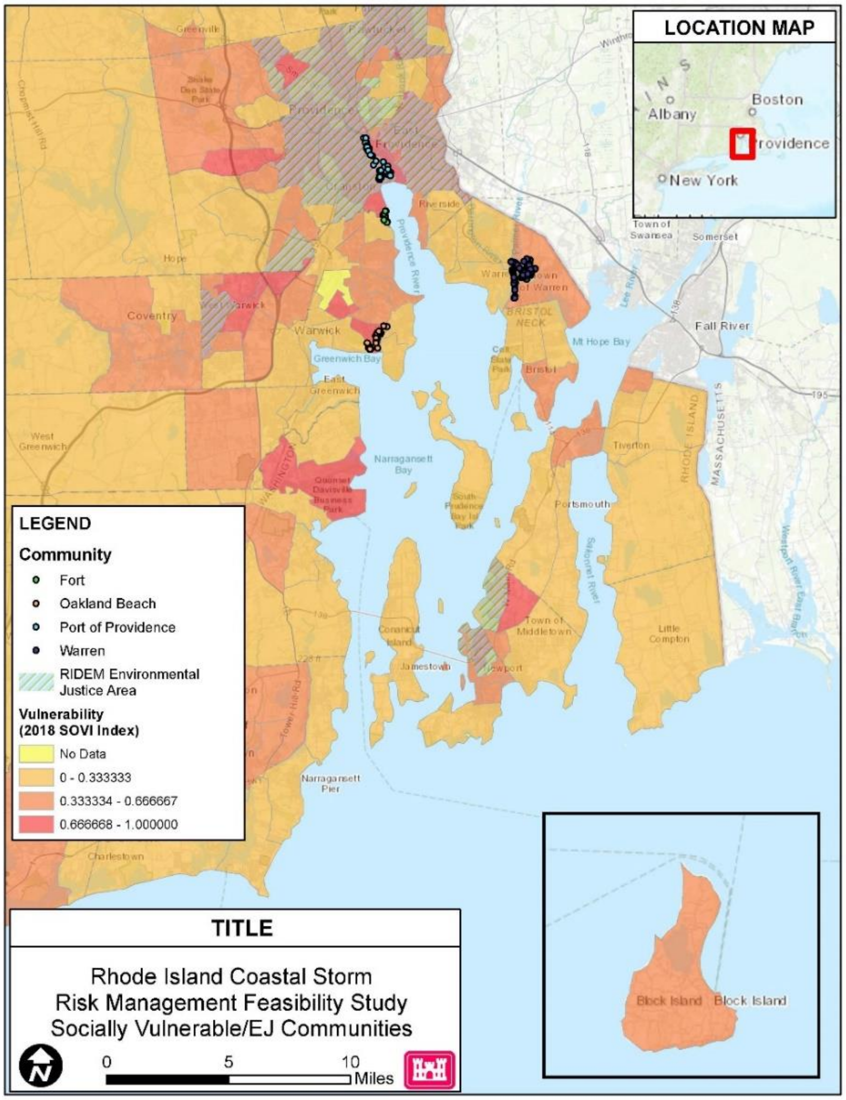

Figure 8-1: Socially vulnerable and revised environmental justice areas within the study area

Due to OSE benefits, the residential properties from the Fort Avenue and Warren community groups, in addition to the entirety of the Oakland Beach community group, are included in the Recommended Plan (**Table 8-5**), adding 106 structures.

Table 8-5: Economic analysis for recommended plan socially vulnerable/environmental justice and historically significant groups

Community Group Name	Total Present Value Benefits	Total Costs	BCR
Fort Avenue (Elevation)	3,053,102	5,142,736	0.6

Oakland Beach (Elevation and Floodproofing)	4,524,449	17,176,000	0.3
Warren (Elevation)	20,452,958	38,221,000	0.5
Wickford (Elevation)	26,585,338	48,215,000	0.6

8.3.4 Wickford Historic District

During plan formulation for the Rhode Island Coastline CSRM project, the Wickford Historic District was included in a community group that included 113 residential structures and 40 non-residential properties. The entire community group (both residential and non-residential structures) didn't have a BCR above 1.0, so it was not included in the base plan. However, the non-residential structures alone did have a BCR above 1.0, so these 40 properties were added to the Recommended Plan due to their NED benefits.

Of the residential properties, 81 are listed on the National Register of Historic Places and are part of the historic district. The remaining residential properties are modern structures and are not part of the historic district. The residential structures located in the Wickford Historic District have been included in the recommended plan.

8.3.5 Critical Infrastructure

Flood risk management measures for critical infrastructure were analyzed as part of this study as explained previously in this report. The list of CI facilities was eventually narrowed to a group of 36 sites. Of that final list, 23 were located in existing community groups that are part of the base plan. The remaining 13 sites are either part of a community group that did not have NED benefits great enough to be include in the plan or were outliers (i.e., not located in any community group).

SECTION 9.0 OTHER SOCIAL EFFECTS AND ENVIRONMENTAL QUALITY BENEFITS PROVIDED BY ELEMENTS OF THE RECOMMENDED PLAN

In accordance with ER 1105-2-100 Planning Guidance Notebook, a separable element must be incrementally justified. The Economic and Environmental Principles & Guidelines for Water and Related Land Resources Implementation Studies, 1983 (P&G) states, "A plan recommending federal action is to be the alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment (the NED plan), unless the Secretary of a department or head of an independent agency grants an exception to this rule." Exceptions may be made when there are overriding reasons for recommending an NED plan that incorporates one separable element that does not meet the 1.0 BCR threshold, based on other federal, State, local, and international concerns.

The Recommended Plan of the Rhode Island Coastline CSRM study includes separable elements with BCRs < 1.0 and must be supported using Environmental Quality and Other Social Effects benefits. These structures fell into three groups – The Wickford Historic

District, Environmental Justice/Socially Vulnerable Communities and Critical Infrastructure Facilities. 194 structures (either as a group or individually) fall into one (1) of these three (3) categories, having BCRs that are below 1.0 (**Table 9-1**). The PDT believes that protecting the structures in these groups, though may not be supported using NED benefits, will provide significant benefits to the community in which they are located and therefore should be allowed to be included in the Recommended Plan.

Table 9-1: Structures included in the recommended plan with BCRs below 1.0

Element	Number & Types of Structures	BCR
Wickford Historic District	81 Residential	0.5
Socially Vulnerable/Environmental Justice Communities		
Oakland Beach	28 Residential, 1 Non-Residential	0.3
Fort Avenue	9 Residential	0.6
Warren	68 Residential	0.5
Critical Infrastructure		
Grace Barker Nursing Home	1 Non-Residential	0.7
East Bay Manor (Assisted Living)	1 Non-Residential	0.5
Bliss Mine Road Pump Station	1 Non-Residential	0.5
Dyers Road Pump Station	1 Non-Residential	0.5
Sakonnet Pump Station	1 Non-Residential	0.5
Sakonnet Electric Substation	1 Non-Residential	0.5
Block Island	3 pump stations, 3 buildings and 1 electric substation	.003

9.1 Environmental Justice and Socially Vulnerable Communities

The PDT considered socially vulnerable populations and environmental justice communities within the RIC study area. Please note that the analysis of socially vulnerable communities was completed before interim guidance was develop of the implementation of Executive Order (EO) 13990 addressing Environmental Justice was developed and the PDT was interested in the inclusion of all socially vulnerable communities and not just those addressed under to concept of Environmental Justice. At that time, the PDT felt that the Social Vulnerability Index (SVI), that was developed by the Centers for Disease Control (CDC) was the best tool available to identify social vulnerability within communities. The CDC SVI ranks each census tract on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four (4) related themes: Socioeconomic status, Household Composition, Race/Ethnicity/Language and Housing and Transportation. A numerical ranking is assigned to each tract for each of the themes, in addition to an overall ranking. The ranking system is on a scale from 0 (lowest vulnerability) to 1 (highest vulnerability). For the RIC Study, the overall ranking was used to identify socially vulnerable communities. Communities with the highest ranking (.66 and above), meaning the community has the highest level of social vulnerability, were included for further study.

The team also considered environmental justice areas. Rhode Island Department of Environmental Management provides maps that identify environmental justice communities located in Rhode Island. The most recent maps, updated in June 2022, showed that the Warren community group is located in environmental justice focus area.

The Fort Ave and Oakland Beach community groups were included in the NED exception because they are both considered vulnerable to the impacts of natural disasters using the CDC's SVI using 2018 data. While the Warren Community Group is included in the exception request because it falls into areas that are considered socially vulnerable by the SVI and part of the group is located in an area that has been identified as an Environmental Justice community by the RI DEM.

Structures included in a community group were not assessed on an individual basis. Instead, structures were aggregated into groups in order to maintain community cohesion.

Oakland Beach - The Oakland Beach Community Group is located in Census Tract 217. This census tract was judged to be socially vulnerable in three of the four themes that are considered by the SVI. In addition, the Community Group had an overall SVI rating that indicated an overarching vulnerability. These being Socioeconomic Status, Household Composition & Disability and Minority Status & Language.
The Socioeconomic Status Theme assesses five different characteristics of a community. These include:

- Below 150% Poverty – The percentage of the population that earns 150% of the poverty level or less.
- Unemployed – The percentage of the population is unemployed.
- Housing Cost Burden – The population that has an annual income of $75,000 or less with a 30% or more of their income spent on housing.
- No High School Diploma – Persons 25+ without a High School Diploma
- No Health Insurance – Percentage of uninsured civilian noninstitutionalized population

The Household Composition & Disability Theme also assesses five characteristics of a household that influence the vulnerability of communities to natural disasters. These include:

- Aged 65 & Older
- Aged 17 & Younger
- Civilian with a Disability – Civilian noninstitutionalized population with a disability
- Single-Parent Households – Single-parent households with children under 18
- English Language Proficiency – Persons (age 5+) who speak English "less than well"

The Minority Status & Language Theme takes into account the percentage of the population that is made up of racial and ethnic minorities. These minority groups include:

- Hispanic or Latino
- Black and African American (not Hispanic or Latino)
- American Indian and Alaska Native (not Hispanic or Latino)
- Asian, Not Hispanic or Latino
- Native Hawaiian and Other Pacific Islander, Not Hispanic or Latino
- Two or More Races, Not Hispanic or Latino
- Other Races, Not Hispanic or Latino

Fort Ave - The majority of the Fort Ave Community Group is located in Census Tract 134, with only one structure being located in Census Tract 210. Census Tact 134 was judged to have medium to high socially vulnerable to the impacts of natural disasters due to the Household Composition and Disability and Racial & Ethnic Minority Status themes. Additionally, the tract is highly vulnerable due to elements that make up the Housing Type & Transportation theme. This them considers the following elements:

- Multi-Unit Structures – Population living in structures with 10 or more units
- Mobile Homes – Population living in mobile homes
- Crowding – At the household level, more people living in the property than there are rooms
- No Vehicle – Population no available vehicle
- Group Quarters – Population living in group quarters.

There is one structure from Census Tract 210 included in the Fort Ave Community group. This Census Tract has a low overall ranking but is considered moderately vulnerable to the impacts of natural disasters for the Household Composition & Disability theme.

Warren - The Warren Community Group includes properties in three Census Tracts (305, 306.01, 306.02). Two of these tracts have been judged to be medium to high socially vulnerable. Additionally, one of the Census Tracts (305) is identified as an Environmental Justice Focus area by the RI DEM (policy dated May 02, 2022). An Environmental Justice Focus Area is a census tract that meets one or more of the following criteria:

- Annual median household income is not more than sixty-five percent (65%) of the statewide annual median household income,
- Minority population is equal to or greater than forty percent (40%) of the population,
- Twenty-five percent (25%) or more of the households lack English language proficiency, or
- Minorities comprise twenty-five percent (25%) or more of the population and the annual median household income of the municipality in which the proposed area does not exceed one hundred fifty percent (150%) of the statewide annual median household income.

Vulnerable communities typically have less resources to cope with crises and natural disasters, making them less resilient to the effects of coastal storms. Residents may be less able to afford preparedness actions such as purchasing flood insurance or making home improvements to increase resilience to flooding and other disasters. In the past, pre-disaster hazard mitigation has not been equally available to all communities. More affluent communities have received a greater proportion of these resources. As a result, vulnerable communities are less resilient to the impact of natural disasters.

In their 2017 report addressing the impacts of natural disasters on people with lower socioeconomic status, the Substance Abuse and Mental Health Services Administration (SAMHSA) found that socially vulnerable people are more likely to live in housing that is vulnerable to natural disasters and in places where the risks from disasters are higher. Moreover, although they will have fewer assets to lose, they will experience a greater impact from the financial loss resulting from disasters. “They also may have their savings concentrated in fewer possessions, such as home and livestock, and so they may be more vulnerable to economic losses in disasters” then less vulnerable people.

The Environmental and Energy Study Institute provided a congressional briefing entitled “Protecting Vulnerable Communities from Climate Impacts” on April 6, 2021That presentation explored the impacts of natural disasters on the availability of affordable housing for vulnerable communities. They found that “areas that are facing extreme shortages of affordable housing units are also extremely vulnerable to coastal flooding, hurricanes, extreme heat, earthquakes, and fire.” The agency suggested that “there is a strong relationship between affordable housing and climate risks, which puts those dependent on affordable housing at extreme risk of losing housing.” The impacts of disasters on vulnerable communities include the loss of affordable housing, displacement of households, impacts to the workforce and the economy, lowered property values, and a lowered tax base. The briefing concluded with the recommendation that the nation should invest in more resilient housing, especially in affordable housing within vulnerable communities.

The SAMHSA also found that socially vulnerable people face greater challenges after a natural disaster. For example, “vulnerable residents face many barriers to receiving aid to help them rebuild their homes and meeting their other needs”. This population often has trouble finding access to housing and other resources after a disaster

Furthermore, these residents were found to fare poorly from a health standpoint in certain types of disasters. The stress linked to a lack of resources may have emotional and behavioral health consequences, resulting in more distress and depression. These people may experience more physical health problems that less vulnerable people experience after a natural disaster. These losses, though very real, are generally undercounted in standard USACE coastal risk analysis because there is considerable ongoing debate on how best to capture them.

Management of coastal storm risk for properties located in socially vulnerable and environmental justice communities will provide significant OSE benefits by enhancing human capital and productivity, reducing inequality, building resilience and ending the inter-generational cycle of poverty. Specific OSE benefits include:

- A more equitable distribution of pre-disaster risk management opportunities to all communities that are vulnerable to the effects of coastal storms,
- Maintenance of community cohesion, identity and resiliency by avoiding displacement of residents,
- Protection and increase the resiliency of the existing stock of affordable housing,
- Maintenance of the economic vitality of the communities and the residents by managing risk to assets before the next natural disaster,
- Support of physical health and safety of residents of socially vulnerable communities by preparing people for the impacts of natural disasters, improving access to resources and increasing resiliency of the community.
- Reduction of the immediate and long-term impacts of natural disasters on vulnerable communities by managing risk to the limited financial assets of community members.

Managing coastal storm risk to vulnerable communities, also, supports the current administration's goals set out in Executive Order (EO) 13390, *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis* (2021) and the existing EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (1994). A complete list of benefits can be found in **Table 9-2**.

9.2 WICKFORD HISTORIC DISTRICT

The Wickford Historic District is a unique cultural resource located in North Kingstown, RI. Initially established in 1709, this community is one of the oldest preserved colonial villages in the country. It consists of the largest collection of owner-occupied Colonial and Federal Period homes in the nation. It also includes many commercial properties including shops and restaurants that support a thriving tourist industry.

The historic district, which includes over 100 buildings, is historically significant as it is listed on the National Register of Historic Places. Buildings that are part of the district include properties situated on Main Street, West Main Street, Brown Street, Boston Neck Road, Tower Hill Road, Phillips Street, and several more. They include houses, churches, industrial and marine buildings and commercial stores. A small sample includes the Old Narragansett Church, St. Paul Episcopal Church, the Baptist Church, the Standard-Times building, and the Waterside Mill.

The community has experienced flood damages due to coastal storms. The village lost power and basements were flooded during Hurricane Sandy. Additionally, modelling predicts that this community will continue to be affected by flooding resulting from coastal storms due to the threat from rising sea level. Modeling completed by USACE, using the intermediate sea level change (SLC) scenario which represents a possible 3-foot rise in sea level over 100 years, when compounded with storm surge due to coastal storms, will increase the extent and depth of inundation. The non-federal sponsor of the study, RI-CRMC, warns that some projections show sea levels will rise a much as 6 feet in the next 100 years.

The measures used to manage the risks caused by coastal storms for historic properties must help avoid or minimize potential adverse impacts. There are federal design standards for rehabilitating historic structures, which are included as one of the stipulations in the Programmatic Agreement that is being prepared by USACE. The Programmatic Agreement outlines the process to identify and evaluate historic properties and avoid, minimize, and where possible, mitigate for any adverse impacts in accordance with Section 106 of the National Historic Preservation Act. The federal design standards are currently being used in other USACE studies, such as the Charleston Peninsula South Carolina CSRM study, to mitigate impact to historic structures and will be followed during the implementation of the RIC recommended plan.

During plan formulation for the RIC CSRM study, a structural solution to manage coast storm risk was considered for the Wickford Historic District. The measure included the construction of a large floodwall that would run along the entire perimeter of Wickford Village. The measure was eliminated during the third planning iteration for a number of reasons. First, the floodwall would result in significant adverse impacts to many resources including cultural resources and the viewshed. The floodwall would limit the view of the Narragansett Bay and damage the unique character of the historic district. Next, this alternative would require many water crossings, which would adversely impact access and use of these water bodies by the citizens living in the area, adversely impact the ecosystems upstream of the crossings and increase the complexity of the design. Finally, the PDT was not able to find an engineeringly acceptable alignment for the wall due to the numerous water crossings and dense development of the area.

Once a structural solution was eliminated from consideration, a nonstructural solution was considered. The Wickford Historic District was included in the South Kingstown community group that incorporated structures from the entire town of South Kingstown. This community group was made up of both historic and modern structures. It included 113 residential structures and 40 non-residential properties. For further discussion of the development of community groups for the RIC study, please see **Appendix A**, *Background Information*. The entire South Kingstown community group (both residential and non-residential structures) had a BCR of 0.6, so the community group was not included in the NED plan.

With community groups that did not have a BCR high enough to be included in the NED plan, the team considered the residential and non-residential structures from the group separately. If a particular structure type (i.e., residential structures or non-residential structures) had a BCR ≥ 1.0, then those properties were added back into the NED plan. In the case of the Wickford community group, the non-residential structures alone did have a BCR above 1.0, so these 40 properties were added to the recommended plan due to their NED benefits.

Of the residential properties included in the South Kingstown community group, 82 are listed in the National Registry and are part of the historic district, while the remaining residential properties are modern structures and are not part of the historic district. Although not having the NED benefits needed for inclusion in the recommended plan, coastal storm risk to the residential structures located in the Wickford Historic District should be managed because of the Environmental Quality (EQ) and Other Social Effects (OSE) benefits the district provides to the community, the state, and the nation. A few of the OSE and EQ benefits gained by managing coastal storm risk to this unique historic resource from future flood damage include:

- Supporting the economic vitality of the area by maintaining a vibrant tourist industry,
- Contributing to the community's pride and cohesion in recognizing and maintaining the historic integrity, setting and significance of the district over the last 300 years while also adapting it to the present day,
- Managing flooding risk to a nationally significant historic district, which is listed on the National Register of Historic Places,
- Managing coastal storm risk to the historic district will maintain a unique research opportunity for students and scholars who can study the neighborhood as a whole and document changes over time, and how this can be applied elsewhere, and
- Maintaining its link to the past, while also functioning as a present-day neighborhood and community, with an active church and other institutional buildings.
- Providing employment opportunities in and around the historic district,
- Supporting recreational activities including site-seeing, dining, and shopping

A full list of OSE and EQ benefits can be found in **Table 9-2**.

9.3 CRITICAL INFRASTRUCTURE

Coastal storm risk management measures for critical infrastructure were analyzed as part of the RIC study. A list of facilities, initially developed from the Rhode Island Emergency Management Office, the Department of the Interior, as well as various Rhode Island localities, were preliminarily identified as critical infrastructure. The list was also provided to the non-federal sponsor for their concurrence. This list included airports, communication sites, electrical substations, emergency facilities (EMS and fire stations, hospitals, police stations), hazardous material facilities (e.g., wastewater treatment plants), nursing homes, and schools.

The PDT focused the investigation on sites that were identified as critical within the designated 100-year floodplain. Ultimately, the list was refined down to 36 facilities and/or sites that were included in the recommended plan. Of that final list, 23 of these facilities were included in the NED Plan, with the community group that they were located in.

Thirteen sites are either part of a community group that did not have NED benefits great enough to be included in the plan or were outliers (i.e., not located in any community group). These facilities include two nursing homes/assisted living facilities, three sewer pump stations and one electric substation, which is associated with a pump station. The seven (7) critical infrastructure sites located on Block Island are also part of the NED exception request. These sites include three (3) pump stations in addition to three (3) buildings and one (1) electrical substation that are located on the campus of the Block Island Power Company.

The full intrinsic benefit of managing coastal storm risk to these sites is difficult to capture monetarily because USACE has not developed a standardized method to capture the true benefits of managing coastal storm risk to critical infrastructure facilities. As a result, BCRs for floodproofing these structures were quite low. However, managing flood risk to these facilities would provide significant OSE and EQ benefits to the community.

Nursing homes and assisted living facilities provide safe housing, specialized on-site medical and nursing care for the most vulnerable members of the community. These facilities also provide a sense of community for their residents. If a nursing homes or assisted living facility experiences significant damage, the residents would have to be relocated to other sites in order to provide for their needs, ultimately disrupting the community. In addition, temporarily or permanently closing a nursing home/assisted living site would negatively affect the economic health of the area, since these businesses would either have to rebuild, relocate or close.

Floodproofing pump stations associated with a town’s sewer system, provides both OSE and EQ benefits. The sewer systems collect and transport sewage away from residences and commercial builds to treatment facilities. If these pump stations are inundated with flood water, untreated sewage can back up into basements, which creates a health hazard, and causes damages private property. In some cases, the untreated sewage will flow into local waterways, again resulting in a health hazard for the community and damaging the environment.

Hardening of equipment and facilities associated with electricity production is essential to maintain a steady and reliable supply of power to the communities which the sites serve. Consistent electrical service is essential to the health and welfare of the community and to a functioning economy. Outages impact the economic health of a community by forcing retail businesses and other services to close. Electric outages also reduce public safety of an area by disrupting communications, transportation and access to clean drinking water. Additionally, grocery stores, ATMs, banks and other essential businesses are forced to close. Residence may be affected by food spoilage and water contamination. And finally, power outage may prevent at-home use of medical devices, reduce access to doctors and medical facilities. If a power outage goes on for too long or if it occurs during extremely hot or cold weather, residents may ultimately have to leave their homes and relocate to facilities with power. A full list of OSE and EQ benefits can be found in **Table 9-2.**

All 36 CI facilities were incorporated in the Recommended Plan, 23 as part of community groups that are supported by NED benefits and 13 through OSE and/or EQ benefits.

The inclusion of these separable elements in the Recommended Plan, despite its BCR below 1.0, will improve the long-term coastal storm resilience, adaptability, and quality of life within the study area (**Table 9-2**). Benefits to human life, health, safety, and resilience are consistent with the Other Social Effects and Environmental Quality Accounts in the P&G and outweigh the small disparity between the average annual benefits and average annual cost. The overall Recommended Plan still reasonably maximizes net NED benefits and has an overall BCR of 1.6.

An NED Exception was developed for the three separable elements (Socially Vulnerable and Environmental Justice Communities, Wickford Historic District, and 13 infrastructure facilities) not supported by NED benefits. The exception would allow these elements to be included in the Recommended Plan. The Assistant Secretary of the Army, Civil Works (OASA-CW) approved the exception in a memo dated 03 February 2023. In that memo, the OASA-CW concluded that "providing non-structural solutions to protect historical structures and critical infrastructure as well as to improve resilience for communities with environmental justice concerns should be part of a comprehensive storm risk management solution for the Rhode Island Coastal area. Implementation of this project without these additional separable elements would leave critical infrastructure and property disproportionally impacted by storms with expensive and longer lasting recovery times for the entire community". The memo is included as **Attachment A** of this appendix.

Table 9-2: Other Social Effects and Environmental Quality Benefits of separable elements with BCR >1.0

Element	Benefits
Wickford Historic District	**<u>OSE BENEFITS</u>** - Provides a community and cultural identity for the area. - Promotes economic vitality by supporting a vibrant tourist industry. - Provides employment opportunities in and around the historic district. - Supports recreational activities including site-seeing, dining, and shopping. - Manages flooding risk to a nationally significant historic district, which is listed on the National Register of Historic Places, - Maintains a unique research opportunity for students and scholars who can study the neighborhood as a whole and document changes over time, and how this can be applied elsewhere.

	EQ BENEFITS - Manages coastal storm risk to a unique and Nationally Significant historic resource from future flood damage.
Socially Vulnerable/ Environmental Justice Communities	**OSE BENEFITS** - A more equitable distribution of pre-disaster risk management opportunities to all communities that are vulnerable to coastal flooding, - Maintain community cohesion, identity and resiliency by avoiding displacement of residents, - Protect and increase the resiliency of the existing stock of affordable housing, - Maintain the economic vitality of the communities and the residents by protecting assets before the next natural disaster, - Supports physical health and safety of residents of socially vulnerable communities by preparing people for the impacts of natural disasters, improving access to resources and increasing resiliency of the community. - Manage the risk of the immediate and long-term impacts of natural disasters on vulnerable communities by protect the limited financial assets of community members. - Meets the requirements of EOs 12898 and 13390 and addressed the directives of the current administration.
Critical Infrastructure	**OSE BENEFITS** ***Nursing Homes/Assisted Living*** - Supports Physical Health and Safety by providing safe housing for the most vulnerable members of the community. - Supports regional healthcare by providing specialized on-site medical and nursing care to residents of the facility. - Manages coastal storm risk to a socially vulnerable population by providing housing to the elderly. - Supports community identify by providing a community for the residents of the facilities. - Provides recreational activities for the residents of the facilities. - Provides employment opportunities to the community. ***Sewer Pump Stations*** - Promotes human health and safety by collecting and treating sewage and wastewater from

	residential and commercial facilities. - Provides a municipal service to the community by collecting and treating sewage and wastewater. ***Electric Power Infrastructure*** - Provides electricity to the surrounding homes and businesses within the surrounding community. Consistent electrical service is essential to the health and welfare of the community and to a functioning economy. - Large disruptions in the electrical supply would result in the disruption of vital services, including water supply, emergency and health services, and could lead to social unrest.
	<u>EQ BENEFITS</u> ***Sewer Pump Stations*** - Manages coastal storm risk to aquatic resources, recreational opportunities (e.g., swimming, beaches, fishing), and commercial and recreational shellfish harvests by reducing the potential for untreated sewage releases into local waterways. - Promotes human health and safety by collecting and treating sewage and wastewater from residential and commercial facilities.

SECTION 10.0 RECOMMENDED PLAN COMPONENTS

As shown in **Table 10-1**, the Recommended Plan is an entirely nonstructural plan that includes 497 total structures – 290 residential recommended for elevation and 207 non-residential recommended for floodproofing. Included with the recommended floodproofing structures are thirty-six (36) facilities that are identified a critical infrastructure currently included in the Recommended Plan.

Table 10-1: The recommended plan

Community Group/Location	Total Costs ($)	Total Present Value Benefits ($)	Elevation	Floodproof	CI Floodproofing	Total parcels	BCR[1]
Elements Supported by OSE and/or EQ Benefits							
PLAN NS-A - Community Groups with a BCR > 1.0							
Block Island	2,276,000	5,084,853	2	3	0	5	2.2
Cranston Mall	1,940,000	1,975,152	0	5	0	5	1.0
Downtown Warwick	7,966,000	8,973,832	5	12	0	17	1.1
East Greenwich	3,683,000	19,628,559	0	10	0	10	5.3
Newport Downtown	73,796,000	249,356,085	83	36	4	123	3.4
Quonset Airport	5,135,000	7,075,514	0	7	3	10	1.4
Sakonnet	1,836,000	3,076,463	2	2	0	4	1.7
Subtotal	96,632,000	295,170,459	92	75	7	174	
Plan Refinement – Floodproofing Only							
Barrington	9,748,000	9,991,468	0	9	15	24	1.0
Bristol	1,842,000	1,898,677	0	4	1	5	1.0
Fort Ave	1,105,000	2,246,692	0	3	0	3	2.0
Nannaquaket Pond	368,000	409,799	0	1	0	1	1.1
Narragansett	737,000	785,395	0	2	0	2	1.1
Shawomet	337,000	348,316	0	1	0	1	1.0
Warren	16,369,000	24,680,711	0	37	0	37	1.5
Wickford	12,891,000	19,989,396	0	35	0	35	1.6
Subtotal	43,397,000	60,350,454	0	92	16	108	
Plan Refinement - Outliers							
Outliers	3,121,000	8,694,303	3	3	0	6	2.8
Subtotal	3,121,000	8,694,303	3	3	0	6	
Plan Refinement - Individual Structures with BCR's >1.0 from Unjustified Community Groups							
Barrington	1,946,000	2,375,876	4	0	0	4	1.2

Community Group/Location	Total Costs ($)	Total Present Value Benefits ($)	Elevation	Floodproof	CI Floodproofing	Total parcels	BCR[1]
Laural Park	486,000	805,741	1	0	0	1	1.7
Little Tree Point	486,000	534,433	1	0	0	1	1.1
MB Narragansett	486,000	466,967	1	0	0	1	1.0
Sakonnet North	478,000	745,345	1	0	0	1	1.6
Sakonnet South	478,000	1,696,043	1	0	0	1	3.5
South Kingstown	478,000	514,306	1	0	0	1	1.1
Shawomet	486,000	1,046,559	1	0	0	1	2.2
Warwick Neck	486,000	493,647	1	0	0	1	1.0
West Passage	478,000	476,606	1	0	0	1	1.0
Wickford	486,000	962,136	1	0	0	1	2.0
Subtotal	6,774,000	10,117,659	14	0	0	14	
Elements Supported by OSE and/or EQ Benefits							
Plan Refinement - Wickford Historic District							
Wickford	48,215,000	26,585,338	82	0	0	82	0.6
Subtotal	48,215,000	26,585,338	82	0	0	82	
Plan Refinement - Socially Vulnerable and Environmental Justice							
Oakland Beach	17,176,000	4,524,449	28	1	0	29	0.3
Fort Ave	5,272,000	3,053,102	9	0	0	9	0.6
Warren	38,221,000	20,452,958	62	0	0	62	0.5
Subtotal	60,669,000	28,030,509	99	1	0	100	
Plan Refinement - Additional Critical Infrastructure[2]							
Outlier (2 Nursing Homes, 1 Pump Station)	1,467,000	608,820	0	0	3	3	0.4
Sakonnet (Pump Station/Substation)	2,026,000	2,836	0	0	2	2	0.001
Dyers Street Pump Station	368,000	17,611	0	0	1	1	0.048

Community Group/Location	Total Costs ($)	Total Present Value Benefits ($)	Elevation	Floodproof	CI Floodproofing	Total parcels	BCR[1]
Block Island	3,868,000	10,116	0	0	7	7	0.003
Subtotal	7,729,000	639,383	0	0	13	13	
TOTAL	**266,541,000**	**429,588,104**	**290**	**171**	**36**	**497**	

[1] Benefit-to-Cost ratio based on total present values and does not account for interest during construction

[2]Critical Infrastructure benefits and BCRs do not fully account for quantified damages prevented due to the unique characteristics of each facility.

10.1 RECOMMENDED PLAN OPTIMIZATION

The elevation design height modeled for the Recommended Plan was determined separately for each structure based on the 1% AEP NACCS water level + wave contribution + sea level change (intermediate through 2080). From the G2CRM User's Manual and per FEMA guidance, the wave contribution was computed as 0.705* (the smaller of the 1% wave height or 0.78* water depth). For optimization of the plan, costs were updated, and damages were modeled in G2CRM for an elevation of plus one foot (if possible, based on an engineering constraints of 12 feet maximum elevation) and minus one foot to the base elevation used for the Recommended Plan. Net benefits were then compared for each to determine where benefits would be maximized, which will determine the optimized design elevation to be used in the Recommended Plan.

The results from the comparison of net benefits associated with three design heights (Base, Base-1, Base+1 and Base+2) showed in increase in net benefit (2.2%) moving from the Base-1 to Base elevation. The results also showed a slight increase in net benefit (0.7%) moving from the Base to Base+1 elevation. However, since the increase from Target to Target+1 was less than the increase from Base-1 to Base, it was determined that benefits are reasonably maximized at the target elevation design height used for the main analysis. These results were consistent for the majority of model areas, so it was determined that this design height would be appropriate for the entire Recommended Plan.

10.2 PLAN ACCOMPLISHMENTS

Table 10-2 shows the accomplishments for the Recommended Plan as compared to the original problems and opportunities that were developed during early coordination with the NFS and local stakeholders.

Table 10-2: Accomplishments of the recommended plan in relation to the initial problems and opportunities

Focused Study Area	Problems	Opportunities	Recommended Plan Accomplishments
Barrington/ Warren	· Route 114 is primary evacuation route subject to flooding · Numerous low-lying structures in both towns along the Warren, Barrington and Palmer Rivers.	· Potential Improvements to roadways · Reduce flood inundation · Move/elevate/floodproof structures out of the floodplain.	The Recommended Plan protects low-lying structures in Warren through the elevation of residential structures and floodproofing of non-residential structures. Low-lying non-residential structures in Barrington will also be protected through floodproofing.
Newport Downtown	· Numerous low-lying structures including historic district	· Reduce flood inundation · Move/elevate floodproof structures out of floodplain	The Recommended Plan protects some low-lying structures in Newport (Newport Downtown and Newport North) through the elevation of residential structures and floodproofing of non-residential structures.
Newport/Middleton Reservoirs	· Four potable water reservoirs located immediately adjacent to shoreline with low-lying perimeter berms that are potentially subject to failure during major storm event	· Reduce flooding potential of the reservoir	The Recommended Plan does not address the Newport/Middleton Reservoirs. The reservoir managers were not interested in participating in this study.
Bristol	· Route 114 is primary evacuation route subject to flooding · Low-lying historic district along downtown waterfront	· Protect/Elevate Route 114	The Recommended Plan provides protection to some low-lying non-residential structures in Bristol through floodproofing.
North Kingstown	· Numerous low-lying structures including historic district located along downtown waterfront	· Reduce flood inundation · Move/elevate floodproof structures out of floodplain	The Recommended Plan protects low-lying structures in North Kingstown through the elevation of residential structures (Shore Acres, West Passage and Wickford) and floodproofing of non-residential structures (Wickford and Quonset Airport).
Portsmouth	· Numerous low-lying structures	· Reduce flood inundation · Move/elevate floodproof structures out of floodplain	No elements of the Recommended Plan address Portsmouth.
Providence	· Low-lying industrial/commercial port is vulnerable to flooding during	· Reduce flooding of the port area	Due to the complexity and challenges outlined in this report, alternatives to reduce coastal storm

Focused Study Area	Problems	Opportunities	Recommended Plan Accomplishments
	extreme storm events, potentially threatening regional critical infrastructure including but not limited to wastewater treatment facilities, and home heating oil terminals	· Floodproof critical infrastructure in the port area	risk at the Port of Providence should be the subject of its own study.
Jamestown	· Route 138 is the only conduit across Narragansett Bay and highly trafficked. The toll plaza portion on Jamestown is low-lying and vulnerable to flooding during extreme flood events	· Reduce flooding of the toll plaza area	No elements of the Recommended Plan address Jamestown.
Narragansett	· Low-lying areas along Town Beach, Bonnet Shores and the Narrow River are subject to coastal flooding	· Reduce flood inundation · Move/elevate/floodproof structures out of floodplain	The Recommended Plan protects some low-lying non-residential structures in the Narragansett through floodproofing.
Warwick	· Low-lying areas along 'The Neck', Potowomut and Apponaug Cove are subject to coastal flooding	· Reduce flood inundation · Move/elevate/floodproof structures out of floodplain	The Recommended Plan protects low-lying structures in the Warwick through the elevation of residential structures (Potowomut, downtown Warwick) and floodproofing non-residential structures (Shawomet, downtown Warwick).
New Shoreham (Block Island)	· Corn Neck Road is subject to erosion and wave attack that threatens the primary access road to the northern half of the island	· Stabilize Corn Neck Road	The Recommended Plan protects some low-lying structures on the Block Island through the elevation of residential structures and floodproofing of non-residential structures. The stabilization of Corn Neck Road is a small project, so it was determined to be more appropriate for the CAP, Section 103, which provides authority to construct small hurricane and storm damage reduction projects.
Regional	· Thousands of residential, commercial and industrial structures as well as critical infrastructure, within the Narragansett Bay coastal zone are subject to coastal flooding	· Reduce flood risk within the entire Bay · Move/elevate/floodproof structures out of harm's way	The Recommended Plan protects low-lying structures through the elevation of residential buildings and floodproofing of non-residential properties throughout the study area including the towns of Barrington, Bristol, Cranston, East Greenwich, Little Compton, Narragansett, New Shoreham, Newport, North Kingstown, Tiverton, Warren, and Warwick,

10.3 RECOMMENDED PLAN BENEFITS

10.3.1 National Economic Development Benefits

The total project first cost for the Recommended Plan is $266.5 million. The average annual cost is $9.6 million and average annual benefits are $14.4 million, resulting in net benefits of $4.8 million and a benefits-to-cost ratio of 1.5. The complete cost and benefit analysis for the Recommended Plan is presented in **Table 10-3.** The project costs were calculated using the October 2021 Price Levels and annualized using the Federal discount rate of 2.25%.

10.3.2 RED Benefit

The Recommended Plan would generate 3,363 full-time equivalence jobs, $260 million in labor income, $651 million in output, and $380 million in total value added. For the state of Rhode Island as a whole, the construction stimulus would generate approximately 2680 Full Time Equivalent jobs, $215 million in labor income, $470 million in output, and $296 million in Gross Regional Product.

The local impact area captures about 65% of the direct spending on the project. About 26% of the spending would occur in other parts of the state. The rest of the nation captures the remaining 8%. The secondary impacts, which include the combined indirect and induced multiplier effects, would account for 48% of the total output. They would also account for approximately 42% of jobs, 31% of labor income, and 42% of gross regional product in the impact area.

10.3.3 Environmental Quality Benefit

The Recommended Plan would result in minor positive environmental effects. The summary of environmental benefits provided in this section is based on the complete environmental analysis that is presented in **Section 4.0** of the main report. The environmental benefits of the Recommended Plan would include a reduction of the release of Hazardous, Toxic, and Radiological Waste (HTRW) into the environment during a flooding event. Structures would either be elevated or floodproofed, which would result in the reduction of hazardous chemical from being washed out of damaged structures into the local waterways.

10.3.4 Other Social Effects Benefits

The OSE benefits of the Recommended Plan include the reduction of safety and health risks that occur during and after coastal storms. The plans would reduce flood inundation, resulting in the benefit of safeguarding health and safety and also improve the recovery process. Elevating property or dry floodproofing would improve a building’s ability to resist direct flooding and other damage (mold), which results in improved safety. Structure elevation or dry floodproofing would reduce the risk of flooding damage but does not eliminate the need for evacuation. Instead, nonstructural measures shorten the recovery process and reduce recovery costs after an event.

The Recommended Plan would also have socioeconomic benefits, specifically environmental justice, within the project area. The Recommended Plan includes four (4) community groups that are considered socially vulnerable. Implementation of Recommended Plan would result in the reduction of risk of loss of life and property due to flooding events for socially vulnerable residents and those located in environmental justice areas. The Recommended Plan would also provide benefits to vulnerable populations, by shortening recovery periods after a flooding event. The Recommended Plan would also improve the economic vitality by reducing damages to private homes and businesses from future flood events and reducing the time and financial stress of rebuilding the community. The Recommended Plan would allow the community and the economy to normalize more quickly.

The plan would also have both short- and long-term benefits on the economic conditions and employment within the study area. Construction of the project would provide job opportunities to the community and would provide economic support to the area, as workers on the project would utilize local businesses. Long-term, the project would provide economic benefits by reducing the amount of damage that would result from flooding events and reducing the time required to return the community back to normal.

10.4 COST ESTIMATE

Total project first costs of the Recommended Plan at October 2021 price levels are approximately $266.5 million (**Table 10-3**). The total fully funded cost of the project, with escalation through the mid-point of construction, is approximately $317 million. Nonstructural costs were developed using information from FEMA and nonstructural projects recently completed in vicinity of the study area.

Table 10-3: Economic summary of the Recommended Plan
(October 2021 price levels and 2.25% discount rate)

Federal discount rate FY22 = 2.25%, OCT 2021 Price Levels, 50-Year Period of Analysis, Figures in $ Except BCR	
Project First Costs	
Construction	168,466,000
Preconstruction Engineering & Design (PED)	27,750,000
Construction Management (CM)	9,344,000
Real Estate	6,675,000
Environmental Mitigation	0
Cultural Resource Mitigation	2,718,000
Contingency	51,589,000
Project First Costs Total	**266,541,000**
Average Annual Costs	
Annualized First Costs	9,555,000
Interest During Construction (IDC)	25,000
Total Average Annual Cost (AAC)	**9,580,000**
Average Annual Benefits (AAB)	14,399,000
Net Benefits	4,819,000
Benefit-Cost Ratio (BCR)	**1.5**

10.5 LANDS, EASEMENTS, AND RIGHTS-OF-WAYS

USACE projects require the NFS to provide all lands, easements, and rights-of-way, (LER) for project implementation. The elevation and floodproofing measures would be offered to owners of structures that have been determined to be eligible and have voluntarily consented to grant a right of entry for construction, staging, and storage. Owners of residential structures must sign a restrictive easement, which restricts alteration of the elevated structure below the designed FFE. Owners of commercial structures will also be required to sign restrictive easements. The NFS would be required to provide temporary relocation assistance benefits to tenants occupying eligible structures. Total Lands, easements, and rights-of-way (LERs) are estimated to be $6,700,000 ($8,040,000 with cost contingency) for the Recommended Plan. Further discussion of the potential real estate requirements is detailed in **Appendix G,** *The Real Estate Plan*.

As noted above, elevations and floodproofing measures are both voluntary. Although project costs and benefits are typically calculated at 100 percent participation, the actual level of participation is normally much lower.

10.6 OPERATIONS, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION

Operation, maintenance, repair, rehabilitation and replacement costs are expected to be '*de minimis*' and will be confined to periodic curb-side assessments by the non-Federal sponsor; the property owner is ultimately responsible for maintenance of the project.

10.7 RISK AND UNCERTAINTY

10.7.1 Sea Level Change

The FWOP conditions and benefits for the Recommended Plan were developed employing the USACE intermediate SLC. The Recommended Plan was further evaluated using the USACE sea level rise scenarios, low and high. These benefits were then compared to the project costs for the Recommended Plan. The results of the sea level rise scenarios are shown in the following table. The analysis shows that the Recommended Plan is economically justified for the high sea level rise scenarios, with a BCR of 2.3, but does result in slight negative net benefit for the low sea level rise scenario, with a BCR of 0.9. More information on the analysis that was completed on sea level change can be found in **Appendix C,** *Economic and Social Consideration*.

Table 10-4: Economic results of the recommended plan for varying rates of sea level change

	High	Intermediate	Low
Average Annual Benefits	20,713,000	11,356,000	8,286,000
Average Annual Costs	8,944,000	8,944,000	8,944,000
Benefit-to-Cost Ratio	2.3	1.3	0.9
Average Annual Net Benefit	11,769,000	2,842,000	-659,000

10.7.2 Residual Risk

Residual risk is the risk that remains in the study area after the Recommended Plan is implemented. Residual risk includes the consequence of exceeding the capacity of the water level associated with the damage reduction measure, as well as, consideration of the project flood risk reduction. The residual risk is the remaining risk that cannot be mitigated given the hydrological, environmental, and economic constraints. The residual risk is assessed here as required by ER 1105-2-101 Risk Assessment for Flood Risk Management Studies, by using remaining expected annual damages and remaining structures at risk. For each metric, the residual risk of the FWP condition can be calculated by subtracting the impact of the Recommended Plan from the risk in the FWOP condition.

Residual risk remains for 11,657 structures and $967M estimated present value damages in the 100-year floodplain; however, inundation damage is reduced by 27 percent for the 100-year floodplain and 73 percent for the structures included in the Recommended Plan (**Table 10-5**). More information on residual risk can be found in **Appendix C,** *Economics and Social Considerations.* It should be noted that the residual damages indicated here are reflective of the damages remaining based on modeling results that include damages in the years prior to project implementation. Since residual risk is defined as the flood risk that remains in the floodplain after a proposed flood risk management project is implemented, the actual residual risk would therefore be less than what is stated here shown in the following table.

Coastal storm risks remain for 9,435 single family residences and 2,197 commercial structures in the study area where flood damages are anticipated to occur. The residual risk on these structures includes high damages on Urban High Rises (RES-4A) in model area NPT, which includes parts of Jamestown, Middletown and Newport, commercial buildings, identified as Commercial-Engineered-Perishable (COM- 2P) in the modeling area CRA, which includes parts of Barrington, Cranston, East Providence, Providence, Warwick, as well as structures such as commercial buildings identified a Commercial-Engineered-Nonperishable (COM-2NP), Commercial-Engineered-Perishable (COM-2P) and Commercial-Non/Pre Engineered-Non-Perishable (COM-3NP) that sustain more damage when compared with the remainder of the occupancy types. Moreover, foundation types with basement and slab have a high variance.

The modeled damage estimates for these residual structures indicates that as water levels rise, the damages increase to 100k on average except for PVD where the damages increase exponentially. Warren is shown to be very vulnerable due to the higher frequency of events compared with other modeled areas. And, when calculating the percent of buildings for which the water level goes above the first floor, the pattern over the period of analysis does not show any monotonic increase or decrease.

Although a total risk reduction of 27 percent seems comparatively low, one must consider the size of the study area. The study area includes over 450 miles of coastline. In the Recommended Plan we considered all of the structures within the 100-year flood plain, which was over 12,000 buildings. As explained previously in this report, the majority of these structures do not experience significant and repetitive damages. So essentially, there is low risk spread across a huge area. The first step that was taken to identify the Recommended Plan was to screen structures that experience repetitive and significant impacts due to coastal storms. The number of structures was narrowed from 12,000 to just over 1,000. When considering only those high-risk buildings, the Recommended Plan eliminates a significant amount of risk (70 percent for structures included in the Recommended Plan). Essentially, the Recommended Plan focuses on small pockets within the study area that experience the highest amount of risk. In the larger study area, the diffused amount of risk does not support the costs of nonstructural protection.

When considering structural measures, the PDT considered measures in areas that experience the most damage due to coastal storms. However, the predicted damages caused by storms were not enough to support the cost of constructing the measures that were considered during the formulation phase. In addition to being prohibitively expensive, characteristics of the study area limits the structural measures that can be constructed. The Rhode Island shoreline is densely populated and contain significant historic and archeological resources. Finding high-ground tie-ins and avoiding impacts to cultural resources made designing structural measures difficult and increased the costs of the measures. Additionally, measures that could reduce flooding also would also significantly negatively impact the biological resources of the area.

Furthermore, the residual damages and number of structures protected by these structural alternatives will not drastically different than the residual risk associated with the Recommended Plan. Even though the Warren surge barrier would provide protection to over 2000 structures, it was estimated to only reduce damages by 28-3 percent. The Middle Bridge and Newport structural alternatives would provide storm risk management to an even smaller number of structures than the Recommended Plan and reduce damages by only 2 percent.

Table 10-5: Residual risk of the recommended plan

	100YR Floodplain FWOP		Plan NS-A.1		Residual		
Locality	Number of Structures at Risk	Total Present Value Damage ($)	Number of Structures Elevated or Floodproofed in Recommender Plan	FWP Present Value Damage Reduced by Recommended plan ($)	Remaining Number of Structures at Risk	Total Remaining Present Value Damage ($)	Percent Damage Reduction
Barrington	3,555	58,812,019	14	12,178,807	3,541	46,633,212	21%
Bristol	345	59,707,474	5	1,898,677	340	57,808,797	3%
Cranston	522	12,925,974	11	3,760,372	511	9,165,603	29%
East Greenwich	16	41,929,449	10	19,628,559	6	22,300,889	47%
East Providence	90	16,055,724	1	374,953	89	15,680,771	2%
Jamestown	56	15,673,039		0	56	15,673,039	0%
Little Compton	58	7,690,694	4	3,076,463	54	4,614,231	40%
Middletown	30	101,183,112		0	30	101,183,112	0%
Narragansett	1,333	19,999,670	5	2,758,140	1,328	17,241,530	14%
New Shoreham	60	43,548,940	5	5,084,853	55	38,464,086	12%
Newport	680	484,122,041	123	175,883,358	557	308,238,683	36%
North Kingstown	549	134,638,450	132	57,330,744	417	77,307,706	43%
Pawtucket	2	137,911		0	2	137,911	0%
Portsmouth	892	48,083,961	1	818,165	891	47,265,797	2%
Providence	84	51,097,737		0	84	51,097,737	0%
South Kingstown	293	12,463,139	1	553,188	292	11,909,951	4%
Tiverton	196	29,063,671	3	1,629,665	193	27,434,006	6%
Warren	2,025	102,869,639	104	46,962,404	1,921	55,907,235	46%
Warwick	1,345	76,763,499	55	18,221,164	1,290	58,542,335	24%
Total	**12,131**	**1,316,766,143**	**499**	**350,159,511**	**11,657**	**966,606,632**	**27%**

10.7.3 Life Safety Risk Analysis

The plan formulation process used for this study includes evaluation of alternatives which address objectives related to coastal storm risk management. An important component of this evaluation is to understand and, if possible, mitigate risk to residents who are affected by flood events. Vulnerable populations, such as the elderly and children, may need additional time and assistance during storms. The G2CRM model utilized to assess life safety risk of the population, including vulnerable groups, living within the study area. A study population of 670,000 in Rhode Island was utilized for the risk analysis. A comparative analysis of the FWOP and FWP showed the potential change in loss of life due to coastal storms that would result from implementation of the Recommended Plan. The model estimated a total loss of life of 0.004 percent of the FWOP population, and approximately a 25 percent reduction was achieved under FWP conditions. These estimated values should be viewed as approximations to give an understanding of the overall magnitude of expected life loss in a specific area. The life loss modeling performed by G2CRM uses bootstrap sampling with replacement which is applicable to storm events but not precise enough to quantify life loss in detail. More information on the analysis that was completed on life risk can be found in **Appendix C,** *Economic and Social Consideration*.

10.7.4 Participation Rate Analysis

Participation in the project is voluntary because the Recommended Plan only includes elevation of residential structures and floodproofing of non-residential buildings. Once the study is completed and a Recommended Plan is finalized, an outreach plan will be collaboratively developed with the NFS to ensure that all eligible owners are notified and have an opportunity to participate in the project. For modeling and plan formulation purposes, the nonstructural economic analysis assumed full participation. However, similar projects that have been undertaken by the USACE have experienced a participation rate that is significantly lower than 100 percent. Instead, participation rates have been 40 percent or less. A sensitivity analysis, a technique using varying assumptions and examines the effects of these varying assumptions on outcomes of benefits and costs was conducted using varying participation rates to ensure that the net benefit will be greater than zero and the BCR will be higher than 1.0 for the Recommended Plan with less than full participation. The results of this participate rate sensitivity analysis showed that the Recommended Plan would result in positive net benefits regardless of participation rate. Details of this analysis can be found in **Appendix C,** *Economic and Social Consideration*.

Participation in nonstructural measures is entirely volunteer, so property owners must decide whether to participate in the project or not.

10.7.5 Engineering Risk

There is uncertainty associated with the engineering and design of the study. Because the elevation of residential structures and floodproofing of non-residential structures require structure-by-structure analysis, this engineering risk will remain until the PED phase, when each structure included in this plan has been evaluated to ensure that they are appropriate for retrofitting.

Inspection of structures during PED - Pre-design level assessment and evaluation of each structure currently included in the Recommended Plan, which will occur during the PED phase, may lead to changes to the plan. For example, unique building characteristics may alter the nonstructural floodproofing measures that will be used. The assessment and evaluation of each structure may also identify structures, which are currently included in the plan, that cannot be elevated or floodproof, so they will have to be removed from the program.

The Pawcatuck River CSRM study provides an excellent example of engineering risk associated with a nonstructural Recommended Plan. This study is a similar CSRM study effort being led by the USACE to investigate solutions to reduce the impacts of coastal storm from Point Judith to the Connecticut border. This study is currently in PED phase. There are a number of lessons learned from the Pawcatuck River Study can be applied to the RIC Study. The continuing work to complete the designs for the Pawcatuck River Study has determined the following:

- Floodproofing some structures, particularly commercial structures, was found to be more difficult than perceived during the feasibility phase. This was primarily due to the type and age of building construction, physical location of the structure, compliance with the Americans with Disabilities Act, and the locations of the heating, ventilation, and air conditioning (HVAC) and other building systems.

- Many structures contain outdated HVAC and other building systems that need to be upgraded before the structure can be elevated or floodproofed

- Some structures that were identified during the Feasibility had been elevated or floodproofed prior to the design phase and removed from the program

- Older building construction required structural improvements prior to elevation.

- Unique building footprints, multiple deck systems, fieldstone or brick chimneys, attached garages or additions, and extensive landscaping features made elevating or floodproofing more difficult and more expensive.

In summary, risk and uncertainty associated with a nonstructural plan remains during the feasibility phase simply due to currently unknown details of each structure included in the plan. The uncertainty will be eliminated once these structures are individually assessed prior to retrofitting.

Local Building Code Analysis for Elevating Structures – Local building codes play a role in whether a residential structure can be elevated or not. If the local codes are not understood, there is a risk of including structures in the Recommended Plan that ultimately cannot be protected. An assessment of town building codes for the structures included in the recommended Plan has been completed. In addition, lessons learned from the Pawcatuck River CSRM Study PED phase and from meetings held with building inspectors from two (2) of the municipalities in that project were also taken into account to assess risk of local building codes on the Recommended Plan of the RIC study.

Meetings with the building inspectors from South Kingstown, RI and Charlestown, RI took place during late 2021 and early 2022. The goal of the meetings was to determine the impact from local land use zoning regulations on the elevation of existing structures. The "take-aways" from the meeting include:

- The zoning regulations for each municipality contains a maximum peak building height from the ground, defined structure yard setbacks from lot lines based on zoning district, and provisions for relief from these dimensional regulations.

- Each municipality inteprets their zoning regulations a little differently and these differences may affect which structures can be protected and how they are protected.

- Maximum peak building height from the ground is between 30 and 35 feet for most municipalities. Relief can be sought from this requirement through a variance to the Zoning Board of Appeals. While a variance is never guaranteed, one building inspector stated that they had never seen a variance denied when raising a structure to reduce future flood damages. The Zoning Board of Appeals generally agrees that variances should be granted for owners attempting to protect the existing structure from flood waters.

The analysis of building codes resulted in a number of conclusions. First, local building codes present minimal risk to the Recommended Plan, in that the structures included in the Recommended Plan will not be deemed ineligible for protections due to the restrictions imposed by local building codes. Additionally, the PED Phase of the Pawcatuck River CSRM study has provided important lessons that can be used to reduce risk in the RIC project. The Pawcatuck River CSRM study demonstrated that any needed dimensional variance from yard setbacks can be almost completely mitigated though careful design. Also, the study has shown that maximum peak building height should not be a significant concern. After completing approximately 20 designs, not a single variance for maximum peak building height has been needed to implement the Pawcatuck River CSRM Project.

Maximum Height for Elevating Structures – An analysis of the maximum height a residential structure could be elevated was completed. This analysis was completed to reduce the uncertainty of the Recommended Plan, by ensuring that the plan did not contain structures that cannot be protected due to elevation height limitations and the design risk.

Structures that need to be elevating above 12 feet from their current height will require additional structural investigation. The International Building Code (IBC) and International Existing Building Code (IEBC) stipulates that if wind load (or seismic load) increases by 10 percent or more, then an analysis must be conducted to ensure that the existing structure can resist the prescribed loads. During the PED phase of the Pawcatuck River CSRM Project, the Structural Engineering Section of the USACE, New England District calculated that designs requiring structures to be elevated higher than 12 feet would result in an increase of wind load >10 percent. For single family homes, however, the USACE is not bound by the IBC or the IEBC. Instead, USACE follow International Residential Code (IRC), which does not have similar provisions. Although not specifically stipulated by the IRC, good engineering practice requires USACE to consider these load increases, so as not to develop designs that would be less "safe" than the original. Many houses in the study area predate building code, so their construction and design cannot be verified. Many of the structures will not meet the current building code prescribed loads, let alone subjecting them to increase loads.

Elevations greater than 12 feet would result in higher overall project costs than those captured during the Feasibility Phase. Assessing and evaluating the existing house structural system will require more time and, more importantly, would be more disruptive to the house since structural elements that are usually behind interior finishes would need to be exposed. Additionally, structural upgrade to a house that is elevated above 12 feet would add significant cost since they would involve extensive interior finish restoration to the house.

For the reasons stated above, it has been decided that elevations will be capped at a maximum of 12 feet.

10.8 COST SHARING

Project First Cost is the constant dollar cost of the Recommended Plan at current price levels and is the cost used in the authorizing document for a project. The "Total Project Cost" is the constant dollar fully funded cost with escalation to the estimated midpoint of construction. Total Project Cost is the cost estimate used in Project Partnership Agreements for implementation of design and construction of a project. Total Project Cost is the cost estimate provided to a NFS for their use in financial planning as it provides information regarding the overall non-Federal cost sharing obligation. For this project, the Recommended Plan First Cost was calculated to be $266.5 million, while the Recommended Plan Total Project Cost (Fully Funded) was determined to be $317 million.

In accordance with the cost share provisions in Section 103 of the WRDA of 1986, as amended (33 U.S.C. 2213), project design and implementation are cost shared 65 percent Federal and 35 percent non-Federal. The non-Federal costs include credit for the value of LERs. Total LERs are estimated to be $6,675,000 as shown in **Table 10-3**. The cost share apportionments for the Project First Costs and Total Project Costs are provided in **Tables 10-6** and **10-7** respectively.

Table 10-6: Project first cost (constant dollar basis) apportionment
(October 2021 price levels)

Project First Cost (Constant Dollar Basis)	$266,541,000
Federal Share (65%)	$173,000,000
Non-Federal Share (35%)	$93,000,000
Less: LER Credit	$5,560,000
Non-Federal Cash Contribution	$87,440,000

Table 10-7: Total project cost (fully funded) apportionment
(October 2021 price levels, fully funded to second quarter 2029)

Total Project Cost (Fully Funded)	$316,992,000
Federal Share (65%)	$206,000,000
Non-Federal Share (35%)	$111,000,000

10.9 DESIGN AND CONSTRUCTION SCHEDULE

Before design and construction may be initiated, the USACE Chief of Engineers must approve the recommended project. Then the Chief's Report and approved IFR/EA are provided to Office of the Assistant Secretary of the Army (Civil Works) and Office of Management and Budget for review, before transmittal to Congress for authorization. The project requires Congressional authorization to receive Federal construction funding. In some cases, funding for design may be available prior to Congressional authorization. Project implementation is currently expected to begin in the year 2025. The following provides the current estimated schedule for the project.

Table 10-8: Estimated design and construction schedule

Action	Estimated Start Date
ASA(CW) Approval of 3X3X3 Exemption for Study Time Extension	Mar-22
Agency Decision Milestone	Jun-22
Integrated Final Feasibility Report/EA to Higher Authority for Approval	Oct-22
Sign Chief's Report and Chief's Report submitted to ASA (CW)	Mar-23
ASA (CW) Integrated Final Feasibility Report/EIS Approval	May-23
ASA (CW) submits report to OMB	May-23
OMB review completed (*assume 60 days*)	Jul-23
Final Report to Congress	Jul-23
Execute PPA with Non-Federal Sponsor*	Dec-23
Start Plans and Specifications (Design Phase)*	Jan-24
Notice to Proceed with Real Estate Acquisition	Mar-24
Finalize Plans and Specifications for Contract	Dec-25
NFS Authorization for Entry for Construction	Dec-25
Real Estate Certification for Contract	Jan-26
Ready to Advertise Construction Contract	Mar-26
Award Construction Contract with Notice to Proceed	Mar-27
Construction Completion	Mar-30

After all analysis was completed on the RIC study yet before the final report was approved, a new fiscal year began. As a result, the cost and benefit were updated to reflect October 2022 price levels and a discount rate of 2.5%. The revised cost and benefit information can be found in Section 8.0 of the main report.

11.0 REFERENCES

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ATTACHMENT A: OASA-CW NED EXCEPTION APPROVAL MEMO

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON, DC 20310-0108

SACW

03 February 2023

MEMORANDUM FOR COMMANDING GENERAL, U.S. ARMY CORPS OF ENGINEERS

SUBJECT: Rhode Island Coastline Coastal Storm Risk Management (CSRM) Feasibility Study, Rhode Island, National Economic Development (NED) Plan Exception Request

1. Reference HQ, USACE, CECW-NAD memorandum (Rhode Island Coastline Coastal Storm Risk Management (CSRM) Feasibility Study, Rhode Island, National Economic Development (NED) Plan Exception Request), 8 December 2022.

2. I am responding to your memorandum requesting an exception to the requirement to recommend the National Economic Development (NED) plan and allow the U.S. Army Corps of Engineers (Corps) to recommend a plan that includes a non-economically justified separable element based on other social effects and environmental quality benefits.

3. My staff has reviewed the memorandum and recommendations by the North Atlantic Division Commander and the assessment by Corps Headquarters and has concluded providing non-structural solutions to protect historical structures and critical infrastructure as well as to improve resilience for communities with environmental justice concerns should be part of a comprehensive storm risk management solution for the Rhode Island Coastal area. Implementation of this project without these additional separable elements would leave critical infrastructure and property disproportionally impacted by storms with expensive and longer lasting recovery times for the entire community. I approve the requested policy exception to include in the Recommended Plan storm risk protection for 195 additional properties not defined in the NED Plan.

4. If there are any questions, your staff may contact Mr. Douglas J. Gorecki, Project Planning and Review at (202) 761-0028.

MICHAEL L. CONNOR
Assistant Secretary of the Army
(Civil Works)

CF:
CECW-ZA
CECW-ZB