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Asterisks (*) designate sections of the report that are required to fulfill the requirements of NEPA.

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SECTION 1.0 INTRODUCTION

1.1 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), New England District is conducting the Coastal Storm Risk Management (CSRM) Feasibility Study for the Rhode Island Coastline (RIC study) and prepared this Integrated Feasibility Report and Environmental Assessment (IFR/EA). This IFR/EA documents the study process and identifies a Tentatively Selected Plan (TSP). This plan would address flood risk “along the shoreline and coastal tributaries of southeastern Rhode Island from Narragansett Bay to the Massachusetts border” (**Figure 1-1**).

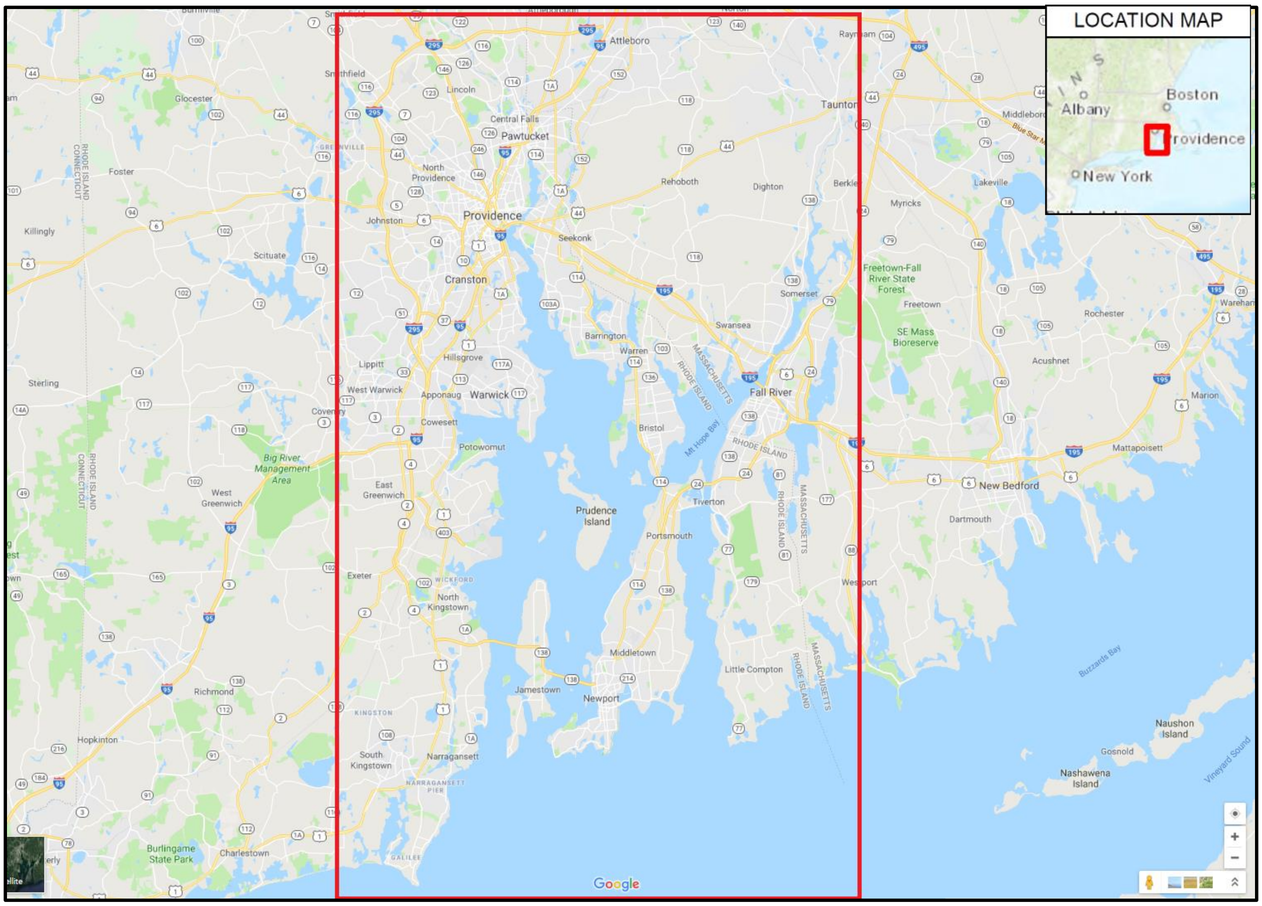

Figure 1-1: Project area

The Non-Federal Sponsor (NFS) for this study is the state of Rhode Island, Coastal Resource Management Council (RICRMC). On March 28, 2019, the USACE and the RICRMC executed a Feasibility Study Agreement (FCSA). The feasibility study was performed with a project cost share of 50 percent Federal funding and 50 percent contributed by the NFS.

This study is being conducted because the Rhode Island shoreline and coastal tributaries from Narragansett Bay to the Massachusetts border experiences recurring and significant coastal flooding during storm events. This flooding contributes to the risk to public safety and causes property damage in the region. The effects of flooding are anticipated to increase due to future sea level rise.

1.2 THE USACE PLANNING PROCESS

The 1983 "*Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies*" (P&G) and Engineering Regulation (ER) 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.

This report was prepared in compliance with the National Environmental Policy Act (NEPA), the Council on Environmental Quality's (CEQ) NEPA Regulations, and USACE's Procedures for Implementing NEPA (33 Code of Federal Regulations (CFR) part 230). Sections of the report that are required to meet the requirements of NEPA are marked with an asterisk (*) in the headings.

NEPA requires Federal agencies to integrate the environmental review into their planning and decision-making process. This IFR/EA is consistent with NEPA statutory requirements. The report reflects an integrated planning process.

1.3 STUDY AUTHORITY

The study is authorized by three congressional documents. These include a resolution adopted by the Senate Public Works Committee dated September 12, 1969, a resolution adopted by the Senate Committee on Environment and Public Works dated August 2, 1995, and by Public Law (PL) 84-71.

The resolution by the Committee on Public Works of the United States Senate, dated September 12, 1969, also known as the Southeastern New England Resolution, states:

> “That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on the Land and Water Resources of the New England-New York Region, transmitted to the President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document Numbered 14, Eighty-fifth Congress, with a view to determining the feasibility of providing water resource improvements for flood control, navigation and related purposes in Southeastern New England for those watersheds, streams and estuaries which drain into the Atlantic Ocean and its bays and sounds in the reach of the coastline of Massachusetts, Rhode Island and Connecticut southerly of, and not including, the Merrimac River in Massachusetts, to, and including, the Pawcatuck River in Rhode Island and Connecticut, with due consideration for enhancing the economic growth and quality of the environment."

The resolution adopted by the Senate Committee on Environment and Public Works on August 2, 1995 states:

> Resolved by the Committee on Environmental and Public Works of the United States Senate, that the Secretary of the Army is hereby directed to review the report on the Land and Water Resources of the New England-New York Region, transmitted to the President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document number 14, Eighty-fifth Congress as modified by Senate Public Works Committee Resolution on September 12, 1969, Ninety-first Congress, with a view to determine whether modification of the recommendations contained therein are advisable in the interest of improved flood control, frontal erosion, coastal storm damage reduction, watershed, stream and ecosystem habitat viability, and other purposes, in the area from Watch Hill, Rhode Island to Narragansett, Rhode Island.”

PL 84-71 was signed on June 15, 1955. It authorized an examination and survey of the coastal and tidal areas of the eastern and southern United States, with particular reference to areas where severe damages have occurred from hurricane winds and tides. PL 84-71 states:

> “Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in view of the severe damage to the coastal and tidal areas of the eastern and southern United States from the occurrence of hurricanes, particularly the hurricanes of August 31, 1954, and September 11, 1954, in the New England, New York, and New Jersey coastal and tidal areas, and the hurricane of October 15,1954, in the coastal and tidal areas extending south to South Carolina, and in view of the damages caused by other hurricanes in the

past, the Secretary of the Army, in cooperation with the Secretary of Commerce and other Federal agencies concerned with hurricanes, is hereby authorized and directed to cause an examination and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.

Such survey, to be made under the direction of the Chief of Engineers, shall include the securing of data on the behavior and frequency of hurricanes, and the determination of methods of forecasting their paths and improving warning services, and of possible means of preventing loss of human lives and damages to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams, and other structures, warning services, or other measures which might be required."

This study is an interim response to the study authorities.

1.4 STUDY AREA

As a result of Hurricane Sandy, Congress authorized the 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 flood risk, including the development of strategies to manage risk associated with relative sea level change (RSLC). The NACCS identified nine (9) high-risk, focus areas in the study area. Two (2) of these focus areas were located on 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 second focus area, with the inclusion of Block Island.

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. The study area covers more than 457 miles of coastline as shown in **Figure 1-2**. All or part of 19 municipalities (**Figure 1-3**) across all five counties within Rhode Island (**Figure 1-4**), are included in the study area, with more than 650,000 people currently residing within the boundaries of the study.

Rhode Island is located in New England, south of Massachusetts and east of Connecticut. The State lies along the western shoreline of the Atlantic Ocean and is characterized by low topographic relief. Providence is the largest city located at the northern point of Narragansett Bay, followed by Cranston and Warwick. Rhode Island is bordered by Massachusetts to the north, Long Island Sound to the south, and Connecticut to the west.

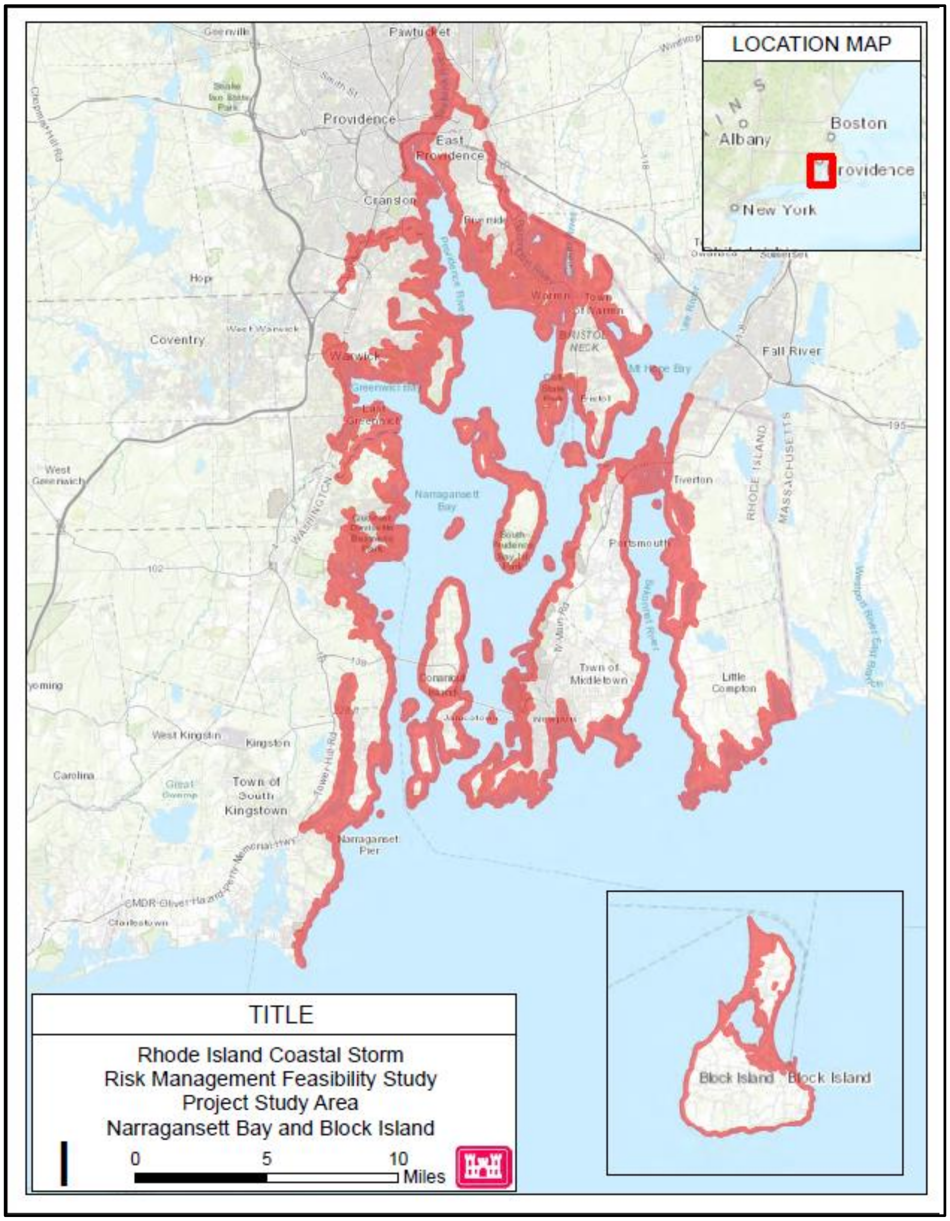

Figure 1-2: The coastline included in the study area

Following the horseshoe shape of the Rhode Island coastline from a southwest point up to the northern-most point, then southeast back down, includes the following main geographical features. Starting with Long Island Sound and moving up the coast, Narrow River runs just a few hundred feet inland parallel to Narragansett Bay. Along the way north up to Providence Harbor there are numerous coves and harbors such as Wickford Harbor and Allen Harbor. The Potowomut River meets the Narragansett Bay and runs inland towards East Greenwich. Moving slightly north again to Greenwich Bay, just south of Warwick. Narragansett Bay reaches its most northern point meeting the Providence River just south of Barrington. The Providence River then breaks off into the Pawtuxet River running west towards Cranston. The Providence River finally meets up with

Providence Harbor before splitting into the Woonasquatucket River, Moshassuck River, and Seekonk Rivers. Further south along the eastern coast of the Narragansett Bay, the Warren River flows north into Barrington and Warren. Bristol Harbor then Mt. Hope Bay, just north of Tiverton and Portsmouth are located even further south. Then finally Easton Bay that splits out into the Long Island Sound.

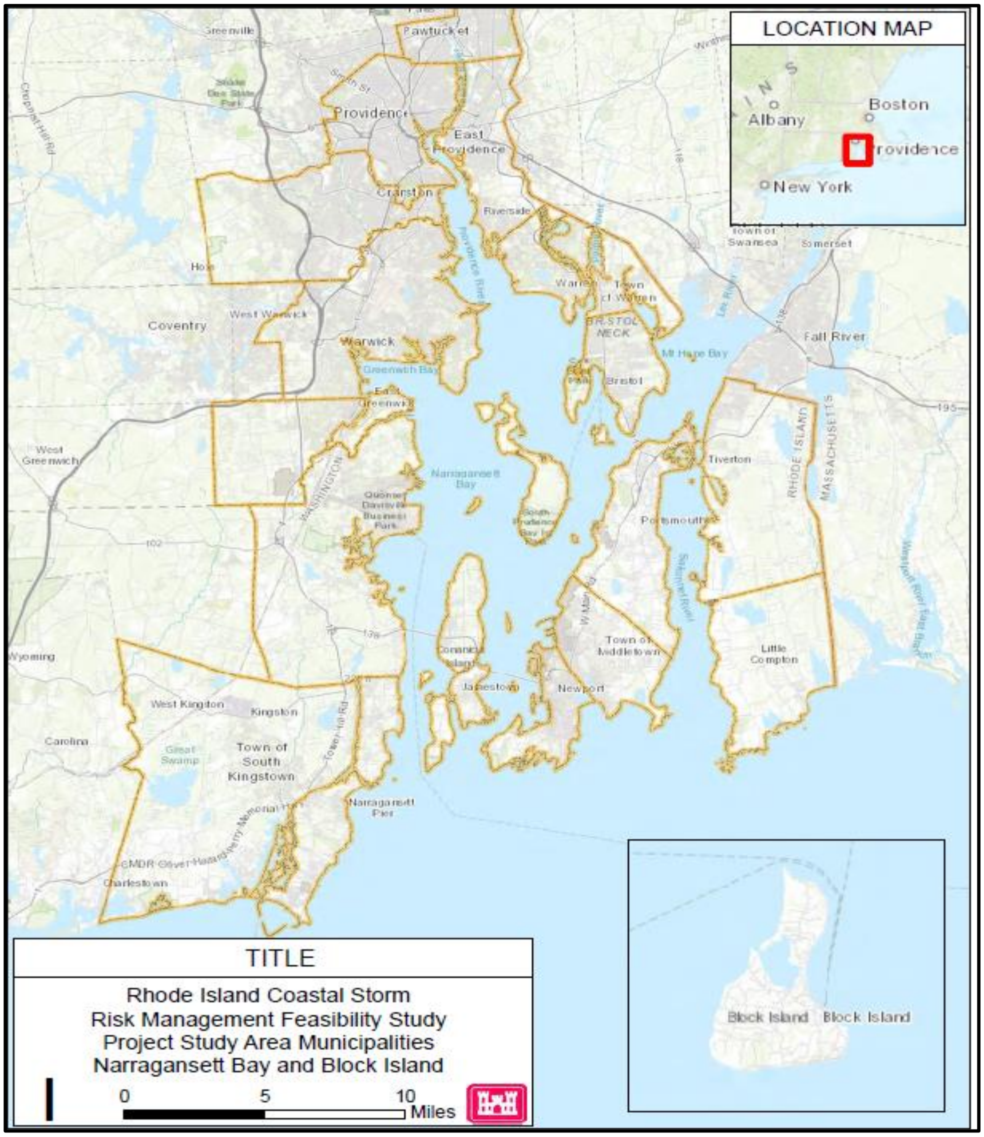

Figure 1-3: Municipalities located in the project area

The study area is located in Rhode Island Congressional Districts RI-01 and RI-02 represented by the following members of the 116th U.S. Congress: Representative David Cicilline (D) and James Landevin (D) respectively; and Senators Jack Reed (D) and Sheldon Whitehouse (D).

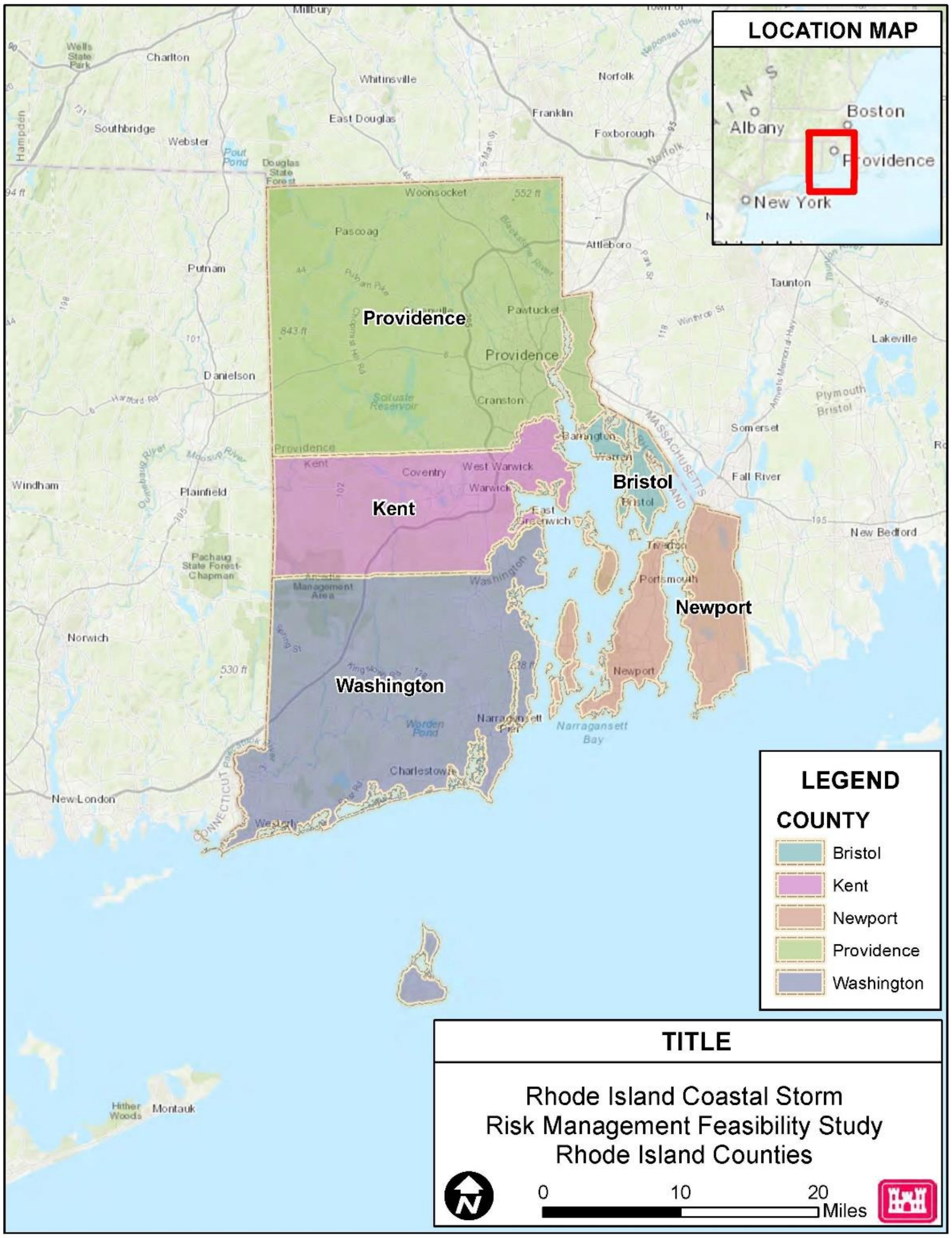

Figure 1-4: Counties located in the project area

1.5 BACKGROUND AND HISTORY

1.5.1 Prior Studies, Reports, and Projects

There are several Federal studies, reports and water projects that have been completed by the USACE addressing coastal storm damage along the Rhode Island coast. The NACCS identified 20 federal projects in Rhode Island; four (4) were storm damage reduction projects and 16 were navigation project (USACE 2015). The majority of these projects fell within the study area, which is identified as RI1 in the NACCS (**Figure 1-5**). Three (3) of the storm damage reduction projects that were mentioned in the NACCS

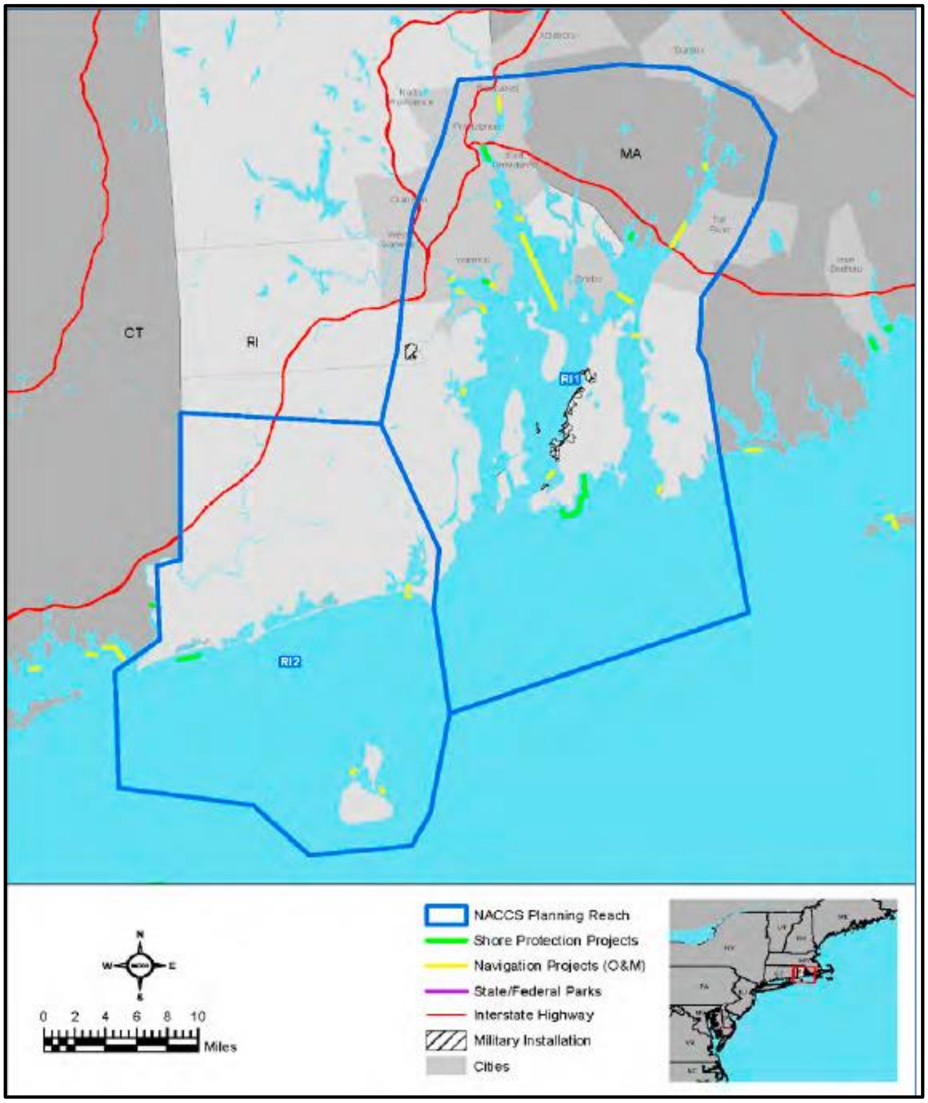

Figure 1-5: Federal projects located in Rhode Island as identified in the NACCS

report (the Cliff Walk Project, the Oakland Beach Project, and the Fox Point Hurricane Barrier Project) are located in the study are for this project and are described below. The NACCS also mentioned a list of 2,201 projects that was provided by the RICRMC, which address CSRM (**Figure 1-6**). This list included 1407 seawalls/bulkheads and 794 projects that were classified as revetments. These structures are both publicly and privately owned.

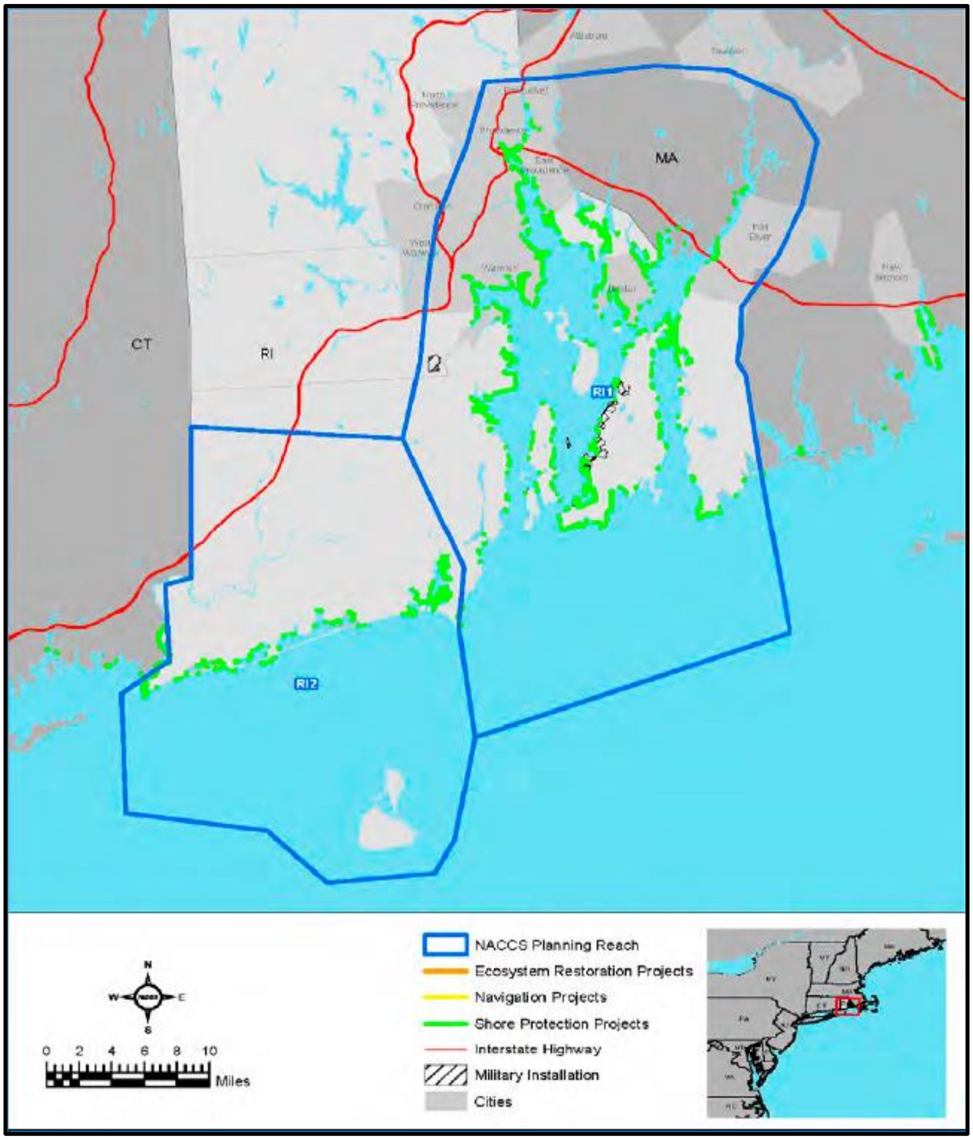

Figure 1-6: State led CSRM projects identified in the NACCS

Below is a list of CSRM projects that have been undertaken by the USACE, two (2) of which were not implemented due to lack of local support.

Sand Hill Cove Beach, Narragansett Project - This beach erosion control project, east of the entrance to Point Judith Pond, was completed in 1955 and consists of widening the beach by 65 feet, constructing five stone groins and a steel bulkhead behind the eastern half of the beach.

Misquamicut Beach, Beach Erosion Control Project - The project was authorized by the River and Harbor Act of July 3, 1958, as amended. The authorized beach erosion control project, completed in 1959, involved the placement of approximately 90,000 cubic yards of a suitable sand fill along 3,250 feet of shoreline. The beach is roughly 150 feet wide shoreward of the mean high-water line with a top elevation of +7.5 feet Mean Low Water.

Misquamicut Beach, Beach Erosion Control Project. - The project was authorized by the River and Harbor Act of July 3, 1958, as amended. The authorized beach erosion control project involved widening 3,250 feet stretch of beach to 150 feet in width by the direct placement of sand and installing nearly 4,075 feet of sand fences. Work was completed in 1960 at a cost of $44,000.

Point Judith Hurricane Barrier (not implemented) - A plan to construct a hurricane barrier from the Sand Hill Cove area of Point Judith, across the south side of Point Judith Pond, and terminating in the Matunuck area of South Kingstown, was developed in 1960. The barrier consisted of a series of beach berms, walls, and engineered dikes. A 300-foot-wide navigation opening would remain (no retractable structure proposed) at the inlet to Point Judith Pond. The proposal was not supported by the public or the regulatory community and therefore never progressed beyond the study phase.

Fox Point Hurricane Barrier Project, Providence - The Fox Point Hurricane Protection Barrier in Providence is located immediately south of the Narragansett Electric Company plant, about 0.2 miles north of Fox Point and one (1) mile south of downtown Providence. The project provides virtually complete protection against tidal flooding from hurricanes and other coastal storms to about 280 acres of downtown Providence. The protected area includes the commercial and industrial center, transportation facilities, public utilities, and many homes. The city suffered extensive damage from the hurricane of 1938 and Hurricane Carol in 1954 when, in each instance, water depths of up to eight (8) feet were experienced in the city’s commercial area. Construction began in July 1961 and was completed in January 1966, at a cost of $15 million.

Oakland Beach Project, Warwick - Oakland Beach, part of Oakland Beach State Park, is located in Warwick along the northern shore of Greenwich Bay. Bordered by Brush Neck Cove on the west and Warwick Cove on the east, Oakland Beach State Park offers the public a variety of recreational opportunities, such as swimming, boating, fishing, clamming, and sporting activities. The project involved widening a total of 200 feet of beach along each side of the existing seawall by the direct placement of sand; construction of five (5) stone groins; and placement of stone slope protection in front of the seawall. The work at Oakland Beach cost $740,000 and was completed in 1981 under Section 103 of the Continuing Authorities Program (CAP).

Cliff Walk Project, Newport - Cliff Walk in Newport is a popular scenic and historical walkway bordering the edge of eroding bluffs and cliffs along the city’s southeastern shoreline. The project originally called for the construction of shore protection measures along much of the walkway’s 18,000 feet. Due to a limitation of local funding available at that time, only 70 percent of the project was completed. The completed work covered a total area of approximately 9,200 feet between Newport Beach and the west property line of the Marble House at Sheep Point. This work involved constructing stone breakwaters and stone slope protection, repairing existing seawalls, using fill to strengthen Cliff Walk’s intermittent reaches, and grading and surfacing the walk. This part of the project began in May 1971 and was completed in September 1972 at a cost of $1.4 million.

In the early 1980's, local officials indicated a desire and willingness to resume construction the unfinished part of the project situated near Salve Regina College. After receiving appropriate funding in 1982, the USACE completed design plans for the additional work. The construction of this portion of the project was completed by the city of Newport using funds provided by the National Park Service and was completed in 1985.

Pawtuxet River Local Protection Project, Warwick - The Pawtuxet River Local Protection Project in Warwick is located on the Pawtuxet River at the northern end of the city's Norwood section, referred to as Belmont Park. The project prevents flood damage to approximately 38 acres of residential land. To help stem severe flooding, the USACE developed a cost-effective nonstructural plan. The work involved moving or eliminating 61 homes; purchasing outright 19 privately-owned vacant lots; constructing 12 above-ground utility room additions to residences in the area, which historically experienced less severe flooding; and installing the automated flood forecasting and warning system so that the remaining homes could be evacuated and property vulnerable to basement flooding could be protected. Work began in September 1982 and was completed in July 1985 at a cost of $4 million.

Interim Hurricane Survey of Westerly, Rhode Island (Project not implemented) - A comprehensive plan (beach fill, numerous groins, tide gates and pump stations) to restore and protect Misquamicut Beach was developed by the USACE, New England Division as an "Interim Hurricane Survey of Westerly, Rhode Island" and transmitted by the Secretary of the Army to Congress in July 1964. The project was subsequently authorized by Congress in December 1965. However, due to a lack of local interest, the project was never constructed and was subsequently de-authorized in January 1986.

Misquamicut Beach, Shore Protection and Flood Damage Reduction Reconnaissance Report, Westerly, Rhode Island - The report, dated January 1994, could not determine an economically justified plan for storm damage protection along the Westerly shoreline. The study was terminated, and no further action taken.

Camp Cronin Shore Protection and East Shore Arm Breakwater Repairs Project, Point Judith - The USACE, in partnership with the Rhode Island Department of Environmental Management (RIDEM), designed and constructed this project to repair and area surrounding Camp Cronin, which was damaged by Hurricane Sandy in 2012. The breakwater repair project included the construction of a 70-foot wide, 480-foot-long hybrid stone revetment to stabilize the shoreline and restore safe public access to the fishing area. The project also included repairs to the adjacent East Shore Arm Breakwater of the Point Judith Harbor of Refuge. This project was completed in 2017.

Pawcatuck River CSRM Feasibility Study (Project on-going) - This study investigated solutions to reduce coastal storm risk for the Pawcatuck River coastal study area in Westerly, Charlestown, South Kingstown, and Narragansett, RI. The proposed project consists of elevating the first floors of 247 structures and flood proofing 21 commercial structures. The study has completed the feasibility phase and is currently in the Preconstruction, Engineering and Design (PED) phase.

1.5.2 Historic Storms

The Rhode Island coastline is continuously affected and transformed by storms and tidal inundation. There are two types of storms of primary significance along the Rhode Island shore: tropical storms (hurricanes), which typically impact the Rhode Island area in summer and fall and extratropical storms (nor'easters), which occur predominantly between November and March but can also occur during other times of the year. Nor'easters are usually less intense than hurricanes but tend to have much longer durations. These storms often cause high water levels and intense wave conditions and are responsible for significant erosion and flooding throughout the coastal region. Storm surge and flooding caused by coastal storms have resulted in loss of life and significant and repetitive damage to coastal communities. The information provided in this section describes the historic flooding events that have been experienced by coastal communities within study area (National Oceanic and Atmospheric Administration (NOAA) 2021a).

The Great New England Hurricane of 1938 - The Great New England Hurricane of 1938 was one of the most powerful and destructive storms ever experienced in southern New England (**Figure 1-7**). The storm came ashore on September 1938 at Suffolk County, Long Island as a Category three (3) Hurricane. The hurricane did not weaken on its way toward southern New England. The center made landfall at the time of astronomical high tide, moving north at 60 mph. Sustained winds of 91 mph, with gust up to 121 mph were recorded on Block Island, while Providence experienced sustained winds of 100 mph and gusts a strong as 125 mph. This storm caused significant flooding, due to rainfall and storm surge. The storm surge in Narragansett Bay was recorded to be as high as 15 feet. Downtown Providence experience a storm tide of 20 feet. The damage caused by the hurricane was catastrophic, destroying coastal homes, marinas, and yacht clubs. Entire fleets of boats associated with these marinas were lost. In total 564 people lost their lives, and 1,700 people were injured. Property damage caused by the storm was also significant, with a total of 8,900 homes, cottages and buildings destroyed, and over 15,000 damaged.

Figure 1-7: The remains of houses in Island Park, Rhode Island after the hurricane of 1938. (Source NOAA)

Hurricane Carol of 1954 - Hurricane Carol is considered the most destructive hurricane to hit New England since the Great New England Hurricane of 1938. This storm reached New England on August 31, making landfall near Old Saybrook, CT. Rhode Island experienced sustained winds between 80 to 100 mph, with gusts of 135 mph recorded on Block Island. The storm caused storm surges from 10 to 15 feet; in addition, 2 to 5 inches of rain fell across the state, resulting in significant coastal flooding. Entire communities, from Westerly and Narragansett, were devastated, with 4,000 houses destroyed along with 3,500 cars and more than 3,000 boats. In addition, all of Rhode Island lost electrical power. 65 people lost their lives during the storm.

Tropical Storms Connie and Diane of 1955 - Two (2) tropical storms (Connie and Diane) passed over southern New England in little over a week during August of 1955. Tropical storm Connie produced 3 to 5 inches of rain across the state. One (1) week later Diane caused three (3) to six (6) inches of rain to fall on central and southern Rhode Island. Due to record floodwaters in the headwaters of the Blackstone River and the torrential rains experienced across northern Rhode Island, devastating record floodwaters were experience through the Blackstone River Valley and the city of Woonsocket. The Blackstone River crested 12.8 feet above flood stage in Woonsocket, which is the worst flood on record for that area. The storms resulted in multiple dam failures.

The Great Flood of 2010 - The Great Flood of 2010 took place in March and April of 2010. This flood event was the result of a series of moderate to heavy rainfall events over a five (5) week period during late February through late March. These nor'easters resulted in record riverine flooding across much of Rhode Island (**Figure 1-8**) as opposed flooding caused by storm surge. Because these events took place in such a short period, the saturated soils and limited opportunities for rivers and streams to recede made the state especially vulnerable to flooding. A river gage on the Pawtuxet River in Cranston broke its record crest during the mid-March event. The next event, only a few weeks later, exceeded the previous record crest by an elevation of six (6) feet. These storms caused significant coastal flooding, including road and bridge washouts, flooded homes and businesses, damaged utilities and major disruptions to utility services. Examples of flooding resulted from this series of events include:

- Warwick - The Warwick Mall was under 2 feet of water. The Airport Connector, which provides access from I-95 to TF Green Airport, was shut down.
- Cranston - I-95 was shut down due to flooding.
- Westerly - A mile of train track was inundated, resulting in a suspension of Amtrak services. Flooding of Chapman Pond shut down Route 91 and Pound Road, prohibiting access to an entire neighborhood.
- Hopkinton - Blue Pond Dam in the headwaters of the Wood River failed, resulting in damage to infrastructure in the area.

"All counties in Rhode Island were included in a Federal Emergency Management Agency (FEMA) Major Disaster Declaration; nearly 26,000 residents applied for assistance, with $79 million in disaster assistance approved for individuals and business owners." (NOAA 2021a) One indirect death was attributed to the Great Flood.

Figure 1-8: Riverine flooding from the Pawtuxet River in West Warwick, Rhode Island during the Great Flood of 2010. (Source: NOAA)

Superstorm Sandy of 2012 - The arrival of Superstorm Sandy on October 29, 2012 was preceded by coastal flood warnings and mandatory evacuations in Rhode Island for coastal towns, low lying areas and mobile homes. This event was a hybrid tropical/extratropical storm. It affected the Rhode Island coastline with storm surge and waves but very little rainfall. Major evacuations from Rhode Island towns along Narragansett Bay and the Southern Atlantic Coast included Bristol, Charlestown, Fall River Middletown, Narragansett, South Kingston, Tiverton and Westerly. The storm surge of Superstorm Sandy destroyed houses and businesses, damaged pilings and deck supports, blew out walls on lower levels, and moved significant amounts of sand and debris into homes, businesses, streets, and adjacent coastal ponds (**Figure 1-9**). In some areas, roads were either flooded or covered in three feet of sand. Propane gas tanks were dislodged from houses, septic systems were damaged and underground septic tanks were exposed, creating potential hazardous material exposure. The National Guard was called out to restrict entry to the community of Misquamicut (located in the town of Westerly) due to the devastation. The Westerly Sun newspaper reported that "houses were ripped from their stilts and deposited in the streets while other structures appeared precariously perched over the ocean."

Figure 1-9: Damaged home in Westerly, Rhode Island after Superstorm Sandy (October 2012).

Damages were most significant in the coast from Narragansett to Westerly. Twenty eight percent of the state's population, approximately 300,000 people were affected by the storm. More than $39.4 million in support from four Federal disaster relief programs was used to assist Rhode Island's recovery efforts from Superstorm Sandy.

In their Shoreline Change Special Area Management Plan (SAMP), the RICRMC point out an important fact about Superstorm Sandy. "…Despite the damage along the south shore, this storm wasn't a hurricane or even a once in 100-year (1 percent annual chance) storm event when it made landfall in Rhode Island, rather it was a once in 25- year storm (4 percent annual chance) event for Westerly, and a much less intense storm event for the rest of the state. Had this storm been a hurricane or a 1 percent annual chance storm event, impacts would have much greater." (RICRMC 2015) The likelihood of larger storms with greater damages supports the need for the current effort to investigate means to reduce risk to coastal communities in the study area.

1.6 PURPOSE AND NEED*

The purpose of the NACCS was to encourage action by all to implement CSRM strategies to reduce the risk from, and make the North Atlantic region more resilient to, future storms and impacts of sea level change (SLC). The RIC study is aligned with the NACCS' goals and purpose towards the completion of a systems analysis to better understand and manage coastal risk. The RIC study is a targeted investigation to identify a plan to reduce the risk of coastal storm damage along the large portion of the Rhode Island coastline, while contributing to the resilience of communities, important infrastructure, and the natural environment. The study area includes significant critical infrastructure at risk of damage from future flooding and coastal storms including police, fire and emergency support service facilities; schools; energy production facilities; water and wastewater facilities; and nursing homes and assisted living facilities.

The study is needed because the study area experiences frequent flooding from high tides, spring tides, and coastal storms; is considered at high risk of coastal storm flooding with an associated threat to life safety; and is susceptible to RSLC. The study will utilize a system-wide, integrated approach that incorporates the natural, social, and built systems to support resilient coastal communities and sustainable ecosystems.

1.7 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, 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. The coastal Rhode Island region experiences extensive inundation (flooding) from storm surge 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 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 represent an unstoppable process causing 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.

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 primary opportunities identified for the study area are:

- Reduce 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.
- Consider other social effects, including community cohesion, stressed communities and prevent post-storm displacement
- Reduce the risk of flooding and economic damages owing to sea level change through formulation analyses.

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 this 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 (1) 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.

1.8 OBJECTIVES AND CONSTRAINTS

As part of the USACE planning process, the Project Development Team (PDT) and the stakeholders identified planning objectives and constraints that will lead to a more desirable future. 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 are:

- Reduce damage from coastal storm surge to residences, business, and critical infrastructure within the study area.
- Reduce risks to public health and safety.

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. Constraints statements that alternative plans should avoid are listed below.

<u>Constraints</u>

- Plans should not increase or induce flooding elsewhere within the Rhode Island coastline through 2079.
- Plans should avoid and minimize environmental impacts within the project area to the maximum degree practicable through 2079.
- Plans should not adversely impact threatened or endangered species, and their habitat within the Rhode Island coastline through 2079.
- Plans should avoid or minimize negative impacts to commercial fisheries and Essential Fish Habitat offshore of the Rhode Island coastline through 2079.
- Plans should avoid or minimize impacts that negatively affect authorized navigation projects along the Rhode Island coastline through 2079.
- Plans should avoid or minimize impacts that contribute to poor water quality along the Rhode Island coastline through 2079.
- Plans should minimize effects on cultural resources and historic structures, sites, and features within the project area through 2079.
- Plans should fall within the USACE business line.

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

- Project area is large so 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 not being able to support/fund nonstructural measures, which could impact the effectiveness of the plan. **Section 6.6.4** of this report further addresses participation rates.

SECTION 2.0 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS*

This section of the report provides both the existing conditions, as well as a forecast of the Future Without Project (FWOP) condition within the study area. The information included in this section provides a basis for the formulation to produce a plan that will reduce risk from coastal storms. Under NEPA regulations, the human environment is also considered the "affected environment." In this integrated report, the Existing Conditions Section represents the Affect Environment for NEPA purposes. Additionally, the FWOP condition described in this section represents the No Action Alternative (NAA) as required by NEPA.

2.1 PERIOD OF ANALYSIS

The period of analysis for the alternatives is the 50-year period, from 2030 through 2079. Project implementation is expected to begin in the year 2025 and last 5 years. The implementation period is the time frame during which construction is expected, which runs from 2025 to 2030. The base year is considered the year the alternatives have been implemented and begin to accrue benefits. The base year for this project is assumed to be 2030. To evaluate plan performance over a minimum 50-year period, which is a standard USACE policy, future damages were calculated through the year 2079.

2.2 GENERAL SETTING

The NFS describes the Rhode Island coastline in their Shoreline Change SAMP report as "one the state's most iconic and treasured assets". The coastline includes "barrier beaches, historic waterfronts, bluffs, headlands and salt marsh that make Rhode Island the 'Ocean State' and give rise to major sectors in the state's economy including tourism and marine trades". The most challenging element of this study is the sheer diversity of the communities that are affected by coastal storms and the size of the study area. The project area communities vary from Providence, the state capital, an urban center with significant industrial development and the Port of Providence (**Figure 2-1**), to the pristine beaches of rural Block Island. These two communities represent the most and least populous communities in Rhode Island. As of the 2020 census, Providence had 190,934 residents (U.S. Census Bureau 2021b), while New Shoreham on Block Island had 1,410 year-round residents (U.S. Census Bureau 2021c). The region also includes significant historic resources, from the historic district and Gilded Age mansions of Newport to numerous pre-historic archeologic sites. Additionally, year-round communities, seasonal resorts and cottages, and commercial facilities are interspersed throughout the project area. Although each focused project area has experienced recurring impacts of coastal storms, each has their own unique needs, expectations, and resources.

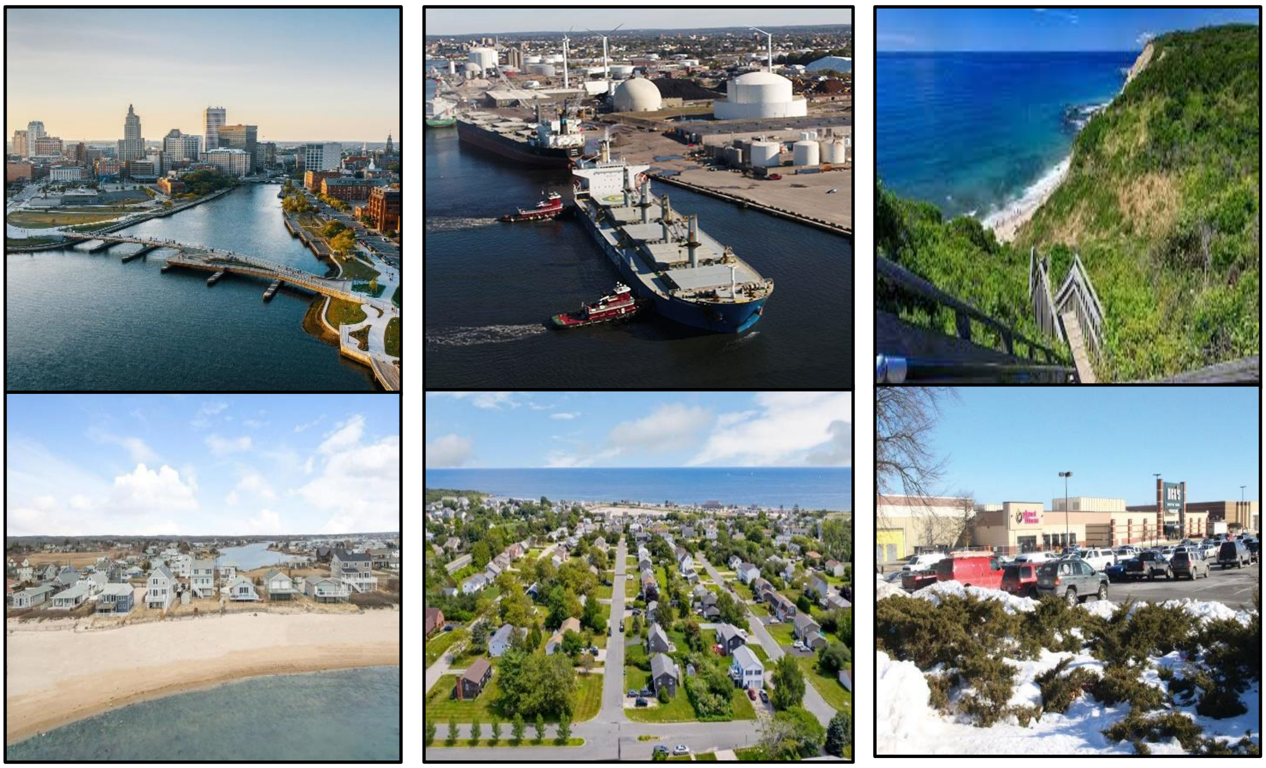

Figure 2-1: The diversity of communities withing the study area: **A.** Providence, RI, **B.** Port of Providence, **C.** A beach on Block Island, RI, **D.** Beach Front Houses in South Kingstown, **E.** Neighborhood in Narragansett, **F.** A shopping mall in Warwick, RI.

The study area includes the majority of Narragansett Bay, which is a major feature of the state's topography. A small portion of the bay is located in Massachusetts. This bay is the largest estuary in New England, covering approximately 14 percent of the state's total area. This body of water ranges from three (3) to 12 miles in width. It extends 28 miles from the inlet at Rhode Island Sound, essentially dividing the state into two halves. The bay acts as a natural harbor and has been an active shipping center since colonial times. The major ports located in the bay are the Port of Providence and Newport Harbor. In addition to the transportation of goods, the vessel fleet in Rhode Island also supports fishing and recreational boating.

Narragansett Bay includes more than 30 islands. Block Island, which is part of this study, however, is not one of these islands. It is located in Rhode Island Sound, approximately 12 miles off of the southern coast of the mainland.

Rhode Island's coastline is continuously transformed by storms and tidal inundation. Extensive and repetitive damage from storm events that occurs in the study area is due to the combination of low-lying topography, densely populated residential and commercial areas, extensive low-lying infrastructure, and degraded coastal ecosystems. In fact, an RICRMC led investigation associated with the Shoreline Change SAMP found that 27,431 or 11.5 percent of the residential structures in Rhode Island's coastal communities are exposed to the combined effects of SLC and storm surge under the Long-range Planning Scenario. This scenario used seven (7) feet of SLC and the storm surge from a 100-year event, which results in inundation of approximately 65 square miles of Rhode Island's existing coastline.

Early in the planning process, scoping meetings were held with the NFS and with representatives from municipalities located within the study area in order to better understand the region at both a micro and macro level. The NFS, with the assistance of stakeholders, identified eleven key focused study areas within the regional study area, which are shown in **Figure 2-2**. Focus areas for the study were identified based on elevation data, structure density, and discussions with town and state officials regarding high damage-prone areas and history of coastal storm damages. A key component of choosing the study focus areas was USACE's ability to construct projects to alleviate coastal storm damage risk while contributing to the NED objective.

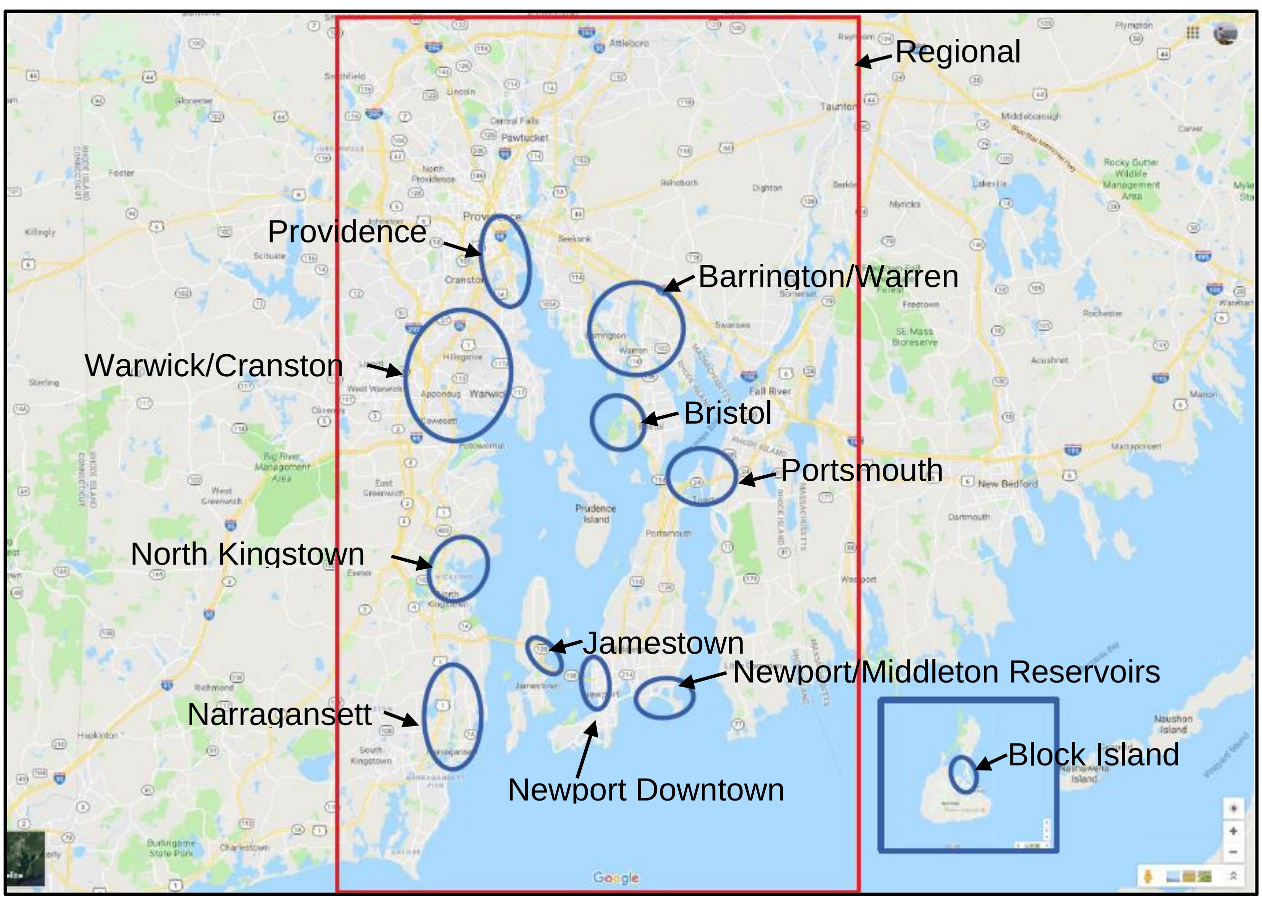

FIGURE 2-2: Focused study areas

A series of problems and opportunities, which are presented in **Table 2-1**, was developed during these early coordination meetings and led to the problems and opportunity statements listed in **Section 1.7**. Using the information obtained during the early stakeholder meetings, the PDT concentrated on developing solutions for the focused study areas. Additionally, nonstructural measures were considered for the entire study area (i.e., the shoreline from Point Judith to the Massachusetts border).

TABLE 2-1: Problems and opportunities identified during early stakeholder meetings

Focused Study Area	Problems	Opportunities
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 floodplain
Newport Downtown	• Numerous low-lying structures including historic district	• Reduce flood inundation • Move/elevate/floodproof structures out of floodplain
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
Bristol	• Route 114 is primary evacuation route subject to flooding • Low-lying historic district along downtown waterfront	• Protect/Elevate Route 114
North Kingstown	• Numerous low-lying structures including historic district located along downtown waterfront	• Reduce flood inundation • Move/elevate/floodproof structures out of floodplain
Portsmouth	• Numerous low-lying structures	• Reduce flood inundation • Move/elevate/floodproof structures out of floodplain
Providence	• Low-lying industrial/commercial port is vulnerable to flooding during extreme storm events, potentially threatening regional critical infrastructure including but not limited to wastewater treatment facilities, and home heating oil terminals	• Reduce flooding of the port area • Floodproof critical infrastructure in the port area
Jamestown	• Route 138 is the only conduit across Narragansett Bay and highly	• Reduce flooding of the toll plaza area

Focused Study Area	Problems	Opportunities
	trafficked. The toll plaza portion on Jamestown is low-lying and vulnerable to flooding during extreme flood events	
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
Warwick	• Low-lying areas along 'The Neck', Potowomut and Apponaug Cove are subject to coastal flooding	• Reduce flood inundation • Move/elevate structures out of floodplain
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
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

2.3 NATURAL ENVIRONMENT

2.3.1 Existing Conditions

2.3.1.1 Wetlands

There are over 1,000 acres of wetlands within the Narrow River portion of the study area, from the Middle Bridge vicinity north of the Route 1A bridge extending north along the river. Approximately 500 acres of wetlands are located in Providence, the majority of which are intertidal and interspersed throughout the urban and industrial shorelines. The Providence shoreline is highly industrial, so the wetland areas occur in a mosaic of bulkheads, hard shorelines, and urban infrastructure. In Bristol County, there are a total of approximately 2,700 acres of wetlands throughout the three (3) towns. There are relatively large areas of intertidal salt marsh north of Smith Cove and on Jacobs Point, both of which abut the Warren River. Tyler Point, Little Island, and Belcher Cove are other parts of the focused study area with large areas of intertidal salt marsh. In Newport, the approximately 1,000 acres of wetlands are confined to estuarine unconsolidated shore that is irregularly flooded. The downtown area of Newport is urban and there are no significant salt marshes or jurisdictional wetlands. Block Island has approximately 700 acres of wetlands (Rhode Island Geographic Information System (RIGIS) 2014).

2.3.1.2 Protected Areas

The U.S. Geological Survey protected areas database was used to determine the presence of all public and non-profit held lands and waters. **Figure 2-3** shows the protected areas in Newport as an example of the information the database provides. In

Providence, there are 54 protected areas totaling approximately 400 acres. Property owners of protected areas bordering the harbor include the City of Providence, RIDEM, and Save the Bay. Collier Point Park borders the study area's shoreline to the north, and Save the Bay maintains public access on its property at Fields Point on the southern end of Providence. In Bristol County, there are 192 protected areas totaling over 2,000 acres. Land managers there include municipal, state, and non-profit property owners. There are numerous protected areas along the Palmer, Barrington, and Warren Rivers. In Newport, there are a total of 35 protected areas covering roughly 1,300 acres. The majority of this acreage is occupied by the U.S. Navy and is not considered part of the study area. Other property managers include the City of Newport, Town of Middleton, RIDEM, and non-profit organizations (**Figure 2-3**). In South Kingston and Narragansett, there are a total of 303 protected areas totaling more than 17,500 acres. In the Narrow River project area, there are 69 protected areas totaling roughly 2,200 acres. This includes almost 550 acres of the John H. Chafee National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service (USFWS) (USGS 2018).

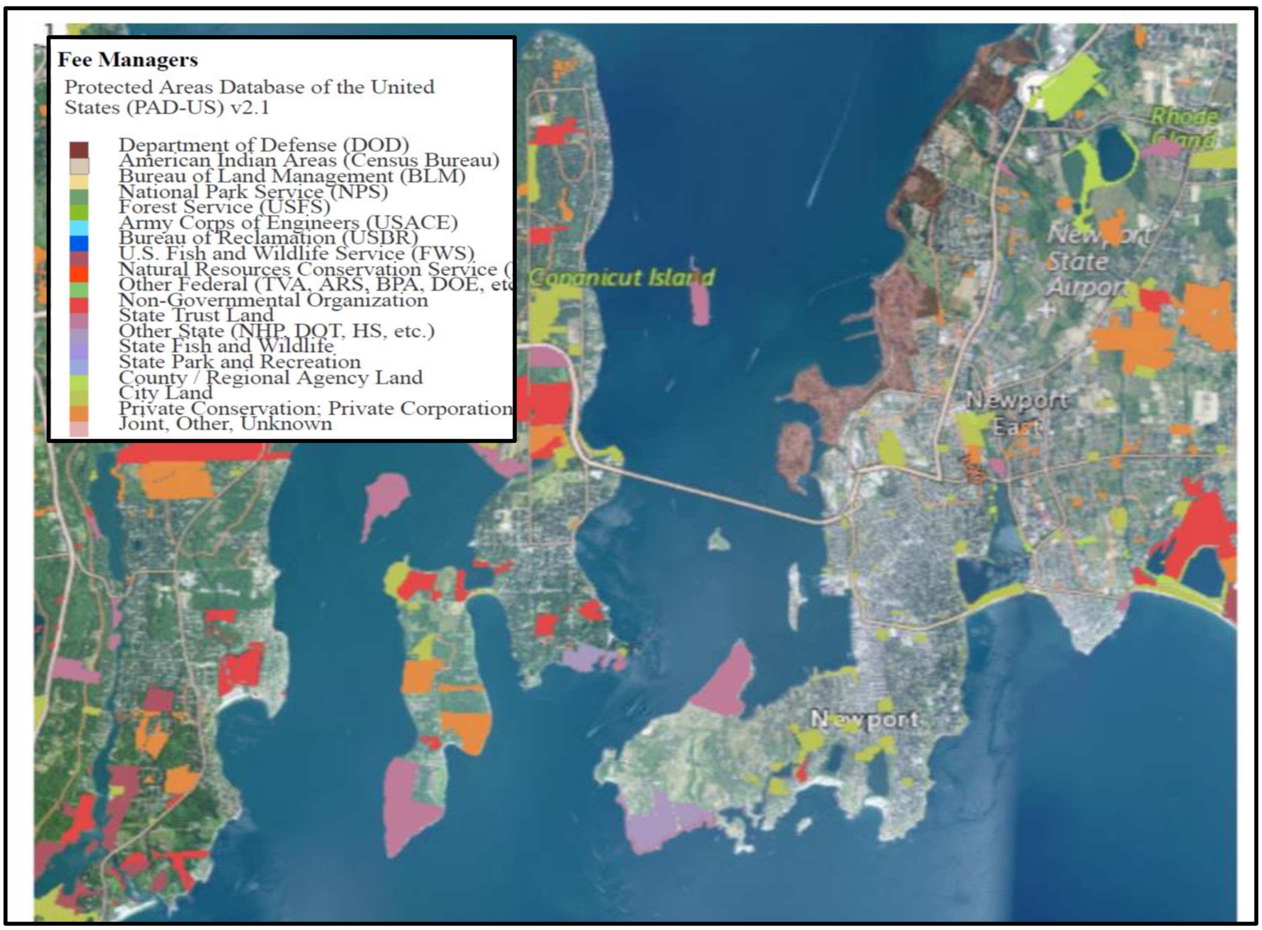

FIGURE 2-3: Protected areas within the Newport focused study area (USGS 2018)

There are no Coastal Barrier Resource Areas (CBRA) located within the Providence study area. Coastal Barrier Resource Unit D02B (Prudence Island) is located at the mouth of the Warren River in the Bristol County Study Area, and also extends into Smith's Cove, which is located west of the Warren River separated by Adams Point. There are no CBRAs in the downtown Newport study area; however, units RI-06 (Almy Pond) and RI-07 (Hazards Beach) are located south of Ruggles Ave about 0.75 miles south of the Wellington Ave portion of the Newport study area. CBRA Unit RI-10 (Narragansett Beach) is located in the Narrow River study area, beginning at the Middle Bridge and covering both Pettaquamscutt Cove and the Narrows portion of the Pettequamscutt River. On Block Island, there are 201 protected areas covering approximately 2,400 acres. Property managers include municipal, state, federal, and non-profit property owners. The majority of these protected areas are managed by non-governmental organizations such as The Nature Conservancy, Block Island Land Trust, and Block Island Conservancy (USGS 2018).

2.3.1.3 Federal Threatened and Endangered Species

No Federally listed plant species have been identified by the USFWS in the focused study areas. Focused study areas are described in further detail in **Section 3.3** of this report. The threatened northern long-eared bat (NLEB) (*Myotis septentrionalis*) is identified as potentially present in the entire study area by the USFWS's Information for Planning and Consultation (IPaC) system (USFWS 2021). The NLEB is found across much of the eastern and north central United States and all Canadian provinces from the Atlantic coast west to the southern Northwest Territories and eastern British Columbia. The species' range includes 37 states. White-nose syndrome, a fungal disease known to affect bats, is currently the predominant threat to this bat, especially throughout the Northeast where the species has declined by up to 99 percent from pre-white-nose syndrome levels at many hibernation sites (USFWS 2020).

During summer, NLEBs roost singly or in colonies. Males and non-reproductive females may also roost in cooler places, like caves, mines, and forts. NLEBs emerge at dusk to fly through the understory of forested hillsides and ridges feeding on moths, flies, leafhoppers, caddisflies, and beetles, which they catch while in flight using echolocation. Breeding begins in late summer or early fall when males begin swarming near hibernacula. Most females within a maternity colony give birth around the same time, which may occur from late May or early June to late July, depending where the colony is located within the species' range. Young bats start flying by 18 to 21 days after birth (USFWS 2020a).

All known hibernacula for NLEBs in the state are in Newport County at Fort Greble (Dutch Island), Fort Getty, and Fort Wetherill, although no NLEBs have been encountered in surveys of those sites in recent years (Charlie Brown, Rhode Island Division of Fish and Wildlife, personal communication, March 4, 2021). No NLEBs have been observed at Fort Adams in Newport, but tricolored (*Perimyotis subflavus*), little brown (*Myotis lucifugus*), and big brown (*Eptesicus fuscus*) bats have been encountered at the site (*ibid*). Fort Adams is located approximately 0.5 miles from the focused study area in Newport. No known maternity roost trees exist within Rhode Island (C. Brown, personal communication, March 4, 2021).

The Federally endangered roseate tern (*Sterna dougallii dougallii*) is also identified by the IPaC system as potentially present within Bristol County, and near the Narrow River (USFWS, 2021). In North America, roseate terns breed in two separate populations, one from Nova Scotia to New York, and the second in the Caribbean. No more than five (5) pairs of roseate terns have nested in Rhode Island since the 1950s (USFWS 1998). The last breeding record is of two (2) birds in 1984 (Center for Biological Diversity n.d). Roseate terns depart from their breeding colonies in late-July and August and concentrate in staging areas around Cape Cod before departing in September for wintering grounds. Recent research suggests that substantial numbers of roseate terns from New York and Connecticut may spend more time on New York and Rhode Island coasts than previously thought (Spendelow 2018; Davis et al. 2019). These staging areas are critical for juvenile and adult roseate terns as they prepare for migration (USFWS 2020b). Roseate terns forage over open water and plunge dive to catch small fish such as sand lance and herring (Massachusetts Division of Fisheries and Wildlife 2015).

The threatened piping plover (*Charadrius melodus*) has been identified by IPaC as potentially present in Washington and Newport Counties, including Block Island (USFWS 2021). The Atlantic piping plover breeds on coastal beaches from Newfoundland to northern South Carolina. Breeding pair numbers in Rhode Island have increased from 10 to 80 pairs in 2019 since being listed in 1986 (USFWS 2020). Piping plovers typically return to breeding grounds on the coast of Rhode Island in March and April. Wintering grounds occur along the Atlantic and Gulf Coast from North Carolina to Mexico and into the Caribbean. Piping plovers' southward migration typically begins in late July and extends into September. Piping plovers forage invertebrates from substrate by gleaning or running and pecking in areas such as beaches, mudflats, lagoons, salt marshes, and other similar coastal habitats that are found on the Atlantic Coast (USFWS 1996).

The Federally threatened Rufa red knot (*Calidris canutus rufa*) has also been identified by IPaC as potentially present in all counties of Rhode Island within Narragansett Bay, and on Block Island. This species breeds in the central Canadian arctic tundra and winters primarily in Central and South America, as well as the southeastern United States and the Caribbean. Although Rufa red knots do not breed or winter in New England, the region serves as part of the reliable network of coastal and inland staging areas during migration. The area provides habitat and food that allow high rates of weight gain while the species migrates between breeding and wintering grounds (USFWS 2021a).

The Federally threatened American burying beetle (*Nicrophorus americanus*) is identified by the IPaC as being potentially present in Washington County, exclusively on Block Island. This is one of a few populations that are extant in the United States, the others being in the Great Plains. The population on Block Island is small but stable (ranging from 200 to 1,000 individuals) and occurs on glacial moraine deposits vegetated with a post-agricultural maritime scrub plant community. This community contains large stands of bayberry (*Myrica spp.*), shadbush (*Amelachier spp*.), and goldenrod (*Solidago spp.*). The American burying beetle is typically active during late April through September with most reproductive activity occurring in June and July. Reproduction depends on the availability of vertebrate carrion with attributes that are preferred by this species of burying beetle.

On Block Island there are only six species of animal that are of optimum size and are located in preferred habitats and occur consistently that can be utilized for burying beetles' reproduction (USFWS 2019).

2.3.1.4 State Listed Threatened and Endangered Species

Table 2-2 contains State listed species of plants that have been identified in the focused study areas (Paul Jordan, Rhode Island Department of Environmental Management, personal communication, March 8, 2021).

Table 2-2: Rhode Island's rare plants by study area

Study Area	Common Name	Scientific Name	Status
Barrington (Bristol County)	Colic-Root	*Aletris farinosa*	Species of Concern
	Slimspike Three-Awn	*Aristida longespica* var. *geniculata*	Species of Concern
	White-Fringed Bog Orchid	*Platanthera blephariglottis*	Threatened
	Gama-grass	*Tripsacum dactyloides*	Species of Concern
Bristol (Bristol County)	Bristly Umbrella Sedge	*Cyperus squarrosus*	Endangered
	Gama-grass	*Tripsacum dactyloides*	Species of Concern
Warwick	Butterfly Weed	*Asclepias tuberosa*	Species of Concern
	Tiny-Flowered Sedge	*Lipocarpha micrantha*	Threatened
	Sickle-Leaved Golden Aster	*Pityopsis falcata*	Species of Concern
	Gama-grass	*Tripsacum dactyloides*	Species of Concern
	Southern Wild Rice	*Zizania aquatica*	Species of Concern
North Kingstown	Sickle-Leaved Golden Aster	*Pityopsis falcata*	Species of Concern
	Post Oak	*Quercus stellata*	Species of Concern
Narragansett	Saltmarsh Spike Rush	*Eleocharis rostellata*	Species of Concern
	Seabeach-sandwort	*Honckenya peploides*	Species of Concern
	Featherfoil	*Hottonia inflata*	Species of Concern
	Northern Blazing Star	*Liatris novae-angliae*	Endangered
	Atlantic Mudwort	*Limosella australis*	Species of Concern

Colic-root is a native, perennial wildflower that grows in open woods, dry or wet meadows, sandy beaches, roadsides, and along peaty bog edges (NC State Extension n.d.(a)).

Slimspike three-awn is an annual, warm-season grass that grows on saturated sandy soils (Smith 2018). White-fringed bog orchids mainly grow in open peat bogs, but are also found in disturbed habitats, fens, wet meadows, and at the edges of wetlands (Native Plant Trust n.d.(a)).

Gama-grass blooms from May to September and is a warm season grass native to eastern and central U.S. It typically grows in pure stands on prairies, limestone slopes, fields, thickets, wood margins and roadsides by rhizomes and self-seeding (Missouri Botanical Garden n.d.). Bristly umbrella sedge or awned flatsedge is found throughout New England on river and lake shores usually in sandy soils (Native Plant Trust n.d.(b)). Butterfly weed is a tuberous rooted, native perennial that occurs in dry/rocky open woods, glades, prairies, fields, and roadsides. This plant is moderately salt tolerant (NC State Extension n.d.(b)).

In New England, the tiny-flowered sedge or small-flowered dwarf bulrush, inhabits the sandy shores of lakes, ponds, and infrequently the shores of tidal rivers. Given this plant's location and small size (only growing up to six (6) inches), it is subject to trampling and rare in all of New England (Native Plant Trust n.d.(c)). The sickle-leave golden aster is found in meadows and fields where sandy glacial deposits were left behind by the Wisconsin glaciation (Native Plant Trust n.d.(d)). Southern wild rice is found along fresh to brackish river shores and in shallow waters of lakes and rivers. It may form huge monocultures and is sometimes planted because it is a significant food source for waterfowl. It was an important element of the diets of many Native American tribes (Native Plant Trust n.d.(e)).

Post oak gets its common name from the use of its wood in making posts, railroad ties, and lumber. These trees are found in meadows, fields, along ridges or ledges and in sandplains, barrens, talus and rocky slopes and woodlands (Native Plant Trust n.d.(f)). Saltmarsh spike rush is a perennial sedge that inhabits salt marshes along the Atlantic coast (MNDNR n.d.). Seabeach-sandwort forms clumps on seaside sand dunes (Native Plant Trust n.d.(g)).

Featherfoil is native to the coastal plain of New England and occasionally inland. It inhabits ponds, pools in swamps, and wet ditches (Native Plant Trust n.d.(h)). Northern blazing star is rare and protected in most of New England where it is endemic. This plant occurs in anthropogenic habitats, along coastal beaches, in grasslands, and woodlands (Native Plant Trust n.d.(i)). Atlantic mudwort is found in tidal areas where it can tolerate inundation by salty or fresh water (Native Plant Trust n.d.(j)).

State listed insect species include the pine barrens tiger beetle (*Cicindela formosa generosa*), which is threatened and has been observed in Barrington and Warwick. The state threatened beach dune tiger beetle (*Cicindela hirticollis*) has been found in Warwick, North Kingstown, and Narragansett. Lastly, salt marsh tiger beetles (*Ellipsoptera marginate*) have been observed in North Kingstown (P. Jordan, personal communication, March 8, 2021).

Pine barrens tiger beetles are found in dry sandy areas such as on dunes and roadsides in the spring and fall (Gaumer 1977). Beach dune tiger beetles, commonly called hairy-necked tiger beetles, are widely distributed in North America. These tiger beetles are typically found in littoral-riparian areas near aquatic environments. Their burrows are located in moist soils that are far enough away from water bodies to avoid being inundated with water. Mating takes place in the spring (Denelsbeck 2014). Salt marsh tiger beetles' range is along the eastern Atlantic coast from Maine to Florida. They live in mud flat areas and are active in the summer months (Roth 2005).

State listed species of birds are also found in two of the focused study areas. In Barrington, seaside sparrows (*Ammodramus maritimus*) and marsh wrens (*Cistothorus palustris*), both species of concern, have been observed. The American oystercatcher (*Haematopus palliatus*), a species of concern in Rhode Island, has been documented in Bristol (P. Jordan, personal communication, March 8, 2021). Seaside sparrows are rarely seen outside of saltmarshes where they forage in the mud for invertebrates and seeds from marsh vegetation (Cornell Lab of Ornithology n.d.). Marsh wrens also occupy wetlands but have a wider range as they are found in salt, brackish, or freshwater sites. They eat invertebrates on or near the marsh ground (Lesperance 2001). American oystercatchers have a breeding range that extends from Massachusetts to Florida; they usually breed between February and July depending on location. They nest in shallow scrapes on the ground in salt marshes or along rocky and sandy shores. During the winter months, American oystercatchers tend to be concentrated in areas with abundant food sources such as reefs, oyster beds, or clam flats. During spring and fall migration, these birds can be found in shellfish beds, sand flats, or intertidal mudflats (Hardin 2014).

Finally, one state listed turtle has been observed in Barrington within the study area. The state endangered northern diamond backed terrapin (*Malaclemys terrapin*) makes its home in salt marshes and shallow bays along the eastern coast of the U.S. from Cape Cod to Texas. They are usually found in brackish water and occasionally travel out into the open ocean; however, they cannot tolerate full-strength saline water for long periods of time. Mating occurs in early spring and females lay their eggs from June to July on sandy beaches and other upland areas above the high tide line (Conserve Wildlife Foundation of New Jersey n.d.).

2.3.1.5 Wildlife Resources

Due to the urban nature of much of the study area, terrestrial wildlife tends to be generalist species adapted to the human environment. These include racoons, eastern grey squirrels, and a variety of other small mammals. White tailed deer (*Odocoileus virginianus*), coyotes (*Canis latrans*), and red fox (*Vulpes vulpes*) are other common mammals of Rhode Island (Rhode Island Woods 2021).

According to the Audubon Society (2020a), the Narrow River area supports a large diversity of bird species, including the largest American black duck (*Anas rubripes*) population in Rhode Island. Other waterfowl species found in this area include mallard duck (*Anas platyrhynchos*), gadwall (*Anas strepera*), American wigeon (*Anas americana*), Canada goose (*Branta canadensis*), and buffleheads (*Bucephala albeola*). Other common waterbirds include herring, black-backed, and ringbilled gulls (*Larus argentatus, L. marinus, and L. delawarensis*) and double-crested cormorant (*Phalacocorax auritus*) (Audubon Society 2020a).

Common mammals that are likely to occur in the Narrow River watershed include species such as mice, masked shrew (*Sorex cinereus*), short-tailed shrew (*Blarina brevicauda*), star nosed mole (*Condylura cristata*), rabbits, chipmunk (*Tamias striatus*), red squirrel (*Sciurus vulgaris*), grey squirrel (*Sciurus carolinensis*), opossum (*Didelphis virginiana*), and skunk (*Mephitis mephitis*) (Audubon Society 2020a).

In the Bristol County study area, the northern diamondback terrapin (*Malaclemys terrapin terrapin*) inhabits the Palmer River, and also nests in Hundred Acre Cove to the north of the project area in the Barrington River. Many species of waterbirds, including black crowned night heron (*Nycticorax nycticorax*) and glossy ibis (*Plegadis falcinellus*) are known to inhabit the area (Warren Land Conservation Trust, Inc. n.d.). Surveys of the Warren area indicate high usage of salt marshes and tidal flats as nesting and breeding grounds by black ducks, mallards, scaup (*Aythya affinis*), and Canada geese (ibid).

Newport is near important wildlife sanctuaries, such as Sachuest Point National Wildlife Refuge, which is an important area of bird habitat roughly 3.7 miles east of the downtown Newport. The sanctuary serves as wintering habitat for marine waterbirds such as grebes (order Podicipediformes), loons (*Gavia immer*), cormorants (*Phalacocorax auratus*), alcids (family Alcidae), and gulls (Larus spp.) (Audubon Society 2020b). It is also a migratory stopover location for snow buntings (*Plectrophenax nivalis*), horned larks (*Eremophila alpestris*), warblers (family Parulidae), thrushes (family Turdidae), and vireos (family Vireonidae) (ibid). While Newport is an urban area, its location along the lower east passage of the bay provides habitat for many of the water bird species found throughout the study area.

Block Island has a variety of wildlife species, few of which are mammals. White-tailed deer (*Odocoileus virginianus*), Muskrat (*Ondatra zibethicus*), white-footed mouse (*Peromyscus leucopus*), and the endemic Block Island meadow vole subspecies (*Microtus pennsylvanicus provectus*) are the predominant mammal species that reside on Block Island (iNaturalist 2022). Block Island meadow voles have been identified as a Species of Greatest Conservation Need (SGCN) in Rhode Island. Harbor seals (*Phoca vitulina*), and gray seals (*Halichoerus grypus*) are known to winter on Block Island. The harbor seal is also considered a SPCN, according to the 2015 Rhode Island Wildlife Action Plan (RIDEM 2015). Block Island National Wildlife Refuge is 134 acres located on the northwestern coast of the Island and provides habitat to the federally listed piping plover (*Charadrius melodus*), federally listed American burying beetle (*Nicrophorus americanus*), and fiddler crabs (*Uca spp.*) (USFWS 2014).

Migratory birds in the study areas identified by the USFWS's IPaC are listed in **Table 2-3** below. Birds that are of Conservation Concern (BCC) by the USFWS are denoted with an *. Bird species considered for the BCC include nongame birds, game birds without hunting season, subsistence-hunted nongame birds in Alaska, and Endangered Species

Act (ESA) candidate, proposed, and recently de-listed species. The overall goal of the BCC designation is to accurately identify the migratory and non-migratory bird species (beyond those already designated as Federally threatened or endangered) that represent the USFWS's highest conservation priorities (USFWS, 2021).

Table 2-3: Migratory Birds that may utilize the study area (USFWS 2021)

Common Name	Scientific Name	Study Area Present
American oystercatcher*	*Haematopus palliatus*	All
bald eagle	*Haliaeetus leucocephalus*	All
black guillemot	*Cepphus grylle*	Newport, Narragansett
black scooter	*Melanitta nigra*	Providence, Bristol, Portsmouth, Newport, Warwick, Narragansett
black skimmer*	*Rynchops niger*	Barrington, Warren, Bristol, Newport, Warwick, Narragansett
black-billed cuckoo*	*Coccyzus erythropthalmus*	All
black-legged kittiwake	*Rissa tridactyla*	Newport, Narragansett
blue-winged warbler*	*Vermivora pinus*	Block Island
bobolink*	*Dolichonyx oryzivorus*	All except North Kingstown
Bonaparte's gull	*Chroicocephalus philadelphia*	All except North Kingstown
Brown pelican	*Pelecanus occidentalis*	Block Island
buff-breated sandpiper*	*Calidris subruficollis*	Bristol, Warwick, North Kingstown, Narragansett
Canada wabler*	*Wilsonia Canadensis*	Bristol, Newport, Warwick, North Kinstown, Narragansett, Block Island
cerulean warbler*	*Dendroica cerulea*	Newport
clapper rail*	*Rallus crepitans*	Bristol, Warwick, North Kingstown, Narragansett
common eider	*Somateria mollissima*	Bristol, Portsmouth, Newport, Warwick, North Kingstown, Narragansett
common loon	*Gavia immer*	All
common murre	*Uria aalge*	Narragansett
common tern	*Sterna hirundo*	All
Cory's shearwater*	*Calonectris diomeded*	Providence, Barrington, Warren, Newport, Warwick, Narragansett, Block Island
double-crested cormorant	*Phalacrocorax auritus*	All
dovekie	*alle alle*	Newport, Narragansett, Block Island
dunlin*	*Calideris alpine arcticola*	All except North Kingstown
Eastern whip-poor-will*	*antrostomus vociferus*	Providence, Barrington, Warren, Warwick
evening grosbeak*	*coccothraustes verpertinus*	Barrington, Warren
golden eagle	*Aquila chrysaetos*	Narragansett
great black-back gull	*Larus marinus*	All
great shearwater	*Puffinus gravis*	Block Island
herring gull	*Larus argentatus*	All
Hudsonian godwit*	*Limosa haemastica*	Block Island
Kentucky warbler*	*Oporornis formosus*	Newport

Common Name	Scientific Name	Study Area Present
Least tern*	*Sterna antillarum*	All
lesser yellowlegs*	*Tringa flavipes*	All except North Kingstown
long-tailed duck	*Clangula hyemalis*	Providence, Barrington, Warren, Portsmouth, Newport, Warwick, Narragansett, Block Island
Manx shearwater*	*Puffinus puffinus*	Narragansett and Block Island
Nelson's sparrow	*Ammodramus nelson*	Providence, Barrington, Warren, Newport, Warwick
North gannet	*Morus bassanus*	Bristol, Portsmouth, Newport, Warwick, North Kingstown, Narragansett
prairie warbler*	*Dendroica discolor*	All
prothonotary warbler*	*Protonotaria citrea*	Newport and Block Island
purple sandpiper*	*Calidris maritime*	Bristol, Portsmouth, Newport, Warwick, Narragansett, Block Island
razorbill	*Alca torda*	Newport, Narragansett, Block Island
red-brested merganser	*Mergus serrator*	All
red-headed woodpecker*	*Melanerpes erythrocephalus*	Newport and Block Island
red-necked phalarope	*Phalaropus lobatus*	Block Island
red-throated loon*	*Gavia stellata*	All
ring-billed gull	*Larus delawarensis*	All
roseate tern	*Sterna dougallii*	Providence, Barrington, Warren, Newport, Warwick, Narragansett, Block Island
royal tern	*Thalasseus maximus*	Block Island
ruddy turnstone*	*Arenaria interpres morinella*	All except North Kingstown
rusty blackbird*	*Euphagus carolinus*	All except Bristol
seaside sparrow*	*Ammodramus maritimus*	All except North Kingstown
semipalmated sandpiper*	*Calidris pusilla*	All
short-billed dowitcher*	*Limnodromu griseus*	All
snowy owl*	*Bubo scandiacus*	All except North Kingstown
surf scoter	*Melanitta perspicillata*	All except Providence
thick-billed murre	*Uria lomvia*	Newport
whimbrel*	*Numenius phaeopus*	Bristol, Newport, Warwick, Narragansett
white-winged scoter	*Melanitta fusca*	All
willet*	*Tringa semipalmata*	All except North Kingstown
Wilson's storm petrel	*Oceanites oceanicus*	Newport and Block Island
wood thrush*	*Hylocichla mustelina*	All

* Denotes BCC Designation

2.3.1.6 Terrestrial Habitats

The Narragansett Bay watershed is one of the most densely populated areas in the country, with an average of 1,100 people per square mile living in the watershed (RIDEM 2000) and much of the study area is covered by urban and suburban development, with limited natural terrestrial habitats. Shorelines in Providence, Bristol County, and Newport are characterized by the presence of hard structures such as bulkheads, revetments, and stone reinforcements. Commercial buildings, residential homes, and other urban infrastructure occupy a majority of the focused study areas.

In the Narrow River focused study area, there are commercial buildings and parking lots with rip rapped shorelines on the eastern side of Middle Bridge. There is residential development with hardened shorelines and forested habitat with fringing salt marsh shorelines on the western side. There are large areas of intertidal salt marsh both up and downstream from the Middle Bridge project area. Upland habitats around the Narrow River are dominated by deciduous forested habitat, with an ecotone of shrubland between the salt marshes and forested areas (Audubon Society 2020a). Upstream along the Narrow River there is a combination of residential development and forested habitat.

The Block Island focused study area has a balance of natural and developed land use across its 6,076 land acres. The developed areas consist of compact mixed-use areas that have commercial buildings, and residencies. Almost half of the area is dominated by openness, interspersed with low-density residential uses with extensive preserved open space which includes a small number of farms. The rest of the island is within a buffer zone between the developed areas and preserved open space. The preserved areas consist of an abundance of freshwater and wetland habitats, coastal shrublands, deciduous forests, coastal ponds, salt marshes, beaches, and dunes (New Shoreham Planning Board 2016).

2.3.2 Future Without Project Conditions

The FWOP conditions are the same as the existing conditions except that climate change is expected to increase flooding and contribute to changes in the natural environment. Over the 50-year project evaluation period, increased average temperatures, great amount of precipitation, and more extreme weather events may occur. Warming temperatures may cause the range of native plants to change or change their ability to compete with invasive species. A shorter winter season could negatively impact flora and fauna communities by causing earlier-season leaf-out, exposure to more extreme freeze-thaw cycles, and changing the availability of forage. The study area would continue to be subject to periodic flooding, and in the event of large coastal storms could experience increased sedimentation in river channels, bank scouring, and erosion.

Development pressure on floodplains and river corridors may increase over the period of analysis leading to lower water quality from increased impervious surfaces and runoff. SLC could drown existing marshes and force marsh migration in areas where there is appropriate elevation and land area. Additionally, SLC and coastal storms could cause erosion of shoreland and beach areas that host threatened and endangered species, causing them to relocate to more suitable habitat.

2.4 PHYSICAL ENVIRONMENT

2.4.1 Existing Conditions

2.4.1.1 Topography, Geology and Soils

The Rhode Island coastline is situated on a narrow, low-lying coastal plain surrounded by rolling hills. U.S. Geological Survey (USGS) 7.5-minute quadrangle topographic maps were used to determine study area topography. The focused study areas in this study area generally have rolling hills rising from the shoreline. The City of Providence has topography shaped by drumlin shaped landforms underlain by compact subsoils (FEMA 2015). Bristol County is located on a peninsula with relatively flat topography in the towns of Barrington, Warren, and Bristol (FEMA 2014). The City of Newport has densely developed shorelines backed by the rolling hills of Aquidneck Island. The urban downtown area of Newport ranges from the shoreline to hilltops in the northern portion of the city. The Narrow River study area has low lying residential development along the river, with hills rising on either side.

The geology of the Rhode Island coastline is dominated by deposits from the Late Wisconsin deglaciation, with surficial material ranging from till to stratified deposits (gravel, sand, and mud). Bedrock in the Narragansett Basin is dominated by Pennsylvanian rock, which is composed of several thousand feet of sedimentary rock with Pennsylvanian Age fossils (Quinn 1971). The Narragansett Basin underlies all study area towns.

Soils in the project area are dominated by urban soils and fill. Providence and Newport are heavily urbanized. In Providence, the soils are mainly urban land, urban land with 0 to 3% slopes and sandy substratum, and Merrimac-Urban land complex with 0 to 8% slopes. The majority of the Warren River study area is Merrimac-Urban land complex with 0 to 8% slopes. There are also a variety of sandy loams present across this study area. Newport-area soils are mostly Newport-Urban Land Complex and other urban soils. The greatest soil component in the Narrow River project area is Merrimac-Urban land complex with 0 to 3% slopes, but a variety of silt and sandy loams are also present across the project area. This zone is less developed than the other study area towns with more naturally occurring upland soils, as well as hydric soils in the fringe wetlands along the Narrow River. The study area for this project covers four (4) towns across Narragansett Bay, so it is impractical to map all of the soil types across this large area.

It is highly unlikely that any prime farmland soils would be located directly in the Providence, Warren-Barrington-Bristol, or Newport study areas because they are heavily developed with little to no farmland in the focused study areas. In order for an area to qualify as important farmland, the land must be available for agricultural use. The term “available” means the land must not have been physically converted to land use that makes it impossible to farm in the future, such as a residential development or urban space. According to the Natural Resource Conservation Service, there are no prime farmland soils in the Providence or downtown Newport focused study areas. There are potential prime farmland soils between the Narrow River and Route 1 to the west, however, the current land cover is primarily forest interspersed with few existing farms. There are also a small number of prime farmland soils areas between the Narrow River and the bay to the east. There are prime farmland soils in Bristol County, however the majority of the focused study in this region is heavily developed.

Block Island’s overall topography consists of two highlands joined by a sandy lowland. The geology of Block Island is heavily influenced by its glacial origins, preserving a

Pleistocene interlobate moraine deposit that contains gravel, sand, and interbedded fine-grained rock. The Island also has glacially transported block of Cretaceous strata and pre-Late Wisconsinan glacial deposits (Veeger et al. 1996). The greatest soil component in the Block Island project area is Gloucester-Bridgehampton complex with rolling slopes, but a variety of sandy loams and loamy sands are also present across the project area (U.S. Department of Agriculture A n.d.).

2.4.1.2 Coastal Hydrodynamics

Daily tidal fluctuations within the study area are semi-diurnal, with a full tidal period that averages 12 hours and 25 minutes; hence there are nearly two (2) full tidal cycles per day. Tidal range generally increases from south to north within the study area and within Narragansett Bay. For instance, the mean tide range at Block Island and Newport is 2.85 feet and 3.46 feet, respectively. In Providence, at the head of Narragansett Bay, the mean tide range is 4.42 feet.

There are several active NOAA tide gages within and adjacent to the study area and shown in **Figure 2-4**. Tidal conversions to North American Vertical Datum 1988 (NAVD88) at these tidal stations are presented

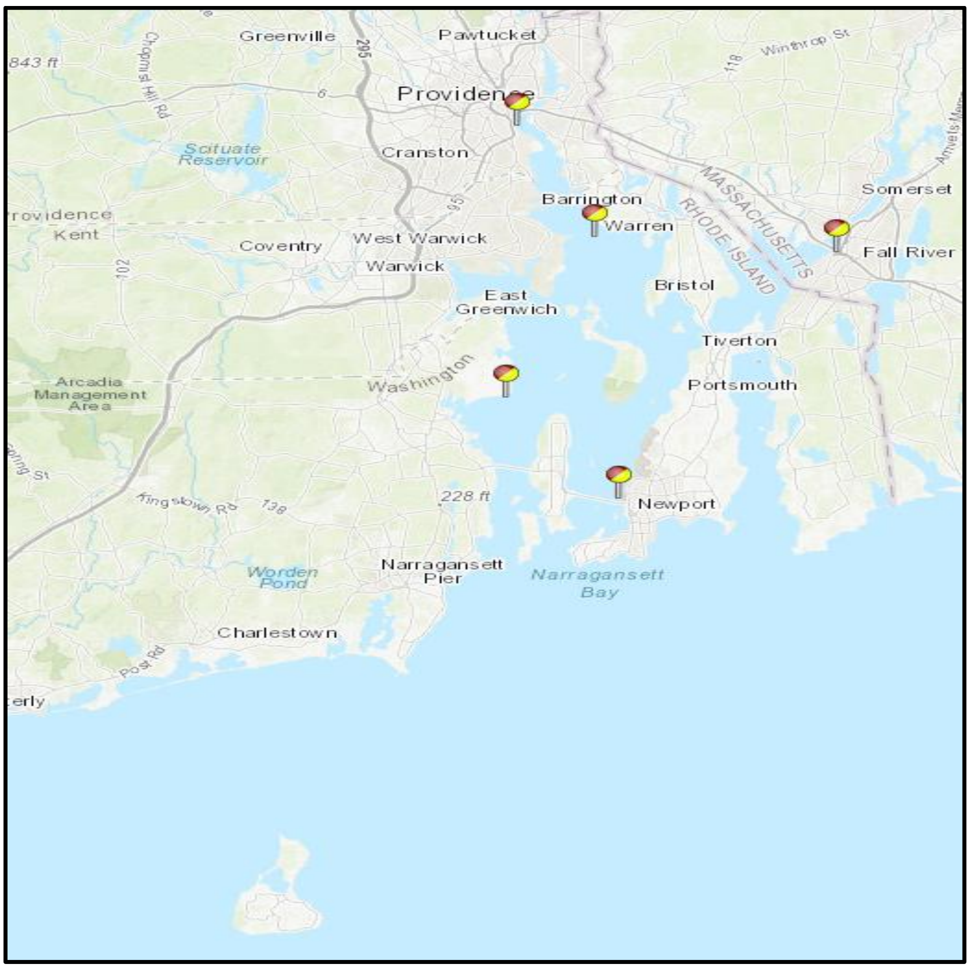

Figure 2-4: Active NOAA tide gages within the study area

in **Table 2-4**. The current National Water Level Observation Network National Tidal Datum Epoch (NTDE) is 1983-2001. Therefore, it is assumed that these tidal datums are representative of the midpoint of the NTDE, 1992.

Table 2-4: Tidal datums for the study area

Datum	Providence	Connecticut Light	Fall River, MA	Quonset Point	Newport
	(feet)	(feet)	(feet)	(feet)	(feet)
Mean Higher High Water	2.37	2.20	2.34	1.87	1.81
Mean High Water	2.12	1.95	2.10	1.62	1.57
NAVD88	0.00	0.00	0.00	0.00	0.00
Mean Sea Level	-0.22	-0.28	-0.23	-0.37	-0.30
Mean Low Water	-2.29	-2.23	-2.26	-2.08	-1.90
Mean Lower Low Water	-2.47	-2.39	-2.43	-2.24	-2.04
Great Diurnal Range	4.84	4.58	4.78	4.10	3.85
Mean Range of Tide	4.42	4.17	4.37	3.70	3.46

2.4.1.3 Water Level

Storm surge is the increased water level above the predicted astronomical tide due to storm winds over the ocean and the resultant wind stress on the ocean surface. The principal factor that creates flood risk for the study area is storm surge generated by tropical and extratropical storms, the two types of storms of primary significance along the Rhode Island coastline. Tropical storms (hurricanes) typically impact the area in summer and fall, whereas extratropical storms (nor'easters) occur predominantly between November and March but can also occur during other times of the year. Nor'easters are usually less intense than hurricanes but tend to have much longer durations. These storms often cause high water levels and intense wave conditions and are responsible for erosion and flooding throughout the coastal region.

Existing coastal processes are driven by high wave energy and water levels generated by both tropical and extratropical storms. Based on data developed by the NACCS (USACE, 2015), significant tropical storm events impacted the Rhode Island coastline area at a frequency of approximately once every 5.75 years. These tropical storms occur between June and November with 74 percent of the storms occurring in the months of August and September.

Extratropical storms, on the other hand, are a more frequently occurring storm type that impacts the study area annually with significant events occurring at a rate of approximately one (1) storm per year. Extratropical storms typically occur at the project area between early fall through the spring (October through May) with most occurring in the months of November through February.

Tropical storm events are typically fast-moving storms associated with elevated water levels and large waves, whereas extratropical storms are slower moving with comparatively lower water level elevations and large wave conditions. Both storm types can produce erosion and morphology change, as well as coastal inundation, leading to economic losses to property within the study area.

Analysis of storm surge levels within Rhode Island waters by Spaulding et al. (2015) showed that surge levels are approximately constant along the southern RI coastline and increase linearly with distance from the mouth to the head of the bay.

As part of the NACCS, the U.S. Army Engineer Research and Development Center completed a coastal storm wave and water level modeling effort for the U.S. North Atlantic coast from Virginia to Maine. This modeling study provided nearshore wind, wave, and water level estimates and the associated marginal and joint probabilities critical for effective coastal storm risk management. This modeling effort involved the application of a suite of high-fidelity numerical models within the Coastal Storm Modeling System to 1050 synthetic tropical storms and 100 historical extratropical storms. Documentation of the numerical modeling effort is provided in Cialone et al. (2015) and documentation of the statistical evaluation is provided in Nadal-Caraballo et al. (2015). Products of the study, which were used as coastal forcing inputs to RIC study, are available for viewing and download on the Coastal Hazards System website: https://chs.erdc.dren.mil/. NACCS water level and wave outputs are provided at save points throughout the study area. **Figure 2-5** depicts the 1 percent annual exceedance probability (AEP) water levels at the mean confidence level at the save points within the study area. The amplification in storm surge from south to north within Narragansett Bay is evident.

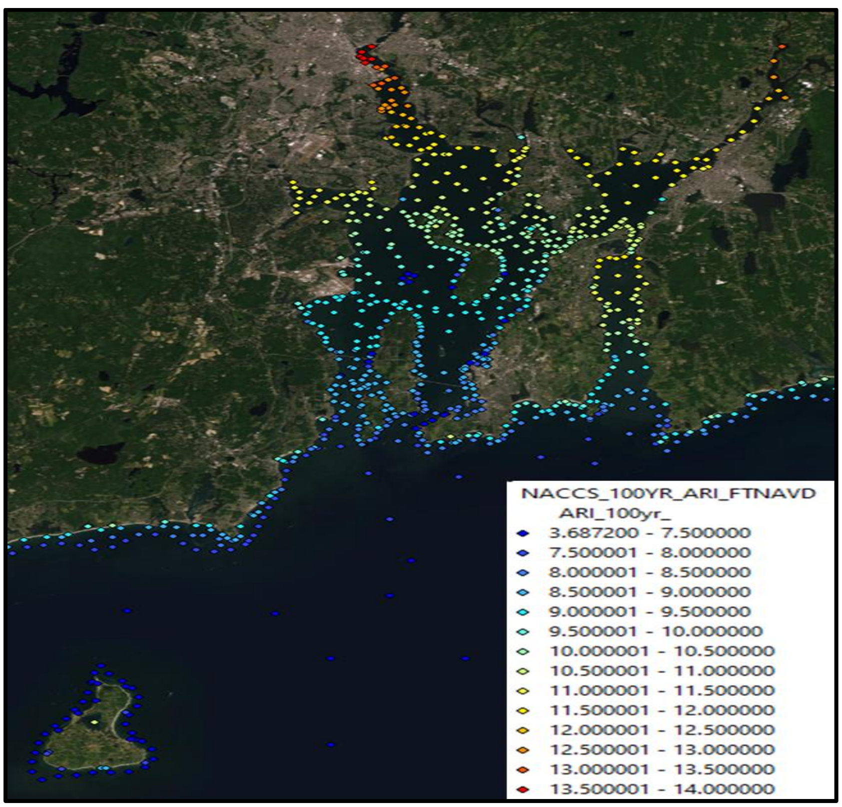

Figure 1-5: NACCS 1-percent AEP water levels within the study area

2.4.1.4 Groundwater Resources

The USGS estimates that 27 million gallons of groundwater per day are used in the state with public and private wells supplying approximately 26 percent of the state's population with drinking water. RIDEM administers a number of programs that address groundwater protection in the state including designated wellhead protection areas for all public wells in Rhode Island identified as of June 2017 (RIDEM N.D.(a)).

In the Block Island project area, water is supplied by both public and private wells and reverse osmosis units. The commercial areas are heavily reliant on the publicly supplied water by the town of New Shoreham while 80% of residential properties are served by private wells. Public groundwater supply has a capacity of 0.225 million gallons per day, which varies between seasons based high demand summer season (New Shoreham Planning Board 2016).

2.4.1.5 Wave Attack

The wave pattern in Rhode Island coastal waters is quite complicated due to the complex bathymetry and associated refraction and diffraction in the vicinity of Block Island Sound. Historically, there have been no specific studies of waves in Rhode Island Sound and Narragansett Bay. The bay has a relatively low wave energy environment given the shallow water. Wave modeling predicts large waves at the mouth of the bay decrease dramatically upon entering the bay as the shallow water in the bay induces energy dissipation by friction for the longer waves as well as wave breaking limiting the wave energy propagating in the bay. However, southerly winds can provide enough fetch to create local short waves, which can grow significantly in the upper part of the bay, although they too are limited by whitecapping. South facing coastlines are typically exposed to the largest wave heights.

Offshore, USACE maintains a wave buoy 25 miles southeast of Block Island (NDBC 44097) that has collected data since 2009. USACE has also performed wind and wave hindcast in the Wave Information Study (WIS) for selected locations off the coast from 1980 to 2014. The nearest WIS site to the coast and directly east of Block Island is #63079 in 108.3 feet (33 meters) of water. The annual mean significant wave height at this point averages 3.3 feet (1.0 meters), varying from 1.6 to 5.2 feet (0.5 to 1.6 meters). The annual mean peak period is recorded to be an average of 8 seconds, varying between 5 and 11 seconds. Waves predominantly approach from the south and south-southeast. The 100-year significant wave height at this station is estimated to be 30.8 feet (9.7 meters) with a peak period of 17 seconds. During Superstorm Sandy, the significant wave height at this location was hindcast to be 28.3 feet (8.6 meters), with a peak period of 15 seconds from the southeast.

The NACCS modeling effort also provided time series and extreme value statistical wave output at the same save points as the storm surge data described above. Compared to the WIS hindcast, the NACCS data generally show slightly higher wave heights and longer periods at the 100-year return period.

2.4.1.6 Surface Water and Water Quality

The state has approximately 1,400 miles of rivers, 20,750 acres of lakes and ponds, and 15,500 acres of freshwater swamps, marshes, bogs and fens, as well as close to 72,000 acres of forested wetlands. Estuaries, including Narragansett Bay and the coastal ponds, cover approximately 160 square miles (RIDEM N.D.(c)). **Table 2-5** provides a list of designated uses for surface waters located in Rhode Island.

Table 2-5: Designated uses for surface waters as described in Rhode Island water quality regulations and 305(b)/303(d) assessments (RIDEM 2014)

305(b) Designated Use	RI WQ Regulations Designated Use	Applicable Classification of Water	Designated Use Definition
Drinking Water Supply	Public Drinking Water Supply	AA	The waterbody can supply safe drinking water with conventional treatment.
Swimming/ Recreation	Primary Contact Recreation	AA*, A, B, B1, B{a}, B1{a}, SA, SA{b}, SB, SB{a}, SB1, SB1{a} (all surface waters)	Swimming, water skiing, surfing and similar water contact activities where a high degree of bodily contact with the water, immersion and ingestion are likely.
Swimming/ Recreation	Secondary Contact Recreation	AA*, A, B, B1, B{a}, B1{a}, SA, SA{b}, SB, SB{a}, SB1, SB1{a}, SC (all surface waters)	Boating, canoeing, fishing, kayaking or other recreational activities in which there is minimal contact by the human body with the water and the probability of immersion and/or ingestion of the water is minimal.
Aquatic Life Support/ Fish, other Aquatic Life, and Wildlife	Fish and Wildlife Habitat	AA, A, B, B1, B{a}, B1{a}, SA, SA{b}, SB, SB{a}, SB1, SB1{a}, SC (all surface waters)	Waters suitable for the protection, maintenance, and propagation of a viable community of aquatic life and wildlife.
Shellfishing/ Shellfish Consumption	Shellfish harvesting for direct human consumption	SA, SA{b}	The waterbody supports a population of shellfish and is free from pathogens that could pose a human health risk to consumers
Shellfish Controlled Relay and Depuration	Shellfish harvesting for controlled relay and depuration	SB, SB{a}	Waters are suitable for the transplant of shellfish to Class SA waters for ambient depuration and controlled harvest.
Fish Consumption	No specific analogous use, but implicit in "Fish and Wildlife Habitat"	AA, A, B, B1, B{a}, B1{a}, SA, SA{b}, SB, SB{a}, SB1, SB1{a}, SC (all surface waters)	The waterbody supports fish free from contamination that could pose a human health risk to consumers.
* - Class AA waters may be subject to restricted recreational use by State and local authorities.			

The Providence River has a water quality classification of SB{a} - suitable for shellfish harvesting for controlled relay and depuration, which means shellfish must be processed to remove potential contaminants prior to consumption. Listed impairments of the Providence River include nitrogen, dissolved oxygen, and fecal coliform. Fish and wildlife habitat, and both primary and secondary contact recreation are listed as impaired due to pollution issues in the Providence River. Significant pollution sources exist around the Providence, including sources from shoreline industrial facilities, wastewater treatment facilities, and urban development in the surrounding land area. The 2001 USACE Providence River and Harbor Maintenance Dredging Environmental Impact Statement

(Providence EIS; USACE 2001) noted that wastewater treatment facilities were suspected to be the dominant pollutant source for the river at the time of that analysis.

In Bristol County, the portion of the Barrington River extending from the Mobil Dam in East Providence to the Route 114 bridge in Barrington and Warren is classified as Class SA, with designated uses including shellfish consumption, recreation, fish consumption, and fish and wildlife habitat. From the Route 114 bridge to the Palmer River confluence, the river is Class SB1, with designated uses including recreation, fish consumption, shellfish harvesting for controlled relay and depuration, and fish and wildlife habitat. Shellfish consumption is currently an impaired use due to fecal coliform in the Barrington River. Shellfishing is currently prohibited in the upper and lower reaches of the Warren River according to RIDEM (2020).

In Newport, the waters of the Narragansett Bay East Passage are designated as Class SA, with the exception of the waters of Newport Harbor, which are designated as Class SB.

The Narrow River has a designated saltwater use classification of SA, which means that the ‘waters are designated for shellfish harvesting for direct human consumption, primary and secondary contact recreational activities, and fish and wildlife habitat, among other uses, and that the river shall have good aesthetic value (RIDEM 2019b). The Narrow River is impacted by fecal coliform and nitrogen pollution (RIDEM 2000).

The Great Salt Pond located in the Block Island project area is designated as Class SA{b} for shellfish consumption and is safe for recreation and as fish and wildlife habitat. The coastal shorelines of Block Island are classified as SA. The remainder of the surface water resources on Block Island in various locations are classified as SB1, SB, and SA, fully supporting fish consumption, primary and secondary contact recreation, with varying levels shellfish consumption (RIDEM 2012).

2.4.1.7 Floodplains

All project areas are located within floodplains. The maps in **Appendix F,** *Plan Formulation* show the location of floodplains in relation to the surrounding land cover for each study area. There are 100-year floodplains (Special Flood Hazard Areas, Zone A) located in all of the study areas, as shown on the maps. Providence, Bristol County, and Newport all have dense urban and residential development located in these floodplains. The Narrow River project 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.

2.4.1.8 Cultural Resources

As a federal agency, USACE has certain responsibilities concerning the protection and preservation of historic properties. Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended (54 U.S.C. 300101), and its implementing regulations, the *Advisory Council on Historic Preservation’s Procedures for the Protection of Historic and Cultural Properties* (36 CFR Part 800), and EO 11593, Protection and Enhancement of the Cultural Environment, May 13, 1971, direct federal agencies to take into account the effect of any undertaking on historic properties included on, or eligible for, the National Register of Historic Places (NRHP). NEPA requires that federal agencies consider whether an action will have significant environmental effects, including effects to historic and cultural resources. Under NEPA, environmental review includes a description of the human environment and the environmental consequences of the proposed action on that environment, which includes aesthetic, historic, and cultural resources. The American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996), the Executive Memorandum Government to Government Relations with Native American Tribal Government, April 29, 1994, the Native American Graves Protection and Repatriation Act (NAGPRA), 25 U.S.C. 3001-3013, 18 U.S.C. 1170, and EO 13175, *Consultation and Coordination with Indian Tribal Governments, November 6, 2000*, direct federal agencies to consult and to consider the effects of any proposed undertaking on the tribes.

The work undertaken for this phase of the project represents only partial identification of significant resources and determination of adverse effects under the NEPA and the NHPA. The current investigation included a review of previously completed survey reports and identified historic properties on file at the Rhode Island Historic Preservation and Heritage Commission (RI HPHC), historic maps, local histories and town reconnaissance reports (found on the RI HPHC website). Cultural resources investigation reports were reviewed to collect background information for the study area and were referenced when identifying historic properties, determining archaeological sensitivity for the study area and identifying areas that have not been surveyed in the past. The municipalities' histories were reviewed as well to provide historical context during the alternative development and impacts assessment phases of the study. Field reconnaissance consisting of a series of site visits through the study area to become familiar with the project area, to determine the current status of certain historic properties, and to determine the need for architectural and archaeological sensitivity assessments in the next phase of the project will be conducted as the study progresses and prior to completion of the Feasibility study.

Prior Surveys

<u>Long Island Sound Dredged Material Management Plan (LIS DMMP) Cultural Resources Inventory</u> - In 2010, Public Archaeology Laboratory (PAL) completed a cultural resources inventory of the entire area bordering Long Island Sound as part of an overall Plan for the management of dredged material and placement in the surrounding area (Cherau et al. 2010). This inventory included terrestrial and underwater archaeological sites within Washington County, Rhode Island and includes the coastal communities of Charlestown, Narragansett, New Shoreham (Block Island), South Kingstown, and Westerly. A total of 118 historic properties were identified in Rhode Island as part of the LIS DMMP. These include buildings, sites, structures, objects, and districts that are listed, determined eligible or potentially eligible for listing on the NRHP.

In Narragansett, four (4) sites have been determined to be eligible for listing in the NRHP and approximately 83 percent of the town was assessed as having sensitivity for Native American and Euro-American archaeological sites at the time of this survey in 2010 (Cherau et al. 2010:59).

In New Shoreham (Block Island), all the NRHP-eligible archaeological sites are located within the Great Salt Pond Archaeological District. The Native American sites are located around the margins of Great Salt Pond and estuary ponds such as Harbor Pond. Approximately 95 percent of Block Island was deemed archaeologically sensitive as part of the LIS DMMP study (Cherau et al. 2010:65).

Hurricane Sandy Archaeological Surveys - Funding for archaeological survey and testing to identify and evaluate archaeological properties affected by Hurricane Sandy was made available in the form of disaster relief grants. One (1) study focused on the south coast of Rhode Island and was entitled *Hurricane Sandy Disaster Relief Grant Phase I and Phase II Archaeological Survey, Rhode Island South Coast – Narragansett, South Kingstown, Charlestown, and Westerly, Rhode Island, 2 volumes, May 2016* prepared by the PAL, and the other was the *Hurricane Sandy Disaster Relief Grant, Phase I and Phase II Archaeological Survey, Block Island, New Shoreham, Rhode Island, June 2016* and prepared by the Mashantucket Pequot Museum and Research Center. Data for the communities within the current study area from these reports will be summarized and incorporated into recommendations for additional investigations during a later planning phase of the study.

Historic Districts within the Area of Potential Effect

Barrington Civic Center Historic District, Barrington - The historic district is located within the Prince's Hill neighborhood and includes an 18th Century cemetery, a late 19th Century town hall and library, an early 20th Century school (Peck School), and a small pond and park all along the crest of Prince's Hill. Overall, this district represents a concentration of historic public and governmental buildings representing a late-19th Century planned community (Morgan 1976).

Bristol Waterfront Historic District, Bristol - Composed of over 400 buildings that encompass the architectural, economic and social development of the original town plan of Bristol from its founding in 1680, the Bristol Waterfront Historic District spans the rise from a colonial seaport into a leading maritime center. Bristol's Town Plan is unique in Rhode Island as it originated purely as a commercial venture with planned community, residential, and commercial spaces (Warren 1974).

Great Salt Pond Archaeological District, New Shoreham, Block Island - This district is located in the northern half of Block Island and includes and "represents a core area of Native American settlement, land use, and resource acquisition that dates to the Middle Woodland through contact periods". Site types range from the Fort Island (fortified village) Site (RI 118) with occupations dating from the Late Woodland through contact periods and into the late 1600s to numerous camp and midden sites that date from the Archaic and Woodland periods. Several of the sites contain evidence of later contact period/seventeenth century and eighteenth- and nineteenth-century occupations. The recorded Native American archaeological sites are found around the margins of the Great Salt Pond and associated estuary ponds such as Harbor Pond. All of the NRHP listed and eligible archaeological sites are located within the Great Salt Pond Archaeological

District (PAL 2010:65). Most of Block Island is archaeologically sensitive according to the PAL report.

Old Harbor Historic District, New Shoreham, Block Island - The historic district is situated at the original landing spot of this fishing and farming community and encompasses its evolution into a popular tourist resort. All of the major commercial and municipal properties on the Island are located along this stretch of the Old Harbor on Water, Spring and Dodge Streets (Gibbs 1974).

Pawtuxet Village Historic District, Cranston and Warwick - Pawtuxet Village is one (1) of the oldest villages in Rhode Island, dating back to Roger Williams. It lies within both Cranston and Warwick, on the west side of Narragansett Bay and around Pawtuxet Cove. Its development can be traced from the earliest settlement around the cove and falls in 1638. It also encompasses the community's evolution from an 18th Century seaport to a 19th Century textile manufacturing center, then later development to a 19th-20th Century summer resort, and finally to its present configuration as a modern suburban community (Warren 1973).

East Greenwich Historic District, East Greenwich - This historic district is known for retaining its architectural fabric covering over three (3) centuries of development, with King Street being an example of an almost entirely turn of the 18th Century style. The surrounding streets contain mostly 19th Century architecture. The later Victorian style was incorporated into buildings and homes, as the town evolved into a modern suburb of Providence (Gibbs and Thatcher-Renshaw 1974).

Brick Market, Newport - The Brick Market, located at Thames Street and Washington Square, is a three-story brick building with a low, hipped roof built. It was built in 1761 and designed by Peter Harrison, one of the most prominent American architects of the 18th Century. The design is based on the Old Somerset House in London and was originally used as a market house. From 1853 to 1900, the old market served as the City Hall for Newport. As recently as 1975, it was used as a crafts shop and open to the public. Today, it is owned by the City of Newport and managed by the Newport Historical Society. The site is used as a shopping center, with shops and stores and. The Museum of Newport History is also located on the premises (Heintzelman 1975).

Perry Mill, Newport - The Perry Mill is a rectangular stone structure (originally four stories in height and now three stories tall) located at 337 Thames Street on Newport's waterfront. It was one of four mills built in the 1830's and 1840's in an attempt to introduce textile manufacturing into Newport's economy. The mill was built in 1835 by Alexander McGregor, a Scottish stonemason who also built the walls at Fort Adams and the Newport Artillery Company's Armory on Clarke Street. "The structure is of the greatest architectural importance for its magnificent stonework and is an example of the early 19th Century artistry achieved by New England stone craftsmen" (Hauck and Renshaw 1971).

Newport Historic District, National Historic Landmark, Newport - The Newport National Historic Landmark District is a dense, waterfront urban concentration of 1,400 residential, commercial, institutional, and public buildings. The site also includes a historic designed park. The district forms the core of the historic maritime town of Newport and the city's present-day downtown (Adams 1995, Heintzelman 1975).

Ocean Drive Historic District, National Historic Landmark, Newport - Ocean Drive is a circular roadway area approximately four (4) miles long that runs east-to-west from the sound end of Bellevue Avenue to Ridge Road, leading back past Fort Adams (which is part of the Landmark) towards the city. Ocean Avenue is bordered by short stretches of beach, some promontories, and primarily ocean inlets and cliffs. Many large "summer residences" in a variety of architectural and landscape styles are located on both sides of the drive. The landscaping was designed in part by Frederick Law Olmsted. His influence can be seen where the roads and structures are incorporated into the natural terrain (Pitts 1976).

Wickford Historic District, North Kingstown - Wickford is a village in the town of North Kingstown on the west bank of Narragansett Bay. This site dates back to the earliest settlement in the 1640's, when it was a trading post on Cocumscussoc Brook just to the north of this current location. After the Revolutionary War, the area became to a maritime community, with fishing, trading and boat building centered around Wickford Harbor. The significance of the historic district lies in its unique location along the water and the cohesiveness of buildings (mostly late 18th and early 19th Century) that represent an essentially intact post-colonial town with wide streets and flat waterside terrain (Ames 1974).

Warren Waterfront Historic District, Warren - The Warren Waterfront Historic District is a dense, urban waterfront area on the west bank of the Warren River. This site includes commercial, residential, institutional, industrial, and maritime buildings, which range in age from the 1740's to the present day. The district extends both east and west from the central spine of Main Street. Many of the earliest buildings were constructed as a result of Warren's prosperity as a shipping and whaling center from the late 18th to the mid-19th centuries. Industrial activity in the 19th century and the rise of a central business district transformed the waterfront district to its present-day form. It continues to serve as an active maritime area today (Woodward 2002).

Apponaug Historic District, Warwick - The Apponaug Historic District is a group of seven (7) buildings clustered around the intersection of Post Road and Arnold's Neck Drive just south of the Apponaug Bridge. It contains the largest concentration of Colonial and Federal style dwellings that can be found in Warwick. Modern 20th century commercial development has seriously impacted the character of this historic district. However, the contributing structures that make up the District are visually distinct from their surroundings and relatively intact and preserved (Jones 1983).

Warwick Civic Center Historic District, Warwick - This historic district encompasses four (4) late 19th and early 20th Century public buildings: the Warwick City Hall, the Henry

Warner Budlong Memorial Library, the Old Fire Station, and the Kentish Artillery Armory all along Post Road in Warwick. The District is located a short distance east of the crossroads that constitute the center of Apponaug Village, founded in 1696, which was a former seaport and mill village. Unfortunately, the historic fabric of Apponaug Village has been impacted by 20th Century commercial development. “The history and usage of the buildings in the Civic Center Historic District distinguishes them from their surroundings and make them a distinctive unit within the physical fabric of Apponaug village” (Jones 1980).

Archeological sites and sensitivity within the study area

The RI HPHC provided Geographic Information System (GIS) files of its overall site database, which includes historic points, districts, cemeteries, archaeological sites, and underwater archaeological sites. These files were reviewed in the area of potential effect (APE) for the RIC study. The historic districts are described above. Underwater archaeological sites are outside of the APE, as it is currently defined essentially terrestrial. Archaeological sensitivity can be described in broad terms as it applies to the study area.

New Shoreham (Block Island) - Phase I and II archaeological surveys were conducted on Block Island in 2014 with funds provided from Hurricane Sandy disaster relief grants (McBride et al. 2016). The purpose of the surveys was to investigate archaeological sites damaged by the hurricane and evaluate their eligibility for listing in the NRHP. Prior to these surveys, archaeological sites on Block Island were recorded throughout the island, but primarily around the area known as the Great Salt Pond.

Narragansett - An investigation and Phase I and II archaeological survey and testing, as described in the previous section, were conducted on the Rhode Island south coast. This study was completed to determine the impact of Hurricane Sandy on known archaeological sites (Waller and Leveillee 2016). This study focused on the communities of Narragansett, South Kingstown, Charlestown, and Westerly. Only the Town of Narragansett is included in the study area of the RIC study.

Portions of the Narragansett shoreline have been determined to have high and moderate archaeological sensitivity. Areas of severe erosion or development have been termed as low sensitivity areas.

2.4.1.9 Sea Level Rise

Sea Level Change Guidance - In accordance with ER 1100-2-8162, potential effects of RSLC were analyzed over a 50-year economic period of analysis and a 100-year planning horizon. USACE guidance states “the period of analysis shall be the time required for implementation of the lesser of: (1) the period of time over which any alternative plan would have significant beneficial or adverse effects, (2) a period not to exceed 50 years” (ER 1105-2-100 section 2-4(j)). However, because infrastructure often stays in place well beyond the economic period of analysis, a 100-year adaptation planning horizon is used to address robustness and resilience in the time of service of the project that can extend past its original design life. Research by climate science experts predict continued or accelerated climate change for the 21st century and possibly beyond, which would cause a continued or accelerated rise in global mean sea level. ER 1100-2-8162 states that planning studies will formulate alternatives over a range of possible future rates of SLC and consider how sensitive and adaptable the alternatives are to SLC.

ER 1100-2-8162 requires planning studies and engineering designs to consider three (3) future SLC scenarios: low, intermediate, and high. The historic rate of SLC represents the low rate. The intermediate rate of SLC is estimated using the modified National Research Council (NRC) Curve I. The high rate of SLC is estimated using the modified NRC Curve III. The high rate exceeds the upper bounds of Intergovernmental Panel of Climate Change estimates from both 2001 and 2007 to accommodate the potential rapid loss of ice from Antarctica and Greenland but is within the range of values published in peer-reviewed articles since that time.

Historic Sea Level Change - Historic RSLC for this study (2.77 millimeters/year or 0.00909 feet/year for the years 1930-2018) is based on NOAA tidal records at Newport, Rhode Island. An additional historic RSLC rate within the study area is available at Providence, Rhode Island (2.27 millimeters/year or 0.00745 feet/year for the years 1938-2018), however the SLC rate at Newport was conservatively applied throughout the study area.

USACE SLC Scenarios – The USACE low, intermediate, and high SLC scenarios over the 100-year planning horizon at Newport, Rhode Island are presented in **Table 2-6** and **Figure 2-6**. Water level elevations at year 2030 are expected to be between 0.35 and 0.88 feet higher than the current NTDE. Water elevations at year 2080 are expected to be between 0.80 and 3.67 feet higher than the current NTDE.

Hydrodynamic modeling performed for the NACCS and used in this study was completed in the current NTDE. Therefore, the modeled water levels represent Mean Sea Level (MSL) in 1992. Future water levels are determined by adding the SLC values in **Table 2-5**. For example, a water elevation of 10 feet NAVD88 based on the current NTDE (1983-2001), will have an elevation in the year 2080 of 10.80, 11.49 and 13.67 feet NAVD88 under the USACE low, intermediate, and high SLC scenarios, respectively.

Table 1.6: USACE Sea Level Change Scenarios for Newport, RI

	Newport, Rhode Island		
	Low	Intermediate	High
2030	0.35	0.47	0.88
2080	0.80	1.49	3.67
2130	1.25	2.95	8.31

*All values are in feet relative to MSL, 1992

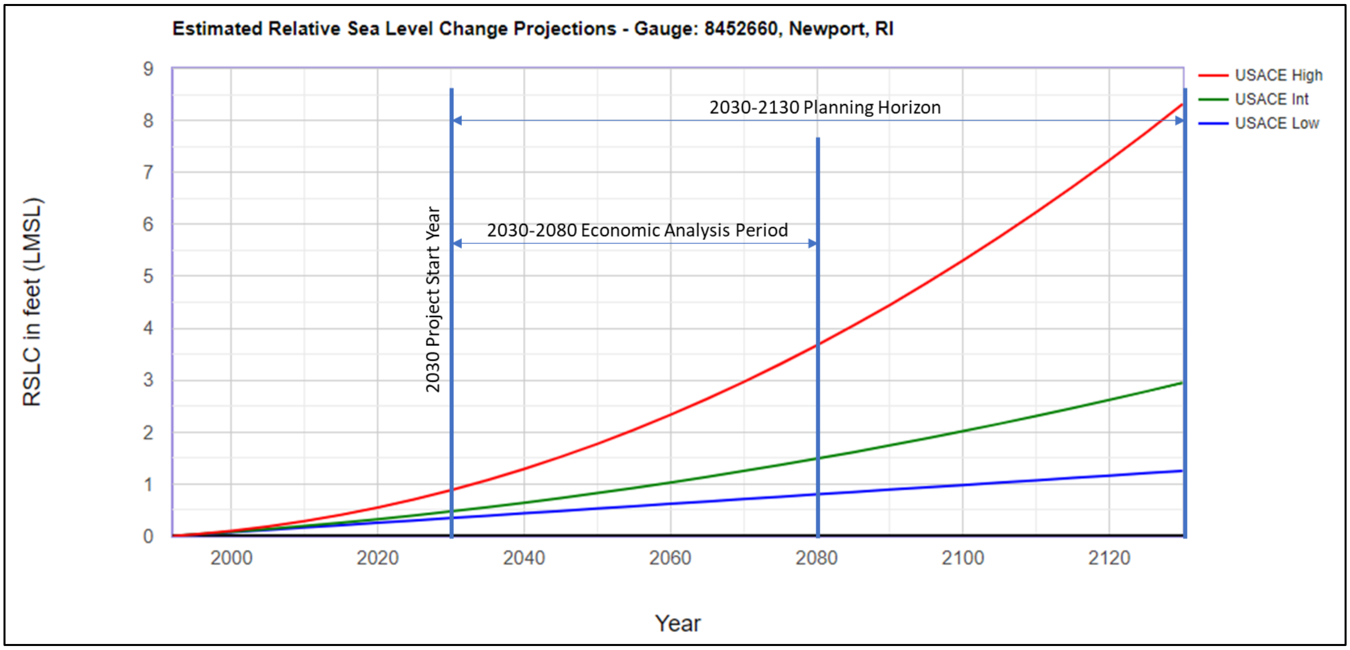

Figure 2-6: USACE Sea Level Change Scenarios for Newport, RI

2.4.1.10 Climate and Climate Change

The State of Rhode Island maintains a website dedicated to climate science and climate related policy in the state (State of Rhode Island 2021). Climate change in Rhode Island is a concern because of observed increases in sea level, precipitation, and temperature in the state. Sea level, measured at the Newport tide gauge, has increased by 10 inches since record keeping began in 1930 (RICRMC 2014). Precipitation rates are rising at a rate of one (1) inch per ten (10) years. The waters in the bay have warmed by 2.5-2.9°F from 1960-2010, and wintertime water temperatures have warmed most rapidly. Sea levels are project to rise in the state by 9 feet by 2100 (State of Rhode Island 2021).

2.4.1.11 Hazardous, Toxic and Radioactive Waste (HTRW)

There are no sites on the National Priorities List (NPL), also known as Superfund, in Providence, Rhode Island. The NPL is a list of sites having known or threatened releases of contaminants throughout the United States (U.S. Environmental Protection Agency (USEPA) 2021b). However, none of these sites are located near any areas affected by the proposed project. There are 36 records of leaking underground storage tanks (USTs) in the Providence study area all of which are either completely remediated or have had soil removal remedial actions (RIDEM N.D (b)).

The USEPA's Toxic Release Inventory (TRI) records how much of each type of chemical is released to the environment from facilities in the United States. The TRI was established under Section 313 of the Emergency Planning and Community Right to Know Act in order to provide information on toxic releases and pollution prevention activities. This database was used to access more specific information about releases in the focused study areas. The 2021 TRI lists 85 sites in the City of Providence. However, there are only six (6) sites located within special hazard flood zones (SFHAs) defined by FEMA floodplain maps. These sites are concentrated in the industrial port area of the city.

There are no NPL sites in the Bristol County study area. There were seven (7) reports of leaking USTs in this area between 1991 and 1995 (RIGIS 2012). All of these sites are either inactive, meaning remediation is complete, or remediation through soil removal took place. Therefore, they present no hazard to the project area. There are 19 sites on the USEPA's TRI in Bristol County. Four (4) of these TRI sites are located within SFHAs. This includes two (2) sites on the Warren River waterfront along Route 114, near the confluence of the Palmer and Warren Rivers. The two (2) manufacturing sites have closed and therefore are not expected to impact the project area. The Rose Hill Regional Landfill is an NPL site located roughly 2.25 miles west of Middle Bridge in South Kingstown, RI. No leaking USTs were reported by RIDEM in the Narrow River study area. The Narrow River study area has no TRI listed sites.

The Newport Naval Education/Training Center is an NPL site located roughly five (5) miles north of the Newport study area. RIDEM lists seven potentially leaking USTs that USACE determined to be in the Newport study area (RIGIS 2012). Leaking USTs were recorded at these sites between 1990 and 1998 and were either remediated through soil removal or no longer active cases, and therefore, no longer present a hazard to the project area. Newport has three (3) listed TRI sites. Two (2) sites are outside of the area of interest, with one (1) on Naval property, and another outside of any special flood hazard zone. There is a TRI site in the Newport project area with a reported release of N-butyl alcohol to air in 1991. The current operating status of this facility is temporarily closed.

The Block Island project area does not contain NPL sites. There were nine (9) reports of leaking USTs on Block Island between 1989 and 2005. Four (4) of the reported USTs are no longer active and one (1) was remediated through soil removal. The remaining four (4) are still considered active in the database and some are located within the 100-year floodplain (RIGIS 2012).

2.4.1.12 Air Quality

In accordance with the Clean Air Act (CAA) of 1977, as amended, (42 U.S.C. 7401), the USEPA developed National Ambient Air Quality Standards (NAAQS) to establish the maximum allowable atmospheric concentrations of pollutants that may occur while ensuring protection of public health and welfare, and with a reasonable margin of safety. The USEPA measures community-wide air quality based on NAAQS measured concentrations of six (6) criteria air pollutants: carbon monoxide, sulfur dioxide, respirable particulate matter, lead, nitrogen dioxide, and ozone. Utilizing this information, the USEPA designates attainment areas and non-attainment areas nationwide. Non-attainment areas are designated in areas where air pollution levels persistently exceed the NAAQS. The entire state of Rhode Island meets the attainment criteria for all NAAQS priority pollutants (USEPA 2021c).

The state of Rhode Island is located within the Ozone Transport Region (OTR) which extends northeast from Maryland and includes all six (6) New England states. The interstate transport of air pollution from other states can contribute significantly to violations of the 2008 ozone NAAQS within the OTR. Under the CAA, states within the OTR are required to submit a State Implementation Plan (SIP) and install a certain level of controls for the pollutants that form ozone, even if they meet the ozone standards. The state of Rhode Island has an approved SIP and has submitted periodic revisions to the USEPA for approval in conformance with the CAA. The latest revision was submitted to the USEPA in September 2020 (RIDEM 2020b).

2.4.1.13 Greenhouse Gases

Greenhouse Gases (GHGs) include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The RIDEM published an inventory of GHGs in the state in 2016 (RIDEM 2016). The key findings of this report were that Rhode Island's total GHG emissions were 11.02 million metric tons of carbon dioxide equivalent (MMTCO2e) in 2016. This is a decrease of 1.46 MMTCO2e, or -11.67 percent, from the baseline level of 1990 (12.48 MMTCO2e). Transportation contributed 36 percent of GHGs in 2016 and was the largest sector by emissions. Electricity consumption (26 percent) and residential heating (17 percent) were the next largest contributors. Commercial heating, industrial processes, and "other" contributors rounded out the total. GHG totals specific to the study areas are not available as of this report writing.

2.4.1.14 Noise

Noise is defined as unwanted or disturbing sound. The day-night noise level (Ldn) is widely used to describe noise levels in any given community (USEPA 1978). The unit of measurement for Ldn is the "A"-weighted decibel (dBA), which closely approximates the frequency responses of human hearing. Decibels are measured on a logarithmic scale, and they correspond to how a human's ear interprets sound pressure. The threshold for audible sound is usually within a range of 10-25 dBA with a threshold of pain at the upper scale of audibility at approximately 135 dBA (US EPA, 1971).

Although noise level measurements have not been obtained in the study area, they can be approximated based on existing land uses. The project sites are composed of urban, suburban, and commercial/industrial areas. The primary sources of noise would be from roadway noise, heavy equipment use in the case of Providence, and use of small engines in suburban areas. Noise levels at the project area vary significantly. During the night in a quiet suburban area, average ambient noise levels would be less than 40 dBA, while the average noise level experienced during the day in a busy urban area could be as high as 80 dBA. Traffic noise experienced at the project sites depends on several elements, including vehicle speed, vehicle characteristics (engine type, transmission type, tire type), road characteristics (e.g., surface type, grade), traffic volume, wind and the surrounding terrain. Diesel trucks can produce 85 dBA at 50 mph (at 50 ft). However, noise produced by light automobile traffic is approximately 50 dBA (100 ft).

2.4.2 Future Without Project Conditions

The FWOP physical environmental conditions are anticipated to be the same as the existing conditions. Climate change and SLC could exacerbate erosion along shorelines affecting the topography of the study area. If efforts are made to reduce greenhouse gases, then air quality would likely improve and some of the predicted effects of climate change may be offset (State of Rhode Island 2021).

2.5 BUILT ENVIRONMENT

2.5.1 Existing Conditions

2.5.1.1 Land Use

To determine land uses in the project area, a land use dataset based on the National Land Cover Dataset was accessed from the Rhode Island GIS website (RIGIS 2003). The dataset contains land use records within approximately 500 feet of the Narragansett Bay shoreline. **Table 2-7** shows the percentage of land cover throughout the study area. This data set was used as a coarse filter proxy for areas potentially vulnerable to coastal storm surge in the bay. Overall, land uses in the Providence, Bristol County, and Newport study areas are predominantly urban, with commercial and residential development.

Block Island is not located in Narragansett Bay, so this area is not included in the database used to describe land use in the majority of the project area. Instead, the RIGIS Land Use and Land Cover database (RIGIS 2011) was provided land use information for the island. The top five (5) land use types on Block Island are medium density residential (19%), mixed forest (11.7%), deciduous forest (9.9%), medium low density residential (8.4%) and softwood forest (7%).

The Providence study area is home to a large deep-water commercial port, with a heavily industrialized shoreline. Dense urban development is located to the north, west, and south of the harbor. The Bristol County study area has dense residential development mixed with commercial land uses around the Warren River. In Newport, there is an urban mix of residential, commercial, and military uses along that city’s shoreline in the project area. The Narragansett - Narrow River study area has low density residential development along both sides of the river.

To determine land uses in the Block Island project area, a land use dataset of all of Rhode Island was accessed through RIGIS (2015). This contains all land uses throughout the state. Most of the land in the Block Island area, about 70%, is either developed for commercial and residential purposes, or is forested.

Table 2-7: Land usage in the study area, not including Block Island

	Land Use (% cover) within 500 ft. of Narragansett Bay Shoreline					
	Developed	Forested	Herbaceous ground cover	Barren	Water or Wetlands	No Data
Providence	81	13	2	4	1	0
Bristol County	54	17	0	0	7	22
Newport	64	16	13		2	4
Narragansett - Narrow River	57	22	1	8	8	4

2.5.1.2 Aesthetic and Scenic Resources

Aesthetically, Rhode Island is known for its coastal setting, historic buildings, and environmental resources such as unique habitats and wildlife. The City of Providence is the capitol of Rhode Island and has a large downtown commercial area with high rise offices and state government buildings. The focused study area in Providence is the deep-water port, which is a hub of industrial activity known for its shipping infrastructure and the frequent presence of deep draft vessels in the port.

The Bristol County study area has numerous historic landmarks and buildings, such as the Maxwell House in Warren (built between 1752 and 1756), and the Blithewolde Mansion and Bristol Art Museum in Bristol (Historical Preservation and Heritage Commission 2021). The historic resources and coastal setting provide aesthetic value in the Bristol County study area.

The Narrow River study area derives aesthetic values from its environmental setting. The river is an important wildlife area and has numerous protected environmental resources present. Located just upstream of the bay and Pettasquamscutt Cove, the area is popular for wildlife viewing and recreational boating.

The City of Newport has many historic buildings and neighborhoods, as well as a nautical aesthetic derived from the large sailing and boating industries in the Newport Harbor area. Outside of the immediate study area, the City of Newport is known for its gilded age mansions, public beaches, and seaside parks, all of which provide aesthetic value to the area. The Point Neighborhood is located directly in the study area and is known for its historic houses and proximity to downtown Newport.

Block Island derives its aesthetic and scenic values from both historic and natural sources. There are many historic features, landmarks, and buildings that are focused on the Native American, farming, maritime and resort histories of the Island. This includes the Old Harbor Historic District (National Register Historic District) that became the landing site for tourists in 1873 rather than the agrarian and fishing communities that existed on the Island for centuries. Other historic features include lighthouses, historic houses, and a Coast Guard Station. The scenic landscape of Block Island includes bluffs, sandy beaches, coastal ponds, shrublands, and salt marshes that provide value to the aesthetic resources on the Island (New Shoreham Planning Board 2016).

2.5.1.3 Recreation

Water based recreation is popular in all study area towns, which border the bay. Rhode Island is nicknamed "The Ocean State," and this is reflected in the number of public water access points, beaches, and shoreline parks found throughout the study area.

While the Providence study area is predominantly industrial, there are two recreational areas. Collier Point Park is located east of the intersection of Interstates 95 and 195 and borders the Providence River. The Park has several piers and a boat launch for public use. A 35-acre recreation area borders the commercial port area of Providence to the south and has playing fields and water access.

Recreational boating is common in the Bristol County study area. The Town of Warren has a public boat ramp and parking lot located adjacent to the wastewater treatment plant on Water St. The Town of Barrington maintains a public boat launch between Route 114 and the East Bay bike path on the Barrington River. The Town of Warren also maintains a public beach on the Warren River, located at the southern end of Water St. The East Bay bike path is a public recreational resource that runs along the shoreline of the Bristol County project area in all three towns. The 464-acre Colt State Park borders the bay in the town of Bristol.

The Newport study area is a popular recreation boating destination. The city hosts sailing competitions, and several yacht clubs are in the project area. There are recreational opportunities at Easton and Sachuest beaches, both located east of the study area in Newport. Fort Adams State Park is a 200-acre recreational area located on the western side of Newport Harbor. The Park has historic areas, as well as fishing and boating access. Cycling and walking are popular recreation activities in the area as well.

The Narrow River study area is used heavily for water-based recreation and nature tourism. The John H. Chafee National Wildlife Refuge is in the project area and provides wildlife viewing opportunities to the public. The project area also provides boater access to popular downstream recreation areas such as the narrows and the Pettasquamscutt River mouth. There is a public fishing access point on the western shore of the Narrow River approximately 3,300 feet north of Middle Bridge. There is a public land trust known as Garrison House Acres on the western shore of the Narrow River directly south of Middle Bridge.

The Block Island study area has many recreational opportunities that are present due to the access to water resources and the high density of preserved areas on the island. There are recreation resources from municipal parks to water-based recreation and conservation lands. The Block Island National Wildlife Refuge is within the study area and provides shore access and wildlife viewing opportunities. The island has a 28-mile trail system maintained by the Block Island Conservancy and The Nature Conservancy, for residents and visitors to enjoy the scenic, natural beauty of the Island (New Shoreham Planning Board 2016).

2.5.2 Future Without Project Condition

In the absence of Federal action, existing floodplain properties would remain at risk from flooding damages resulting from storm events. Climate change may impact land use and recreation over the period of analysis. Flooding and higher sea levels may flood land that was previously intertidal or upland. This could affect water-based recreation sites that may need to retreat, construct adaptive measures (e.g., higher piers, access through bulkheads, etc.), or close.

Structures in the study area consist of a mix of single-family homes, apartment buildings, and commercial buildings. A considerable portion of these buildings have basements and are over 50 years old. Over 12,000 structures in the study area are designated as FEMA special flood hazard area zones VE, which means that they are inundated at 1 percent AEP with additional hazards associated with storm-induced waves, and AE (inundation at 1 percent AEP using methods with Base Flood Elevations). Hurricane Sandy, the last major Hurricane to impact the area, resulted in more than $39.4 million in support from four (4) federal disaster relief programs for the state of Rhode Island. The website of the FEMA reports the National Flood Insurance Program (NFIP) paid more than $31.1 million for more than 1,000 claims as a result of the storm.

2.6 ECONOMIC ENVIRONMENT

2.6.1 Existing Conditions

Under existing conditions, coastal Rhode Island is subject to significant risk from coastal storms as described in the preceding paragraphs. There are currently more than 650,000 people residing in the 19 towns included in the study area in Rhode Island and approximately 75 percent of the state population resides in a 40-mile long urban/suburban corridor along the shores of Narragansett Bay. About 20 percent of the existing population would be expected to require additional time and resources to assist in evacuation due to a storm event due to age (people over 65 or under 10 years of age). Structures in the area consist of a mix of single-family homes, apartment buildings, and commercial buildings, and many of the buildings in the area that have basements and are over 50 years old.

The shoreline and coastal tributaries of southeastern Rhode Island from Narragansett Bay to the Massachusetts border experiences recurring and significant coastal flooding, due to inundation caused by storm events. This flooding contributes to risk to public safety and property in the region. The effects of inundation are anticipated to increase due to future SLR.

2.6.1.1 Socioeconomics and Demographics

Existing demographic and economic information were drawn from the U.S. Census

Bureau, Bureau of Labor Statistics. Based on the 2020 census, the eleven towns included as the focus areas in the study area had a total population of 416,234 and contained 162,886 housing units. Other than Providence and Jamestown, the towns in the study area showed slight population declines from 2010 to 2020. All are projected to show continued decreases in population through 2040 except Bristol, Jamestown, Narragansett, North Kingstown and Block Island, according to state projections. Providence is the largest town in the study area, followed by Warwick. The actual population of all eleven towns increases in the summer months, with the influx of tourists, boaters, and beach goers.

The population in the focused study areas is primarily white, with other races generally making up less than ten (10) percent of the population. Providence and Warwick contain the most housing units in the study area, with 62,046 and 38,625 housing units respectively, of which 4.1 percent and 20.9 percent are seasonal or recreational housing units. In contrast, the state as a whole, has a surprising 23 percent of housing units that are seasonal or recreational.

The state-wide median income in Rhode Island is $67,167 (U.S. Census Bureau 2021a). Major industries in Rhode Island include medicine, data cyber and data analytics, defense ship building and maritime products, business services, transportation, and tourism (U.S. News and World Report 2021). **Table 2-8** presents socio-economic data relative to the study area. Providence has the lowest civilian labor force participation and high school graduation rate, while Washington County ranks the highest in those variables out of the four study area towns.

Table 2-8: Socioeconomic factors in the study area

	Providence	Bristol County	Newport	Washington County	Rhode Island
Median Income ($)	45,610	83,092	67,102	85,531	67,167
Civilian labor force participation (% age 16+)	61.2	63.8	58.2	64.2	64.4
High school graduate (% age 25+)	81.6	90.9	94.1	94.9	88.8
Population per square mile	9,677	2,064	3,215	386	1,018

2.6.1.2 Economy and Unemployment

Major employment sectors in the focused study areas include educational services, and health care and social assistance, management, administrative and waste management services, arts, entertainment, and recreation, and accommodation and food services. After high unemployment rates in Rhode Island during the economic crisis of 2008 – 2009, many parts of Rhode Island had high unemployment rates of 10 percent to 12 percent. However, in recent years the economic recovery has taken hold and the October 2021 unemployment rate in the towns of the focused studies area was 5.4 percent.

2.6.1.3 Environmental Justice

EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 16, 1994" requires Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its program, policies, and activities on minority and low-income populations in the United States, including Native Americans.

The City of Providence has a median income of $45,610, and 25.5 percent of persons live in poverty (U.S. Census Bureau 2021b). According to the USEPA's environmental justice screening tool (2021a), the City of Providence has 66 percent of residents classified as people of color, and 50 percent of the City's population is low income. The USEPA compiles environmental justice indices to compare populations vulnerable to environmental factors across the United States. The City of Providence has environmental indices for all listed hazards between 84th-92nd percentile, meaning that this City has a higher proportion of vulnerable populations exposed to environmental hazards than most other areas of Rhode Island.

Washington County, where the Narrow River study area is located, has a median income of $85,531, with eight (8) percent of persons living in poverty (U.S. Census Bureau 2021a). Nine (9) percent of the population is classified as people of color (USEPA 2021a). Environmental justice indices compiled by the USEPA range from 19-42nd percentile, meaning that vulnerable populations in this area have a low exposure to environmental hazards relative to the rest of Rhode Island.

Bristol County has a median income of $83,092, with 6.8 percent of persons living in poverty, with eight (8) percent of the population is classified as people of color by the USEPA's environmental justice screening tool. Environmental Justice indices produced by the USEPA range from 17-52nd percentile, meaning that vulnerable populations in Bristol County have low to roughly equal exposure to environmental hazards compared to the rest of Rhode Island.

Newport has a median income of $67,102, with 14.5 percent of persons in poverty (U.S. Census Bureau 2021a). Twenty-three percent of the population is classified as people of color, according to the USEPA's environmental justice screening tool. Environmental Justice indices are neutral for most indicators, meaning that vulnerable populations experience roughly equal exposure to environmental hazards as the rest of the state. However, the index for proximity to wastewater discharge is 99 percent, meaning that low-income and/or minority populations in Newport have high exposure to streams impacted by wastewater discharge relative to the rest of Rhode Island.

Block Island has a median income of $59,423 with 7.9 percent of persons in poverty (U.S. Census Bureau 2020). Six (6) percent of the population is classified as people of color by USEPA's environmental justice screening tool. Environmental Justice indices range from 53th-71st percentile, meaning that vulnerable populations have a roughly equal to slightly higher exposure to environmental hazards compared to the rest of Rhode Island (USEPA 2021a).

EO 13045, “Protection of Children from Environmental Health Risks and Safety Risks April 21, 1997” requires Federal agencies to identify and assess environmental health risks and safety risks that may disproportionately affect children.

The following information was gathered from the U.S. Census Bureau regarding the presence of children in the project area. In the state of Rhode Island, 19.3 percent of the population is under the age of 18. **Table 2-9** shows the percent of the population under Age 18 for each study area town.

Table 2-9: Percentage of population under Age 18 in the study area

Study Area Name	Percent (%) of PopulationUnder Age 18
Providence	22.4
Bristol County	18.6
Newport	14.1
Washington County	16.2
Block Island	17.9

2.6.1.4 Structure Inventory

The structure inventory was compiled using geospatial data available from the state of Rhode Island. All processing was done with the ArcGIS 10.1 mapping software using Rhode Island State Plane NAD83 feet as the horizontal projection and NAVD88 feet as the vertical datum. A database, with point shapefiles that were obtained through the state of Rhode Island’s 911 emergency response system, was used to develop the structure inventory within the study area. The 911 database is in the format of a point shapefile with each point overlaying a structure location. A ground elevation was determined using the ‘Extract by Value’ tool on the FEMA 2011 Light Detection and Ranging (LiDAR) raster grid. Most structures were viewed individually in either Google Earth or online real estate sites to determine the type of construction, type of foundation and the first-floor elevation relative to the ground elevation. The first-floor elevations were calculated by estimating the height from the ground to the first floor that would experience damages during a flood. Lowest adjacent ground elevations were obtained from LiDAR digital elevation model downloaded from the National Elevation Dataset. Foundation type was obtained from 911 data and Google StreetView. Foundation heights were estimated for each structure by visual inspection using Google StreetView, summing up the number of steps, assuming each to be six (6) inches high. The foundation height was added to the ground elevation to determine the first-floor elevation of each structure in NAVD88. Structures with ground elevations below zero (0), often adjacent to waterbodies, were updated to reflect positive ground elevations adjacent to the boundary of the structure. Most elevations on structures with pier foundations were very low, while structures with basement or pile foundations had much higher First Floor Elevation (FFE) values.

2.6.2 Future Without Project Condition

The FWOP condition serves as the base condition to use as a comparison for all other alternatives. In the absence of a Federal project, homeowners and businesses will continue individual efforts to repair damages after coastal storms, using emergency funding or personal resources when available. In the event a residential structure sustains damage equal to or greater than 50 percent of its depreciated replacement cost, it is assumed that the structure will be elevated in accordance with NFIP and local rules. The FWOP condition within the period of analysis (2030-2079) is identified as continued damages to coastal floodplain structures and property from future storm events.

Limited future growth or development in the study area was projected for this analysis, therefore structure inventory and values were kept the same as those under existing conditions. Much of the coastal floodplain in the study area is already developed, and there are limited opportunities for new expansion.

Planning efforts were conducted using the intermediate SLC scenario for all modeling and formulation. The FWOP damages was modeled as a “no action” scenario to identify the risk and damage potential to Rhode Island infrastructure in the absence of any action and also to provide a commensurable baseline for comparative purposes.

2.6.2.1 Economic Models Applied

The Generation 2 Coastal Risk Model (G2CRM) was used to estimate the inundation damages for project alternatives within the study area. The model takes into account a probabilistic suite of storms and estimates the resulting present value damage over a specified period of time. This allows economic decisions to be made based on the entire range of storms that may occur in a study area, as opposed to damages resulting from a specific storm event. G2CRM is distinguished from other models by virtue of its focus on probabilistic life cycle approaches. This allows for examination of important long-term issues including the impact of climate change and avoidance of repetitive damages. Additionally, G2CRM allows for incorporation of time-dependent and stochastic event-dependent behaviors such as waves, tides, and structure modifications. The model is based upon driving forces (storms) that affect a coastal region (study area). The study area is comprised of individual sub-areas (model areas) of different types that may interact hydraulically and may be defended by coastal defense elements that serve to shield the areas and the assets they contain from storm damage.

Model areas were developed for use in G2CRM modeling based on location of save points that were determined to have the appropriate water level and wave hazard. For the economic analysis, 16 model areas were evaluated as individual studies in G2CRM. **Figure 2-7** shows the model areas in relationship to the eleven focused project areas. Each study was defined as an upland model area with a bulkhead protective system element. The waterside ground elevation is used by the model to diminish wave action as water overtop the beach system and inundate the area. The bulkhead top elevation is set to the existing ground elevation throughout the life cycle for the FWOP scenario.

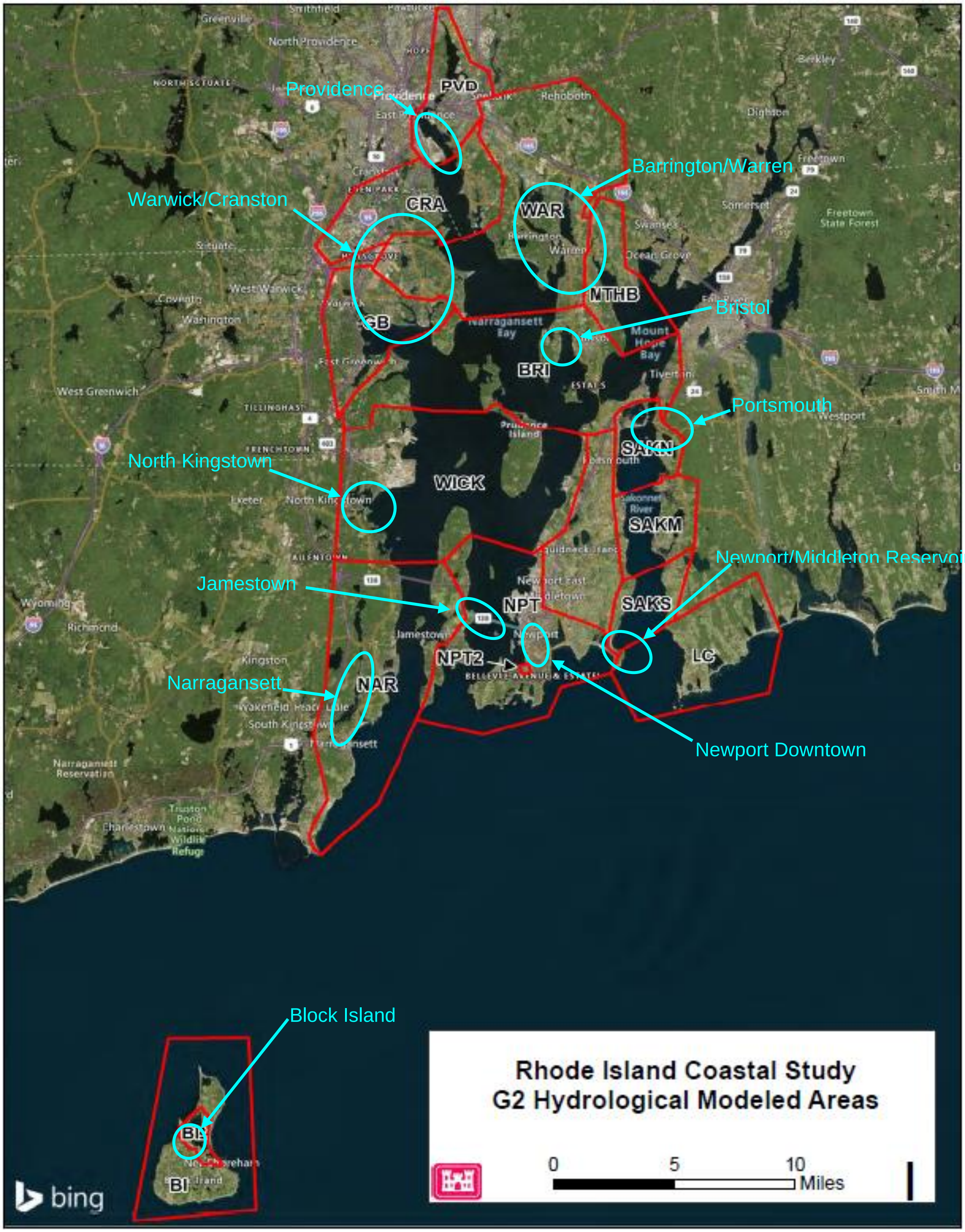

Figure 2-7: G2CRM modeled areas in relationship to the focused study areas

The damages assigned to each model area were estimated in G2CRM using economic and engineering inputs to generate expected present value damages for each asset throughout the life cycle (i.e., the period of analysis). The possible occurrences of each economic and engineering variables were derived using Monte Carlo simulations and a total of 100 iterations were executed by the model. The expected present value damages were calculated as the average of present value damages across all iterations.

2.6.2.2 Economic Application

Development and Land Use Projections - The U.S. Census reports that the area of developed and undeveloped land within Rhode Island as 668 square miles. The Rhode Island Department of Environmental Management has developed an open space grant program that protects land with significant natural, ecological or agricultural value. Since 1985 approximately 12,500 acres of land has been preserved in its natural state as open space. Residential buildings make up only 22 percent of land within the state. However, within the coastal study area, residential buildings make up the majority of the land use.

The Rhode Island coastline is almost entirely built out, and therefore no significant development of land that is not already developed in some form is expected. Any significant future developments are expected to be redevelopments. Any redevelopment is expected to be constructed to comply with established minimum standards for finished floor elevations. This trend will continue to apply to new construction and remodels when over half the value of the asset will be changed. Retroactive requirements for existing structures are not anticipated.

Structure Valuation - Depreciated replacement value per square foot was calculated for residential and non-residential structures using values for the Rhode Island area using data from Gordian's 40th edition of "*Square Foot Costs with RSMeans Data*" and updated to 2021 price levels. In the case of this study, the term "non-residential" refers to both commercial structures and multi-family housing units, such as apartment buildings. Various structure characteristics such as occupancy type, type of material, square footage, number of floors, basements, and garages were included in the structure value estimate for each individual structure.

According to the RSMeans depreciation schedule, each individual structure was depreciated based on the effective age, and then, depreciated an additional percentage to equal a regional adjustment of 107 percent for residential structures and 104 percent for commercial buildings, as determined by RSMeans for the Rhode Island area. This process was used to calculate a most-likely cost per square foot for each structure. The most-likely depreciated cost per square foot was then multiplied by the square footage calculated for individual structures in each occupancy to obtain a total depreciated cost or value for each structure.

The resulting Depreciated Replacement Values are in FY2021 values, which was the most current value at the time the analysis was originally completed. Each structure was also classified into different structure occupancies as required. The total estimated value of structures and content for structures located within the 100-year floodplain is approximately $3.6 Billion. The number and average structure value associated with each occupancy type can be found in the following table (**Table 2-10**). In this table, perishable refers to business with goods that have a limited shelf life (e.g., groceries) as opposed to non-perishable business that has goods with an expected longer shelf life (e.g., furniture).

Table 2-10: Average structure value by occupancy type within the 100-year floodplain

Occupancy Type	Count	Average Structure Value ($)	Average Contents Value ($)	Average Total Value ($)
Commercial-Engineered-Non-Perishable	720	657,000	296,000	952,000
Commercial-Engineered-Perishable	150	601,000	271,000	872,000
Commercial-Non/Pre-Engineered-Non-Perishable	317	987,000	444,000	1,431,000
Commercial-Non/Pre-Engineered-Perishable	27	265,000	119,000	384,000
Apartment 1 Story No Basement	254	218,000	18,000	236,000
Apartment 3 Stories No Basement	940	346,000	32,000	378,000
Urban High Rise	2	17,520,000	3,175,000	20,696,000
Beach High Rise	1	19,000	2,000	21,000
Residential 1 Story No Basement	2,193	105,000	53,000	158,000
Residential 2 Story No Basement	1,261	152,000	76,000	228,000
Residential 1 Story with Basement	1,926	117,000	58,000	175,000
Residential 2 Story with Basement	4,198	141,000	71,000	212,000
Building on Open Pile Foundation	136	153,000	69,000	222,000
Building on Pile Foundation with Enclosures	12	156,000	70,000	227,000
Total	**12,137**	**211,000**	**88,000**	**299,000**

<u>Content to Structure Value Ratios</u> - Content-to-Structure value ratios (CSVRs) used in this feasibility study were obtained from the Non-residential Flood Depth-Damage Functions Derived from Expert Elicitation Draft Report, revised 2013. A CSVR was computed for each residential and non-residential structure in the study as a percentage of the total depreciated replacement value.

Stage Damage Functions - Depth-damage relationships developed for the NACCS were used for all structures in the inventory. These depth-damage functions estimate the likely degree of damage to structure and contents at each elevation of flooding relative to the first floor, expressed as a percentage of structure and content value, based on actual damages experienced during Hurricane Sandy in the northeast. Structure values are based on depreciated replacement value of the building.

Stage-Probability Data - Stage-probability relationships were provided for the existing without-project condition through FWOP conditions, based on the USACE Intermediate SLC curve. Water surface profiles were provided for eight annual exceedance probability (AEP) events at various confidence limits: fifty percent (2-year), twenty percent (5-year), ten percent (10-year), five percent(20-year), two percent (50-year), one percent (100-year), 0.50 percent (200-year), and 0.20 percent (500-year) events. The without-project water surface profiles were based on the NACCS hydrodynamic model output data at selected ADCIRC nodes or “Save Points” throughout the study area. ADCIRC is a model that simulates storm surge, tides and coastal circulation problems.

2.6.2.3 Economic Risk and Uncertainty

The uncertainty surrounding the four (4) key economic variables (structure values, contents-to-structure value ratios, FFEs, and depth-damage relationships) was quantified and entered into the economic models. The G2CRM model used the uncertainty surrounding these variables to estimate the uncertainty surrounding the stage-damage relationships developed for each study area reach.

2.6.2.4 Engineering Risk Uncertainty

For the G2CRM model, uncertainty is incorporated not only within the input data (ground elevations/shoreline profiles, storm occurrence and intensity, structural parameters, SLC, structure and contents valuations, and damage functions), but also in the applied methodologies (probabilistic seasonal storm generation and multiple iteration, life cycle analysis). Over the project 50-year period of analysis, the model estimates inundation in response to a series of storm events and these plausible storms are randomly generated using a Monte Carlo simulation. By using a storm suite that is sampled randomly based on relative and seasonal probabilities, the uncertainty of occurrence of any give storm, regardless of intensity, is assured through the Monte Carlo sampling scheme as well as the multiple iterations of the project lifecycle. Results from multiple iterations of the life cycle can be averaged or presented as a range of possible values.

2.6.2.5 FWOP Modeled Damage Estimates

The FWOP damages for the study area was quantified using the G2CRM model. The planning efforts were conducted using the intermediate sea-level rise scenario (SLR2) for all modeling and formulation. Most damages in the study area are estimated to occur in the Providence, Warwick, and Wickford (North Kingstown) modeled areas (**Figure 2-9**). In present value terms, accumulated damages to 2079 was estimated up to $1.3 billion for the entire study. Damages per structure are estimated to be highest in in Block Island, Providence, and Newport modeled areas where damages per structure were estimated to be as much as $500,000 to over $1 million per structure.

Residential structures dominate the Rhode Island coastline, making up 80 percent of all structures in the study area inventory. The primary residential building type is a two-story single-family residence with basement (RES-6B); there are almost 4,200 such residences. However, there are also over 1,200 commercial buildings and 2,400 multi-family buildings accounting for a substantial portion of the inventory as well. Commercial structures are the greatest source of damage in the study area, accounting for almost 30 percent of all damages. Present value damages estimated for the FWOP can be seen in the following figure (**Figure 2-8**) along with structure value for each modeled area include in the analysis. Further details of the estimation of the FWOP conditions can be found in the **Appendix C,** *Economic and Social Considerations*.

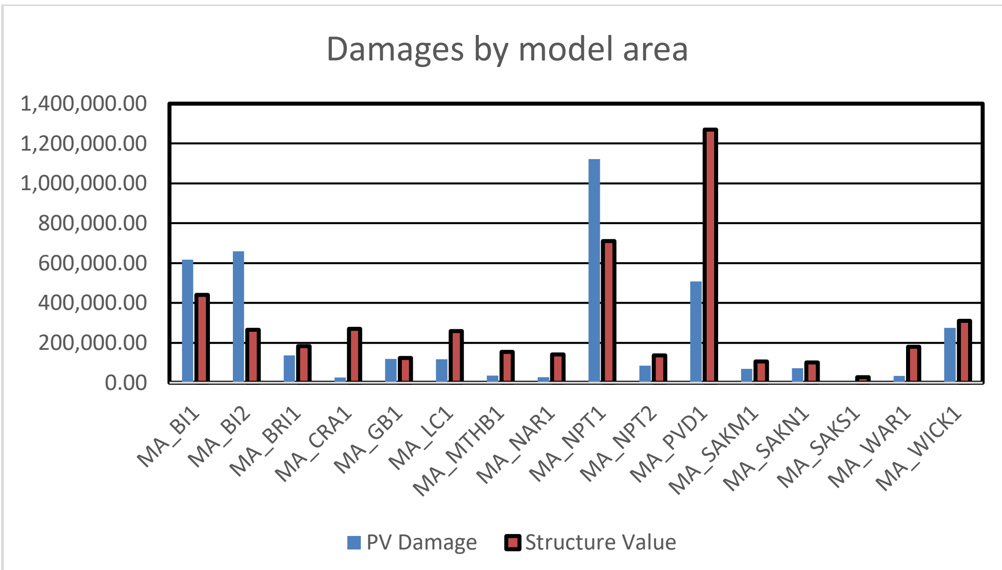

Figure 2.8: Future without project damages by modeled areas

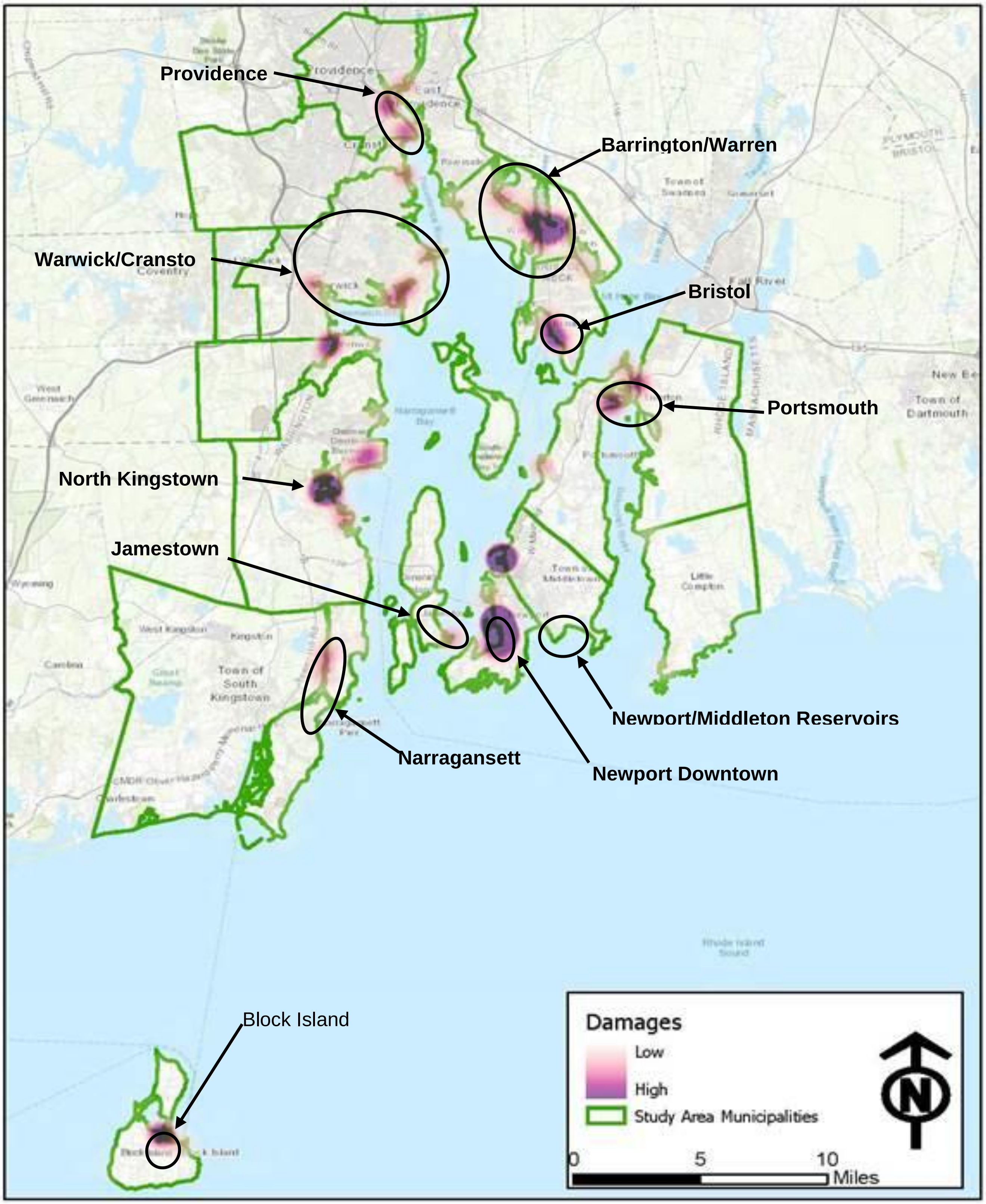

Figure 2-9: Future without project damages in relation to the focused study areas

SECTION 3.0 PLAN FORMULATION AND EVALUATION

3.1 PLANNING FRAMEWORK

Plan formulation is the process of creating plans that meet objectives and, thereby, solve problems and realize opportunities for gain. Formulation has three basic phases: identify measures that meet planning objectives, combine these measures to build plans, and change the plans as necessary. A management measure is a feature or activity that can be implemented at a specific geographic location to address one or more planning objectives. An initial list of management measures is developed and then screened by the PDT to identify those measures suitable to combine into alternatives. Next the alternatives are evaluated and compared.

3.2 ASSUMPTIONS

3.2.1 Future Without Project Conditions Assumptions

For the 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.

3.2.2 Economic Assumptions

The 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 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 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.

3.2.3 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% AEP NACCS water level + wave contribution + 1 ft + 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.

3.3 MANAGEMENT MEASURES

A management measure is a feature or activity at a site, which addresses one or more of the study objectives. Coastal flood 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.

3.3.1 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 flood 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.

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.

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.

3.3.2 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 flood risk management measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. 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 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.

3.3.3 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, two (2) NNBFs that attenuate waves and or slow and store tidal flooding, were considered. These included living shorelines and reefs.

Living Shorelines – This technique uses vegetation, with or without low sills and reefs, to stabilize the shoreline. "Living shorelines provide a natural alternative to 'hard' shoreline stabilization methods like rip rap or bulkheads, and provide numerous benefits including nutrient pollution remediation, essential fish habitat structure, and buffering of shorelines from waves and storms. Research indicates that living shorelines are more resilient than bulkheads in protecting against the effects of hurricanes." (NOAA 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.

3.3.4 Initial Screening of Measures

The list of measures that would address coastal storm risk was developed and 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?

Due to their size, tables that include the complete initial screening analysis for all management measures considered in each problem area were not included in the main report, but can be found in **Appendix F,** *Plan Formulation*. This initial screening, not including the NAA, resulted in 28 management measures (**Table 3-1**) that were kept for additional study.

Table 3-1: 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 Living Shoreline
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

Initial Array of Measures			
ID #	Description	Location	Management Measure
PR2	Nonstructural	Providence	Structure Raising/Floodproofing
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

3.4 ARRAY OF ALTERNATIVES*

3.4.1 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 bought 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 3-2**, 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 3-2**) 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 3-2**), 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 two (2) NNBFs (living shorelines and reefs) as management measures for the RIC study. The main coastal hazard within the RIC study area is storm surge. Both reefs and living shorelines are more effective at dissipating wave energy, and less effective at decreasing storm surge. While living shorelines 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 3-2: 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	N/A	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	N/A	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	N/A	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	N/A	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

Alternative		Location	Measures	Project Cost ($)	Annual Cost ($)	Annual Damage Reduced ($)	BCR	Carried Forward?
BI2	Corn Neck Road Raising	Block Island	Elevate Corn Neck Road	25,875,000	981,956			YES
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	N/A	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	N/A	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	N/A	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	N/A	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

Alternative		Location	Measures	Project Cost ($)	Annual Cost ($)	Annual Damage Reduced ($)	BCR	Carried Forward?
PR3	Providence Harbor Bulkhead	Providence	Bulkhead	46,080,000	1,748,736	568,704	0.33	YES
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	N/A	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	N/A	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 BCE and were carried forward to the next screening.
Dark Gray – Alternatives removed from consideration because their BCR was lower than 1.0.

3.4.2 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 3-3**.

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 3-3: The results of third screening iteration

Alternative		Location	Measures	Completeness	Effectiveness	Efficiency	Acceptability	Notes
NAA	No Action	Entire Study Area	N/A	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	N/A	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	N/A	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 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	

Alternative		Location	Measures	Completeness	Effectiveness	Efficiency	Acceptability	Notes
BW2	Nonstructural	Barrington/ Warren	Elevations/ Acquisitions/ Floodproofing	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.
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/	Yes	Yes	Yes	Yes	Included in the nonstructural analysis for the entire study area.

Alternative		Location	Measures	Completeness	Effectiveness	Efficiency	Acceptability	Notes
			Floodproofing					
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. primary dimensions."

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.

3.4.3 Focused Array of Alternatives

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

3.4.3.1 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 coastal 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. The following paragraphs highlight key assumptions for the NAA condition.

3.4.3.2 Structural 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 3-1**).

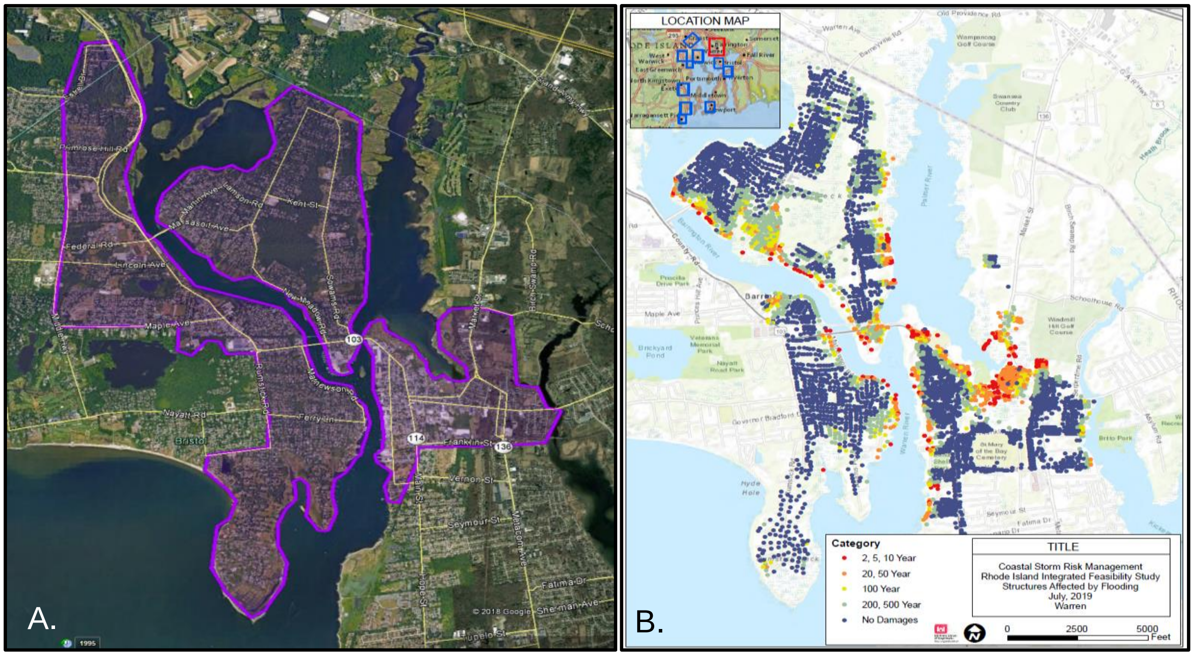

Figure 3-1: **A.** The 100-year floodplain in the Barrington/Warren focused study area. **B.** Structures affected by flooding in the Barrington/Warren focused study area

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.

A hurricane barrier system was considered for the upper reach of the Warren River (**Figure 3-2**). Alignments that provided protection from a 100-yr storm (1.0% chance) and 500-yr storm (0.2% chance) were investigated. The design that provided the greatest amount of protection (i.e., the 500-yr storm) was developed. 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 3-2**). 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.

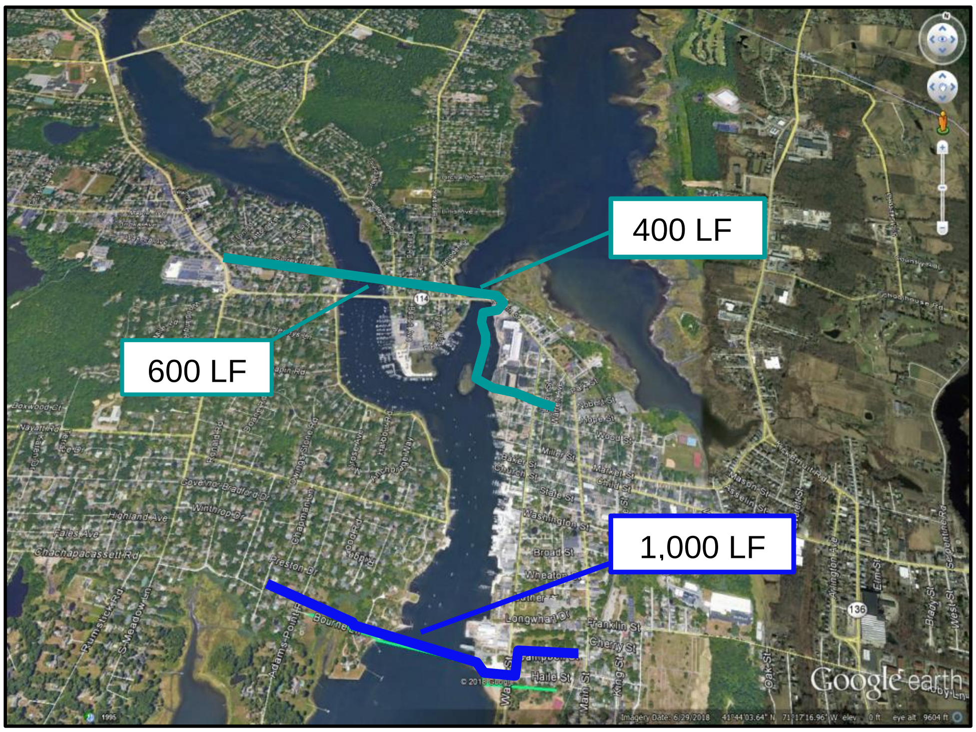

Figure 3-2: The placement of the lower and upper surge barriers on the Warren River

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 3-3**).

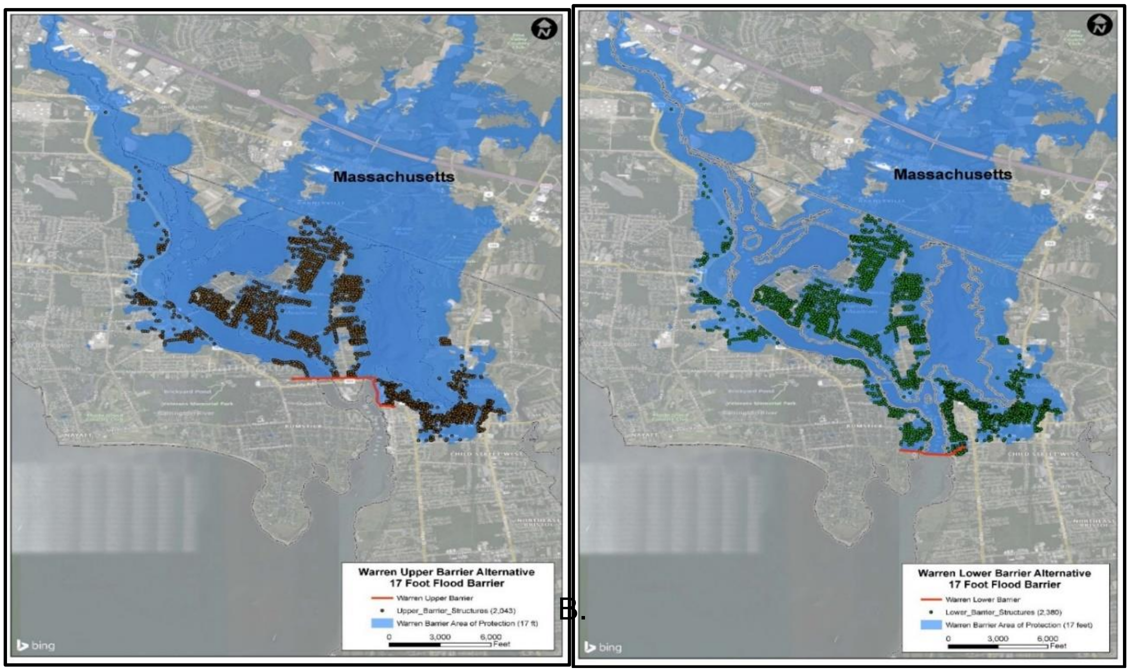

Figure 3-3: Areas of protection and structures that would be protected by **A.** the upper surge barrier and **B.** the lower surge barrier on the Warren River

Narragansett – Middle Bridge Surge Barrier - The Narragansett study area includes communities that lie along the Narrow River (**Figure 3-4**). 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 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.

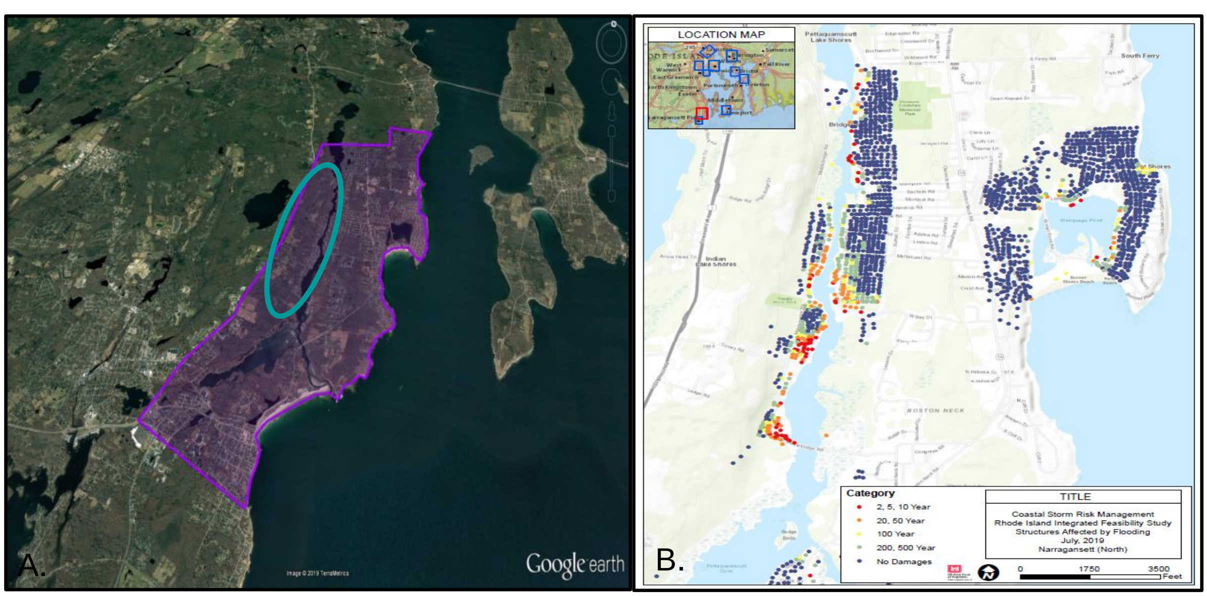

Figure 3-4: **A.** The 100-year floodplain in the Narragansett study area. **B.** Structures affected by flooding in the Narragansett study area

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 3-5**). 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 3-5: The placement of the surge barrier in Middle Bridge on the Narrow River

Newport - Wellington Levee/Floodwall: 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 3-6**). 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.

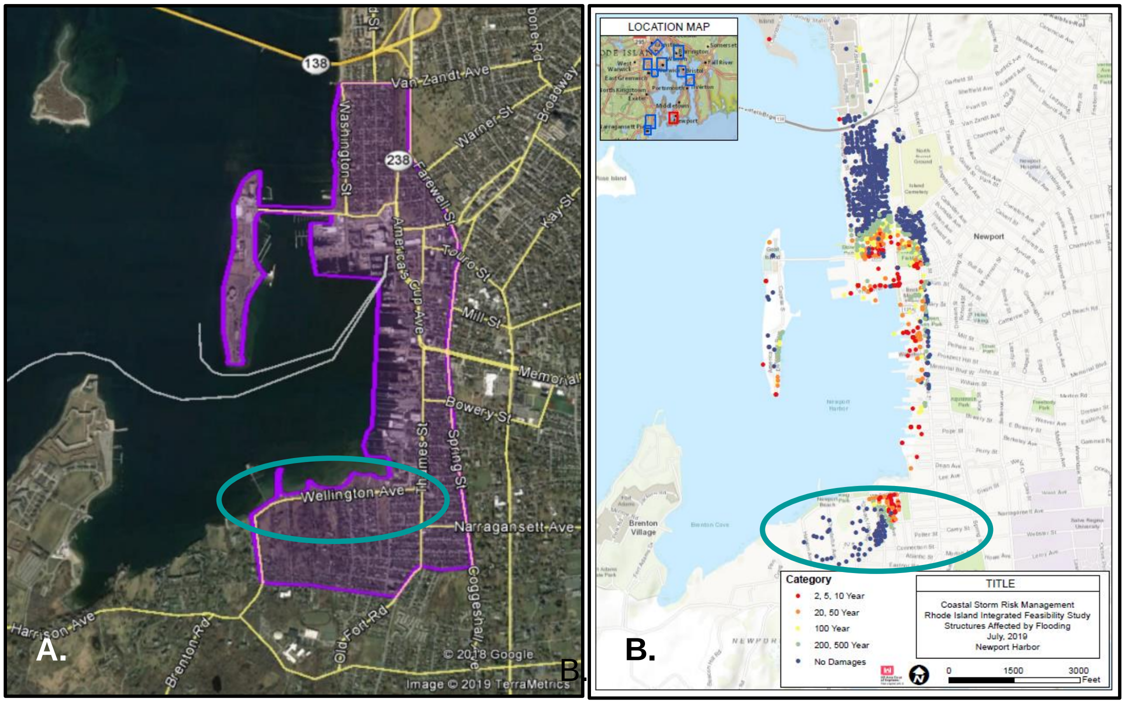

Figure 3-6: A. The 100-year floodplain in the Newport Downtown – Wellington Avenue study area. **B.** Structures affected by flooding in the Newport Downtown - Wellington Avenue study area

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 3-7**). 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.

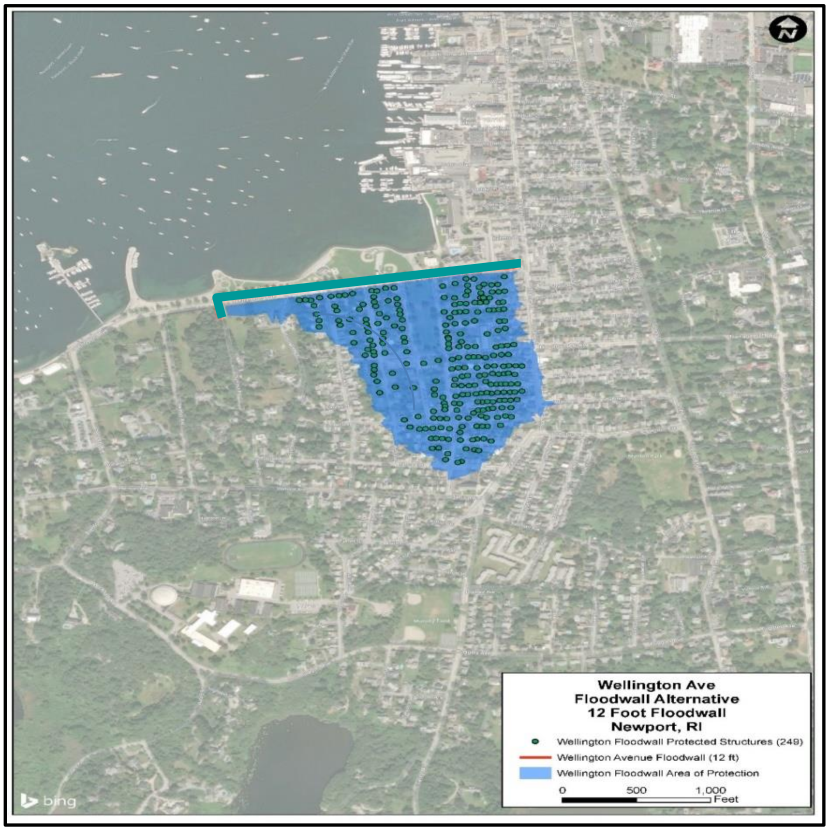

Figure 3-7: The placement of the floodwall in the Newport Downtown Wellington Avenue and the area and structures that would be protected by the wall

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 3-8**). 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.

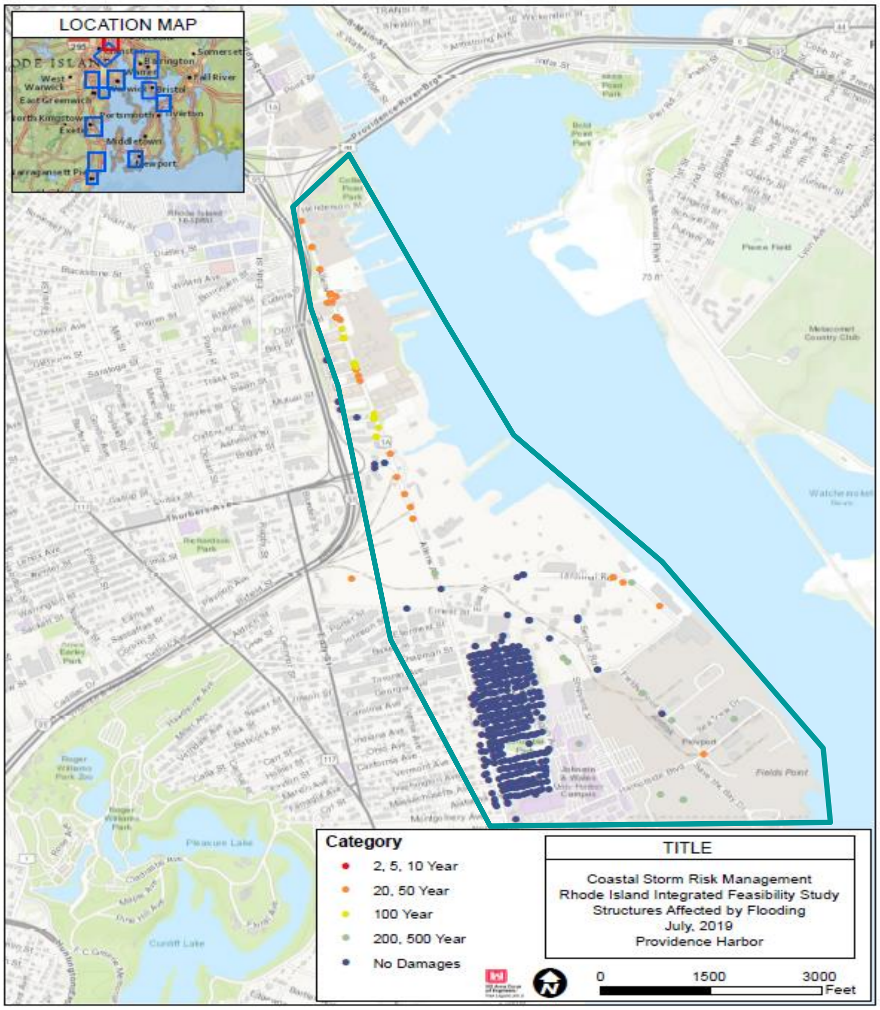

Figure 3-8: The Port of Providence study area and the structures that would be affected by flooding in the Port

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.

3.4.3.3 Nonstructural Alternatives

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 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 Target Elevation Design Height,
- Structures with current FFE within 1 foot of Target 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 3-4**). Non-residential structures include commercial properties and multi-family housing, such as apartment buildings. **Figure 3-9** shows the location of the Baseline Inventory.

Table 3-4: Baseline Inventory

Baseline Inventory	Structures
Residential	757
Non-Residential	276

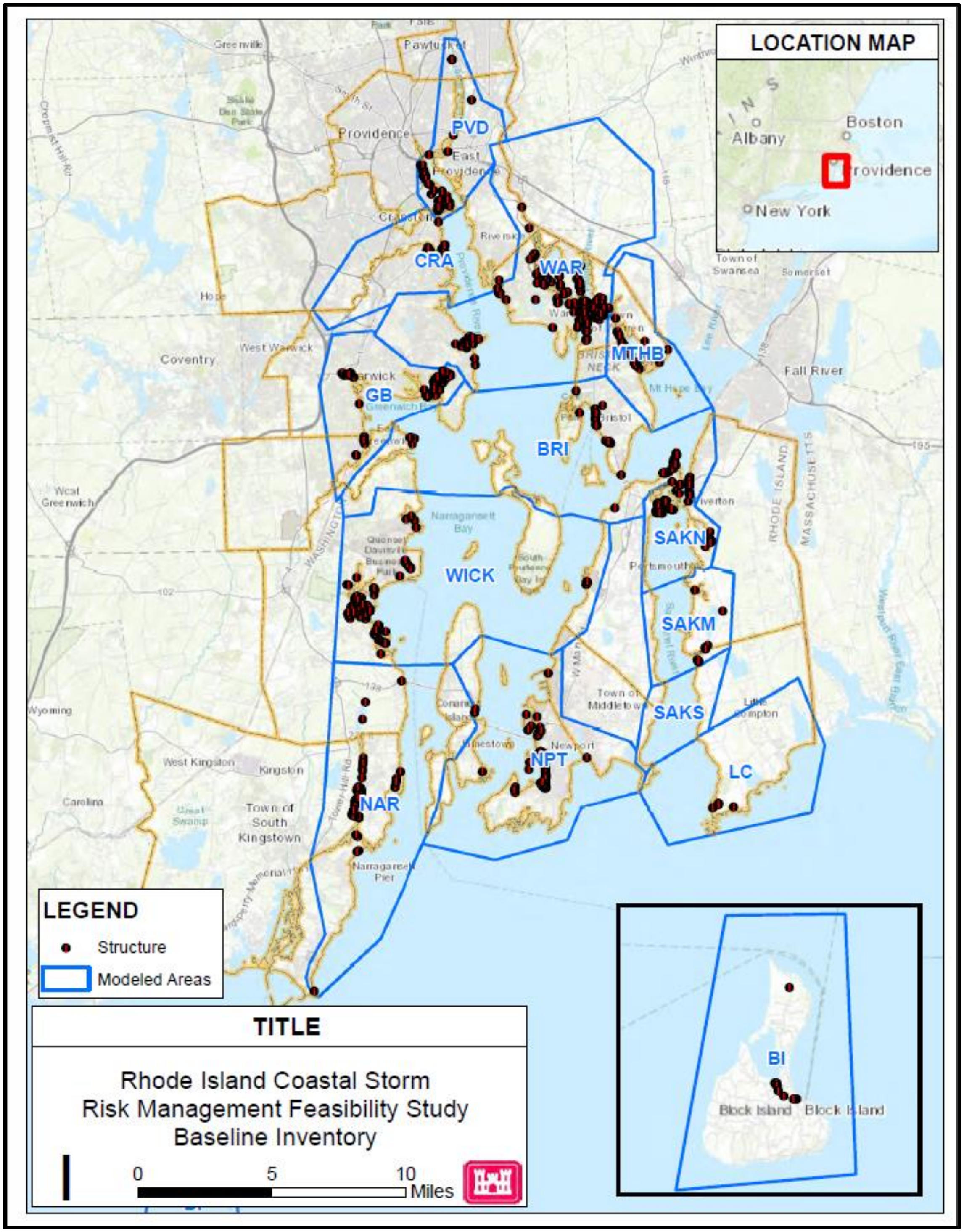

Figure 3-9: Structures include in the baseline inventory, with modeling areas illustrated in solid, blue lines and town boundaries shown in the dashed yellow lines

Structures included in the baseline inventory were divided into community groups using three criteria (**Table 3-5**). 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 3-9.**

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.

Thirty two community groups were developed from the baseline structure inventory and are shown in **Figure 3-10**. 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 3-5: 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 Kingston	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 Kingston	0	9
Sakonnet	Little Compton	3	2
Sakonnet North	Tiverton	8	0
Sakonnet South	Tiverton	10	0
Shawomet	Warwick	21	3
Shore Acres	North Kingston	7	0
South Kingston	South Kingston	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 Kingston	9	0
Wickford	North Kingston	113	40
Outliers		47	27

Figure 3-10: 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 + 1 ft + 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 Mean High High Water plus 1.5ft (King tide) using the intermediate SLC 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*.

Plan Nonstructural (NS)-A - 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 3-6**). Three (3) community groups had a BCR of 0.9. At this point in the study, there is a large amount of uncertainty in the initial economic analysis 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 3-6**, community groups that are highlighted in blue were part of Plan NS-A, while grayed-out groups were removed from the plan. Additional cost analysis will be completed prior to the final report to reduce the uncertainty. This plan included 494 total structures: 313 residential recommended for elevation and 181 non-residential recommended for floodproofing (**Figure 3-11**).

Table 3-6: Economic analysis for the Plan NS-A
(Fiscal Year 2021 price levels and 2.25% 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 Kingston	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

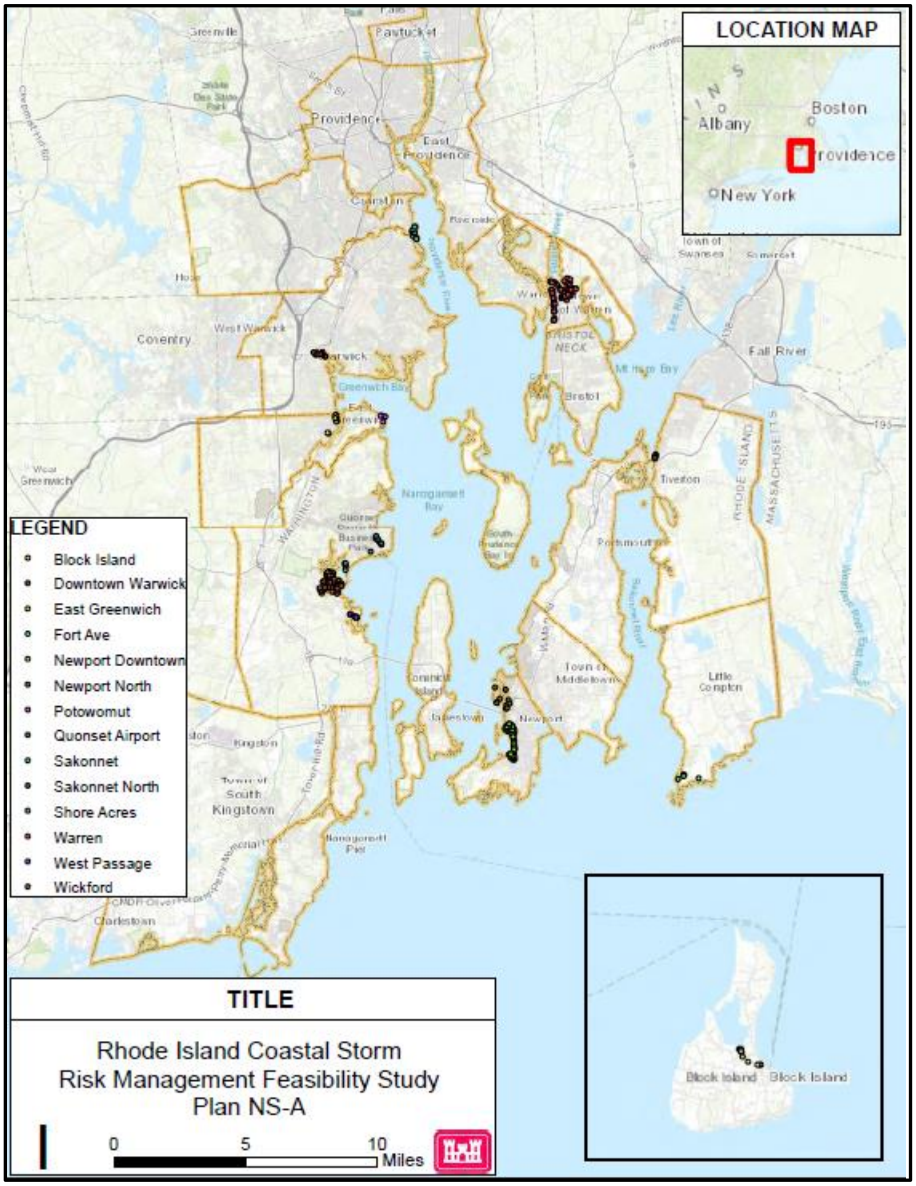

Figure 3-11: Elements of Plan NS-A

<u>Plan NS-B – Vulnerable Communities</u> - 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 3-12**). Four (4) community group are located in vulnerable communities. Two (2) of these communities (Quonset Airport & Fort Ave – highlighted in blue in **Table 3-7**) 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 3-7**) 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 3-7: Socially vulnerable communities included in Plan NS-B
(Fiscal Year 2021 price levels and 2.25% 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

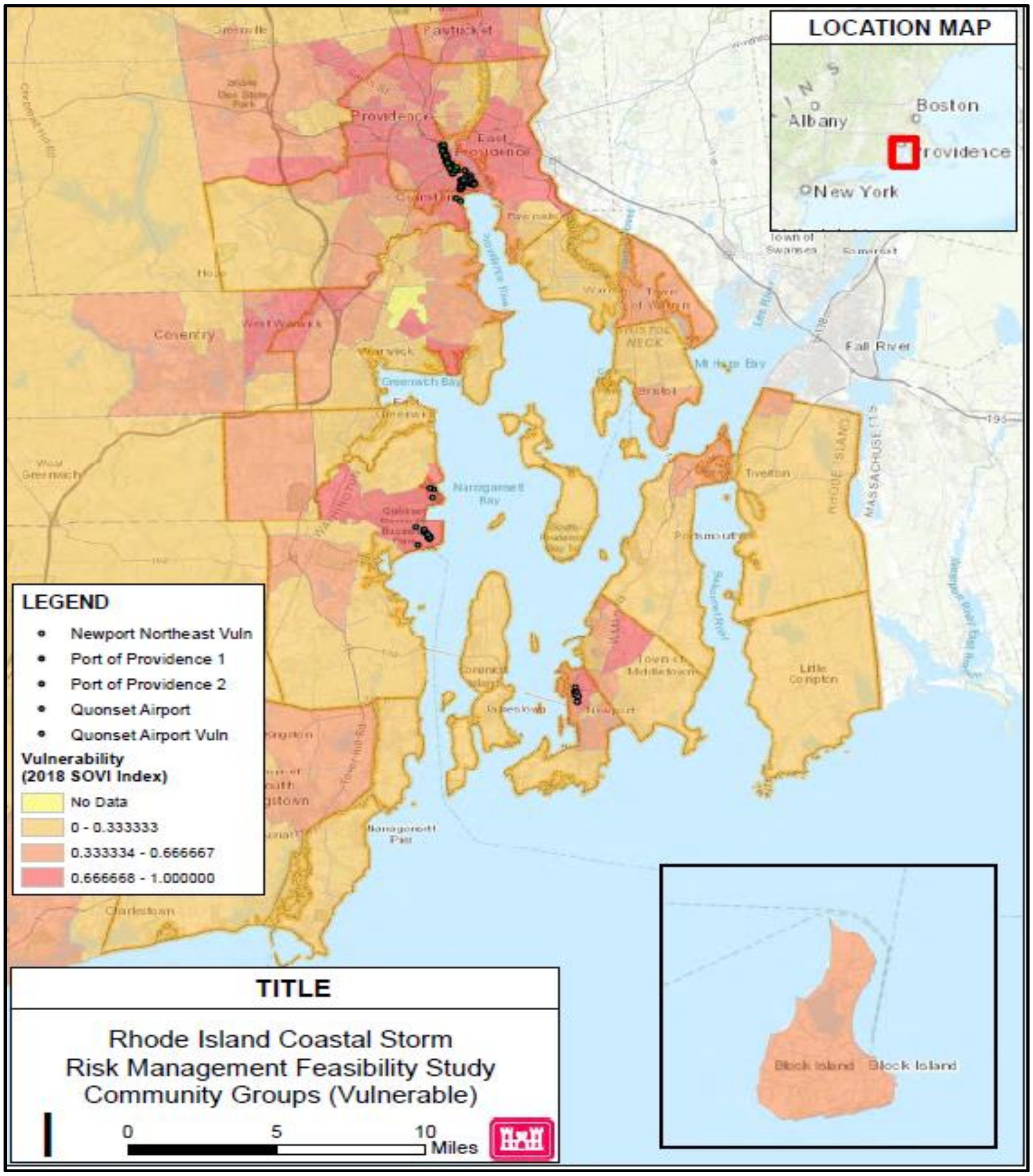

Figure 3-12: Community groups located in socially vulnerable communities

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 3-7**).

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 3-13**).

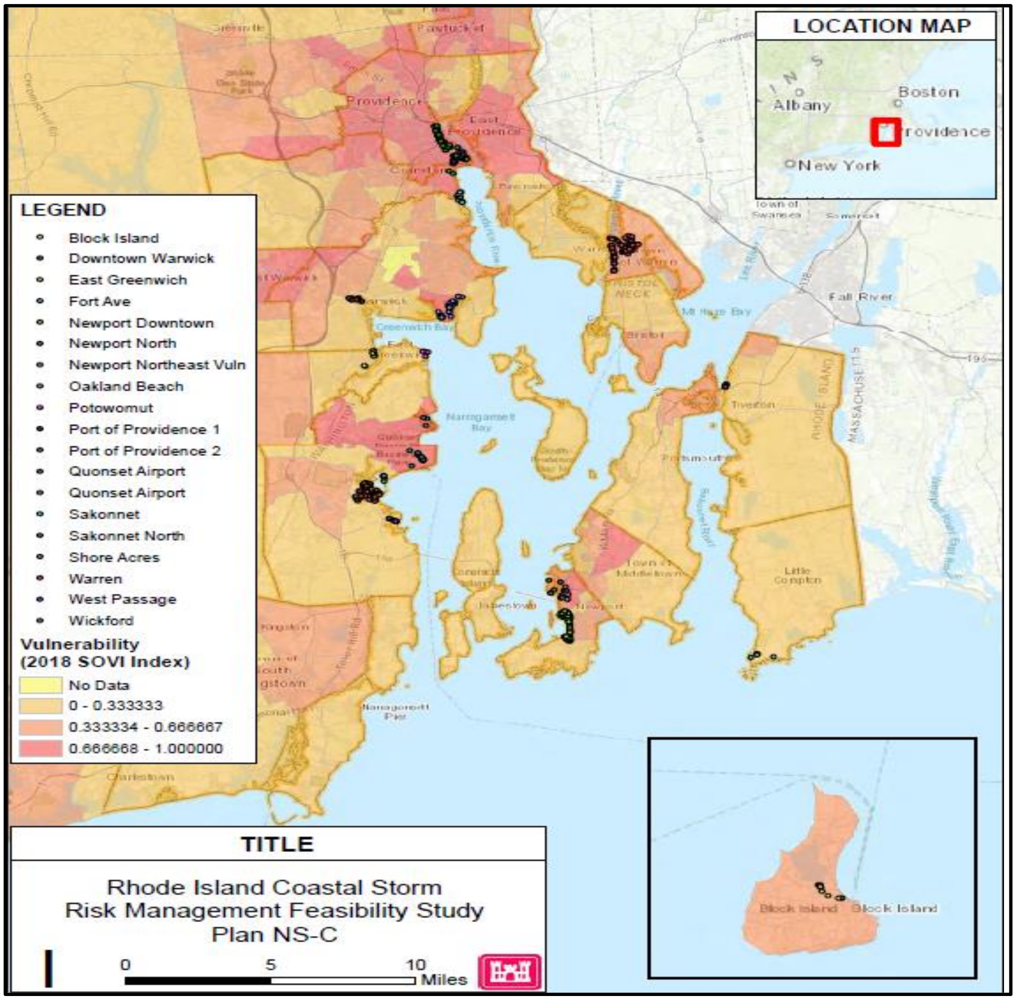

Figure 3-13: Elements of Plan NS-B

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 SLR and storm flooding. This was done by modeling inundation levels at Mean Higher High Water plus 1.5ft (King tide) using the USACE intermediate SLC model. Residential structures that were predicted to be inundated at this future flood level were recommended for acquisition, instead of elevations (**Figure 3-14**). 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 every King 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.

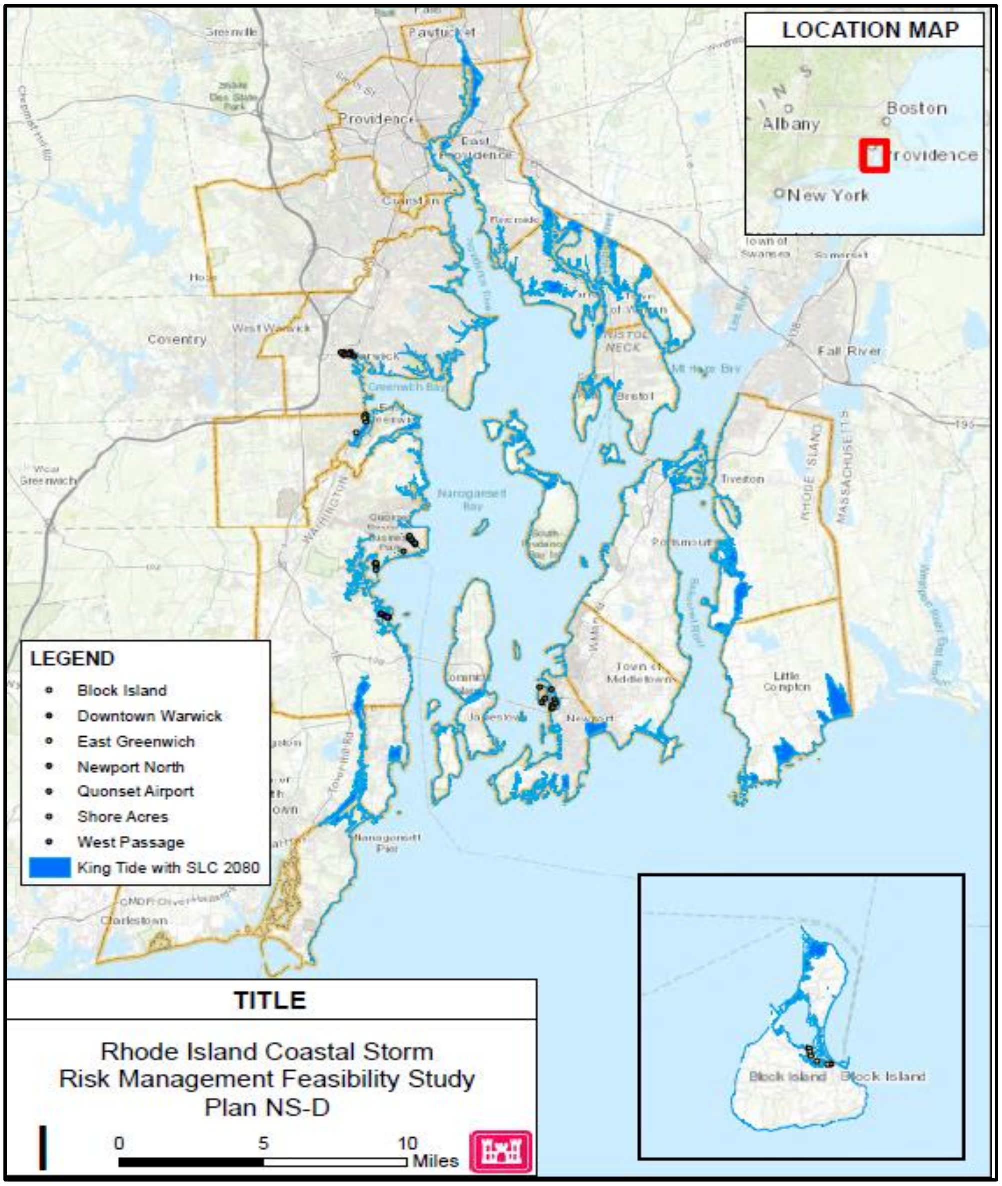

Figure 3-14: Elements of Plan NS-C

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 less than 0.9 (highlighted in blue in **Table 3-8**). Twenty-five (highlighted in gray in **Table 3-8**) 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 3-8**).

Table 3-8: Economic analysis for Plan NS-C
(Fiscal Year 2021 price levels and 2.25% 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
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

Community Group Name	Total Present Value Benefits ($)	Total Costs ($)	BCR	Acquisition	Elevation	Floodproof
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

3.4.3.4 Critical Infrastructure

Flood risk management measures for critical infrastructure were analyzed as part of this study. FEMA identifies critical infrastructure 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). 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 NFS for their concurrence. This 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. There 73 facilities preliminarily identified as critical within the designated 100-year floodplain. The list was refined down to 51 structures and/or sites to be considered for flood risk management measures (**Table 3-9**). Structures that were removed from the list included Federal facilities that could 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 and structures that were not truly critical infrastructure, such as bus stops. The formulation strategy was to provide flood risk management measures for critical infrastructure as part of the nonstructural component of the alternative plan selected for recommendation, regardless of whether or not the critical infrastructure is located in a community group that is otherwise economically justified. As such, critical infrastructure could be incorporated throughout the study area, including those areas where no other nonstructural action is recommended.

Preliminary costs and benefits for providing flood risk management for critical infrastructure were developed for those facilities identified to have associated buildings that could potentially be protected by dry floodproofing. From the refined list off 51 discussed previously, there were 43 critical infrastructure sites that had identified buildings on the premises. The preliminary costs associated with those 43 structures totaled $18.9 million. The total present value benefit based on damage to a general commercial building was estimated to be $4.9 million. Due to the individualized characteristics associated with critical infrastructure, further investigation on both the costs and benefits is necessary prior to making a decision regarding inclusion in the recommended plan for this study. A summary of the number and types of critical infrastructure considered in the analysis can be seen in the following table.

Table 3-9: Critical Infrastructure with in the 100-yr floodplain

Type of Critical Infrastructure	Number of Sites	Number of Buildings	Average Total Present Value Benefit Floodproofing of Building ($)	Average Total Cost Estimated for Floodproofing of Building ($)
Airport	1	0		
Electrical Power Station	4	3	373,715	206,928
Energy Production	1	0		
Fire/police	5	5	373,715	212,315
FP - Chemical/Single Building	2	2	373,715	58,042
Nursing Home	4	4	804,143	121,842
School	9	9	522,991	201,818
Sewer	22	18	363,391	42,275
Structural - WWTF	1	0		
Tank Farm	2	2	373,715	6,404
Total	**51**	**43**		

3.5 PLAN EVALUATION

3.5.1 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 Account (NED) discussed below in **Section 3.5.3.1**. 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.

3.5.2 P&G Constraints

The third screening iteration found in **Section 3.4.2** 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 subjective standards of these criteria.

3.5.3 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.

3.5.3.1 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 was completed for all structural alternatives that were included in the final array (**Table 3-10**). However, none of these alternatives had BCRs above 1.0 and they were all ultimately eliminated from consideration as they were not economically justified.

Table 3-10: Economic analysis of the final array of structural alternatives
(Fiscal Year 2021 price levels and 2.5% discount rate)

	Lower Barrier (Barrington/ Warren)	Upper Barrier (Barrington/ Warren)	Middle Bridge (Narraganset)	Wellington Ave (Newport Downtown)
Initial Construction	$496,112,000	$546,295,000	$100,166,000	$36,640,000
Total Mitigation[2]	$72,098,933	$68,335,940	$30,800,406	$0.00
Total First Cost	$568,210,933	$614,630,940	$130,966,406	$36,640,000
Total Maintenance[1]	$70,287,000	$110,935,000	$10,382,000	$0.00
Average Annual Cost	$24,142,000	$27,276,000	$5,138,245	$1,305,000
FWOP Present Value Damages	$483,330,000	$483,330,000	$35,407,132	$542,150,960
FWP Present Value Damages	$58,547,000	$107,651,000	$4,910,711	$517,684,386
Average Annual Benefits	$14,977,023	$13,245,712	$1,075,245	$862,644
Average Annual Net Benefit	-$9,164,977	-$14,030,288	-$4,063,000	-$442,356
Benefit-to-Cost Ratio	0.6	0.5	0.2	0.7

1 – Not included in the Total Project Cost Summary, which is included in **Appendix E**, *Cost Engineering*
2- Not estimated for Newport Downtown alternative

Table 3-11 provides the results of the cost/benefit analysis for the three (3) non-structural plans, while **Table 3-12** is a summary of the components that makes up each plan. All of the nonstructural plans have a BCR above 1.0. Plan NS-A maximizes Net Benefits and is therefore the NED Plan.

Table 3-11: Economic summary of the nonstructural plans
(Fiscal Year 2021 price levels and 2.25% discount rate)

Plan	Total Project First Costs ($)	Annual Average Benefit ($)	Annual Average Cost ($)	Net Benefits ($)	BCR
NS-A	188,000,000	9,730,000	6,770,000	2,960,000	1.4
NS-B	237,000,000	10,360,000	8,530,000	1,830,000	1.2
NS-C	30,000,000	1,170,000	1,070,000	100,000	1.1

Table 3-12: 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

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

3.5.3.2 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, and environmental justice 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. A complete assessment of the environmental impacts of the proposed plans is provided in **Section 4.0** of this 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.

3.5.3.3 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 political 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-D 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 3-15**) shows the SVI across the study area.

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

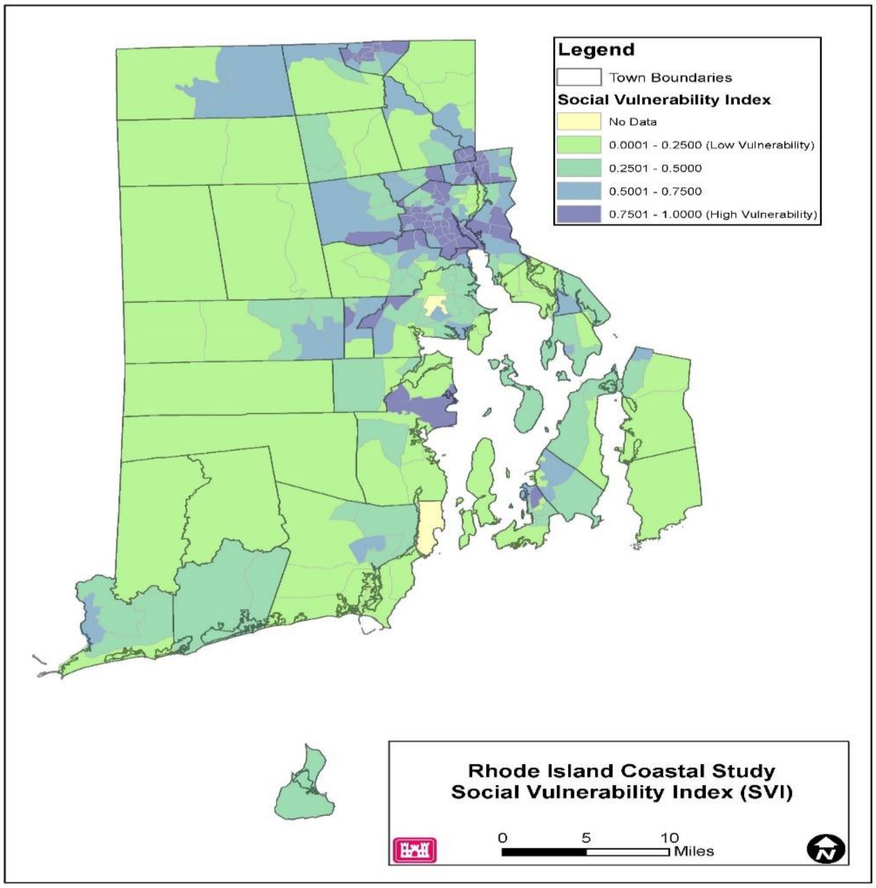

Figure 3-15: Social Vulnerability Index for the Rhode Island coastline

3.5.3.4 Regional Economic Development

The 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.

3.5.3.5 System of Accounts Assessment

Table 3-13 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 first cost associated with each alternative. Since RED is calculated as a multiplier of total cost, the comparison of alternatives for plan selection can be made using this information without actually calculating the RED for each alternative. Additional information on how RED benefits were estimated can be found in Section 8 of the **Appendix C**, *Economic and Social Considerations*.

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 3-13**. 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.

Table 3-13: System of accounts analysis

Alternative	NED ($)	RED ($)	OSE			EQ		
			Value	Pros	Cons	Value	Pros	Cons
Wellington Perimeter (Newport)	-440,000	36.6M	1	•Maintains communities, local roads and utilities.	•Localized Benefits •Does not protect socially vulnerable communities.	1	No Significant Impacts	•Effects to aesthetics
Warren River Surge Barrier (Upper)	-14,030,000	614.6M	1	•Maintains communities, local roads and utilities.	•Localized Benefits •Does not protect socially vulnerable communities.	-3	No Significant Impacts	•Effects to wetlands and fish passage.
Warren River Surge Barrier (Lower)	-9,165,000	568.2M	1	•Maintains communities, local roads and utilities.	•Localized Benefits •Does not protect socially vulnerable communities.	-3	No Significant 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	None
Middle Bridge Protection (Narragansett)	-4,063,000	131M	1	•Maintains Communities	•Localized Benefits •Does not protect socially vulnerable communities.	-3	No Significant Impacts	•Effects to wetlands, eelgrass, and fish passage. •Located near a wildlife sanctuary.
NS - Plan A	2,960,000	181M	2	•Benefits on regional scale •Maintain communities •Includes some vulnerable communities	•Does not reduce risk for local roads and utilities.	1	No Significant Impacts	No Significant Impacts
NS - Plan B	1,830,000	228M	2	•Benefits on regional scale •Maintain communities •Includes all vulnerable communities	•Does not reduce risk for local roads and utilities.	1	No Significant Impacts	No Significant Impacts
NS - Plan C	100,000	29M	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 Impacts	No Significant Impacts

SECTION 4.0 ENVIRONMENTAL EFFECTS*

The NEPA process is intended to ensure Federal agencies consider the environmental impacts of their actions in their decision-making process and take actions that protect, restore, and enhance the environment. The USACE complies with the requirements of the CEQ regulations (40 CFR 1500-1508) and the USACE regulations (33 CFR 230) for implementing NEPA. An Environmental Assessment (EA) is prepared by the Federal agency, which provides information concerning potential environmental effects of a proposed action for determining whether to prepare an environmental impact statement or a Finding of No Significant Impact (FONSI). 40 CFR 1508.1(h); 33 CFR 230.10–230.11. An effect is a consequence of a federal action that could occur from modifying the existing environment due to a proposed action or alternative. Effects can be beneficial or adverse and can include either short-term or permanent consequences.

4.1 NATURAL ENVIRONMENT

4.1.1 Wetlands

Individual structure elevations or floodproofing would not result in any impacts to wetlands adjacent to the study areas described in Section **2.3.1.1.** The location of structures and existing lots would not change as a result of implementation of either measure (elevation or floodproofing). Existing wetlands would continue to be protected by state and federal laws and their contribution to flood storage capacity would not be altered. Construction equipment used for residential elevations or floodproofing would access sites using existing roads and driveways. Best Management Practices (BMPs), including soil erosion controls, would be implemented to ensure wetlands in the vicinity of construction sites are protected.

4.1.2 Protected Areas

The properties targeted for elevations and floodproofing do not exist within protected areas, as described in **Section 2.3.1.2**; therefore, those areas will not be impacted.

4.1.3 Federal Threatened and Endangered Species

Endangered roseate terns and threatened NLEBs are identified as potentially present within the project area. The project area does not support suitable breeding habitat or feeding habitat for roseate terns. The proposed project involves modifications to buildings within the existing footprint of the structure. Therefore, no effect on roseate tern is anticipated.

No known maternity roost trees exist within Rhode Island (C. Brown, personal communication, March 4, 2021), but because no surveys have been conducted to determine the presence/absence of the NLEB in the project area, it is assumed that the NLEB could be present and may utilize mature trees and the surrounding forest habitat for roosting. No trees are expected to be removed as part of project activities, but if it is necessary then the proposed action is not likely to adversely affect the threatened NLEB for the following reasons in accordance with the January 14, 2016, USFWS final 4(d) rule (50 CFR §17.40(o)):

- No purposeful take will occur except to protect human life and property and;
- In order to avoid incidental take of NLEBs, no trees within 0.25 miles of a known hibernaculum will be cut and;
- No known occupied maternity roost trees or trees within a 150-foot radius from a maternity roost tree will be cut or destroyed during the pup season (June 1 through July 31).

Consultation with the USFWS is on-going to ensure that all reasonable measures are taken to avoid, minimize, and/or mitigate any adverse impacts to Federally listed species.

4.1.4 State Listed Threatened and Endangered Species

State listed plants, insects, birds, and turtles are not expected to be adversely affected by the proposed action. Given the highly developed nature of the project area and the fact that construction is targeted to the footprint of existing buildings, suitable habitat for rare species is not expected to be present. BMPs will be incorporated into project planning to ensure that sediment runoff does not impact any rare plants that may abut the properties targeted for elevation and floodproofing. Noise during construction will be short-term and commensurate with other levels of construction noise.

4.1.5 Fish and Wildlife Resources

Wildlife resources may be temporarily disturbed during project implementation. The most abundant species in the project area are likely to be habitat generalists that are tolerant of development. Increased noise and heavy machine activity could cause their displacement or disruption in foraging within the immediate vicinity of the construction. However, these temporary effects are not likely to be lasting or substantial. Avian species are expected to avoid the construction area and return after completion of the construction. BMPs would be implemented to ensure that runoff or debris from construction sites would not affect fish. Therefore, fish and wildlife resources are not likely to be significantly affected by elevating or floodproofing residential or nonresidential structures.

4.1.6 Terrestrial Habitats

No impacts to terrestrial habitat are expected as a result of the proposed action. The properties selected for elevation and/or floodproofing are existing structures, and no new structures are expected to be built as a result of the project.

4.2 PHYSICAL ENVIRONMENT

4.2.1 Topography, Geology and Soils

Individual structure elevations and floodproofing would result in insignificant, long-term topographic changes to individual lots. These minor changes include the installation of supports for home-elevating structures, such as pilings or raised concrete foundations. These elements would be installed where the existing building foundations are located. The proposed plan would result in impacts to soils on the properties as construction equipment is brought in implement the project. Changes to building utilities may also occur as the vertical position of the structures are elevated, which could include earthwork if access to underground lines is required. These short and long-term changes to topography and soil are not considered significant, because they would occur on lots actively used as residences or nonresidential buildings. Existing rights-of-way and open access areas, such as lawns, driveways, and parking lots, would be used for construction equipment access.

No impacts would occur to the geology with the implementation of the proposed action. Prime farmland soils would not be affected. According to 7 CFR 657.5, *Identification of Prime Farmland Soils*, areas that are already developed cannot be considered prime farmland. All areas under consideration under the proposed action are populated with existing structures. Construction equipment access would be contained to managed lawns, rights-of-way, driveways, and or parking lots. There would be no foreseeable impact to farmland soils.

4.2.2 Groundwater Resources

Elevating and floodproofing individual structures would not result in short-term or long-term impacts to groundwater resources. Protecting utilities associated with the structures would reduce the risk of flood-related contaminant releases to the environment. However, accidental non-point source discharges (i.e., spills) that occur during construction could result in temporary negative effects to groundwater resources. To reduce or eliminate the potential of impacts, BMPs, spill response plans, and the means to control and recover product, such as spill kits, would be required during project implementation. Incidental release of contaminants during storm events may continue to occur and could negatively affect groundwater resources in the project area, however structures that are elevated or flood proofed are expected to be less vulnerable to such effects.

4.2.3 Surface Water

The proposed plan would have positive impacts on surface water bodies, even though the plan does not include any in-water work or direct modification of channels, flow rates, or water quality. Many structures in the study area towns, including North Kingstown, Narragansett, and Warren, are adjacent to surface water bodies. Future flooding events could result in the release of contaminants and debris into the waterways from these properties. Floodproofing and elevating structures would have a net positive impact on adjacent rivers and streams by reducing the number of structures vulnerable to flooding. Individual structure elevations or floodproofing would not have any long-term, negative impacts on adjacent surface water resources or their classifications. However, the implementation of the project could result in temporary effects to resources, such as accidental non-point source discharges (*e.g*., petroleum products) during construction. Although small, isolated, and temporary accidental discharges are not anticipated to result in significant effects to surface water resources, measures, such as BMPs and spill response plans, would be implemented to reduce or eliminate the risk of contaminating surface water resources. Surface waters will continue to be protected by existing local, state, and federal laws, and the contributions of surface waters to flood events are expected to remain the same over the period of analysis.

4.2.4 Floodplains

EO 11988, *Floodplain Management, 24 May 1977*, requires that Federal agencies avoid, to the extent possible, adverse impacts associated with the occupancy and modification of floodplains and to avoid support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities."

The *Water Resources Council Floodplain Management Guidelines for implementation of EO 11988*, as referenced in ER 1165-2-26, requires an eight (8)-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to, or are within the floodplain. The eight (8) steps and project-specific responses to them are summarized below.

Table 4-1: Analysis of Compliance with EO 11988

EO 11988 Step	Project Specific Response
Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).	The proposed action is within the base floodplain.
If the action is in the base floodplain, identify and evaluate practicable alternatives to the action or to location of the action in the base floodplain.	Practicable measures and alternatives were formulated and evaluated using USACE guidance, including nonstructural measures such as floodproofing, elevations, and buy-outs.
If the action must be in the floodplain, advise the general public in the affected area and obtain their views and comments.	The draft IFR/EA will be released for public review and coordinated with agency officials.
Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial floodplain values. Where actions proposed to be located outside the base floodplain would affect the base floodplain, impacts resulting from these actions should also be identified.	The project would not alter or impact the natural or beneficial floodplain values. Nonstructural measures would impact existing structures and prevent future damages to those structures. No additional land located in the floodplain would be disturbed. The proposed action would not affect the timing or magnitude of flooding in downstream reaches.
If the action is likely to induce development in the base floodplain, determine if a practicable non-floodplain alternative for the development exists.	The proposed action would not encourage additional development in the floodplain, because all properties available for development have been developed. The project provides benefits solely for existing development.
As part of the planning process under the P&G, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial floodplain values. This should include reevaluation of the "no action" alternative.	The proposed action would not induce development in the floodplain. **Sections 3 and 5** of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.
If the final determination is made that no practicable alternative exists to locating the action in the floodplain, advise the general public in the affected area of the findings.	The draft and final IFR/EA will be publicly available documents. The final IFR/EA will include the final determination.

4.2.5 Cultural Resources

The APE for this project includes structures identified for non-structural measures to include elevation and floodproofing measures to reduce coastal storm risk. In addition to the structures themselves, the surrounding footprint and any associated access, storage and staging areas are considered part of the APE and will be assessed as part of the identification and evaluation of historic properties.

The northernmost structures (eight (8) properties) selected for nonstructural measures on Block Island are located in close proximity to recorded archaeological sites around the edges of the Great Salt Pond and estuary ponds, such as Harbor Pond, which are included in the Great Salt Pond Archaeological District. Elevation or floodproofing of these structures would need to be preceded by archaeological testing to determine if historic properties would be impacted by these measures. The remaining four (4) properties are within the Old Harbor Historic District, located south of Harbor Pond, which has several archeological sites recorded along the shore. Further assessment of these areas would be required during the PED phase as part of the overall identification of historic properties. Archaeological sensitivity is generally high on Block Island, especially near the Great Salt Pond.

In Narragansett, four (4) sites have been determined eligible, based on the report findings and acceptance of the 2010 SHPO report, for the NRHP and approximately 83 percent of the town was assessed as having sensitivity for Native American and Euro-American archaeological sites at the time of this survey in 2010 (Cherau et al. 2010:59). Two (2) of the NRHP sites may be in the vicinity of the three (3) properties in Narragansett, and further research is required to determine proximity and location.

The Camp Cronin archaeological site (RI-2852) in Narragansett is located along the shore to the south and east of the three (3) properties selected for nonstructural measures in Narragansett. Although this Native American site was located in a favorable location for occupation by prehistoric people, extensive soil disturbance resulted in a recommendation that this site is not eligible for listing in the NRHP (Waller and Leveillee 2016:203). However, as the three (3) properties are close to areas of high archaeological sensitivity, further assessment will be required during the PED phase of the study.

At this point, the USACE cannot fully determine the CRSM Feasibility Study's effects on historic properties. When effects on historic properties cannot be fully determined prior to approval of an undertaking, the USACE may enter into a Programmatic Agreement (PA) (36 CFR 800.14(b)(1)(ii)). The USACE is preparing a PA that 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 NHPA. The PA allows the USACE to complete the necessary historic and archaeological surveys during the follow-on PED phase of the project, once the nonstructural measures and identified properties have been confirmed.

The PA, entitled "*Programmatic Agreement among the United States Army Corps of Engineers, New England District and the Rhode Island State Historic Preservation Officer regarding the Rhode Island Coastline Coastal Storm Risk Management Project in Barrington, Bristol, Cranston, East Cranston, East Greenwich, Little Compton, Narragansett, Newport, Now Shoreham, North Kingstown, Tiverton, Warren, and Warwick, Rhode Island*" is in development and currently under review .When complete, it will be submitted to the Rhode Island State Historic Preservation Officer (RI SHPO), along with any other consulting parties, for review and concurrence.

Therefore, pursuant to 36 CFR 800.4(b)(2), and 36 CFR 800.14(b)(1)(ii), USACE defers final identification and evaluation of historic properties until after project approval when additional funding becomes available during the PED phase, and through execution of an approved PA. The RI SHPO is expected to concur with this determination. The Advisory Council on Historic Preservation will also be contacted regarding development of the PA relevant coordination and the signed PA will be included in the final IFR/EA.

There are historic districts and properties listed in the NRHP within, or in the vicinity of the APE, in Barrington, Bristol, Cranston, East Greenwich, Newport, New Shoreham (Block Island) North Kingstown, Warren, and Warwick. Nonstructural alternatives such as elevation, relocation and floodproofing could also impact historic structures and the associated archaeological footprint of both individual buildings and districts as a whole. Impacts to historic properties will be taken into account through implementation of the provisions in the PA.

4.2.6 Climate and Climate Change

The proposed action is not expected to mitigate or exacerbate changes to the climate. Short-term increases in greenhouse gases during construction will occur due to the use of diesel-powered construction equipment. However, these increases will be short-term, and construction is anticipated to only minorly contribute to the overall amount of greenhouse gases released to the environment when compared with other sectors (USEPA, 2021d). By reducing future damages, the project would reduce future carbon emissions associated with disaster recovery and cleanup.

4.2.7 Hazardous, Toxic and Radioactive Waste

There will be a beneficial long-term impact to the environment from elevating or floodproofing structures. This is because HTRW releases that would otherwise occur because of flooding of the structures would decrease or be eliminated. For short-term impacts, the presence of HTRW will be assessed for each structure proposed for elevation or floodproofing during the design phase of the project. Measures will be undertaken to secure the site (e.g., disconnect utilities, avoid underground tanks, etc.) prior to the commencement of construction activities. Therefore, no short-term impacts will occur from implementation of the proposed action.

4.2.8 Air Quality

The entire state of Rhode Island is in attainment with the NAAQS for all six (6) criteria pollutants. As such, a conformity review is not required. The proposed action will produce temporarily localized emission increases from the diesel and gas-powered construction equipment working onsite. The localized emission increases from the diesel and gas-powered equipment will last only during the project's construction period and then end when the project is over. Thus, any potential impacts will be temporary.

4.2.9 Greenhouse Gases

The primary GHG emitted by diesel-fueled engines is carbon dioxide (CO_2) (USEPA 2021d). The project is estimated to generate approximately 83,000 metric tons of CO_2 (see USEPA Greenhouse Gas Equivalent Calculator, www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator). The GHG emissions associated with the project are temporary and insignificant compared to the more than 11 million metric tons of CO_2 generated in Rhode Island in 2016 (latest data available) (RIDEM 2019a).

4.2.10 Noise

With implementation of the proposed action, there would be negative short-term impacts from noise due to use of construction equipment. There will be no long-term impacts.

4.3 BUILT ENVIRONMENT

4.3.1 Land Use

Implementation of the proposed action will have no negative short- or long-term impacts to land use. Implementation of the proposed action is not expected to significantly induce future development in the adjacent residential areas, because most, if not all, of the developable areas are already developed.

4.3.2 Aesthetic and Scenic Resources

Implementation of the proposed action will have negative short-term impacts to aesthetics and scenic resources. Over the short-term, there will be an increase in construction equipment and vehicles in the area, which is generally not considered visually appealing. The long-term impacts of the proposed action will be positive due to a reduction in future storm damage to existing properties.

4.3.3 Recreation

The implementation of the proposed action will have no short-term or long-term impacts to recreation because structure elevations and floodproofing are located on private properties. All recreation sites will be accessible during and after construction.

4.4 ECONOMIC ENVIRONMENT

4.4.1 Socioeconomic and Demographics

Socioeconomic effects are anything that alters the way in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society. Socioeconomic effects also include cultural impacts involving changes to the norms, values and believes. Implementation of the TSP would positively affect the socioeconomics of the project area and surrounding communities over the long term since project implementation would reduce the risk of loss of life and property due to flooding events. The TSP is not expected to have a negative effect on socioeconomics. The TSP is not expected to have no short-term or long-term impacts on the demographics within the study area.

4.4.2 Economy and Unemployment

Construction of the TSP could provide temporary positive benefits to the community as workers may be hired from the local area or workers from outside of the community would be expected to utilize local businesses during the construction phase. The TSP would bring additional money into the community and benefit the community. USACE has determined that the project implementation would not have a negative effect upon socioeconomics within the study area of Vermont

4.4.3 Environmental Justice

Environmental Justice is the fair treatment and meaningful involvement of all people, regardless of race, color, national origin or income with respect to the development, implementation and enforcement of the environmental laws, regulations and policies. EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* directs federal agencies to address disproportionately high adverse human health or environmental health effects of their actions on minority and low-income populations to the greatest extent practicable and permitted by law.

Implementation of the proposed nonstructural TSP would positively affect environmental justice by benefitting low-income residents who live within the focused study areas. The TSP includes two (2) community group that have been identified as being socially vulnerable. Low-income residents who currently living within that flood zone continue to experience recurring flooding in their homes. The elevation of residential structures would reduce the risk of loss of life and property due to flooding events, while nonresidential floodproofing would reduce property damage. However, certain environmental justice variables would not change with the implementation of either the TSP. These include indices for particulate matter (PM) 2.5, Ozone, Diesel PM, Air Toxics Cancer Risk, Respiratory Hazards, Traffic Proximity and Volume, Lead Paint, Superfund Proximity, Hazardous Waste Proximity, and Wastewater Discharge.

4.4.4 Structure Inventory

The TSP is not expected to have any no short-term or long-term impacts on the structure inventory. The study area is currently densely developed and the only anticipated changes to the structure inventory would be the result of redevelopment.

SECTION 5.0 PLAN COMPARISON AND SELECTION

5.1 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 3.14**. Plan NS-A maximized NED benefits and 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 significant 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, so the comparison of a structural and nonstructural plans provides limited insight when trying to compare the structural and nonstructural plans.

5.2 IDENTIFICATION OF THE NED PLAN

The National Economic Development (NED) plan is Plan NS-A.

5.3 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.

SECTION 6.0 THE TENTATIVELY SELECTED PLAN

6.1 PLAN REFINEMENT

To be as inclusive as possible and reduces the greatest amount of flood risk in the study area, two (2) refinements were made to Plan NS-A. These refinements resulted in the inclusion of an additional 39 structures to the TSP. 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 0.9 when both elevations and floodproofing were considered, the BCR for non-residential floodproofing alone was greater than 1.0. **Table 6-1** 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 6.1: Community groups with BCRs above 1.0 for the non-residential floodproofing

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
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

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. Of the 74 structures, 14 were justified, with BCR's greater than 0.9. These structures were added to the TSP plan.

6.2 PLAN COMPONENTS

The TSP is an entirely nonstructural plan that includes 533 total structures – 323 residential recommended for elevation and 210 non-residential recommended for floodproofing (**Table 6-2**). There are five (5) facilities that are identified a critical infrastructure currently included in the TSP (2 schools, 2 fire/police, and 1 building at an electric power station).

Table 6-2: The Tentatively Selected Plan

Community Group Name	Total Costs ($)	Residential Structures (Elevations)	Non-Residential Structures (Floodproofing)	Total Structures
PLAN NS-A				
Block Island	4,384,340	2	10	12
Downtown Warwick	6,467,902	5	12	17
East Greenwich	3,737,150	0	10	10
Fort Ave	4,113,303	9	3	12
Newport Downtown	47,593,332	85	38	123
Newport North	4,678,317	3	8	11
Potowomut	1,591,669	5	0	5
Quonset Airport	4,498,113	0	9	9
Sakonnet	1,747,901	3	2	5
Sakonnet North	2,775,778	8	0	8
Shore Acres	2,542,409	7	0	7
Warren	42,055,525	64	49	113
West Passage	3,187,718	9	0	9
Wickford	51,653,408	113	40	153
Plan Refinement - Floodproofing only				
Barrington	5,454,351	0	11	11
Bristol Downtown	2,989,720	0	8	8
Narragansett	1,121,145	0	3	3
Shawomet	1,121,145	0	3	3
Plan Refinement - Outliers				
Outliers		10	4	14
TOTAL		**323**	**210**	**533**

6.3 PLAN ACCOMPLISHMENTS

Table 6-3 shows the accomplishments for the TSP as compared to the original problems and opportunities that were developed during early coordination with the NFS and local stakeholders.

Table 6-3: Accomplishments of the Tentatively Selected Plan in relation to the initial problems and opportunities

Focused Study Area	Problems	Opportunities	TSP 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 TSP 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 TSP 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	TSP 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 TSP 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 TSP 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 TSP address Portsmouth.
Providence	• Low-lying industrial/commercial port is vulnerable to flooding during extreme storm events, potentially threatening regional critical infrastructure including but not limited	• Reduce flooding of the port area • Floodproof critical infrastructure in the port area	Due to the complexity and challenges outlined in this report, alternatives to reduce coastal storm risk at the Port of Providence should be the subject of its own study.

Focused Study Area	Problems	Opportunities	TSP Accomplishments
	to wastewater treatment facilities, and home heating oil terminals		
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 TSP 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 TSP 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 TSP 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 TSP 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 TSP 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,

6.3.1 National Economic Development Benefits

The total project first cost for the TSP is $197 million. The average annual cost is $7.1 million and average annual benefits are $10.4 million, resulting in net benefits of $3.3 million and a benefits-to-cost ratio of 1.5. The complete cost and benefit analysis for the TSP plan is presented in **Table 6-4.** The project costs were calculated using the Fiscal Year (FY) 2022 Federal discount rate of 2.25% and FY 2021 price levels.

6.3.2 RED benefit

The TSP would generate 85 full-time equivalence jobs, $7 billion in labor income, $13 billion in output, and $8.9 billion in total value added. For the state of Rhode Island as a whole, the construction stimulus would generate approximately 120 Full Time Equivalent jobs, $11 billion in labor income, $19 billion in output, and $13.7 billion 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.

A detailed discussion of the RED analysis can be found in **Appendix C,** *Economic and Social Considerations*.

6.3.3 Environmental Quality Benefit

The TSP 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 5.0** of this report. The environmental benefits of the TSP plan would include a reduction of the release of 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.

6.3.4 Other Social Effects Benefits

The OSE benefits of the TSP 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 TSP plan would also have socioeconomic benefits, specifically environmental justice, within the project area. The TSP includes three (3) community groups that is considered socially vulnerable. Implementation of TSP would improve Environmental Justice because it would result in the reduction of risk of loss of life and property due to flooding events for socially vulnerable residents. The TSP would also provide benefits to vulnerable populations, by shortening recovery periods after a flooding event. The TSP 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 TSP 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.

6.4 COST ESTIMATE

Total project first costs of the TSP at FY 2021 price levels are approximately $197 million (**Table 6-4**). The total fully funded cost of the project, with escalation through the mid-point of construction, is approximately $247 million. Nonstructural costs were developed using information from FEMA and nonstructural projects recently completed in vicinity of the study area.

Table 6-4: Economic summary of the Tentatively Selected Plan
(Fiscal Year 2021 price levels and 2.25% discount rate)

Federal discount rate FY22[1] = 2.25%, OCT 2020 Price Levels, 50-Year Period of Analysis, Figures in $ Except BCR	
Project First Costs	
Construction[2]	120,130,000
Preconstruction Engineering & Design (PED)	20,254,000
Construction Management (CM)	5,480,000
Real Estate	6,120,000
Environmental Mitigation	0
Cultural Resource Mitigation	0
Contingency	44,983,000
Project First Costs Total[2]	**196,967,000**
Average Annual Costs	
Annualized First Costs[2]	7,060,000
Interest During Construction (IDC)	20,000
Total Average Annual Cost (AAC)	**7,080,000**
Average Annual Benefits (AAB)	10,420,000
Net Benefits	3,340,000
Benefit-Cost Ratio (BCR)	**1.5**

6.5 LANDS, EASEMENTS, RIGHTS-OF-WAYS, AND DISPOSAL

USACE projects require the NFS to provide all lands, easements, rights-of-way, relocations, and disposal areas (LERRD) 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. For structures of human habitation owners must sign a floodproofing agreement, which restricts alteration of the elevated structure below the targeted FFE. The NFS would be required to provide temporary relocation assistance benefits to tenants occupying eligible structures. Total LERRDs are estimated to be $14,450,000 for the TSP. Further discussion of the potential real estate requirements is detailed in **Appendix F,** *The Real Estate Report*.

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 (see **Section 6.7.4** for discussion of participation rates).

6.6 OPERATIONS, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION

Operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs are expected to be '*de minimis*' and will be confined to periodic site visits by the non-Federal sponsor; the property owner is ultimately responsible for maintenance of the project.

6.7 RISK AND UNCERTAINTY

6.7.1 Sea Level Change

The FWOP conditions and benefits for the TSP were developed employing the USACE intermediate SLC. Prior to selection of the final recommended plan, the benefits associated with that plan will be further evaluated using the USACE SLC scenarios, low and high. The benefits will then be compared to the project costs for the recommended plan.

6.7.2 Residual Risk

Residual risk is the risk that remains in the study area after the TSP 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 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 TSP from the risk in the FWOP condition.

Residual risk remains for nearly 11,500 structures in the 100-year floodplain; however, inundation damage is reduced by about 20 percent for the 100-year floodplain and approximately 70 percent for the structures included in the TSP (**Table 6-5**). More information on residual risk can be found in **Appendix C,** *Economics and Social Considerations.*

Table 6-5: Residual risk of the Tentatively Selected Plan

	100YR Floodplain FWOP		Plan NS-A.1		Residual		
Locality	Number of Structures at Risk	Total Present Value Damage ($)	Number of Structures Elevated or Floodproofed in TSP	FWP Present Value Damage Reduced by TSP ($)	Remaining Number of Structures at Risk	Total Remaining Present Value Damage ($)	Percent Damage Reduction
Barrington	3,555	68,358,069	11	5,818,260	3,544	62,539,808	9%
Bristol	345	65,045,922	8	3,630,072	337	61,415,850	6%
Cranston	522	13,564,690	11	2,710,191	511	10,854,499	20%
East Greenwich	16	32,567,198	10	16,110,150	6	16,457,048	49%
East Providence	90	13,928,015		0	90	13,928,015	0%
Jamestown	56	15,082,887		0	56	15,082,887	0%
Little Compton	58	7,645,408	5	1,837,250	53	5,808,158	24%
Middletown	36	96,176,509		0	36	96,176,509	0%
Narragansett	1,333	24,292,418	3	1,586,023	1,330	22,706,395	7%
New Shoreham	60	39,265,643	12	13,981,081	48	25,284,562	36%
Newport	680	467,967,258	134	128,819,281	546	339,147,977	28%
North Kingstown	549	151,467,813	178	66,047,605	371	85,420,208	44%
Pawtucket	2	487,336		0	2	487,336	0%
Portsmouth	892	57,335,789		0	892	57,335,789	0%
Providence	84	44,825,083		0	84	44,825,083	0%
South Kingstown	293	15,598,910		0	293	15,598,910	0%
Tiverton	196	31,063,501	8	2,413,607	188	28,649,894	8%
Warren	2,025	102,040,575	113	44,663,135	1,912	57,377,440	44%
Warwick	1,345	87,621,119	26	14,938,409	1,319	72,682,710	17%
				0			
Total	**12,137**	**1,334,334,144**	**519**	**302,555,065**	**11,618**	**1,031,779,079**	**23%**

6.7.3 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 TSP. The model estimated a total loss of life of 0.004% of the FWOP population, and approximately a 25% 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*.

6.7.4 Participation Rate Analysis

Participation in the project is voluntary because the TSP 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, will be 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.

While nonstructural measures are optional, acquisition or relocation are mandatory. However, these recommendations would require the use of eminent domain.

6.8 COST SHARING

Project First Cost is the constant dollar cost of the TSP 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 (PPA) 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 TSP First Cost was calculated to be $197 million, while the TSP Total Project Cost (Fully Funded) was determined to be $254 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 LERRDs. Total LERRDs are estimated to be $6,120,000 as shown in **Table 6-4**. The cost share apportionments for the Project First Costs and Total Project Costs are provided in **Tables 6-6** and **6-7** respectively.

Table 6-6: Project first cost (constant dollar basis) apportionment
(Fiscal Year 2021 price levels and 2.25% discount rate)

Project First Cost (Constant Dollar Basis)	$196,967,000
Federal Share (65%)	$128,000,000
Non-Federal Share (35%)	$69,000,000
Less: LERRD Credit	$4,920,000
Non-Federal Cash Contribution	$64,080,000

Table 6-7 Total project cost (fully funded) apportionment
(Fiscal Year 2021 price levels and 2.25% discount rate)

Total Project Cost (Fully Funded)	$254,236,000
Federal Share (65%)	$165,000,000
Non-Federal Share (35%)	$89,000,000

6.9 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 6-8: Estimated Design and Construction Schedule

Action	Estimated Start Date
Agency Decision Milestone	Apr-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
Final Report to Congress	May-23
Start Plans and Specifications (Design Phase)	Dec-23
Execute PPA with Non-Federal Sponsor	Dec-23
Finalize Plans and Specifications for Contract	Dec-25
Real Estate Certification for Contract	Jan-26
Ready to Advertise Contract	Mar-26
Award Construction Contract with Notice to Proceed	Mar-27

6.10 ENVIRONMENTAL COMMITMENTS

No project specific commitments have been made and none are anticipated to be made throughout the course of the study.

6.11 PROJECT-SPECIFIC CONSIDERATIONS

There are no additional project specific considerations that have not been addressed in previous sections of this report.

6.12 USACE ENVIRONMENTAL OPERATING PRINCIPLES

First introduced in 2002 and later reissued in 2012, the USACE Environmental Operating Principles (EOPs) were developed to ensure that the USACE missions include totally integrated sustainable environmental practices (USACE 2021). The EOPs provided corporate direction to ensure the workforce recognized the USACE's role in, and responsibility for, sustainable use, stewardship, and restoration of natural resources across the Nation.

Since their introduction, the EOPs have instilled environmental stewardship across business practices from recycling and reduced energy use at USACE and customer facilities to a fuller consideration of the environmental impacts of USACE actions and meaningful collaboration within the larger environmental community.

The EOP relate to the human environment and apply to all aspects of business and operations. They apply across Military Programs, Civil Works, Research and Development, and across the USACE. The EOPs require a recognition and acceptance of individual responsibility from senior leaders to the newest team members. Re-committing to these principles and environmental stewardship will lead to more efficient and effective solutions and will enable the USACE to further leverage resources through collaboration. This is essential for successful integrated resources management, restoration of the environment and sustainable and energy efficient approaches to all USACE mission areas. It is also an essential component of the USACE's risk management approach in decision making, allowing the organization to offset uncertainty by building flexibility into the management and construction of infrastructure.

The USACE's EOPs were considered in the planning process of this study. In particular, the planning process and selection of the TSP leveraged scientific, economic and social knowledge to assess the effects of USACE actions, met the USACE's responsibility and accountability under applicable law for activities which may impact human and natural environments, worked collaboratively with individuals, groups and agencies interested in USACE's activities and employed an open, transparent process. The TSP provided a mutually supported economic and environmentally sustainable solution to flood risk reduction within the project area.

6.13 VIEW OF THE NON-FEDERAL SPONSOR

During the TSP milestone meeting, which was held on November 17, 2021, the RI CRMC, project's NFS, expressed support for the TSP and continuation of the feasibility analysis.

6.14 ADDITIONAL ANALYSIS TO BE COMPLETED

Between the present and the Agency Decision Milestone meeting, the PDT will continue to complete the analysis descripted below.

Cultural Resources and the PA - For the communities included in the TSP, additional research is required to identify known archaeological sites and determine historic and archaeological sensitivity. This research and assessment will continue through the remainder of the study and, particularly during the PED phase when further identification, assessment, and evaluation will take place in coordination with the RI SHPO and consulting parties. The PDT will continue to develop and execute the PA. This document is currently under review and will be completed prior to the conclusion of this IFR/EA.

Sea Level Change Analysis - The FWOP conditions and benefits for the TSP were developed employing the USACE intermediate SLC. Prior to selection of the final recommended plan, the benefits will be further evaluated using the USACE SLC scenarios, low and high. The benefits will then be 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 will be investigated to find properties located in the 100-yr floodplain that store, generate, treat, or dispose of large amounts of hazardous material. These properties will be identified using Resource Conservation and Recovery Act data and spill records. To reduce the potential environmental damage caused by hazardous materials released due to coastal storm events and related flooding, these structures will be considered for inclusion in the recommended plan.

Additional Economic Tasks – The economic team members will revise the economic analysis by applying historical value to depreciated replacement values. Also, the design structure height used for elevations will be optimized by analyzing one (1) foot higher and lower than that included in the TSP. In addition, the floodplain associated with the structures included in the plan will be reviewed to ensure net benefits are not maximized by including only structures located in a higher frequency storm event floodplain than the 100-year floodplain.

Refinement Cost and Real Estate Information – Addition work must be completed to refine the cost and real estate information and calculate accurate project costs.

Critical Infrastructure Analysis – Currently, the TSP includes five (5) buildings that have been identified as critical infrastructure (2 schools, 2 fire/police, and 1 building at an electric power station) within the 100-year floodplain. Due to the individualized characteristics associated with critical infrastructure, further investigation on both the costs and benefits will be necessary prior to making a decision regarding inclusion of critical infrastructure facilities in the recommended plan. The PDT will contact the facility managers to determine if the property is appropriate for inclusion in the project. They will also investigate protection measures that would be implemented to protect facilities, where floodproofing would not be effective, such as electrical substations and sewer lift/grinder stations.

Participation Rate Analysis - The TSP includes elevation of residential homes and floodproofing of non-residential structures throughout the study area. The total project cost prepared for Congressional Authorization is the estimated cost to implement 100% of the structures recommended for nonstructural measures. However, while project economics confirmed that 100% of these structures comprise a plan that reasonably maximizes NED benefits, these measures will be implemented on a voluntary basis. The structure owners may or may not choose to participate in the project. Prior to the final recommended plan, a sensitivity analysis will be completed to examine the economic impact of different participation rates. The PDT will also inform stakeholders of the uncertain BCR for voluntary nonstructural measures

Building Code and Maximum Height for Elevating Structures – Additional analysis will be completed based on lessons learned from the Pawcatuck Coastal Storm Risk Management project during design phase. Issues encountered during design revolve around town/municipality specific zoning ordinances limiting overall structure height in relation to the average existing grade around the structure and proposed structure encroachments into property line yard setbacks associated with new stairs/landings. The analysis will focus on minimizing the risk of structures falling out of the program due to specific zoning ordinances that limit maximum building heights or yard setbacks where there is no mechanism for relief from the ordinances in the form of a special permit process or variance when elevating properties above flood elevations.

Further, additional analysis is necessary to refine how many structures require elevation more than 12 feet from their current elevations. Elevating structures beyond 12 feet from their current elevations requires additional structural modification resulting in higher overall costs, which should be captured during the feasibility phase.

Project Performance - Project performance is discussed in **Appendix B**, *Coastal Engineering.* This analysis will be further refined as the TSP is optimized, and project performance across all three (3) USACE SLC scenarios will be reported in the final report.

SECTION 7.0 ENVIRONMENTAL COMPLIANCE*

7.1 ENVIRONMENTAL COMPLIANCE TABLE

Table 7-1: Summary of primary federal laws and regulations

Legislation	Citation	Compliance
Clean Air Act	42 U.S.C. 7401 et seq.	The state of Rhode Island is in attainment with all criteria pollutants.
Clean Water Act	33 U.S.C. 1251 et seq.	There is no in-water work. A Clean Water Act (Section 401) Water Quality Certificate is not required.
Coastal Zone Management Act	16 U.S.C. 1451	A preliminary Coastal Zone Management Consistency Determination is provided in Appendix A2.
Endangered Species Act of 1973	16 U.S.C. 1531 et seq.	USACE is in consultation with the USFWS.
Environmental Justice in Minority and Low Income Populations	EO 12898	USACE performed an analysis and has determined that a disproportionate negative impact on minority or low-income groups in the community is not anticipated.
Fish and Wildlife Coordination Act	16 U.S.C. 661 *et seq*.	USACE is in consultation with the USFWS.
Magnuson-Stevens Act Fishery Conservation and Management Act	16 U.S.C. 1855	No in-water work. An EFH Assessment is not required.
National Environmental Policy Act of 1969	42 U.S.C. 432 *et seq*.	Preparation and circulation of the Draft IFR/EA partially fulfills requirements of NEPA. Full compliance shall be noted at the time the FONSI is issued.
National Historic Preservation Act of 1966	54 U.S.C. 300101 et seq	USACE is in consultation with the Rhode Island SHPO.
Protection of Wetlands	EO 11990	Avoidance of adverse impacts to wetlands satisfies compliance with this order.
Protection of Children from Environmental Health Risks and Safety Risks	EO 13045	The proposed action should not result in any adverse environmental or health impacts to children.

7.2 PUBLIC INVOLVEMENT

A 30-day public review will be part of the concurrent review process. Information describing the public review will be added to this section once the concurrent review has been completed.

7.2.1 Scoping

Early in the planning process, scoping meetings were held with representatives of the appropriate resource agencies to ensure that these stakeholders would understand the study and provide their input throughout the investigation. A list of agencies that were part of the scoping meetings are listed below in **Section 7.2.2**. Additionally, scoping meetings were held with the NFS and with representatives from the nineteen municipalities that were located withing the study area. These meetings produced a list of areas of special concern and idea on how to address the recurring flooding that those areas experienced.

7.2.2 Agency Coordination

Coordination with appropriate resource agencies has been ongoing as part of the planning process. Agencies that have been contacted or will be contacted as part of the project include:

Federal
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
National Marine Fisheries Service

State of Rhode Island
Rhode Island Department of Environmental Management
Rhode Island Coastal Resources Management Council
Rhode Island Historical Preservation and Heritage

Tribal Governments
Narragansett Tribe
Wampanoag Tribe of Gay Head (Aquinnah) Tribe
Mashpee Wampanoag Tribe

Local Governments
Town of Little Compton
Town of Aquidneck Island (Middletown)
City of Newport
Newport Department of Utilities
Town of Jamestown
Town of Narragansett
Town of North Kingstown
Town of Tiverton
Town of Portsmouth
Town of Bristol
Town of Warren
Town of Barrington
City of Warwick
City of Cranston
City of East Providence
Town of East Greenwich
Town of New Shoreham

Other Stakeholders
Provport
Narragansett Bay Commission
Save the Bay

The Nature Conservancy, Rhode Island Chapter

Coordination letters and correspondence with the agencies listed in this section are provided in **Appendix A,** *Environmental*.

7.2.3 Tribal Consultation

Pursuant to 36 CFR 800.4(b)(2), and 36 CFR 800.14(b)(1)(ii), the USACE defers final identification and evaluation of historic properties until after project approval, when additional funding becomes available during the next project phase, and through execution of an approved PA. The RI SHPO is expected to concur with this determination. The Advisory Council on Historic Preservation will be contacted regarding development of the PA. The final approved PA would be included in the final IFR/EA.

EO 13175, *Consultation and Coordination with Indian Tribal Governments, November 6, 2000,* directs Federal agencies to coordinate and consult with Native American tribal governments whose interests might be directly and substantially affected by activities on federally administered lands. To comply with legal mandates, the Narragansett Tribe, the Aquinnah Tribe, the Mashpee Wampanoag Tribe, the state recognized tribes that are affiliated historically with the geographic region of the study area will be invited to consult on the proposed project.

7.2.4 List of Statement Recipients

The list will be provided once the Public and Agency review has been completed.

7.2.5 Public Comments Received and Responses

Public comments will be added to the feasibility report once the Public and Agency review has been completed.

SECTION 8.0 DISTRICT ENGINEER RECOMMENDATION

I recommend that the coastal storm risk management project, as described in this report for coastal areas in Rhode Island, be authorized in accordance with the reporting officers' recommended plan, with such modifications as in the discretion of the Chief of Engineers may be advisable.

- Elevation of 323 Residential Structures
- Floodproofing 210 Non-Residential Structures

I also recommend that, due to the complexity and challenges outlined in the IFR/EA, alternatives to reduce coastal storm risk at the Port of Providence should be the subject of its own study.

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

Federal implementation of the project for coastal risk management includes, but is not limited to, the following required items of local cooperation to be undertaken by the non-Federal sponsor in accordance with applicable Federal laws, regulations, and policies:

a. Provide 35 percent of construction costs, as further specified below:

1. Provide, during design, 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide all real property interests, including placement area improvements, and perform all relocations determined by the Federal government to be required for the project;

3. Provide, during construction, any additional contribution necessary to make its total contribution equal to at least 35 percent of construction costs;

b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might reduce the level of coastal storm risk reduction the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

c. Inform affected interests, at least yearly, of the extent of risk reduction afforded by the project; participate in and comply with applicable Federal floodplain management and flood insurance programs; prepare a floodplain management plan for the project to be implemented not later than one year after completion of construction of the project; and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with the project;

d. Operate, maintain, repair, rehabilitate, and replace the project or functional portion thereof at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal laws and regulations and any specific directions prescribed by the Federal government;

e. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project to inspect the project, and, if necessary, to undertake work necessary to the proper functioning of the project for its authorized purpose;

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

g. Perform, or ensure performance of, any investigations for hazardous, toxic, and radioactive wastes (HTRW) that are determined necessary to identify the existence and extent of any HTRW regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601 et seq, and any other applicable law, that may exist in, on, or under real property interests that the Federal government determines to be necessary for construction, operation and maintenance of the project;

h. Agree, as between the Federal government and the non-Federal sponsor, to be solely responsible for the performance and costs of cleanup and response of any HTRW regulated under applicable law that are located in, on, or under real property interests required for construction, operation, and maintenance of the project, including the costs of any studies and investigations necessary to determine an appropriate response to the contamination, without reimbursement or credit by the Federal government;

i. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the owner and operator of the project for the purpose of CERCLA liability or other applicable law, and to the maximum extent practicable shall carry out its responsibilities in a manner that will not cause HTRW liability to arise under applicable law; and

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4630 and 4655) and the Uniform Regulations contained in 49 C.F.R Part 24, in acquiring real property interests necessary for construction, operation, and maintenance of the project including those necessary for relocations, and placement area improvements; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to higher authorities as proposals for authorization and implementation funding. However, prior to transmittal to higher authority, the sponsor, the states, interested federal agencies, and other parties will be advised of any modifications and with be afforded an opportunity to comment further.

Date: ___________________ ____________________________

John Atilano II
Colonel, U.S. Army
District Engineer
New England District
US Army Corps of Engineers

SECTION 9.0 LIST OF PREPARERS

Table 9-1: List of Preparers

Name	Discipline
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Christopher Hatfield	USACE - Planning
Jennifer Spencer	USACE - Economics (Team Leader)
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Marcos Paiva	USACE - Cultural Resources
Paul Morelli	USACE - GIS
David Sleeper	USACE - Structural Engineering
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John McSwiggin	USACE - Office of Counsel
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SECTION 11.0 LIST OF ACRONYMS AND ABBREVIATIONS

AEP	Annual Exceedance Probabilities
APE	Area of Potential Effect
BCC	Birds of Conservative Concern
BCR	Benefit Cost Ratio
BMPs	Best Management Practices
CAA	Clean Air Act
CAP	Continuing Authorities Program
CBRA	Coastal Barrier Resource Area
CDC	Center of Disease Control
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	Carbon Dioxide
CSO	Combined Sewer Overflow
CSRM	Coastal Storm Risk Management
CSVRs	Content-to-Structure Value Ratios
dBA	"A"-Weighted Decibels
EA	Environmental Assessment
EO	Executive Order
EOPs	Environmental Operating Principles
EQ	Environmental Quality
ER	Engineering Regulation
ESA	Endangered Species Act
FCSA	Feasibility Cost Sharing Agreement
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation
FONSI	Finding of No Significant Impact
FWOP	Future Without Project
FWP	Future With Project
FY	Fiscal Year
G2CRM	Generation 2 Coastal Risk Model
GIS	Geographic Information System
GHGs	Greenhouse Gases
HTRW	Hazardous, Toxic, and Radiological Waste
IDC	Interest During Construction
IFR/EA	Integrated Feasibility Report and Environmental Assessment
IPaC	Information for Planning and Consultation
Ldn	Day-Night Noise Level
LERRDs	Lands, easements, rights-of-way and relocations, and disposal/borrow Areas
LF	Linear Feet
LiDAR	Light Detection and Ranging
LIS DMMP	Long Island Sound Dredged Material Management Plan
MSL	Mean Sea Level
MMTCO2e	Carbon Dioxide Equivalent
NAA	No Action Alternative
NAAQS	National Ambient Air Quality Standards
NACCS	North Atlantic Coast Comprehensive Study
NAVD88	North American Vertical Datum 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NFS	Non-Federal Sponsor

NLEB	Northern long eared bat
NOAA	National Oceanic and Atmospheric Administration
NNBF	Natural and nature-based features
NHPA	National Historic Preservation Act
NPL	National Priorities List
NRC	National Research Council
NRHP	National Register of Historic Places
NTDE	National Tidal Datum Epoch
OMRR&R	Operation, maintenance, repair, rehabilitation and replacement
OSE	Other Social Effects
OTR	Ozone Transport Region
P&G	Principles and Guidelines, 1983
PA	Programmatic Agreement
PAL	Public Archaeology Laboratory
PED	Preconstruction Engineering and Design
PDT	Project Delivery Team
PL	Public Law
PPA	Project Partnership Agreement
RECONS	Regional Economic System
RED	Regional Economic Development
RIC	Rhode Island Coastline
RICRMC	Rhode Island Coastal Resource Management Council
RIDEM	Rhode Island Department of Environmental Management
RIGIS	Rhode Island Geographic Information System
RI HPHC	Rhode Island Historic Preservation and Heritage Commission
RI SHPO	Rhode Island Historic Preservation Officer
RSLC	Relative Sea Level Change
SAMP	Shoreline Change Special Area Management Plan
SFHA	Special Hazard Flood Zone
SIP	State Implementation Plans
SLC	Sea Level Change
SLR2	Intermediate Sea-Level Rise Scenario
SVI	Social Vulnerability Index
TRI	Toxic Release Inventory
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
WIS	Wave Information Study
WRDA	Water Resources Development Act
WWTF	Wastewater Treatment Facility