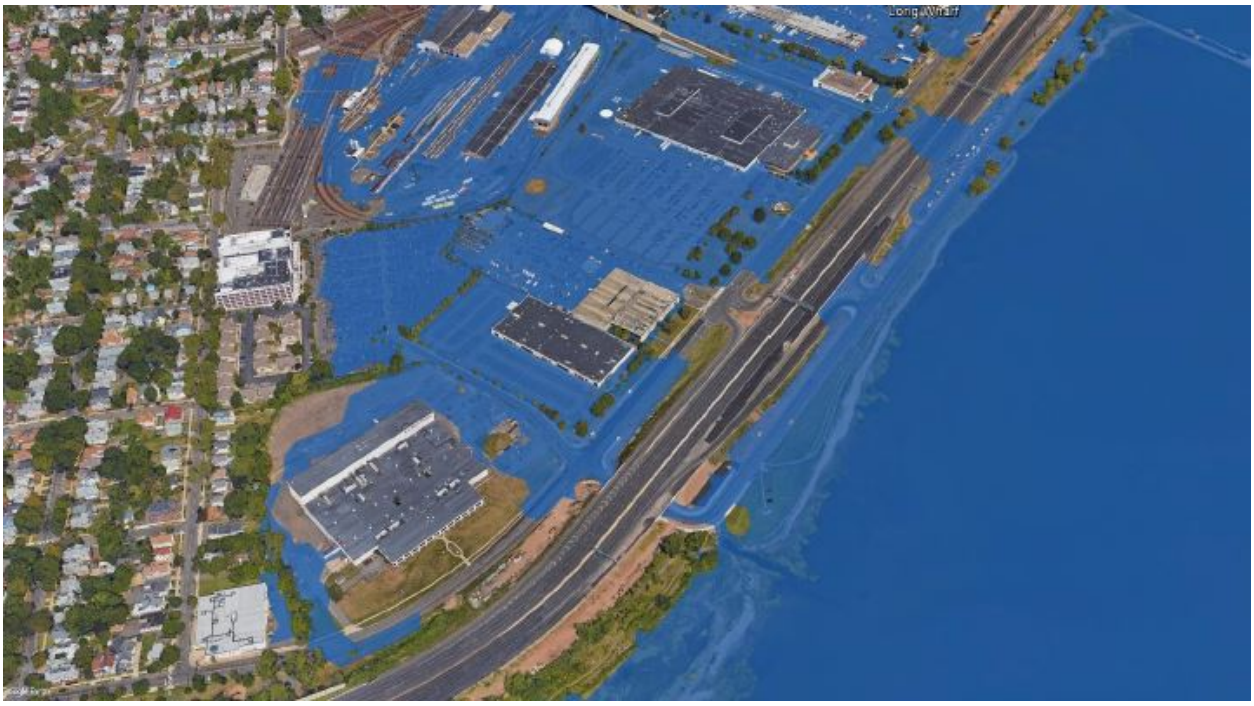
Fairfield & New Haven Counties, Connecticut
Coastal Storm Risk Management
Feasibility Study



(Long Wharf, New Haven, CT focused study area: predicted flooding associated with the 2016 1% annual chance exceedance flood event. Flood simulations performed by GZA GeoEnvironmental, Inc., 2017)

Draft Integrated Feasibility Report
& Environmental Assessment

December 2019

Connecticut
Department of Energy &
Environmental Protection

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

Fairfield & New Haven Counties, Connecticut

Coastal Storm Risk Management Feasibility Study

Draft Integrated Feasibility Report
& Environmental Assessment
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Draft Fairfield and New Haven Counties, Connecticut
Coastal Storm Risk Management Feasibility Study
and Environmental Assessment

EXECUTIVE SUMMARY

This Draft Integrated Coastal Storm Risk Management Feasibility Report and Environmental Assessment (IFR/EA) has been produced by the U.S. Army Corps of Engineers (USACE) in partnership with the state of Connecticut Department of Energy and Environmental Protection (CT DEEP), the non-Federal sponsor of this study.

This study is authorized in a resolution approved by the Committee on Transportation and Infrastructure of the United States House of Representatives, dated April 29, 2010. This resolution gives the Secretary of the Army the authority to "review the report of the Chief of Engineers on Land and Water Resources of the New England-New York Region, published as Senate Document No. 14, 85th Congress, 1st Session, and other reports to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, coastal storm damage reduction, coastal erosion, and other related purposes in the vicinity of the estuaries and shoreline of Fairfield and New Haven Counties, Connecticut."

The Congressionally authorized study area includes about 1,700 square miles in Fairfield and New Haven Counties in both coastal and riverine floodplains and includes agricultural/rural towns, moderately developed suburbs, and densely populated cities. The authorized study area borders Long Island Sound and the Atlantic Ocean. The study area includes numerous coastal communities which frequently experience coastal storm damages including the town of Fairfield and city of New Haven (see Figure ES-1). Coastal storm risk from hurricanes and northeasters threaten these waterfront communities. The most recent hurricane to significantly impact these areas was Hurricane Sandy in 2012.

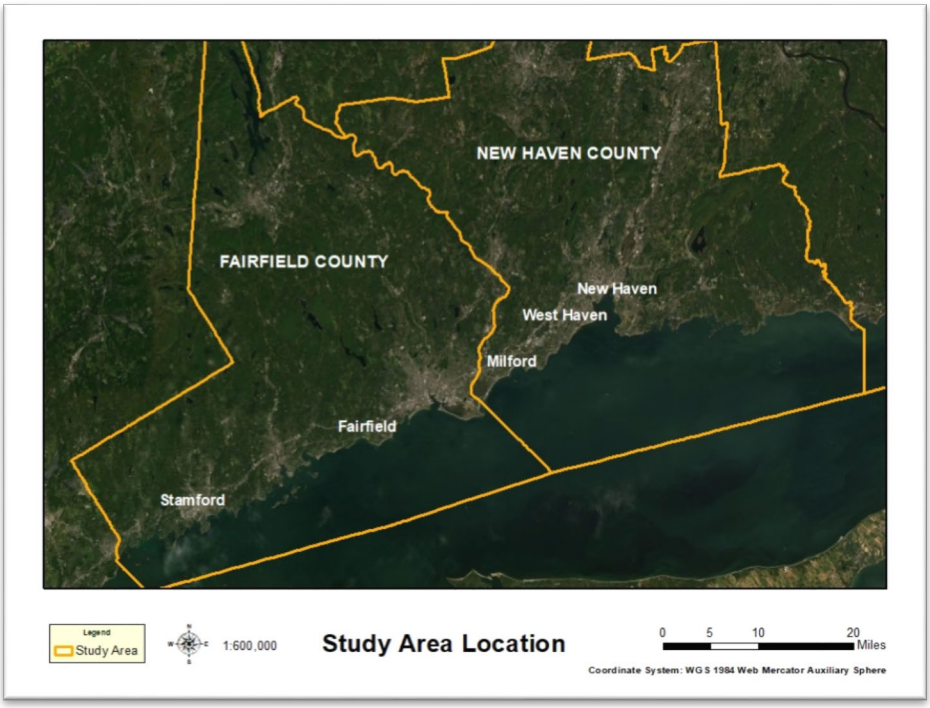

Figure ES-1: Authorized Study Area

Although the authorized study area covers two counties, this report focuses on a proposed coastal storm risk management project in the city of New Haven, Connecticut, in the developed waterfront area known as the "Long Wharf" area. The Long Wharf study area (Figure ES-1) contains more than 100 high value structures, the majority of which are classified as commercial. Key infrastructure includes the New Haven Rail Yard and Interstate 95, each of which dominates access in and around the city and surrounding region. The total value of New Haven's existing industrial and commercial inventory analyzed within the Long Wharf study area is estimated to be worth over $780 million.

Figure ES-2: Long Wharf Study Area, New Haven, Connecticut

At the start of this investigation, an extended study area was considered in both Fairfield and New Haven Counties. Five primary damage areas (Stratford, Milford, New Haven, West Haven, and Fairfield) were identified in partnership with the Regional Councils of Governments in Connecticut for initial review. Following site visits, the town of Fairfield and city of New Haven were selected for further consideration based on local level of interest, density of development, and vulnerability to coastal storm damages. Due to an extremely limited study budget, it was necessary for the Project Delivery Team (PDT) to take advantage of available data sets and past studies conducted within the two municipalities. Both Fairfield and New Haven had a substantial amount of high quality data and coastal studies and the study team used this information for study scoping efforts.

In early 2019, the study team provided a suite of initial coastal storm risk management solutions to the town of Fairfield and city of New Haven, Connecticut as part of the study planning efforts. In discussions with the town of Fairfield, it was agreed that the potential solutions would be too

costly for the community to support at this point in time. The developed alternatives for Fairfield would require a significant non-Federal investment (ranging approximately from $500-700 million), including the non-Federal responsibility and costs to acquire large tracts of privately-owned real estate, and a potentially large environmental mitigation component.

Following discussions with the municipalities, the decision was made at the USACE Tentatively Selected Plan (TSP) milestone in June 2019 to focus the costal storm risk planning efforts and this draft IFR/EA on development, evaluation, comparison, and selection of a proposed Federal project for the New Haven, Long Wharf area. The plan formulation process considered a range of structural and nonstructural measures to manage the risk of coastal storm damage in the Long Wharf study area. Through an iterative planning process, potential coastal storm risk management measures were identified, alternatives formulated, evaluated, and compared. Initial screening of alternatives identified structural, (floodwalls and closure structures) and nonstructural alternatives, (wet/dry flood proofing) that would reduce coastal storm risk for the Long Wharf area and potentially provide sufficient damage reduction benefits to support justification of a Federal cost-shared coastal storm risk management project.

Five coastal storm risk management alternatives and No Action were carried forward in the focused array of alternatives for further analysis. This included using the existing Interstate 95 embankment (alternative 3A), enhancing the I-95 embankment with a floodwall (alternative 3B), and building a floodwall along the shoreline of Long Wharf Park and Maritime Center (alternatives 4A and 4B). These alternatives also included a combination of closure structures, and pump stations, and potential nonstructural features. A stand-alone non-structural alternative (alternative 2) was also analyzed.

The annual benefits, annual costs, benefit to cost ratio (BCR) and annual net befits for each alternative were evaluated and compared using the FY 20 discount rate of 2.75% and October 2020 dollars (FY 21 price level) to identify the NED plan.

Economic evaluation of costs and benefits (damage reduction) of the five alternatives showed that the cost of the alternatives provided a positive BCR (i.e. a BCR >1.0) required for project justification.

Further evaluation and comparison to select an alternative showed that alternatives 2, 3A, 4A and 4B were not as economically or environmentally attractive as the enhanced I-95 embankment (alternative 3B). The net benefits were compared for each plan and alternative 3B was shown to be the plan that reasonably maximizes net benefits. Alternative 3B is the National Economic Development (NED) plan and this is also the TSP as it is the plan that reasonably maximizes net

annual benefits while minimizing impacts to the environment and is supported by the city of New Haven and CT DEEP.

The TSP, Alternative 3B, augments the existing Interstate 95 embankment in New Haven. Approximately 5,950 linear feet of floodwall with a top elevation of +15 feet North Atlantic Vertical Datum of 1988 (NAVD88) would be constructed along with 475 linear feet of deployable flood gates (closure structures). Five deployable road closure structures and two pump stations would be constructed along with potentially flood-proofing 14 structures within the Long Wharf Maritime Center which is located seaward of the I-95 embankment.

The non-Federal sponsor for the study is the CT DEEP. The non-Federal sponsor for project implementation has not been identified at this point in the study, but a non-Federal sponsor (or sponsors) for the project will be required for project implementation and will be identified prior to completion of the draft IFR/EA.

PERTINENT DATA

PROPOSED PROJECT AREA

The proposed project will provide coastal storm risk management to the Long Wharf study area in the city of New Haven, New Haven County, Connecticut. (As noted above, the original study reaches within the project area, included the communities of Fairfield, Stratford, Milford, West Haven, and New Haven). In partnership with the non-Federal sponsor, these study reaches were scoped down, prior to the TSP Milestone Meeting, to the city of New Haven Long Wharf area.)

TENTATIVELY SELECTED PLAN FEATURES

The TSP consists of five road closure structures (one at Long Wharf Drive approximately 60 feet wide by 4 feet high; one at Canal Dock Road approximately 130 feet wide by 5 feet high; one at Brewery Street approximately 65 feet wide by 2 feet high; two at Exit 46, (approximately 50 feet wide and 6-8 feet high); two pumping stations which would handle approximately 400-500 cubic feet of water per second (cfs); enhancement of the I-95 embankment with approximately 5,950 linear feet of "T-wall" type floodwall along with 475 feet of deployable closure structures; and potential floodproofing of commercial and residential structures seaward of the I-95 embankment. The proposed floodwall would be built to a height +15 feet NAVD88. This elevation was selected considering future annual exceedance probability water levels under the intermediate and high sea level change scenarios. Elevation +15 feet NAVD88 aligns well with both the 2074 1-percent annual exceedance probability water level under the intermediate sea level rise scenario (+13.02 feet NAVD88), with some allowance for wave action, and the 2074 1-

percent annual exceedance probability water level under the high sea level change scenario (+14.92 feet NAVD88) alone. Relative to the current FEMA designated Base Flood Elevation (VE Zone) at the proposed wall location of 13 feet NAVD88, elevation +15 feet NAVD88 allows for 2 feet of sea level rise. The TSP floodwall height will be refined and optimized following public review.

PROJECT COST

The "Project First Cost" estimate is broken out by cost component in Table E-1. The Project First Cost includes the initial construction, a risk-based contingency, pre-construction engineering & design, construction management, and lands, easements, right of ways, and relocation (LERRD) costs. The TSP initial construction Project First Cost is estimated at $164,612,000. Operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs associated with the TSP are estimated to be $1.65 million annually. For commercial properties potentially eligible for floodproofing, the owner of the property will be responsible for all costs associated with maintaining, repairing, rehabilitating and replacing the floodproofed structure. Costs for OMRR&R floodproofing efforts have not been calculated at this point in the study.

Table E-1. TSP, Project First Cost Summary,
(October 2020 Price Level)

Cost Account/Feature	**Cost ($)**
15 – Floodwall Structure	80,064,000
15 – Closure Structures	5,555,000
15 – Pump Stations	51,000,000
15 – General Conditions	13,621,000
Subtotals	150,240,000
01- LERRD	397,000
30 – Pre-Construction Engineering & Design (PED)	8,596,000
31 – Construction Management (S&A)	5,379,000
Total	164,612,000

REAL ESTATE REQUIREMENTS

Detailed discussion of the potential real estate requirements can be found in the Real Estate Report (Appendix F). Real estate (LERRD) requirements for the floodwall include permanent and temporary easements. The project will impact approximately 8 identified properties, the majority of which are owned by the City of New Haven or the CT Department of Transportation.

Non-structural floodproofing measures will be offered to owners of eligible commercial structures on a voluntary basis. For those structures that are determined to be eligible, the non-Federal sponsor will be required to obtain the real estate interests (in this case, temporary work area easements for construction, staging and storage areas, temporary relocation assistance benefits (tenants only), and permanent restrictive easements) for the project and their costs are then credited against the non-Federal share of the project.

ECONOMIC ANALYSIS

The Annual Benefit and Cost Summary of the TSP is provided in Table E-2. The Total First Cost is annualized over a 50-year period of analysis at the Fiscal Year 2020 (FY20) Federal interest rate for evaluation of water resource projects (2.75%). Cost and benefits are presented in constant dollars at October 2020 price level. (The year the study will be completed.) Net benefits for the TSP are $6,220,000. The project is economically justified with a BCR of 2.2.

Table E-2. TSP, Average Annual Equivalent Benefit and Cost Summary
2.75% interest rate and October 2020 price level

TSP Project Economic Cost	**($)**
Investment Cost	
First Cost (includes constr., cont., PED, S&A, LERRD)	164,612,000
Interest During Construction	6,776,000
Total Investment Cost	171,388,000
Annualized Investment Cost	6,348,000
Annualized OMRR&R Cost	1,646,000
Total AAEQ Cost	7,995,000
TSP Economic Benefit	
Total Annual Damage and Loss Reduction Benefit	14,210,000
Net Benefit and BCR	
Annual Net Benefit	6,220,000
TSP Benefit-Cost Ratio	2.2

FEDERAL AND NON-FEDERAL PROJECT COST SHARING

In accordance with the cost share provisions in Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213), the Federal and non-Federal shares are as follows: Initial construction is cost shared 65% Federal and 35% non-Federal. Table E-3 provides the cost details of the recommended plan and cost apportionment at the current price

level. Table E-4 provides the cost details of the recommended plan and cost apportionment at the fully funded price level that includes cost escalation to the mid-point of construction (approximately November 2025).

Table E-3. Cost Apportionment (October 2020 price level)

	Federal Share ($)	Non-Federal Share ($)	Total Cost ($)
Project First Cost:			
	65%	35%	
Initial Construction	106,739,750	57,475,250	164,215,000
LERRD (to be acquired by non-Federal sponsor)	258,050	138,950	397,000
Total First Cost	106,997,800	57,614,200	164,612,000

Table E-4. Cost Apportionment (fully funded price level)

	Federal Share ($)	Non-Federal Share ($)	Total Cost ($)
Project First Cost:			
	65%	35%	
Initial Construction	123,456,450	66,476,550	189,933,000
LERRD (to be acquired by non-Federal sponsor)	274,300	147,700	422,000
Total First Cost	123,730,750	66,624,250	190,355,000

ENVIRONMENTAL CONSEQUENCES

The possible environmental consequences of the TSP are considered in terms of probable environmental, social, and economic factors. Avoidance and minimization measures were incorporated in development of the project. There would be no significant impacts anticipated to fish and wildlife resources, or water quality. All impacts are anticipated to be temporary and minor in nature. No cultural resources impacts are anticipated during project implementation.

The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction

program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. Prior to transmittal to the Congress, the Non-Federal sponsor, interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Draft Fairfield and New Haven Counties, Connecticut
Coastal Storm Risk Management Feasibility Study and Environmental Assessment

Chapter 1: Introduction

1.1 Draft Integrated Feasibility Report and Environmental Assessment

The U.S. Army Corps of Engineers (USACE), New England District prepared this draft Integrated Feasibility Report and Environmental Assessment known as an Integrated Feasibility Report (IFR/EA) for the Fairfield and New Haven Counties Coastal Storm Risk Management (CSRM) Feasibility Study. This draft IFR/EA documents the elements of the feasibility study process including problems and opportunities, assessment of measures and alternatives to address problems, analysis of the environmental effects associated with implementing alternatives, evaluation of the alternatives and the identification of a Tentatively Selected Plan (TSP).

This report presents the TSP for managing coastal storm risk specifically within the Long Wharf area located in the city of New Haven, New Haven County, Connecticut (Figure 1). This community is located along the Connecticut coast bordering Long Island Sound. Chapter 4 describes the plan formulation process used by the New England District to narrow the focus of the study from a two-county area to the single focused study area located within the city of New Haven. Over the course of the review process, the report will be updated to include input from Connecticut Department of Energy and Environmental Protection (CT DEEP), who is the non-Federal Sponsor, local governments, natural resource agencies, key stakeholders and the public.

The Federal objective of water and related land resources project planning is to contribute to National Economic Development (NED) consistent with managing and reducing risk to the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements (Principles and Guidelines (P&G), 1983).

Water and related land resources projects are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective. Pursuant to this, the draft IFR/EA (1) summarizes the problems, needs, and opportunities for coastal storm risk management along the southern Connecticut coast; (2) presents and discusses the results of the plan formulation for managing coastal storm risk to coastal resources; (3) identifies specific details of the TSP, including inherent risks; (4) and will be used in part to determine the extent of the Federal interest and local support for the plan.

This draft IFR/EA is being released for concurrent public and agency technical review. USACE has evaluated an array of alternatives including using the existing Interstate 95 embankment, enhancing the I-95 embankment with a floodwall system, building a floodwall system along the shoreline of Long Wharf Park and Maritime Center in combination with closure structures, pump stations, and nonstructural features. The TSP consist of road closure structures at Long Wharf Drive, Canal Dock Road, and Brewery Street; two pumping stations and enhancement of the I-95 embankment with approximately 5,950 linear feet of "T-wall" type floodwall with flood gates (closure structures), and potential flood proofing of fourteen commercial and residential structures on the seaward side of the I-95 embankment in New Haven, Connecticut

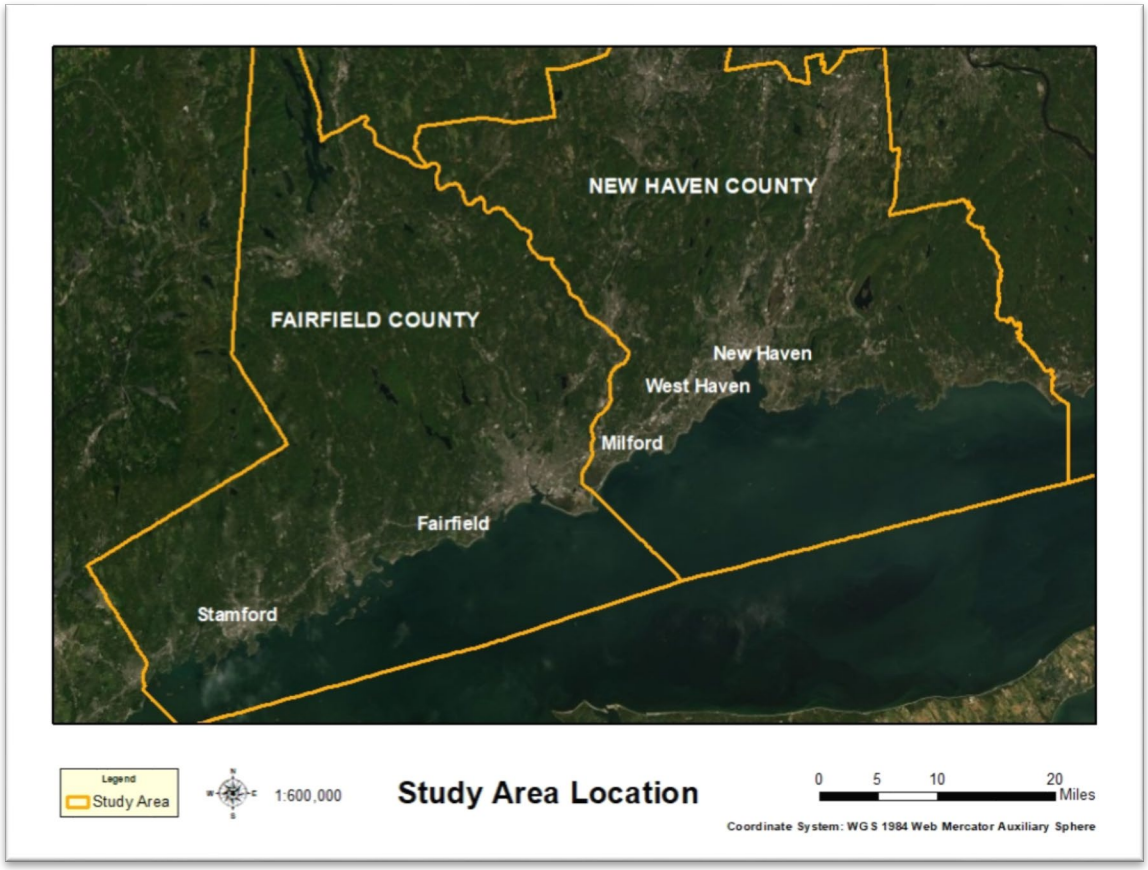

Figure 1. Fairfield and New Haven Counties Coastal Study Location Map

1.2 National Environmental Policy Act Requirements

This draft IFR/EA was prepared pursuant to the National Environmental Policy Act (NEPA), the Council on Environmental Quality's (CEQ) Guidance Regarding NEPA Regulations, and the USACE's Procedures for Implementing NEPA (33 CFR part 230).

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

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

The EA must discuss:

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

NEPA requires Federal agencies to integrate the environmental review into their planning and decision-making process. This integrated report and EA is consistent with NEPA statutory requirements. The report reflects an integrated planning process, which avoids, minimizes, and mitigates adverse project effects associated with coastal storm risk management actions.

1.3 Study Authority

This study is authorized in a resolution approved by the Committee on Transportation and Infrastructure of the United States House of Representatives, dated April 29, 2010. This resolution gives the Secretary of the Army the authority to "review the report of the Chief of Engineers on Land and Water Resources of the New England-New York Region, published as Senate Document No. 14, 85th Congress, 1st Session, and other reports to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, coastal storm damage reduction, coastal erosion, and other related purposes in the vicinity of the estuaries and shoreline of Fairfield and New Haven Counties, Connecticut."

1.4 Non-Federal Sponsor

CT DEEP is the non-Federal study sponsor. The USACE and the CT DEEP signed a 50 percent Federal/50 percent non-Federal Feasibility Cost Sharing Agreement (FCSA) on 24 June 2016 for the feasibility study. The initial FCSA was modified by an amended agreement which was signed on 11 June 2018. This amendment increased the study budget from $600,000 to $1,470,000.

1.5 Prior Studies, Reports, and Existing Water Projects

The North Atlantic Coast Comprehensive Study (NACCS): In 2015, the USACE completed a report detailing the results of a two-year study to address coastal storm and flood risk to vulnerable populations, property, ecosystems, and infrastructure affected by Hurricane Sandy in the United States' North Atlantic region. The NACCS study was designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. It builds on lessons learned from Hurricane Sandy and attempts to bring to bear the latest scientific information available for state, local, and tribal planners. The Fairfield and New Haven Counties study area was included as part of the NACCS analysis including a tier 2 analysis which was conducted for a portion of the two-county area.

The NACCS Tier 2 evaluation in Connecticut built upon several prior efforts. As part of the NACCS, extensive analyses of existing and future without project (FWOP) conditions were evaluated for the coastal areas of the state of Connecticut. Additionally, Connecticut was included in a large regional application (Tier 1 evaluation) of the NACCS CSRM Framework. A Focus Area Analysis (FAA) was conducted to determine area-specific problems, needs, and opportunities in addition to identifying structural, nonstructural, natural and nature-based features (NNBF) and policy/programmatic CSRM strategies and opportunities within Connecticut. A visioning session was held with local and regional stakeholders with regard to CSRM to continue the conversation of coastal resilience. Results of those analyses were summarized in a Tier 2 report and were used to inform the current CSRM feasibility study.

Prior reports documenting coastal storm damage in the study area include:

- Long Wharf Flood Protection Final Report, March 2017: This report was prepared for the city of New Haven, CT by GZA GeoEnvironmental, Inc. The report characterizes the coastal flood hazard within the Long Wharf study area under tidal and extreme water level (storm surge and waves) flood conditions. The effects of sea level rise on both tides and extreme water levels are also evaluated. The report

utilizes the results of the flood hazard characterization to evaluate the flood vulnerability and flood losses within the Long Wharf study area assets, including buildings, infrastructure and shoreline features. Four flood protection alternatives are presented and a detailed discussion of one alternative was presented. This GZA report served as a launching point for the USACE CSRM feasibility study within the Long Wharf, New Haven focused study area.

Existing Federal Navigation Project:

The New Haven Harbor Federal Navigation Project is located near the Long wharf study area. The Federal navigation project features include:

- A main ship channel, -35 feet Mean Lower Low Water (MLLW), extending about 5 miles from deep water in Long Island Sound to the head of the harbor at the mouth of the Quinnipiac River, varying in width from 500 feet (outer-harbor) to 400 feet (inner-harbor), and widened to 800 feet along the upper harbor terminals to provide a maneuvering area; a turning basin in the upper harbor west of the channel also at -35 feet MLLW; two anchorages west of the main channel, at -15 and -16 feet MLLW; the Quinnipiac River Channel, at -18 feet MLLW (lower channel) and -16 feet MLLW (upper channel), and generally 200 feet wide; the Mill River Channel, at -12 feet MLLW, 200 feet wide, including two branches (east branch at 100 feet wide, and west branch at 125 feet wide); the West River channel authorized at -12-feet MLLW, 100 to 150 feet wide, with a -6 foot MLLW anchorage; a pile and stone T-dike at Stony Point (~4.200 feet long) west of the main channel; and three offshore stone breakwaters, totaling 12,100 feet in length providing a refuge in the outer harbor.

Planned Future Projects:

- City of New Haven, Long Wharf Park Living Shoreline Project: The city of New Haven is currently designing plans for this project which received grant funding by the CT DEEP. According to engineers with the City, the Long Wharf living shoreline project seeks to enhance the shoreline and nearshore environment to improve resiliency as part of an overall flood protection strategy. The 3,600 linear foot project abuts Long Wharf Park, a highly utilized city park, which is currently threatened by coastal erosion. Sea level rise and storm surge continue to degrade the park's edge, reducing the surface area of the park, damaging infrastructure and vegetation, and limiting access to the waterfront. The living shoreline project will deploy several strategies to dampen wave energy and reduce scouring while providing enhanced natural resource and recreational value. From the harbor moving inland, a new rock sill will be placed parallel to the park shoreline and approximately 8 acres of new tidal wetlands will be created behind it. Approximately 2 acres of new beach will be created through the placement of sand between the new wetlands and existing

revetment. Multiple points of access will be created to allow park visitors to traverse over the existing revetment onto the new beach. Also, invasive species will be removed and replaced with native plantings. The city of New Haven plans for these improvements to provide a first layer of defense against the impacts of future storm events (Dawn Henning pers. comm., 10/9/2019).

- USACE New Haven Harbor Navigation Improvement Study: A feasibility study and Environmental Impact Statement to examine navigation improvements to the existing New Haven Harbor Federal Navigation project are currently being conducted. The USACE participation in this study is authorized by a resolution of the Senate Committee on the Environment and Public Works dated July 31, 2007. The study was initiated at the request of the New Haven Port Authority and the Connecticut State Port Authority to assess navigation improvements in New Haven Harbor with the aim of increasing navigation efficiency and safety. The proposed improvements consist of deepening and widening the main ship channel, maneuvering area, and turning basin to -40 feet MLLW and widening the channel bend at the breakwaters. These improvements will allow larger vessels to efficiently access the Port of New Haven's terminals. The project would remove about 4.28 million cubic yards of predominately glacially deposited silts from the Federal channel. Additionally, approximately 43,500 cubic yards of rock would be blasted and removed from the channel. Several feasible alternative dredged material placement sites were identified and include: an area for shellfish habitat creation, two borrow pits in the harbor, an area for salt marsh creation, an area for rock reef creation, and open water disposal at an EPA designated ocean dredged material disposal site in Long Island Sound.

1.6 Study Area

The authorized study area faces the Atlantic Ocean and includes the counties of Fairfield and New Haven, Connecticut. Figure 2 shows FEMA repetitive loss and significant repetitive loss data in the study area.

Five primary damage areas (Stratford, Milford, New Haven, West Haven, and Fairfield) were initially identified in partnership with the Regional Councils of Governments (COG) in Connecticut for assessment. Over the course of a multiple year screening and evaluation process, the town of Fairfield and city of New Haven were selected for in-depth evaluation based on their density of development, an evaluation of coastal storm risk and potential to economically support a federally constructed project. Due to an extremely limited study budget, it was necessary for the PDT to take advantage of available data sets and previous studies within

the two municipalities. Both Fairfield and New Haven had a substantial amount of high quality data and coastal studies that the study team utilized to inform the plan formulation process.

In early 2019, a suite of coastal storm risk management solutions were developed for the town of Fairfield. The developed alternatives would require a significant investment (ranging approximately from $500-700 million) including the non-Federal responsibility and costs of acquiring large tracts of privately-owned real estate and a large environmental mitigation component. Prior to the TSP milestone, the Town made a decision that the alternatives developed by the USACE would be too costly for the community to support at this point in time. A decision was made at the TSP milestone to move forward with a focus only on the Long Wharf study area located within the city of New Haven. In the interest of report succinctness and clarity, this draft IFR/EA focuses solely on the Long Wharf, New Haven study area.

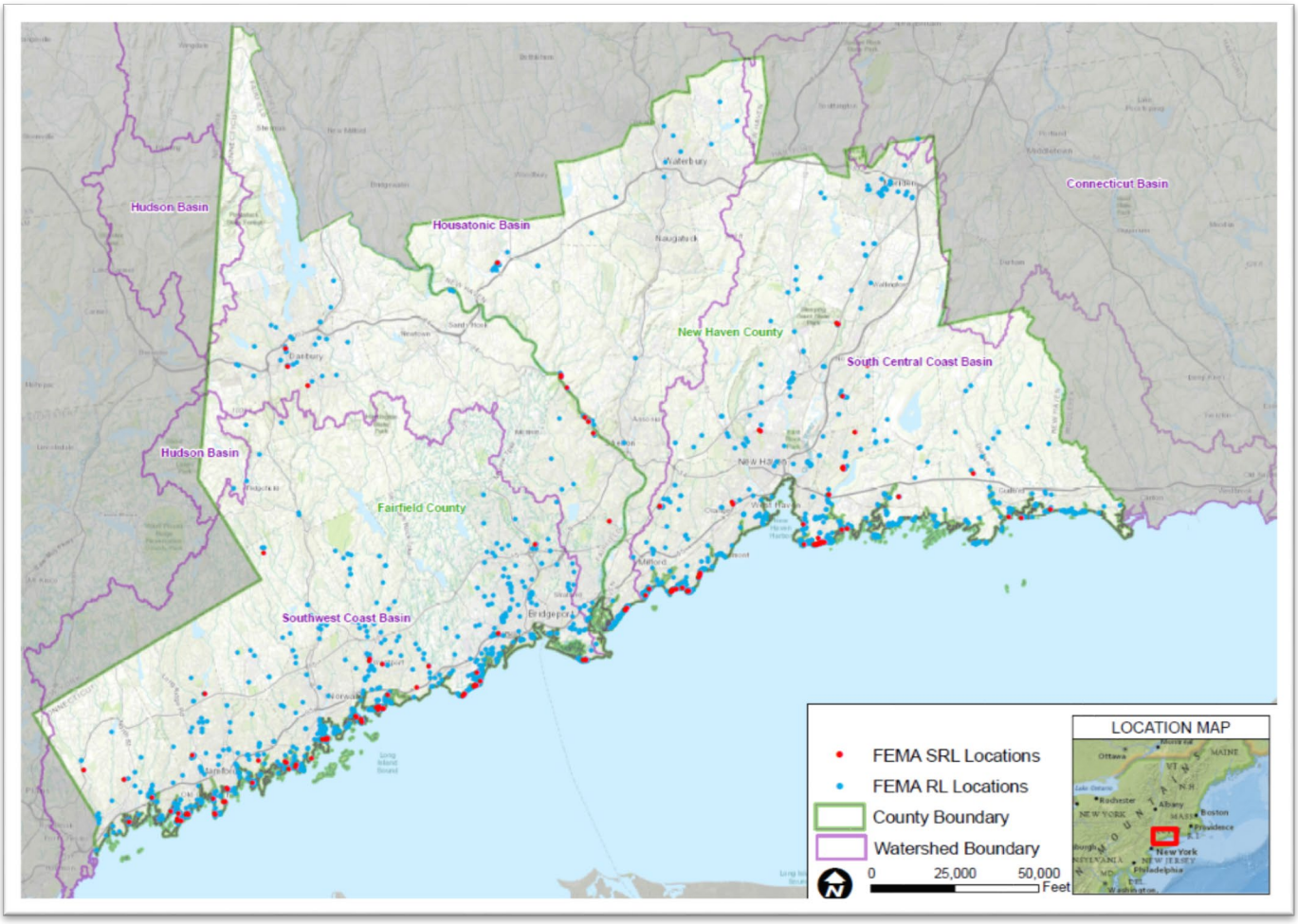

Figure 2. Fairfield and New Haven Counties Repetitive Loss Locations (FEMA, 2017).

The city of New Haven is located within the 3rd Congressional District. The Long Wharf New Haven focused study area is a socio-economic center of southern Connecticut comprised largely of industrial and commercial users. More than 70 commercial properties including IKEA, ASSA ABLOY, and Jordan's Furniture, worth hundreds of millions of dollars are located within this area. These properties experience damages during coastal storm events approximately greater than the 17.5-percent annual exceedance probability.

Key regional transportation infrastructure is vulnerable in the study area as well. The Northeast Corridor mainline tracks, owned by the Connecticut Department of Transportation (CT DOT), serves approximately 130,000 daily riders across multiple rail lines and carries 7.5 metric tons of freight annually through the study area. The New Haven Union Station passenger rail station opened in 1920 and serves approximately 700,000 annual boardings on four platforms with nine tracks. The New Haven Rail Yard, a 74-acre CT DOT-owned railyard in the study area, received $1.2 billion in recent capital improvements for a new maintenance facility and 25 new storage tracks. Interstates 91 and 95 dominate vehicular access in and around the City and surrounding region. An excess of 140,000 vehicles use the Long Wharf stretch of I-95 daily (Anagnostou, et. al., 2017).

Figure 3. New Haven Long Wharf Study Area

1.7 Problem Statement/Purpose and Need

The purpose of the study is to reduce the potential damage caused by coastal storms and improve safety and coastal resiliency of the Long Wharf study area in New Haven. The Long Wharf study area is located on a low elevation coastal floodplain and is highly susceptible to the impacts of inundation due to coastal storms. Multiple underpasses underneath the Interstate 95 highway embankment create pathways for coastal surge to inundate the area landward (northwest) of the embankment. Given the right combination of coastal surge, tides and wave action, the many businesses within the study area along with the I-95 and rail corridor could experience major damage from a present-day storm with a 1% annual exceedance probability (GZA, 2017). Life safety is not presently a major concern from a plan formulation perspective

but it could be in the future when considering the effects of sea level change. The risk of coastal storm damage within the study area is expected to increase with time due to the impacts of sea level and climate change.

The study is needed as existing coastal floodplain properties are at risk from coastal storm damage. Some risk management solutions including a partially hardened shoreline have been implemented by property owners such as the city of New Haven, but the area experiences and will continue to experience storm damage due to flood inundation and to some extent, wave effects.

1.8 Federal Policy and USACE Procedures

Project-specific planning guidance used in USACE project planning is guided by the P&G of 1983, the Planning Guidance Notebook, ER 1105-2-100 (22 April 2000), and NEPA of 1969, the CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500-1508), and Procedures for Implementing NEPA, ER 200-2-2 (4 March 1988).

The Federal objective of water and related land resources planning is to contribute to NED consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. In support of the Federal objective, it is within both the National and USACE interest to participate in studies to reduce coastal storm risk.

The "Federal Interest" decision in USACE planning is generally limited to instances where benefits of a potential project are expected to exceed the costs to the nation (i.e. a benefit to cost ratio (BCR) greater than unity) and the project is consistent with protecting the nation's environment. Because this is a single purpose coastal storm risk management project, NED benefits are evaluated in terms of reduced storm damages and other applicable NED benefit categories. Project costs include all construction costs, real estate costs, any environmental mitigation costs, and long term operation and maintenance costs. Benefits (such as reduced damages or delays) attributed to a plan are expressed in terms of a time value of money as average annual equivalent benefits and compared to average annual equivalent economic costs for the project.

Planning guidance also requires identification of the plan (from among the plans with BCRs >1) that would produce the greatest contribution to NED. The NED plan is defined as the environmentally acceptable plan that reasonably maximizes the net annual benefits. Net annual benefits are determined by subtracting annual costs from annual benefits. USACE policy

requires recommendation of the identified NED plan unless there is adequate justification to do otherwise.

USACE project planning process to identify, evaluate, and compare plans follows the six-step process first described in the P&G and further elaborated in the Planning Guidance Notebook. Although presented in series, these steps are applied in an iterative process. Steps in the USACE plan formulation process include:

1. Specification of water and related land resources problems and opportunities (relevant to the planning setting) associated with the federal objective and specific state and local concerns;
2. Inventory, forecast, and analysis of water and related land resource conditions within the planning area relevant to the identified problems and opportunities;
3. Formulation of alternative plans;
4. Evaluation of the effects of the alternative plans;
5. Comparison of alternative plans; and
6. Selection of a recommended plan.

The planning practice has continued to evolve since the 1983 P&G, an evolution that now includes its confluence with risk analysis. The challenge in a world of limited time and budget is to efficiently reduce uncertainty by gathering only the instrumental evidence needed to make the next planning decision and to manage the risks that result from doing so without more complete information (USACE, 2017). This study utilizes the model of risk identification, analysis and management throughout the planning decision making process.

Chapter 2: Existing Conditions

Existing conditions serve as the basis for the characterization of problem identification and projection of future without project conditions. Existing conditions are described in this Chapter (coastal setting, storms and assets at risk) and in Chapter 3 (environmental resources).

2.1 Coastal Setting and Storms

2.1.1 Climate

Connecticut is characterized by cold, snowy winters and warm, humid summers. The polar jet stream is often located near the state leading to highly variable weather patterns and generally abundant precipitation throughout the year. Temperatures along the coast are moderated by

close proximity to the Atlantic Ocean with warmer winters than inland areas. The temperature averages 52 degrees Fahrenheit (°F) annually along the coast, ranging from a low monthly average of 31°F in February to a high monthly average of 74°F in July. Precipitation throughout the state is abundant, but highly variable from year to year; amounts range from 31 to 63 inches per year. In the winter months, average accumulated snowfall ranges between 30 and 35 inches along the coast (Runkle et al., 2017).

2.1.2 Tides

Tides in the study area are semi-diurnal. The mean tide range along the coast of Connecticut is estimated at 6.2 feet and the great diurnal range is 6.7 feet in New Haven Harbor (NOAA, 2018). Currents in New Haven Harbor are generally less than 0.5 knots. See the Coastal Engineering Appendix C for additional information on tides and currents.

2.1.3 Historical Storms

Two types of storms of primary significance along the coast of Connecticut are tropical storms (hurricanes), which typically impact the area in summer and fall and extratropical storms (nor'easters), which are primarily winter storms. 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. Based on National Weather Service records, Connecticut has experienced approximately 30 hurricanes throughout recorded history with 15 occurring in the 20th century (NOAA, n.d.). Table 1 lists historic storms that have impacted the study area and total reported damages.

Table 1.

Historic Storms Impacting Connecticut (NOAA, n.d.)

Hurricane			Nor'easter		
Date	Damages	Name	Date	Damages	Name
21 Jul 1916			02 Mar 1960		
21 Sep 1938	$100,000,000		2 Feb 1961		
14 Sep 1944	$ 2,000,000		11 Jan 1964		
31 Aug 1954	$200,000,000	Carol	06 Feb 1978	$ 15,000,000	
11 Sep 1954		Edna	10 Feb 1983		
11 Aug 1955	$ 5,000,000	Connie	12 Mar 1993		Storm of the Century
18 Aug 1955		Diane	07 Jan 1996		
12 Sep 1960		Donna	15 Feb 2003		President's Day Storm II
09 Aug 1976		Belle	21 Jan 2005		
27 Sep 1985	$ 20,000,000	Gloria	26 Dec 2010		
19 Aug 1991	$115,000,000	Bob	08 Feb 2013		
12 Jul 1996		Bertha	27 Jan 2015		
07 Sep 1999		Floyd	23 Jan 2016		
28 Aug 2011		Irene	09 Feb 2017		
29-30 Oct 2012	$ 39,400,000	Sandy	04 Jan 2018		

Notes: Nor'easters generally have no assigned names.
SOURCES: Coastal Hazards Primer – Tropical Storms and Hurricanes. Connecticut Department of Energy and Environmental Protection. ; and Storm Events Database. National Centers for Environmental Information, National Oceanic and Atmospheric Administration.

2.1.4 Coastal Storm Climatology

Existing coastal processes in the study area are driven by waves and water levels generated by coastal storms. The observed number of extreme precipitation events (greater than two inches of precipitation in a 24 hour duration) has increased since the year 2000, with the greatest amounts during the last decade. Increases in the frequency and intensity of extreme precipitation from coastal storms are projected (Runkle et al., 2017).

2.1.5 Relative Sea Level Change

Along the Connecticut coast, sea level has risen 10-11 inches per century (Runkle et al., 2017). The current mean sea level trend at Bridgeport, CT (NOAA 8467150) is 0.00942 feet/year based on regionally corrected mean sea level data over 53 years. This gauge was selected to represent the project site since it was the closest long term gauge to the project location. Current USACE guidance on sea level change (SLC) (USACE, 2013) outlines the development of three scenarios:

Low, Intermediate, and High (Figure 4). Over a period of 50 years, from 2024 the USACE curves predict increases of 0.4 ft, 0.9 ft, and 2.5 ft for the low, intermediate, and high scenarios, respectively. The CT DEEP is required by Public Act 18-82 to publish Connecticut sea level change scenarios updated by the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) at the University of Connecticut. CIRCA's recommended sea level change scenario is an increase of 0.5 m (20 inches) by 2050. This 2050 estimate lies slightly above the USACE Intermediate scenario.

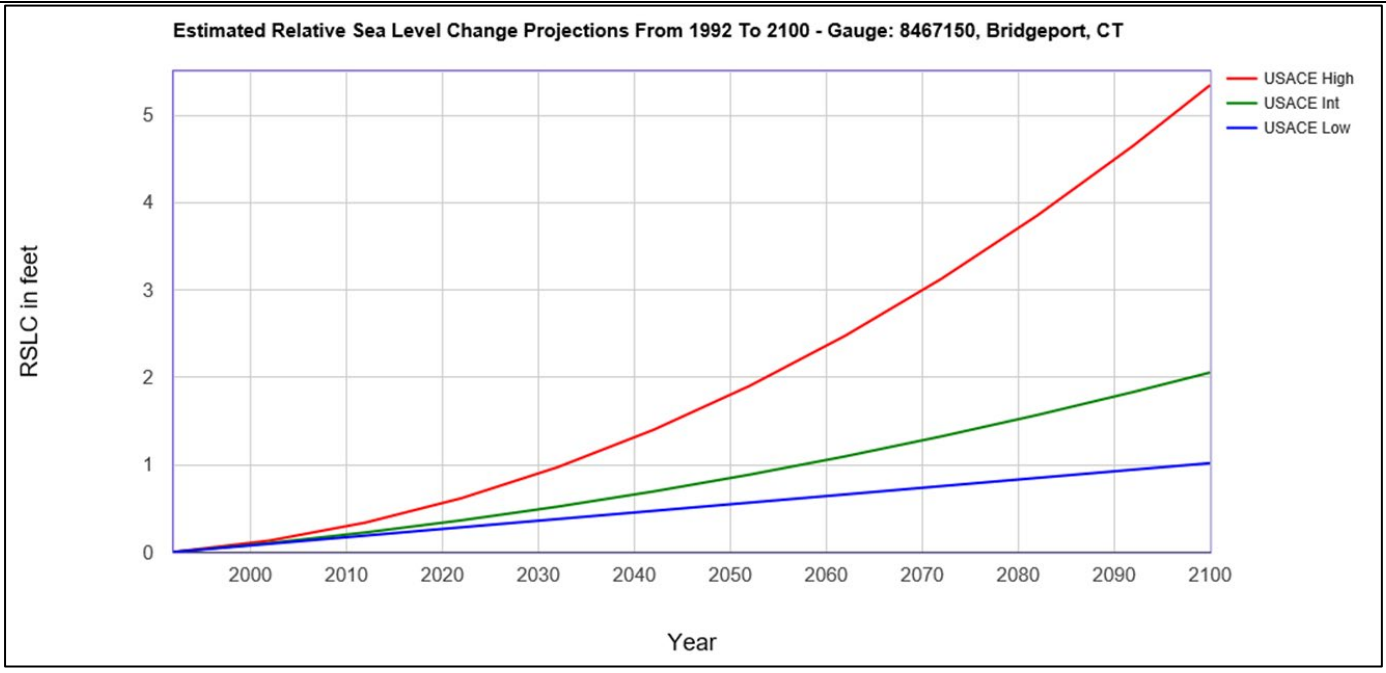

Figure 4. Relative Sea Level Change for Connecticut

2.1.6 Coastal Erosion

Coastal erosion is a shore process that reduces the width of beaches and land along the coast. These processes include long-shore and cross-shore sediment transport resulting from both typical and storm-induced wave conditions (Komar, 1998). In some cases, the storm-induced erosion component of shoreline change, although devastating to development, may be short-term in nature. Following storms, the coastline tends to reshape itself into its former configuration. For example, some sand displaced from beaches is returned by wave action. The beach shape then conforms to the prevailing wave climate and littoral processes. However, over time, portions of the coast can experience permanent land loss. In developed areas, bulkheads and revetments will help to limit landward erosion but these structures may fail due to toe erosion and wave overtopping.

In the New Haven area, the Long Wharf shoreline consists of a combination of structures and natural features. The hardened shoreline, which is maintained by the city of New Haven, consists of steel sheetpile bulkhead and quarry stone revetment. The revetment has been repaired and is in good condition in some areas. In other areas, it is damaged. Areas upland of the revetment have experienced storm-related impacts from hurricanes such as Irene in 2011 and Superstorm Sandy in 2012 (Langan, 2015).

As erosion of the Long Wharf natural shoreline features is a concern for the city of New Haven, the City is designing plans for the construction of a living shoreline in this area to enhance both the recreational and environmental values of the Long Wharf shoreline and to support the integrity of the shoreline in response to sea level rise. The living shoreline is intended to provide wave attenuation and erosion protection of adjacent upland areas including Long Wharf Drive and existing utilities. Therefore, future conditions assume the living shoreline will protect against erosion at the shoreline.

2.1.7 FEMA Flood Plain

The effective Flood Insurance Study (FIS) and associated mapping of New Haven County (2017) was reviewed in the vicinity of the study area. The FEMA Base Flood Elevation (BFE), shown in Figure 5, identifies areas affected by the 1-percent annual exceedance probability flood. Areas shown in red are FEMA VE Zones and depict areas subject to significant storm surge and wave effects where wave heights exceed 3 feet. Green areas are also affected by storm surge, but wave effects are less severe where wave heights are below 3 feet.

At the Long Wharf shoreline the FEMA BFE ranges from Elevation 13 in the VE Zone to Elevations 11 and 12 in the AE Zone. In the northeast section of the study area (near the Maritime Center), the BFEs are higher at Elevation 16 in the VE Zone and Elevation 13 in the AE Zone.

Figure 5. Effective FEMA floodplain mapping

2.2 Existing Coastal Structures

USACE conducted field visits of the study area in January 2019 to visually inspect the area and existing coastal protection structures along the shoreline. It should be noted that although erosion was identified along the shoreline, this study addresses coastal storm risk management and does not seek to resolve issues of erosion. In the New Haven area, the primary method of erosion protection are stone rip-rap revetments, steel sheetpile bulkheads, and sloped sandy beach areas fronted by tidal wetlands, mudflats or sand dunes. Overall, the sandy beach areas appeared to be in fair condition with some signs of erosion and scarping along the shoreline. The rip-rap revetments appeared to be in stable condition, but erosion behind the revetments was evident. From the Canal Dock Boathouse north to the Maritime Center, the bulkheads were in

good condition, but in the Long Wharf Park area, the bulkheads were in poor condition due to corrosion. The city of New Haven is responsible for maintaining these structures.

2.3 Critical Infrastructure

Critical infrastructure elements include sewage, water, electricity, academics, trash, medical, and safety. As depicted in Figure 6, infrastructure within Fairfield and New Haven Counties was impacted as a result of Hurricane Sandy in 2012. In New Haven County, 2,637 elements were affected (NACCS, 2015).

Critical infrastructure in the city of New Haven includes New Haven Harbor which is surrounded by many petroleum and cargo-based industries that rely heavily on the port for moving these products. Two major interstates, Routes 91 and 95, run through New Haven and are critical to the region for moving traffic and goods. The New Haven Union Station Rail Yard is the most used passenger rail facility in Connecticut and serves the Northeast Corridor which runs from Boston, Massachusetts to Washington D.C. Several wastewater treatment facilities are also located in the focused study area.

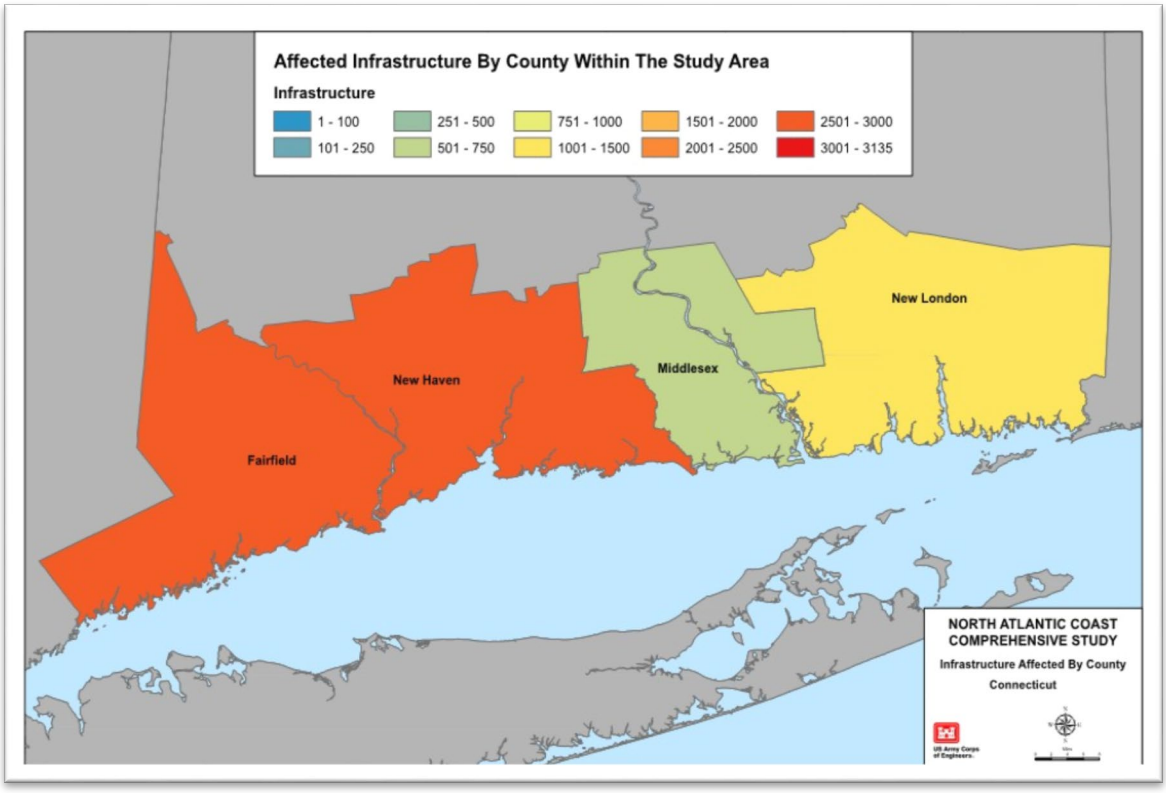

Figure 6. Affected Infrastructure by Hurricane Sandy (NACCS, 2015)

Chapter 3: Existing Conditions Affected Environment

This description of the existing environment conditions is in accordance with the requirements of NEPA, and provide information to inform the evaluation of alternatives in Chapter 5: Environmental Effects and Chapter 6: Cumulative Impacts of this draft IFR/EA.

3.1 Topography, Geology, and Soils

Connecticut is located at the southwestern corner of New England, with Long Island Sound to the south, New York to the west, Massachusetts to the north, and Rhode Island to the east. The total area of Connecticut is about 5,009 square miles, extending for 90 miles in an east-west direction and 75 miles from north to south (UConn, 2001). The topography of Connecticut is predominantly hilly. The highest terrain is found in the northwest portion of the State, with elevations of 1,000 to 2,000 feet. The southwestern quarter and most of the eastern half have elevations of 300 to 1,000 feet. The state of Connecticut is bisected by the Connecticut River which rises in Canada (UConn, 2001).

The physiography of Connecticut was shaped over a span of five hundred million years (LISRC, 2011). After the breakup of Pangea, three mountain building events occurred in the area of Connecticut which assembled bedrock units having a north-south "grain". This grain persisted through the glacial period (~150,000 to 15,500 years ago), and is manifested in the numerous headlands and inlets that characterize the coastline of Connecticut that is seen today (LISRC, 2011). This means that bedrock lies at or near the surface along much of the north shore of Long Island Sound. Pocket beaches and marshes along the coastline were valleys that filled with sands and gravels as the glaciers retreated (LISRC, 2011). Connecticut is made up of three natural geologic regions, the eastern and western highlands and the central lowland. New Haven lies within the central lowland and the predominant bedrock is New Haven arkose, which is reddish, poorly sorted arkose, a detrital sedimentary rock (USGS, 1985).

The focused study area in New Haven is located west of New Haven Harbor along the coastal area known as Long Wharf (Figure 3). The study area encompasses Long Wharf Park, a section of Interstate 95, the Long Wharf Maritime Center, New Haven Union Station, commercial businesses, and the New Haven Police Headquarters building. This area also includes the CT DOT largest rail yard which was recently transformed with over $1 billion in capital investment. The shoreline that fronts the study area is made up of Long Wharf Park which contains a Food Truck Paradise, the Liberty Bell Building, the newly constructed Canal Dock Boathouse, and Long Wharf pier to the north. A narrow beach, waterfront walkways, tidal marsh, and the Veterans Memorial Park exist alongside Long Wharf Drive. The park ends with the Long Wharf Nature Preserve to the south.

The majority of the project will take place adjacent to Long Wharf Park which extends about 3,500 linear feet on a linear north-south alignment alongside I-95. The general subsurface of the park consists of miscellaneous fill material and compressible organic clayey silt underlain by fine sand and silt. A shallow layer of granular fill underlain by stone rip rap is located in some areas of the southern portion of the site (Langan, 2015). See Appendix D3 for further soils and geotechnical design information.

The shoreline of the park is predominantly made up of stone rip rap revetment features. Other portions of the shoreline consist of sloped sandy beach areas and sand dunes as well as tidal wetlands. A steel sheet pile bulkhead forms a vertical wall at one location in the central portion of the site that coincides with a storm water outfall structure (Langan, 2015).

3.2 Wind and Wave Climate

Connecticut lies in a transition zone of westerly air currents that encompass the southward movement of dry polar air masses and the northern movement of moist tropical air masses. It is in this transition zone that storm centers form and move. Superimposed on these large-scale effects are those created by New Haven's proximity to Long Island Sound (UConn, 2001). During warmer months when air temperatures exceeds water temperature, a sea breeze is likely to occur which tends to reinforce normal wind flow from the south or southwest. Such sea breezes occur when the pressure gradient is weak along Long Island Sound. This environment moderates the climate of New Haven by producing cooler summers and warmer winters in comparison to inland areas of Connecticut. In addition, the low-level air mass wind speeds are increased by the sea breeze in the spring and summer (UConn, 2001).

Long Island shelters the New Haven shoreline from long period waves from the Atlantic Ocean. Therefore, waves in Long Island Sound in the New Haven Harbor vicinity are fetch-limited only, driven by winds blowing over a length of the Sound. The inner harbor is fairly well protected from storm and wave action in the sound by virtue of its location away for the sound. The outer harbor is protected by the breakwaters that separate the harbor from Long Island Sound. A detailed review of the available wind and wave data for the study area is detailed in Appendix C, Coastal Engineering.

3.3 Water Resources

3.3.1 Regional Hydrogeology and Groundwater Resources

Local climate, physiography and geology are largely responsible for the groundwater conditions in the state. Median annual precipitation ranges from 42 to 52 inches (Runkle et al., 2017). Approximately 7 to 20 inches of precipitation on average percolates to the saturated zone, and the remainder flows overland to surface-water bodies. Groundwater recharge is mainly from precipitation over the drainage basin. Water percolates from the land surface through the till, stratified drift, or along bedrock fractures to the water table. Unconsolidated stratified drift aquifers, located throughout the Connecticut Valley, are composed of sand and gravel and are the most productive sources of water yielding between 1 and 10 million gallons of water per day. Bedrock aquifers underlie the entire state and are the source of most self-supplied water, commonly in the range of 3 to 5 gallons per minute. These aquifers are broadly subdivided into sedimentary, crystalline, and carbonate rock types (CT DEEP, 2018a).

The flow of ground water in Connecticut is concentrated in the upper part of the saturated zone, (below the water table), generally within 300 feet of the surface. Because of the relatively shallow depth of the flow system, high rates of recharge, and moderate topographic relief, ground water circulation in most of the state is localized within each basin that is drained by a perennial stream (CT DEEP, 2018a).

New Haven is served by the South Central Connecticut Regional Water Authority (RWA) which is a non-profit public corporation created by the Connecticut Legislature in 1977. The RWA owns more than 27,000-acres of land and, on average, supplies 45 million gallons of water a day to a population of some 430,000 people. The RWA provides water and other services in all or portions of Ansonia, Bethany, Branford, Cheshire, Derby, East Haven, Hamden, Milford, New Haven, North Branford, North Haven, Orange, Seymour, West Haven and Woodbridge (RWA, 2018). The RWA draws from aquifers located in the state, but not within the study area itself (CT DPH, 2013).

3.3.2 Surface Water

Surface water resources within the project area includes the West River which separates West Haven from New Haven, and the Quinnipiac River which flows into New Haven Harbor. Three waste-water pollution control facilities in the cities of New Haven, West Haven, and North Haven release effluent into the Quinnipiac River and New Haven Harbor.

The waters of New Haven Harbor are classified by the state of Connecticut as SB throughout the harbor (CT DEEP, 2017a). The term SB is for coastal waters of overall good quality. The Connecticut Class SB waters designated uses are for: marine fish, shellfish and wildlife habitat, commercial shellfish harvesting, recreation, industrial water supply, and navigation (CT DEEP, 2017a).

3.4 Vegetation

3.4.1 Upland

The majority of the state of Connecticut is forested, however Fairfield and New Haven counties host the least forest compared to the other six counties in the State. New Haven is 47% forested and 37% of Fairfield is forest with the majority of forested land small, discontinuous patches of 25 acres or less (Wharton et al., 2004). Oak (*Quercus* spp.), hickory (*Carya* spp.) and northern hardwood trees: sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), eastern hemlock (*Tsuga Canadensis*), yellow birch (*Betula alleghaniensis*), and white pine (*Pinus strobus*) make up the majority of timberland in New Haven and Fairfield counties. Common shrubs in Connecticut are blueberry (*Vaccinium* spp.), viburnum (*Viburnum* spp.), mountain laurel (*Kalmia latifolia*), raspberry (*Rubus* spp.), spicebush (*Lindera benzoin*), huckleberry (*Gaylussacia* spp.), barberry (*Berberis* spp.), arrowwood (*Viburnum dentatum*), honeysuckle (*Lonicera* spp.), and roses (*Rosa* spp.) (Wharton et al., 2004).

Upland vegetation within the New Haven project area is characteristic of a maintained park with mowed grass lawns and clusters of trees. Approximately 50 trees, between 6 inches to 36 inches in diameter, are located throughout Long Wharf Park. At the southernmost end of the park, the Veterans Memorial Park contains landscaping shrubs and trees (Langan, 2015).

3.4.2 Wetlands

The U.S. Fish and Wildlife Service (USFWS) classifies wetlands based upon the Classification of Wetlands and Deepwater Habitats (Cowardin et al., 1979). This classification divides wetlands into systems, subsystems, classes and subclasses with modifiers for water regime. All five wetland systems; Marine (saltwater), Estuarine (areas where salt water from the ocean mixes with freshwater), Riverine (systems of inland wetlands and deep-water habitats associated with nontidal flowing water), Lacustrine (freshwater lake), and Palustrine (freshwater) are represented within the overall study area.

Based upon the U.S. Fish and Wildlife Service National Wetland Inventory (USFWS, 2015), there are two wetland systems represented in the New Haven focused study area: marine and

estuarine wetland, and estuarine and marine deepwater. The deepwater segment is located within New Haven Harbor. Along the shorefront of Long Wharf Park, the approximately 55 acres of marine and estuarine wetland exists in the subtidal and intertidal zone extending approximately 150 feet from the edge (Figure 7).

The CT DEEP requires permits for all proposed projects that may alter the natural character of wetlands and their functions and/or values. The city of New Haven established the "Inland Wetlands and Waterways Regulations" in 1988. The regulations, which have been amended multiple times over the years, serve to protect and preserve wetlands and watercourses from unnecessary and unregulated uses (New Haven, 2008). No inland wetlands are located in the study area.

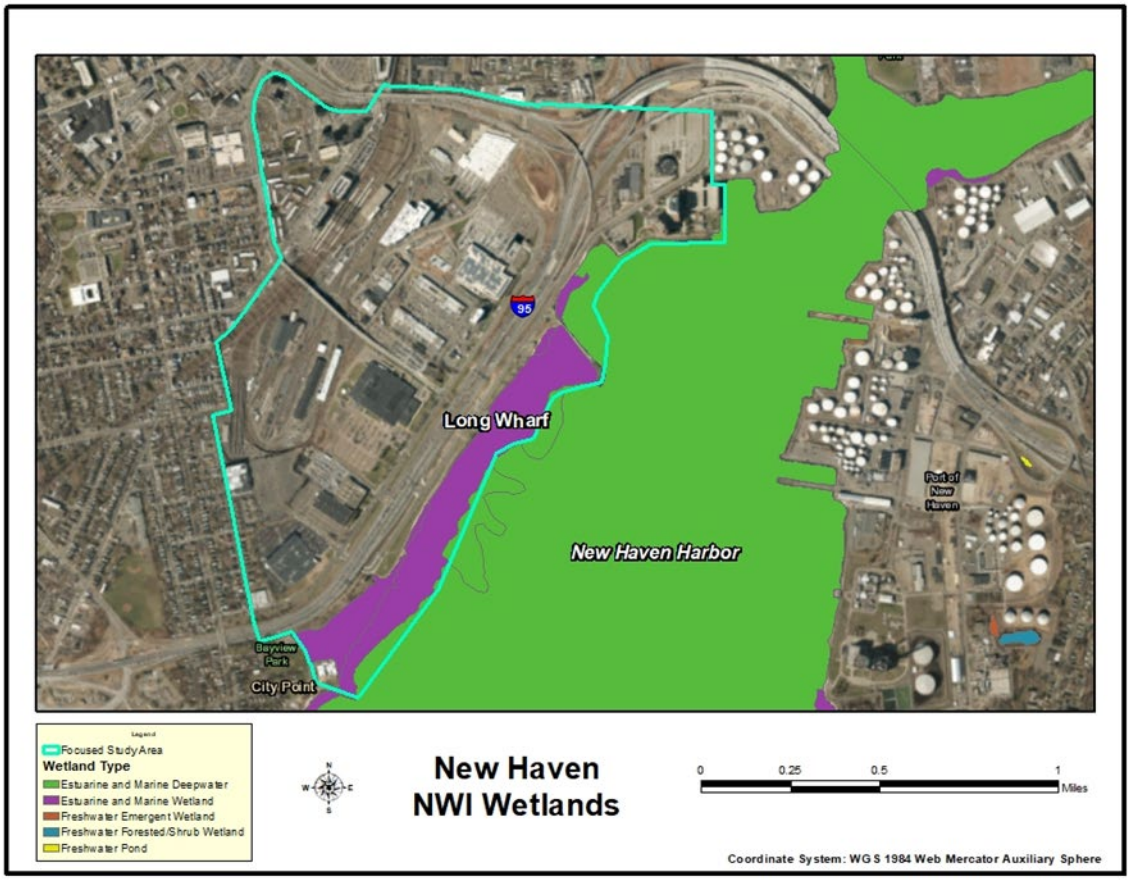

Figure 7. New Haven USFWS National Wetlands Inventory Map (USFWS, 2015)

3.5 Fish and Wildlife

3.5.1 Finfish

Long Island Sound, which abuts the overall project area and includes New Haven Harbor, supports a diverse assemblage of fish. Many of the fish species in Long Island Sound are commercially and recreationally important. Commercial and recreational fisheries in Long Island Sound are valued at over one billion dollars (LIS Study, n.d.).

Table 2, based on data from Stone et al. (1994) and CT DEEP (2017b), presents a list of highly abundant, abundant, common, and rare species collected in Long Island Sound and, by extension, in New Haven Harbor. Field work conducted in New Haven Harbor from early February to late May 2001 and 2002 to evaluate the ichthyoplankton community in the harbor (Lawler, Matusky, and Skelly Engineers, 2003) revealed that life stages of the majority of the species noted in the "highly abundant" and "abundant" sections of Table 2 were recovered during the sampling.

Table 2. Fish Species Found in Long Island Sound Grouped by Abundance Categories (Data from Stone et al. (1994) and CT DEEP (2017b))

Common Name	Scientific Name	Characteristics
Highly Abundant		
Alewife	*Alosa pseudoharengus*	anadromous, schooling, shallow water fish
Atlantic menhaden	*Brevoortia tyrannus*	schooling, pelagic, shallow water fish
Atlantic silversides	*Menidia menidia*	estuarine, schooling
Blueback herring	*Alosa aestivalis*	anadromous, schooling, shallow water fish
Butterfish	*Peprilus triacanthus*	coastal/oceanic, pelagic
Skates	*Raja* species	demersal
Scup	*Stenotomus chrysops*	demersal, prefers bays and shallow waters
White perch	*Morone americana*	anadromous
Windowpane flounder	*Scophthalmus aquosus*	demersal
Winter flounder	*Pseudopleuronectes americanus*	demersal
Abundant		
American eel	*Anguilla rostrata*	catadromous
American sand lance	*Ammodytes americanus*	demersal, burrowing fish
American shad	*Alosa sapidissima*	anadromous, schooling, shallow water fish
Atlantic herring	*Clupea harengus,*	schooling shallow water fish
Atlantic tomcod	*Microgadus tomcod*	demersal
Bay anchovy	*Anchoa mitichilli*	schooling, shallow water fish
Bluefish	*Pomatomus saltatrix*	pelagic, schooling oceanic fish
Killifishes	*Fundulus* species	small schooling fish
Red hake	*Urophycis chuss*	demersal
Striped bass	*Morone saxitilis*	anadromous, schooling
Weakfish	*Cynoscion regalis*	pelagic
Yellow perch	*Perca flavescens*	primarily freshwater; semi-anadromous

Common Name	Scientific Name	Characteristics
Common		
Atlantic mackerel	*Scomber scombrus*	pelagic
Black sea bass	*Centropristes striata*	groundfish
Channel catfish	*Ictalurus punctatus*	freshwater species, demersal
Cunner	*Tautogolabrus adspersus*	demersal
Gobies	*Gobiosoma* species	estuarine, often associated with oyster reefs
Hogchoker	*Trinectes maculatus*	demersal
Northern pipefish	*Syngnathus fuscus*	demersal
Northern searobin	*Prionotus carolinus*	demersal
Oyster toadfish	*Opsanus tau*	demersal
Pollock	*Pollachius virens*	groundfish
Rainbow smelt	*Osmerus mordax*	anadromous
Sheepshead minnow	*Cyprinodon variegatus*	estuarine, prefers open vs. vegetated bottom
Shortnose sturgeon	*Acipenser brevirostrum*	anadromous (amphidromous)
Tautog	*Tautoga onitis*	demersal, shore fish
Rare		
Atlantic stingray	*Dasyatis sabina*	anadromous, demersal
Cownose ray	*Rhinoptera bonasus*	benthopelagic, brackish, marine
Atlantic sturgeon	*Acipenser oxyrhynchus*	anadromous, demersal
Atlantic salmon	*Salmo salar*	anadromous, benthopelagic
Atlantic cod	*Gadus morhua*	schooling, benthopelagic, brackish, marine
Haddock	*Melanogrammus aeglefinus*	demersal, marine
Spot	*Leiostomus xanthurus*	demersal, brackish, marine
Northern kingfish	*Menticirrhus saxatilis*	demersal, brackish, marine, shallow coastal waters
Mullets	*Mugil* species	schooling, anadromous, benthopelagic
Summer flounder	*Paralichthys dentatus*	demersal, marine, shallow coastal waters

3.5.2 Shellfish and Benthos

Common shellfish species in coastal Connecticut are the eastern oyster (*Crassostrea virginica*), surf clam (*Spisula solidissima*), northern quahog (*Mercenaria mercenaria*), blue mussel (*Mytilus edulis*), soft-shell clam (*Mya arenaria*), bay scallop (*Argopecten irradians*), razor clam (*Ensis directus*), and whelks, conchs, or scungilli (*Busycon* spp.) (Sea Grant, 2017). No site specific shellfish or benthic surveys were conducted for the overall project area.

The harvesting of shellfish is an intensive aquaculture industry in the shallow subtidal areas of New Haven Harbor. Shellfish species commercially managed and harvested in New Haven Harbor include the eastern oyster (*Crassostrea virginica*) and the hard-shell clam (*Mercenaria mercenaria*). Shellfishing in the inner harbor is prohibited and the outer harbor is designated as a "restricted relay" area. A "restricted relay" area is one where harvested shellfish stock is relayed (moved) to approved or conditionally approved waters for natural cleansing or depuration. Shellfish can only be harvested from restricted areas by special license, and may not be directly harvested for market or consumption. Due to the lack of hard substrate, lobsters

(*Homarus americanus*) are not prevalent in the project area.

According to the USACE's New Haven Harbor Navigation Improvement Project Draft Integrated Feasibility Report and Environmental Impact Statement, the harbor area is generally occupied by a mix of opportunistic early-successional stage benthic communities and mid-successional stage benthic communities (USACE, 2019). Early successional stage polychaete worms (e.g., *Streblospio benedicti* and *Capitella capitata*) and organisms such as the tubiculous polychaetes *Clymenella torquata* and *Spiochaetopterus oculatus* were prevalent in samples taken from the harbor (USACE, 2019).

3.5.3 Reptiles and Amphibians

No site-specific reptile or amphibian surveys have been conducted in the study area. No amphibians are expected to inhabit the New Haven focused study area because of the density of development and lack of freshwater habitat. Several threatened and endangered sea turtles may occur near the project area (see Section 3.5 Threatened and Endangered Species for additional information).

3.5.4 Birds

The most abundant species likely to be found in the overall project area are habitat generalists that are tolerant of development such as house sparrow (*Passer domesticus*), mourning dove (*Zenaida macroura*), crow (*Corvus brachyrhynchos*), eastern tufted titmouse (*Parus bicolor*), northern cardinal (*Cardinalis cardinalis*), Carolina wren (*Thryothorus ludovicianus*), American robin (*Turdus migratorius*), gray catbird (*Dumetella carolinensis*), European starling (*Sturnus vulgaris*), common grackle (*Quiscalus quiscula*), and brown-headed cowbird (*Quiscalus major*). Shorebirds are also common along the Connecticut coast including within the project area. Waterfowl (ducks and geese) are common inhabitants of these areas, and are more abundant during migration and wintering periods.

Long Wharf Park in the New Haven study area is a public area with a mix of beach, tidal wetland, and stabilizing structures such as seawalls. The area around the park is developed so it provides only limited wildlife habitat value. The beach width is not conducive for shore bird nesting. Historical studies of the New Haven Harbor, from 1971-1977, reported a total of 125 bird species observed in the harbor (Normandeau, 1979). The western side of the harbor, where the study are is located, was used extensively by waterfowl, gulls, and shorebirds. The fewest species were observed in spring and the highest numbers observed in summer and fall. Scaup (*Aythya marila*) were the most numerous of the diving ducks, and black ducks (*Anas rubripes*) the most predominant of the dabblers (Normandeau, 1979). Other waterfowl species that were

abundant in the harbor include horned grebe (*Podiceps auritus*), canvasback (*Aythya valisineria*), common goldeneye (*Bucephala clangula*), and bufflehead (*Bucephala albeola*). Commonly found shorebirds include black-bellied plover (*Pluvialis squatarola*), dunlin (*Calidris alpina*), sanderling (*Calidris alba*), semipalmated sandpiper (*Calidris pusilla*), great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), ring-billed gull (*Larus delawarensis*), Bonaparte's gull (*Chroicocephalus Philadelphia*), and common tern (*Sterna hirundo*). A review of The Cornell Lab of Ornithology's ebird database revealed observations of 346 species from locations abutting New Haven Harbor between 2008 and 2018 (Cornell Lab of Ornithology, 2019). Bird species present were similar to those noted previously from the historical studies.

The Sandy Point Bird Sanctuary, located about 2 miles south of the study area, is one of the most significant nesting locations for the federally threatened piping plover (*Charadrius melodus*) in Connecticut (USACE, 2019). It is also contains habitat for least tern (*Sternula antillarum*) and common tern colonies. The area receives significant usage by migrating shorebirds, which roost on the sand spit and sandbars at high tide and forage on the tidal flats at lower tides (USACE, 2019). It is one of the primary stopover areas for red knot (*Calidris canutus*) in Connecticut. There is also a small nesting colony of saltmarsh sharp-tailed sparrows (*Ammodramus caudacutus*) in the small tidal marsh, and the area receives significant usage by saltmarsh and Nelson's sharp-tailed sparrows (*Ammodramus nelsoni*) in migration (Cornell Lab of Ornithology, 2019).

3.5.5 Mammals

Site specific studies describing the diversity and abundance of mammals within the study area are not available. Mammals likely to inhabit the study area would be generalists tolerant of development such as raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), gray squirrels (*Sciurus carolinensis*), and opossums (*Didelphis virginiana*).

3.6 Federal Threatened and Endangered Species

The following species were identified by the U.S. Fish and Wildlife Service Information, Planning and Conservations System (IPaC) website as threatened or endangered resources that may occur in the study area (USFWS, 2019):

- Red knot (*Calidris canutus rufa*) – Threatened
- Roseate Tern (*Sterna dougallii dougallii*) – Endangered

Red Knot - The red knot was listed as a federally threatened species on 12 January 2015. The red knot makes one of the longest yearly migrations of any bird, traveling 9,300 mi (15,000 km)

from its Arctic breeding grounds to Tierra del Fuego in southern South America. During migration, red knots concentrate in huge numbers at traditional staging grounds. Delaware Bay is an important staging area during spring migration where the knots feed on the eggs of spawning horseshoe crabs. The red knot breeds in drier tundra areas, such as sparsely vegetated hillsides. Outside of breeding season, it is found primarily in intertidal marine habitats, especially near coastal inlets, estuaries, and bays (USFWS, 2013). It is unlikely that the Long Wharf project area is used by red knots; however, Sandy Point Bird Sanctuary in West Haven may be used as a transient stopover to or from their breeding grounds in the Canadian Arctic. Although no site specific bird surveys were conducted, there have been no documented observations of red knot in the project area according to the ebird.org website (Cornell Lab of Ornithology, 2019).

Roseate Tern - The northeastern population of the roseate tern was designated as federally endangered on 2 November 1987. Roseate terns were once abundant, but a variety of threats have resulted in reduced populations. According to the 1998 U.S. Fish and Wildlife Service Roseate Tern Recovery Plan – Northeastern Population, the numbers of roseate terns were severely reduced in the 1870's and 1880's by commercial hunting for the millinery trade. The total number of roseate terns was estimated to be roughly 2,000 pairs at the lowest point in about 1890 (Nisbet, 1980 in USFWS, 1998). Roseate tern populations increased following protection efforts but declined again to a low of 2,500 pairs in 1977 due to habitat loss and gull encroachment.

Roseate terns generally nest on sandy, gravelly, or rocky islands. Per the U.S. Fish and Wildlife Service 2010 Caribbean Roseate Tern and North Atlantic Roseate Tern (*Sterna dougallii dougallii*) 5-Year Review: Summary and Evaluation, in 2009, approximately 94% of the population of roseate tern pairs were concentrated at just 3 colonies: Great Gull Island, NY; Bird Island, Marion, MA; and Ram Island, Mattapoisett, MA (USFWS, 2010). Roseate terns feed almost exclusively on small and/or juvenile fish, occasionally including crustaceans and insects in its diet. Its feeding habits are fairly specialized, consuming primarily sand lance. Roseate terns capture food mainly by plunge-diving (diving from heights of 1-12 m and often submerging to ≥ 50 cm), but also by surface-dipping and contact-dipping (MA NHESP, 2007). One roseate tern has been reported at Sandy Point Bird Sanctuary in West Haven, but no sightings have been recorded within the project area (Cornell Lab of Ornithology, 2019).

In addition, two alternatives in the New Haven study area involve in-water work and as such, have the potential to impact aquatic species designated on the National Marine Fisheries Service (NMFS) species distribution maps (NOAA Fisheries, 2019). The project location overlaps with areas of potential distribution for the following species:

- Atlantic sturgeon (*Acipenser oxyrinchus*) – Endangered

- Shortnose sturgeon (*Acipenser brevirostrum*) – Endangered
- Atlantic loggerhead (*Caretta caretta*) – Threatened
- Green sea turtle (*Chelonia mydas*) – Threatened
- Atlantic leatherback (*Dermochelys coriacea*) – Endangered
- Atlantic Kemp's ridley (*Lepidochelys kempi*) – Endangered

Atlantic sturgeon - Atlantic sturgeon from any of the five Distinct Population Segments (DPS), (Gulf of Maine DPS is listed as threatened other four DPSs are listed as endangered), may be present in the project area. After emigration from the natal estuary, sub-adult and adult Atlantic sturgeon forage within the marine environment, typically in waters less than 50 meters depth (ASSRT, 2007 in USACE, 2014). Adult and subadult Atlantic sturgeon are known to occur in Long Island Sound, as well as within the waters off Connecticut and are likely to be migrating and possibly foraging opportunistically should suitable forage be available. In bays and harbors, foraging often occurs at or near areas with submerged vegetation or shellfish resources. The project area does not provide suitable habitat for overwintering, so the presence of Atlantic sturgeon is likely limited to the warmer months. The nearest spawning rivers are the Hudson River, New York, and the Kennebec River, Maine so no eggs, larvae or juvenile Atlantic sturgeon are likely to occur in the project area.

Shortnose sturgeon - Shortnose sturgeons have a range that extends from St. John River in New Brunswick, Canada to St. Johns River in Florida. Shortnose sturgeons are anadromous, spending a portion of their lives in salt water, but returning to freshwater to spawn. However, in some northern populations (e.g., in the Kennebec River), a portion of the population forages in the saline estuary while others forage in fresh water. The shortnose sturgeon exhibits delayed sexual maturity, high reproductive capacity, and long life expectancy (NOAA, 2014). Adult shortnose sturgeon primarily eat mollusks and large crustaceans. Feeding and overwintering activities may occur in both fresh and saline habitats; overwintering occurs in freshwater from late fall to early spring (NOAA, 2014). The Merrimack River in Massachusetts is the closest known spawning, rearing, foraging, and overwintering habitat for this species.

Sea Turtles - Four species of federally threatened or endangered sea turtles may be found seasonally in the coastal waters of Connecticut. The leatherback is generally found in deep offshore waters and as such, is unlikely to occur in the action area. In general, listed sea turtles are seasonally distributed in coastal U.S. Atlantic waters, migrating to and from habitats extending from Florida to New England, with overwintering concentrations in southern waters. As water temperatures rise in the spring, these turtles begin to migrate northward. As temperatures decline rapidly in the fall, turtles in northern waters begin their southward migration. Sea turtles can be expected in the waters of Long Island in warmer months, typically when water temperatures are at least l5°C. This typically coincides with the months of May

through November, with the highest concentration of sea turtles present from June to October (Morreale, 1999; Morreale and Standora, 1998; Shoop and Kenney, 1992).

Although loggerhead turtles are much more abundant off southern New England than leatherbacks they are also not likely to occur in the project area. The loggerhead, has a conspicuously large, block-like head, and averages 3 ft. long and 300 pounds. Loggerheads feed on benthic organisms found in large bay systems and forage in the open waters in search of hard-shelled prey (crabs, crustaceans, mollusks), in addition to jellyfish, fish and eelgrass. Juvenile loggerheads regularly inhabit bays where they feed mainly on crustaceans and shellfish (Kenney et al., 2010).

The most endangered and smallest of the sea turtles, the Kemp's ridley averages 20-28 inches long and 80-110 pounds. The Kemp's ridley appears to prefer estuarine areas where green crabs and mussels are found. Kemp's ridley sea turtles are much rarer that the leatherbacks or loggerheads having been sighted off southern New England only a few times. Their main center of distribution is off the southeastern U.S. and in the Gulf of Mexico. Small juveniles are known to utilize shallow developmental habitats around eastern Long Island and Cape Cod (Kenney et al., 2010). No sightings of Kemp's ridley turtles have occurred in New Haven Harbor.

There has been only one recent sighting of a green sea turtle off southern New England, and it was not near the project location. They are primarily found in shallow, tropical waters. Small juveniles are known to utilize shallow developmental habitats around eastern Long Island and Cape Cod (Kenney et al., 2010), but their occurrence in New Haven Harbor would be considered rare.

3.7 State Threatened and Endangered Species

The Natural Diversity Data Base (NDDB) Areas depicted on Figures 8 and 9 identify the general locations of endangered, threatened, and special concern species and significant natural communities in the general study area and focused area in New Haven, respectively (CT DEEP, 2018b). An initial review of the New Haven study area was provided by the CT DEEP NDDB. Two species of invertebrates, seven species of vertebrates, and five species of vascular plants were identified that occur within or close to the boundaries of the project (CT DEEP, 2019a). Table 3 lists the species identified by CT DEEP NDDB.

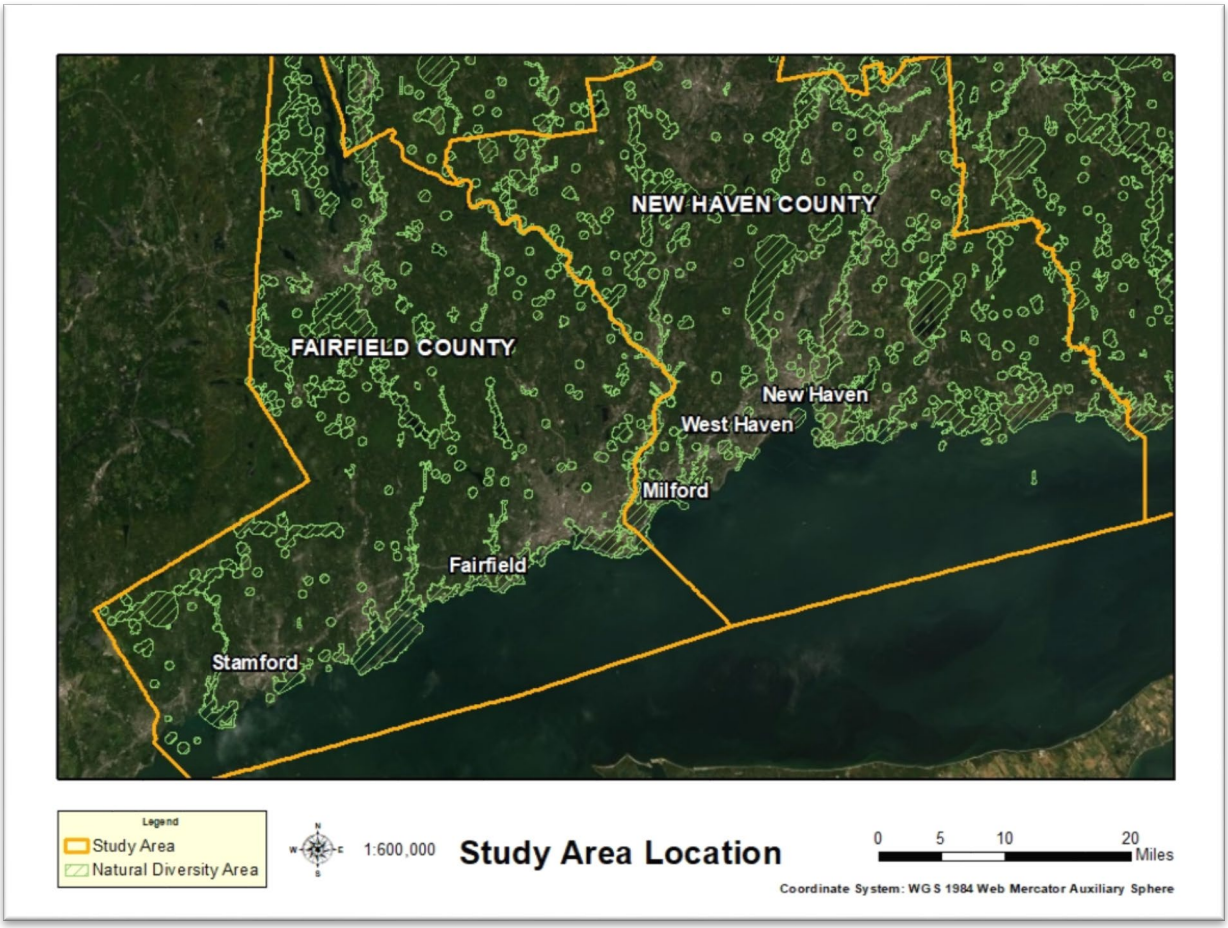

Figure 8. Fairfield and New Haven Counties Natural Diversity Data Base Areas (CT DEEP, 2018b).

Figure 9. New Haven Natural Diversity Data Base Areas (CT DEEP, 2018b).

Table 3. Natural Diversity Data Base species list for the New Haven study area (CT DEEP, 2019a).

Species	Common Name	State Status
Brachinus medium	Bombardier beetle	SC
Brachinus ovipennis	Bombardier beetle	SC
Acipenser oxyrinchus oxyrinchus	Atlantic sturgeon	E
Eremophila alpestris	Horned lark	E
Malaclemys terrapin terrapin	Northern diamondback terrapin	SC
Opheodrys vernalis	Smooth green snake	SC
Rana pipiens	Northern leopard frog	SC
Falco sparverius	American kestrel	SC
Alosa aestivalis	Blueback herring	SC
Asclepias viridiflora	Green milkweed	E
Cirsium horridulum	Yellow thistle	E
Coeloglossum viride	Long-bracted green orchid	E
Opuntia humifusa	Eastern prickly pear	SC
Pedicularis lanceolata	Swamp lousewort	T

3.8 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act mandates that Federal agencies conduct an Essential Fish Habitat (EFH) consultation with National Marine Fisheries Service (NMFS) regarding any of their actions authorized, funded, or undertaken that may adversely affect EFH. Essential Fish Habitat is broadly defined as "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity."

The alternatives involving floodwall construction in the intertidal area of Long Wharf Park and in the subtidal area of the northern portion of the New Haven study area have the potential to impact EFH. As such, sixteen federally managed species have the potential to occur within the in-water portion of the New Haven project area (NMFS, 2018). Managed species listed for the New Haven project area are detailed in Table 4.

Table 4. Summary of Essential Fish Habitat Designations at the New Haven study area (NMFS, 2018).

Species	Eggs	Larvae	Juveniles	Adults
pollock (*Pollachius virens*)			X	X
red hake (*Urophycis chuss*)	X	X	X	X
winter flounder (*Pleuronectes americanus*)	X	X	X	X
windowpane flounder (*Scopthalmus aquosus*)	X	X	X	X
black sea bass (*Centropristis striata*)			X	
scup (*Stenotomus chrysops*)	X	X	X	X
longfin inshore squid (*Doryteuthis pealeii*)	X		X	X
Atlantic mackerel (*Scomber scombrus*)	X	X	X	X
bluefish (*Pomatomus saltatrix*)			X	X
Atlantic butterfish (*Peprilus triacanthus*)	X	X	X	X
summer flounder (*Paralichthys dentatus*)			X	X
Atlantic herring (*Clupea harengus*)			X	X
sand tiger shark (*Carcharias Taurus*)			X	
smoothhound shark (*Mustelus* sp.)			X	X
winter skate (*Leucoraja ocellata*)			X	X
little skate (*Leucoraja erinacea*)			X	X

3.9 Socioeconomics

The majority of Connecticut's population is concentrated in densely urbanized areas. In 2010, there were more than 3.5 million residents in the state of Connecticut with five cities that have a population exceeding 100,000 people. There are 21 cities in total throughout Connecticut and 169 towns that are spread across eight counties (World Population Review, 2019).

New Haven is the second largest city in Connecticut with a population of about 130,000 people in 2010 (World Population Review, 2019). It is projected that New Haven's population will expand by nearly 15% by 2025 (New Haven CPD, 2015). New Haven is a part of the New York metro area and was the first planned city in the United States. The city of New Haven's total area is over 20 square miles, meaning that the population density is 6,500 people per square mile. The largest age group is 25 to 44, and over 25% of the total population is under the age of 18. The City's largest employer is Yale University. The services industry accounts for about 56% of the total economy (World Population Review, 2019).

3.9.1 Demographics

According to the 2010 U.S. census, Fairfield County had a population of 916,829 individuals and 361,221 total housing units. At that time, Fairfield County's population was 66.2% white, 10.1% black, 0.1% American Indian, 4.6% Asian, 16.9% Hispanic, and 1.5% two or more races (U.S. Census Bureau, 2010a). New Haven County had a population of 862,477 individuals with 362,004 housing units in 2010. The population was 67.5% white, 11.8% black, 0.2% American Indian, 3.5% Asian, 15.0% Hispanic, and 1.7% two or more races (U.S. Census Bureau, 2010b).

In the city of New Haven, the population was 129,779 individuals in 2010. Total housing units numbered 56,399 with a median price of $190,700. In 2010, New Haven's population was 30.9% white, 34.5% black, 0.3% American Indian, 4.7% Asian, 28.7% Hispanic and 17.8% reported as other or multi-racial (CERC, 2018). The median age in New Haven is 30.7 years old and females out number males with 52.7% of the population being women. The rate of home ownership is 27.8% in New Haven, with the majority of unmarried people renting. Thirty-one percent of people over the age of 25 had attained a high school degree and over 18% had a graduate degree (World Population Review, 2019).

3.9.2 Economy and Employment

The highest period of unemployment in Connecticut's recent history was in the early 1980's when the unemployment rate was close to 11%. The rate of unemployment declined until 2010 when unemployment spiked to 10% following the recession. In 2018, Connecticut's unemployment rate declined to 4.4% which is higher than the national average unemployment rate of 4% (Mills and Silbermann, 2018). From 2008 to 2017, Connecticut lost over 23,000 public sector jobs, a 9% decrease. The State gained 16,000 private sector jobs over that time period (CERC, 2018).

Median household income across the State was $71,755 in 2018. The same year, the median household income in New Haven was $38,126 with 26.1% of persons below the poverty level as

compared to 10.4% for the State (CERC, 2018). The average unemployment rate in New Haven was approximately 6.6% in 2018, while the State rate was 5.1 percent. The majority of jobs in New Haven are in health care and social assistance, government, and accommodation and food services (CERC, 2018).

3.10 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" require 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 U.S., including Native Americans. The Connecticut Department of Economic and Community Development (CDECD) identifies and annually updates a list of the state's most fiscally and economically distressed municipalities in order to target funds for needs such as housing, insurance, and economic development programs. The list is developed using information pertaining to municipalities' tax base, personal income of residents, and the residents' need for public services. In 2017, the city of New Haven ranked 20th on the CDECD's list of distressed municipalities (CDECD, 2017).

Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks," requires federal agencies to identify and assess environmental health risks and safety risks that may disproportionately affect children. Long Wharf Park in the project area is used by parents and their children.

3.11 Cultural Resources

The Quinnipiac tribe of Native Americans were settled in the New Haven Harbor area prior to the arrival of Europeans. The natives subsisted on fishing and the farming of maize. In 1637 a small party of Europeans wintered over in the New Haven Harbor area. In 1638, the main party of five hundred people arrived from Massachusetts and bought land from the Quinnipiacs. They set up a theocratic (they forbade the establishment of other churches) government and began to exploit the area's excellent potential as a port.

The town was named Newhaven in 1640. The community set up a nine-square grid plan for the town with the middle square being the town common. In 1664, New Haven became part of the Connecticut Colony under pressure from England and could no longer function as a theocracy. It was made co-capital of Connecticut in 1701, a status it retained until 1873. New Haven was incorporated as a city in 1784.

In 1716, the Collegiate School relocated from Old Saybrook to New Haven. In 1718, in response to a large donation from British East India Company merchant Elihu Yale, the name of the Collegiate School was changed to Yale College.

Industrialization came to New Haven in the late eighteenth century. A notable Yale graduate developed the cotton gin and established a gun manufacturing factory. It was in Whitney's plant the Samuel Colt invented the automatic revolver in 1836. Other manufacturing included other gun manufacturing companies, clock making and brass hardware.

The Civil War boosted the local economy with wartime purchases of industrial goods, including that of the New Haven Arms Company, which would later become the Winchester Repeating Arms Company (which remained in New Haven until 2006). After the war, population grew and doubled by the start of the twentieth century, most notably due to the influx of immigrants from southern Europe. New Haven reached its peak population after World War II. Immigrant labor helped New Haven become a leading producer of clocks, plows, wagons, guns, and clothing.

After World War II, with the increasing availability of cars, there was an exodus of people to the suburbs. Several urban renewal projects have taken place since with mixed results. (Note that much of the information referenced in section 3.11 was taken from a "Planning Assistance Letter-Cultural Resources Inventory" (dated 2010), Long Island Sound - Dredged Material Management Plan, Long Island Sound, Connecticut, New York, and Rhode Island. For Woods Hole Group, Inc., East Falmouth, MA.)

3.12 Coastal Zone Management

The state of Connecticut's federally approved Coastal Management Program is administered through the CT DEEP Office of Long Island Sound Programs. Pursuant to the Federal Coastal Zone Management Act (CZM), Connecticut has defined its coastal zone boundaries and developed policies to be utilized to evaluate projects within the designated coastal zone under the statutory umbrella of the Connecticut Coastal Management Act, enacted in 1980 (CT Gen Stat § 22a-90 Chapter 444, as amended).

Pursuant to Section 307 of the Coastal Zone Management Act (CZMA) (16 USC §§ 1451-1464), federal agencies conducting an activity which is reasonably likely to affect any land or water use or natural resource of the coastal zone are required to do so in a manner consistent, to the maximum extent practicable, with the enforceable policies of the state's coastal management program developed and implemented under the CZMA. Connecticut's approved coastal zone, for the purposes of exercising the federal consistency requirement of the CZMA, includes the area encompassed within the state's seaward boundary to the interior contour elevation of the one

hundred year frequency coastal flood zone, as defined and determined by the National Flood Insurance Act, as amended (USC 42 Section 4101, P.L. 93-234). The coastal boundary is further defined in Chapter 444, Sec 22a-94 (CT, 1980).

A Draft Coastal Zone Management Consistency Determination is provided in Appendix A2 and concurrence by the State will be requested.

3.13 Land Use and Zoning

According to the University of Connecticut's Center for Land Use Education and Research, as of 2010 approximately 19% of the state of Connecticut is developed land (UConn CLEAR, 2015). Increasing development from 1985 to 2010 caused a loss of 6.5% of forested land, but the majority of the State (59% total) has remained as deciduous and coniferous forest (UConn CLEAR, 2015). Approximately 7% of the State were fields for active agricultural purposes in 2010, but in 1985 about 22% of the State's land was used for agricultural (UConn CLEAR, 2015). Recent conservation efforts to protect the State's remaining farmland have resulted in municipalities owning 78,000 acres, land trusts owning 58,000 acres of protected open space, and approximately 47,000 acres of farmland permanently protected through easements as of 2008 (American Farmland Trust, 2011). In order to increase open space preservation, Connecticut set a goal to preserve or otherwise protect 21% of the state's land by 2023. As of September 2018, the State and DEEP's partners had achieved 75% of the goal through the direct purchase of open space, meaning that 507,347 acres had been preserved (CT DEEP, 2019c).

In the New Haven focused study area, the City Plan Commission advises the Board of Alders on land use including zoning and property dispositions (New Haven CPD, 2015). About 69% of the total land cover in New Haven is developed, 14% is forest, 8% is turf and grass, 3% is water, and 4% is wetlands (UConn CLEAR, 2015). From 2005-2015, approximately 1,000 housing units were added to the already developed downtown area with 1,000 more units planned to be added in the near future (New Haven CPD, 2015). There are three local historic districts in New Haven. Wooster Square which was established in 1970, Quinnipiac River established in 1978, and City Point established in 2001. There are 19 National Register Historic Districts as well as 40 individual properties or sites on the National Register in New Haven (New Haven CPD, 2015).

3.14 Hazardous, Toxic, and Radioactive Waste

A hazardous, toxic, and radioactive waste database search was not conducted for the entirety of the study area due to the large dimension of the area as well as the uncertainty of viable Federally-funded projects throughout the study's range. In the New Haven study area, the CT

DEEP's Significant Environmental Hazards (SEH) webmap (2018) was used to identify sites within the focused study site. Two sites in the northern portion of the study area were identified in the webmap (CT DEEP, 2018c). In 2001 at the 85 East Street Terminal, pollution was detected in groundwater that discharged to surface waters which may have posed risk to aquatic life. Water monitoring and a cleanup effort were conducted and the current status is listed as controlled. At the same site, the following year, the William Street Terminal Holdings L.P. found pollution in the top two feet of soil that might have posed risk to human life as a result of direct contact. Long term care was implemented and the SEH was also listed as controlled (CT DEEP, 2018c).

3.15 Aesthetic and Scenic Resources

The southern coast of Connecticut includes wetlands, barrier beaches and dunes, rocky shores and bluffs, upland fields and woodlands. In New Haven, the study area overlooks New Haven Harbor to the southeast providing a view of the water and marine traffic. Long Wharf Park provides visitors a place to enjoy these scenic water views.

3.16 Recreation

A large network of Federal, state and local public access sites in Fairfield and New Haven County support many outdoor activities such as biking, hiking, boating, fishing, bird-watching, golfing, and horseback riding. During the summer, Connecticut's beaches are heavily utilized drawing both local and out of state visitors each year.

The city of New Haven hosts over 2,200 acres of parks and a tree belt overseen by the Department of Parks, Recreation and Trees (New Haven CPRT, 2019). The Departments manages various sports and recreation activities including youth summer camps, adult tennis lessons, dance and yoga lessons, and a Friday night summer movie series (New Haven CPRT, 2019). Recreational facilities in New Haven include a skate park, golf course, carousel, and multiple pavilions, parks, and playgrounds. Within the project area, Long Wharf Park hosts a "Food Truck Paradise" which draws many visitors to the park during lunch hours to enjoy a multitude of food trucks that vend there. A visitor survey of the park in 2018 found that many visitors enjoyed the park's access to the waterfront, but remarked that more seating and bathroom options were needed to enhance the experience (LWP, 2018).

In September 2018, the Canal Dock Boathouse opened on Long Wharf Drive in New Haven. The non-profit community facility allows the public access to the harbor, kayak, sail, and rowing lessons, and an interpretive area and science lab. A living shoreline project along Long Wharf Park received funding from the CT DEEP in 2019. The project is intended to protect the park's

shoreline against erosion and help ease the effects of sea level rise. A stone sill, intertidal marshes, sand fill, and native plants will be added to the park area (City of New Haven, 2019a).

3.17 Air Quality

In accordance with the Clean Air Act (CAA) of 1977, as amended, the U.S. Environmental Protection Agency (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 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 national ambient air quality standards. The overall study area in New Haven and Fairfield Counties, Connecticut both meet the attainment criteria for all NAAQS priority pollutants except for 8-hour ozone (2008 and 2015) (USEPA, 2019).

The state of Connecticut is located within the Ozone Transport Region (OTR) which extends northeast from Maryland and includes all six 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 Connecticut has an approved SIP and has submitted periodic revisions to the EPA for approval in conformance with the CAA (CT DEEP, 2019b).

3.18 Greenhouse Gases

Greenhouse gases (GHGs) trap heat within the earth's atmosphere which increase temperatures. The largest source of greenhouse gas emissions from human activities in the United States is from burning fossil fuels for electricity, heat, and transportation (USEPA, 2016). Each Federal Agency project's NEPA assessments needs to consider and evaluate GHGs consistent with CEQ draft guidance released on the consideration of GHGs emissions and the effects of climate change (CEQ, 2019). For purposes of this guidance, CEQ defines GHGs as carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Also for purposes of this guidance, "emissions" includes release of stored GHGs as a result of destruction of natural GHG sinks such as forests and coastal wetlands, as well as future sequestration capability. The common unit of measurement for GHGs is metric tons of CO_2 equivalent [mt CO_2-e].)

The CT DEEP tracks GHG emissions across the state in an effort to meet the climate goals set by the Global Warming Solutions Act and An Act Concerning Climate Change Planning and Resiliency. These statutory requirements set targets of reducing GHG emissions 10% below 1990 levels by 2020, 45% below 2001 levels by 2030, and 80% below 2001 levels by 2050. In order to track GHG emissions, the state relies on the USEPA's State Inventory Tool which calculates sector-based GHG emissions based on various state-level data sets. In 2016, the latest reporting year, Connecticut's transportation sector was the largest emitter of GHGs. Economy-wide, Connecticut's GHG emissions were 41 million mt CO_2-e which is 9% below 1990 levels and 16% below 2001 levels (CT DEEP, 2016).

3.19 Noise

Noise is defined as unwanted sound. The day-night noise level (L_{dn}) is widely used to describe noise levels in any given community (USEPA, 1978). The unit of measurement for L_{dn} is the "A"-weighted decibel (dBA), which closely approximates the frequency responses of human hearing. The primary source of noise in the study area is vehicular traffic on Interstate-95 and local roadways and local construction projects that may be underway. Although noise level measurements have not been obtained in the study area, they can be approximated based on existing land uses. The typical L_{dn} for urban areas and homes next to a freeway range from 85-90 dBA (USEPA, 1978). It is assumed that the existing sound levels in the New Haven study area are roughly within this range.

Chapter 4: Formulation and Evaluation of Alternative Plans

This chapter presents the process used to scope, formulate and evaluate alternatives to achieve the study objectives and realize opportunities), where possible. The 1983 Economic and Environmental P&G for Water and Related Land Implementation Studies laid out an iterative 6-step planning process used for all USACE Civil Works studies in developing and evaluation of alternatives. For coastal storm risk management problems, the study team develops and evaluates potential alternatives consistent with USACE policy, regulations, and guidance. From the range of alternatives compared, the team will identify the plan with the highest net NED benefits while protecting the Nation's environment.

4.1 Problems and Opportunities

The problems in the study area are coastal storm damages caused primarily from inundation (flooding) caused by coastal storms that impact the region including hurricanes, tropical storms,

and nor'easters. High-valued commercial structures, residential development, and critical infrastructure (highway and rail systems, New Haven Police Station etc.) are at risk of damage. Additionally, during coastal storm events, there are concerns regarding public health and safety.

Opportunities are instances in which the implementation of a plan has the potential to create a desirable future condition and potential ways to address the specific problems within the study area. The primary opportunities identified for the study area are: Reduce economic damage from coastal storm events to residents, infrastructure and business within study area; Reduce risks to critical infrastructure (e.g. I-95 and the New Haven Rail system) from coastal storm impacts; Reduce risks to public health and safety.

4.2 Objectives and Constraints

Objectives: A planning objective asserts the intended purposes of the planning process and is a statement of what solutions should try to achieve.

The primary objective over the 50-year period of analysis (2024-2074) is to reduce costal storm risk within the Long Wharf, New Haven, CT focused study area. The specific objectives for the study area over the period of analysis is to:

- Reduce risk of coastal storm damage to residential, commercial, and infrastructure development in the Long Wharf, New Haven focused study area
- Reduce risk of coastal storm disruption to critical services and transportation infrastructure including the New Haven railroad system and Interstate 95
- Reduce risk of costal storm impacts to public health and safety
- Reduce risks to critical infrastructure from coastal storm impact
- Consider alternatives that support functional coastal ecosystems

Constraints:

Constraints are restrictions that limit the extent of the planning process. They can be divided into general constraints and study-specific constraints. General planning constraints are the technical, legal, and policy constraints to be included in every planning study that are recognized in the development of alternatives. Study-specific planning constraints are statements identified in particular for the study that are used to specifically screen or revise an alternative or plan that would violate a constraint.

General Constraints

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

Study Specific Constraints

- Alternatives should not restrict or significantly alter current shoreline/ocean access and use.
- Alternatives should not adversely impact operations or structural integrity of the adjacent I-95 highway system.
- Alternatives should not adversely impact operations of the adjacent New Haven Federal navigation project.

4.3 Plan Formulation and Evaluation Rationale

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 study team to identify those measures suitable to combine into alternatives. Next the alternatives are evaluated and compared. Alternatives are evaluated in consideration of the four P&G criteria stated below and through evaluation and comparison of four P&G accounts described below. (U.S. Water Resources Council, 1983)

4.3.1 P&G Criteria

Federal P&G establish four criteria for evaluation of water resources projects. These are completeness, effectiveness, efficiency, and acceptability (CEEA). These criteria and their

definitions are listed below. Alternatives considered in the study should meet minimum subjective standards of these criteria to qualify for further consideration and comparison 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. 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." Does the plan meet the objectives? 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. Does the plan minimize costs? Is it cost effective? Does it provide net benefits?

Acceptability

Acceptability is defined 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. It does not include local or regional preferences for particular solutions or political expediency." Is the plan acceptable and compatible with laws and policies?

4.3.2 P&G Evaluation Accounts

The P&G also established four 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 criteria is based on an estimate of costs and benefits for each alternative and selection of the plan that reasonably maximizes net benefits. Development of costs and benefits for each alterative is discussed below.

4.4 Without Project Condition (No-Action Alternative)

The forecast of the future without-project condition reflects the conditions expected during the period of analysis and includes consideration of sea level rise. The future without project condition serves as the condition to use as a comparison for all the other alternatives. The future without project condition within the period of analysis (2024-2074) for this study is identified as continued damages to coastal floodplain structures and property from future storm events. This will result in continued maintenance and reconstruction of residential and commercial property. The without project condition also assumes the living shoreline project will be constructed by the city of New Haven to address shorefront erosion.

4.4.1 Environmental Without Project Conditions

The effects of climate change (e.g., sea level rise, increased storm activity) may increase damages along the coast of New Haven. In addition, there may be some impacts to wetlands, flora and fauna, etc. over the life of the project. However, the location, intensity and magnitude of impact to environmental resources is dependent on specific storm events and it is assumed the areas would recover and be similar to what is present today. (See Chapter 6 for a more detailed description of natural resources in the "No Action" i.e. without project condition).

4.4.2 Economic and Social Without Project Conditions

The majority of the coastal floodplain in the study area is already developed; there are limited opportunities for new expansion. There are a few vacant parcels spread throughout the study reach, most of which are strictly regulated in terms of development. The total value of the existing residential and commercial inventory in the study area is estimated to be approximately $780 million.

It is assumed that in the absence of a Federal project, homeowners and businesses will continue individual efforts to repair damages after coastal storms. In the event a commercial structure sustains damage equal to or greater than 50% of its depreciated replacement cost, it is assumed that the structure will be flood proofed in accordance with NFIP and local rules. Other coastal storm damage (e.g. road repair and clean-up, debris removal) will continue to occur.

4.4.3 Estimate of Future Without Project Damages

In order to estimate damages in the Without Project condition within the Long Wharf, New Haven study area, the PDT utilized the USACE certified model, HEC-FDA (Flood Damage Analysis). Developed by the USACE Hydrologic Engineering Center, the software provides the

capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood risk management plans and is especially useful in evaluating the single damage mode (flooding) in those damage areas.

Future Without Project Condition Damages. The HEC-FDA model was used to estimate damages to the assets over the 50 year period of analysis with no Federal action (i.e. the "future without project condition" (FWOP)). For the alternatives evaluation and comparison an intermediate rate of sea level rise was assumed. Detailed information on the damage inventory, damage calculations, and HEC-FDA outputs are provided in Appendix B, Economics.

Table 5 provides a summary of structure and content damages for the FWOP. Structure damages include damages to commercial and residential buildings. Content damages, includes damages to material items housed within the buildings.

Table 6 provides the annualized damages for the Long Wharf, New Haven focused study area. No traffic delay costs were included in the benefit estimates but the PDT expects to include that analysis in the final draft of the IFR/EA in order to more accurately quantify NED benefits that the TSP will provide.

Table 5. Number of Structures and Damages by Probability Flood Event

New Haven 2024	50%	20%	10%	4%	2%	1%	0.4%	0.2%
Structures Affected	1	1	10	18	34	57	97	123
Total Damage (000s)	$28	$118	$22,008	$62,920	$129,853	$180,181	$228,306	$297,570
New Haven 2074	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.4%**	**0.2%**
Structures Affected	1	11	18	29	50	78	108	132
Total Damage (000s)	$106	$24,347	$65,390	$113,062	$170,943	$212,275	$260,760	$321,045

Table 6. Total Estimated Damages (2024-2074) Without-Project Condition

	Expected Annual Damage		% increase	Equivalent Annual Damage
	2024	2074		
New Haven	$10,990,000	$22,043,000	101%	$15,194,000

4.5 Key Uncertainties

Limitations to the quantity and quality of information result in uncertainties. Four major uncertainties in this phase of the planning process are:

Survey Data. No topographic surveys were completed for Long Wharf. Instead, available data and remote sensing techniques were used. This is an inherent data uncertainty but it was cost prohibitive to obtain detailed surveys for the entire Long Wharf study area.

Stage-Frequency Information. Stage-frequency information used for the HEC-FDA flood inundation damage evaluation modeling was obtained from the NACCS coastal modeling effort known as the Coastal Hazard System data. The NACCS annual exceedance probability stage frequency water surface elevation information is an estimate dependent on the costal storms processed in the modeling and other modeling inputs. These data are considered reasonable for use in USACE planning studies.

Sea Level Change (SLC). The rate of SLC in future years is not known, but there are several projections of what may occur varying from low (historic) to high rate of change projections. This uncertainty will be addressed by considering three rates of rise per USACE guidance in ER 1100-2-8162 dated 31 December 2013. Based on sea level trends for the area and the estimates provided by CIRCA, the economic damages were calculated assuming the intermediate rate of SLC. The TSP will be evaluated under the high rate of SLC as a sensitivity analysis prior to study completion.

Subsurface Investigations. Existing information was used from various past studies within the Long Wharf study area to characterize the subsurface conditions for the floodwall and closure structure designs. Data was provided by the city of New Haven and the CT DOT.

4.6 Management Measures – Developing and Screening Candidate Measures

Strategies to address coastal storm risk include accommodation, retreat, and no action (USACE 2015). To enact these strategies, structural measures (physical modifications designed to reduce the frequency of damaging levels of flood inundation) and nonstructural measures (actions to reduce flood damages without significantly altering the nature or extent of flooding) may be deployed.

Examples of structural accommodation measures include the construction of seawalls, bulkheads, revetments, breakwaters, etc. which are all considered hard structural measures. Beach nourishment projects (sand dunes and beach berms) are also a structural measure, but it is

considered a soft structural measure and is sacrificial requiring repeated renourishment over the project life. Non-structural accommodation include flood proofing and elevating or raising the first floor of the structure at risk. Retreat measures consist of moving at-risk structures back from the shoreline and/or property buy-outs (nonstructural).

The wide range of measures considered to reduce coastal storm damages for this study area are discussed below. The measures can be used individually or combined with other management measures to form alternative plans. The list of measures considered was derived from a variety of sources including prior studies, the public scoping process, and the study team's experience. Measures were screened based on the ability of the measure to: 1) meet the objective to reduce coastal storm induced damages and delays and reduce risk to health and safety; 2) be engineering practicable; 3) be economically feasible; 4) minimize environmental impacts; and 5) avoid the navigation constraint. Table 7 summarizes the results of the screening of measures and a brief discussion of each measure follows. The screening of measures left the study team with five measures to develop into alternative plans. Measures carried forward to develop the project alternatives are highlighted in Table 7 in yellow.

Table 7. Evaluation of Initial Measures

		Reduce coastal storm hazards & damages? (Effectiveness)	Reduce risk to public health/safety?	Engineeringly Feasible (Best professional judgement)	Economically feasible?	Negative impact to T&E /Critical habitat/commercial fisheries	Negatively impact existing Navigation Projects?	Retained for Further Evaluation?
Structural	Storm Surge Barrier	Yes	Yes	No	Not likely	Yes	Yes	No
	Beach Fill and Dunes	Yes	Yes	Yes	Likely	Potentially	No	No (1)
	Breakwater w/Beach Restoration	Yes	Yes	Yes	Not likely	Yes	No	No
	Rock Sill w/Beach Restoration	Yes	Yes	Yes	Not likely	Potentially	No	Yes(1)
	Shoreline Protection	Yes	Yes	Potentially	Not Likely	Potentially	No	No
	Pump Stations	Yes	Yes	Yes	Likely	No	No	Yes
	Closure Structures	Yes	Yes	Yes	Likely	No	No	Yes
	Small individual levees, berms or walls	Yes	Yes	Potentially	Not likely	No	No	No
	Floodwall/Seawall/Dikes/	Yes	Yes	Yes	Likely	No	No	Yes
Non-Structural	Elevation	Yes	Yes	Potentially	Not Likely	No	No	Yes
	Acquisition/Relocation	Yes	Potentially	Yes	Not Likely	No	No	No
	Flood proofing (dry & wet)	Yes	No	Yes	Likely	No	No	Yes
	Flood warning & Management plan	Yes	Yes	Yes	Likely	No	No	Yes(1)
	National Flood Insurance Program	Yes	Yes	Yes	Likely	No	No	Yes(1)
	Land Use Development Regulations	Yes	Yes	Yes	Likely	No	No	Yes (1)
	Community Education	Yes	Yes	Yes	Likely	No	No	Yes (1)
NNBF	Living Shorelines	Yes	Potentially	Yes	Likely	No	No	Yes (1)
	Wetlands	Yes	Yes	Yes	Not likely	No	No	Yes (1)
	Reefs	Yes	Yes	No	Not likely	Yes	No	No

(1): These measures are part of the without project condition. These living shoreline measures will be integrated into the Long Wharf living shoreline project which will be implemented by the city of New Haven and the state of Connecticut.

Structural Measures:

Storm Surge Barrier

This structural measure was not retained for further consideration due to the nature of the coastline in the vicinity of study area, the environmental impacts associated with such structures, extremely large costs (to build and maintain), and navigation and coastal use constraints.

Beach Fill and Dunes

This structural measure has proved to be a successful as a coastal erosion and flood risk management measure along a shorefront. This measure will be integrated into the Long Wharf living shoreline project which will be implemented by the city of New Haven and the state of Connecticut. Since this component will be completed by others, this measure was not carried forward. More information on the living shoreline project may be found in Section 1.5.

Rock Sill with Beach Restoration

This structural measure was has proved to be a successful coastal protection measure particularly for attenuating wave energy from low magnitude, high frequency coastal storm events. This measure will be integrated into the Long Wharf living shoreline project which will be implemented by the city of New Haven and the state of Connecticut. Since this component will be completed by others, this measure was not carried forward. More information on the living shoreline project may be found in Section 1.5.

Shoreline Protection

Given the nature of the existing shoreline and the upcoming Long Wharf living shoreline project (which is funded and as of October 2019 is moving forward to implementation) measures such as hardened revetments were not considered for the Long Wharf study area. Features such as cobble berms or "dynamic" revetments have proven successful in other parts of the country but would not integrate well into the living shoreline concept. This feature would also lack sufficient economic benefits to be considered further and is not carrying forward.

Pump Stations

While not a stand-alone measure to reduce coastal storm damage, pump stations could be integrated with other measures in order to formulate a complete plan for the Long Wharf study area. Specifically, pump stations could be utilized landward of I-95 to prevent flooding due to interior drainage issues during large coastal storm events. Pump stations are carried forward for further evaluation.

Closure Structures

While not a stand-alone measure to reduce coastal storm damage, closure structures could be integrated with other measures in order to formulate a complete plan for the Long Wharf study area. There are numerous road underpasses within the study area that create pathways for coastal storm surge to flood low elevation businesses landward of the I-95 highway embankment along with the New Haven Rail Yard. Permanent deployable flood gates could be designed to manage the risk of flooding via these pathways under the highway. Closure structures are carried forward for further evaluation.

Small Individual Levees, Berms and Floodwalls

These structures function in the same manner as structural project levees, berms, and floodwalls to reduce flooding. Small levees or floodwalls, built to ring a single building or a few adjacent buildings are intended to reduce the flood risk but not eliminate floodplain management and flood insurance requirements. The buildings within the Long Wharf study area (and critical infrastructure such as the New Haven Railyard) are relatively close to each other, but it is unlikely due to limited land area that this measure could be implemented from a practical and engineering standpoint. This measure was not retained for further evaluation.

Floodwalls/Seawalls/Dikes

Floodwalls and/or Seawalls- these measure were retained for further consideration as they could be used to augment the existing I-95 embankment and manage the risk of I-95 potentially being overtopped by coastal storm surge. Floodwalls in particular are a good fit for the study area in that they have a small footprint and can be engineered to integrate into other measures such as closure structures. An earthen dike structure along the coast of Long Wharf was determined to be economically infeasible and dropped from further consideration.

<u>Nonstructural Measures</u>:

Elevating Buildings

Other than relocating a building entirely from the coastal storm hazard area, elevating buildings is the nonstructural measure (doesn't modify the floodplain) that provides the greatest amount of flood risk management. Local building codes determine the maximum height to which a structure can be elevated.

Buildings would be elevated on solid concrete foundation walls (AE-zone) or appropriately designed piers (VE-zone). If the foundation below the first floor is an enclosed perimeter, then appropriately sized vents must be included to allow flooding of the space below the first floor to balance static water pressures. Appropriate access to the elevated first floor will be provided and all utilities, including furnaces and electrical panels, will be elevated. Due to

the fact that the study area is comprised primarily of large commercial properties, this measure was not retained for further evaluation.

Acquisition/Relocation

This measure requires purchasing impacted properties outright or physically moving the building and buying the land upon which the building is located. In both cases the impacted property reverts to protected open space. Development of acquisition and relocation plans to achieve the planning objectives and retain such aspects as community tax base and neighborhood cohesion can be part of any acquisition/relocation project. This measure may be applicable anywhere within the study area. Cost (especially outright acquisition), structural integrity of the building and land availability are the primary deciding factors on whether this is a viable alternative. Due to the fact that the study area is comprised primarily of large commercial properties, this measure was not retained for further evaluation.

Dry Flood Proofing

This measure waterproofs the building envelope. This measure can provide flood risk management for residential and commercial buildings but it is recognized for flood insurance purposes by the NFIP only for commercial buildings. Masonry or concrete buildings can generally be dry flood proofed up to design depth of 3 to 4 feet. This concept does not work with basements or with crawl spaces. For buildings with basements and/or crawlspaces, dry flood proofing could only be considered if the first floor is made impermeable to floodwater.

Due to the number of commercial structures within the Long Wharf study area, the PDT decided to retain this measure for further evaluation. Due to the magnitude of the coastal flooding (> 3-4 ft.), there may be limited application of dry flood proofing within the study area, particularly the structures located seaward of the Interstate 95 embankment.

Wet Flood Proofing

As a stand-alone measure, all construction materials and finishing materials are required to be water resistant. Flood vents are installed in the walls to allow floodwaters into the building and equalize the hydrostatic forces. All utilities must be elevated above the design flood elevation. Due to these requirements, wet flood proofing of finished residential buildings is generally not recommended. Wet flood proofing is applicable to commercial and industrial buildings when combined with a flood warning, flood preparedness and flood response plan. These plans provide time for valuable assets to be removed from the anticipated wet area. This measure is generally not applicable to large flood depths and high velocity flows.

Due to the number of commercial structures within the Long Wharf study area, the PDT decided to retain this measure for further evaluation.

Flood Warning Systems and Flood Preparedness Plans

These measures are applicable to the entire study area. All of the above nonstructural measures, with the exception of buyout and relocation to a completely flood-free site, should be combined with the development and implementation of flood warning and preparedness planning.

Comprehensive storm warning systems and evacuation plans are currently in place, therefore, the measure was not retained for further evaluation.

National Flood Insurance Program, Land Use Development Rights/Regulations & Community Response Education

Flood mitigation and floodplain regulation parts of the National Flood Insurance Program (NFIP) are the two measures that reduce flood risk. Five mitigation programs exist within the NFIP. They are the hazard mitigation grant program (HMGP), pre-disaster mitigation grant program, flood mitigation assistance program, repetitive loss program, and severe repetitive loss program. Within the floodplain regulation part of the NFIP, this serves as a nonstructural mitigation measure indirectly through adoption of minimum floodplain management standards by communities participating in the NFIP.

Comprehensive flood insurance is available and educational programs are supported by the city of New Haven which is a Community Rating System (CRS) community. The National Flood Insurance Program's CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS: 1) Reduce flood damage to insurable property; 2) Strengthen and support the insurance aspects of the NFIP, and 3) Encourage a comprehensive approach to floodplain management. Comprehensive participation in the NFIP is currently in place, therefore this measure was not retained for further evaluation by the USACE study team.

Natural and Nature-Based Features

Though not a stand-alone measure, Natural and Nature-Based Features (NNBF) were analyzed as a complimentary measure to several of the structural measures that were retained. However, based on the developed nature of the area the only area suitable for this type of measure is along the shorefront. The city of New Haven in partnership with the state of Connecticut is working on implementing a living shoreline project in this area. Due to the fact that NNBF features along the shoreline will be implemented by others, (state of Connecticut and city of New Haven,) these measures were not retained for further evaluation.

4.7 Alternatives – Developing and Screening the Array of Alternatives

The five measures carried forward from the above screening of measures included perimeter protection (floodwalls, levees, dikes), closure structures, pump stations, and flood proofing (dry and wet). These management measures were used to formulate the initial array of alternatives. Preliminary economic analysis and parametric cost estimates of the initial array of alternatives for New Haven were used to identify the final array of alternatives for more detailed study. The initial array of alternatives was agreed to by the USACE vertical team at the USACE Alternatives Milestone Meeting (AMM) in September 2017. The initial array of alternatives for the Long Wharf, New Haven focused study area were: 1) No Action alternative; 2) The Structural alternative, consisting of a conceptual levee/floodwall system; 3) The Non-structural alternative, consisting of conceptual floodproofing, elevation and/or acquisition, and potential Natural and Nature Based Features (NNBF); 4) The Combination/Hybrid alternative (combining structural and non-structural elements and lastly; 5) The "Soft-Structural" Alternative (i.e. berm/dune system.)

As the study progressed, the Project Delivery Team worked to develop the conceptual initial array of alternatives into detailed plans. Engineering analyses were conducted, alternatives were fully developed, scoping meetings were held with local stakeholders, cost estimates were calculated and NEPA impacts were analyzed. As the iterative alternative development and screening process was conducted, the final array of alternative plans began to take shape. Alternative 5, the "Soft-Structural" Alternative (i.e. berm/dune system) was dropped out of consideration based on failure to avoid the constraint of "adversely impact operations or structural integrity of the adjacent I-95 highway system." The Long Wharf area is composed primarily of hydraulically placed fill (from when I-95 was built in the 1950's). From a geotechnical perspective, the area cannot support the induced loading from a berm/dune system which could result in structural issues with the I-95 embankment. Alternative 5 was therefore dropped from further consideration.

The focused array of five alternative plans and No Action are listed below and described in the following paragraphs. Note that Alternatives 3A, 3B, 4A and 4B are all derivations of the initial Alternative #4 presented at the AMM meeting (The Combination/Hybrid alternative, combining structural and non-structural elements).

Alternative 1: No Action
Alterative 2: Non-Structural
Alternative 3A: Existing I-95 Embankment
Alternative 3B: Enhanced I-95 Embankment
Alternative 4A: Shoreline Floodwall

Alternative 4B: Extended Shoreline Floodwall

Engineering considerations for the existing I-95 embankment heavily influenced the development of the final array of alternatives. Following the TSP milestone meeting in June 2019, numerous discussions were held with the non-Federal sponsor, CT DOT and Federal Highways regarding the I-95 embankment and how to best integrate it into the selected plan.

As part of the Long Wharf, New Haven, CT CSRM study, consideration was given to using the I-95 embankment as a CSRM structure in addition to floodwalls. In order to assess the suitability of using the I-95 embankment in this matter, the feasibility design team conducted a potential failure modes analysis (PFMA) to brainstorm failure scenarios that could occur if the embankment was used as a flood barrier. The failure scenarios developed in the assessment considered how well the I-95 embankment would perform as a CSRM structure. Damage to the I-95 embankment itself due to wave erosion, sloughing, or bridge stability issues during a storm event was not considered "failure" for the purposes of this analysis as long as the damage did not result in flooding of the protected areas.

Of all the potential failure modes (PFMs) considered in the PFMA, the team was most concerned about wave attack on the embankment. Given the relatively short duration of wave loading during an extreme event, erosion of the seaward face of the embankment would be expected but would not lead to significant erosion back into the I-95 embankment. This type of erosion damage would occur during the 100-year event even for the existing (i.e. no project) condition. Placing flood barriers along the bridge underpasses would not make wave attack on the embankment any worse. Placing properly sized riprap or other slope protection on the embankment could potentially mitigate this damage.

Seepage related PFMs were not considered to be of high concern given the available information, as loading is not expected to be of sufficient duration to allow these PFMs to progress to failure. PFMs related to bridge stability are very unlikely to occur, and even if they did, would be unlikely to result in subsequent breach of the embankment. Drains could be installed at the base of the abutment walls to reduce seepage pressures if necessary.

The PFMA was conducted with limited available information. While the team did receive a large package of as-built drawings and reports, much of the information that would have provided clarification for some of the PFMs could not be readily located. Information regarding the nature of the embankment fill materials is unclear, as are the configurations of the bridge overpasses. It is recommended that the following investigations/analyses be performed during the design phase of the project:

- Perform a thorough review of all available as-built and design information. This should be done in coordination with personnel at the CT DOT who are knowledgeable regarding this stretch of the I-95 embankment. This should include identifying penetrations which may exist through or underneath the I-95 embankment, as well as a thorough review of all bridge overpass as-built drawings.
- Conduct subsurface borings on the landward and seaward sides of the embankment to better define the nature of the fill materials within the embankment. Due to the high traffic volume, explorations within the embankment itself may not be feasible. If there are other available historic borings that contain this information, then additional borings may not be necessary.
- A seepage and slope stability analysis of the embankment should be conducted as part of the design phase to confirm the assumptions made for the seepage related failure modes discussed above.
- While the "feasibility-level" PFMA indicated that the embankment would perform adequately during the 1% annual chance exceedance design storm, it is critical that the state and Federal DOT have complete acceptance of the use of this embankment as a CSRM feature. At a stakeholder coordination meeting held in September 2019, the CT DOT notified the USACE team that much of the I-95 embankment was constructed using lightweight fills and that the embankment side slope stability was not as robust as the USACE team had previously assumed.
- During the design phase, it is strongly recommended that all changes or improvements to the I-95 embankment be closely coordinated with the CT DOT. This should be initiated at the beginning of the design phase, as well as at multiple points during the process.
- It is recommended that during the design phase, a more robust PFMA be conducted, and include CT DOT and other key stakeholders as appropriate

Alternative 1: No Action

This alternative assumes no Federal action to manage costal storm risk within the study area.

Alternative 2: Non-Structural Floodproofing

The Nonstructural alternative for the Long Wharf focused study area consists of providing non-structural storm risk management benefits through a combination of elevating or floodproofing eligible structures within the study area. 138 structures were initially found to be eligible for potential floodproofing or elevation of the first floor. The majority of these structures are large commercial properties. There are 12 residential structures within the study area that are potential candidates for elevating the first floor. There are 126 commercial structures within the study area that are potential candidates for either wet or dry floodproofing. Most of the buildings are large commercial buildings that would be extremely difficult, if not impossible to properly

floodproof. This option would not reduce the risk of coastal storm damage to the rail and highway infrastructure. (Note that additional analysis of non-structural components will occur following public and agency review of the draft feasibility report and the Agency Decision Milestone.)

Figure 10. Alternative 2, (Non-Structural)

Alternative 3A: Existing I-95 Embankment

This alternative uses deployable closure structures under I-95 to reduce the flood event frequency. Deployable closure structures would be used to prevent floodwaters from passing through where Long Wharf Drive, Canal Dock Road pass under I-95 and where Brewery Street passes under the Oak Street Connector. For costing purposes, a post and panel type system was assumed, however a more detailed analysis will be required during the design phase of the project. These systems would need to be stored near the openings and installed by a work crew prior to a storm event. The structure to close Long Wharf Drive would be roughly 60 foot wide and 3-4 foot high. Canal Dock Road would require a roughly 190 foot wide structure 4-5 foot high and Brewery Street would be approximately 65 feet wide and 1-2 foot high. Foundations for the system will require significant coordination with the existing utilities in the streets as well as coordination with CT DOT to tie the structures effectively into the I-95 walls or embankment. This option would provide protection only up to a flood elevation of approximately elevation

10.5’ NAVD88 after which water would start flooding across I-95 near where Long Wharf Drive crosses under I-95. Pumps will be required to move any stormwater out of the protected area. By the end of the fifty year period of analysis (2074), this alternative would potentially be exceeded by the 7.7-percent annual exceedance probability water level, considering the intermediate sea level change scenario.

Alternative 3A would rely heavily on the existing I-95 embankment to perform as a flood control structure during a coastal storm event. The existing embankment was not designed to perform in such a manner as communicated by the Federal Highways and the CT DOT. Additionally, the use of lightweight fills in the construction of the embankment (along with questionable side slope stability) casts uncertainty on the non-Federal acceptability of this alternative.

Figure 11. Alternative 3A, (Existing I-95 Embankment)

Alternative 3B: Enhanced I-95 Embankment

This alternative combines structural storm damage reduction features described in Alternative 3A including pumps and deployable structures, designed with a top elevation of 15.0 feet (NAVD88). In order to reduce the risk of structural failure of the I-95 embankment, this

alternative entails a 6,425 liner foot system that parallels I-95 along the length of the Long Wharf area. The system includes 5,950 linear feet of pile-supported floodwall along the seaward side of I-95 from near the Howard Avenue overpass to 600 feet North of Canal Dock Road. The system also includes a combined 475 linear feet of deployable closure structures (i.e. floodgates). In addition to the closure structures described for alternative 3A, two deployable structures approximately 6-8 feet high, would be needed for protection at the exit 46 on and off ramps. The alignment was assumed to be as close to the grade break at the top of I-95 in order to minimize the height. Maximum wall height in that scenario is in the range of 6 to 8 feet. This Alternative would protect the commercial and railroad areas behind I-95 from storms and waves up to approximately elevation 15 NAVD88. By the end of the fifty year period of analysis (2074), this alternative would potentially be exceeded by the 0.4-percent annual exceedance probability water level, considering the intermediate sea level change scenario. The Long Wharf Maritime Center would not be protected by this alternative and those structures and other residential properties may potentially be eligible for floodproofing which will be further analyzed by the study team following the Agency Decision Milestone.

Figure 12. Alternative 3B, (Enhanced I-95 Embankment)

Alternative 4A: Shoreline Floodwall

This alternative uses an approximate 6,850 foot long pile supported floodwall along Long Wharf Drive (rather than along I-95). Due to the low elevations in the area, the floodwall would be as high as 9 feet above existing grade and would reduce the risk of coastal storm damage to the commercial and transportation facilities extending to the same endpoints as Alternative 3B. At least 4 deployable structures would be required, one at Brewery Street (described in option 3A), one crossing Long Wharf Drive roughly 65 feet wide and 7 feet high, one at the Canal Dock Boathouse Access approximately 35 feet long and 9 feet high and one at the Long Wharf Park parking area which would be roughly 50 foot wide and 5 feet high. Additional access doors and/or structures would be needed to make the Long Wharf Park access convenient to pedestrians and other users. This alternative would restrict access and views of Long Wharf Park and would require some tree removal. Pumps will be required to move any stormwater out of the protected area as described in alternatives 3A and 3B.

This Alternative would protect the commercial and railroad areas behind I-95 from storms and waves up to approximately elevation 15' NAVD88. By the end of the fifty year period of analysis (2074), this alternative would potentially be exceeded by the 0.4-percent annual exceedance probability water level, considering the intermediate sea level change scenario. The Long Wharf Maritime Center would not be protected by this alternative and those structures and other residential structures on the seaward side of I-95 may potentially be eligible for floodproofing which will be further analyzed by the study team following the Agency Decision Milestone.

Figure 13. Alternative 4A, (Shoreline Floodwall)

Alternative 4B: Extended Shoreline Floodwall

This alternative consists of all the structures in alternative 4A except the Long Wharf Drive closure structure and extends the wall around the Long Wharf Maritime Center extending the floodwall approximately 3,000 feet. Due to the low elevations in the area, the floodwall would be as high as 13 feet (NAVD88) above existing grade. Part of this alignment would be along an existing seawall alignment and would pose difficult construction and design issues due to the available space to work around the existing wall.

In addition to the deployable closure structures in 4A, closure structures would be needed at the entrance to the Tank Farm (55 foot long 9 foot high), crossing East Street (90 feet long, 5 foot high) and crossing Water Street at the intersection with East Street (90 feet wide, 5 foot high). At least one additional pump would be needed in the Long Wharf Maritime Center to handle stormwater behind the floodwalls. This additional pump station would require a pumping capacity of approximately 100 cfs.

This Alternative would protect the commercial and railroad areas behind I-95 from storms and waves up to approximately elevation 15 feet (NAVD88).

Figure 14. Alternative 4B, (Extended Shoreline Floodwall)

4.8 Alternatives and CEEA criteria

The five alternatives and No Action identified above were evaluated against the P&G criteria with available information (see Table 8). Alternatives in the focused array meet the CEEA criteria except for the without project condition or "No Action Alternative". However, this alternative is carried forward through evaluation and comparison phase as required by NEPA and USACE guidance.

Table 8. Alternatives Verified: CEEA P&G Criteria

Alternative	Completeness	Effectiveness	Efficiency	Acceptability
	Includes all actions (including those of others) to achieve outputs	Meets objectives and avoids constraints	Likely cost effective means of achieving objectives	Plan is viable with respect to applicable state and federal laws and regulations
No Action Alternative 1: No Action	No	No	No	Yes
Alterative 2: Non-Structural	Yes	Yes	Yes	Yes
Alternative 3A: Existing Embankment	Yes	Yes	Yes	Yes
Alternative 3B: Enhanced Embankment	Yes	Yes	Yes	Yes
Alternative 4A: Shoreline Floodwall	Yes	Yes	Yes	Yes, may require environmental mitigation
Alternative 4B: Extended Shoreline Floodwall	Yes	Yes	Yes	Yes, may require environmental mitigation

4.9 Costs for Alternatives

Project First Cost of Alternatives:

Detailed project first cost estimates were developed for each alternative. See Cost Engineering Appendix E. Costs for floodwall, closure structures and pump station alternatives were estimated using a conceptual design to determine material and quantities and include pre-construction engineering and design and construction management. Contingencies on these features ranged from 46% to 49%. Contingency percentages were estimated for the alternatives using the abbreviated cost risk methodology. There were no mitigation costs estimated although

alternatives 4A and 4B my require mitigation. Real Estate Costs were estimated for the structural alternatives and include the permanent easement cost, incidental costs, and contingencies.

Economic Cost of Alternatives:

For the economic evaluation, interest during construction is added (opportunity cost of money) and the cost amortized over the 50-year planning horizon at the Federal discount rate of 2.75 %. Annualized OMRR&R is also included to determine the average annual equivalent (AAEQ) cost of the project. The economic cost of the alternatives is provided in Table 9.

Table 9. Economic Costs for the Final Array of Alternatives

Alternative	Total Project First Cost	IDC	Project Investment Cost	Average Annual Cost	O&M (0.01)	Total Average Annual Cost
Alternative 2	$ 47,449,000	$ 1,953,000	$ 49,402,000	$ 1,830,000	$ -	$ 1,830,000
Alternative 3A	$ 72,515,000	$ 2,985,000	$ 75,500,000	$ 2,797,000	$ 725,000	$ 3,522,000
Alternative 3B	$ 164,612,000	$ 6,776,000	$ 171,388,000	$ 6,348,000	$ 1,646,000	$ 7,995,000
Alternative 4A	$ 192,265,000	$ 7,915,000	$ 200,180,000	$ 7,415,000	$ 1,923,000	$ 9,337,000
Alternative 4B	$ 287,675,000	$ 11,842,000	$ 299,517,000	$ 11,094,000	$ 2,877,000	$ 13,971,000

4.10 Economic Evaluation and Comparison

The USACE flood damage analysis tool, Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4.2, was used to model all existing and future (2074) inundation damages in with- and without-project scenarios. Alternatives were evaluated based on the 2020 Federal Discount Rate of 2.75 percent and a period of analysis of 50 years. Damages under future with- and without-project conditions were estimated based on the frequency and extent of flooding damages experienced in each structure.

HEC-FDA requires the following inputs to calculate flood damages to structures: flood depth, depth/damage relationships, structure values, content value percentages, first floor elevations, and flood stage-probabilities.

The calculation of benefits (reduction in damages) for the structural and non-structural alternatives in all study reaches were evaluated using HEC-FDA software. Damages for both the without and with project conditions were determined in order to calculate the reduction in damages achieved by the alternative. A 50-year planning period (2024-2074) and the Fiscal Year 2020 (FY20) discount rate of 2.75% were used for present value (PV) calculations. Table 10 provide results of the benefits evaluation.

Table 10. Without Project Damages

	Expected Annual Damage		% increase	Equivalent Annual
	2024	2074		Damage
New Haven	$10,990,000	$22,043,000	101%	$15,194,000

Table 11. Long Wharf, New Haven "With Project" Benefits

Alternative	Description	With Project Dmg	Reduced Dmg	Total Plan Benefit
Alternative 3A	deployables; 10.5 ft	$ 6,337,000	$ 8,857,000	$ 9,325,000
Alternative 3B	Partial floodwall; 15 ft	$ 1,449,000	$ 13,745,000	$ 14,213,000
Alternative 4A	Floodwall; 15 ft	$ 1,449,000	$ 13,745,000	$ 14,213,000
Alternative 4B	Extended floodwall; 15 ft	$ 1,449,000	$ 13,745,000	$ 14,213,000

A proposed project is considered economically justified (a potential sound investment of Federal dollars) if the economic benefits of the project exceed the costs (e.g. if it has a BCR greater than 1.0).

Table 12 below shows the summary of the economic analysis. The BCRs were calculated by dividing the annual benefits by the annual cost. All alternatives examined had a BCR >1.

Planning guidance also requires identification of the plan (from among the plans with BCRs >1) that would produce the greatest contribution to NED. The NED Plan is the plan with a positive BCR that reasonably maximizes net annual benefits. The net annual befits of a plan are equal its annual benefits minus its annual costs. The alternative that reasonably maximizes net benefits is Alternative 3B and is the NED plan. All the floodwall alternatives provide annual benefits of 14.2 million but alternative 3B provides the highest net benefits due to its lower project cost. The BCR for Alternative 3B is 2.2.

Table 12. Final Array of Alternatives - Benefit-Cost Analysis

Alternative	Description	AAE Benefit	AAE Cost	Net Benefits	BCR
Alternative 2	Nonstructural	$ 2,210,000	$ 1,830,000	$ 380,000	1.2
Alternative 3A	Existing Embankment	$ 9,330,000	$ 2,800,000	$ 5,800,000	3.3
Alternative 3B	Enhanced Embankment	$ 14,210,000	$ 6,350,000	$ 6,220,000	2.2
Alternative 4A	Shoreline Floodwall	$ 14,210,000	$ 7,410,000	$ 4,880,000	1.9
Alternative 4B	Extended Shoreline Floodwall	$ 14,210,000	$ 11,090,000	$ 240,000	1.3

4.11 Environmental

A summary of the environmental impacts of the four alternatives and no action evaluated is shown in Table 13. Two alternatives (4A and 4B) may require mitigation due to permanent environmental impacts from the construction of a shoreline floodwall which would convert intertidal and subtidal habitat to a hard structure. Alternative 4A would have an estimated impact of 6,850 linear feet on intertidal and subtidal habitat and wetlands. Alternative 4B would have an estimated impact of 9,800 linear feet on intertidal and subtidal habitat and wetlands. It is unclear at this time if the sub-tidal impacts would need to be mitigated. No final cost for mitigation was calculated, but costs could be substantial; making a marginally justified alternative not justified. In-water work for Alternatives 4A and 4B would require additional environmental permitting (Section 404 and 401 of the Clean Water Act, Essential Fish Habitat Review pursuant to the Magnuson-Stevenson Act, and coordination with the National Marine Fisheries Service pursuant to the Endangered Species Act).

Alternatives 2, 3A, and 3B would have the least amount of impacts to natural resources as shown in Table 13. Although each of these alternatives have a positive BCR (>1), Alternative 3B protects a low-lying section of Interstate 95 (via a floodwall with a top elevation 15' NAVD88) which provides the most protection to the area with the least environmental impacts.

Table 13. Comparison of Environmental Impacts of Alternatives

	Final Array Alternatives					
	No Action *	Alt 2 - Nonstructural	Alt 3A - Existing I-95 Embankment, Potential Floodproofing in Maritime Center	Alt 3B - Enhanced I-95 Embankment, Potential Floodproofing in Maritime Center	Alt 4A - Shoreline Floodwall, Potential Floodproofing in Maritime Center	Alt 4A – Extended Shoreline Floodwall to Maritime Center
Environmental Resource Impacts						
Topography, Geology and Soils	Potential	Potential	Potential	Yes (topography/soil)	Yes (topography/soil)	Yes (topography/soil)
Wind and Waves	Potential	No	No	Yes (hard structural measures)	Yes (hard structural measures)	Yes (hard structural measures)
Water						
Hydrogeology/ Groundwater	No	No	No	No	No	No
Surface Water	Potential	No	No	No	Yes (in-water work)	Yes (in-water work)
Vegetation						
Upland	Potential	Potential	No	Yes (short term and long term grass removal)	Yes (short term and long term tree and grass removal)	Yes (short term and long term tree and grass removal)
Wetland (intertidal/subtidal)	Potential	No	No	No	Yes (fill in intertidal/subtidal)	Yes (fill in intertidal/subtidal)
Fish and Wildlife						
Finfish	Potential	No	No	No	Yes (in-water work)	Yes (in-water work)
Shellfish	Potential	No	No	No	Yes (in-water work)	Yes (in-water work)
Benthic	Potential	No	No	No	Yes (in-water work)	Yes (in-water work)
Reptiles/Amphibians	Potential	Potential	Potential	Potential	Potential	Potential
Birds	Potential	Potential	Potential	Yes (short term noise impacts)	Yes (short term noise, long term foraging area)	Yes (short term noise, long term foraging area)
Mammals	Potential	Potential	Potential	Yes (short term noise impacts)	Yes (short term noise, long term foraging area)	Yes (short term noise, long term foraging area)
Threatened and Endangered Species						
Federal	Potential	No	No	No	Potential (intertidal impacts)	Potential (intertidal impacts)
State	Potential	No	No	No	Potential (intertidal impacts)	Potential (intertidal impacts)
Essential Fish Habitat	Potential	No	No	No	Yes (in-water work)	Yes (in-water work)
Socioeconomics	Potential	Yes (benefit)	Yes (benefit)	Yes (benefit)	Yes (benefit)	Yes (benefit)
Environmental Justice	Potential	Yes (benefit)	Yes (benefit)	Yes (benefit)	Yes (benefit)	Yes(benefit)
Cultural	Potential	Yes	No	No	No	No
Coastal Zone Management	Potential	No	No	No	Yes	Yes
Land Use Zoning	Potential	No	No	No	No	No
HTRW	Potential	No	No	No	No	No
Aesthetic/Scenic	Potential	Potential	Potential	Yes (short and long-term)	Yes (short and long-term)	Yes (short and long-term)
Recreation	Potential	No	No	Potential (short-term)	Yes (short and long-term)	Yes (short and long-term)
Air Quality (NAAQS/GHG)	No	No	No	No	No	No
Noise	No	Potential	Yes (short-term)	Yes (short-term)	Yes (short-term)	Yes (short-term)

*The study area will continue to experience storm damage due to flood inundation, wave effects, and erosion. Although individual structures or natural resources may be affected over the life of the project, specific impacts are dependent on the intensity and location of storm events.

4.12 Other Social Effects Benefits and Regional Economic Development

In the OSE category, the benefit of the alternatives are to reduce safety and health risks that occur during and after storms. Structural floodwalls combined with closure structures and pump stations that actually reduce flood inundation will result in the benefit of safeguarding health and safety and will also improve the recovery process following a coastal storm event. The TSP also contributes to improving the resiliency of critical transportation assets (I-95 and New Haven Railyard). Potentially floodproofing commercial property in the Maritime Center will improve the buildings' ability to resist direct flood and other (mold) damage and that translates to improved safety as well.

The RED account reflects changes in the distribution of regional economic activity that result from each alternative plan. No items are identified that would impact the RED account.

4.13 Identification of Tentatively Selected Plan

Alternative 3B is the NED plan and the TSP. This alternative reasonably maximizes net annual benefits while protecting the Nation's environment. Net benefits for the TSP 3B equal $6,220,000 and return a BCR of 2.2 at the Federal discount rate of 2.75%. A summary of NED, EQ, OSE, and RED of the alternatives is shown in Table 14.

Table 14. Comparison of Alternatives NED, EQ, OSE, and RED Accounts

	No Action	Alt 2	Alt 3A	Alt 3B	Alt 4A	Alt 4B
NED (AAEQ net benefits)	-	$2.200,000	9,325,000	14,213,000	14,213,000	14,213,000
NED (total AAEQ residual damage)	$15,194,000	$13,462,000	$6,337,000	$1,449,000	$1,449,000	$1,449,000
EQ	Potential impacts - severity dependent on future storm events	Short and long term direct and indirect impacts	Short and long term direct and indirect impacts	Potential minor short-term impacts	Potential minor short-term impacts	Potential minor short-term impacts
OSE	Existing social behavior: mitigate as funding allows, evacuation as necessary and clean-up from storm events	Yes, recovery efforts greatly reduced. Evacuation not eliminated.	Yes, recovery efforts greatly reduced. Evacuation not eliminated.	Yes, but recovery effort compared to other structural alternatives greater. Evacuation not eliminated.	Yes, but recovery effort compared to other structural alternatives greater. Evacuation not eliminated.	Yes, but recovery effort compared to other structural alternatives greater. Evacuation not eliminated.
RED	Existing economic activity	Slight/temporary increase in local employment	Slight/temporary increase in local employment	Slight/temporary increase in local employment	Slight/temporary increase in local employment	Slight/temporary increase in local employment

The TSP, which is also the NED plan, consists of the construction of an approximately 6,425 linear foot coastal floodwall system running parallel to the I-95 embankment. The project could potentially include the floodproofing of commercial and residential structures located seaward of the I-95 embankment. Additional analyses are needed following the ADM milestone to determine if non-structural options are economically justified. Economic benefits of the TSP are summarized below in Table 14. **The costs shown in this table reflect the "working estimates" available at this point in the study process (draft report).**

The TSP meets the 1983 P&G criteria of completeness, effectiveness, efficiency, and acceptability. The plan includes all necessary components to obtain the objectives (complete), is the plan with the largest net benefits (efficient), the plan makes a significant contribution to the planning objectives to reduce coastal storm damages within the study area and is acceptable as a solution for reducing damages. Refinement and optimization of the TSP will occur after public review of the draft IFR/EA. Currently, no locally preferred plan has been identified.

Table 15. Tentatively Selected Plan, Annual Benefit and Cost Summary
(FY20 Price Level (FY 2021) 2.75 % discount rate, IDC applied)

TSP Project Economic Cost	**($)**
Investment Cost	
First Cost (includes constr., cont., PED, S&A, LERRD)	164,612,000
Interest During Construction	6,776,000
Total Investment Cost	171,388,000
Annualized Investment Cost	6,348,000
Annualized OMRR&R Cost	1,646,000
Total AAEQ Cost	7,995,000
TSP Economic Benefit	
Total Annual Damage and Loss Reduction Benefit	14,210,000
Net Benefit and BCR	
Annual Net Benefit	6,220,000
TSP Benefit-Cost Ratio	2.2

Chapter 5: Tentatively Selected Plan

5.1 Proposed Action/Plan Components for Alternative 3B

The TSP (alternative 3B), which is also the NED plan, consists of the construction of an approximately 6,425 linear foot coastal floodwall system running parallel to the I-95 embankment. The length of the system consists of 5,950 linear feet of floodwall and a combined 475 linear feet of closure structures. The TSP includes two pump stations and five deployable roadway closure structures which are displayed as "C1" through "C5" in Figure 15. The system would have a top elevation of +15 feet NAVD88. The TSP also includes the potential flood proofing of commercial and residential structures located seaward of the I-95 embankment. Opportunities for flood proofing commercial properties will be further analyzed before the study is completed. Optimization of the TSP will occur after public and agency review of the draft IFR/EA. Optimization of the TSP will include refinements to the plan and design based on any additional study and consideration of comments received during the review process.

5.2 TSP Features

Figure 15 displays the general features of the TSP. See Appendix D1, Civil Engineering, for more details and discussion of the TSP. A Potential Failure Mode Analysis (PFMA) Report is included in Appendix G to detail potential failure modes of the highway and additional design analyses which need to be completed during the Pre-Construction Engineering and Design (PED phase.

Two pump stations will be needed to manage stormwater on the landward side of the I-95 embankment in the event the closure structures are sealed during a coastal storm event. Exact locations of the pump stations have not been established at this point in the study but one will be needed on the south end of the project in the vicinity of the intersection of Long Wharf Drive and Sargent Drive. The other pump station will be located to the north in the vicinity of the intersection of Canal Dock Road and Sargent Drive. For planning purposes, it is assumed that the pump stations will be located on city and/or state owned property and will require permanent easements as described in Appendix F.

The feasibility-level pump size estimate of 400-500 cfs was developed by civil engineering based on available data and best professional judgment. Following the ADM milestone, the PDT will attempt to refine the pump station design to reduce the contingency from 49.5%. Detailed H&H evaluation and pump sizing will need to be performed during the Pre-Construction Engineering and Design (PED) phase when there is funding available to complete all necessary engineering evaluations.

Three different types of floodwall designs were analyzed as part of the study. The three types include a 4-6 foot high wall (Type 1), a 6-8 foot high wall (Type 2) and an 8-10 foot high wall (Type 3). Similarly, 3 different types of closure structures were analyzed based once again on design heights. The 3 types include a 3-5 foot flood gate (Type 1) a 5-7 foot high flood gate (Type 2) and a 7-9 foot high flood gate (Type 3). Details on these conceptual designs may be found in the Structural Engineering Appendix D2. Additional structural and geotechnical engineering evaluations will be required during the PED phase of the project to complete the final designs of floodwalls and closure structures

Figure 15: Tentatively Selected Plan- Alternative 3B, Enhanced Embankment

The TSP includes potential floodproofing of commercial and residential structures that are located seaward of the I-95 embankment. The study team will further evaluate these structure prior to completion of the final report to determine the feasibility and local support for floodproofing these commercial properties. The floodproofing could entail either "dry" or "wet" floodproofing.

Dry floodproofing consists of sealing all areas from the ground level up to approximately 3 feet of a structure to reduce the risk of damage from storm surge resulting from storms of a certain magnitude

by making walls, doors, windows and other openings resistant to penetration by storm surge waters. Walls are coated with sealants, waterproofing compounds, or plastic sheeting is placed around the walls and covered, and back-flow from water and sewer lines prevention mechanisms such as drain plugs, standpipes, grinder pumps, and back-up valves are installed. Openings, such as doors, windows, sewer lines and vents, may also be closed temporarily, with sandbags or removable closures, or permanently. Critical utilities may be relocated to a less vulnerable elevation.

Wet floodproofing generally involves the installation of flood vents in the walls of the structure to allow floodwaters into the building and equalize the hydrostatic forces. All utilities must be elevated above the design flood elevation. Due to these requirements, wet flood proofing is applicable to commercial and industrial buildings when combined with a flood warning, flood preparedness and flood response plan. This measure is generally not applicable to large flood depths and high velocity flows.

Land, Easements, and Rights-of-Way Requirements: USACE projects require the non-Federal sponsor provide lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRDs) for a project. Temporary work area easements (TWAEs) for 5 years (access, staging, construction, and mobilization) will be required to construct a floodwall 5,950 feet long adjacent to the I-95 embankment, five road closure structures, approximately 475 feet long in total, and two pump stations. Construction of the floodwall will require TWAEs over two privately-owned residential properties with total lot sizes of +/- 0.14 acre and +/- 0.17 acre and over four City-owned parcels; acreage of the municipal properties totals +/- 5.48 acres. A TWAE will also be required from CT DOT for construction of the floodwall and five road closure structures adjacent to and in the right of way of the I-95 embankment; and from the city of New Haven for the construction of the two pump stations on City-owned property. The actual areas encumbered by the TWAEs will be a 10 to 20 linear foot wide work area along the length required on each property.

Permanent easements from CT DOT will be required for the floodwall and the road closure structures. Permanent easements from the city of New Haven will be required for two pump stations.

The nonstructural floodproofing measures described above will be offered to owners of structures that have been determined to be eligible and that have voluntarily consented to grant a temporary work area easement for construction, staging and storage areas and a permanent restrictive easement limiting alteration of the structure for human habitation below a height corresponding to the targeted first floor elevation for each structure (if applicable). The non-Federal sponsor will also be required to provide temporary relocation assistance benefits to

tenants occupying eligible structures (as applicable). Details are provided in Appendix F, Real Estate Report.

5.3 TSP Cost Estimate

The costs presented for the TSP were developed using the USACE Micro-Computer Aided Cost Estimating System (MCACES), Second Generation (MII). The MII cost estimate used RS Means, MII Cost Libraries, and vendor quotations. The project contingencies were developed through the Abbreviated Risk Analysis (ARA) tool provided by the USACE Cost Center of Expertise. Detailed information for the cost estimates can be viewed in the Cost Engineering Appendix, (Appendix E).

The "Project First Cost" estimate is broken out by cost component in Table 16. The Project First Cost includes the initial construction, a risk-based contingency, pre-construction engineering & design, construction management, and LERRD costs. Annual operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs are currently estimated at 1% of the total project first cost. The TSP initial construction Project First Cost is estimated at $164,612,000.

Table 16. TSP Cost Estimate[1]
(Fiscal Year 2020 Price Level)

Account/Cost Component	Cost ($)
Initial Construction Cost (Project First Cost)	
15 – Floodwall Structure	80,064,000
15 – Closure Structures	5,555,000
15 – Pump Stations	51,000,000
15 – General Conditions	13,621,000
Subtotals	150,240,000
LERRD	397,000
30 – Pre-Construction Engineering & Design (PED)	8,596,000
31 – Construction Management (S&A)	5,379,000
Total	164,612,000

[1] Initial construction is cost shared 65% Federal and 35% non-Federal. See Section 9.2 for cost apportionment.

5.4 Refined Annual Cost and Benefit of the TSP

Annual Cost and Benefit of the TSP is provided in Table 17. Dividing the annual benefits of the TSP by the annualized investment costs results in an estimated BCR of 2.2 for the TSP.

Table 17. TSP Refined Annual Benefit and Cost Summary
(FY20 Price Level, FY20 2.75 % discount rate)

TSP Project Economic Cost	**($)**
Investment Cost	
First Cost (includes constr., cont., PED, S&A, LERRD)	164,612,000
Interest During Construction	6,776,000
Total Investment Cost	171,388,000
Annualized Investment Cost	6,348,000
Annualized OMRR&R Cost	1,646,000
Total AAEQ Cost	7,995,000
TSP Economic Benefit	
Total Annual Damage and Loss Reduction Benefit	14,210,000
Net Benefit and BCR	
Annual Net Benefit	6,220,000
TSP Benefit-Cost Ratio	2.2

5.5 Risk and Uncertainty Analysis

Risk and uncertainty has been explicitly factored into the economic analysis of this project. HEC-FDA, which is a probability based model, was used in the study to formulate and evaluate the structural and non-structural alternatives within the Long Wharf at New Haven study area. Residual risk was also analyzed as part of the economic evaluation. Alternative 3B carries a with-project residual risk (i.e. remaining damages) of $1.4 million annually.

A sensitivity analysis was conducted as part of the study to capture the effect of “low” (.47 feet over 50 years and 0.94 over 100 years) and “high” (2.59 feet over 50 years and 7.02 feet over 100 years) sea level change over time on the TSP (see Table 18).

Table 18. TSP Structure Total Change with Alternative Regional Sea Level Change (RSLC) Rates

Long Wharf, New Haven CT study area	Percent Change from Intermediate RSLC (0.98 ft. over 50 years and 2.40 ft. over 100 years)			
	Low RSLC (year 2074)	High RSLC (year 2074)	Low RSLC (year 2124)	High RSLC (year 2124)
	43.8%	58.1%	55.6%	63.8%

Chapter 6: Environmental Effects

This section evaluates the environmental effects of the TSP and the no action alternative only because the other alternatives presented less net economic development benefits and greater negative impacts to the environment.

6.1 Topography, Geology, and Soils

No-Action Alternative: Under the no action alternative, topography may change due to soil erosion as a result of storm events and flooding. The effects of these events and climate change may be mitigated to some extent by the Long Wharf Park living shoreline project for which the city of New Haven received funding in 2019 to design. The construction schedule for the project has not yet been released. The geology of the project area is not expected to change within the lifespan of the project.

Tentatively Selected Plan: The construction of the floodwall adjacent to I-95 will change the topography and soils of the area. No short or long-term changes to the geology of the project site would occur with the TSP. The proposed plan will limit the extents of flooding and potentially alter the mapped floodplain designations. As the floodwall and closure structures will prevent storm surge from penetrating the Long Wharf area northwest of I-95, areas landward of the proposed structural measures could potentially be remapped if the idea is pursued by the city of New Haven. The AE Zone boundary will likely be coincident with the floodwall and closure structures. The limits of the FEMA VE Zone will not be changed by the project.

6.2 Wind and Wave Climate

No-Action Alternative: The effects of climate change such as increased storm events may cause changes to the wind and wave climate of New Haven Harbor. These storm events in conjunction

with projected sea level rise will likely cause waves to overtop Long Wharf Park resulting in flood conditions on I-95 and properties within the study area.

TSP: The floodwall and closure structures of the proposed project will prevent waves from flooding I-95 and properties behind it. Wave conditions within New Haven Harbor and on the seaward side of the floodwall and closure structures may increase in severity with sea level change. However, waves with the potential to propagate overland and impact the floodwall and closure structures are only anticipated to occur during extreme storm events. Impacts will therefore be short term and localized and are not expected to cause increased erosion seaward of the wall. Erosion and scour due to wave reflection nearest the floodwall and closure structures can be mitigated by armoring the embankment slope at the toe of these vertical structures. No long-term changes to wind conditions in the project area are expected as a result of floodwall construction. Potential non-structural alternatives in the Maritime Center area will cause no long or short-term changes to winds and waves.

6.3 Water Resources

6.3.1 Regional Hydrogeology and Groundwater Resources

No Action Alternative: The 50-year life of the project is not long enough to affect change to the on regional hydrogeology. Increased development in the project area may put additional pressure on groundwater resources. However, projects affecting groundwater resources would be subject to Federal, state and local laws and regulations promulgated to protect this resource.

TSP: No short and long-term changes to regional hydrogeology and groundwater resources would be expected with the implementation of the TSP.

6.3.2 Surface Water

No Action Alternative: The project area will continue to be subject to storm events and flooding over the life of the project. Natural coastal flood processes will continue under the no action alternative.

TSP: Under the TSP, no long-term impacts to surface water are anticipated. The two pump stations to be constructed for the TSP would be connected to existing City-owned stormwater pipelines and utilities. No work below high tide or in wetlands is proposed, thus, a Clean Water Act (CWA) Section 401 Water Quality Certificate and Section 404(b)(1) Evaluation and Essential Fish Habitat review are not required. Best management practices (BMP's)

implemented during construction would minimize sediment laden storm water runoff (e.g. utilization of silt fences to prevent sediment runoff into local waterways).

6.4 Vegetation

6.4.1 Upland

No Action Alternative: The no action alternative may have some minor impacts to upland vegetation as a result of storm events or coastal flooding. The amount of change would be dependent on site-specific conditions and the magnitude of the storm event(s).

TSP: The TSP would have temporary and long term impacts to vegetation in the project area which consists of a mowed grass landscape. Grass will be removed and/or buried during construction, but seeding and/or sodding following construction will return the majority of landscape to its original condition. The floodwall is expected to be 12-24 inches wide and a total of 5,950 linear feet long which will convert grassy land to a wall structure along its length. Some ornamental vegetation may require removal to enable construction vehicle access. The removal of upland vegetation will be assessed during the preparation of plans and specifications. No removal of trees is expected to be required, but if tree or shrub removal is required, replanting will be required following construction. Therefore, the TSP will have no significant long-term impacts on the project area's vegetation.

6.4.2 Wetlands

No Action Alternative: The project area will continue to be impacted by coastal storm events over the life of the project which may affect wetlands. The magnitude and location of impacts to coastal wetlands (e.g., inundation, sedimentation, etc.) would be dependent on specific storm events. The living shoreline project in New Haven along Long Wharf Park is projected to increase the size and health of intertidal wetlands. The enhanced shoreline landscape should help attenuate waves during coastal storms.

TSP: There will be no short or long-term direct or indirect impacts to wetlands as a result of the TSP. Construction activities will be located within the footprint of existing structures in the Maritime Center area where nonstructural measures are proposed. Construction along the I-95 embankment will take place approximately 150 feet from the shoreline and wetlands. BMP's during construction will minimize sediment runoff to wetlands.

6.5 Fish and Wildlife

6.5.1 Finfish

No Action Alternative: Finfish species may gain more and enhanced habitat with the city of New Haven's living shoreline project which is expected to increase intertidal wetland habitat in the project area.

TSP: The proposed action does not include any in-water work and therefore, no short or long-term impacts to finfish are anticipated to occur. BMP's will be implemented during construction in order to reduce and/or eliminate impacts to aquatic organisms and their habitat (e.g. utilization of silt fences to prevent sediment runoff into local waterways).

6.5.2 Shellfish and Benthos

No Action Alternative: Shellfish and benthic resources may be temporarily impacted by the construction of Long Wharf Park's living shoreline, but the marsh restoration component may enhance shellfish and benthic habitat in the project area. Coastal storm events will continue to impact the project area which may affect shellfish and benthic resources.

TSP: The proposed action does not include any in-water work and therefore, no short or long-term impacts to shellfish and benthos are anticipated to occur. BMP's will be implemented during construction in order to reduce and/or eliminate impacts to aquatic organisms and their habitat (e.g. utilization of silt fences to prevent sediment runoff into local waterways).

6.5.3 Reptiles and Amphibians

No Action Alternative: As stated in section 3.5.3, large numbers of reptiles and amphibians are not expected to be found in the construction area. Therefore, impacts from coastal storms and the construction of the City-designed living shoreline at Long Wharf Park are not expected to cause significant impacts to these species.

TSP: The implementation of the TSP is not expected to have long or short-term impacts to reptiles and amphibians. Few to no reptiles or amphibians are expected to be within the construction area.

6.5.4 Birds

No Action Alternative: Bird species that use the shoreline of Long Wharf Park may temporarily be impacted by the construction of the city of New Haven's living shoreline. However, these species are expected to return following construction and may increase in variety and numbers due to habitat enhancement. Coastal storm events will continue to impact the project area which may affect bird habitat and food resources. Birds are mobile and would generally avoid or move away from impacted areas. As such, significant impacts are not expected, however, the magnitude and location of these effects would be dependent on specific storm events.

TSP: The most abundant species in the project area are common shorebirds, waterfowl, and gulls which have been habituated to the area's marine and vehicle traffic. Increased noise and heavy machine activity could cause their displacement or disruption in foraging within the immediate vicinity of the construction, but given the natural noise of the area this is not likely to be a significant impact. Avian species are highly mobile and are expected to avoid the construction area and return after completion of construction. There will be no long-term impacts on bird species. See Sections 6.6 and 6.7 for additional information regarding Federal and state-listed bird species.

6.5.5 Mammals

No Action Alternative: The project area will temporarily be impacted by the construction of the city of New Haven's living shoreline project along Long Wharf Park. The area will also continue to be impacted by coastal storm events which may affect mammal habitat and food resources. The magnitude and location of impacts to mammals would be dependent on specific storm events. However, neither short nor long-term significant impacts would be expected.

TSP: Mammals are not expected to be in the construction area given its proximity to a major highway. Any mammals that are present may experience short-term impacts during construction activities of the floodwall along I-95. During construction, heavy machinery and increased noise levels may cause displacement of individuals near construction activities. Mammals are mobile species and will move to avoid the construction areas, thus minimizing the impacts of construction activities on them. Mammals inhabiting the study area are accustomed to human activities and high levels of noise and would therefore likely return following the completion of construction. There will be no long-term impacts to upland mammals. There are no aquatic mammals in the project area and therefore, there will be no short or long term impacts to these species.

6.6 Federal Threatened and Endangered Species

No Action Alternative: The project area will continue to be impacted by coastal storm events over the life of the project which may affect the habitat and food resources of some federally-listed threatened and endangered species. The magnitude and location of impacts to species would be dependent on specific storm events. Plans for the living shoreline at Long Wharf Park will undergo Federal and state review to ensure that the construction will not adversely affect listed species.

TSP: There are two federally protected animal species under the jurisdiction of the USFWS that have been identified as possibly being present in the proposed project area: roseate tern (northeastern population) and red knot. The project area does not support suitable breeding habitat or feeding habitat for either species. Construction noise may increase the amount and duration of noise in the project area. Any transiting roseate terns will only briefly be subjected to increased noise as they fly through the area, thus no impacts to their migrations are anticipated as a result of the TSP. The same is true for red knots which make one of the longest yearly migrations to Arctic breeding grounds in Canada from southern South America. During migration, red knots concentrate in massive numbers at traditional staging grounds. The project area does not support suitable staging area, breeding habitat or feeding habitat for red knots. Therefore, the USACE has made a "no effect" determination for both roseate terns and red knots.

Under the TSP, no in-water work would occur and therefore, no federally protected species under the jurisdiction of the NMFS will be impacted.

6.7 State Threatened and Endangered Species

No Action Alternative: The project area will continue to be impacted by coastal storm events over the life of the project which may affect the habitat and food resources of some state-listed threatened and endangered species. The magnitude and location of impacts to these species would be dependent on specific storm events. Plans for the living shoreline at Long Wharf Park will undergo state review to ensure that the construction will not adversely affect listed species.

TSP: There are fourteen state-listed species in the New Haven project area that have been identified by the CT DEEP NDDB. However, the immediate construction area does not provide suitable habitat for any listed species. Therefore, no impacts to state listed threatened and endangered species are expected as a result of the TSP.

6.8 Essential Fish Habitat

No Action Alternative: The project area will continue to be impacted by coastal storm events over the life of the project which may affect the Essential Fish Habitat (EFH). However, the magnitude and location of impacts to EFH (e.g., nearshore areas, benthos, etc.) would be dependent on specific storm events. The living shoreline project at Long Wharf Park will undergo Federal review to ensure that the work is in compliance with the Magnuson-Stevens Fishery Conservation and Management Act.

TSP: There is no in-water work associated with the proposed project and therefore, no impact to EFH will occur.

6.9 Socioeconomics

No Action Alternative: The no action alternative may have short- or long-term impacts on socioeconomics. Flooding and storm related impacts may permanently impact existing homes and businesses. Businesses may leave the area which would cause a decrease in available work opportunities for residents.

TSP: The implementation of the TSP may have positive short- and long-term socioeconomic impacts. Protecting existing houses and businesses from flooding may help to preserve the area as an attractive coastal destination which should have positive socioeconomic impacts over the period of analysis. In the construction phase of the project, the introduction of construction workers into the community should result in their purchasing of supplies and food which may contribute to a minor temporary economic benefit to the local economy. The implementation of the plan is expected to have a direct positive impact on transportation and housing due to a reduction in future storm damage to existing properties, and the subsequent reduction in costs to repair such damages. Property values may increase in the project area due to the added coastal storm risk management of damages.

6.10 Environmental Justice

No Action Alternative: The city of New Haven is ranked 20th on the CDECD's list of distressed municipalities (CDECD, 2017). Continued coastal storms and their resultant damages could lead to further economic distress as properties and businesses take time to rebuild or relocate from the area altogether.

TSP: The construction of the TSP will reduce coastal storm-related damages to properties within the city of New Haven which is ranked on the list of distressed municipalities in the state of

Connecticut (CDECD, 2017). This long-term benefit increases the chance that economic opportunities will either remain the same or improve.

6.11 Cultural Resources

No Action Alternative: Continued coastal storms and their resultant damages could cause damage to the historic Amtrak railroad station.

TSP: The expansion of the Long Wharf area began in 1810, with the extension of the wharf to 0.75 miles, making it at the time the longest wharf in the U.S. Infilling of the land around and at Long Wharf continued into the twentieth century, therefore, the area has very low pre-contact archaeological sensitivity. While there is an historic district adjacent to Long Wharf and a railroad station listed on the National Register of Historic Places at Long Wharf, they will not be impacted by the project. Consultation has begun with the Connecticut State Historic Preservation Officer (SHPO), and the Tribal Historic Preservation Officers (THPOs) of the Mashantucket Pequot and Mohegan tribes. The placement of floodwalls and other project features will have no effect on any historic properties. The SHPO and THPOs are expected to concur with this determination.

6.12 Coastal Zone Management

No Action Alternative: The no action alternative will have neither short nor long-term impacts in terms of Coastal Zone Management policies. The city of New Haven's Long Wharf Park living shoreline project will be subject to the state's CZM consistency review.

TSP: In conformance with the established policies of Connecticut's Coastal Zone Management Program (CZM), USACE has determined that the proposed action is consistent with the State's Coastal Policies. For further information, see Appendix A1. Coordination with the CT DEEP Office of Long Island Sound Programs on the USACE's consistency determination is on-going. This section will be updated once coordination is complete.

6.13 Land Use and Zoning

No Action Alternative: The no action alternative may have short- and long-term impacts as storm damage and flooding will continue and possibly necessitate changes in land use as property is destroyed and land lost. The city of New Haven has long term goals for the redevelopment of the Long Wharf area which would include changes to the zoning of the area (City of New Haven, 2015). However, no construction plans have been developed or are planned for development in the near-term.

TSP: Implementation of the proposed action will have no negative short- or long-term impacts to land use and zoning. The implementation of the proposed coastal storm risk management measures is not expected to significantly induce future development in the adjacent areas.

6.14 Hazardous, Toxic, and Radioactive Waste

No Action Alternative: The project area will continue to be impacted by coastal storm events over the life of the project. As such, there is an on-going risk of impacts from HTRW due to infrastructure damage (spills, leaking pipes, etc.). However, the magnitude and location of HTRW damage would be dependent on specific storm events.

TSP: An evaluation of potential HTRW within the footprint of the floodwall may be conducted during the next phase of the project. However, it is not likely that HTRW will be found due to the fact that the site is composed primarily of hydraulically placed fill and highway embankment material and is far removed from all CTDEEP identified sites of Significant Environmental Hazards. HTRW, if found, would need to be remediated by the non-Federal sponsor to avoid short or long-term impacts to the environment from the implementation of floodwall construction. Measures will be undertaken to secure the site(s) (e.g., disconnect utilities, etc.) prior to the commencement of construction activities. Therefore, no short or long-term impacts will occur from implementation of the TSP.

6.15 Aesthetic and Scenic Resources

No Action Alternative: The no action alternative may have negative short- and long-term impacts as flooding and storm related impacts may permanently impact existing infrastructure. Businesses may not rebuild and leave empty lots or unrepaired properties which may impact the aesthetic and scenic resources in the area. The living shoreline project along Long Wharf Park will enhance the area's aesthetic and scenic resources by adding natural features to the shoreline such as intertidal wetlands and an increased area of beach.

TSP: The construction of the TSP will have negative and positive short and long-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 are generally not considered visually appealing. The long-term impacts of the proposed action will be permanent views of the floodwall from I-95, which will block the view of the neighborhood by the Howard Street Overpass and the park and coastline from around Exit 46 on the interstate. However, the views from Long Wharf Park to the west (toward the interstate) will be improved as the sound and sight of the interstate will be blocked from view where the floodwall is built in that area.

6.16 Recreation

No Action Alternative: The project area will continue to be impacted by coastal storm events over the life of the project which may impact recreational resources. However, the magnitude and location of damage and the effects on the recreational value or use in the area would be dependent on specific storm events. The construction of the living shoreline project along Long Wharf Park may increase recreation at the park through access to an expanded beach area.

TSP: The implementation of the TSP may have short-term impacts on recreation due to construction related disturbances (e.g., noise, increased traffic, etc.) near and within Long Wharf Park. No long-term impacts to recreation are anticipated.

6.17 Air Quality

No Action Alternative: The no action alternative may have negative short-term impacts to air quality as construction may occur more often due to repairs to property from continued flooding damages. No long-term impacts are expected under the no action alternative.

TSP: New Haven County is in attainment with the National Ambient Air Quality Standards (NAAQS) for all NAAQS priority pollutants except for 8-hour ozone (2008 and 2015) (USEPA, 2019). The TSP will produce temporarily localized emission increases from the diesel powered construction equipment working onsite. These localized emission increases will last only during the project's construction period and end when the project is over, thus any potential impacts will be temporary in nature. Based on a preliminary, qualitative assessment of the construction requirements, it is anticipated that this project will be within the de minimis levels in any one construction year. A Record of Non-Applicability is provided in Appendix A4. Coordination with the U.S. Environmental Protection Agency on this project's impacts as they apply to the Clean Air Act are on-going.

6.18 Greenhouse Gases (GHGs)

No Action Alternative: The project area will continue to be impacted by coastal storm events over the life of the project which may cause GHG-emitting construction methods to occur more often due to repairs to property from continued flooding damages. However, a significant increase in the amount GHGs, as a result of the increased use of diesel-fueled engines (which emits CO_2), is not expected under the no action alternative.

TSP: The primary GHG emitted by diesel-fueled engines is CO2. The project is estimated to generate a total of 17,572 metric tons of CO2 equivalent (see EPA Greenhouse Gas Equivalent

Calculator, www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator, website accessed December 5, 2019). The GHG emissions associated with the project are temporary and insignificant compared to the total of 41,000,000 metric tons of CO2-equivalent generated in Connecticut during 2016 (latest reporting period) (CT DEEP, 2016).

6.19 Noise

No Action Alternative: Under the no action alternative there may be negative short-term impacts from noise due to construction activities associated with storm and flooding damage repairs.

TSP: Implementation of the proposed action will have minor negative short-term impacts to noise as construction vehicles and actions will increase the noise levels temporarily up to 100 dBa. Long-term impacts may be positive as construction noise from necessary repairs due to flood damages will be reduced. Furthermore, the section of floodwall may reduce traffic noise from Interstate 95 to Long Wharf Park and the neighborhood by the Howard Street Overpass.

Chapter 7: Cumulative and Secondary Impacts

The CEQ defines “cumulative impact" as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The following section describes past, present and future Federal and local projects in the New Haven area.

Past actions in New Haven include the construction of bulkheads, rock revetments, seawalls, and groins along the harbor, development of the harbor as a commercial shipping port, and the filling of salt marsh and deforestation of forested uplands for residential and commercial development. Wastewater treatment plants and a power generation station was constructed adjacent to New Haven Harbor. Past actions also include the maintenance dredging of the New Haven Harbor FNP which has occurred approximately every 10 years since its establishment (USACE, 2019).

Past actions specifically associated with the Long Wharf area include the construction of commercial and industrial businesses, and the construction and expansion of the New Haven Rail Yard and Interstate 95. At Long Wharf Park, new bicycle paths, the Canal Dock Boathouse, and the Food Truck Paradise are all recent additions to the area.

Some past actions (ex. bulkheads and seawall construction, the filling of salt marshes, and the destruction of maritime forest) have significantly impacted the New Haven ecosystem by

removing valuable habitat and replacing it with commercially and residentially developed properties. Other past actions (construction of waste-water treatment plants and electric generating stations, port development, navigation) have impacts to water quality in the project area which range from short-term impacts to long-term.

As noted in Section 1.7, the city of New Haven's Long Wharf area is a major economic hub for the state. More than 70 commercial properties and key regional transportation infrastructure are located within the Long Wharf study area. Thus, present actions consist of the operation of these businesses and the railyard, as well as the transport of people and goods on I-95 and the Northeast Corridor mainline tracks. Impacts from these actions are generally related to short-term impacts to air quality from engine emissions.

Future activities in the study area are anticipated to remain similar to present actions. Additionally, the city of New Haven has focused efforts on redevelopment opportunities in the Long Wharf area over the last few years consistent with the City's overall plan "New Haven Vision 2025" (City of New Haven, 2015). The plan recommends further development of the Long Wharf area for office space, light industrial, residential, and retail and restaurant type uses. However, no zoning changes or construction projects to increase these uses in the area have been planned to date. The City has funding and construction plans for further enhancements in Long Wharf Park including the construction of a living shoreline which will serve the dual purpose of increasing recreational opportunities and protecting the area's shoreline from erosion.

Other future work that may occur in the area is detailed in the Long Wharf Responsible Growth Plan which envisions a green infrastructure park and street connecting five neighborhoods within and adjacent to the study area (City of New Haven, 2019b). The City and State are also pursuing efforts to enhance the area of Union Station through a comprehensive development program consisting of mixed-use commercial and residential developments within a half-mile of the station (City of New Haven, n.d.). No funding has been allocated for construction of any of the projects to date. The city of New Haven's population is projected to grow by about 9% from 2015 to 2040 (CT State Data Center, 2015).

Future Federal work in the area includes the USACE's New Haven Harbor Navigation Improvement Project (USACE, 2019). The proposed harbor improvements consist of deepening the main ship channel, maneuvering area, and turning basin to 40 feet MLLW and widening the main channel and turning basin to allow larger vessels to efficiently access the Port of New Haven's terminals. The project would remove about 4.28 million cubic yards of predominately glacially deposited silts from the Federal channel. Additionally, approximately 43,500 cubic yards of rock would be blasted and removed from the channel. Several feasible alternative dredged material placement sites were identified and include: an area for shellfish habitat

creation, two borrow pits in the harbor, an area for salt marsh creation, an area for rock reef creation, and open water disposal at an EPA designated ocean dredged material disposal site in Long Island Sound (USACE, 2019).

The effects of these future actions have been or will be documented in environmental assessments/impact statements and will be subject to Federal, state, and local permitting. Generally, most of the cumulative impacts related to the range of present and future actions will occur on land (e.g., construction-related impacts) and in the water column (e.g., impacts from dredging and stormwater discharges). However, the majority of impacts to these areas are short-term in nature and should not significantly contribute to a decline in the ecological or socioeconomic importance of Long Wharf or the city of New Haven overall.

There will not be secondary, or indirect, impacts likely associated with construction of this project. Direct effects are those caused by the TSP (i.e. construction of the floodwall and closure structures) and occur contemporaneously at or near the location of the action. As defined in NEPA, indirect effects:

> "are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems." (40 CFR 1508.8)

Long Wharf is an established area which hosts over 70 commercial businesses and the New Haven Rail Yard, an integral component of the Northeast Corridor rail line. Construction of the TSP will not cause increases in transportation or business production, but will allow a continuation of the current uses. Although the city of New Haven has a vision for redevelopment of the Long Wharf area which may attract businesses and housing developers, the TSP will not enable or disable these conceptual plans. Therefore, no secondary impacts from the project will be realized.

Chapter 8: Coordination & Compliance with Environmental Requirements

8.1 Compliance Summary

Table 19. Summary of Applicable Federal Laws and Regulations

Item	Citation	Compliance
Clean Air Act	42 U.S.C. §§ 7401 et seq.	A Record of Non-Applicability (RONA) is provided in Appendix A4. Coordination with the USEPA is on-going.
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. §§ 1451-1464 CT Gen Stat § 22a-90 Chapter 444, as amended	A CZM Determination was prepared and is located in Appendix A1 and will be coordinated with the CT DEEP Office of Long Island Sound Programs during public review of the Draft Integrated Feasibility Report and Environmental Assessment.
Endangered Species Act of 1973	16 U.S.C. 1531 et seq.	USACE Section 7 Coordination with USFWS is on-going regarding endangered species.
Environmental Justice in Minority and Low Income Populations	Executive Order 12898	USACE performed an analysis and has determined that a disproportionate negative impact on minority or low-income groups in the community is not anticipated; a full evaluation of Environmental Justice issues is not required.
Fish and Wildlife Coordination Act	16 U.S.C. 661 *et seq*.	On-going
Magnuson-Stevens Act Fishery Conservation and Management Act	16 U.S.C. 1855(b)(2)	No in-water work. An EFH Assessment is not required.
National Environmental Policy Act of 1969	42 U.S.C. 432 *et seq*.	The circulation of the Draft EA fulfills requirements of this act.
National Historic Preservation Act of 1966	16 U.S.C. 470 et seq.	On-going. Correspondence included in Appendix A3.
Protection of Wetlands	Executive Order 11990	Circulation of this report for public and agency review fulfills the requirements of this order.
Protection of Children from Environmental Health Risks and Safety Risks	Executive Order 13045	Implementation of this project will reduce environmental health risks. Circulation of this report for public and agency review fulfills the requirements of this order.

8.2 Compliance with Executive Order 11988

Executive Order 11988 requires that Federal agencies avoid, to the extent possible, adverse impacts associated with the occupancy and modification of flood plains and to avoid support of

floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

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

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 flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.	Practicable measures and alternatives were formulated and evaluated against USACE guidance, including nonstructural measures such as buy-outs (land acquisition and demolition of structures).
If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.	The Draft Integrated Feasibility Report and Environmental Assessment will be released for public review, and coordination with agency officials and the public have been held throughout the study.
Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.	The anticipated impacts associated with the Selected Plan are summarized in Chapter 6 of this report. The project would not alter or impact the natural or beneficial flood plain values.
If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.	The project will not encourage development in the floodplain because all properties available for development have been developed. The project provides benefits solely for existing development.
As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.	The project would not induce development in the flood plain. Chapter 4 of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.
If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.	The Final Integrated Feasibility Report and Environmental Assessment will document the final determination.
Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.	The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

8.3 List of Environmental Assessment Report Preparers

Individual	Responsibility
Grace Moses	Biologist; NEPA
Kathleen Atwood	Archaeologist: NHPA, SEC. 106

Chapter 9: Plan Implementation

The implementation process would carry out the plan that is recommended through pre-construction engineering and design (PED), including development of plans and specifications, and construction. Funding by the Federal Government to support these activities would have to meet the requirements of applicable civil works budgeting criteria.

9.1 Cost Sharing and Non-Federal Sponsor Responsibilities

Cost Apportionment: In accordance with the cost share provisions in Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213), the Federal and non-Federal project cost shares are 65% Federal and 35% non-Federal.

The non-Federal sponsor is required to obtain and LERRD for the project and this cost is then credited against their cost share payment.

The details of cost of apportionment of the TSP project first cost are shown in Table 19 and 20 below. Table 19 provides the cost details of the recommended plan and cost apportionment at the current (October 2020) price level. Table 20 provides the cost details of the recommended plan and cost apportionment at the fully funded price level that includes cost escalation to the mid-point of construction (approximately November 2025).

Table 20. Cost Apportionment (October 2020 price level)

	Federal Share ($)	Non-Federal Share ($)	Total Cost ($)
Project First Cost:			
	65%	35%	
Initial Construction	106,739,750	57,475,250	164,215,000
LERRD* (to be acquired by non-Federal sponsor)	258,050	138,950	397,000
Total First Cost			164,612,000

*LERRD will be acquired by the non-Federal sponsor and applied towards their project cost share.

Table 21. Cost Apportionment (Fully Funded Price Level)

	Federal Share ($)	Non-Federal Share ($)	Total Cost ($)
Project First Cost:			
	65%	35%	
Initial Construction	123,456,450	66,476,550	189,933,000
LERRD* (to be acquired by non-Federal sponsor)			422,000
Total First Cost			190,355,000

*LERRD will be acquired by the non-Federal sponsor and applied towards their project cost share.

OMRR&R Cost

Operations, Maintenance, Repair, Rehabilitation and Replacement (OMRR&R) costs are the costs necessary for annual maintenance of the project and are 100 percent non-Federal cost. The OMRR&R costs associated with the TSP are currently estimated to be approximately 1% of the total first project cost which equates to about $1.65 million annually. This number will be refined following public review of the draft IFR/EA.

9.2 TSP Schedule

Draft Schedule. The draft schedule for plan implementation was developed for planning and cost estimating purpose. See Appendix E, Cost Engineering, for more detail on the proposed

construction schedule. The construction duration for the TSP is currently estimated to be 35 months (Table 22).

Table 22. Draft TSP Implementation Schedule

Long Wharf, New Haven, Connecticut Coastal Storm Risk Management Project	
Implementation Schedule	Date
Submission of Chief's Report	
Chief Signs Report	Dec-2020
Project Partnership Agreement (PPA)	
PPA Execution	Jun-2022
Pre-Construction Engineering & Design	
Plans & Specifications; Real Estate Acquisition	Nov-2023
Contract Award	Jan-2024
Construction	
Construction complete	Oct-2027

9.3 Real Estate Requirements

Land, Easements, and Rights-of-Way Requirements: TWAEs for 5 years (access, staging, construction, and mobilization) will be required to construct a floodwall 5,950 feet long adjacent to the I-95 embankment, five road closure structures, approximately 475 feet long in total, and two pump stations. Construction of the floodwall will require TWAEs over two privately-owned residential properties with total lot sizes of +/- 0.14 acre and +/- 0.17 acre and over four City-owned parcels; acreage of the municipal properties totals +/- 5.48 acres. A TWAE will also be required from CT DOT for construction of the floodwall and five road closure structures adjacent to and in the right of way of the I-95 embankment; and from the city of New Haven for the construction of the two pump stations on City-owned property. The actual areas encumbered by the TWAEs will be a 10 to 20 linear foot wide work area along the length required on each property.

Permanent easements from CT DOT will be required for the floodwall and the road closure structures. Permanent easements from the city of New Haven will be required for two pump stations. Further discussion of the potential real estate requirements are detailed in the Real Estate Report (Appendix F).

9.4 Views of Non-Federal Sponsors, Public and Agency Coordination

Coordination with agency officials and the public have been held throughout the study. A list of the agencies that have been contacted are below. Initial study coordination letters were sent to required stakeholders on 21 February 2017. Resource agency meeting letters were sent to required agencies on 20 March 2019. The letters and associated responses are included in Appendix A2. Numerous scoping and plan formulation meetings have been held with the city of New Haven, CT DEEP, CT DOT and other key stakeholders. The Draft Integrated Feasibility Report and Environmental Assessment will be released for public review in December 2019. All comments received during the Pubic and Agency review period will be documented and formally responded to. The non-Federal sponsor's support for the TSP will be confirmed through a Letter of Support following Public and Agency reviews (see Appendix A2).

Federal

U.S. Fish and Wildlife Service (USFWS)
U.S. Environmental Protection Agency
National Marine Fisheries Service

State

Connecticut Department of Energy and Environmental Protection
Office of Long Island Sound Programs
Bureau of Natural Resources
Bureau of Water Protection and Land Reuse
Connecticut Department of Agriculture, Bureau of Aquaculture
Connecticut Historic Preservation Office

Tribal Governments

Mashantucket (Western) Pequot Tribal Nation - Tribal Historic Preservation Office
Mohegan Tribe - Tribal Historic Preservation Office

Local

City of New Haven

Non-Governmental Agencies

The Nature Conservancy Connecticut Chapter

9.5 Environmental Operating Principles

The USACE Environmental Operating Principles (EOPs) are considered throughout the study process, and will continue to be part of construction and operation of the proposed CSRM Project.

Below are the USACE EOPs:

- Foster sustainability as a way of life throughout the organization.
- Proactively consider environmental consequences of all USACE activities and act accordingly.
- Create mutually supporting economic and environmentally sustainable solutions.
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the USACE, which may impact human and natural environments.
- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.
- Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.
- Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

In coordination with the agencies and other stakeholders, the USACE proactively considered the environmental consequences of the proposed deepening project. In accordance with the mandate of this designation and the EOPs, the USACE has proposed a project that supports economic and environmentally sustainable solutions.

9.6 USACE Campaign Plan

***USACE Vision*:** A great engineering force of highly disciplined people working with our partners through disciplined thought and action to deliver innovative and sustainable solutions to the Nation's engineering challenges.

USACE Mission: Provide public engineering services in peace and war to strengthen our Nation's security, energize the economy, and reduce risks from disasters.

Commander's Intent: The USACE will be one disciplined team, in thought, word, and action. We will meet our commitments, with and through our partners, by saying what we will do and doing what we will say. Through execution of the Campaign Plan, the USACE will become a GREAT organization as evidenced by the following in all mission areas: delivering superior

performance; setting the standard for the profession; making a positive impact on the Nation and other nations; and being built to last by having a strong "bench" of educated, trained, competent, experienced, and certified professionals.

The draft IFR/EA for this project is consistent with these themes. The vertical USACE project team jointly applied the latest policy and planning guidance and worked closely with Federal, State and local stakeholders and professionals familiar with the problems, opportunities and resources to fully and fairly evaluate the feasibility of improving the Long Wharf, New Haven focused study area to achieve the common goals of providing a safe, effective and efficient CSRM project while protecting the environment.

Chapter 10: Local Cooperation Requirements

The non-Federal Sponsor, would need to provide their support of the recommendations presented in this report and agree that they intend to execute a Project Partnership Agreement (PPA) for the recommended plan before this Integrated Feasibility Report and Environmental Assessment can be finalized and sent to HQ USACE for final approval.

Federal implementation of the recommended project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

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

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

(2) Provide, during construction, any additional amounts necessary to make its total contribution equal to 35 percent of initial project costs assigned to coastal storm risk management;

b. Once eligible properties have been identified, the non-federal sponsor will be required to obtain TWAEs for construction, staging and storage, in accordance with construction requirements. The non-Federal sponsor will also be required to obtain permanent restrictive easements limiting alteration of the elevated structure for human habitation below a height corresponding to the targeted first floor elevation for each structure. The easement agreement shall be recorded by the non-Federal sponsor in the public records of the county in

which the property is located prior to commencement of the nonstructural improvements on the property;

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

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

e. For so long as the project remains authorized, ensure continued use of the elevated structure in a manner consistent with which the Federal participation is based;

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

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

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

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

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

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

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

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

n. Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations

for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

Chapter 11: Recommendations

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

I recommend that the selected plan for coastal storm risk management within the Long Wharf area of the city of New Haven as fully detailed in this Draft Integrated Feasibility Report and Environmental Assessment, be authorized for construction as a Federal project, subject to such modifications as may be prescribed by the Chief of Engineers.

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

William M. Conde
Colonel, U.S. Army
District Engineer

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