Final Integrated Feasibility Report & Environmental Assessment

Rahway River Basin, New Jersey Coastal Storm Risk Management Feasibility Study

April 2020

New Jersey Department of Environmental Protection

U.S. Army Corps of Engineers New York District

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EXECUTIVE SUMMARY

The devastating impacts of Hurricane Sandy in October 2012 demonstrated how vulnerable Rahway River Basin communities are to the dangers of flooding. Although a few flood risk management projects have already been implemented in the basin by the U.S. Army Corps of Engineers (USACE) and others since the 1960s, there are opportunities to better manage flood risk. The Rahway River study, which was authorized in 1998, and was revised to focus on coastal flooding in particular in 2013, investigated alternatives to manage coastal storm risk in the Rahway River Basin, given existing and anticipated future conditions. The enclosed integrated Feasibility Report and Environmental Assessment presents the results of the study, including a recommended plan that would contribute to national economic development by reducing the risk of storm surge damages by more than the cost of the project over a 50-year period, while minimizing impacts to the environment.

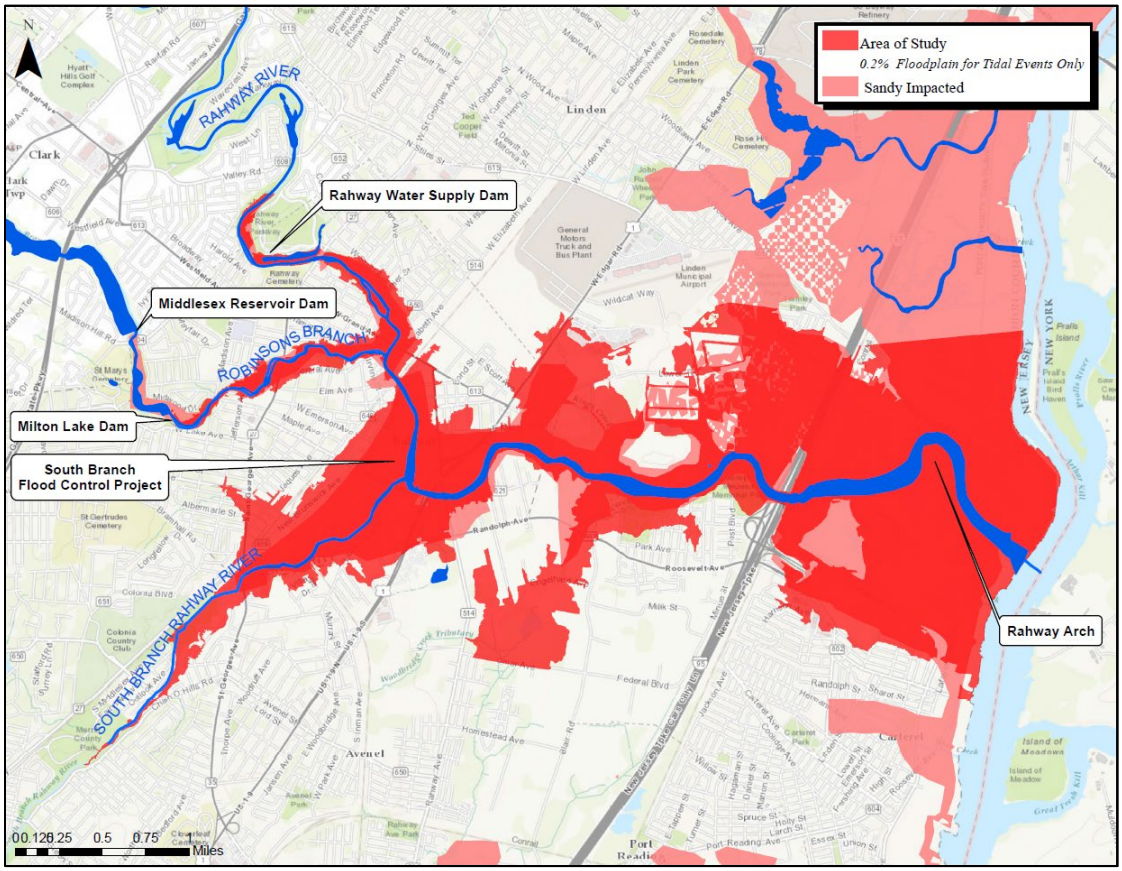

Figure ES-1. Rahway River Basin Coastal Storm Risk Management Feasibility Study Area

The Rahway River Basin is located in northeastern New Jersey, within the New York metropolitan area. Storm surge-induced flooding threatens communities in the lower Rahway River basin including Linden and Rahway in Union County and Carteret and Woodbridge in Middlesex County. Figure ES-1 is a map of the study area that shows the 0.2% Annual Exceedance Probability (AEP) or 500-year floodplain for coastal storm events and the area Hurricane Sandy impacted. Two major tributaries to the Rahway River, Robinson's Branch and

the South Branch Rahway River, join the river in Rahway. In 1966, USACE constructed a levee and floodwall system at the confluence of the South Branch and Rahway River, which the New Jersey Department of Environmental Protection, the non-federal sponsor for this study, maintains. From the South Branch, the Rahway River flows east for about five miles and into the Arthur Kill, a major navigation channel that connects Newark Bay to the Raritan and Lower bays of the New York and New Jersey Harbor.

Coastal storms, including nor'easters and hurricanes, frequently affect the New Jersey coast. The most notorious recent coastal storms that led to flooding in the study area were Hurricane Sandy in 2012 and Hurricane Irene in 2011. The storm surge measured during Sandy at the nearest tide gage to the study area, Bergen Point West Reach, New York, exceeded predicted astronomical tide levels by 9.56 feet. During Irene, the storm surge at the same gage was 4.56 feet. The storm surges from these storms caused the Rahway River and its tributaries to overflow their banks, damaging property, interrupting services, threatening lives, and endangering public safety.

The Rahway Tidal Study is a coastal storm risk management study. This study considers the coastal-fluvial relationship while formulating to reduce the risk of storm surge-induced flooding from elevated water levels in the Rahway River Basin. The planning objectives identified for the study are to: reduce the risk of storm surge-induced flood dangers to life safety and damages to property in the study area; and increase public awareness about the risk of flooding from the Rahway River.

The alternative plans developed to meet the planning objectives combined a variety of structural and nonstructural measures. Plans in the final array of alternatives included: no action; levees and floodwalls; a surge barrier; a surge barrier plus nonstructural measures; nonstructural measures plus ringwalls; a levee plus nonstructural measures and ringwalls; and a levee plus nonstructural measures and no ringwalls. The alternatives were evaluated and compared on the basis of their costs and benefits, including their potential environmental impacts. The plan that maximized net national economic benefits while minimizing impacts to the environment was chosen as the Tentatively Selected Plan.

The Tentatively Selected Plan was optimized to find the National Economic Development Plan, which is the recommended plan. Figure ES-2 shows an overview of the plan. The recommended plan features a continuous levee and floodwall structure located along the right (southern) bank of the Rahway River in Woodbridge and Carteret, from Joseph Medwick Park to the Rahway Valley Sewerage Authority wastewater treatment plant. The 4,488 ft-long structure consists of 2,520 ft of levee and 1,968 ft of floodwalls. The top elevation of the structure is 14.2 ft NAVD88. The levee top width is 12 ft and side slopes are 1 vertical to 3 horizontal (1V:3H). Incorporating floodwalls into the design was necessary due to land use in the project area; sections of the structure are located adjacent to existing commercial buildings and major utilities. The levees and floodwall were designed to allow nondamaging overtopping flowrates until the end of the period of analysis and can allow for future modification and raising for an additional 2.8 feet to meet an elevation above the USACE "intermediate" sea level rise elevation for the 100 year adaptation horizon. The design includes eight (8) interior drainage structures. The recommended plan also includes raising approximately 1,350 ft of Engelhard Ave in

Woodbridge to a top elevation of 14.2 ft. Finally, the recommended plan includes the wet floodproofing of nine (9) structures, elevation of 91 structures, and buyouts of 10 structures. Floodproofing and elevations were designed to the joint-probability water surface elevation of the 1% AEP assuming the USACE "intermediate" sea level rise scenario, plus one foot to account for water surface perturbations.

Floodproofing and elevations were designed to the water surface elevation of the 1% AEP coastal storm surge-induced flood event, assuming the USACE "intermediate" sea level rise scenario, plus one foot to account for water surface perturbations.

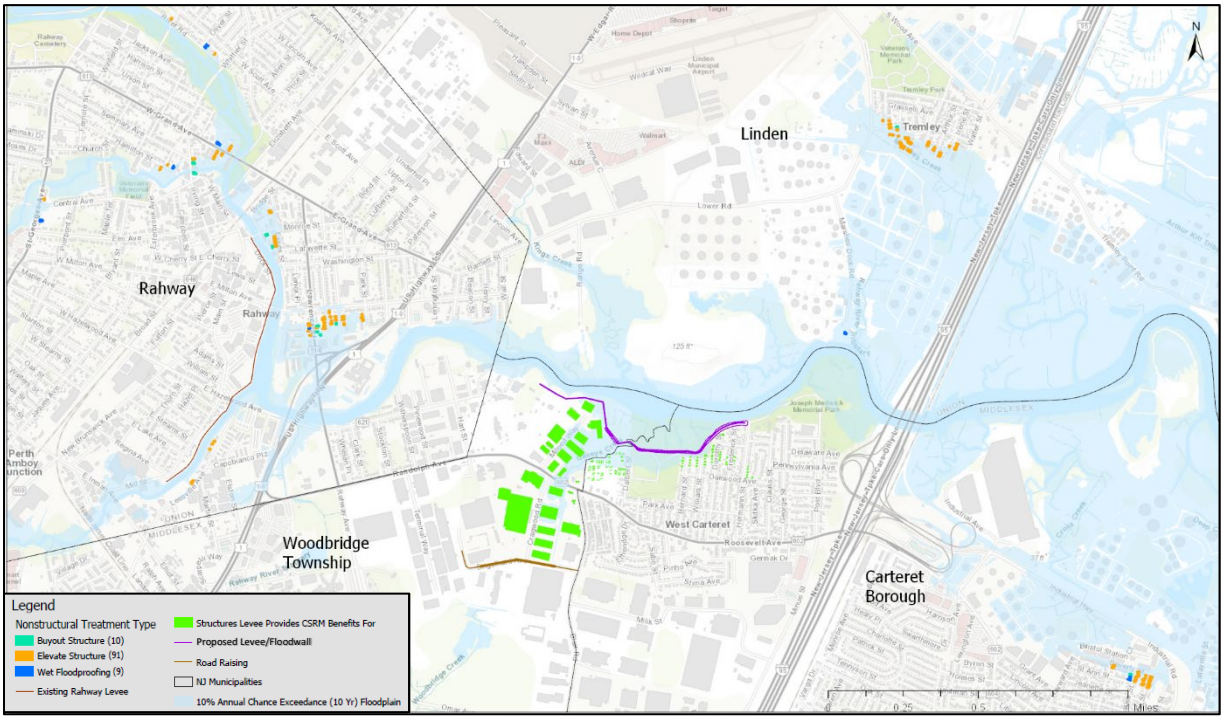

Figure ES-2. Rahway River Basin Coastal Storm Risk Management Recommended Plan

The recommended plan will reduce the risk of flood damages in the lower Rahway River basin. The hydraulic model runs used to generate water surface elevations for the economic analysis of the plan accounted for the joint probability of flooding from storm surge and high precipitation. For the intermediate relative sea level change scenario, the plan provides estimated net benefits of $4,276,000[1] per year.

The estimated first cost of the recommended plan is $71,929,000. The estimated total or fully-funded project cost (inflated to the midpoint of construction of May 2026) is $88,130,000. The benefit-cost ratio for the recommended plan is 2.4.

[1] Final benefits and costs were estimated using October 2019 price levels and a discount rate of 2.75%.

The performance of the levee and floodwalls is expected to decline over time. For the intermediate relative sea level change scenario, at the beginning of the period of analysis (2029[2]), there is a 71% assurance that the Rahway River will not exceed the top of the levee and floodwalls during the 2% AEP or 50-year coastal storm event. By the end of the period of analysis (2079), there is a 6% assurance that the river will not overtop the levee and floodwalls during the 2% AEP event.

Residual risk for the recommended plan may be characterized by the average annual damages that are expected to remain even if the plan is implemented. For the intermediate relative sea level change scenario, the expected remaining average annual damages for the recommended plan are $39,218,000 per year, compared to $46,480,000 per year if the recommended plan is not implemented. Another way to characterize the recommended plan's residual risk is the annual probability that the Rahway River will exceed the top elevation of the levee in the plan. At the beginning of the period of analysis, the annual probability the river will overtop the levee is 1.4%, and at the end of the period of analysis, the annual probability the river will overtop the levee is 7.2%.

In addition to national economic development, USACE considers the contribution of all its plans to national ecosystem restoration, other social effects, and regional economic development. The recommended plan is not expected to have significant adverse environmental impacts. Mitigation measures to avoid or minimize adverse environmental effects of the recommended plan were analyzed and will be implemented with the plan. Table ES-1 summarizes planned mitigation. Mitigation for unavoidable adverse impacts to wetlands will include on-site restoration.

The recommended plan is expected to have positive social effects, the most significant of which would be keeping transportation routes, including for emergency vehicles and other vital services, open behind the levees and floodwalls during events up to as infrequent as the 1% AEP or 100-year coastal storm event. Regional economic development is also expected to benefit from the plan, as resources residents and business owners would otherwise have spent on repairing and replacing structures and goods damaged by flooding would become available to spend on other goods and services.

New Jersey Department of Environmental Protection, the non-federal sponsor for the study, will serve as the non-federal sponsor for project implementation. Project implementation will require the execution of a Project Partnership Agreement (PPA) that specifies a 65% federal and 35% non-federal cost-share for preconstruction, engineering, and design (PED) and construction. The non-federal sponsor will be responsible for acquiring all of the lands, easements, and rights-of-way required for the construction, operation, and maintenance of the recommended plan. The non-federal sponsor is also responsible for performing any necessary facility and utility relocations, and for providing any necessary disposal areas. The non-federal sponsor's lands lands, easements, right-of-ways, relocation, and disposal area (LERRDs) costs for the

[2] A risk-informed decision was made to assume that the analysis that was completed for a period of analysis of 2023 to 2073 sufficiently approximates the analysis for a period of analysis of 2029 to 2079. For more information, please see Section 4.4.

recommended plan are $10,550,000. Once the plan is constructed, the non-federal sponsor will be responsible for the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the project. The estimated annual OMRR&R costs for the project are $232,000.

Table ES-1: Summary of Mitigation Measures
(spans two pages)

Land Use • Disturbed areas will be restored and their use returned to pre-construction land uses.
Soils • Implementation of Erosion and Sediment Control Best Management Practices (BMPs) during construction, including the installation of a cofferdam or temporary culvert diversion to install the floodwall drainage structure in Casey's Creek and to construct the floodwall over Casey's Creek.
Water Resources • Implementation of Erosion and Sediment Control Best Management Practices (BMPs) during construction, including the installation of a cofferdam or temporary culvert diversion to install the levee drainage structure in Casey's Creek and to construct the floodwall over Casey's Creek. • Restoration of 200 linear feet of tidal creek including 0.14 acres of mudflat habitat. • Maintaining an open gate on the floodwall drainage structure in Casey's Creek during normal flows.

Wetlands
• Implementation of Erosion and Sediment Control BMPs including the use of wetland access/anti-tracking mats.
• Compensation of wetland habitat through:
  • Restoration of 1.13 acres of high marsh habitat.
  • Restoration of 1.29 acres of low marsh habitat
  • Restoration of 1.14 acres of deciduous scrub shrub wetland.
• Restoration of 0.55 acres of low marsh wetland habitat, 0.44 acres of high marsh habitat, 0.10 acres of scrub shrub wetland and 0.15 acres of upland forest subject to temporary impacts during construction.

Vegetation • Restoration of 0.15 acres of upland forest vegetation temporarily impacted by construction activities. • Establishment of a total of 3.56 acres of native vegetation through compensatory wetland mitigation
Aquatic Resources and Wildlife • Tree and shrub clearing restriction from 1 March through 31 August to comply with the Migratory Bird Treaty Act • Tree clearing restriction from 1 April through 30 September to protect Federally listed endangered and threatened bat species. • Re-establishment of native herbaceous, shrub and tree species in disturbed areas and in mitigation sites. • In-water work restriction from 1 March through 30 June to protect spawning fish species. • Restoration of 200 linear feet of tidal creek including 0.14 acres of mudflat habitat.

• Restoration of 1.29 acres of high marsh wetland habitat. • Restoration of 1.13 acres of low marsh wetland habitat. • Restoration of 1.14 acres of deciduous scrub shrub habitat.
Cultural Resources • The project has the potential to have an adverse impact on historic properties, however, additional investigation is required to ensure all potentially affected resourced are identified. A Programmatic Agreement among the New York District and the New Jersey State Historic Preservation Office (NJSHPO) has been prepared that outlines the steps that will be taken to determine adverse effects and the appropriate mitigation measures in consultation with interested parties (see Appendix A). Some mitigation measures to be considered include HABS/HAER documentation of historic structures, archaeological data collection, replacing or providing substitute resources, monitoring during construction, and enhancement of historic districts through signage and public outreach.
Recreation • Planting native herbaceous, shrubs and trees within Joseph Medwick Park after construction. • Erecting temporary fences and other physical barriers to control movement through construction areas and maintain a safe distance for pedestrians • Installing signage that informs residents and others using the effected recreational spaces of the proposed actions purpose and closure duration. • Installing a footpath on top of the levee. • Replacing the existing wildlife observation deck following construction of the levee.
Aesthetics and Scenic Resources • Replanting disturbed areas with native herbaceous, shrub and tree material after construction.
Transportation • Preparation of a Construction Traffic Management Plan. • Routing and scheduling construction vehicles to minimize conflicts with other traffic • Strategically locating localized staging areas to minimize traffic impacts; and • Establishing detours and alternate routes when it is important to close the work area to perform certain construction tasks or when diverting traffic will substantially reduce traffic volumes.
Air Quality • Because the air emissions are below de minimis levels for NO_x, VOC, $PM_{2.5}$ and SO_2, no specific mitigation is required. Construction will be performed in compliance with current New Jersey Air Pollution Control requirements (N.J.A.C. 7:27-1-34).
Noise • Construction will occur within the timeframes allowed as per local noise ordinances.

PERTINENT DATA

LOCATION

Watershed: Rahway River (HUC: 02030104)
State: New Jersey
Counties: Union, Middlesex
Municipalities: City of Rahway, City of Linden, Township of Woodbridge, Borough of Carteret

FEATURES

- Levee (2,520 ft length; 12 ft top width; 1V:3H side slopes; 14.2 ft NAVD 88 top elevation) and floodwalls (1,968 ft length; 14.2 ft NAVD 88 top elevation), with interior drainage structures (8 gates), on the right (southern) bank of Rahway River, from Joseph Medwick Park in Carteret to the Rahway Valley Sewerage Authority wastewater treatment plant in Woodbridge
- Road raising (approximately 1,350 ft length; 14.2 ft NAVD 88 top elevation) of Engelhard Ave in Woodbridge
- Wet floodproofing (9 structures), elevation (91 structures), and buyouts (10 structures); Floodproofing and elevations were designed to the joint-probability water surface elevation of the 1% AEP assuming the USACE "intermediate" sea level rise scenario, plus one foot to account for water surface perturbations.
- Ecosystem restoration as compensatory mitigation (200 linear ft of tidal creek, including 0.14 ac of mudflats; 1.13 ac of high marsh habitat; 1.29 ac of low marsh habitat; 1.14 ac of deciduous scrub shrub wetland; and 0.15 ac of upland forest)

COSTS

First Cost: $71,929,000[3]
Total Project Cost: $88,130,000
Annualized Investment Cost: $2,754,000
Annualized OMRR&R[4] Cost: $232,000

BENEFITS

Average Annual Benefits: $7,262,000
Average Annual Net Benefits: $4,276,000
Benefit-Cost Ratio: 2.4

COST APPORTIONMENT

	Total	Federal	Non-Federal
First Cost	$71,929,000	$46,754,000	$25,175,000
Non-Federal Sponsor's LERRDs[5]	$10,550,000	--	$10,550,000
Cash Contribution	$14,625,000	--	$14,625,000

[3] All dollar values use October 2019 price levels and a discount rate of 2.75%
[4] Operation, maintenance, repair, rehabilitation, and replacements costs are the non-federal sponsor's responsibility
[5] Required lands, easements, rights-of-way, relocations, and disposal areas (LERRD) are the non-federal sponsor's responsibility and are creditable towards the 35% non-federal cost share

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**Sections of text marked with an asterisk are applicable to the satisfaction of National Environmental Policy Act (NEPA) requirements*

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ACRONYM GUIDE

Acronym	Stands For
AEP	Annual Exceedance Probability
AMNET	Ambient Biomonitoring Network
APE	Area of Potential Effect
ARA	Abbreviated Risk Analysis
BCR	Benefit Cost Ratio
CEQ	Council of Environmental Quality
CSRA	Cost Schedule Risk Analysis
CZM	Coastal Zone Management
District	United States Army Corps of Engineers, New York District
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ETL	Engineering Technical Letter
FEMA	Federal Emergency Management Agency
FHACA	Flood Hazard Area Control Act
FR/EA	Feasibility Report and Environmental Assessment
HEC-FDA	Hydrologic Enginereing Center – Flood Damage Analysis
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HTRW	Hazardous, Toxic and Radioactive Waste
IBA	Important Bird Area
KCS	Known Contaminated Site
LERRD	Lands, Easements, Rights of Way, Relocations and Disposal/Borrow Areas
LIDAR	Light Detection and Ranging
MBTA	Migratory Bird Treaty Act
MHHW	Mean Higher High Water
MCACES	Micro-Computer Aided Cost Estimating System
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MTL	Mean Tide Level
NAAQS	National Ambient Air Quality Standards
NACCS	North Atlantic Coast Comprehensive Study
NAVD 88	North American Vertical Datum of 1988

Acronym	Stands For
NED	National Economic Development
NEPA	National Environmental Policy Act
N.J.A.C	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDEP BFBM	New Jersey Department of Environmental Protection, Bureau of Freshwater and Biological Monitoring
NJDEP DLUR	New Jersey Department of Environmental Protection, Division of Land Use Regulation
NJDEP DFW	New Jersey Division of Fish and Wildlife
NJSHPO	New Jersey Historic Preservation Office
NOAA-NMFS	National Oceanic and Atmospheric Administration – National Marine Fisheries Service
NOS	National Ocean Service
NPL	National Priority List
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
OEM	Office of Emergency Management
OSE	Other Social Effects
PM	Particulate Matter
RED	Regional Economic Development
SLC	Sea Level Change
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WSE	Water Surface Elevation

Chapter 1.0 Introduction

1.1 Integrated Feasibility Report and Environmental Assessment

The New York District of the U.S. Army Corps of Engineers (USACE) prepared this integrated feasibility report and Environmental Assessment (FR/EA) for the Rahway River Basin, New Jersey, Coastal Storm Risk Management Feasibility Study, with input from the study's non-federal sponsor, the New Jersey Department of Environmental Protection (NJDEP). The 2017 draft version of the FR/EA underwent technical, policy, public, and local, state, and federal agency reviews. This final version addresses comments that were received on the draft FR/EA and presents a recommended plan for managing coastal storm risk in the Rahway River Basin.

1.2 Study Authority

A March 24, 1998 resolution of the U.S. House of Representatives Committee on Transportation and Infrastructure provided the authority for USACE to conduct the study:

> *"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Rahway River, New Jersey, published as House Document 67, 89th Congress, and other pertinent reports to determine whether any modifications of the recommendations contained therein are advisable at the present time, in the interest of water resources development, including flood control, environmental restoration and protection and other related purposes."*

After Hurricane Sandy struck the Atlantic coastline in 2012, Congress passed and the President signed into law the Disaster Relief Appropriations Act of 2013 (Public Law 113-2). Public Law 113-2 provided supplemental appropriations to address damages from Sandy, including in the Rahway River Basin. Previous to the enactment of this law, the scope of the Rahway River study included managing flood risk both from the coast (storm surge) and the river. Subsequent to the law's enactment, the study was split into two: this study, which focuses on coastal storm risk management, and a separate, currently suspended study that focuses on flood risk in upstream areas of the basin that are not susceptible to storm surge.

1.3 Non-Federal Sponsor

NJDEP is the non-federal sponsor for the study. Public Law 113-2 provided for the study to be 100% federally funded, as reflected in the Feasibility Cost Sharing Agreement (FCSA) for the study executed with NJDEP in October 2014. NJDEP and representatives from municipalities in the study area were fully involved in plan formulation.

1.4 Study Area

The Rahway River Basin, which is located in northeastern New Jersey, has a drainage area of 83.3 square miles (Figure 1-1). The study area included the part of the basin that is susceptible to coastal storm risk (cross-hatched in Figure 1-2). Storm surge has the potential to extend from the Arthur Kill approximately five miles up the Rahway River, including up into the South Branch

and Robinson's Branch of the river. Higher elevations and dams on the river and its branches prevent storm surge from extending further upstream.

The study area is primarily urban and suburban, with residential, commercial, and industrial development and little open space. Municipalities in the study area include the cities of Rahway and Linden, in Union County, and Woodbridge Township and Carteret Borough, in Middlesex County. The study area is within New Jersey's 10th congressional district, which Donald Payne, Jr. (D-NJ) represented at the time of the publication of this report.

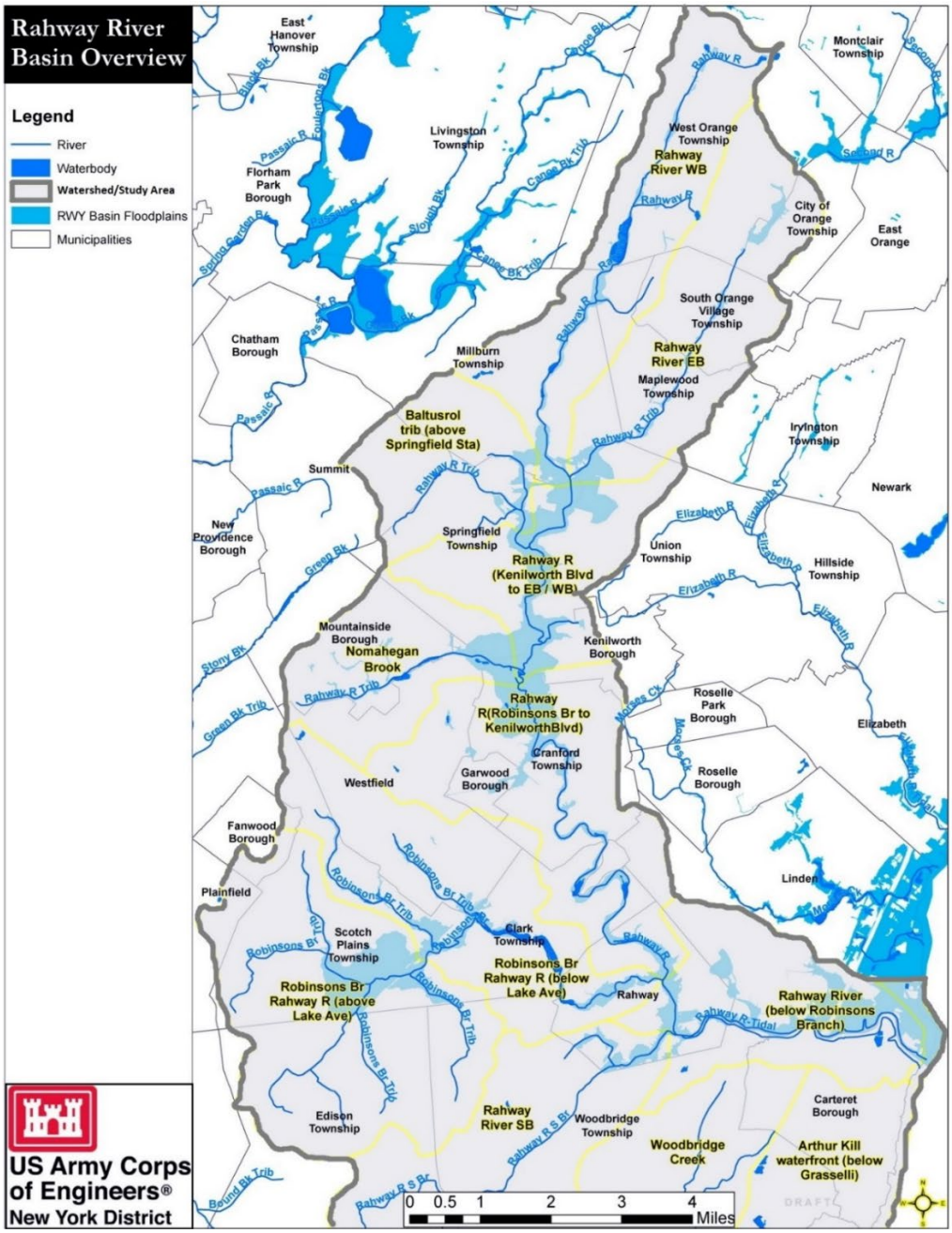


Figure 1-1. Rahway River Basin

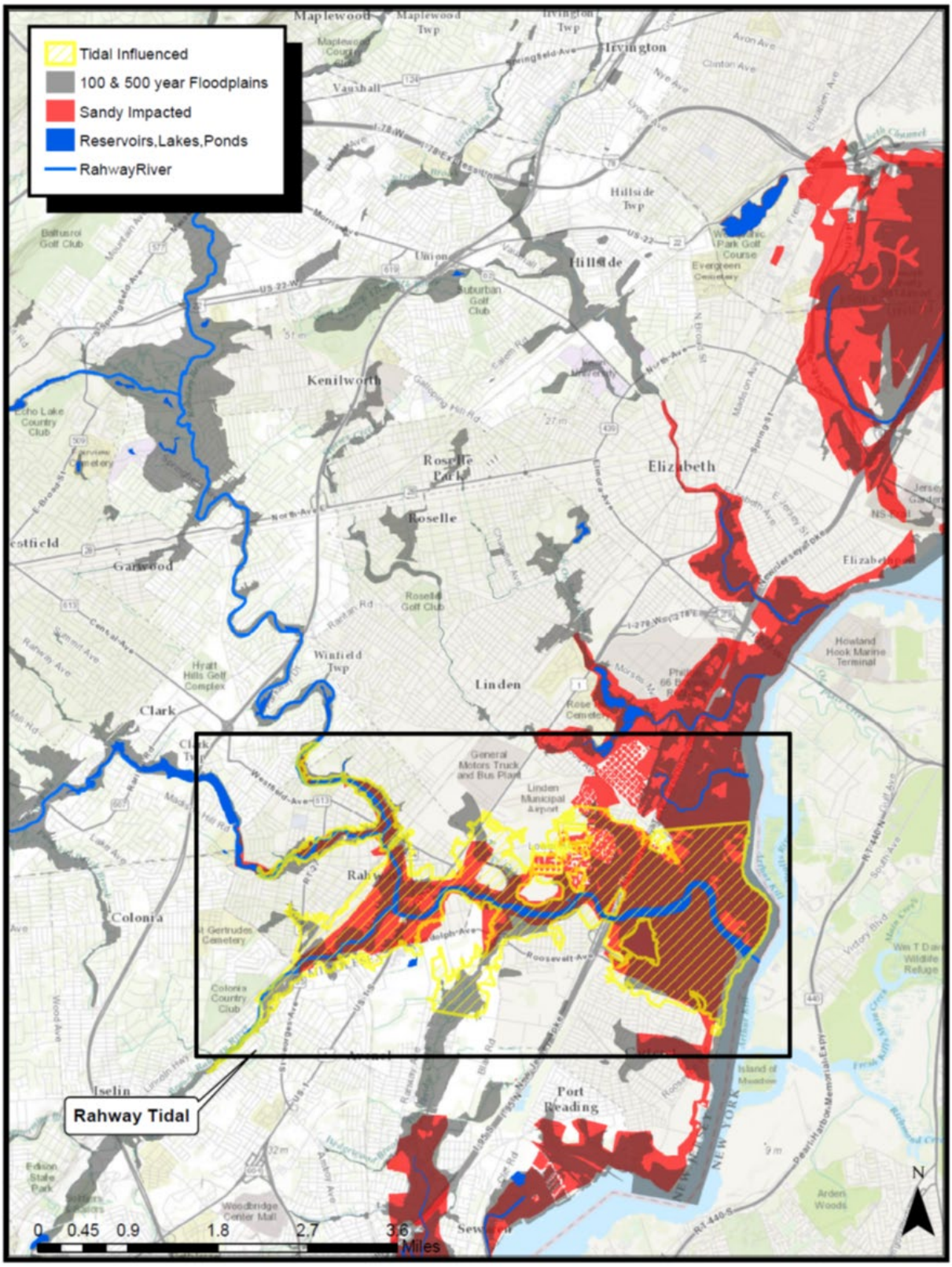


Figure 1-2. Rahway River Basin Coastal Storm Risk Management Study Area

1.5 Project Area

The project area (Figure 1-3), or the area that was considered when formulating plans, was determined to be the portion of the study area that experiences the majority of storm surge-induced flood damages in the Rahway River Basin. Municipalities in the project area include the cities of Rahway and Linden, Woodbridge Township, and Carteret Borough.

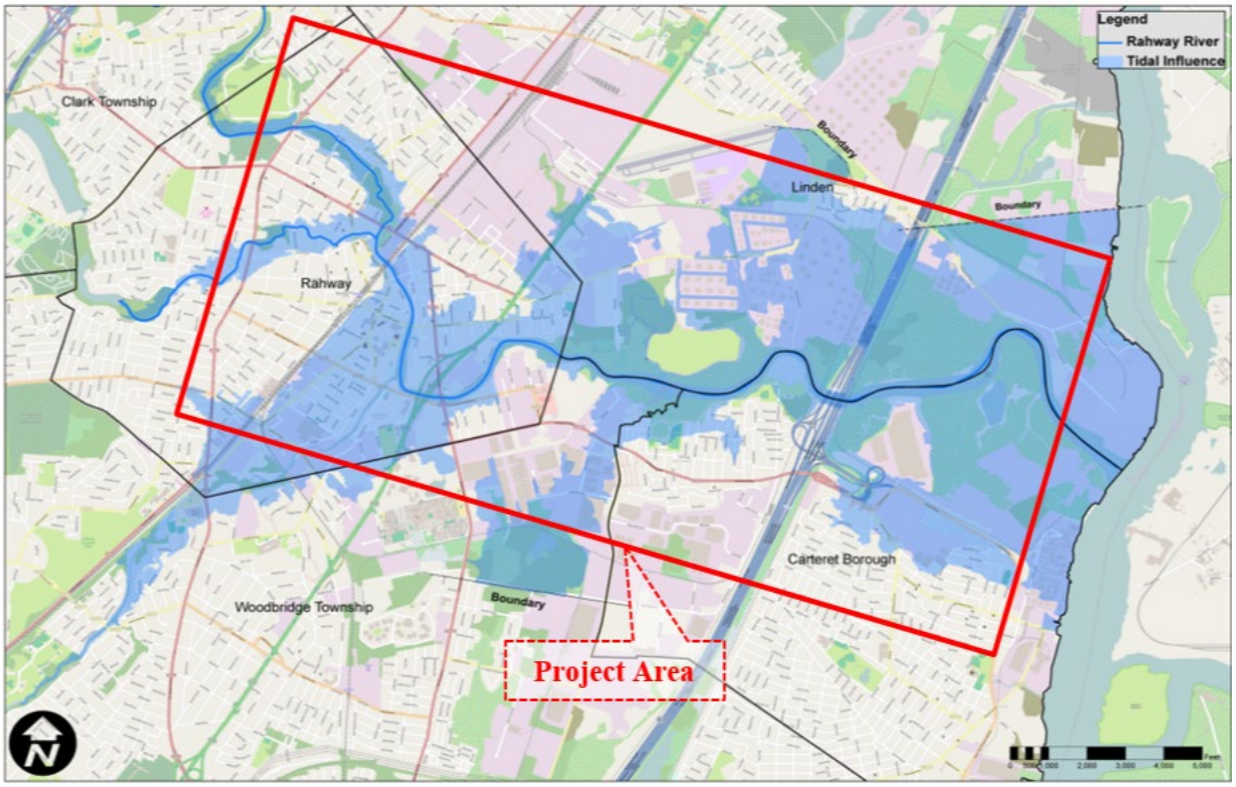


Figure 1-3. Rahway River Basin Coastal Storm Risk Management Project Area

1.6 Study Purpose

The purpose of the study is to determine if there is a technically feasible, economically justified, and environmentally acceptable recommendation for federal participation in coastal storm risk management in the Rahway River Basin. USACE inventoried existing conditions and forecasted future without-project conditions in the study area. USACE also formulated, evaluated, and compared an array of alternatives for coastal storm risk management that combined structural and nonstructural measures including levees, floodwalls, surge barriers, ringwalls, floodproofing, elevation of structures, and buyouts. This process and a tentatively selected plan (TSP) were documented in the draft FR/EA. The recommended plan presented in this final FR/EA was developed based on review comments received on the draft FR/EA. The recommended plan has undergone feasibility-level optimization and has the non-federal sponsor's support (see Appendix F: Letter of Support).

1.7 National Environmental Policy Act Requirements

The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental impacts of their proposed actions and reasonable alternatives to those actions. The intent of NEPA is to ensure that information about major federal actions is made available to public officials and citizens and that federal agencies identify and consider public concerns and issues. NEPA requirements are found in Title 40 of the Code of Federal Regulations (CFR) Parts 1500-1508, and implementing guidance for NEPA that applies to USACE actions includes the Council on Environmental Quality's Guidance Regarding NEPA Regulations and USACE Procedures for Implementing NEPA (Engineering Regulation [ER]-200-2-2).

The feasibility report for this study integrates an environmental assessment, in accordance with 40 CFR §1506.4, which states: "any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork." Environmental assessment sections of the FR/EA are marked with an asterisk. Documented in the FR/EA are: the need for the proposed action; proposed action and alternatives; probable environmental impacts of the proposed action and alternatives; and agencies and persons consulted during the preparation of the FR/EA.

As documented in this FR/EA, USACE's planning process for coastal storm risk management actions avoids, minimizes, and mitigates for adverse effects.

1.8 Prior Studies, Reports, and Existing Water Projects

The Rahway River Basin has been the subject of several USACE reports. The most significant to this study is the July 1999 reconnaissance report for the Rahway and Woodbridge River Basins Reconnaissance Study, which led to the initiation of the Rahway River Basin, New Jersey, Flood Risk Management Feasibility Study. That feasibility study included coastal storm risk management until after Public Law 113-2 split it into two studies, as discussed in Section 1.2. The purpose of the Rahway and Woodbridge Basins Reconnaissance Study was to determine if there was a federal interest in flood risk management in the Rahway River Basin, beyond the geographic scope evaluated in the Robinson's Branch General Revaluation Report (GRR). The draft reconnaissance report summarized eleven prior reports completed within the basin since 1962 and identified two potential projects with positive benefit-to-cost ratios (BCRs). The first project was a system of levees, floodwalls, channel modifications, and interior drainage improvements along Robinson's Branch, which had been included in the Robinson's Branch GRR. The second project, located along the South Branch in Woodbridge Township, entailed regrading the parking lot of a shopping center as an overland flow route. This project did not advance to construction given that the shopping center was replaced by a new commercial development with flood proofing. Floodproofing the development reduced the economic benefits of the project such that it was no longer economically justified.

USACE's Rahway, NJ Flood Risk Management Project, which was completed in 1966 and is still maintained by NJDEP, and other existing and future projects and actions applicable to this study are summarized in tables 1-1 to 1-3. These projects were identified through best practice research and coordination with study stakeholders.

Table 1-1. Existing and Future USACE Actions Within the Rahway River Basin

Project Name	Description	Location	Status
Rahway, NJ Flood Risk Management Project	2,040 ft of protective levee, 1,740 ft of closure levee and I wall, 2 aluminum stop log structures, 2 pump stations (now 3), misc. interior drainage facilities, land fill, and road raising	Rahway River right bank (Monroe St to Hazelwood Ave) and South Branch left bank (Hazelwood Ave to Regina Ave), City of Rahway, Union County	Completed 1966
South Orange, NJ, Flood Risk Management Project (upstream and outside of the study area)	Channel enlargement 7,000 ft: 3,824 ft of walls and flumes, 690 ft of levees, 500 ft of dikes, 5 drainage structures	Montrose Ave to Erie-Lakawanna Railroad Yard, South Orange, Essex County	Completed 1974
Medwick Tidal Marsh Mitigation Site	Restoration of 14 acres of low marsh wetland as mitigation for impacts related to the New York/New Jersey Harbor Deepening Project	Medwick Park, City of Rahway, Union County	Constructed 2007
Rahway River Basin Flood Risk Management Feasibility Study	Evaluation of flood risk management measures	Rahway River Basin upstream of the area affected by storm surge	Feasibility study in progress
Hudson-Raritan Estuary Restoration Study	Identification and evaluation of potential ecosystem restoration sites within the Hudson-Raritan Estuary watershed	Hudson-Raritan Estuary, New York and New Jersey. Numerous sites are within the Arthur Kill, of which the Rahway is a tributary	Feasibility study nearing completion
New York and New Jersey Harbor Tributaries Focus Area Study	Coastal Storm Risk Management	New York and New Jersey metropolitan area	Feasibility study in progress
Rahway River Section 1135 Aquatic Ecosystem Restoration Study	Wetland habitat restoration	City of Rahway, Union County	Terminated due to lack of funding. Site has since been developed into Lower Essex Street Park.
South Branch Rahway River Section 14 Emergency Streambank Stabilization	Emergency streambank stabilization of 3,050 linear ft of the South Branch Rahway River	Township of Woodbridge, Middlesex County	Suspended due to lack of funding

Table 1-2. Existing and Future Flood Risk Management Actions by Others

Project Name	Description	Location	Responsible Entity	Status
Lenape Park Dam	Dam and 900 linear ft of embankments within Lenape Park	Springfield and Cranford Townships, Union County	Union County	Constructed in 1983
Nomahegan Park Levees	Levees, primarily along the left bank of Rahway River	Cranford Township, Union County	Union County	Unknown completion date
Single Family Home Raising	17 homes raised	Riverside Drive Cranford Township, Union County	Federal Emergency Management Agency (FEMA)	Completed 2013
Home Buyout	Acquisition and removal of homes within floodplain	3 homes in City of Rahway	New Jersey, Blue Acres Program	Agreement signed May 2016

Table 1-3. Other Actions Within the Rahway River Basin

(spans two pages)

Project Name	Type	Description	Location	Responsible Entity	Status
Michael S. Bezega Wetland Observation Park	Ecosystem Restoration	4.45 acre park constructed as stormwater wetlands along the Rahway River floodplain	City of Rahway	City of Rahway in partnership with FEMA, NJDEP and local stakeholders	Completed 2005
East Branch Rahway River Stream and Wetland Restoration	Ecosystem Restoration	Riparian and wetland restoration within USACE channel modification project	City of South Orange, Essex County	City of South Orange	Completed 2011
Fish Ladder at Rahway River Dam	Ecosystem Restoration	Installation of fish ladder to improve fish passage at Rahway River Dam	City of Rahway, Union County	Environmental Protection Agency	Feasibility Report completed in March 2006, has not been implemented
Fish Ladder at Milton Lake	Ecosystem Restoration	Installation of fish ladder to improve fish passage in Robinson's Branch	City of Rahway, Union County	Unknown	Unknown

Project Name	Type	Description	Location	Responsible Entity	Status
Marshes Creek Resiliency Project	Ecosystem Restoration	Potentially 200 acres of tidal marsh restoration	City of Linden	Rutgers University, National Fish and Wildlife Foundation	In planning phase
Diamond Mills Pond Repair	Dam rehabilitation	Installation of articulated concrete block, replacement of spillway and 36" sluice gate to control water level.	South Mountain Reservation Millburn Tw Essex County	Essex County	Completed 2012
Cranford Municipal Rain Garden	Stormwater Management	Installation of rain garden	Cranford, Union County	Cranford Township	Completed 2014
Kiwanis Park Rain Gardens/Storm water Management	Stormwater Management	Installation of rain garden/vegetatio n	City of Rahway, Union County	City of Rahway	Completed 2015
1,000 Rain Gardens Initiative	Stormwater Management	Installation of rain gardens on public and private properties	Rahway River Basin	Mayors Council; Association of New Jersey Environmental Commissions	Ongoing
Joseph Medwick Park	Contamination Remediation/ Park Facility Construction	Removal of contaminated soil; installation of park infrastructure	Carteret Borough	Middlesex County	Completed 2012
Rahway Arch	Contamination Remediation	Remediation of site containing heavy metals, VOCs and cyanide	Carteret Borough	Rahway Arch, LLC.	Permits issued by NJDEP; construction initiated
Tremley Point Connector Road	Transportation	Road connecting Turnpike Interchange 12 to Tremley Point Road.	City of Linden and Borough of Carteret	New Jersey Department of Transportation	Environmental Assessment completed in 2010. Construction has not yet been initiated.

Chapter 2.0 Existing Conditions*

Plans for managing coastal storm risk in the Rahway River Basin were formulated based on an inventory of existing conditions and forecast of future without-project conditions. Existing conditions in the study area are described in both chapters 2 and 3. Chapter 2 more generally describes existing conditions, whereas Chapter 3 focuses on environmental conditions in the project area relevant to NEPA. Future without-project conditions are described in Chapter 4.

2.1 Climate

The Rahway River Basin climate is characteristic of the Middle Atlantic Seaboard. Marked changes of weather are frequent, particularly during the spring and fall. The winters are moderate in both temperature and snowfall. Average minimum temperatures in January range from 25 - 30°F. The summers are moderate, with hot and humid weather in mid-summer and frequent thunderstorms. Average maximum temperatures in July range from 85 - 90°F. Rainfall is moderate and well-distributed throughout the year. The average annual precipitation for the New Jersey coast is 40 in. The relative humidity is high year-round. The Atlantic Meridional Overturning Circulation, a current system that includes the Gulf Stream, helps regulate the climate in the study area. Storms are discussed in Section 2.4.

Annual temperatures in New Jersey are increasing, and so is annual precipitation.

2.2 Storms

The study area experiences thunderstorms, nor'easters, tropical storms, and hurricanes. Thunderstorms can occur at any time of year, but tend to be the most severe from March through October. Tropical storms, which may develop into hurricanes, occur from the beginning of June to the end of November, and peak between mid-August to late October. Nor'easters, which may include heavy rain or snow, tend to be the most frequent and damaging between October and April. Thunderstorms tend to be limited in extent and may cause local flooding on flash flood prone streams. Tropical storms, hurricanes, and nor'easters tend to affect more widespread areas and can cause coastal flooding. Though nor'easters tend to bring with them less intense winds and precipitation than hurricanes, they may last longer. The Rahway Tidal Study considers the coastal-fluvial relationship while formulating to reduce the risk of storm surge-induced flooding from elevated water levels in the Rahway River Basin.

Storm surge is the water surface height above predicted tide level. Storm surge occurs when the surge effects of strong winds combine with those of low pressure. Strong winds blowing along the surface of coastal waters cause water to pile up as the water approaches the shoreline, the surge effects of which are exacerbated by low pressure at the center of a storm off the coast causing water to bulge upwards around it. The peak water surface elevation observed during the storm event, based on the additive effect of storm surge with predicted tide, is termed storm tide.

The storms on record as having caused the most damage in the study area are Hurricane Sandy in October 2012 and Hurricane Irene in August 2011.

Hurricane Sandy: October 22-29, 2012

Hurricane Sandy formed in the southwestern Caribbean Sea and affected Jamaica, Cuba, Haiti, the Dominican Republic, Puerto Rico, and the Bahamas before it reached the United States. The hurricane grew in size and reached a secondary peak intensity of 98 mph while turning northwestward towards the mid-Atlantic states. By the time it made landfall near Brigantine, New Jersey, just to the northeast of Atlantic City, on October 29th, Sandy had weakened to a post-tropical cyclone with 81 mph maximum sustained winds. With a wind span of over 1,150 miles across, it drove a catastrophic storm surge into the New Jersey and New York coastlines.

The storm surge was highest in the areas bordering the lower New York Bay, Raritan Bay, and Raritan River. The maximum recorded water level for the tide gage at Bergen Point West Reach, NY, which best reflects the hydraulic conditions at the mouth of the Rahway River, was measured during Sandy, on October 29, 2012 at 8:30 pm EDT. The measurement was 9.56 ft for the storm surge (observed water level, or storm tide, minus predicted astronomical tide levels), or 14.57 ft North American Vertical Datum of 1988 (NAVD 88) for the storm tide. Of all the tide gages in the United States at which water levels were measured during Sandy, Bergen Point had the third highest measurement. The highest storm surge was measured at the gage at Kings Point, NY, and the second highest surge was measured at Bridgeport, Connecticut. Measured storm surges at other tidal gages near the study area include: 9.40 ft at The Battery, NY; 8.57 ft at Sandy Hook, NJ; and 5.82 ft at Atlantic City, NJ (NOAA, 2013a).

Ranges of storm tides in counties in and near the study area during Sandy were estimated at:

Monmouth and Middlesex counties	4 - 9 ft NAVD 88
Union and Hudson counties	3 - 7 ft NAVD 88
Essex and Bergen counties	2 - 4 ft NAVD 88
Ocean County	3 - 5 ft NAVD 88
Atlantic, Burlington, and Cape May counties	2 - 4 ft NAVD 88

The storm surge from Sandy caused seawater to surge into the Hudson River and the coastal waterways and wetlands of northeastern New Jersey, including Newark Bay, the Passaic and Hackensack rivers, the Kill Van Kull, and the Arthur Kill, which the Rahway River flows into. Significant inundations occurred along the Hudson River in Weehawken, Hoboken, and Jersey City, where many high-water marks indicated that inundations were between 4 and 6.5 ft above ground level. Inundations of 4 to 6 ft were also measured across Newark Bay in Elizabeth and the area around Newark Liberty International Airport. The highest high-water mark measured by the U.S. Geological Survey (USGS) following Sandy was 8.9 ft above ground level at the U.S. Coast Guard Station on Sandy Hook, NJ. At Keyport, NJ, on the southern side of Raritan Bay, a high-water mark of 7.9 ft above ground level was measured, and a mark of 7.7 ft was measured in Sayreville, NJ near the Raritan River.

The estimated cost of Sandy to the United States is $70.2 billion. In New Jersey, more than 346,000 homes were damaged or destroyed, and more than 2 million people lost power (FEMA, 2018). Twelve direct deaths associated with Sandy were identified in New Jersey, but none were identified in the study area.

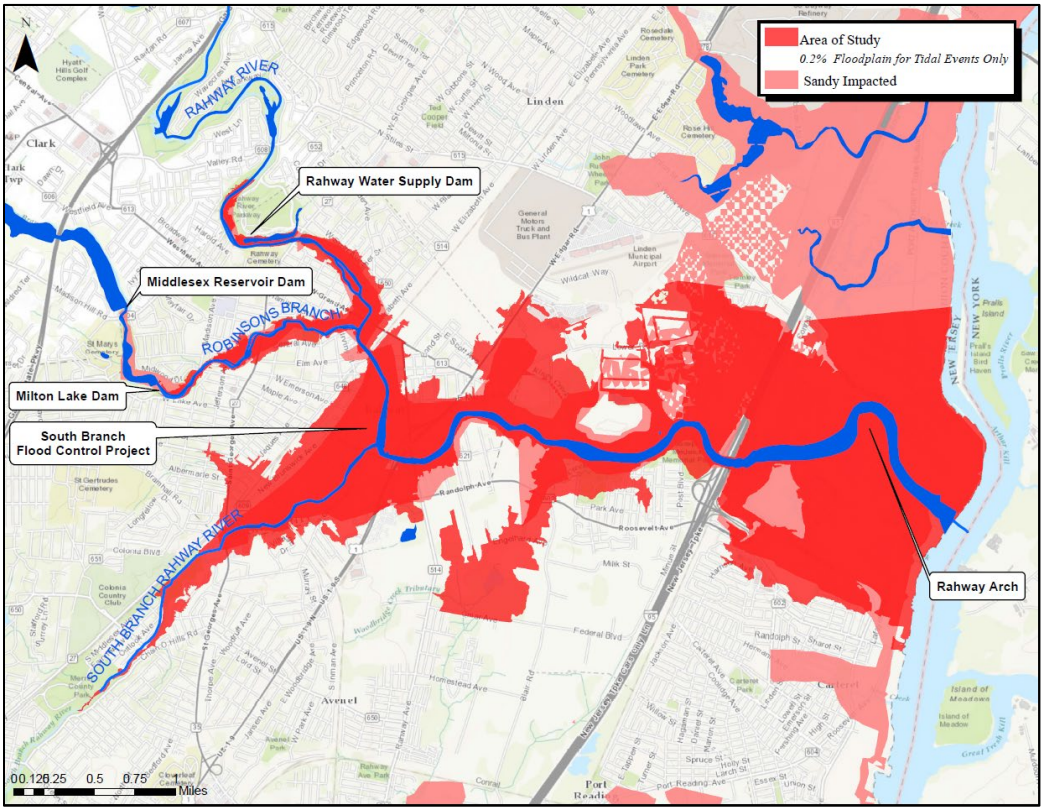


Figure 2-1. Sandy-Impacted Areas In and Near the Study Area

In the study area, Sandy caused tens of millions of dollars of flood damages. Figure 2-1 is a map of Sandy-impacted areas in and near the study area. Conversations with the Middlesex Office of Emergency Management (OEM) confirmed that flood damages in municipalities in the lower Rahway River Basin were storm surge-induced. The City of Rahway sustained an estimated $35 million in damages, with approximately $15 million of it to city property, and another $20 million to private property. Repairs to the three pump stations at the existing USACE flood risk management project in Rahway, NJ, totaled $252,000 ($60,000 for the Milton station, $90,000 for the Hazelwood station, and $102,000 for the Stearns station). Water levels reached 12.5 ft NAVD 88 at the stations during Sandy, and after the storm the pump controls and emergency generators for the stations were elevated to 13.9 ft NAVD 88. Damages for the Borough of Carteret are estimated at $53.1 million. Woodbridge Township suffered damages estimated at $7 million, with 200 structures damaged, including 40 destroyed. The PSE&G power plant in Woodbridge was destroyed. The NJDEP Blue Acres Program is in the process of buying out 221 homes in Woodbridge (as of April 2020). During Sandy, bulk fuel tanks were damaged and fuel flowed into the Arthur Kill. The storm also temporarily shut down oil refineries in the study area, leading to shortages of fuel in northern New Jersey.

Hurricane Sandy resulted in extensive impacts to critical infrastructure and the economy in the study area and surrounding communities. New Jersey Transit was shut down in its entirety. PATH light rail services were also shut down. Starting 1 November 2012, New Jersey Transit

restored bus service on 68 bus routes in northern and central New Jersey and 18 bus routes in southern New Jersey, providing service over the entire routes with no detours or truncations. Partial service was scheduled to be restored on 58 bus routes in northern and central New Jersey and 17 routes in southern New Jersey, to operate with detours or truncations due to the impact from Hurricane Sandy. These service disruptions made commutes to work challenging for many citizens in and around the study area.

The hurricane not only halted the public transportation system, but lead to many road closures in and around the study area. The Garden State Parkway was closed approximately 130 miles from Exit 129 in Woodbridge Township to Cape May. The New Jersey Turnpike's Hudson County Extension was closed between Exit 14 (Newark Airport/I-78/Routes 1 & 9) and the Holland Tunnel, speed restrictions of 45mph were in place below Exit 12 (Carteret/Rahway), and the turnpike was closed farther south[6]. Additionally, there were multiple closures along Route 35 and Route 9 preventing the flow of traffic along these highways[7].

More than 8 million people were without power in New Jersey as stations flooded and trees fell on power lines. Governor Christie said on the morning of 30 October 2012 that some 2.4 million households in the state were without power. As of the morning of 2 November 2012, 1.6 million customers were still without power, down from 2.7 million. As of 3 November 2012, 31 percent of homes and businesses in the state did not have electricity.

Hurricane Sandy also threatened the environment due to the spread of pollutants and contaminants. In addition to the threat of contaminants from the Superfund sites, there were an estimated 630 storm-related oil spills in New York City. New Jersey, on the other hand, took the worst blow regarding oil contamination after a significant diesel fuel spill at the Motiva Refinery into the 10-mile-long, 600-foot wide tidal strait separating New Jersey from New York's Staten Island, known as Arthur Kill which is connected to the Rahway River. According to New Jersey environmental officials, the AP reported 336,000 gallons of diesel fuel spilled into the Arthur Kill waterway after a storage tank ruptured from the storm surge. The resulting damaging environmental implications resulting from the spill could leave a lasting scar on the sensitive salt marshes in the waterway, which are important wildlife habitats and nursery areas for fish. According to NOAA, there was a threat of large fish kills due to low oxygen levels in the water resulting from the biodegradation of the oil.

In the aftermath of the hurricane and its damage to the petroleum facilities, many gas stations were closed and people lined up for hours to get gasoline. According to American Automobile Association on 2 November 2012, about 60% of the gas stations in New Jersey were closed. On the night of 2 November 2012, Governor Christie took action to prevent a fuel shortage and ease the problem of extended wait times and lines at gas stations by signing Executive Order 108, declaring a limited state of energy emergency with regard to the supply of motor fuel and implementing odd-even rationing for gasoline purchases in 12 New Jersey counties. Gas price

[6] Source: https://www.nj.com/news/2012/10/hurricane_sandy_wreaks_continu.html
[7] Source: https://nj1015.com/nj-traffic-road-closures-flooding-and-more-in-sandys-aftermath/

dropped after the storm, despite the closure of some refineries. Oil prices initially fell, since there was temporarily less regional demand from closed refineries.

Hurricane Irene: August 27-28, 2011

Irene first made landfall in the United States in North Carolina, and continuing north-northeastward, made landfall again with an intensity of 60 knots (69 mph) at Brigantine Island in New Jersey near Atlantic City, on August 28, 2011 at 4:35 am EDT. By this time Irene had weakened from a hurricane to a tropical storm with maximum sustained winds near 45 knots (52 mph). Irene continued to move north-northeastward, passing over Coney Island, Brooklyn and Manhattan in New York before it continued to move north-northeastward and up into the northeastern states.

Irene generated 10 inches of intense rainfall in the Rahway River Basin. The total rain measured at Newark, NJ was 8.92 inches. The rain resulted in major flooding and record-high water levels in New Jersey rivers. Irene also caused a storm surge, which measured from 3 to 5 feet along the New Jersey coast. At Bergen Point West Reach, NJ, the storm surge was measured at 4.56 ft, for a storm tide of 10.22 ft NAVD 88. The storm surge caused moderate to severe tidal flooding with extensive beach erosion in New Jersey (NOAA, 2013b).

The estimated cost of Irene to the United States is $15.8 billion, including an estimated $7.2 billion in losses from inland flooding and storm surge. Seven direct deaths associated with Irene were identified in New Jersey, but none in the study area.

Other Storm Events

Other notable storms of the last century that have caused storm surge and flood damages in the study area include:

- Storm of April 15-16, 2007
- Tropical Storm Floyd, September 15-16, 1999
- Storm of October 19, 1996
- Nor'easter Storm of December 11-12, 1992
- Halloween Nor'easter of October 31, 1991
- Hurricane Gloria, September 27, 1985
- Coastal Storm of March 29-30, 1984
- Tropical Storm Doria, August 26-28, 1971
- Coastal Storm of March 6-8, 1962
- Hurricane of September 12, 1960 (Donna)
- Storm of November 6-7, 1953
- Storm of November 25, 1950
- Hurricane of September 14, 1944

2.3 Winds

Wind conditions in the study area may be estimated using the measurements taken at Sandy Hook, New Jersey (SDHN4 8531680), which is located approximately 13 miles southeast of the mouth of the Rahway River. A wind rose constructed based on 2005-2018 data indicates that

18% of wind occurrences are from the west (Figure 2-2). Winds from the northwest occur approximately 15% of the time. Winds from the north, northeast, east, and southeast occur between 5% and 10% of the time, and winds from the south and southwest occur a little more than 10% of the time. The data also shows that there were 33 occasions when sustained winds (2 minute) exceeded 40 mph, two of these events experienced sustained winds over 50 mph. The west and northwest account for the most winds greater than 40 mph. The winds at Sandy Hook were greater than 20 mph about 7% of the time. The maximum storm wind velocity recorded near the study area was 78 mph at Long Branch, New Jersey, located south of Sandy Hook occurring on June 11, 1953. The maximum recorded winds for Hurricane Sandy near the study area was at Perth Amboy (XPER) (40.50N, 74.28W) on October 30, 2012 at 0210 at a height of 10 meters. The maximum sustained velocity (2 minute) was 46 knots (53 mph). The maximum gust was 63 knots (72 mph).

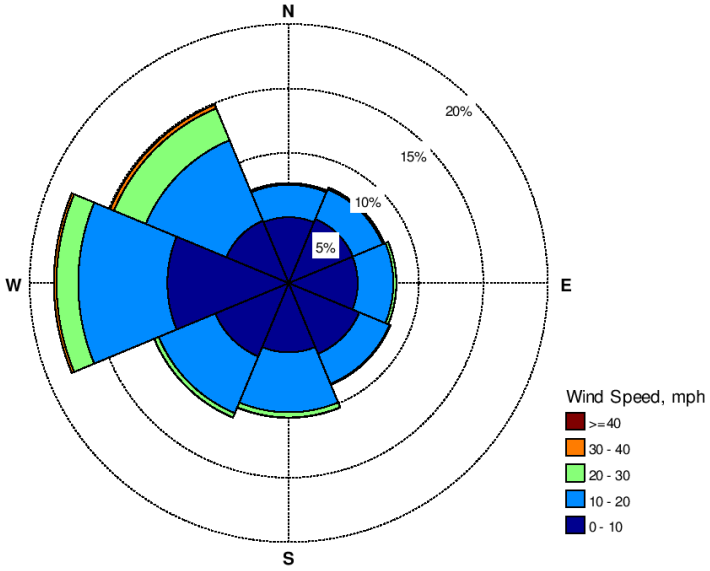


Figure 2-2. Wind Rose for the Study Area

2.4 Tides

The study area experiences semidiurnal tide cycles, i.e., there are two high tides and two low tides every lunar day. Table 2-1 shows tidal datums for the current National Tidal Datum Epoch of 1983-2001 for the nearest tide gage, Bergen Point West Reach, New York (Station ID 8519483), which has a period of record from 1981 to present. The conditions at the Bergen Point West Reach, NY gage are the most hydraulically similar to those at the mouth of the Rahway River, compared to the conditions at other tide gages in New Jersey and New York. The mean range of tide at Bergen Point West Reach, NY is 4.98 ft and the great diurnal range is 5.51 ft.

Table 2-1. Bergen Point West Reach, NY Tide Gage Datums

Tide Datum	Height Above MLLW (ft)	Elevation (ft, NAVD 88)
Mean Higher High Water	5.51	2.56
Mean High Water	5.19	2.24
Mean Sea Level	2.77	-0.18
Mean Tide Level	2.70	-0.25
Mean Low Water	0.21	-2.74
Mean Lower Low Water (MLLW)	0.00	-2.95

2.5 Stage-Frequency Relationship

A stage-frequency relationship for where the Rahway River flows into the Arthur Kill was obtained from the USACE Coastal and Hydraulics Laboratory's Coastal Hazards Systems (CHS) webtool. The stage-frequency relationship for Arthur Kill/Rahway Mouth (ID: 11659) was developed as part of the USACE North Atlantic Coast Comprehensive Study (NACCS). Table 2-2. Stage-Frequency Curve for Arthur Kill/Rahway Mouth (Point ID 11659) shows the NACCS stage-frequency curve and the results of converting stage from mean sea level (MSL) to the NAVD 88 datum and transforming the stage to reflect base year conditions.

Table 2-2. Stage-Frequency Curve for Arthur Kill/Rahway Mouth (Point ID 11659)

Frequency (Return Interval, Years)	Annual Exceedance Probability	NACCS Stage (m, MSL)	Base Year Stage (ft, NAVD 88)
1	0.99	1.59	5.10
2	0.5	1.88	6.05
5	0.2	2.27	7.33
10	0.1	2.58	8.35
20	0.05	2.9	9.40
50	0.02	3.37	10.94
100	0.01	3.78	12.28
200	0.005	4.22	13.73
500	0.002	4.78	15.56

2.6 Shoreline Conditions

The shoreline of the Rahway River area along the Arthur Kill consists of docks, bulkheads, industrial areas, and tank farms. The elevation of the ground surface in the shoreline region ranges from 0 to 25 ft.

2.7 Existing Hydraulic Features

USACE constructed a levee system for flood risk management in Rahway, New Jersey, in 1966. The Rahway Flood Risk Management Project (also referred to as the South Branch "flood control" project), which NJDEP maintains, begins about 4.5 miles upstream of the mouth of the Rahway River. The project is located along 1,740 ft of the left (west) bank of the South Branch, from Regina Avenue (Ave) to Hazelwood Ave, and along 2,040 ft of the right (west) bank of the Rahway River, from Hazelwood Ave to Monroe Street (St). The project consists of a levee from

Regina Ave to Sterling Place, a floodwall from Sterling Place to Hazelwood Ave, and a levee from Hazelwood Ave to Monroe St. The project also includes two stop-log structures: one at the Hazelwood Ave bridge and another at the Milton Ave bridge, and three pump stations. USACE inspects the levee system annually, and the levees are independently surveyed every five years, to ensure the levees are not settling and remain in good condition. The levees were regraded in 2015, after having been overtopped during hurricanes Irene in 2011 and Sandy in 2012. Inspections after the hurricanes showed the levees had settled by about a foot; the 2015 regrading restored the levees to their original top elevation of 12.6 ft NAVD 88.

2.8 Critical Infrastructure

Critical infrastructure in the study area includes schools, a hospital, oil and gas pipelines, oil refineries, road and rail transportation routes including the New Jersey Turnpike and State Routes 1 and 9, a PSE&G substation, police stations, fire stations, and wastewater treatment plants including the Rahway Valley Sewerage Authority. Figure 2-3 shows storm surge impacts on Rahway Police and Fire Departments, transportation routes, and petroleum facilities in the storm surge floodplain. Appendix B: Economics contains high resolution maps of the critical infrastructure in the study area and a table of the depth and stage of flooding at critical infrastructure in the study area.

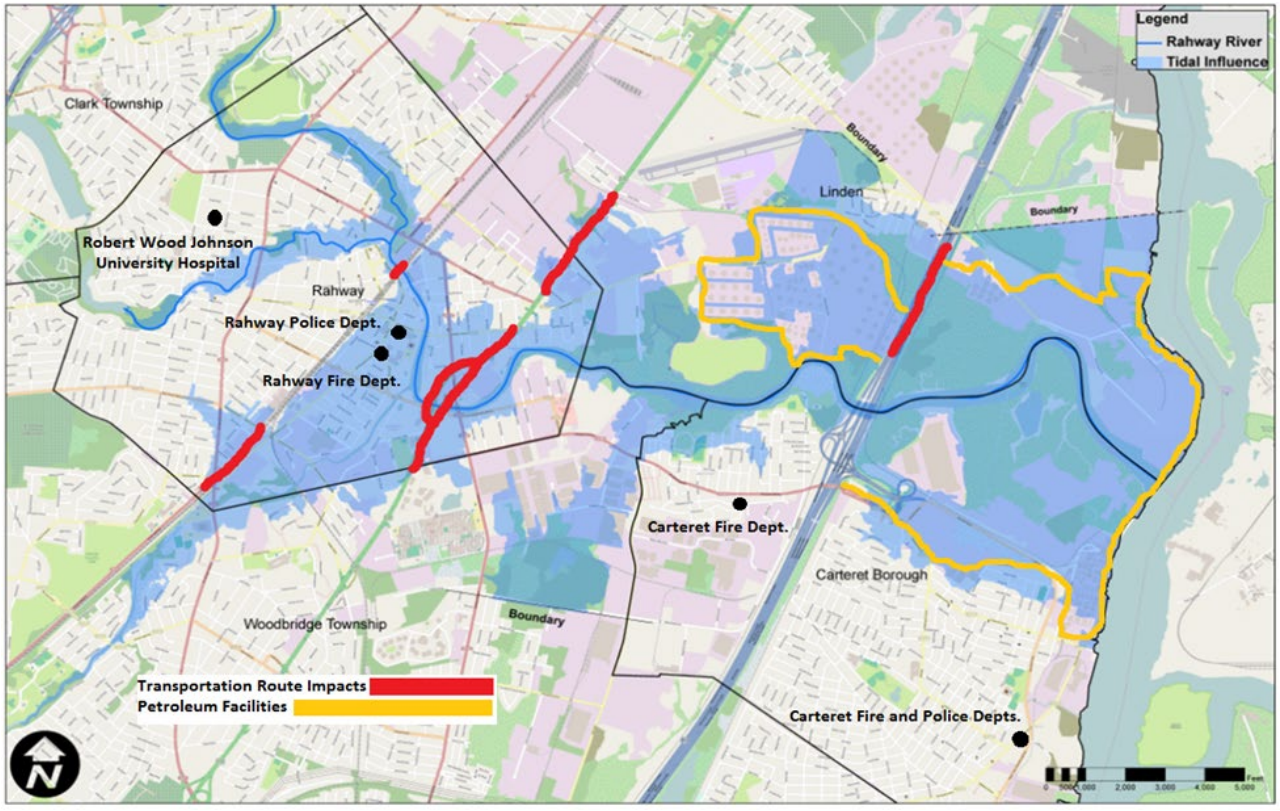


Figure 2-3. Critical Infrastructure in the Study Area

Observe that petroleum facilities as outlined in yellow in Figure 2-3 make up a substantial share of the study area. These petroleum facilities are located at the mouth of the Rahway River along

the Arthur Kill for the purpose of ease of transportation. This location for these petroleum facilities, also known as tank farms, also means that the facilities are at considerable risk of damage from coastal storms. Damages from Hurricane Sandy to the Kinder Morgan facility alone totaled $69 million. It has been reported to the USACE New York District by various terminal operators that the damage included tanks slipping off of their foundations. Oil was also lost into the Arthur Kill, damaging the environment. The terminal facility operators have plans for hardening the facilities which they expect would reduce damages to similar storms in the future by 20%[8]. These facilities nonetheless remain exposed to the damaging effects of coastal storms.

2.9 Flood Prone Areas

Flood inundation maps for the study area were developed using calibrated USACE Hydrologic Engineering Center models including the Hydrologic Modeling System and River Analysis System models (HEC-HMS and HEC-RAS, respectively). Figure 2-4 maps the 10% Annual Exceedance Probability (AEP) or 10-year, 1% AEP (100-year), and 0.2% AEP (500-year) floodplains in the study area, for coastal storm-surge induced flooding only (NACCS, 2015). Details about hydrology and hydraulic model creation, parameterization, set-up, calibration, runs, and results are provided in Appendix CI: Hydrology, and CII: Hydraulics. A joint probability analysis between coastal and fluvial storms served as the basis for the flood damage analysis but the mapping software used to create Figure 2-4 does not have the capability of mapping the joint probability result; the difference in mapping results is minor at the figure's scale.

The downstream reach of the Rahway River, by the Arthur Kill, starts producing minimal damages to the tank farms at the 99.9% AEP (1-year) flood at 5.3 ft; in recent years the owners of these tank farms have implemented nonstructural measures to protect their tanks. Street flooding in this downstream reach begins at the 20% AEP (5-year) flood and significant damages to structures begin at the 4% AEP (25-year) flood at the Tower Trailer Park, Mileed Way Industrial Park, and Beverly St residences in Carteret.

The confluence of the Rahway and South Branch rivers at Edgar Road Bridge begins street flooding at the 50% AEP (2-year) flood by Essex St in Rahway. Significant damages begin at the 1% AEP (100-year) flood, including to automotive businesses and residences, without raised foundations, between Route 1 and Milton Ave.

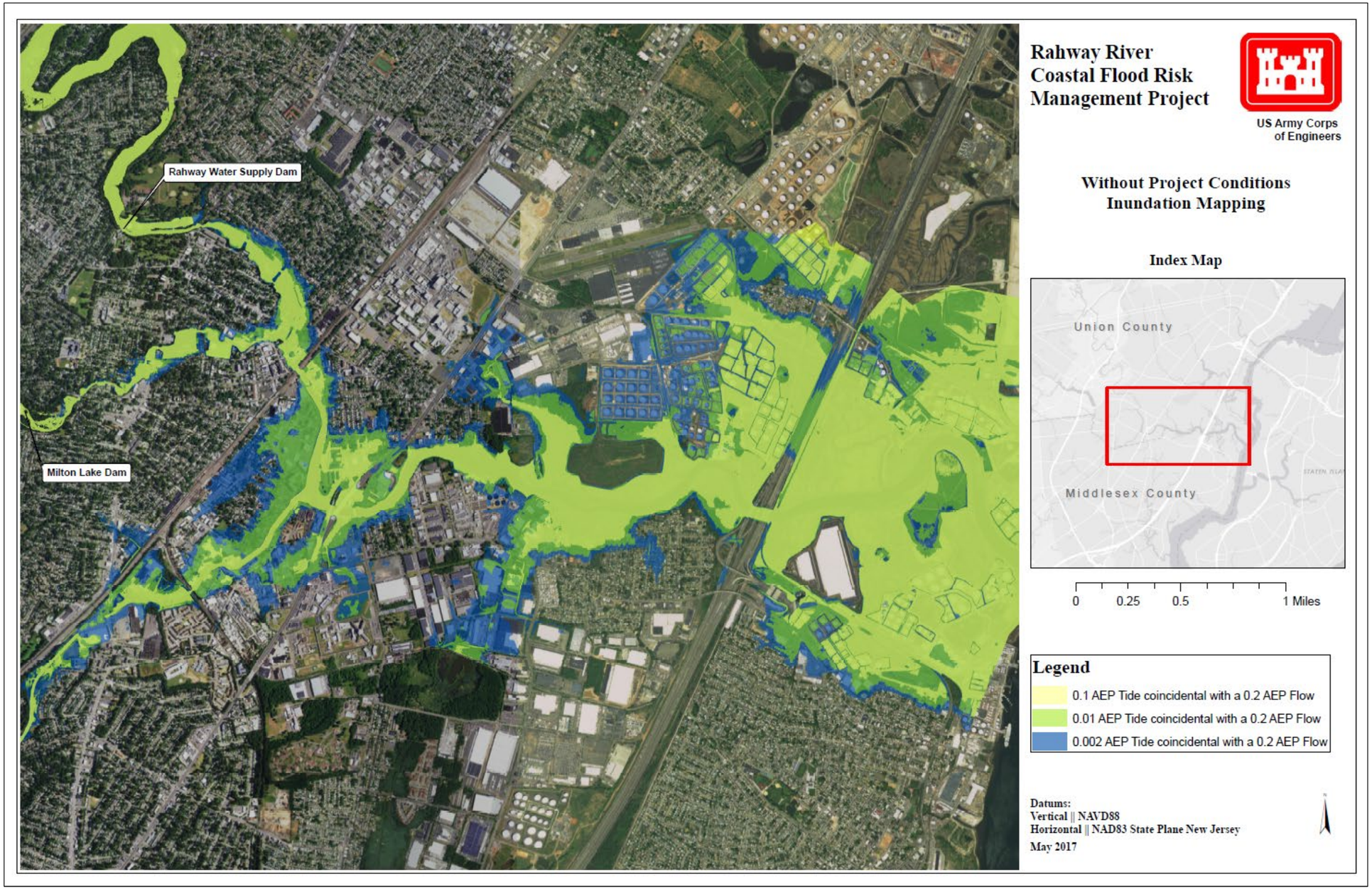
South Branch starts producing minimal damages to industrial areas at the 1% AEP (100-year) flood at St. Georges Ave and Elliot St. Street flooding and residential damage in South Branch begin at the 2% AEP (50-year) event at Leesville Ave.

[8] During optimization, damage to the petroleum facilities was excluded from the estimates of the future with- or without-project condition damages. An engineering regulatory-compliant method for estimating the damage to petroleum facilities does not exist. Abstracting from the damage estimates to the petroleum facilities was suggested and verified by Agency Technical Review. The exclusion of the petroleum facilities from the with- and without-project condition damage estimates does not affect plan selection as it relates to optimization.

Levee overtopping at South Branch and Rahway River currently begins slightly above the 1% AEP (100-year) flood. For future conditions that include some increase in flow and sea level, the levees will be overtopped before the 1% AEP flood.

Robinson's Branch has street flooding beginning at the 2% AEP (50-year) flood at the intersection of Central Ave and St. Georges Ave and at Hamilton Ave. Significant damages beginning at the 20% AEP (5-year) flood occur at the confluence with the Rahway River near the Rahway Arts District.

Flooding upstream of Robinson's Branch is not heavily influenced by storm surge. Although coastal storm events alone would not cause significant damages upstream of the confluence of Robinson's Branch and the Rahway River, the joint probability of a fluvial and storm surge event occurring at Robinson's Branch and south of the Rahway Water Supply Dam suggests that a 4% AEP (25-year) flood would cause damages.



*Note: Map displays storm surge inundation only, does not represent tidal-fluvial joint probability water surface elevations (WSEs).

Figure 2-4. Existing Conditions Inundation Map for the 10%, 1%, and 0.2% Annual Exceedance Probability Events

Chapter 3.0 Existing Conditions: Affected Environment*

This description of existing environmental conditions meets NEPA requirements, and serves as the baseline for Chapter 6: Environmental Effects and Chapter 7: Cumulative Effects. For the purposes of consistent orientation during discussions related to streambanks, banks are referred to as left or right based on a downstream viewpoint.

3.1 Land Use

Municipalities in the project area have little undeveloped land or open space, ranging from essentially none to a few percent of the total area within each municipality. Most of the watershed is heavily urbanized, of which residential housing developments comprise the largest sub-category with remaining uses consisting of recreation, municipal, commercial and industrial. Undeveloped lands consist predominantly of county- and municipally-owned open space and wetlands.

3.2 Topography, Geology and Soils

3.2.1 Geology and Topography

The study area is located within the Piedmont Physiographic Provence. The Piedmont Provence is described as gently rolling plains, 200 to 400 ft above sea level, and includes the crescent-shaped Watchung Mountains ranging from 450 to 900 ft above sea level. The underlying geology is mainly shale with siltstones and sandstones occurring infrequently, with the mountains being composed of basalt flows. Glacial deposits overlie the surface throughout the Piedmont area (Amy S. Greene Environmental Consultants Inc., 2014).

The study area generally has flat to gently sloping topography consistent with its location at the confluence of numerous branches of tidal and nearly tidal streams and rivers. Elevations within the study area range from sea level to 25 ft above mean sea level.

3.2.2 Soils

Dominant soil types within the project area consist of Boonton loam, Boonton-Urban land complex, Haledon silt loam, fluvaquents, Haledon-Urban Land complex, Transquaking mucky peat, and Udorthents.

Within the project area, Boonton soils occur on 3 to 8 percent slopes. This soils series consists of deep or very deep moderately well and well drained soils formed in till on uplands. The soils formed in glacial till are composed mostly of red to brown shale, sandstone, basalt, and some granitic gneiss (NRCS, 2012).

The Urban land component of the Boonton-Urban Land complex is classified as land mostly covered by streets, parking lots, buildings and other structures of urban areas with slopes ranging from 0 to 8 percent (NRCS, 2002).

The Haledon component is on ground moraines on till plains with parent material consisting of coarse-loamy basal till derived from basalt. The natural drainage class is somewhat poorly

drained. This soil series consists of very deep, somewhat poorly drained soils in low positions on undulating uplands. Slope ranges from 0 to 15 percent (NRCS, 2013a).

Fluvaquent soils generally occur on slopes ranging from 0 to 3 percent. Parent material consists of recent alluvium and are commonly found on floodplains and in river valleys. The natural drainage class is somewhat poorly drained and is frequently flooded.

The Hasbrouck soil series consists of very deep, poorly drained soils in depressions on uplands with slopes ranging from 0 to 8 percent. They generally occur on nearly level or gently sloping depressions, drainage ways, and areas adjacent to narrow floodplains of minor streams on uplands. They typically formed from eroded and redeposited glacial materials overlying till (NRCS, 2013b).

The Transquaking mucky peat soils are found along coastal plains in brackish estuarine marshes along tidally influenced rivers and creeks. Slopes in which this soil occurs range from 0 to 2 percent. The parent material consists of organic deposits underlain by loamy mineral sediments. This soil type is very poorly drained and frequently flooded by tidal waters (NRCS, 2002).

The Udorthents soil type is typically identified in areas where the original in-situ soils have been altered through human activity. Substratums included within this series includes refuse substratum, where areas have been used for refuse disposal (e.g. landfill), and loamy substratum, where the in-situ soil has either been removed and/or covered with a loamy fill material These soils typically consist of moderately deep to deep well drained to somewhat poorly drained soils. Within the project area, Udorthents are found on slopes ranging from 0 to 8 percent (NRCS, 2016).

Hydric Soils

Transquaking, Fluvaquents and Hasbrouck soils are included on the list of hydric soils for New Jersey developed by the Natural Resources Conservation Service. Soils with this classification are those saturated through natural or artificial means sufficiently enough to support the growth and regeneration of hydrophytic vegetation (NRCS, 2007).

Prime Farmland Soils

Prime farmland soils found in the project area include Boonton and Haledon soils. Prime farmland soils are defined by the U.S. Department of Agriculture (USDA) as land that has the best combination of characteristics for producing food. It can have any land use ranging from cultivated land, pastureland, forest, or other; however, it is usually not urban or water areas. The USDA states that “The soil qualities, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management and acceptable farming methods are applied” (NRCS, 2016).

3.3 Water Resources

3.3.1 Surface Water

The Rahway River originates in the Watchung Mountains in Essex County and flows south for approximately 24 miles before discharging into the Arthur Kill strait. The Rahway River Basin has a drainage area of 83 square miles. Within the study area, the Rahway River has two major tributaries: Robinsons Branch and the South Branch Rahway River.

Several smaller, tidally influenced tributaries to the Rahway River are located in the lower portion of the study area. Four of the more notable tributaries include Kings Creek located in wetland complex on the left bank of the Rahway River just north of Hawk Rise Sanctuary, Caseys Creek located in wetland complex along the right bank of the Rahway River within Joseph Medwick Park, Marshes Creek located along the left bank of the Rahway River south of the New Jersey Turnpike, and Cross Creek located on the right bank of the Rahway River south of the New Jersey Turnpike (Figure 3-1).

The channel width of the Rahway River within the study area ranges from approximately 50 feet in the northern portion of the study area to approximately 475 feet near the confluence with the Arthur Kill. The depth of the river ranges from two feet in the northern portion of the study area to an average depth of 10 ft near the confluence with the Arthur Kill (Miller, 2012; NOAA, 2012). The substrate of the Rahway River in the northern portion of the study area is comprised of cobble, gravel and sand (Miller, 2012). Around the Route 1 bridge the substrate transitions to a predominantly silty-muck substrate (USACE, 2001). This substrate type is consistent for remaining segment of the Rahway River to its confluence with the Arthur Kill, where the substrate predominantly consists of mud and sand (U.S. Coast Guard, 2010).

Along with receiving point and non-point discharges related to stormwater runoff, the Rahway River has experienced modifications associated with water supply, recreation, flood risk management, and infrastructure development. In the City of Rahway, near the northern portion of the study area, United Water uses Rahway River Dam to withdraw approximately 4.85 million gallons of water per day from the river to serve about 26,500 customers (United Water, 2016). The Rahway Flood Risk Management Project levee system is located along the right bank of the Rahway River at the confluence of the South Branch, in the vicinity of the Rahway Municipal Complex.

3.3.2 Water Quality and Habitat

In the study area, the Rahway River has three separate water quality classifications (Figure 3-1). From its headwaters until around the railroad tracks in the City of Rahway, the Rahway River is designated as FW2-NT. Robinson's Branch is also designated as FW2-NT. FW2-NT waters are those freshwaters not supporting trout spawning or maintenance. By definition, designated uses for FW2 waters include: 1. maintenance, migration and propagation of the natural and established biota; 2. primary contact recreation; 3. industrial and agricultural water supply; 4. public potable water supply after conventional filtration treatment and disinfection; and 5. any other reasonable uses. Non-trout waters are those that are "not generally suitable for trout

because of their physical, chemical or biological characteristics but are suitable for a wide variety of other fishes".

Between the railroad tracks and the Route 9 bridge, the classification of the Rahway River changes to SE2. Designated uses of SE2 are: 1. maintenance, migration and propagation of the natural and established biota; 2. migration of diadromous fish; 3. maintenance of wildlife; 4. secondary contact recreation; and 5. any other reasonable uses. The South Branch Rahway River is designated SE2 near its confluence with the Rahway River but then changes to FW2-NT in its upper reaches.

From the Route 9 bridge to the confluence with the Arthur Kill, the water classification of the Rahway River is saline waters of estuaries 3 (SE3). The four tidal tributaries to the Rahway River, Kings Creek, Caseys Creek, Marshes Creek and Cross Creek are also classified as SE3. Designated uses for SE3 waters include: 1. secondary contact recreation; 2. maintenance and migration of fish populations; 3. migration of diadromous fish; 4. maintenance of wildlife; and 5. any other reasonable uses (N.J.A.C. 7:9B, 2011).

Salinity levels in the Rahway River range from around 8 parts per thousand (ppt) near the Route 9 bridge to 17 to 26 parts per thousand in the lower portion of the study area near the Arthur Kill (USACE, March 2004; U.S. Coast Guard, 2010).

The NJDEP Bureau of Freshwater and Biological Monitoring (BFBM) conducts monitoring of surface water quality through a combination of chemical analyses and surveys of macroinvertebrates and/or fish surveys. NJDEP BFBM fish and macroinvertebrate monitoring stations (FIBI019 and ANO195) are co-located immediately above the northern boundary of the study area.

An evaluation of the habitat within the monitoring station by the NJDEP BFBM during fish and benthic surveys noted characteristics consistent with a stressed aquatic community. These characteristics included sediment deposition, channel modification, severe bank erosion, poor flow regime, and the absence of a vegetated riparian zone along the left bank. In addition, several storm water outfalls which directly drain stormwater runoff from adjacent roadways were noted (Vile, September 2011).

The segment of the Rahway River below Robinson's Branch is included on the 303(d) List of Impaired Waters in the New Jersey draft 2016 Integrated Water Quality Monitoring and Assessment Report (NJDEP, 2019). Parameters causing the use impairment are listed in Table 3-1. In addition, the NJDEP has issued fish consumption advisories for blue crab, striped bass, American eel, white perch and white catfish within the Arthur Kill and its tidal tributaries, including the Rahway River (NJDEP, 2016).

Table 3-1. Sources of Parameters Causing Use Impairment in the Rahway River

Parameter	Source 1	Source 2	Source 3	Source 4
Heptachlor epoxide	Contaminated sediments	Source Unknown		
Chlordane in Fish Tissue	Contaminated sediments	Source unknown		
DDT in Fish Tissue	Contaminated sediments	Source Unknown		
Hexachlorobenzene	Source Unknown			
Benzo(a)Pyrene	Source Unknown			
Mercury in Fish Tissue	Atmospheric Deposition - Toxics			
PCB in Fish Tissue	Contaminated Sediments	Source Unknown		
Dioxin	Atmospheric Deposition – Toxics	Combined Sewer Overlfows	Municipal Point Source Discharges	Urban Runoff/Storm Sewers
Dieldrin	Contaminated Sediments	Source Unknown		

Source: 2016 New Jersey Integrated Water Quality Assessment Report

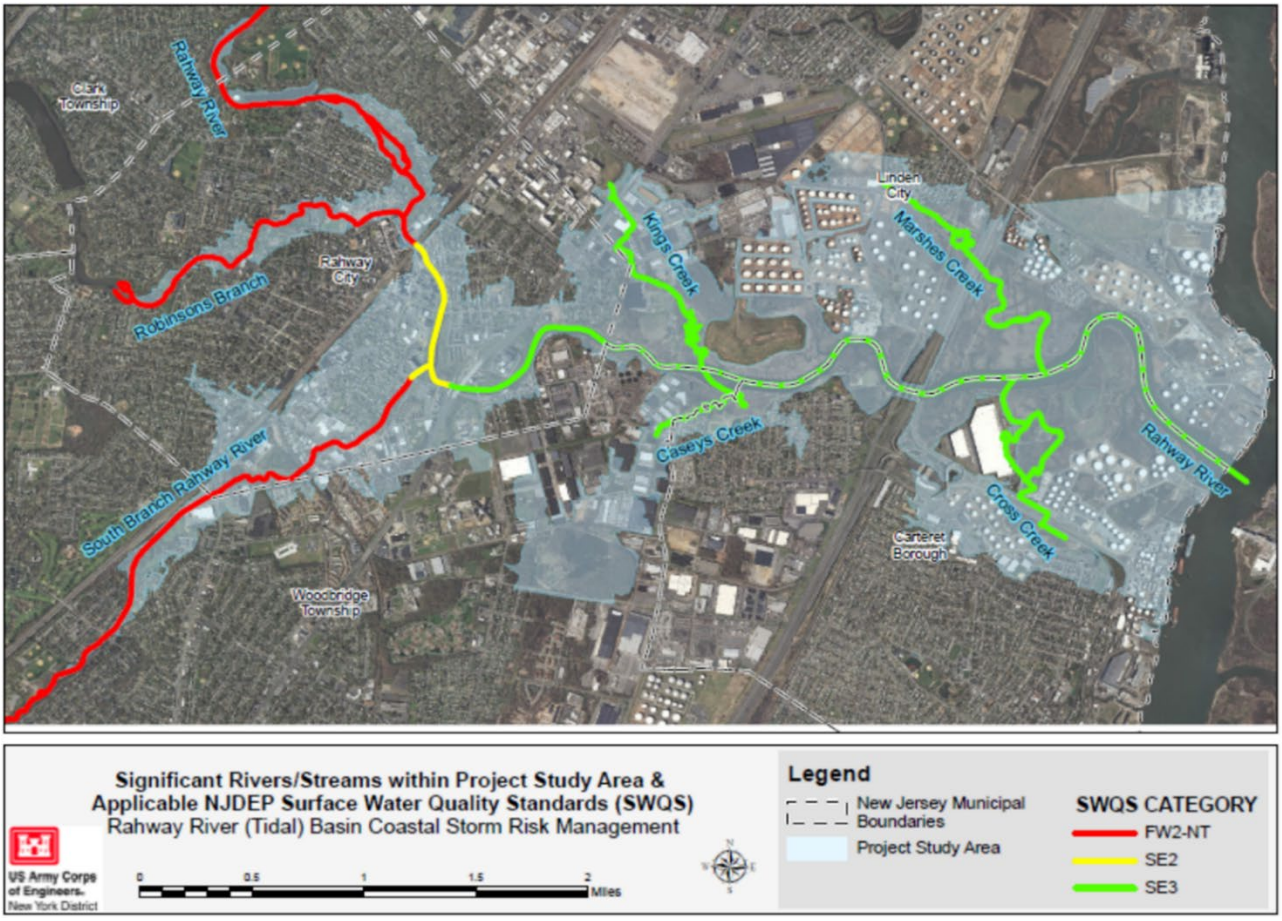


Figure 3-1. Surface Water Quality Designations

3.3.3 Wetlands

Federal (33 CFR 328.3(b); Executive Order 11990) and state (N.J.A.C. 7:7A1.4) definitions of wetlands are similar, identifying wetlands as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." As defined above, wetlands generally include swamps, marshes, bogs, and similar areas.

A review of New Jersey's GIS environmental mapping database (NJ Geoweb) and the USFWS National Wetland Inventory (NWI) maps was conducted to assess potential wetlands within the study area. Both NJ Geoweb and the USFWS NWI maps indicate the presence of multiple wetland complexes along the Rahway River. Figure 3-2 is a map of wetlands in the project area. There is a 3-acre forested wetland near the confluence of the South Branch Rahway River and Rahway River main stem. Further downstream, there are several large wetland complexes ranging from 12 acres to over 20 acres. The wetland complexes are predominantly tidal marsh, although there is a freshwater emergent wetland inside one of the wetland complexes along the left bank of the Rahway River. Refer to Figure 1 in Appendix A.1 for the various wetland types within the project area.

Most of the wetlands in the project area have been subjected to significant human alterations, such as encroachment from residential, commercial, and industrial development. These alterations have led to hydrological changes that have resulted in wetland degradation.

In 2007, USACE completed a 14-acre tidal marsh wetland mitigation in Joseph Medwick Park, which is located along the right bank of the Rahway River in Carteret. The purpose of the mitigation was to compensate for wetland impacts associated with deepening the Arthur Kill. Deepening the Arthur Kill was part of the New York/New Jersey Harbor Deepening Project.

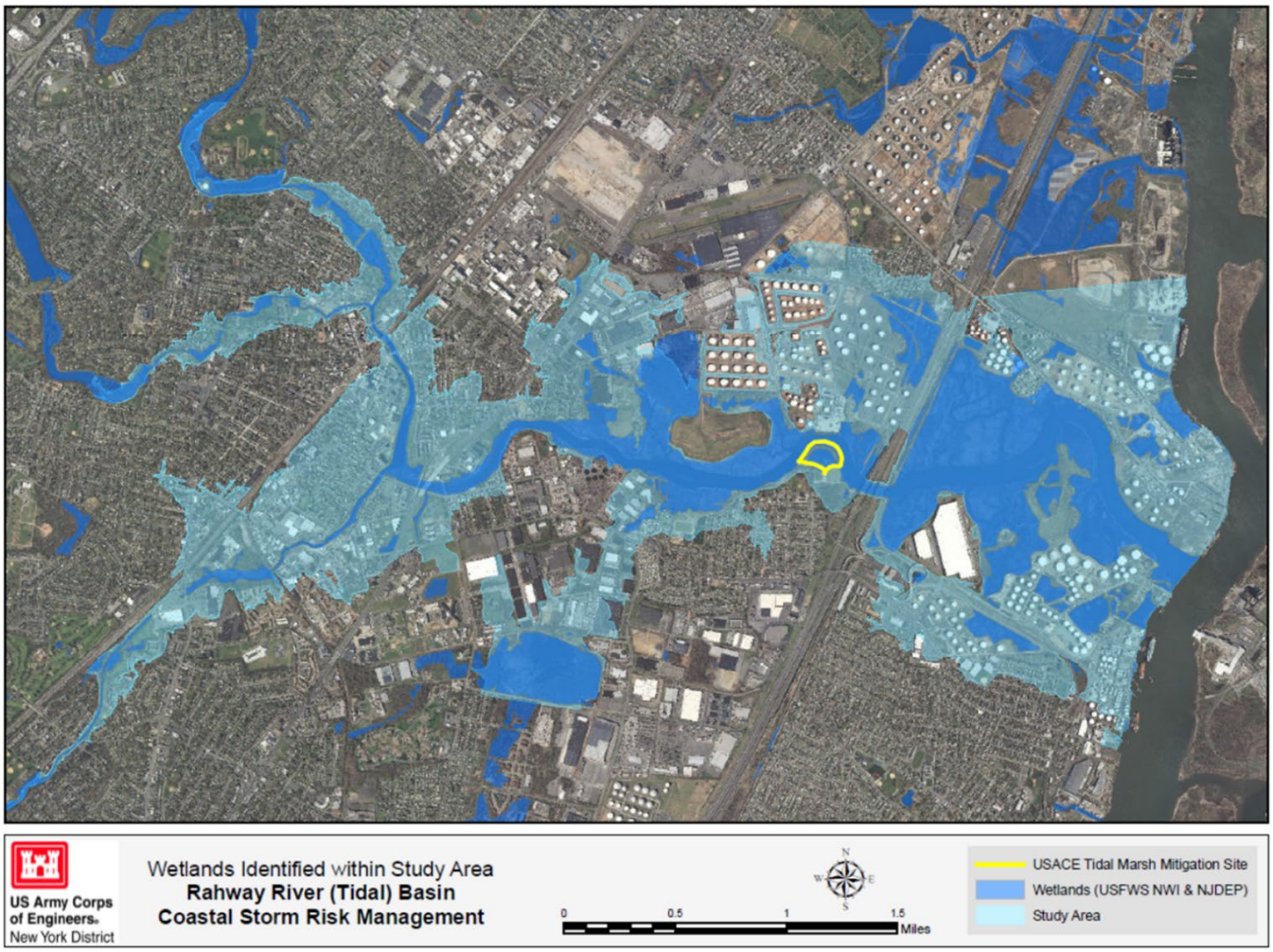


Figure 3-2. Wetlands in the Study Area

3.4 Vegetation

3.4.1 Uplands and Riparian Corridor

The majority of the upland area in the project area consists of residential, commercial and industrial development with few areas of undisturbed mature deciduous vegetation. Vegetation in the uplands consists mostly of maintained lawns dominated by a variety of common native and nonnative grass species interspersed with deciduous shrubs and trees.

The New Jersey Flood Hazard Area Control Act Rules, N.J.A.C. 13 (FHACAR) establishes and requires the preservation of riparian zones. The width of the established riparian zone is based on the environmental resources being protected and can range from 50, 150 or 300 ft as measured from the side of surface waters. Given that the Rahway River and Robinson's Branch are designated FW2-NT and SE3 the riparian zone is 50 ft as described in N.J.A.C. 7:13-4.1c 3.

Within the northern portion of the project area, development occurs right up to the streambank, thus limiting the riparian zone to a width ranging from 5 to 25 ft. Development within the

southern portion of the project area is situated further away from the river. Therefore, the majority of the 50 ft within the regulated riparian zone is vegetated.

Common tree and shrub species observed in the upland areas and riparian zone in the northern portion of the project area include sweet gum (*Liquidambar styraciflua*), eastern cottonwood (*Populus deltoides*), black cherry (*Prunus serotina*), indigobush (*Amorpha fruticosa*), black locust (*Robinia pseudoacacia*), white mulberry (*Morus alba*), American elm (*Ulmus americana*), winged sumac (*Rhus copallina*), and willow oak (*Quercus phellos*).

Invasive plant species observed in the project area include Norway maple (*Acer platanoides*), tree of heaven (*Ailanthus altissma*), Japanese knotweed (*Fallopia japonica*), mugwort (*Artesemia vulgaris*), multiflora rose (*Rosa multiflora*), and common reed (*Phragmites australis*).

3.4.2 Wetlands

Species occurring in the forested wetland in the northern portion of the project area include pin oak (*Quercus palustris*), box elder (*Acer negundo*), red maple (*Acer rubrum*), southern arrowwood (*Viburnum dentatum*), American elder (*Sambucus canadensis*), spotted touch-me-not (*Impatiens capensis*), and miscellaneous sedges and grasses.

Species common to the low marsh wetlands within the project area include smooth cordgrass (*Spartina alterniflora*). Species common to high marsh and marsh border/upland edges include saltmeadow cordgrass (*Spartina patens*), orach (*Atriplex patula*), fleabane (*Pluchea purpurascens*), salt marsh spike rush (*Eleocharis halophila*), water hemp (*Acnida cannabina*), and maritime marsh-elder (*Iva frutescens*).

Common reed (*Phragmites australis*) is the dominant species found within high marsh wetlands in the project area. Other species found along the Phragmites/upland transition zone include tree of heaven (*Ailanthus altissma*) and multiflora rose (*Rosa multiflora*).

The wetland mitigation in Joseph Medwick Memorial Park planted vegetation within four distinct zones: low marsh, supratidal zone, upland transition, and upland. Vegetation planted within the low marsh zone included smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*Spartina patens*). Within the supratidal zone, maritime marsh-elder (*Iva frutescens*) and saltmeadow cordgrass (*Spartina patens*) were planted. The upland transition zone included saltgrass (*Distichlis spicata*), saltmarsh rush (*Juncus gerardii*), and groundsel tree (*Baccharis halmifolia*). Upland vegetation included beach plum (*Prunus maritima*), northern bayberry (*Myrica Pensylvanica*), and winged sumac (*Rhus copallinum*) (USACE, December 2004).

3.5 Aquatic Resources and Wildlife

3.5.1 Fish

The NJDEP Division of Fish and Wildlife (DFW) conducts fish sampling studies in New Jersey waters as part of their long-term biomonitoring program, to determine the level of water quality impairments to state waters. The fish survey station (FIBI019) referred to in Section 3.3.2 is on

the Rahway River at Church St in Rahway, approximately 0.75 miles from the northern border of the project area (also see Figure 2, Appendix A.1). Based on fish surveys conducted in 2010, fish species that inhabit the Rahway River include American eel (*Anguilla rostrata*), tessellated darter (*Etheostoma olmstedi*), redbreast sunfish (*Lepomis auritus*), banded killifish (*Fundulus diaphanous*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosu*s), spottail shiner (*Notropis hudsonius*), hybrid green sunfish and pumpkinseed (*Lepomis cxg*), largemouth bass (*Micropterus salmoides*), and white sucker (*Catostomus commerson*i) (NJDEP BFBM, 2011). The majority of species collected generally consist of warm water species that are relatively tolerant to degraded water quality conditions and are generalist feeders.

USACE conducted a survey in the creek in Joseph Medwick Memorial Park in the fall of 2004 as part of the wetland mitigation project. The only species caught were killifish (USACE, December 2004).

USACE also conducted a spring and fall fish survey of the Rahway River directly adjacent to the study in 2002 (USACE, 2002e)(see Figure 2, Appendix A.1). The dominant species captured were mummichog (*Fundulus heteroclitus*), followed by white perch (*Morone americana*), common carp (*Cyprinus carpio*), pumpkinseed (*Lepomis gibbosu*s), northern hog sucker (*Hypentelium nigricans*), striped bass (*Morone saxatilis*), alewife (*Alosa pseudoharengus*), American eel (*Anguilla rostrata*), gizzard shad (*Dorosoma cepedianum*), and bluefish (*Pomatomus saltatrix*) (USACE, March 2004).

3.5.2 Essential Fish Habitat

EFH is defined under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." The MSFCMA requires federal agencies to conduct an assessment to determine whether the proposed action “may adversely affect” designated EFH and to consult with NOAA NMFS on activities that may adversely affect EFH. The objective of an EFH assessment is to determine the potential effects of the proposed action on relevant commercial, federally managed fisheries species within the proposed action area.

Based on coordination with NOAA-NMFS staff and a review of the NOAA-NMFS EFH Mapping System, the Rahway River downstream of the Route 9 bridge is designated as EFH for all life stages (eggs, larvae, juvenile and adult) of the species listed in Table 3-2.

Table 3-2. Essential Fish Habitat Species Listed for the Rahway River

Common Name	Latin Name
Atlantic herring	*Clupea harengus*
Black sea bass	*Centropristis striata*
Bluefish	*Pomatomus saltatrix*
Butterfish	*Peprilus triacanthus*
Clearnose skate	*Raja eglanteria*
Cobia	*Rachycentron canadum*
Little skate	*Leucoraja erinacea*
Red hake	*Urophycis chuss*
Windowpane	*Scophthalmus aquosus*
Winter flounder	*Pseudopleuronectes americanus*
Winter skate	*Leucoraja ocellata*

3.5.3 Benthic Resources

NJDEP DFW also includes macroinvertebrate studies in their biomonitoring program. A macroinvertebrate station, referred to as Ambient Biomonitoring Network (AMNET) station (ANO195), is located in the same area as the fish survey station (see Figure 2, Appendix A.1). Macroinvertebrates NJDEP BFBM collected at the AMNET station in their most recent survey conducted in 2011 include freshwater oligochaete worms (*Nais*), non-biting midges (*Cryptochironomous*, *Cricotopus*, *Polypedilum*, *Rheotanytarsus*, *Tanytarsus*), freshwater crustaceans (*Gammarus*, *Caecidotea*), water beetles (*Stenelmis*), caddisfly (*Hyrdroptila*), freshwater worm (*Prostoma*), and mayfly (*Slavina*). The dominant species collected (*Nais, Cricotopus,* and *Polypedilium*) have a moderate to high tolerance to pollution (Miller, 2012).

USACE conducted macroinvertebrate surveys near the wetland mitigation site in Joseph Medwick Memorial Park in the fall of 2003 and fall of 2004. Species caught included ribbed mussel (*Guekensia demissa*), salt marsh snail (*Melampus bidentatus*), and mud dog whelks (*Ilynassa* sp.). Fiddler crab burrows were also observed (USACE, December 2004).

USACE also conducted benthic surveys of the Rahway River in the project area in the spring and fall of 2002. Grass shrimp (*Hippolytes* spp.) were the dominant shellfish species, followed by blue crab (*Callinectes sapidus*). In addition, fiddler crab burrows were observed on the marsh (USACE, March 2004).

3.5.4 Birds

The project area lies within the Atlantic Flyway, which is a migration route for over 400 bird species. USACE conducted spring and fall avian surveys in the project area in 2001 as part of an ecosystem restoration study. The surveys identified a total of 71 different bird species. The most abundant species encountered during the surveys were habitat generalists that are tolerant of the

disturbance and fragmented habitats found in developed urban environments. A table of the species observed is included in Appendix A.1.

Bird surveys conducted from December 2012 through November 2013 by the National Audubon Society at the Hawk Rise Sanctuary located on the left bank of the Rahway River in Linden identified a total of 120 bird species utilizing the sanctuary (Munafo and Allen, 2013).

Surveys conducted by NJDEP DFW identified two bald eagle nests located within two miles of the project area (Smith and Clark, 2018).

The open water and intertidal areas in the lower portion of the Rahway River provide feeding, resting, and brood-rearing habitat for a number of waterfowl, gulls, and wading birds. The most common species observed in these habitats include Canada goose (*Branta canadensis*), snowy egret (*Egretta thula*), double crested cormorant (*Phalacrocorax auritus*), great egret (*Casmerodius albus*), greater black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), killdeer (*Charadrius vociferous*), mallard duck (*Anas platyrhynchos*), and ring-billed gull (*Larus delawarensis*) (USACE, 2004).

Additionally, the forest scrub-shrub, herbaceous/scrub-shrub, and grass areas provide habitat for a wide range of resident and migratory passerines. Examples of the most commonly observed avian species utilizing these habitat types include generalists adapted for urban environments such as American robin (*Turdus migratorius*), Canada goose(*Branta canadensis*), common grackle (*Quiscalus quiscula*), European starling (*Sturnus vulgaris*), gray catbird (*Dumetella carolinensis*), house sparrow (*Passer domesticus*), mourning dove (*Zenaida macroura*), and rock dove (*Columbia livia*). Species commonly found in Phragmites-dominated portions of the project area include marsh wren (*Cistothorus palustris*), red-winged blackbird (*Agelaius phoeniceus*), and song sparrow (*Melospiza melodia*).

The Rahway River from Lenape Park in Cranford, upstream of the project area boundary, to the Arthur Kill is part of the Arthur Kill Complex and Tributaries Important Bird Area (IBA) as designated by the National Audubon Society. IBAs are sites that support habitat necessary for breeding, overwintering or migration and the goal of the IBA Program is “to stop habitat loss by setting science-based priorities for habitat conservation and promoting positive action to safeguard vital bird habitats.” The National Audubon Society considers the Arthur Kill Complex and Tributaries IBA important due to the extensive habitat located in a densely urbanized region (National Audubon Society, 2017).

3.5.5 Mammals

Site specific surveys to document mammal species have not been conducted. However, given the level of urbanization within the majority of the project area, species expected to occur within the project area are those adapted to urban environments. Such species include raccoon (*Procyn lotor*), chipmunk (*Tamias striatus*), red fox (*Vulpes vulpes*), woodchuck (*Marmota monax*), muskrat (*Ondatra zibethicus*), eastern gray squirrel (*Sciurus carolinenensis*), and opossum (*Didelphis virginiana*).

White tailed deer (*Odocoileus virginianus*) are known to occur within the Hawk Rise Sanctuary along the left back of the Rahway River in Linden, as evidenced by the ongoing deer management program operated by Union County within the sanctuary (Rubino, 2017). Deer have also been observed in Joseph Medwick Park during site investigations.

3.5.6 Reptiles and Amphibians

Site specific surveys were not conducted to identify reptile and amphibian species. However, species that could be expected to occur in the project area include bullfrog (*Rana catesbeiana*), Fowler's toad (*Bufo woodhousii fowleri*), eastern box turtle (*Terrapene carolina*), snapping turtle (*Chelydra serpentina*), eastern garter snake (*Thamnophis sirtalis sirtalis*), northern water snake (*Nerodia sipedon*), eastern painted turtle (*Chrysemys picta*), and eastern redback salamander (*Plethodon cinereus*).

3.6 Threatened and Endangered Species

Section 7 of the ESA requires federal agencies to ensure that any action they authorize, fund or carry out do not jeopardize the continued existence of federally-listed endangered and threatened species or result in the destruction or adverse modification of designated critical habitat of the federally-listed species. The USFWS and NOAA-NMFS maintain jurisdiction over federally-listed species.

State-listed endangered, threatened and special concern species are protected under the New Jersey Endangered Species Conservation Act of 1973.

3.6.1 Federal Endangered, Threatened and Special Concern Species

USFWS Trust Species

The District originally obtained an official list of endangered and threatened species that may occur within the project area on March 5, 2017 as part of preparation of the draft report. Included in the list was Indiana bat and northern long-eared bat. As the official lists are only valid for three months, an additional list was obtained on December 16, 2019. No changes to the species list has occurred. The list is located in Appendix A.3 of the report.

Information provided in the list was further supplemented by a review of the "New Jersey Municipalities with Hibernation or Maternity Occurrence of Indiana bat or Northern Long-eared bat" list (USFWS, June 2017). Based on this list, several municipalities located in Union County have known Indiana bat and/or northern long-eared bat maternity colonies. These municipalities include the Townships of Millburn, Berkeley Heights, New Providence and Scotch Plains, the Borough of Mountainside Borough and City of Summit.

There are no known hibernaculums for either species in Union County. There are no known occurrences of maternity colonies or hibernaculums for either species in Middlesex County (USFWS, June 2017).

Brief descriptions of the species' habitat preferences are below. Based on habitat requirements, the upper portion of the project area has a greater potential to support bat species than the lower portion of the project area.

Indiana bat

Indiana bats spend the winter hibernating in caves and mines; with hibernation beginning in late October and emergence occurring typically in April. The Hibernia Mine located in Hibernia, NJ is a known Indiana bat hibernaculum and is located approximately 21 miles from the project area.

During the summer months, numerous female bats roost together in maternity colonies under the loose bark of dead or dying trees within riparian, flood plain and upland forests. Maternity colonies use multiple roosts in both living and dead trees. Adult males usually roost in trees near maternity roosts, but some males remain near hibernaculum.

Tree species commonly used as roost sites include American elm (*Ulmus Americana*), slippery elm (*Ulmus rubra*), shagbark hickory (*Carya ovata*) silver maple (*Acer saccharinum*), and green ash (*Fraxinus pennsylanica*). Adult males usually roost in trees near maternity roosts, but some remain near the hibernaculum.

Preferred foraging areas are streams, associated flood plain forests, and impounded bodies of water such as ponds and reservoirs. However, they have been observed in upland forests, pastures and clearings with early successional vegetation, cropland borders, and wooded fencerows (USFWS 2007).

Northern Long-Eared Bat

Similar to the Indiana bat, northern long-eared bats hibernate in caves and abandoned mines, with hibernation generally beginning in October/November and emergence typically occurring in April. Northern long-eared bats roost singly or in colonies underneath bark, in cavities or in crevices of both live and dead trees. Unlike Indiana bats, northern long-eared bats have also been observed in manmade structures such as buildings, barns, sheds, cabins, under eaves of buildings and bat houses. Preferred foraging areas are in forested habitats. (USFWS, 2015)

Other Species

The U.S. Fish and Wildlife Service noted in their 2018 Fish and Wildlife Coordination Act Report (2018 FWCAR)(Appendix A.3) that the agency published a proposed rule in the Federal Register on October 9, 2018 listing the eastern black rail (*Laterallus jamaicencis jamaicensis)* as a threatened species. The final rule was anticipated to be published December 2019, but remains pending (USFWS, 2019a). Current primary Eastern black rail spring and summer range includes salt/brackish marshes with dense vegetation along coastal areas of southern New Jersey, Maryland, Delaware and Virginia although the potential range extends into New Hampshire (USFWS, 2019b).

At the time the 2018 FWCAR was prepared, the USFWS was conducting a species status review in support of a 12 month petition finding for the yellow banded bumblebee (*Bombus terricola*).

The USFWS published a finding in the Federal Register on August 15, 2019 that listing this species as endangered or threatened is not warranted (USFWS, 2019a).

In addition, the USFWS is currently evaluating the little brown bat (*Myotis lucifugus*), and the tricolored bat (*Perimyotis subflavus*) to determine if listing under the Endangered Species Act (ESA) is warranted (USFWS, 2017).

The USFWS also noted in their 2018 FWCAR the presence of three bald eagle nests within a 2 mile radius of the project area. The report did not identify the specific locations of the nests and cited via coordination with the NJ Division of Fish and Wildlife (NJDEP DFW) that one of the nests may have been abandoned. Studies conducted by the New Jersey Department of Environmental Protection Division of Fish and Wildlife (NJDEP DFW) in 2018 identified two active American bald eagle nests; one in Linden and one in Kearny, approximately two miles from the project area (Smith and Clark, 2018). Although the bald eagle was removed from the Federal List of Endangered and Threatened Wildlife in 2007, it remains protected through the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.

NOAA-NMFS Trust Species

A list of endangered species under the jurisdiction of the NOAA-NMFS Greater Atlantic Regional Fisheries Office is included in Appendix A.1. USACE consulted the Estimated Range Maps of each listed species on the Greater Atlantic Regional Fisheries Office website to determine the potential occurrence of listed species within the project area. Based on a review of the Estimated Range Maps, the project area is within "Accessible Waterways" for both shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) (NOAA-NMFS, May 2017a; NOAA-NMFS, May 2017b). The Estimated Range Maps for the shortnose and Atlantic sturgeon are located in Appendix A.1.

Brief descriptions of the species' habitat preferences are below:

Shortnose Sturgeon

Shortnose sturgeon is an anadromous species that inhabit rivers and estuaries. They spawn in the coastal rivers along the east coast of North America from the St. John River in Canada to the St. Johns River in Florida. They prefer the nearshore marine, estuarine, and riverine habitat of large river systems and do not appear to make long distance offshore migrations. Shortnose sturgeon's preferred food sources include crustaceans, mollusks, and insects (NOAA-NMFS, 2017d).

Atlantic Sturgeon

Atlantic sturgeon are an anadromous species that spawn in freshwater in the spring and early summer and migrate into estuarine and marine waters where they spend most of their lives. They spawn in moderately flowing water (46-76 cm/s) in deep parts of large rivers. Sturgeon eggs are highly adhesive and are deposited on bottom substrate, usually on hard surfaces (e.g., cobble). Once larvae begin migrating downstream they use benthic structures (especially gravel matrices) as refuges. Juveniles usually reside in estuarine waters for months to years.

Subadults and adults live in coastal waters and estuaries when not spawning, generally in shallow (10-50 m depth) nearshore areas dominated by gravel and sand substrates. Long distance migrations away from spawning rivers are common. Preferred food sources are worms, mollusks and crustaceans (NOAA-NMFS, 2017e).

3.6.2 State Endangered, Threatened and Special Concern Species

A review of NJ Geoweb indicated that the large wetland complex located on the left bank of the Rahway River near and at the Hawk Rise Sanctuary has documented foraging activity by state special concern species such as little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), and glossy ibis (*Plegadis falcinellus*), and state threatened species including black-crowned night heron (*Nycticorax nycticorax*), cattle egret (*Bubulcus ibis*), and yellow-crowned night heron (*Nyctanassa violacea*). A breeding sighting of the state endangered northern harrier (*Circus cyaneus*) occurred within this wetland complex.

The wetland complex located within Joseph Medwick Park has documented foraging activity by cattle egret (*Bubulcus ibis*), snowy egret (*Egretta thula*), black-crowned night heron (*Nycticorax nycticorax*), little blue heron (*Egretta caerulea*), and glossy ibis (*Plegadis falcinellus*).

State endangered, threatened or special concern species observed during surveys conducted at the Hawk Rise Sanctuary from 2010 through 2013 are listed in tables 3-3 through 3-5 (Munafo and Allen, 2013).

Table 3-3. State Endangered Bird Species Observed at Hawk Rise Sanctuary

Common Name	Latin Name
Grasshopper sparrow	*Ammodramus savannarum*
American bald eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Savannah sparrow	*Passerculus sandwichensis*
Black skimmer	*Rynchops niger*

Table 3-4. State Threatened Bird Species Observed at Hawk Rise Sanctuary

Common Name	Latin Name
Northern harrier	*Circus cyaneus*
Bobolink	*Dolichonyx oryzivorus*
Peregrine falcon	*Falco peregrinus*
American kestrel	*Falco sparverius*

Table 3-5. State Special Concern Bird Species Observed at Hawk Rise Sanctuary

Common Name	Latin Name
Cooper's hawk	*Accipiter cooperii*
Sharp-shinned hawk	*Accipiter striatus*
Spotted sandpiper	*Actitis macularius*
Great blue heron	*Ardea Herodias*
Semipalmated sandpiper	*Calidris pusilla*
Canada warbler	*Cardellina Canadensis*
Veery	*Catharus fuscescens*
Snowy egret	*Egretta thula*
Least flycatcher	*Empidonax minimus*
Wood-thrush	*Hylocichla mustelina*
Yellow-breasted chat	*Icteria virens*
Nashville warbler	*Oreothylpis ruficapilla*
Black-throated blue warbler	*Setophaga caerulescens*
Black-throated green warbler	*Setophaga virens*
Eastern meadowlark	*Sturnella magna*
Brown thrasher	*Toxostoma rufum*
Winter wren	*Troglodytes hiemalis*

As Section 3.5.4 mentioned, there are two bald eagle nests within two miles of the project area, based on NJDEP DFW surveys.

3.7 Socioeconomics

3.7.1 Demographics and Economy

Rahway

The 2010 U.S. Census listed the City of Rahway's population as 27,346, reflecting an increase of 846 (+3.2%) from the 26,500 counted in the 2000 U.S. Census. The U.S. Census 2009-2013 American Community Survey 5-Year Estimates lists 10.9% of the city as below the poverty line.

Linden

The 2010 U.S. Census listed the City of Linden's population as 40,499, reflecting an increase of 1,105 (+2.8%) from the 39,394 counted in the 2000 U.S. Census. The U.S. Census 2011-2015 American Community Survey 5-Year Estimates lists 9.4% of the city as below the poverty line.

Approximately 13% of Linden's population are seniors (65 years and older); a third of those seniors live alone. Approximately 9.1% of seniors in Linden are below the poverty level. Almost a quarter of Linden's senior residents do not have access to a vehicle. Just under 8% of the population under 65 years are classified as disabled.

Carteret

The 2010 U.S. Census listed the Borough of Carteret's population as 22,844, reflecting an increase of 2,135 (+10.3%) from the 20,709 counted in the 2000 U.S. Census. The U.S. Census 2011-2015 American Community Survey 5-Year Estimates lists 15.1% of the borough as below the poverty line.

Eleven percent of the population is 65 year and older. More than a quarter of these seniors live alone and have an annual income of $20,000. Approximately 83% of the seniors own their own home. Overall, 19% of the senior households in Carteret do not have access to a vehicle. 11.4% of seniors live below the poverty line. Approximately 5.6% of the population under 65 years is classified as disabled.

Woodbridge

The 2010 U.S. Census listed the Township of Woodbridge's population as 99,585, reflecting an increase of 2,382 (+2.5%) from the 97,203 counted in the 2000 U.S. Census. The U.S. Census 2011-2015 American Community Survey 5-Year Estimates lists 6.3% of the township as below the poverty line.

Twelve percent of the population of Woodbridge are seniors. A third of those seniors live alone and a quarter of seniors have an annual income of less than $20,000. Twenty-six percent of seniors rent their home. Thirteen percent of Woodbridge senior households do not have access to a vehicle. 6.2% of seniors live below the poverty line. Approximately 5.8% of the population under 65 years is classified as disabled.

Union and Middlesex County

The 2010 U.S. Census listed the County of Union's population as 536,499, reflecting an increase of 13,958 (+2.7%) from the 522,541 counted in the 2000 U.S. Census. The U.S. Census 2011-2015 American Community Survey 5-Year Estimates lists 10.9% of the county as below the poverty line.

The 2010 U.S. Census listed the County of Middlesex's population as 809,858, reflecting an increase of 56,696 (+8.0%) from the 750,162 counted in the 2000 U.S. Census. The U.S. Census 2009-2013 American Community Survey 5-Year Estimates lists 8.8% of the county as below the poverty line.

It is apparent from the above statistics that populations in the cities of Rahway and Linden, the Township of Woodbridge and Union County have increased at a slow, steady rate or remained relatively constant between 2000 and 2010. Population has increased at a greater rate in the Borough of Carteret and Middlesex County. The Borough of Carteret has the greatest poverty rate while the Township of Woodbridge the least.

Economy

The majority of land in the project area contains residential, commercial and industrial development. The local commercial and industrial facilities in the area represent an important

regional commercial resource.

The City of Rahway has seen the rise of service-dependent jobs within its borders and growth in finance, pharmaceuticals and telecommunications throughout the region as Rahway residents traveled throughout New Jersey and New York for employment.

The east side of Linden is located along the Arthur Kill. The Arthur Kill plays an important role in bulk cargo transportation in the Port of New York and New Jersey. Along with Elizabeth, Linden is home to the Bayway Refinery, a refining facility that helps supply petroleum based products to the New York and New Jersey area, producing approximately 230,000 barrels per day. Linden, together with Rahway, is also home to Merck & Company, one of the world's leading pharmaceutical companies.

The Township of Woodbridge is home to a large shopping mall.

3.7.2 Environmental Justice

The U.S. Environmental Protection Agency (USEPA) defines environmental justice as the "fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development implementation and enforcement of environmental laws, regulations and policies. Fair treatment means no group of peoples should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies."

Executive Order 12898, Federal Actions to address Environmental Justice in Minority and Low Income Populations, mandates that each federal agency identify and address potential disproportionately high and adverse effects of its activities, programs, and policies on minority populations and low income populations. Specifically, adverse effects that pertain to human health and the environment must be identified and addressed. According to Executive Order 12898, minority populations exist where the percentage of minorities exceeds 50% or where the minority population percentage in the affected area is meaningfully greater than in the general population. Executive Order 12898 does not provide criteria to determine if an affected area consists of a low-income population.

A cursory analysis was conducted to identify any environmental justice concerns relevant to plan formulation. For each municipality, the percentages of the population that are low income and/or minority was compared to the percentages for the county in which that municipality is located. Environmental justice could be a concern in municipalities where there are higher percentages of low income and/or minority residents than there are in the county as a whole.

The combined minority population of Middlesex County is 52.8%. The percentage of individuals living below the poverty line is 8.8% and the percentage of families living below the poverty line is 6.4%.

Carteret Borough has a combined minority population of 65.8%, which is higher than for Middlesex County. In addition, the percentage of individuals and families living below the

poverty level, 15.1% and 11.1%, respectively, are higher than for Middlesex County. Disproportionately high and adverse effects of proposed alternatives on the population of Carteret, particularly pertaining to human health and the environment, could be an environmental justice concern.

Woodbridge Township has a combined minority population of 52.6%, lower than Middlesex County. The percentage of individuals and families living below the poverty level, 6.3% and 5.3%, respectively, also lower than Middlesex County.

Union County has a combined minority population of 55.7%. The percentage of individuals living below the poverty level is 10.9% and the percentage of families living below the poverty level is 8.6%.

The City of Linden has a combined minority population of 60.8%, which is higher than for Union County. The percentage of individuals and families living below the poverty level, 9.4% and 7.4%, respectively, are lower than for Union County.

The City of Rahway has a combined minority population of 62.7%, which is higher than for Union County and higher than the City of Linden. The percentage of individuals and families living below the poverty level, 8.5% and 6.8%, respectively, are lower than for Union County.

Based on the cursory analysis, the cities of Rahway and Linden meet environmental justice criteria.

3.8 Hazardous, Toxic and Radioactive Waste (HTRW)

Federal and state environmental databases were reviewed to prepare an inventory of known locations with contaminated soils and impacts to groundwater. The inventory covers the 1% AEP (100-year) floodplain of the lower Rahway River, from its confluence with the Arthur Kill upstream to the limits of tidal influence within the City of Rahway.

Databases that were reviewed included:

- USEPA National Priority List (NPL)
- NJDEP Known Contaminated Sites (KCS) List
- USEPA Resource, Conservation, Recovery Information System (RCRIS)
- USEPA Superfund Enterprise Management System (SEMS)

There is one USEPA Superfund site, LCP Chemicals, in the study area, in Linden near the Arthur Kill (Figure 3-3). This site is not in or near the proposed line of construction. There are no other Superfund sites within the study area.

The NJDEP KCS lists active sites where contamination has been confirmed, as well as pending sites where remedial actions have not yet been undertaken. For the portions of Rahway, Linden and Carteret that are in the study area, a review of the NJDEP KCS list identified: 1) 41 active sites and seven pending sites for Rahway; 2) 26 active and four pending sites for Linden; and 3)

18 active and one pending sites for Carteret (Figure 3-3). These sites consist of gas stations, dry cleaners, mechanic shops and light manufacturing. Sites along the Arthur Kill are associated with large-scale industrial chemical and fuel oil storage activities.

When conducting wetland mitigation at Joseph Medwick Memorial Park, USACE encountered debris consisting of drums of pesticides. The soil around the debris was found to be contaminated with pesticides and heavy metals, specifically lead and arsenic. Middlesex County remediated and cleaned up the contamination prior to constructing new football, soccer, and multi-purpose fields, as well as two baseball fields, in the park. The remediation strategy excavated contaminated material, capped the contamination with pervious and impervious surfaces, installed fencing, and posted signs to prevent public access to contaminated areas. The pervious cap material in place consists of 10 inches of compacted clean fill and four inches of topsoil. Within Joseph Medwick Park, there is HTRW within the footprint of the recommended plan that USACE was alerted to via comments on the draft FR/EA from Middlesex County. As a result of coordination between USACE, NJDEP, and Middlesex County, Middlesex County committed to remediating the HTRW prior to project construction, so that USACE will have a clean project site for construction, pending Congressional authorization.

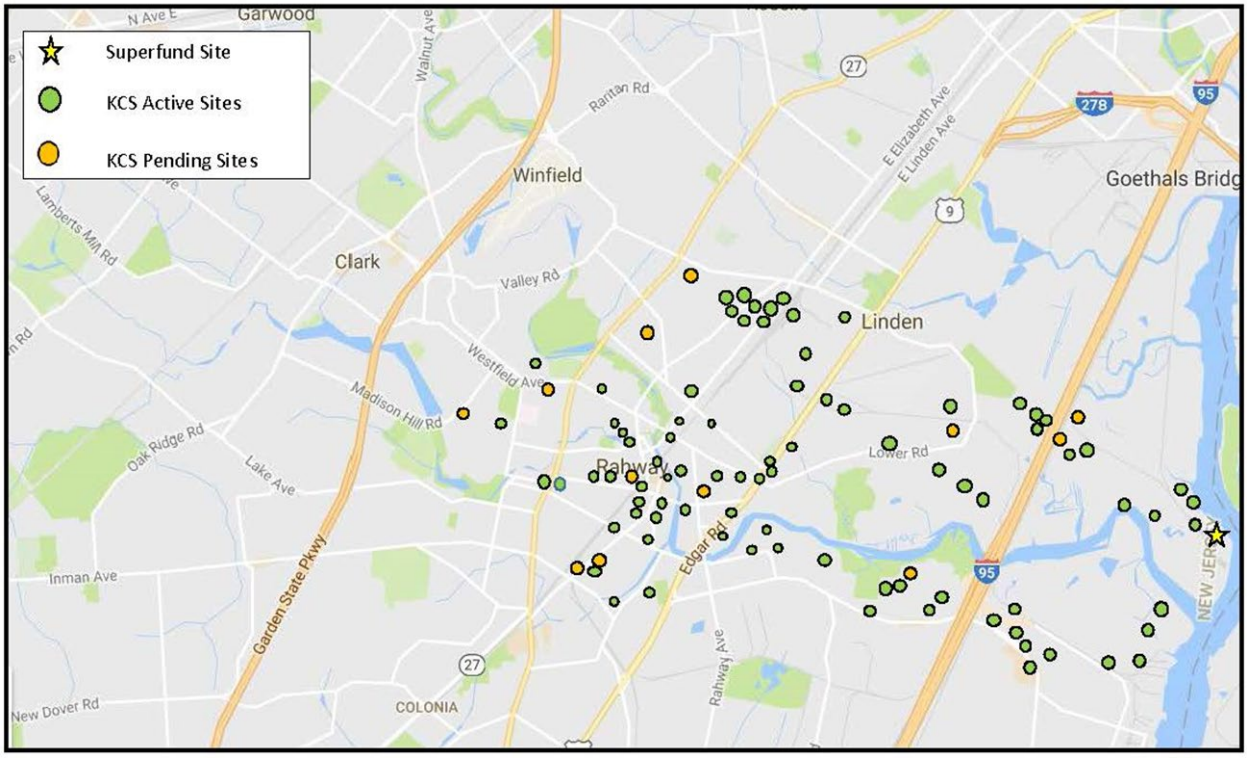


Figure 3-3. Superfund and Known Contaminated Sites in the Study Area

3.9 Cultural Resources

As an agency of the federal government, USACE has certain responsibilities concerning the protection and preservation of historic properties. Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulations, the Advisory Council on Historic Preservation's Procedures for the Protection of Historic and Cultural Properties (36 CFR 800), and Executive Order 11593 direct federal agencies to take into account the effect of any undertaking on historic properties included on, or eligible for, the National Register of Historic Places (NRHP). NEPA requires that federal agencies consider whether an action will have significant environmental effects including effects to historic and cultural resources. In particular, under NEPA, environmental review includes a description of the human environment and the environmental consequences of the proposed action on that environment, which includes aesthetic, historic, and cultural resources. The American Indian Religious Freedom Act (1978), the Presidential Memorandum "Government to Government Relations with Native American Tribal Government (1994), the Native American Graves Protection and Repatriation Act (1990), and Executive Order 13175 "Consultation and Coordination with Tribal Governments" (2000) direct federal agencies to consult and to consider the effects of any proposed undertaking on the tribes.

In accordance with these guiding regulations, USACE carried out a preliminary cultural resources investigation of the project area to identify previously documented historic properties and archaeological sites and initiated coordination with the NJSHPO, the Federally Recognized Tribes, and local interested parties (Scarpa, 2017). USACE held a public information meeting in May of 2015 in order to inform regulatory agencies and the public of the feasibility study and to solicit feedback. The Project Archaeologist also met with members of the Merchant and Drovers Museum of Rahway, NJ in November of 2016 to discuss the project alternatives. A draft of this Preliminary Case Report was also made available to the public and coordinated with interested parties as part of the draft FR/EA in May 2017.

The current investigation included a review of previously completed survey reports and historic properties on file at the NJSHPO, historic maps and local histories located at the Rahway, Linden and Woodbridge libraries, and archaeological site files held at the New Jersey State Museum. Cultural resources investigation reports were reviewed to collect background information for the project area and were referenced when identifying historic properties, determining archaeological sensitivity for the project area and identifying areas that have not been surveyed in the past. Histories of the Middlesex and Union counties and of the municipalities were reviewed as well to provide historical context during the alternative development and impacts assessment phases of the study. Field reconnaissance consisted of a series of site visits through the project area to become familiar with the area, to determine the current status of certain historic properties, and to determine the need for architectural and archaeological sensitivity assessments in the next phase of the project when the plan is further developed. A detailed discussion of the prehistory and history of the project area can be found in the Case Report in Appendix A4.

Seven archaeological sites in the project area have been documented (Table 3-6). Three contained pre-contact materials and all seven contained a historic component as well.

Table 3-6. Archaeological Sites in the Study Area

Site #	Site Name	Muni.	Period	Source
28-UN-13	Edgar Farm Site	Rahway	19th Cent. and Pre-contact	NJDOT, 1984
28-UN-38	River View Manor, historically known as the Dolbier-Housman House	Rahway	1800s	Maser Consulting, 2006
28-UN-51	King's Creek	Linden	Pre-contact and Post-contact	PAL, Inc., 2011
28-UN-53	Tremley Site	Linden	Middle to Late Woodland and early-mid twentieth century	PAL, Inc. 2011
28-UN-40	Rahway City Hall-Municipal Building Historic Site	Rahway	1800-20th Century	CRCG, 2007
28-UN-41	Historic House Site Lot 3	Rahway	1800-20th Century	CRCG, 2007
28-UN-42	The Peace Tavern-Woodruff Historic House Site	Rahway	1800-20th Century	CRCG, 2007

Nine historic districts in the study area have been documented: 1) the Upper Rahway Historic District; 2) the Rahway River Parkway Historic District; 3) the Union County Park System Historic District; 4) the Lower Rahway/Main St Historic District; 5) the Regina Historic District; 6) the Pennsylvania Railroad New York to Philadelphia Historic District; 7) the Perth Amboy and Elizabethport Branch of the Central Railroad of New Jersey Historic District; 8) the Sound Shore Railroad Historic District; and 9) the Inches Line Linear Multistate Historic District (Figure 3-4).

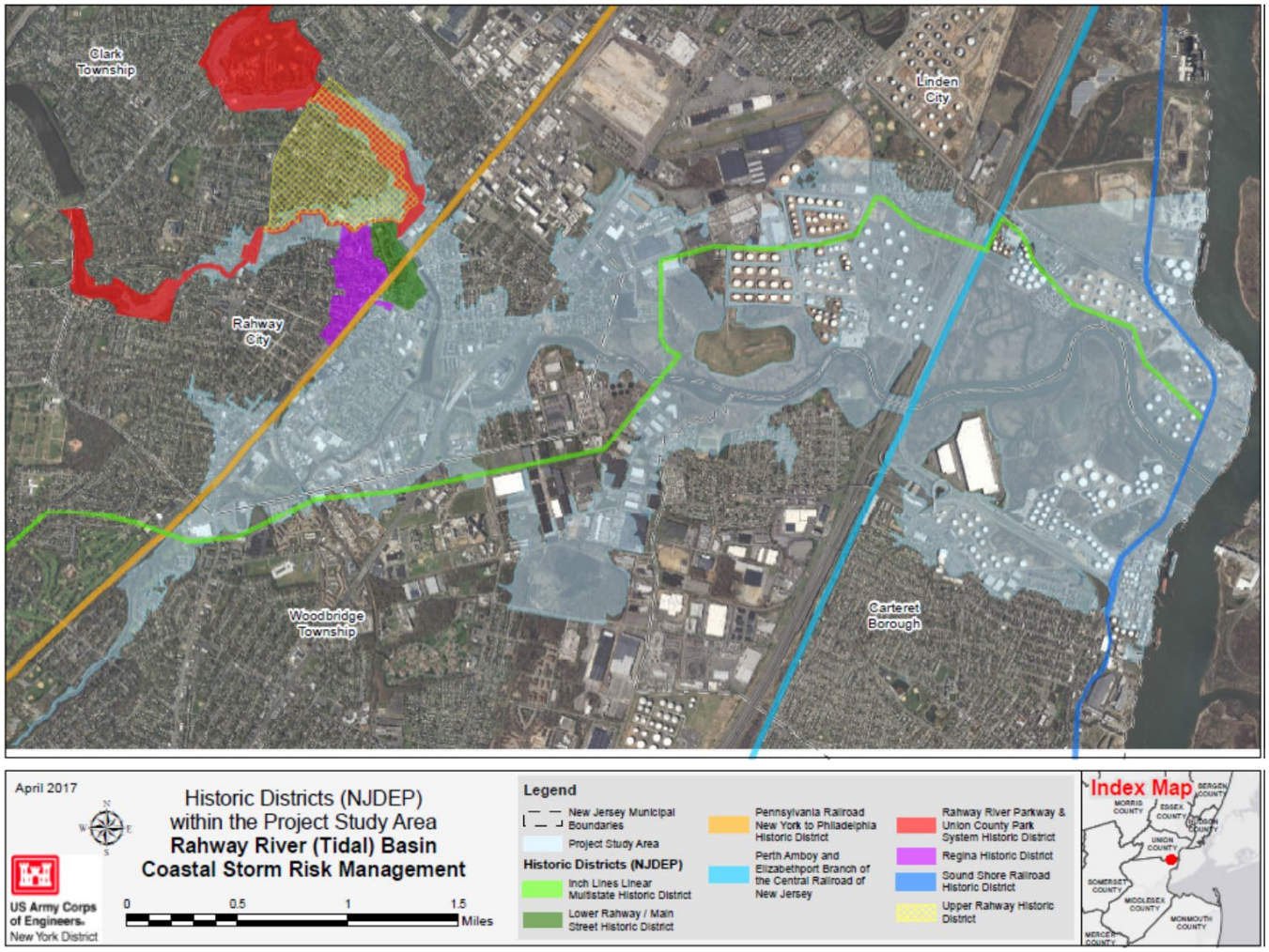


Figure 3-4. Historic Districts in the Study Area

3.10 Recreation

Specific areas supportive of active and/or passive recreational activities in the project area include the Rahway Recreation Center, the Lower Essex Street park, Waterfront Park, Joseph Medwick Park, and Hawk Rise Sanctuary.

The Rahway Recreation Center is an indoor facility on the right bank of the Rahway River that provides space for concerts, arts and crafts and indoor sporting events such as volleyball. The Lower Essex Street park is located across the river from the Rahway Recreation Center, on the river's left bank. This park contains a paved walkway, exercise stations, benches, and a pagoda with four benches. On the left bank, in between Essex St and before Route 1, is the Waterfront Park.

Joseph Medwick Park is on the right bank of the Rahway River, in Carteret, where Caseys Creek flows into the river. This approximately 80-ac park contains picnic areas, playgrounds, tennis courts, walking trails, athletic fields, a little league field, and two wildlife observation decks

overlooking tidal wetlands.

The Hawk Rise Sanctuary is located across the river from Joseph Medwick Park, in Linden, where King's Creek flows into the Rahway River. The Sanctuary is a 95-ac ecological preserve and wetland complex that New Jersey Audubon maintains. The Sanctuary contains trails with interpretive signage, overlook decks and pedestrian bridges. The Sanctuary was developed at the site of a former landfill.

Within the project area, the Rahway River itself offers limited water-based recreational opportunities due to a lack of public access points. The Rahway Yacht Club owns a small marina on the left bank of the Rahway River approximately half a mile downstream of the Route 9 bridge.

3.10.1 Green Acres Program

NJDEP administers the Green Acres Program, which was created in 1961 to provide funding for the state and local municipalities to acquire and maintain lands for recreation purposes. A review of the Green Acres Program Open Space Database indicates that the Lower Essex Street park, Hawk Rise Sanctuary, and Joseph Medwick Park were acquired with Green Acres Program funds (Figure 3-5).

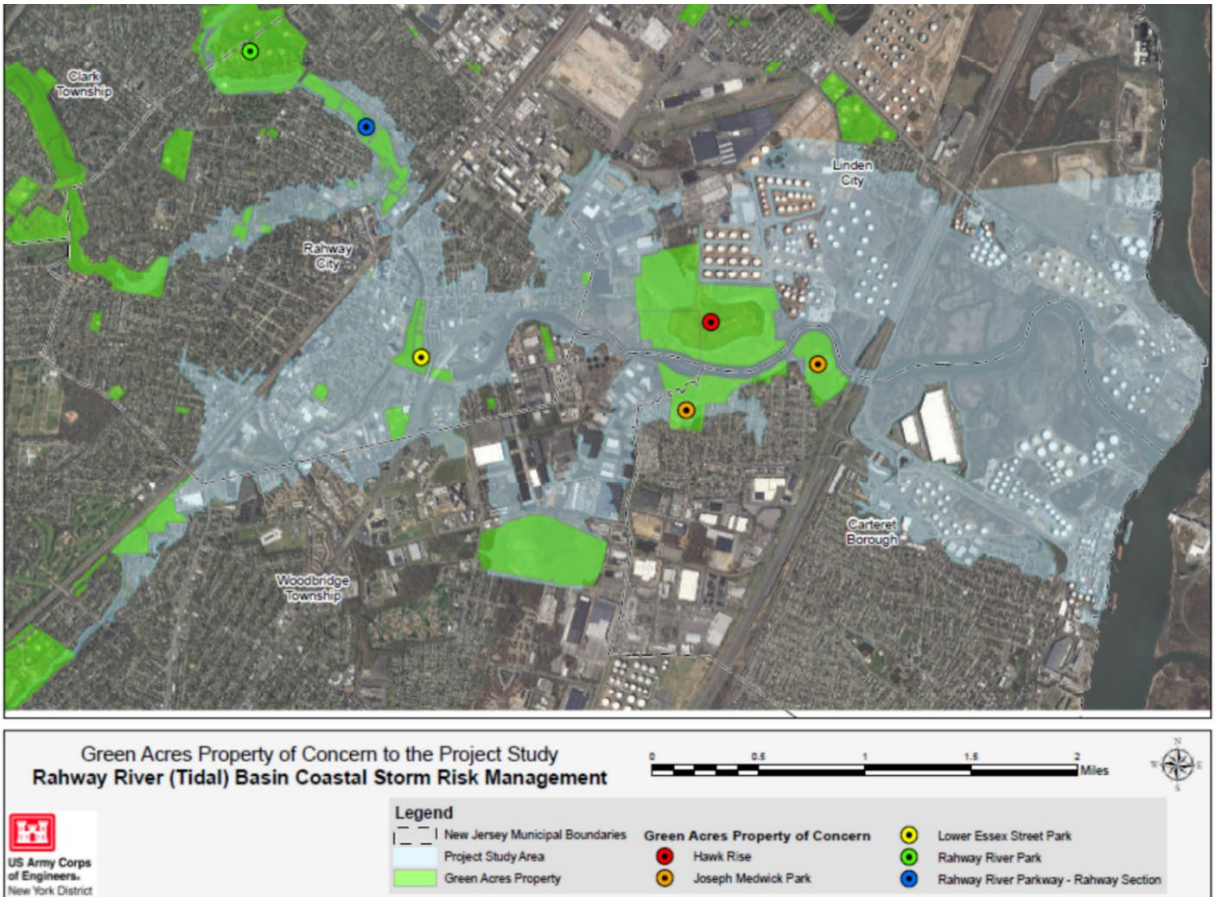


Figure 3-5. Green Acres Encumbered Lands in the Project Area

3.11 Aesthetics and Scenic Resources

The aesthetic quality of the upper portion of the project area is influenced by heavy residential and business development. Much of the land along the river shorelines or wetland margins is developed with single-family residential dwellings and local business/industries. The visual setting of the project area is characterized by moderate to high-density development along the river and on the margins of the wetlands. The lower portion of the project area is characterized by tidal wetlands and industrial development. The left bank of the Rahway River south of the Route 9 bridge offers the greatest visual appeal in that the view is comprised of approximately 2.5 miles of contiguous tidal marsh complexes. A portion of this viewshed is accessible from Joseph Medwick Park, which is located on the right bank of the Rahway River.

There are no scenic byways, National Wildlife Refuges, National Parks, National Forests, National Natural Landmarks or National Heritage sites within one mile of the project area. Neither the Rahway River nor any of its tributaries within the study area are listed as wild, scenic or recreation rivers.

3.12 Coastal Zone Management

Congress enacted the Coastal Zone Management Act (CZMA) of 1972 (16 U.S. Code 1451-1464) to balance the demands for growth and development with competing demands to protect coastal resources. The act requires that federal activities affecting land or water resources located in the coastal zone be consistent to the maximum extent practicable with the federally approved state coastal zone management plans. The NJDEP Division of Land Use Regulation regulates compliance with the act in New Jersey. Local governments can participate in Coastal Zone Management compliance through the development of Municipal Public Access Plans (MPAPs). Municipalities in the project area that have prepared MPAPs include the Borough of Carteret and City of Linden.

New Jersey's coastal zone management program primarily derives its authority from three state statutes: The Waterfront and Harbor Facilities Act of 1914 (NJSA 12:5-3), the Wetlands Act of 1970 (NJSA 13:9A), and the Coastal Area Facility Review Act (CAFRA) (NJSA 13:19).

The Rahway River is not located within the region of New Jersey subject to the CAFRA. However, the lower portion of the Rahway River is subject to the regulations set forth in the Waterfront and Harbor Facilities Act of 1914. USACE has prepared a feasibility-level Statement of Compliance for Coastal Zone Management, which is included in Appendix A.6.

3.13 Transportation

A network of modern highways makes the project area convenient to major population centers. The Garden State Parkway, Routes 1 and 9, and New Jersey Turnpike provide access to various northern and southern areas of the state as well as urbanized cities such as Newark, New Jersey, and New York, New York. The area is also served by the busy Northeast Corridor and North Jersey Coast rail lines, which link Rahway with Newark, Manhattan, Trenton and the Jersey Shore. Additionally, a significant part of the tidal portion of the Rahway River is navigable by small boat.

Flooding impairs transportation in to, out of, and across the project area. Routes 1 and 9, the rail lines, and the New Jersey Turnpike all cross the Rahway River, and may be inundated by storm surge. Storm surge may also render numerous local roads in the project area inaccessible.

3.14 Air Quality

The counties in the study area, Middlesex and Union, are in the New York, Northern New Jersey, Long Island, and Connecticut ozone nonattainment area. These counties have been designated with the following attainment status with respect to the National Ambient Air Quality Standards (NAAQS) for criteria pollutants: both are in a 'moderate' nonattainment area for the 2008 8-hour ozone standard; both are in a maintenance area for the 2006 particulate matter less than 2.5 microns ($PM_{2.5}$) standard; and Union County is a maintenance area for the 1971 carbon monoxide (CO) standard (40 CFR §81.331). These counties are part of a larger Ozone Transport Region. Oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) are precursors for ozone, while sulfur dioxide (SO_2) (commonly reported as sulfur oxides (SO_x)) is a precursor pollutant for $PM_{2.5}$. Union and Middlesex counties are in attainment of the NAAQS for all other criteria pollutants.

Emissions from federal actions, such as the plan for coastal storm risk management in the Rahway River Basin recommended in this FR/EA, are regulated under 40 CFR §93 Subpart B General Conformity, which aims to ensure that emissions from federal actions do not impede a state's progress toward achieving or maintaining compliance with NAAQS under their applicable State Implementation Plan (SIP). Potential emissions from the construction of a coastal storm risk management project are associated with non-road construction equipment working on the site and on-road trucks moving on public roads to and from the site. Emissions from these two source categories, primarily generated from their diesel engines, include NO_x, VOCs, SO_2, CO, and $PM_{2.5}$. Fugitive dust on the worksite could also be generated due to trucks and equipment moving on unpaved surfaces, but this dust can be significantly reduced through the use of best management practices relating to site work dust mitigation.

3.15 Noise

Noise is generally defined as unwanted sound. The day-night noise level (Ldn) is widely used to describe noise levels in any given community (USEPA, 1978). The unit of measurement for Ldn is the "A"-weighted decibel (Dba), which closely approximates the frequency responses of human hearing.

Primary noise sources in the project area are vehicular traffic on local roadways, local construction projects underway, and the operation of businesses. Although noise levels have not been measured in the project area, they can be approximated based on existing land uses. The project area is characterized as residential and business development. Therefore, existing noise levels in the project area are likely within the range of Ldns measured in similar residential areas: 39 to 59 Dba (USEPA,1978).

Chapter 4.0 Plan Formulation

A review of existing conditions in the study area informed the identification of coastal storm risk management problems and opportunities. Problems and opportunities were used to develop planning objectives and constraints. These guided the identification of management measures. Measures were screened, and alternatives combining the remaining measures were developed. Alternatives in the final array of alternatives were evaluated, and compared on the basis of their economic costs and benefits, and environmental and social effects. A tentatively selected plan (TSP) that maximizes net economic benefits while protecting the environment was selected. The TSP was revised based on review comments received on the draft FR/EA, and optimized to develop a recommended plan. This chapter describes the plan formulation process. The recommended plan is described in Chapter 5.

4.1 Problems and Opportunities

Frequent storms may cause storm surges that flood the lower Rahway River basin. Storm surge-induced flooding, like that experienced during hurricanes Sandy and Irene (Section 2.4; Figure 4-1), threatens lives, public safety, the economy, and the environment. Carteret, Linden, Rahway, and Woodbridge, in Union and Middlesex counties, are vulnerable to flood damages from coastal storms.

Figure 4-1. Flooding in Rahway during Hurricane Irene in 2011

Problem Statement

The primary problem encountered in the study area is flooding with elevated water levels associated with storm surge on the Rahway River and tributaries within the study area.

Opportunities

In areas of the lower Rahway River basin that are susceptible to storm surge, there are opportunities to:

- Reduce risks to life and public safety due to flooding from storm surge
- Decrease risk of damages to structures and roadways due to flooding from storm surge
- Improve public awareness of storm surge-induced flood risk

4.2 Planning Objectives

The federal objective for water and related land resources planning is to contribute to national economic development (NED) while protecting the nation's environment, in accordance with national environmental statutes, applicable executive orders, and other federal planning requirements.

Consistent with the federal objective, the planning objectives developed for this study are to:

- Reduce the risk of dangers to life safety and damages to property and resulting from storm surge flooding within the study area, lying within portions of the municipalities of Carteret, Linden, Rahway and Woodbridge
- Increase public awareness of the risk of flooding from the Rahway River

4.3 Planning Constraints

Universal constraints, which include resource, legal, and policy constraints, limit all federal water and related land resources planning. Of particular relevance to this study, in accordance with Executive Order 11988, Floodplain Management, and E.R. 1165-2-26, USACE must: "avoid or minimize impacts associated with the use of the base flood plain[9] unless there is no practicable alternative." USACE must also avoid or minimize damage to the environment and preserve important cultural resources.

Additional, study-specific constraints that limit coastal storm risk management planning in the study area include:

- **Navigation Channel:** The Arthur Kill contains a navigation channel for large ships that would preclude implementation of structural measures in the Arthur Kill itself.
- **Industrialized Shoreline:** The shoreline and area directly inland of the Arthur Kill are highly industrialized and no room exists for structural measures.
- **Green Acres:** Lower Essex Street Park in Rahway, Hawk Rise Sanctuary in Linden, and Joseph Medwick Park in Carteret were acquired with NJDEP Green Acres Program funds. To comply with Green Acres Program rules, plans should avoid to the extent

[9] The "base flood" is the 1% AEP (100-year) flood.

practicable, minimize, and mitigate for any adverse impacts to the use of these lands for recreation and conservation.

Other considerations that were identified to take account of during planning include:

- **Cultural Resources:** There are existing previously identified NRHP listed or eligible historic properties in the study area. Impacts to these resources must be taken into consideration when formulating alternatives, with the understanding that, following selection of an alternative, additional investigations must be carried out to determine the presence or absence of previously unidentified historic properties and archaeological sites within the project area.
- **HTRW:** The chemical facilities and petroleum refineries along the right and left banks of the Rahway River in Carteret and Linden in the vicinity of the Arthur Kill are active and have ongoing HTRW issues that would make implementation of a structural solution in their direct vicinity difficult.
- **Models:** USACE must use certified models to evaluate and compare alternatives, in coordination with the relevant USACE Planning Centers of Expertise (PCXs). Certified models used in this study included HEC-HMS, HEC-RAS, Hydrologic Engineering Center - Flood Damage Analysis (HEC-FDA), Institute for Water Resources Planning Suite, and Evaluation of Planned Wetlands.
- **Floodproofing Measures:** USACE develops flood damage reduction plans that reasonably maximize net benefits and considers floodproofing as a nonstructural measure (See Section 4.5). FEMA requirements state that "Flood proofing of areas below the Base Flood Elevation [BFE] in residential buildings is not permitted under the National Flood Insurance Program except in communities that have been granted an exception to permit flood proofed basements. Flood proofing is not permitted in Coastal High Hazard Areas (Zone V, VE, or V1-30)." FEMA guidelines do not apply to the USACE coastal storm risk management studies. USACE does not design to meet FEMA certification criteria, unless requested by the local non-federal sponsor. Floodproofing can be a component of the recommended plan. It is the responsibility of the local non-federal sponsors to comply with the National Flood Insurance Program regulations as a participant in the FEMA Flood Insurance program.

4.4 Future Without-Project Conditions

The period of analysis, or planning horizon, selected for the study was 50 years, from 2029 to 2079. Future without-project conditions were forecast over the planning horizon to identify measures and develop alternatives likely to remain complete, efficient, effective, and acceptable over the life of a potential project. The future without-project conditions are equivalent to the probable effects of the "No Action" alternative. The most likely scenario for the future without-project condition would be the continuation of existing environmental conditions and trends within the study area.

Period of Analysis

The 50-year period of analysis for the study is 2029 to 2079. The base year of 2029 accounts for the time required for the non-federal sponsor to address contaminated soil in the project footprint

and a construction schedule involving nonstructural mearues. A risk-informed decision was made to assume that the analysis that was completed for a period of analysis of 2023 to 2073 sufficiently approximates the analysis for a period of analysis of 2029 to 2079. This assumption is founded on the only time-dependent input to the location of the period of analysis for the purpose of the economics: water surface elevations. Conditional on the intermediate and high relative sea level scenarios, the water surface elevations for the various flood events are slightly higher, the farther into the future that the period of analysis takes place. However, it is expected that the water surface elevations that were calculated for 2023 to 2073 approximate the water surface elevations for 2029 to 2079 within an acceptable margin of error. This acceptable margin of error may result in some benefits being left on the table because slightly higher water levels and the coinciding reductions in flood risk are not being captured. The margin of error also means slightly higher residual risk than quantified for the reaches that do not have any proposed coastal storm risk management measures.

Subsection 4.4.1 is devoted to the hydrologic and hydraulic aspects of the future without-project conditions. Hydrologic and hydraulic modeling was used to predict the depth and extent of flooding in the study area over the planning horizon. Flood depths and extents were used to identify measures and develop alternatives, and provided data required for the evaluation of alternatives' economic benefits.

Subsection 4.4.2 is devoted to environmental aspects of the future without-project conditions. These were used to assess the environmental effects of action alternatives.

Subsection 4.4.3 is devoted to economic aspects of the future without-project conditions. Economic modeling was used to evaluate the economic benefits, or flood damages reduced, of action alternatives.

4.4.1 Future Without-Project Conditions: Hydrology and Hydraulics

Future without-project conditions hydrology and hydraulics includes sea level change (SLC), vertical land movement, and urbanization. Changes to trends in inland hydrology (potential non-stationarity) over time were also considered. There are expected to be increases in water surface elevations (WSEs) due to urbanization in the fluvial area of the study area, at the upstream boundary conditions, and due to SLC in the tidal area of study at the downstream boundary condition.

HEC-HMS and the HEC-RAS models were created and calibrated to model existing hydrologic and hydraulic conditions in the study area. The future conditions HEC-RAS model was created using future hypothetical peak discharges, changes in mean sea level (MSL) due to vertical land movement and SLC, and the calibrated existing conditions HEC-RAS model. Increases in flow and tide elevations will cause an increase in flooding for future without-project conditions in the tidal area. Increased flows due to urbanization will only have an impact in the tidal area up to the 20% AEP (5-year) event, with a negligible impact near the mouth of the Rahway River. Tidally influenced flooding does not go beyond the Milton Lake dam or the Rahway Water Supply dam for future without-project conditions due to the steep bed slope and topographic characteristics of the overbanks.

Sea Level Change

Engineering Regulation ER 1100-2-8162 provides guidance on incorporating the effect of projected SLC across the project life of USACE projects. Engineering Technical Letter (ETL) 1100-2-1 requires the use of at least three scenarios to estimate future sea levels. The USACE low rate of future SLC is based on the historic rate in the vicinity of the project area. Readings of the Bergen Point tide gage over a 33-year period show sea levels increasing at an average annual rate of 4.65 millimeters/year with a 95% confidence interval of +/- 0.92 mm/yr. This equates to 0.8 ft in the 50 year period of analysis of the study. The intermediate and high rates of future SLC are determined from the modified National Research Council (NRC -1987) eustatic sea-level change scenarios and the IPCC (2007) Types I and III, respectively. The hydraulics analysis incorporated the historic rate of SLC projected over the life of the project and curves Type I and Type III as part of the future conditions. The three scenarios were used in a joint probability analysis that determined the combined risk of flooding from storm surge and fluvial flooding.

Flow Line Computation

HEC-RAS was used to determine the present and future, with and without-project WSEs on the Rahway River, Robinson's Branch, and South Branch in the study area, for the 99%, 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% AEP (1, 2, 5, 10, 25, 50, 100, 200, and 500-year) storm events.

More details on the future without-project hydrologic and hydraulic conditions are provided in Appendix CI: Hydrology, and Appendix CII: Hydraulics.

4.4.2 Future Without-Project Conditions: Environment

For Environmental future without-project conditions, the sea level change analysis presented in 4.4.1 indicating a 0.8 ft increase within the period of analysis was used.

Land Use

In the short-term, land use, land cover and zoning in the project area are not expected to change. However, in the long-term, properties abutting the Rahway River and its tributaries, particularly in flood prone areas, are likely to sustain continued flood damage during storm events. Without proactively addressing coastal flood risk, costly damages will continue to accrue, and some businesses and residences may eventually be abandoned, property values may decrease, or development may be prohibited, all of which could lead to changes in land use, land cover and zoning.

Topography, Geology and Soils

No changes to the project area's topography, geology, or soils are expected.

Water Resources

Small scale aquatic ecosystem and/or water quality projects being planned by others within the project area are indicated in Table 1-3. However, overall water quality in the project area would

be expected to remain unchanged unless large scale and comprehensive watershed based restoration and water quality actions (e.g. stormwater management) efforts are undertaken by others. Based on available information, the likelihood of such a comprehensive watershed based restoration action is low. As result, there is a reasonable assumption that modifications to or loss of wetland communities could potentially occur due to sea level rise or from resultant salt water intrusion into areas that would normally support freshwater wetlands.

Vegetation

As with water resources, restoration actions planned by others are more likely to occur at discreet locations rather than through large scale efforts. Therefore, overall the FWOP conditions of vegetation assume that the majority of upland and wetland communities would remain as they are except for changes associated with natural disturbance events - including future floods and sea level change - and community succession. Any vegetation currently established in flood prone areas is assumed to be adapted to flooding. Vegetation could become established on properties that may be abandoned.

Fish and Wildlife

Fish and wildlife presence in and use of the project area is not expected to appreciably change. The likelihood of large scale habitat restoration projects within the project area that would result in a significant change in use by fish and wildlife resources or modify the types of fish and wildlife species that utilize the project area is low. The same is true for any state and/or federal endangered, threatened or special concern species that may occur in the project area. Due to the level of urbanization in the Rahway River Basin, any potential land use change would have little to no effect on terrestrial or aquatic habitat quality.

Cultural Resources

Continued flooding in parks and historic neighborhoods in the project area would likely result in the deterioration of historic resources, leading to their degradation and possible loss.

Recreation

Parks and water-based recreational opportunities in the project area are not expected to change. Flooding related to coastal storms would continue to impact the use of open space and parks adjacent to the Rahway River and its tributaries, through inundation or the deposition of debris, which could result in park closures.

Aesthetics and Scenic Resources

Aesthetics and scenic resources in the project area are not expected to change. The flooding of parks, deposition of debris in flood prone areas, and debris removal activities would continue to impact aesthetics and scenic resources.

Hazardous, Toxic and Radioactive Waste

HTRW conditions in the project area are not expected to change.

Air Quality

Ambient air quality in the project area is not expected to change. Due to the level of urbanization in the project area, any potential land use change, including property abandonment, would have extremely little to no effect on air quality.

Noise

Noise conditions in the project area are not expected to change. Due to the level of urbanization in the project area, any potential land use change, including property abandonment, would not appreciably change noise levels.

4.4.3 Future Without-Project Conditions: Economics

Because the study and project areas are well developed, there is little opportunity for new expansion. The total depreciated structure replacement value of the existing structure inventory in the project area is estimated to be approximately $1.83 billion, with a total residential (non-apartment) valuation of over $358 million (October 2019). In general, the future without-project economic conditions are identified as continued damages to structures, content, vehicles, infrastructure, life safety and quick access to emergency services from future storm events. This will result in continued maintenance and reconstruction of private armoring (bulkheads) and repairs to houses and roads following storm events.

Estimate of Future Without-Project Damages

The HEC-FDA model was used to link hydraulic modeling output with project area infrastructure information, structure and content damage functions, and economic valuations to estimate the damages and benefits of alternatives within a project area. HEC-FDA fully incorporates risk and uncertainty, and is used to simulate flood damages at existing and future years and to compute accumulated present worth damages. HEC-FDA is an event-driven model that estimates damages over a 50 year period of analysis based on storm probabilities and other factors. Damages or losses include depreciated structure value, content and vehicle damage.

Future Without-Project Condition Damages. The HEC-FDA model was used to estimate damages to the assets in the study area over the 50 year period of analysis with no federal action. Appendix B: Economics provides detailed information on the damage inventory, damage calculations, and HEC-FDA.

Structures in the study area were identified within the 500-year storm surge floodplain for inclusion in the structure inventory (NACCS, 2015). It was found that 195 of the structures were constructed after 1990. In accordance with Section 308 of WRDA 1990 (33 USC 2318), structures in the 100-year floodplain that were built after 1990 were selected for exclusion from the benefit pool. Examination of the structures constructed after 1990 via Google Earth in aerial and street view indicated that the structures are not necessary for conducting water-dependent activity and could be excluded from further analysis. During optimization, it was found that 24 structures in the inventory no longer existed and were removed from the inventory. The remaining 2,284 structures formed the inventory upon which all analyses were conducted.

Table 4-1 presents a summary of the quantity of structures experiencing damage at selected annual chance exceedance events across the whole study area, broken down by damage category. It is estimated that 123 structures experience repetitive damage as measured by positive annual damages in the 2073 future without-project condition at the intermediate relative sea level change scenario. These 123 structures represent approximately 6% of the structure inventory. Non-structural measures have been recommended for 61 of these structures, and 7 of the structures reside behind the recommended levee. There are two clusters of structures that experience repetitive damages. There are 18 structures on Madison, Arthur, and Parkway streets in Linden, and 25 structures on Lafayette, Essex, Bridge, Elizabeth, Grand, Irving, and Main streets in Rahway. Many of these structures are included in the non-structural portion of the recommended plan.

The structures for which no coastal storm risk management measures have been proposed and that experience repetitive flooding may be assumed to be hardened in the future with- and without-project conditions. Hardening measures may include applying sealants to cracks in foundations, installing sump pumps, pointing downspouts away from a structure, placing sandbags in front of exposed gaps, or using bricks to limit pooling. These hardening measures are important actions for reducing residual risk now and in the future. It should be observed however that these hardening measures are too granular to be captured by the modeling implemented with the Hydrologic Engineering Center Flood Damage Anaylsis software.

Table 4-1. Summary of Damaged Structures by Flood Event

Damage Category	Annual Chance Exceedance Event						
	50% (2-yr)	20% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)	< 1% (>100-yr)
Residential	76	231	565	971	1,165	1,395	1,419
Apartment	2	7	11	18	21	27	31
Commercial	45	99	192	266	305	342	350
Total	**123**	**337**	**768**	**546**	**794**	**1,764**	**1,800**

Table 4-2. Proportions of Structures by Damage Category

Damage Category	Average Value ($)*	Sum Value ($)*	Percent Value	Quantity	Percent Quantity
Residential	240,000	358,296,000	20%	1,490	65%
Apartment	4,599,000	165,561,000	10%	36	2%
Commercial	1,582,000	1,199,147,000	70%	758	33%
Total	**761,860**	**1,808,665,980**	**100%**	**2,284**	**100%**

* Price level October 2019

Table 4-2 presents a summary of the distribution of building types in the study area and total depreciated structure replacement values at October 2019 price levels by damage categories. Using HEC-FDA, average annual damages (AAD) were calculated for the without-project base year (2029) and the future condition (2079)[10], and equivalent annual damages (EAD) were calculated for the 50-year period of analysis, using the 2020 Fiscal Year USACE project evaluation and federal plan formulation discount rate of 2.75%. Table 4-3 shows that the total EAD resulting from these calculations is approximately $46.5 million for the study area.

Table 4-3. Summary of Without-Project Equivalent Annual Damages by Category and Damage Reach

Damage Reach	RES ($)	APT ($)	AUTO ($)	COM ($)	TOTAL ($)
Carteret & Woodbridge	2,461,000	200	105,000	22,806,000	25,372,000
Millburn-Clark	756,000	472,000	36,000	505,000	1,769,000
Rahway	1,819,000	3,256,000	77,000	7,719,000	12,871,000
Robinsons Branch	734,000	225,000	18,000	546,000	1,523,000
South Branch	793,000	300	21,000	4,130,000	4,944,000
Total	**6,563,000**	**3,954,000**	**257,000**	**35,706,000**	**46,480,000**

Price level October 2019, 2.75 % discount rate, relative SLC Intermediate Scenario

Inspection of the results shows that the reaches that experience the largest without-project condition expected damages are within Carteret and Woodbridge.

4.5 Management Measures

Both structural and nonstructural measures to manage storm surge-induced flooding in the study area were identified. Structural measures are physical modifications that would reduce the frequency of damaging levels of flood inundation. Nonstructural measures would reduce human exposure or vulnerability to a flood hazard without altering the nature or extent of that hazard. Measures were derived from a variety of sources, including experience from prior studies and coordination with the non-federal sponsor and local stakeholders.

Structural Measures

Structural features are often employed to reduce peak flows (flood storage); direct floodwaters away from flood prone property (flood barriers); or facilitate the flow of water through or around an area (channel modifications or diversions). All of these features have the potential to reduce the risk of flood damages; however, not all may be economically justified. Structural measures include diversion culverts, floodwalls and levees, surge barriers, road raising, ring

[10] A risk-informed decision was made to assume that the analysis that was completed for a period of analysis of 2023 to 2073 sufficiently approximates the analysis for a period of analysis of 2029 to 2079. For more information, please see Section 4.4.

floodwalls/levees, channel modifications, detention basins, and clearing and snagging. The following structural measures were evaluated.

- **Floodwalls:** Floodwalls are structures composed of steel, concrete, rock, or aluminum that help to contain flows to a channel and away from areas vulnerable to flood damage. They are often used when residential properties directly abut a channel or the shoreline and there is not enough space to construct a levee, or in cases where storm-induced floods are too severe for a levee. Floodwalls may require interior drainage facilities, located on the landward side of the floodwall, to collect, control, and disperse water trapped behind the floodwall, as that water could otherwise pond behind the floodwall, creating the potential for induced flooding.
- **Levees:** Levees are typically low, wide earthen embankments built to contain flows to a channel and away from areas vulnerable to flood damage. Levees may require interior drainage facilities, located on the landward side of the levee, to collect, control, and disperse water trapped behind the levee, as that water could otherwise pond behind the levee, creating the potential for induced flooding. Floodwaters ponded behind a levee could potentially breach the levee.
- **Surge Barriers:** Surge barriers are used to alleviate the inundation of landward areas as floodwater enters canals and creeks. During flood events, surge barriers placed across waterways would be closed. Levees and floodwalls are often used in conjunction with surge barriers to tie-off to appropriate points of elevation to prevent floodwaters from flanking the surge barrier.
- **Road Raising:** Roads that currently experience flooding during storms due to storm surge or surface runoff would be elevated to heights that would minimize or eliminate the impacts of such events. While road raisings are not usually recommended as measures on their own, they are sometimes used in conjunction with levees and floodwalls where roads intersect levees and floodwalls.
- **Channel Modification:** Modification of the cross-section of a channel of water along a length or lengths of that channel would be used to change flow characteristics to reduce or prevent fluvial flooding.
- **Bridge Modifications:** Bridge modifications can include modifying or removing bridges to improve the conveyance of water flow to reduce or prevent fluvial flooding and accommodate channel modifications.
- **Ring Floodwalls/Levees:** Ring floodwalls or levees are barriers around buildings used to keep floodwater out of the buildings. They may be appropriate for structures for which elevation is infeasible, as in the case of a large commercial structure.
- **Beachfill:** The process of placing sand on a beach where it eroded previously.
- **Breakwaters:** They are structures (dike or jetty type) established in a landscape area or a coastline vulnerable to erosion.

Nonstructural Measures

Nonstructural measures for coastal storm risk management include floodproofing, elevation, relocation, acquisition, flood warning systems, flood preparedness training, flood evacuation planning, and regulation of floodplain uses. Acquisitions, which are also referred to as "buy-outs," involve buying and removing high-risk properties from flood prone areas. Most of the other nonstructural measures would maintain existing residential, commercial, and industrial areas. The following nonstructural measures were evaluated:

- **Dry Floodproofing**: Floodproofing is the process of making adjustments to the design or construction of buildings to reduce potential flood damages. Dry flood proofing allows water to reach the structure, but diminishes the flood threat by preventing water from entering the structure. This would be accomplished by making the portion of a building below the flood level watertight, by attaching watertight membranes (sealants) to and installing closure structures (closures) in doorway and window openings.
- **Wet Floodproofing:** Wet floodproofing allows water to get inside lower, non-living space areas of the structure via vents and openings, in order to reduce the effects of hydrostatic pressure. This reduces flood damage to the structure's foundation. When a basement is involved, it is filled with compacted earth for foundational stability. Wet flood proofing also involves elevating and/or protecting utilities.
- **Elevation (Raising):** Elevation involves raising the lowest finished floor of a building to a height that is above the flood level. In most cases, the structure is lifted in place and the foundation walls are extended up to the new level of the lowest floor. The elevation process differs for different foundation types: slab-on-grade, subgrade basement, walkout basement, raised (crawlspace) foundation, bi-levels/raised ranches, or split levels. In this study, no structures were assumed to be elevated on piers, posts, or piles. Elevation was assumed to be feasible for structures with footprints of less than 3,000 sq ft.When a building is in poor condition, elevation is not feasible; in these cases demolishing the building and reconstructing an improved building on the same site with the lowest finished floor above the flood level, also known as "mitigation reconstruction," may be considered. While mitigation reconstruction is considered in the formulation analysis presented in this chapter, it has since been determined to not be compliant with USACE policy and was therefore not considered during optimization of the Tentatively Selected Plan (Section 4.10).
- **Property Buyouts:** Buyouts involve the acquisition of property and its structures and/or the purchase of development rights. A buyout plan would result in the permanent evacuation of the floodplain in areas of frequent and severe inundation. Development in the areas would cease and structures would be demolished or relocated. A buyout plan would be successful in re-establishing and maintaining a natural state of the floodplain for purposes that would not be jeopardized by the flood hazard. However, this type of program causes emotional hardship, involves expensive relocation costs, and results in the loss of a community/local tax base. For this study, buyouts were only considered for properties for which the cost of floodproofing or elevation would exceed the buyout cost of the buyout; this evaluation occurred later, during feasibility-level design.

4.6 Measures Screening

Measures that would be much more challenging to implement, and not more effective than other measures, were screened out. Table 4-4 summarizes the screening of measures.

Table 4-4. Screening of Measures
(spans two pages)

Measure	Outcome	Challenges	Retained for Further Study?
Levee / Floodwall	• Reduces flood damages by keeping storm surge-induced flood waters out of areas behind the levee.	• Destruction of wetlands and impacts to jurisdictional waters; high environmental mitigation costs. • High costs for acquisition of real estate interests	• Yes, while costs may be high, this measure will meet the planning objectives.
Surge Barrier	• Reduces flood damages by keeping storm surge-induced flood waters out of areas behind the barrier.	• Impacts to navigation must be fully assessed. • Construction costs could be significant.	• Yes, while costs may be high, this measure will meet the planning objectives.
Beachfill and breakwaters	• Reduces flood damages by dissipating the energy of storm surges.	• Shoreline and area directly inland of the Arthur Kill are highly industrialized and no room exists for such measures. The Arthur Kill also contains a navigation channel for large ships, which precludes putting breakwaters in the Arthur Kill itself.	• Not considered for further study as challenges are too great compared to the outcome.
Floodproofing	• Reduces flood damages by either keeping water out of (dry floodproofing), or reducing the impact of water on (wet floodproofing), flood prone residences, businesses, and public facilities. • Minimizes environmental impacts.	• Floodproofing a significant portion of flood prone properties would be prohibitively expensive. • Public acceptability of a large-scale plan may be challenging.	• Retained for further study as this measure will meet the planning objectives, and because USACE policy requires nonstructural measures to be evaluated.
Elevation	• Reduces flood damages by raising lowest finished	• Not feasible for buildings in poor condition or buildings with a large	• Retained for further study as this measure will meet the planning objectives,

Measure	Outcome	Challenges	Retained for Further Study?
	floor of property above the floodplain. • Minimizes environmental impacts.	(over 3,000 sq ft) footprint.	and because USACE policy requires nonstructural measures to be evaluated.
Property Buyouts	• Reduces flood damages by removing properties from flood prone areas. • Minimizes environmental impacts. • Creates open space and may restore natural floodplain functions.	• Acquisition and relocation of a significant portion of floodplain properties would be prohibitively expensive. • Public acceptability of a large-scale plan is sometimes challenging.	• Retained for further study as this measure will meet the planning objectives, and because USACE policy requires nonstructural measures to be evaluated.

4.7 Alternative Plans

This section describes the alternatives that were developed to meet the planning objectives, consisting of one or more of the retained measures. Figure 4-2 indicates where measures were sited in the study area, for the alternatives that were developed. Engineering judgement was used to site measures.

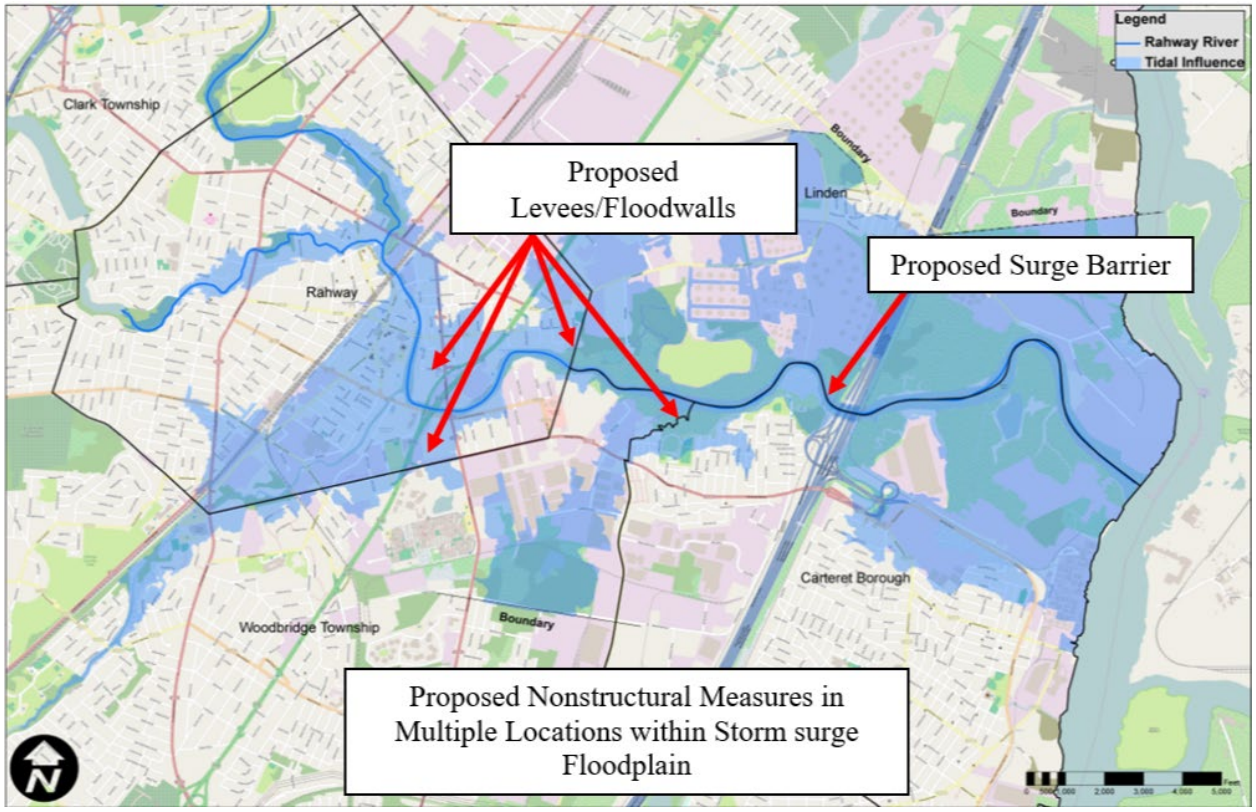


Figure 4-2. Location of Measures for Alternatives

The final array of alternatives, which includes the alternatives of those developed that were expected to perform the best, for the least cost and fewest environmental impacts, consisted of:

- No Action (Without-Project)
- Alternative #1: Levees and Floodwalls
- Alternative #2: Surge Barrier
- Alternative #3a & 3b: Nonstructural Measures + Barriers
- Alternative #4 & 4a: Levee Segment D + Nonstructural Measures

4.7.1 No Action Plan

Under the No Action Plan, no federal action would be taken to manage coastal storm risk in the Rahway River Basin. The No Action Plan would be implemented if the study were to find that none of the other alternatives are likely to have benefits exceeding their costs over the planning horizon – that is, if the study were not able to find a federal interest in coastal storm risk managment in the Rahway River Basin. The No Action Plan would not contribute towards meeting the planning objectives; however, it would avoid the costs and environmental and social effects of implementing another alternative. The effects of the No Action Plan over the planning horizon are equivalent to the future without-project conditions (as described in Section 4.4), and are the baseline against which the effects of other alternatives are compared.

4.7.2 Structural-Only Alternatives

Alternative #1: Levees and Floodwalls

Alternative 1 consists of structural measures only, including four (4) levee/floodwall segments, two (2) closure gates, interior drainage structures, bridge replacement, and channel modification (Figure 4-3). This alternative was designed to reduce flood damages for up to the present conditions 1% AEP (100-year) storm surge-induced flood.

Alternative 1 has four segments lettered A-D:

(1) Segment A: Levees and floodwalls, channel modification, bridge replacement, and road closure gate.

The upstream section of Segment A, Segment A1, starts with “T-wall” floodwalls on both banks of the Rahway River near Bridge St in Rahway. The left bank floodwall is approximately 325 ft long while the right bank floodwall is approximately 210 ft long, each at elevation 13.8 ft. This section of floodwalls on both banks of the river ends at Monroe St Bridge. The bridge shall be raised by 2.8 ft, and the left abutment shall be moved inland by 15 ft. As a result of bridge modification, approximately 300 ft of Monroe St shall be raised by a maximum of 2.8 ft. The raised section of road ties into the existing roadway surface at the intersection of Monroe St and Essex St.

The left bank floodwall continues downstream towards Essex St with a top elevation of 12.6 ft NAVD 88. The floodwall tie-in to Essex St requires the road to be raised by approximately 1.5

ft. The raised section is approximately 150 ft long and starts 50 ft south of the intersection of Essex St and Washington St.

Segment A2 starts on the left bank of the Rahway River, approximately 150 ft north of East Milton Ave Bridge. This section is a sheet pile wall with a maximum height of approximately 2 ft. Sheet pile ties into high ground at the recently modified bridge. A levee section starts downstream of East Milton Ave Bridge and ties into high ground on the abutments of the Edgar Road exit (Route 1). The levee is approximately 1,510 ft long, with an average height of 4 ft, having a 12 ft top width and one vertical to three horizontal (1:3) side slopes.

The final section of Segment A2 is a floodwall approximately 580 ft long with an average height of 5.5 ft, located between the Route 1 exit and Route 1 itself. This section will also include a flood hydrostatic gate (road closure structure) approximately 65 ft wide by 6 ft high. The gate is located on Lawrence St approximately 300 ft south of the Hancock St and Lawrence St intersection.

In addition to the levees and floodwalls, Segment A also includes channel modifications. The upstream and downstream ends of channel modification are: 500 ft upstream of West Grand Ave Bridge, upstream of the confluence with Robinson's Branch and approximately 100 ft downstream of the Lawrence St Bridge, downstream of the confluence with the South Branch, respectively. The channel modification consists of a natural trapezoidal channel with one vertical to two and a half horizontal (1:2.5) side slopes. It is approximately 6,540 ft long, totaling 60,000 cy of dredged material. The channel modification slope and bottom width are variable. The slope upstream of the NJ Transit Railroad Bridge is approximately 9.5 ft/mile and downstream is approximately 1.6 ft/mile, having bottom widths ranging from 35 ft to 140 ft. This channel modification mostly removes high ground sections along the channel caused by high deposits of sediment. The channel modification will not only reduce upstream impacts but will reduce flood risk during frequent fluvial events.

(2) Segment B: Levees, floodwalls and road closure gate.

Segment B is a combination of levee and floodwall. Segment B has a top elevation of 12.6 ft NAVD 88. The levee has a 12 ft top width and one vertical to three horizontal (1:3) side slopes. It is approximately 640 ft long with an average height of approximately 8 ft from grade. This levee is located on the right side of Edgar Rd just north of Randolph Ave.

The floodwall is a sheet pile approximately 5,700 ft long with an average height of approximately 3.8 ft. The floodwall is located on the right bank of the South Branch, between the river and Leesville Ave. The upstream end of the floodwall is approximately 1,300 ft downstream of East Inman Ave and the downstream ends is approximately 600 ft upstream of East Hazelwood Ave. Segment B also includes a flood hydrostatic gate (road closure structure). The dimension of the road closure structure is 40 ft wide by 5 ft high and it is located on the north end of Capobianco Plaza Rd.

(3) Segment C: Levee.

This levee segment is 890 ft long with a 12 ft top width and one vertical to three horizontal (1:3) side slopes. Segment C has a top elevation of 12.6 ft NAVD 88. The average height is approximately 7.5 ft from grade. The levee is located on the left bank of the Rahway River, approximately one mile downstream of the confluence with the South Branch. The upstream end is located by Beacon St, continues downstream, and ties in into high ground approximately 150 ft downstream of Wall St.

(4) Segment D: Levee.

This levee segment is 3,360 ft long with a 12 ft top width and one vertical to three horizontal (1:3) side slopes. Segment D has a top elevation of 12.6 ft NAVD 88. The average height is approximately 7.5 ft from grade. The levee is located next to the right bank of the Rahway River, approximately 1.2 miles downstream of the confluence with the South Branch. The upstream end is located at the industrial/commercial area by Ardemore Ave, and it continues downstream to Dorothy St.

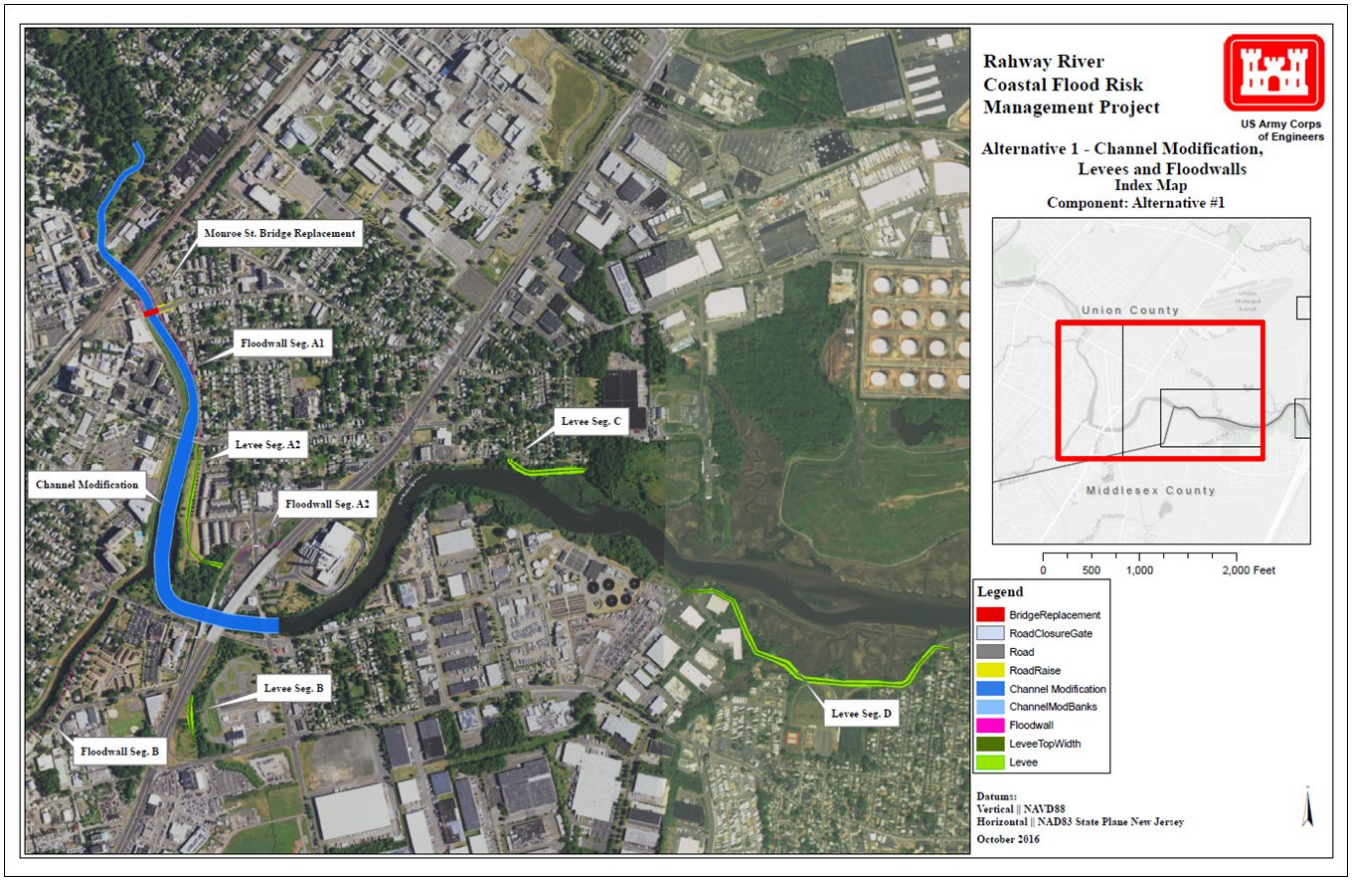


Figure 4-3. Alternative #1 Plan Overview

Alternative #2: Surge Barrier

Two alignments were developed for a surge barrier, but only one made it to the final array of alternatives. The alignment that was not carried forward was a surge barrier/closure gate at the mouth of the Rahway River by the Arthur Kill. A levee on the Arthur Kill and north of the left bank of the Rahway River in the City of Linden and a levee on the Arthur Kill and south of the right bank of the Rahway River in the Borough of Carteret would be included to tie-off to high ground. This alignment could provide storm risk management to various residential, commercial and industrial structures within all four municipalities in the study area, including the petroleum refineries. This alignment was not carried forward due to: 1) following Hurricane Sandy in 2012, some of the petroleum facilities implemented measures to manage storm surge-induced flood risk, which reduced this alignment's potential benefits; 2) technical difficulty in placing tie-in floodwalls along the Arthur Kill on top of industrial petroleum/chemical facilities and anticipated high real estate mitigation costs; and 3) HTRW issues in the direct vicinity of contaminated sites that would require remediation prior to implementation of a USACE project (further complicated by the immediately adjacent location of the Arthur Kill channel and the ongoing chemical/petroleum operations in the direct vicinity). The other alignment, which is included in Alternative 2 in the final array of alternatives is a surge barrier on the Rahway River just upstream of the NJ Turnpike Bridge.

Alternative 2, similar to Alternative 1 consists of structural measures only. This alternative includes tide gates, a pumping station, levees, channel modification, a floodwall, a closure structure, and relocation (Figure 4-4). This alternative would manage, for present conditions, flood risk for up to the 1% AEP (100-year) storm event. This formulation that took place in the draft report in FY2017 and was used for TSP selection and that subsequent analysis for optimization resulted in the recommended plan.

The surge barrier is located approximately 775 ft upstream of the New Jersey Turnpike with a design elevation of 13 ft NAVD 88. It includes:

- Six tainter gates allowing navigable passage,
- A pumping station with four pumps at a total capacity of 2.7 million gpm,
- Levee tie-ins to high ground (the turnpike) on the left and right banks, and
- Channel modification at the surge barrier for a length of approximately 2,000 ft.

The surge barrier's six tainter gates are each 60 ft wide and 30 ft tall from invert to top of gate. Gates will be open during normal tide conditions and fluvial events. During storm surge events, the gates will close during a rising tide as long as the headwater (landside) has a lower water surface elevation than the tailwater (ocean-side). The pump station is located on the left bank and will tie into the line of protection of the gate components. It contains four 1,500 cfs pumps with a total capacity of 6,000 cfs, or 2.7 million gpm. Pump operation is necessary when the gates are operating so that damage is not incurred to structures upstream of the barrier.

Levees on the left and right banks of the surge barrier will tie into the NJ Turnpike. Levees will have a top width of 12 ft and a 1 vertical to 3 horizontal (1:3) side slope. Levee length on the left bank is approximately 380 ft with a top elevation of 13 ft NAVD 88, having a maximum exposed

levee height of 11 ft. Levee length on the right bank is approximately 1,040 ft with a top elevation of 13 ft NAVD 88, having a maximum exposed levee height of 11 ft. The right bank levee includes an 18 inch diameter interior drainage structure.

The surge barrier involves approximately 2,000 ft of channel modifications, totaling 322,000 cubic yards of dredged material. Modification begins approximately 500 ft upstream of the barrier to just downstream of the railroad bridge. Channel modification includes a new alignment of the left bank at the pump station, rectangular cuts immediately upstream and downstream of the barrier, trapezoidal cuts along the length of the channel with a 1:3 side slope, and 1:5 side slopes under the Turnpike and railroad bridges. The channel bed slope will be constant at a natural slope of 0.0013 ft/ft.

The remainder of the project will include:

- A floodwall along New Jersey Turnpike Northbound,
- Regrading approximately 300 linear ft of Memorial Field Park in Linden to an elevation of 13 ft NAVD 88,
- Three manual flapgates in the floodwall on the northbound side of the Turnpike at Marshes Creek,
- A 6-ft high swing gate railroad closure structure on the southbound side of the Turnpike by the Citgo oil tank farm, and
- Relocating the transmission tower on the left bank approximately 130 ft toward the left bank levee, away from the river.

The floodwall component of the alternative is located along the northbound side of the Turnpike between the highway and the railroad running parallel to it. The floodwall is approximately 3,090 ft long, with a design elevation of 13 ft NAVD 88, and a maximum exposed height of 13 ft. The floodwall includes three 8-ft diameter manually operated flapgates at the Marshes Creek outlet. The flapgates will be open during normal conditions so as to not affect the tidal environment.

Regrading at Memorial Field Park is minor but necessary to distinguish the Rahway River Basin from the Arthur Kill-Upper Bay basin, including Elizabeth River and Morses Creek. The one foot regrading will prevent elevated water levels in the nearby basin from causing flooding in the study area.

Figure 4-4. Alternative #2 Plan Overview

4.7.3 Nonstructural Analysis

Alternatives combining nonstructural measures and ringwalls to manage the risk of flood damages to structures from the 10% and 2% AEP (10- and 50-year) storm events were included in the final array of alternatives. Structures within the 10% and 2% AEP floodplains were analyzed based on structure type, condition, and build characteristics (NACCS, 2015). Measures for structures were selected based on the USACE National Nonstructural/Flood Proofing Committee (NFPC) Flood Damage Reduction Matrix (March 2016). Design elevations for selected measures are one foot above the WSE for the future conditions 1% AEP (100-year) event. WSEs for the analysis were derived using tidal-fluvial joint probability and assumed a low rate of SLC.

Alternative #3a: 10 Percent Floodplain

Alternative 3a was formulated by selecting nonstructural measures and ringwalls to reduce damages to structures in the 10% AEP (10-year) floodplain. For the approximately 577 structures (211 residential, 366 non-residential) in the 10% AEP floodplain, measures are recommended for 257 structures, and not for the remaining 320 structures. Approximately 33 ringwalls are included in the alternative. Each ringwall surrounds from one to 30 structures, varies in length from 300 to 3,500 ft, and varies in height above grade from 5 to 15 ft. The measures in Alternative 3a are summarized in Table 4-5.

Alternative 3a has the potential to produce backwater effects during fluvial floods. The ringwalls in the alternative could constrict flow, increasing WSEs at the confluence of Robinson's Branch and Rahway River down to Monroe St. The proximity of ringwalls to the river, expansiveness of ringwalls, and minimal storage capacity could contribute to localized increases in flooding upstream. Additional flood risk management measures would be required to be implemented to mitigate for these effects.

Alternative #3b: 2 Percent Floodplain

Alternative 3b was formulated by selecting nonstructural measures and ringwalls to reduce damages to structures in the 2% AEP (50-year) floodplain. For the approximately 983 structures (561 residential, 422 non-residential) contained in the 2% AEP floodplain, measures are recommended for 597 structures, and not for the remaining 386 structures. Approximately 40 ringwalls are included in the alternative. Each ringwall surrounds from one to 62 structures, varies in length from 300 to 10,000 ft, and varies in height above grade from 5 to 15 ft. The measures in Alternative 3b are summarized in Table 4-5.

Alternative 3b includes more and longer ringwalls than Alternative 3a, so its potential to constrict flow, producing backwater, is greater than for Alternative 3a. As for Alternative 3a, additional flood risk management measures would be required to be implemented to mitigate for these effects.

Table 4-5. Nonstructural Alternatives for the 10% and 2% AEP Floodplains

Nonstructural Floodproofing Measure / Ringwalls	Alt #3a: 10 Percent Floodplain			Alt #3b: 2 Percent Floodplain		
	Residential	Non-Residential	Total	Residential	Non-Residential	Total
Dry Floodproofing	0	2	**2**	12	34	**46**
Dry Floodproofing with Tank Anchoring	0	0	**0**	0	3	**3**
Wet Floodproofing	10	1	**11**	66	1	**67**
Pump Replacement	0	3	**3**	0	3	**3**
Elevation	138	3	**141**	292	4	**296**
Ringwalls	47	53	**100**	92	90	**182**
Total of Structures	**195**	**62**	**257**	**462**	**135**	**597**

4.7.4 Alternatives Combining Structural and Nonstructural Measures

Preliminary Analysis of Structural and Nonstructural Alternatives

The improved hydraulic condition analysis showed that Alternative 2 would reduce WSEs by more than Alternative 1. Hydraulic modeling showed Alternative 2 would reduce WSEs up to 3.4 ft in the location of the Turnpike Bridge. Alternative 1 would reduce WSEs by about half a foot at the river's confluence with Robinson's Branch and South Branch, but only for more frequent, less severe, storm events.

An initial economic analysis and cost estimates collectively determined that an alternative combining nonstructural measures with a levee segment would provide the greatest benefits compared to costs. Alternative 2 did not produce a positive benefit-to-cost ratio within the entirety of the hydraulically dependent alternative. Alternative 1 produced one levee segment (Segment D) with a positive benefit-to-cost ratio as determined by economic reach due to hydraulic independence. For more information on the incremental benefit-cost analysis of levee segments in Alternative 1, see Section 4.9. To identify a TSP, alternatives combining measures from the nonstructural analysis with the Segment D levee were formulated.

Prior to identifying a TSP, USACE Planning Bulletin (PB) 2016-01, Clarification of Existing Policy for USACE Participation in Nonstructural Flood Risk Management and Coastal Storm Damage Reduction Measures, reclassified ringwalls, which had previously been classified as nonstructural measures, as structural measures. In developing alternatives combining structural and nonstructural measures, appropriate ringwall buffers for construction and inspection were included in the combination plan reassessment of the 10% AEP floodplain.

Alternative #4: 10 Percent Floodplain Nonstructural Plan + Levee

Alternative 4 consists of levee Segment D from Alternative 1 and a subset of the nonstructural measures and ringwalls in Alternative 3a. Figure 4-5 is an overview of the alternative. The

design height of the levee was evaluated at elevation 12.6 ft NAVD 88, consistent with the existing levees in the City of Rahway. Nonstructural measures were designed to the future conditions 1% AEP (100-year) WSE plus one foot to account for water surface perturbations. Additionally, Alternative 4 included a preliminary investigation of ringwall suitability with respect to their engineering feasibility and economic practicability, given new guidelines.

Alternative 4 includes nonstructural measures or ringwalls for approximately 149 structures (131 residential, 18 non-residential) of the 577 structures in the 10% AEP floodplain. Seven ringwalls are included, each surrounding from one to 5 structures, varying in length from 600 to 1,500 linear feet, and varying in height above grade from 5 to 10 feet. There are fewer nonstructural measures and ringwalls in Alternative 4 than in Alternative 3a because no measures were selected for structures on the protected side of levee Segment D. The measures in Alternative 4 are summarized in Table 4-6. Ringwall characteristics can be found in Table 4-7.

There are 26 fewer ringwalls in Alternative 4 than Alternative 3a, which reduces the ringwalls' collective potential to produce backwater effects during fluvial floods. Additional flood risk management measures might still be required to be implemented to mitigate for these effects.

Table 4-6. Nonstructural Measures in Alternative #4

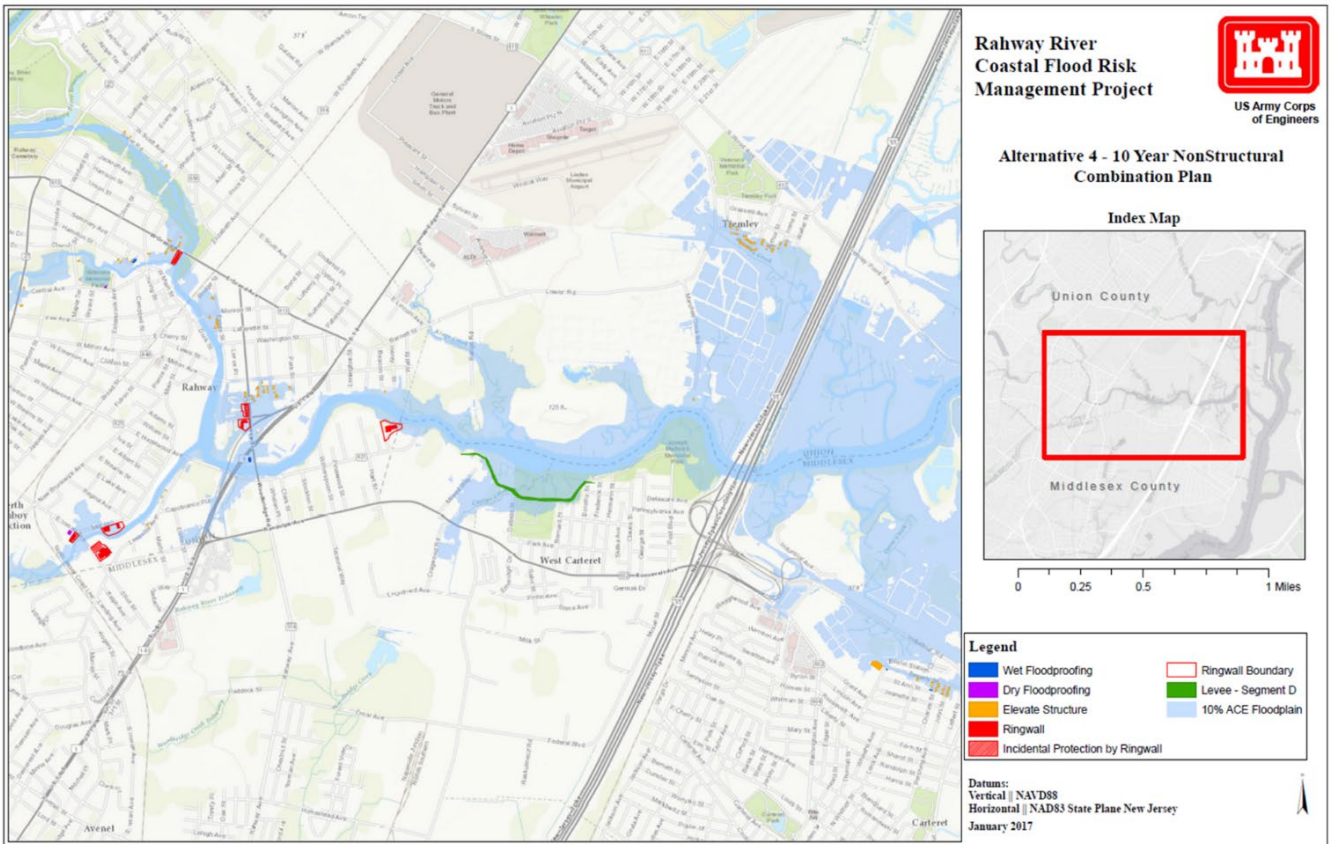
Nonstructural Flood Proofing Measure / Ringwalls	10 Percent Floodplain Combination Plan		
	Residential	Non-Residential	Total
Dry Flood Proofing	0	2	**2**
Wet Flood Proofing	1	3	**4**
Elevation	123	4	**127**
Mitigation Reconstruction	1	2	**3**
Ringwalls	6	7*	**13**
Total of Structures	**131**	**18**	**149**

* Structure is incidentally protected by ringwall. There is no associated cost with the additional structure but there are additional benefits.

Table 4-7. Characteristics of Ringwalls for Alternative #4

Ringwall	Structures within Ringwall	Avg Height of Ringwall (in feet)	Top of Ringwall (elevation in ft NAVD 88)	Perimeter (ft)
R001	2*	10	14.4	1226
R002	1	5	14.4	609
R003	2	10	14.4	1192
R004	1	10	14.3	1437
R005	1	10	14.4	859
R006	5	10	14.4	813
R007	1	10	16	790

* Structure is incidentally protected by ringwall. There is no associated cost with the additional structure but there are additional benefits.



*Note: Map displays storm surge inundation only, does not represent tidal-fluvial joint probability WSEs.

Figure 4-5. Alternative #4 Plan Overview

Alternative #4a: 10% AEP Nonstructural Plan + Levee, No Ringwalls

Alternative 4a is identical to Alternative 4 except that no ringwalls are included. An incremental economic analysis of the ringwalls in Alternative 4, which compared the benefits of each ringwall to its cost, showed that none of the ringwalls are economically justified. For more information on the incremental benefit-cost analysis of the ringwalls, see Section 4.9, Table 4-10. During the formulation of Alternative 4, it had already been determined that no nonstructural measures were feasible for the structures for which ringwalls had been recommended. Therefore, Alternative 4a does not include additional nonstructural measures as compared to Alternative 4.

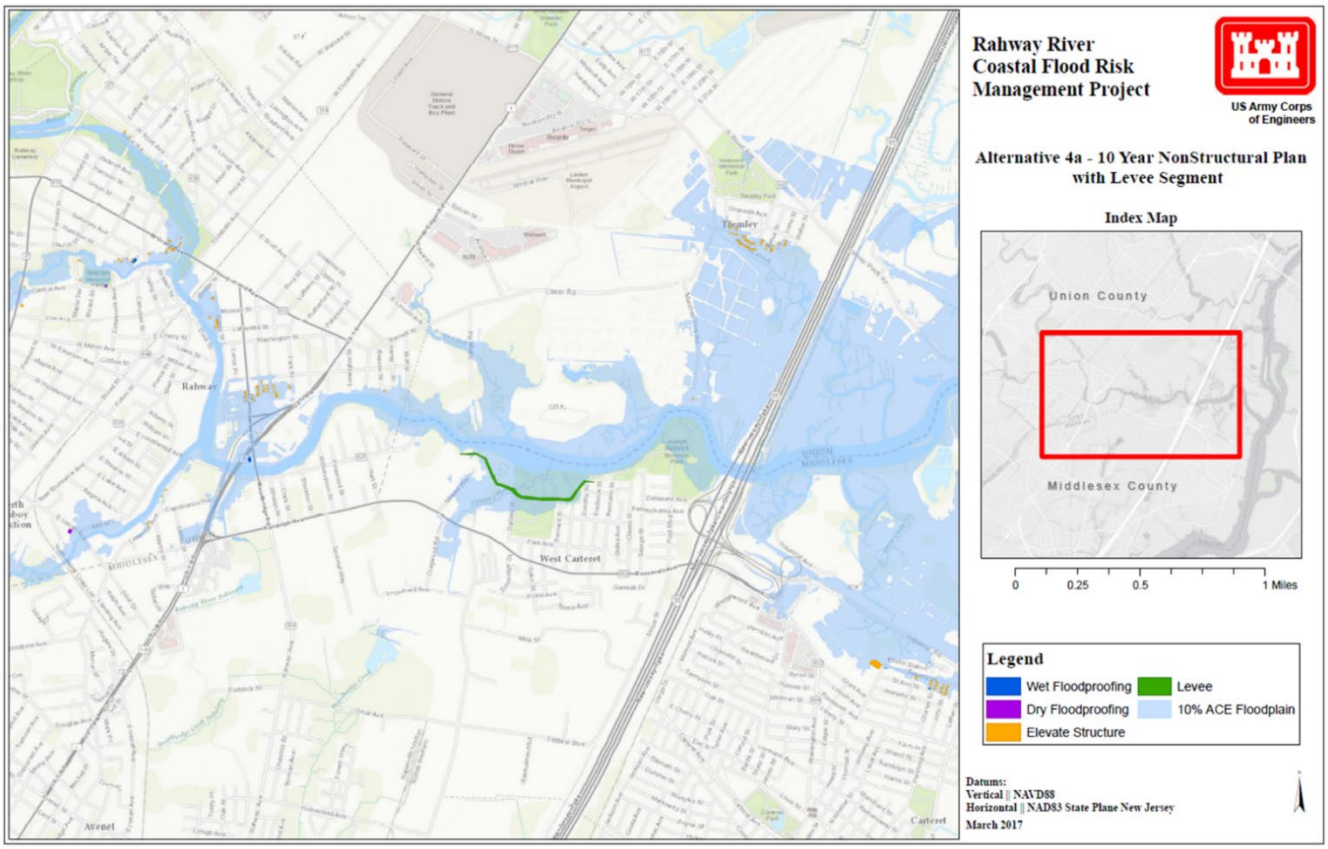
Alternative 4a includes nonstructural measures for approximately 136 structures (125 residential, 11 non-residential) of the 577 structures in the 10% AEP floodplain. Nonstructural measures were designed to the future conditions 1% AEP (100-year) WSE plus one foot to account for water surface perturbations. The nonstructural measures in Alternative 4a are summarized in Table 4-8.

The levee (Segment D) in Alternative 4a is 3,360 ft long with a 12 ft top width and one vertical to three horizontal (1:3) side slopes. The average height is approximately 7.5 ft and top elevation is 12.6 ft NAVD 88. The levee is located next to the right bank of the Rahway River,

approximately 1.2 miles downstream of the confluence with the South Branch. The upstream end is located at the industrial/commercial area by Ardemore Ave, and it continues downstream to Dorothy St. Figure 4-6 is an overview of Alternative 4a.

Table 4-8. Nonstructural Measures in Alternative #4a

Nonstructural Flood Proofing Measure	10% AEP Combination Plan		
	Residential	Non-Residential	Total
Dry Floodproofing	0	2	**2**
Wet Floodproofing	1	3	**4**
Elevation	123	4	**127**
Mitigation Reconstruction	1	2	**3**
Total of Structures	**125**	**11**	**136**



*Note: Map displays storm surge inundation only, does not represent tidal-fluvial joint probability WSEs.

Figure 4-6. Alternative #4a Plan Overview

4.8 Alternative Evaluation and Comparison

Alternatives in the final array of alternatives were evaluated, and compared on the basis of their economic costs and benefits, and environmental and social effects, to identify a TSP that maximizes net economic benefits while protecting the environment.

Cost estimates for alternatives were developed in the Micro-Computer Aided Cost Estimating System (MCACES), Second Generation (MII) program. Cost estimates included costs for planning, engineering and design, construction management, interest during construction, and Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R). Cost estimates were based on estimated environmental and real estate mitigation costs and quantities provided by hydrology and hydraulics, civil, and structural engineering team members. Resources used to develop the estimates included RSMeans, historical data from similar construction features, and MII Cost Libraries. Contingency percentages were estimated using an Abbreviated Cost Schedule Risk Analysis (ARA) using a template provided by the USACE Cost Mandatory Center of Expertise (MCX) at Walla Walla District. Contingencies were applied to the construction cost estimates to develop total project first costs for each alternative. Construction schedules were developed based on the assumption that multiple crews would work simultaneously. Average annualized costs were based on an economic project life of 50 years. The annual charges include the annualized investment costs along with annual OMRR&R costs. OMRR&R costs were assumed to be 0.5% of total construction costs based on historical data. Appendix D: Cost Engineering provides more detail on how cost estimates were developed.

Benefits for alternatives were estimated using the HEC-FDA model. Model output of damages was used to calculate the reduction in damages achieved by an alternative. Appendix B: Economics provides more detail on how benefits were estimated.

For the evaluation and comparison of alternatives used to identify a TSP, cost estimates and benefits used October 2016 price levels, a discount rate of 2.875%, and 2021 to 2071 as the period of analysis. For TSP optimization and the development of the recommended plan, as described in Section 4.10 and Chapter 5.0, the period of analysis was updated to 2029 to 2079 and October 2019 price levels and the current discount rate of 2.75% were used. Contingency percentages for TSP optimization and the development of the recommended plan were estimated using the more comprehensive Cost Schedule Risk Analysis (CSRA).

4.9 Tentatively Selected Plan Identification

The alternative that maximized net benefits for each independent reach was selected as a separable and incrementally justified element of the TSP. Alternative 4a (10% AEP Nonstructural Plan + Levee, No Ringwall) was identified as the TSP. Alternative 4a provides coastal storm risk management for portions of the municipalities of Carteret, Linden, Rahway, and Woodbridge.

Table 4-9 displays the results of the benefit-cost analysis for alternatives in the final array. The analysis indicated that Alternative 2: Surge Barrier lacks economic justification with a BCR of 0.1. Alternatives 3A, 3B, and 4 also lacked economic justification. Ringwalls within Alternative 3A were assessed structure by structure. Most ringwalls in Alternative 3A were removed via

engineering judgement and practice when formulating Alternative 4, with seven ringwalls remaining within Alternative 4. However, subsequent incremental economic analysis performed on the seven remaining ringwalls within Alternative 4 demonstrated that all seven ringwalls lacked incremental economic justification. The seven ringwalls in Alternative 4 were thus removed from Alternative 4 to form Alternative 4a. Table 4-10 displays the incremental economic analysis for the seven ringwalls in Alternative 4.

Table 4-9. Benefit-Cost Analysis for Alternatives in the Final Array

	Equivalent Annual Damages		Equivalent Annual Benefits	First Cost	Equivalent Annual Cost	Equivalent Net Benefits	BCR
	Without Project	With Project					
Alternative 1: Levee/Floodwall with Channel Modification	$17,527,000	$11,940,000	$5,586,000	$106,507,000	$4,761,000	$826,000	1.2
Alternative 2: Tidal Surge Barrier	$17,527,000	$11,181,000	$6,345,000	$988,809,000	$47,012,000	-$40,667,000	0.1
Alternative 3A:Nonstructural Measures (10% AEP Floodplain)	$17,527,000	$8,849,000	$8,678,000	$623,323,000	$26,920,000	-$18,243,000	0.3
Alternative 3B: Nonstructural Measures (2% AEP Floodplain)	$17,527,000	$7,840,000	$9,687,000	$973,143,000	$45,395,000	-$35,709,000	0.2
Alternative 4: Levee Segment D & Nonstructural Measures (10% AEP Floodplain)	$17,527,000	$11,757,000	$5,770,000	$180,536,000	$7,736,000	-$1,966,000	0.7
Alternative 4A: Levee Segment D & Nonstructural Measures without Ringwalls (10% AEP Floodplain)	$17,527,000	$13,138,000	$4,388,000	$66,900,000	$2,651,000	$1,737,000	1.7

October 2016 price levels, 2.875% discount rate**.** Annual costs include First Cost, IDC, and OMRR&R.

Table 4-10. Incremental Economic Analysis for Ringwalls within Alternative 4

Segment	First Cost	Annualized Cost	Annualized Benefits	BCR	Net Benefits
Ringwall R001	$20,311,000	$901,000	$274,000	0.3	-$627,000
Ringwall R002	$9,847,000	$425,000	$89,000	0.2	-$336,000
Ringwall R003	$19,570,000	$842,000	$115,000	0.1	-$727,000
Ringwall R004	$23,513,000	$1,012,000	$245,000	0.2	-$767,000
Ringwall R005	$14,469,000	$623,000	$488,000	0.8	-$136,000
Ringwall R006	$13,919,000	$600,000	$47,000	0.1	-$554,000
Ringwall R007	$13,302,000	$575,000	$125,000	0.2	-$450,000
Total	**$114,931,000**	**$4,977,000**	**$1,382,000**	**0.3**	**-$3,596,000**

October 2016 price levels, 2.875% discount rate**.** Annual costs include First Cost, IDC, and OMRR&R.

In addition, Alternative 1: Levee/Floodwall consists of four hydraulically separate segments identified as Segments A, B, C and D, each needing incremental justification. Table 4-11 displays the incremental economic analysis for the four segments.

Table 4-11. Economic Analysis for Alternative 1: Levee/Floodwall Segments

	Equivalent Annual Damages		Equivalent Annual Benefits	First Costs	Annual Costs	Net Benefits	BCR
	Without Project	With Project					
Segment A	$1,753,000	$14,633,000	$2,894,000	$7,141,000	$3,255,000	-$331,000	0.9
Segment B	$1,753,000	$17,464,000	$62,000	$11,958,000	$522,000	-$460,000	0.1
Segment C	$1,753,000	$17,482,000	$45,000	$4,938,000	$212,000	-$167,000	0.2
Segment D	$1,753,000	$15,183,000	$2,344,000	$18,203,000	$801,000	$1,542,000	2.9
Total	$1,753,000	$12,182,000	$5,345,000	$106,507,000	$4,761,000	**$584,000**	**1.1**

*Without Project Equivalent Annual Damages is equivalent to the annual damage pool for the total project area.
(October 2016 price level and discount rate of 2.875%)

Table 4-11 illustrates that only levee Segment D is economically justified and is thus identified as the TSP project element for that area.

As stated previously, Alternative 4 is a mix of ringwalls and nonstructural measures (in addition to the Segment D levee). When the cost of the ringwalls was removed, the nonstructural measures maximized net benefits in areas where flood risk management is not provided by the Segment D levee. Nonstructural measures in the levee Segment D area provided lower net benefits (~$1.1M in the 10% AEP floodplain) than the Segment D levee. The economics of nonstructural measures within the 10% AEP floodplain are shown in Table 4-12.

The TSP was thus identified as the Segment D levee/floodwall found in Alternative 1 in combination with nonstructural measures for selected structures in the 10% AEP floodplain in the remainder of the project area. The Segment D levee/floodwall and the nonstructural measures are separable and justified elements of the TSP. Table 4-12 displays the economic analysis for the TSP.

Table 4-12. Economic Analysis for Alternative 4a, the TSP

	Equivalent Annual Damages		Equivalent Annual Benefits	First Costs	Annual Costs	Net Benefits	BCR
	Without Project	With Project					
Nonstructural Measures (10% AEP Floodplain)	$17,527,000	$15,489,000	$2,038,000	$47,712,000	$1,850,000	$187,000	1.1
Segment D Levee/Floodwall	$17,527,000	$15,176,000	$2,350,000	$17,892,000	$809,000	$1,541,000	2.9
Total	**$17,527,000**	**$13,138,000**	**$4,388,000**	**$65,604,000**	**$2,659,000**	**$1,729,000**	**1.7**

(October 2016 price level and discount rate of 2.875%)

All alternatives were evaluated against four planning and guidance criteria: 1) *acceptability*, the workability and viability of the alternative plan with respect to acceptance by Federal and non-Federal entities and the public and compatibility with existing laws, regulations, and public policies; 2) *completeness*, the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects; 3) *effectiveness,* the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities; and 4) *efficiency,* the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. Coordination during the study with the non-federal sponsor, other agencies, and local stakeholders helped ensure the acceptability of the TSP and the suite of alternatives. Plans were formulated to be complete, effective and efficient through economic, engineering and environmental analysis. The plan selection process assisted in promoting efficiency by identifying the TSP as the plan that maximized net benefits among the suite of alternatives.

4.10 Optimization of the Tentatively Selected Plan

To optimize the TSP for the development of a recommended plan, the effects of varying the dimensions of the Segment D levee and design elevations for the nonstructural measures, to provide different levels of flood risk management, were analyzed. A 2029-2079 period of analysis, October 2019 price levels, and discount rate of 2.75% were used during optimization[11].

Alternative sizes of the TSP analyzed included:

- Small Plan:
  - Levee/floodwall Segment D (12.6 ft NAVD 88) + Nonstructural Measures (Designed for Low SLC)
- Medium Plan:
  - Levee/floodwall Segment D (14.2 ft NAVD 88) + Nonstructural Measures + Road Raising (Designed for Intermediate SLC)
- Large Plan:
  - Levee/floodwall Segment D (16 ft NAVD 88) + Nonstructural Measures + Road Raising (Designed for High SLC)

The top elevations of the levee for the small, medium, and large plans analyzed during optimization were set as follows. The levee/floodwall in the small plan has a top elevation of 12.6 ft NAVD 88, consistent with the design elevation of the existing levees upstream of the project area in Rahway, at the confluence of the Rahway River and South Branch. The levee/floodwall in the medium plan has a top elevation of 14.2 ft NAVD 88, and the levee/floodwall in the large plan has a top elevation of 16 ft NAVD 88. Incorporating floodwalls

[11] The structure inventory used in the economic analysis leading to identification of the tentatively selected plan contained 2 Blue Acres-participating structures. These structures were removed from the structure inventory during optimization.

into the design was necessary due to land use in the project area; sections of the structure are located adjacent to existing commercial buildings and major utilities. The levee and floodwall elevations were designed to allow nondamaging overtopping flowrates until the end of the period of analysis.

In the small plan, nonstructural measures were designed to an elevation one foot above the WSE for the 1% AEP (100-year) storm event, assuming the low relative SLC scenario. The design elevations for nonstructural measures in the medium plan and large plan were designed to one foot above the WSE for the 1% AEP event, assuming the intermediate relative SLC and high relative SLC scenario, respectively. The number of structures nonstructural measures are included for in each plan is 105 in the small plan, 110 in the medium plan, and 145 in the large plan.

Benefits for the small, medium, and large plans were estimated for the USACE low, intermediate, and high relative SLC scenarios. Table 4-13 shows the average annual net National Economic Development (NED) benefits and the probability distribution of average annual net NED benefits. The plan with the highest average annual net NED benefits was identified as the recommended plan. For all relative SLC scenarios, the medium plan has the highest average annual net NED benefits. Therefore, the medium plan is the recommended plan and is expected to provide $7,262,000 in damage reduction benefits and $4,276,000 in average net NED benefits annually.

Table 4-13. Expected Net Benefits and Probability Distribution of Net Benefits - Optimization

Relative SLC Scenario	Alternative	Expected Benefits	Annual Cost	Net Benefits Mean	Net Benefits Exceeded With Specified Probability		
					0.75	0.5	0.25
Low	Small	4,669	2,383	2,286	1,590	2,325	3,020
	Medium	5,330	2,986	2,344	1,737	2,342	3,230
	Large	6,076	5,585	491	-702	659	1,601
Intermediate	Small	6,154	2,383	3,771	3,037	3,821	4,420
	Medium	7,262	2,986	4,276	3,281	4,321	5,290
	Large	8,600	5,585	3,015	1,663	3,124	4,328
High	Small	7,241	2,383	4,858	4,107	4,910	5,634
	Medium	8,656	2,986	5,670	4,674	5,715	6,613
	Large	10,373	5,585	4,788	3,330	4,893	6,207

October 2019 price level, project evaluation and formulation rate (discount rate) of 2.75% in accordance with EGM 20-01
Values in thousands.

Chapter 5.0 Recommended Plan*

5.1 Proposed Action/Plan Features

The recommended plan is the NED Plan, and consists of a levee and floodwalls in combination with nonstructural measures and a road raising. Figure 5-1 provides an overview of the recommended plan. The elements of the recommended plan are separable.

The recommended plan was optimized to be part levee at 2,520 feet long and part floodwall at 1,968 feet long. The levee has a 12-foot top width and one vertical to three horizontal (1:3) side slopes. The average height is approximately 10.2 feet. The top elevation is 14.2 ft NAVD 88. The levee is located next to the right bank of the Rahway River, approximately 1.2 miles downstream of the South Branch confluence. The upstream end is located by the Rahway Valley Sewerage Authority wastewater treatment plant, and the downstream end is at Joseph Medwick Park by Hermann St.

The recommended plan includes nonstructural measures for 110 structures (106 residential, 4 non-residential) of the 768 structures (565 residential, 203 non-residential) in the 10% AEP (10-year) floodplain. No nonstructural measures were recommended for structures on the landward side of the levee. Nonstructural measures were designed to the future conditions 1% AEP (100-year) WSE plus one foot to account for water surface perturbations in the relative SLC intermediate scenario. No measures are recommended at this time for the remaining 658 structures in the floodplain. Recommended nonstructural measures include wet floodproofing, elevation, and buyouts. Buyouts are a mandatory component of the recommended plan. Two non-residential structures, a school and an industrial site, were removed from the list of recommended buyouts during plan optimization. Floodproofing and elevation will be offered to property owners on a voluntary basis. Table 5-1 shows how many residential and non-residential structures nonstructural measures are recommended for, by type of nonstructural measure.

The recommended plan would also raise approximately 1,350 ft of Engelhard Avenue in Woodbridge to a top elevation of 14.2 ft NAVD 88 to reduce the risk of storm surge flooding from the Woodbridge Creek.

More information on the recommended plan design is provided in Appendix CII: Hydraulic Engineering. The real estate requirements of the recommended plan are provided in Appendix E: Real Estate Plan.

Table 5-1. Recommended Plan Nonstructural Measures

Nonstructural Measure	Residential	Non-Residential	Total
Wet Floodproofing	7	2	**9**
Elevation	89	2	**91**
Buyout	10	0	**10**
Total of Structures	**106**	**4**	**110**

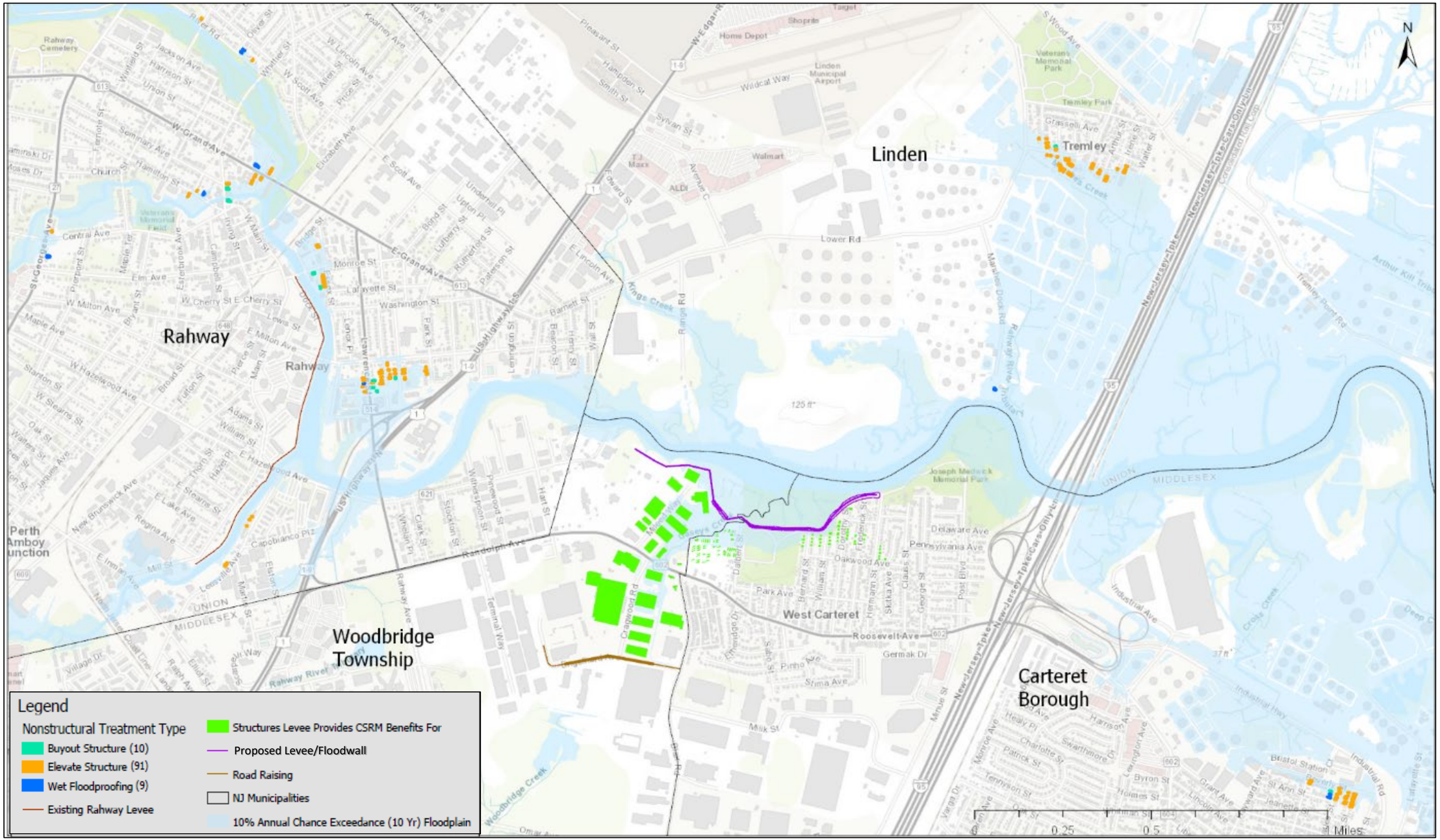


Figure 5-1. Recommended Plan Overview

5.2 Plan Costs and Benefits

The estimated first cost is $71,929,000 and the total project cost is $88,130,000 (October 2019 price levels, 2.75% discount rate). Contingencies for the cost estimate for the recommended plan were developed based a Cost Schedule Risk Analysis (CSRA). The project cost estimate is broken out by cost component in Table 5-2. The construction cost estimate for the recommended plan was developed from estimated quantities in the MCACES, MII program, using RSMeans, historical data from similar construction features, and MII Cost Libraries. Appendix D: Cost Engineering provides more detail on how the cost estimate was developed.

Table 5-2. Recommended Plan Cost Estimate

Account/Cost Component	First Cost	Total Cost
01 – Lands and Damages	$9,060,000	$10,450,000
02 – Relocations	$1,854,000	$2,284,000
06 – Fish & Wildlife Facilities	$2,912,000	$3,589,000
11 – Levees & Floodwalls	$23,149,000	$28,527,000
18 – Cultural Resource Preservation	$1,445,000	$1,780,000
19 – Buildings, Grounds & Utilities	$17,038,000	$20,996,000
30 – Planning, Engineering & Design	$11,600,000	$14,165,000
31 – Construction Management	$4,872,000	$6,339,000
Total	**$71,929,000**	**$88,130,000**

October 2019 price levels, 2.75% discount rate, Midpoint of Construction May 2026

Table 5-3 shows the estimated total interest during construction; annual operation, maintenance, repair, rehabilitation, and repair (OMRR&R) costs; and investments costs, as well as estimated annual benefits and the project's benefit-cost ratio. Estimated benefits of the recommended plan are $7,262,000 per year, and the plan's estimated net benefits are $4,276,000 per year. The estimated benefit-cost ratio for the project is 2.4. Appendix B: Economics provides more detail on how benefits were evaluated.

Table 5-3. Recommended Plan Benefit-Cost Summary

First Cost	$71,929,000
Interest During Construction	$2,424,000
Total Investment Cost	$74,353,000
Annual Investment Cost	$2,754,000
Annual OMRR&R Cost	$232,000
Annual Cost	$2,986,000
Annual Without Project Damages	$46,480,000
Annual With Project Damages	$39,218,000
Annual Benefits	$7,262,000
Net Benefits	$4,276,000
Benefit Cost Ratio	2.4

October 2019 price levels, 2.75% discount rate

The annual exceedance probability (AEP), long-term exceedance probability, and assurance by flood event were calculated for the levee and floodwalls in the recommended plan at 10-year intervals. These statistics are provided for a representative plan reach, which is reach D-CW-2-R where the recommended levee is located. The AEP is the annual chance that the target stage will be exceeded. The target stage in the reach with a levee is the elevation of the levee. As such, the AEP measures the chance that the water surface elevation will exceed the levee elevation in any given year. In other words, this is the annual chance that the elevation of the river will exceed the levee. This probability measures from just below 2% to just over 7% for the recommended plan. The long-term exceedance probability measures the chance that the levee elevation will be exceeded by the water elevation at least once in the stated period. At the beginning of the period of analysis, there is a nearly 13% chance that the levee elevation will be exceeded by the river at least once in 10 years, and approximately a 50% chance of this happening at least once in 50 years. These probabilities increase to about 52% and 98%, respectively, by the end of the period of analysis. Finally, assurance is the probability of containing a specific exceedance probability event (e.g. the 2% AEP or 50-year storm event) conditional on that event occurring. The recommended plan will pass the 2% AEP event with 71% assurance at the beginning of the period of analysis and with 6% assurance at the end of the period of analysis. Appendix B: Economics provides more detail the recommended plan's expected performance.

5.3 Risk and Uncertainty

Risk and uncertainty were explicitly factored into the economic analysis of the plan. HEC-FDA is a statistical risk-based damage model. The HEC-FDA model for the plan integrated the engineering and economic analyses and incorporated variability in both physical parameters and storms, which enables quantification of risk with respect to project evolution and economic costs and benefits of project implementation. For more information please refer to Appendix B: Economics. For information on risk and uncertainty with respect to hydrology and hydraulics please refer to Appendix CI: Hydrology, and Appendix CII: Hydraulics.

Assumptions were made to account for uncertainty during the course of the study with respect to hydrology (flows for hydraulics), hydraulics (water surface elevations for economics), design (dimensions of structures for hydraulics and economics, and quantities for cost engineering), economics (damages and performance), cost engineering (cost estimates), environmental conditions (environmental impacts and mitigation), cultural resources, and HTRW. Key assumptions included that: hydrologic, hydraulic, and economic modeling represented existing and future conditions in the study area adequately to determine which of the alternatives in the final array would maximize national economic development over the planning horizon and to optimize the TSP; the presence or absence and significance of environmental and cultural resources in the study area were accounted for adequately to assess and avoid, minimize, and mitigate for any potential adverse impacts of the recommended plan to environmental and cultural resources; designs developed based on existing geotechnical and HTRW information were adequate to estimate costs, benefits, and impacts from and would not require major revisions after surveys are conducted in the project pre-construction engineering and design (PED) phase; and that designs are compatible with existing deed restrictions for land in the project footprint.

5.4 Sea Level Change

The rate at which sea level changes will affect the performance of the recommended plan. The plan was optimized assuming an intermediate rate of SLC, using a 2029 to 2079 period of analysis. The optimal levee height for this rate of SLC over the period of analysis is 14.2 ft NAVD 88. The performance of the levee and floodwalls is expected to decline over time with relative SLC. For the intermediate relative SLC scenario, at the beginning of the period of analysis (2029), there is a 71% assurance that the Rahway River will not exceed the top of the levee and floodwalls during the 2% AEP or 50-year coastal storm event. By the end of the period of analysis (2079), there is a 6% assurance that the river will not overtop the levee and floodwalls during the 2% AEP event.

The recommended plan maximized net benefits at a design height of 14.2 NAVD 88 assuming the intermediate relative SLC scenario over the 50-year period of analysis. However, the recommended plan was designed to be able accommodate future modifications to adapt to rising sea levels. The levee can be made higher and the floodwall footing and underpinning was designed on average for an approximately 3 ft higher floodwall. Should sea levels rise more quickly than the intermediate rate, or should a need to adapt the project for the anticipated conditions in future years arise, the levee and floodwall could be raised by 2.8 ft. Figure 5-2 plots the 1% and 10% low, medium (intermediate), and high SLC scenarios over time and shows the levee height in the recommended plan, as well as the levee built 2.8 ft higher. The figure shows the period of analysis as well as the adaptation horizon 50 years beyond the end of the period of analysis. While the performance of the recommended plan decreases as sea level rises, the recommended plan is expected to continue to perform effectively and benefit the community.. Refer to Appendix CII: Hydraulics for more detail on adaptability of the recommended plan with respect to SLC.

5.5 Critical Infrastructure

The critical infrastructure that resides behind the recommended levee/floodwall in reach D-CW-2-R would experience a reduction in coastal storm risk. There is substantial critical infrastructure behind the recommended levee/floodwall, as can be seen in maps provided in Appendix B: Economics. The critical infrastructure that resides just south of the western half of Joseph Medwick Memorial Park is that which benefits from coastal storm risk reduction. A quantitative assessment of the reduction in coastal storm risk to this critical infrastructure has not been performed. It is important to observe the wealth of critical infrastructure that will experience the reduction in coastal storm risk. Randolph Avenue is hurricane evacuation route and resides behind the recommended levee/floodwall. Additionally, there are oil and natural gas pipelines, a natural gas receipt/delivery facility, gas stations, and rail roads. There are no nonstructural measures recommended for critical infrastructure.

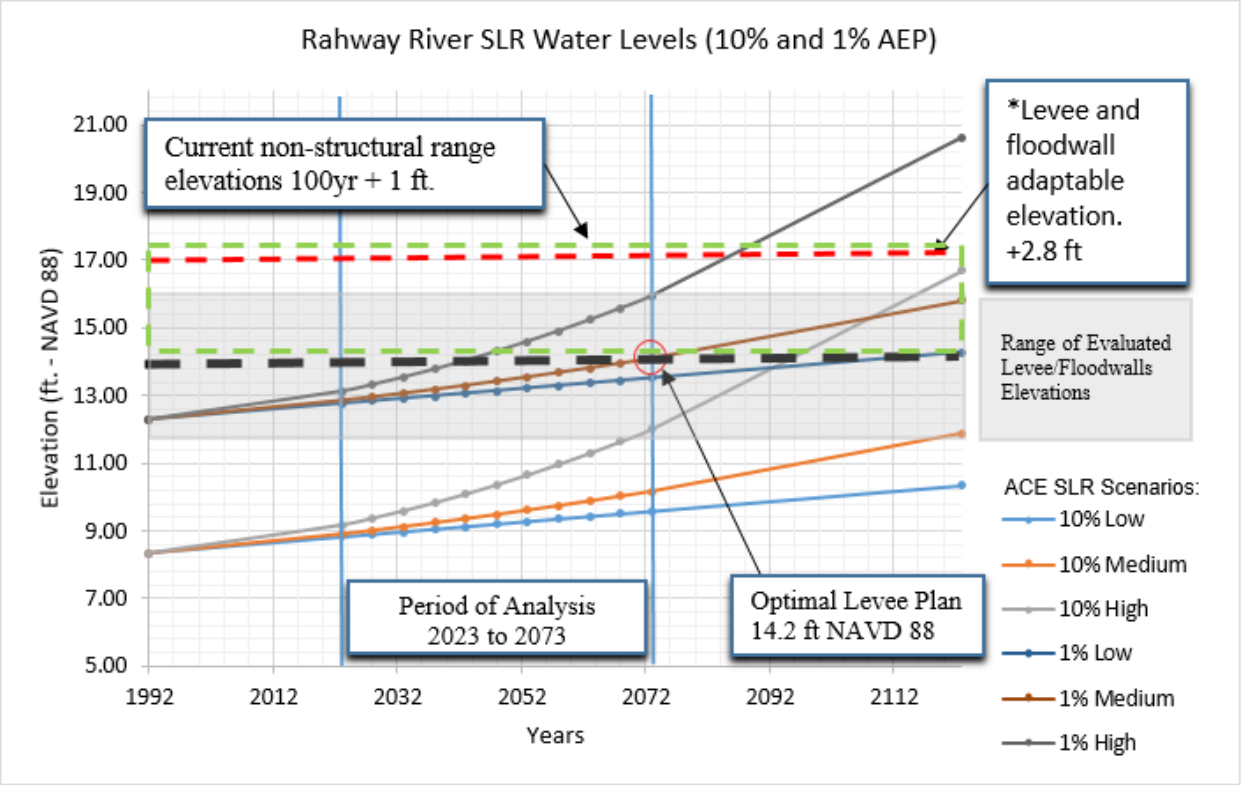


Figure 5-2. Rahway Tidal Sea Level Change Curve Plot

5.6 Economic, Environmental, and Other Social Effects

In reducing damages from future storm surge-induced flooding events, the recommended plan contributes to NED. National Environmental Restoration considerations are addressed in Chapter 6 (Environmental Effects) of this report. As for Other Social Effects (OSE), the project would maintain the viability of routes of transportation, including emergency and other vital services in the 1% AEP floodplain behind the levee in the recommended plan. The viability of routes of transportation is one aspect that adds to life safety. Implementation of the project could induce Regional Economic Development (RED) benefits as losses or transfers of income and output and employment losses are avoided in the area behind the levee. There are 35 commercial structures behind the recommended levee from which RED benefits may be potentially generated. Additionally, NED benefits will be generated in the area as residents and business owners may be able to allocate resources and spending on other goods and services than repairing and replacing structures or goods damaged by flooding.

Residual risks associated with the recommended plan include remaining average annual damages of $39,218,000 out of a total average annual damage pool of $46,480,000, resulting in 84% residual risk. See the economic appendix for a detailed analysis of the residual risk.

5.6.1 Life Safety

The Rahway River Basin, New Jersey Coastal Storm Risk Management Feasibility Study recommended plan includes a levee, and therefore must assess life safety and the qualification of

the tolerable risk guidelines, according to Planning Bulletin 2019-04. Levee risk which is sometimes considered as incremental risk is used to describe the additional risk imposed by non-performance of the levee. The incremental risk may occur from one or more of 4 scenarios: 1) breach prior to overtopping, 2) overtopping with breach, 3) malfunction or improper operation of levee system components, and 4) levee overtopping without breach. Flood waters would inundate the community protected by the levee in the event of non-performance, posing a risk to life loss.

The scenario first considered in this analysis is the fourth scenario, levee overtopping without breach. It has been assumed for exceedance probabilities and the concomitant WSEs beyond the 14.2-foot elevation of the recommended plan levee that the WSE inside the levee immediately reaches the WSE outside the levee. This equilibrium of the interior and exterior WSEs represents the most extreme case of inundation of the community protected by the levee. SuchWSEs have been estimated to be the same with as without the levee, indicating that the incremental risk in this scenario is null.

The residual risk attributed to the alternative scenarios, breach prior to overtopping, overtopping with breach, and malfunction or improper operation of levee system components can be informed by the USACE Levee Portfolio Report. The Levee Safety program has identified five different levels of risk for different levee conditions: very low, low, moderate, high, and very high. The level of risk is determined by, among other things, the size of the population receiving flood risk reduction by a levee and the levee height and expected flood loading hazard. Low risk levees typically reduce the risk of flooding to rural areas and are generally shorter in height, overtopping generally more frequently than higher risk levees. Moderate risk levees have over 1,000 people in the adjacent area receiving flood risk reduction and these levees have similar levee heights and flood loading hazards to that of very high and high risk levees. The area behind the recommended plan levee has 196 structures, and the recommended plan levee has an average height of 10.2 ft at a 14.2-ft NAVD 88 elevation. The recommended plan levee can therefore be assigned low to moderate risk.

Among all USACE moderate risk levees, less than one-half were found to have performance failure modes that would likely result in a breach prior to overtopping. Embankment and foundation seepage and piping was found to be the most common likely failure mode of moderate risk levees at 30%. Embankment erosion and closure system malfunction or improper operation are two major risk drivers that were found among 20% of moderate risk levees. The recommended plan levee will be constructed pursuant to Engineering Manual 1110-2-1913 and other up-to-date engineering best practice, which reduces the probability of these risk drivers occurring. The incremental risk attributed to scenarios 1--3 nonetheless is determined to be low to moderate.

Part of a qualitative life safety assessment includes statistical information on the hazard conditions in the study area. Such conditions are developed for the future without-project condition. The percentage of the population in the study area of 65 years or older is considered an important statistic in considering the population at risk. Demographic information is obtained

from the U.S. Census Bureau's American Community Survey 2018 5-year Estimates. The average percent of the population that is 65 years or older is 14% throughout the study area. Other hazard conditions include the maximum inundation levels predicted in each of the study area damage reaches and the inundation levels at critical infrastructure throughout the study area. The maximum inundation levels in terms of flood depth in the study area occur in reach A-CW-4-L at 13.48 ft for the 1% AEP event and 13.54 ft for the .2% AEP event.

There is substantial critical infrastructure throughout the study area. There are many sewage and water treament plants, power plants, pump stations and substations, and power plants. The depth of the 1% AEP event ranges from 4.05 ft to 11.96 ft.

Pursuant to Planning Bulletin 2019-04, the information gathered in the life safety assessment must be applied to the Tolerable Risk Guidelines framework. Specifically, Tolerable Risk Guidelines 1 and 4 must be assessed. Tolerable Risk Guideline 1 requires an understanding of the risk; consider whether society is willing to live with the risk associated with the levee system to secure the benefits of living and working in the leveed area. Tolerable Risk Guideline 1 requires assessing whether the risks are commensurate with the benefits. An evaluation of life safety risk, societal life risk, individual life risk, economic risk, and environmental risk should all play into the determination as to whether the risks are commensurate with the benefits of the levee.

The life safety risk, societal life risk, individual life risk, and economic risk are informed by the Life Risk Matrix (Figure 1) from PB 2019-04. Observe that life safety risks generally meet Tolerable Risk Guideline 1 when the annual exceedance probability of life loss with respect to individual life and societal life are both below 1.E-04. Typically a determination of the project's location on the life risk matrix would require separate quantitative modeling to identify the respective annual exceedance probabilities.

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

Tolerable Risk Guideline 4 must also be assessed. Tolerable Risk Guideline 4 requires determination of cost-effective, socially acceptable, or environmentally acceptable ways to reduce risk from an individual or societal risk perspective. It should be considered whether appropriate actions have been taken to reduce risks, could any actions be reasonably taken that would reduce risks further, what would be the cost of reducing risk and how much would the risk

be reduced, if the actions should be detailed in further study, and if there is demonstrated progress toward implementing risk reduction measures. An appropriate action that has been taken to reduce risks includes the inclusion of adaptability in the design to sea level rise. As the levee is expected to overtop frequently late in the period of analysis, it can be expected that this would by exacerbated if the rate of sea level change accelerated. Designing the levee to be adaptable allows for a more nimble response to changing sea levels. Other actions could be taken. For example, educational materials communicating the incremental risk could be prepared for the population behind the levee. Minimizing transformed and transferred risk might also be considered by the local authorities once the levee is constructed. Consideration could be put into whether it is useful to continue developing the area behind the levee. These recommendations for other actions to reduce risks further are recommendations that are made to the local authorities for their consideration.

5.7 Executive Order 11988

Executive Order 11988 "Floodplain Management" requires Federal agencies such as USACE, when taking an action, to avoid short- and long-term adverse effects associated with the occupancy and the modification of a floodplain. The agency must avoid direct and indirect support of floodplain development whenever floodplain siting is involved. In addition, the agency must minimize potential harm to development in the floodplain and explain why the action is proposed. USACE implementation guidance for Executive Order 11988 was issued as ER 1165-2-26 "Water Resources Policies and Authorities, Implementation and Executive Order, Engineer Regulation 11988 on Flood Plain Management."

The wise use of floodplains concept, as described in Executive Order 11988, was incorporated as a life safety consideration as part of the study. This approach was based on study objectives of applying qualitative rather than quantitative analysis; use of existing data/inventory; and professional judgment. The eight-step evaluation process outlined in Executive Order 11988 is included here, with a discussion of how it was considered during plan formulation and selection.

Step 1: 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, i.e., one percent flood). The Proposed Action is within the defined base floodplain.

Step 2: Conduct early public review, including public notice. USACE has coordinated with NJDEP, local municipalities, and the public during the course of the study.

Step 3: Identify and evaluate practicable alternatives to locating in the base floodplain, including alternative sites outside of the floodplain. All practicable alternatives were identified by following the USACE six-step planning process. A wide range of measures and plans using available information, engineering analysis, professional judgment, and risk-informed decision-making were evaluated. Practicable alternatives considered, and the reasons they were screened from consideration are presented in Chapter 4.

Step 4: Identify impacts of the proposed action. As detailed in Chapter 6, there would be no significant environmental impacts due to implementation of the plan. The plan would support

community resilience and cohesion by reducing flood risk to residents, businesses, and infrastructure.

Step 5: If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate. The proposed project is the plan that maximizes NED benefits while being consistent with the requirements of Executive Order 11988. The plan would avoid short-term and long-term adverse effects associated with the occupancy and modification of the existing floodplain.

Step 6: Reevaluate alternatives. Plan formulation, evaluation, comparison, and selection are detailed in Chapter 4.

Step 7: Present the findings and a public explanation. This report presents USACE's recommendation for federal action to the public.

Step 8: Implement the action. NJDEP is willing to execute a PPA with the federal government for implementation of the plan.

5.8 Environmental Operating Principles

The Environmental Operating Principles are an essential component of USACE's risk management approach in decision making, allowing the organization to offset uncertainty by building flexibility into the management and construction of infrastructure. The Environmental Operating Principles are:

- 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's actions in a collaborative manner
- Employ an open, transparent process that respects views of individuals and groups interested in USACE activities

Plan selection took into account these principles to ensure the sustainability and resiliency of the NED plan while considering the environmental consequences of implementation. In addition to construction best management practices to maintain water quality standards, other opportunities to implement sustainable measures and/or materials (e.g. low volatile organic paint, recycled industrial materials) that are cost effective and comply with USACE construction standards will be further evaluated during the pre-construction engineering and design (PED) phase. Planting plans will utilize native vegetation that support pollinator species, have a lower susceptibility to disease or pests, and are more adaptable to climate change. In addition, the ability to potentially recycle/re-use material such as excavated material from the channel on-site where feasible for

on-site restoration and/or proposed compensatory mitigation activities will be evaluated during the PED phase.

The study team considered avoiding and minimizing adverse impacts to existing environmental resources and cultural resources within the project area to the extent practicable during the plan formulation process. Where impacts to these resources are unavoidable, compensatory mitigation will be performed.

Continuous coordination with NJDEP, the Borough of Carteret and Woodbridge Township of Little Falls, the Borough of Woodland Park, and the public occurred throughout the study to ensure an open and transparent process that respects views of individuals and groups. The project will be constructed in compliance with all applicable environmental laws and regulations.

Chapter 6.0 Environmental Effects of the Recommended Plan*

This chapter discusses the potential positive and adverse environmental effects and consequences resulting from implementation of the recommended plan. The effects of the TSP are directly compared against the baseline Future Without-Project /No Action alternative conditions as described in Section 4.4.2.

In summary, the recommended plan will permanently impact the following types of habitat: a) 1.29 acres of low marsh; b) 1.13 acres of high marsh; c) 0.57 acres of scrub shrub wetland; d) 0.55 acres of upland forest; and e) 100 ft linear ft of tidal creek equaling to 0.05 acres of open water and 0.07 acres of mudflat. Approximately 0.55 acres of low marsh, 0.44 acres of high marsh, 0.10 acres of scrub shrub wetland and 0.15 acres of upland forest will experience temporary impacts as a result of construction activities. These areas will be restored on site following construction completion.

In order to compensate for the permanent direct impacts, the District is proposing to restore approximately 1.29 acres of low marsh, 1.13 acres of high marsh, 1.14 acres of scrub shrub wetland, 0.10 acres of open water and 0.14 acres of tidal mudflat. Based on USACE policy, no compensation for the loss of 0.55 acres of upland forest is proposed.

As mentioned in Chapter 3, streambank orientation is referred to as left or right based on a downstream viewpoint.

6.1 Land Use

The proposed action will have a short term minor impact on residential and commercial land use around temporary workspaces during construction. Permanent easements will be acquired from property owners within the footprint of the levee and the 15 ft vegetation free zone that is required by Engineering Technical Letter (ETL) 1110-2-583 Guidelines for Landscape Planting and Vegetation Management at Levees, Embankment Dams and Appurtenant Structures to enable inspection and operation and maintenance activities.

Approximately 2,000 ft of the levee is located within Joseph Medwick Park. There will be restrictions on park use during construction. However, the levee is situated in a location that will not affect or change the use of the park and its facilities once it is completed. Further discussion regarding the impacts to the park is included in Section 6.10.1 Green Acres.

The remainder of the levee is located on private property. The downstream portion of the levee is located near homes. In addition to maintain a 15 ft woody vegetation free zone from the levee, the ETL 1110-2-583 also requires certain restrictions from property owners such as not putting permanent structures (e.g. sheds, above ground/underground pools). The landowner will be compensated fair market value for the easement obtained. The upstream portion of the levee will be located on the portions of the property that are not expected to interfere with the normal use of the property.

There will be no permanent changes to land use for the properties where nonstructural measures are proposed.

In general, the implementation of the proposed action will likely produce long term benefits by reducing flood risk and future damage to residential, manufacturing/industrial, commercial/office, transportation/utilities and open space land uses located within the project area.

Mitigation

Disturbed areas will be restored and their use returned to pre-construction conditions through restoration measures such as regrading to restore pre-construction contours and replanting with native vegetation where feasible. Mitigation measures proposed to minimize the impacts the levee will have to the use of Joseph Medwick Park is discussed in Section 6.11.1 Green Acres.

6.2 Topography, Geology and Soils

6.2.1 Topography and Geology

The current topography of the area within the footprint of the levee is very flat with minimal grade and an average elevation of 6 ft above sea level. The height of the levee will have an average height of 12.6 ft with a side slope grade of 3:1. Therefore, the construction of the levee will change the topography in the immediate. This modification will be limited to the immediate footprint of the levee and is necessary to provide the necessary storm risk management.

For the nonstructural measures proposed, grading may be required around the foundation and potentially the lot. The topographical changes are expected to be negligible.

No short or long term adverse impacts to geology from implementation of the proposed action is anticipated.

6.2.2 Soils

Approximately four acres of area will be disturbed during construction of the project. The interior of the levee will be constructed with an impermeable clay core to prevent seepage. Compacted fill material is typically used for the levee exterior. Geotechnical borings of the site to determine the suitability of the soils to be used for the levee will be conducted during the PED phase. However, in-situ soils frequently do not meet the geotechnical specifications for the impermeable clay core and/or the fill material for the exterior levee construction, requiring the appropriate material to be imported from an approved, permitted, off-site source.

Any importation of soils to construct the levee could represent a change in the existing soil type within the immediate footprint of the levee. This modification is necessary to maintain the structural integrity of the levee and the desired level of coastal storm risk management. Approximately 70% of the total area that will be impacted by the levee/floodwall has already experienced some level of disturbance or conversion to pavement/asphalt associated with development. Therefore, significant adverse impacts to soils will not occur.

Staging areas will be identified in the PED Phase. There is a possibility that a portion of the staging area will occur in undisturbed locations resulting in potential short-term minor impacts

during construction activities. These areas will be restored through regrading to pre-construction contours/elevations following construction.

No significant impacts to soils as a result of implementation of the nonstructural measures in the project area is expected.

Prime Farmland

The proposed action occurs in an urbanized setting that does not include any additional land uses related to agriculture or silviculture. Therefore, significant adverse impacts to Prime Farmland soils will not occur.

Hydric Soils

A portion of the proposed levee/floodwall is located within areas that have soils that meet hydric soil criteria (Refer to Figure 3 in Appendix A.1). Because there are specific requirements for the type of soil used to construct levees, fill material that meets the construction specifications will be imported in to construct the levee. This will constitute as a change in soil type and will impact hydric soils. However, this impact is limited to the footprint of the levee as is necessary to achieve the desired storm protection. No adverse impacts to hydric soils beyond the levee footprint are expected.

Mitigation Measures

An Erosion and Sediment Control Plan will be developed and submitted to the Somerset-Union Conservation and Freehold Conservation Districts for approval prior to construction the proposed project. Best management practices including but not limited to silt fence, turbidity curtains and temporary seeding will be implemented to reduce soil erosion within the project footprint. Following completion of modifications and structures, temporary work locations will be restored to pre-construction conditions.

6.3 Water Resources

6.3.1 Surface Water

Approximately 100 linear feet of the creek will be modified through the installation of the floodwall and associated drainage structure. Casey's Creek is a tidally influenced tributary that begins at Randolph Ave and flows for approximately 2,700 ft before discharging into the Rahway River. There are two catch basins on Randolph Ave that direct stormwater discharge from the road and into Casey's Creek. The upper portion resembles a drainage ditch with ephemeral flow created by stormwater discharge and high tides. The channel is overgrown with invasive vegetation such as phragmites, Japanese knotweed and tree of heaven. Based on a review of past aerials, the creek width has been significantly reduced, more than likely due to sedimentation, fill activities associated with development, and the overgrowth of vegetation. Approximately 1,500 ft downstream from its origin at Randolph Ave, characteristics of the creek become more reflective of a natural tidal creek with mudflats and high marsh and low marsh wetland complexes. The levee/floodwall is located in the vicinity where Casey's Creek transitions from a drainage ditch to a tidal creek.

The drainage structure will consist of a concrete culvert containing a gate. The gate will remain open during normal flows and will only be closed prior to storm events.

In compliance with the federal objective of no net loss of open water/wetland resources, the District will be evaluating the on-site restoration of 200 linear feet of tidal creek within the wetland complex in which Casey's Creek is located. The goal of the restoration is to improve tidal flow through the realignment or modification of either Casey's Creek or one of the smaller tidal tributaries within the wetland complex.

The implementation of nonstructural measures will have no adverse impacts to the Rahway River or associated tributaries.

Mitigation

Discussions of water resources mitigation, monitoring and adaptive management are described in Section 6.3.2 below.

6.3.2 Water Quality and Aquatic Habitat

The installation of the floodwall and drainage structure in Casey's Creek will permanently adversely effect approximately 100 linear feet equaling to 0.14 acres of natural channel with a silt/clay substrate and shorelines vegetated with herbaceous plant species. Specifically, 0.05 acres of open water and 0.07 acres of tidal mudflat will be converted to an enclosed concrete pipe resulting from the levee drainage structure. This conversion represents a permanent loss of natural open water habitat that may be used by fish and wildlife resources that inhabit or utilize the area.

Although a gate will be installed in the drainage structure and will remain open during normal flows, the enclosed nature of the drainage structure may deter movement of some fish and benthic resources to the upstream portions of Casey's Creek. However, the degraded habitat conditions of the upper portion of Casey's Creek does not provide adequate aquatic habitat and would unlikely be used by many aquatic resources.

In addition, Casey's Creek is located within a 23 acre wetland complex that includes other smaller, tidal tributaries. The total linear footage of available tidal creek habitat within the wetland complex, including the portion of Casey's Creek that is downstream of the proposed floodwall, is 2,400 feet. Excluding the 0.07 acres of mudflat impacted by construction of the floodwall, the wetland complex has approximately 1.3 acres of mudflat habitat.

To compensate for the impact, the District will either obtain credits from a state approved wetland mitigation bank or perform on-site restoration of 200 linear ft of tidal channel equaling to 0.10 acres of open water and 0.14 acres of mudflate within either Casey's Creek or one of the smaller tributaries within the wetland complex and on-site restoration of mudflat habitat.

The availability of other tidal creek and mudflat habitat within the wetland complex in combination with the proposed mitigation will result in no significant adverse impacts aquatic habitat.

Construction of the levee/floodwall and open water and wetland mitigation may create short term, minor water quality impacts within the immediate project area. The implementation of erosion and sediment best management practices such as turbidity curtains will minimize transport of sediment downstream. The installation of the drainage structure and construction of the portion of floodwall extending over Casey's Creek will be conducted in dry conditions utilizing cofferdams or a temporary diversion culvert. The gate will remain open during normal flows and the culvert will be placed at a grade to maintain flow of the creek. Therefore, there will not be any permanent adverse impacts to water quality as a result of the proposed project. There may be minor improvements to water quality through the any on-site compensatory open water/mudflat restoration through the improvement of tidal flows.

It is expected that through the implementation of erosion and sediment control best management practices, that the Rahway River will not be impacted. In addition, the construction of the levee/floodwall and proposed tidal creek/wetland mitigation will not affect the use of the Rahway River as a water source for the City of Rahway given that treatment already occurs and the treatment plant is approximately three miles upstream from the proposed levee/floodwall.

The implementation of the nonstructural measures as proposed will not have any impacts on water quality or aquatic habitat.

Mitigation

Federal mitigation rules typically require wetland compensation to be consistent with a minimum of 1:1 ratio based on functional value using ecological models. However, functional based models become imprecise in differentiating changes in the functional capacity indices/units for smaller acreages. Such is the case with the tidal channel impacts.

The NJDEP is the administering authority of the Section 404 of the Clean Water Act and utilizes a ratio based system of compensatory wetland mitigation. Therefore, the District is following the NJDEP ratio system to determine compensatory mitigation impacts for the tidal channel. In order to determine the appropriate ratio, the District conducted a qualitative analysis of Casey's Creek.

Because the tidal channel is part of a large wetland complex, exhibits mostly natural characteristics with minimal surrounding development, and has the potential ability to support fish species, particularly EFH designated species, the District is designating Casey's Creek as being of intermediate resource value. Therefore, the District will utilize a ratio of 2:1 to create/restore on-site 200 linear ft of tidal creek equaling to 0.10 acres of open water and 0.14 acres of mudflat habitat within the impacted wetland complex.

Refer to Appendicies A.8 and A.9 for further discussion regarding the compensatory mitigation alternative selection process for water resources.

Monitoring and Adaptive Management

Refer to Appendix A.10 for full description of the monitoring procedures and potential adaptive management measures that could be employed to achieve mitigation success.

6.3.3 Wetlands

The implementation of nonstructural measures will have no adverse direct or indirect impacts on wetland resources.

The District has not conducted formal wetland delineations and will not do so until the PED phase. The District utilized New Jersey (NJ Geoweb) and U.S. Fish and Wildlife wetland mapping to assess potential wetland impacts.

The proposed levee/floodwall is located along the upper boundary of a 23 acre wetland complex consisting of several wetland habitat types. In absence of formal wetland delineations, it is assumed that 2.99 acres of wetlands will be impacted by construction of the levee/floodwall. Specific wetland types being impacted by the construction of the levee/floodwall and the required 15 ft vegetation free zone include approximately 1.13 acres of phragmites dominated high marsh, 1.29 acres of low marsh, and 0.57 acres scrub-shrub deciduous wetland (Refer to Figure 4 in Appendix A.1).

The wetland complex has approximately six acres of high marsh dominated by a monotypic stand of phragmites. This area will serve as the compensatory high and low marsh mitigation site. The upper boundaries of the wetland complex will be utilized to restore/create scrub-shrub wetlands.

Approximately 0.55 acres of predominantly phragmites dominated low marsh, 0.44 acres of high marsh wetlands and 0.10 acres of scrub-shrub wetland will experience temporary impacts during construction. These areas will be restored with native vegetation after construction is completed. In areas where phragmites dominates, elevation changes through excavation may occur to manage its reestablishment.

The wetlands identified as managed wetlands in Figure 4, Appendix A.1 within the footprint of the levee have already been extensively modified from actions taken to remediate contamination within the Joseph Medwick Park and install recreational infrastructure (asphalt walking trail, athletic fields). It should be noted that the remediation described in Section 3.8 and the installation of new park facilities were completed in September 2012 (Borough of Carteret, 2012). New Jersey does not routinely update their wetland mapping and the most recent version of wetland mapping available from the state is 2012. Therefore, the wetland mapping does not reflect the disturbance associated with the park remediation and construction. Consequently, the construction of the levee will not cause any direct or indirect impacts to these wetlands that would require compensatory mitigation.

<u>Mitigation</u>

During construction of the levee/floodwall and open water and wetland compensatory mitigation, standard erosion and sediment control BMPs will be implemented to reduce the potential adverse impacts to wetland resources. Where equipment must be operated in wetlands, wetland access/anti-tracking mats will be used to reduce further damage to wetlands.

In accordance with the USACE Civil Works Planning Policy, during optimization of the recommended plan, the District utilized the Evaluation of Planned Wetlands model to identify the scope of compensatory mitigation required to reduce the magnitude of the impacts to below a significant level.

Based on the incremental cost analysis, the most cost effective plan identified the restoration of 1.29 acres of low marsh, 1.13 acres of high marsh, and 1.14 acres of scrub shrub wetland. As mentioned in Section 3.3.3, the District completed a compensatory mitigation project involving the restoration of 14 acres of tidal marsh at the eastern end of Joseph Medwick Park in 2007. Based on cursory site investigations, the site is still functioning as designed and will potentially serve as a reference area for the compensatory marsh restoration proposed for this action.

Further discussion of the mitigation plan is located in Appendix A.8.

Monitoring and Adaptive Management

Monitoring of the compensatory mitigation will be conducted on a bi-annual basis (spring and fall) for a minim of five years. Criteria evaluated to determine success includes evaluating hydrological and soil conditions, measuring tree and shrub growth, and comparing percent areal coverage of native vegetation with invasive vegetative species.

Depending on the results of the monitoring efforts, adaptive management techniques will be employed to ensure success of the mitigation. Refer to Appendix A.10 for the full description of the monitoring procedures and potential adaptive management measures that could be used to achieve mitigation success.

6.3.4 Tidal Influences

The levee/floodwall is set back from the Rahway River and will not interfere with the river's normal daily tidal fluctuations. However, it will limit inundation of developed areas by storm surge for up to a 100-year coastal storm event. The gate in the floodwall drainage structure located in Casey's Creek will remain open during normal flows and will only be closed prior to storm events. The intent of the wetland and open water mitigation is to restore natural tidal creeks and low marsh wetland by lowering elevations and provide better overall tidal inundation and circulation within the project area. The alteration of on-site tidal influences is necessary to manage coastal storm risk as well as improve the hydrology for salt marsh habitat restoration. Significant adverse on-site and off-site impacts are not expected.

The nonstructural component will not have any effect on tidal influences although it will provide protection to treated structures against storm surge for up to a 100-year coastal storm event.

6.4 Vegetation

6.4.1 Uplands and Riparian Corridor

Approximately 0.70 acres of upland vegetation in the form of shrubs and trees will be cleared to for access and construction of the levee/floodwall and the 15 ft vegetation free zone on either

side of the levee as required by ETL 1110-2-583 *Guidelines for Landscape Planting and Vegetation Management at Levees, Embankment Dams and Appurtenant Structures*.

The levee/floodwall is located outside of the 50 ft riparian zone as regulated by the New Jersey Flood Hazard Area Control Act. Therefore, no adverse impacts to riparian vegetation will occur as a result of project implementation.

In regards to nonstructural measures, any clearing of vegetation to implement the nonstructural measures will be limited to what is necessary to construct the specific measure. Therefore, any vegetation immediately adjacent to the structure at which nonstructural measures are implemented may need to be removed. This impact is expected to be negligible and no mitigation is proposed.

Mitigation

Any temporary disturbance to upland vegetation will be compensated through general on-site restoration of native plantings and plantings that support pollinator species where appropriate. As the USACE does not have a policy requiring the compensation of loss of upland vegetation, no compensatory mitigation is proposed.

Monitoring and Adaptive Management

As no compensation for upland vegetation is proposed, any vegetation planted as part of general site restoration will be subject to the USACE's standard one year contractor warranty period. During this time, the construction contractor will be required to perform activities such as watering and weeding to ensure survivability of the plant material. The District will inspect the vegetation for successful establishment and the contractor will be required to replace any plant material that has not survived during this one year warranty period. As the replanting is part of general site restoration and not compensatory mitigation, no other post construction monitoring or adaptive management actions are proposed.

6.4.2 Wetlands

The proposed action will result in insignificant impacts to wetland vegetation. The construction of the levee/floodwall and the 15 ft vegetation free zone will convert approximately 2.99 acres of wetland vegetation to maintained lawn and embankment fill. The majority of the vegetation being converted is phragmites, a non-native and invasive species. The District is proposing on-site mitigation that will restore native marsh and scrub shrub wetland species in areas currently dominated with invasive vegetation to compensate for this loss. The 0.40 acres of area identified as managed wetland is already comprised of turf grass and asphalt. Therefore, further disturbance resulting from the levee construction will not have any adverse direct or indirect impacts.

The nonstructural component of the recommended plan will not adversely impact wetland vegetation.

Mitigation
As mentioned in Section 6.3.3, compensatory mitigation will occur on-site and will utlize native vegetation. Refer to Appendix A.8 for a full description of proposed mitigation.

Monitoring and Adaptive Management
In addition to the one year contractor warranty period, vegetation planted as part of wetland mitigation will be monitored by the District on a bi-annual basis (spring and fall) for a minimum of five years not to exceed 10 years. Refer to Appendix A.10 for full description of the monitoring procedures and potential adaptive management measures that could be employed to achieve mitigation success.

6.4.3 Invasive Plant Species Management

Within the recommended plan footprint, phragmites is the dominant invasive plant species which will require a comprehensive management plan to prevent the unintended spread of it to other locations within and/or downstream of the project area during construction.

The comprehensive plan along with any specific criteria and requirements within the construction plans and specifications for the contractor will be developed in the PED phase. Types of measures that will be assessed include: a) preparation and adherence to an Environmental Protection Plan that includes invasive species management strategies; b) herbicide applications followed by mowing and/or excavation of phragmites before initiating construction; c) implementing proper disposal techniques such as bagging waste containing phragmites plant parts; d) inspection and removal of any phragmites plant parts on equipment to prevent the accidental dispersal of it to other construction sites; and e) ensuring that any materials such as mulch and topsoil are free from from undesirable items such as weeds and invasive species and that equipment be cleaned prior to transport to/from the site in order to prevent transport of invasive plant/animal species.

The non-federal sponsor is ultimately responsible for the long term management and operation of both the coastal storm risk management project features and the mitigation site once the project is turned over. Language describing how to manage invasive plant species and prevent unintended dispersal during maintenance operations will be included in the Operations and Maintenance Manual. In addition, inspections for the occurrence of invasive species may be included as part of the required periodic levee inspection since a 15 ft vegetation free zone from levee/floodwall toe is required. The District will work with the non-federal sponsor to identify potential local environmental groups that could assist the non-federal sponsor in continuing any necessary monitoring and management of invasive plant species.

During the post construction monitoring period of the open water and wetland mitigation, it is assumed there will also be adaptive management actions such as herbicide applications occurring to ensure success of the mitigation.

6.5 Aquatic Resources and Wildlife

6.5.1 Fish

Fish species that would be most impacted by the construction of the levee and open water and marsh wetland restoration would be alewife, American eel, bluefish, mummichog, and striped bass due to the fact that they inhabit tidal creeks and marsh habitat for some or all of their life cycle.

During construction of the levee and open water and marsh wetland mitigation, any juvenile or adult fish within the project area are expected to be mobile enough to leave the area. Erosion and sediment control best management practices will be employed during construction to reduce turbidity. However, there may be a minor increase in turbidity and sedimentation would be generated by the proposed construction activities. The turbidity could hinder predation efficiency of sight feeding species along with suspension/filter feeding species within the creek.

An in-water work restriction from March 1st through June 30th will be implemented . However, there may be a loss of any egg deposits or larvae that may be present in the construction area in the months prior to the in water work restriction window.

In addition, there may be a very localized loss of aquatic macroinvertebrate species within the immediate area of the construction site resulting from excavation associated with levee/floodwall and mitigation construction that may diminish a food source for fish until the aquatic macroinvertebrates recolonize the 200 linear feet of channel restored as part of compensatory mitigation and marsh areas. Recolonization is expected to occur within one month. Given the close proximity of the Rahway River to Casey's Creek, fish will more than likely utilize that river and other tidal tributaries within the vicinity of the project in the interim.

The 200 linear feet of restored channel proposed as compensatory mitigation will create new spawning and foraging habitat.

Because the levee/floodwall construction and marsh restoration will be occurring within the upper portions of the wetland complex, fishery resources within the Rahway River are not expected to experience any significant temporary and/or permanent adverse impacts.

The implementation of nonstructural measures within the project area will not adversely impact fish species.

Mitigation

The use of erosion and sediment control best management practices will minimize sedimentation and turbidity that can negatively impact fish species and their habitat. In addition, an in-water work restriction from 1 March through 30 June as per the NJDEP Flood Hazard Area Control Act Rules will be implemented during construction to protect any spawning fish species. The proposed wetland and open water mitigation will enhance foraging, resting and spawning habitat for fishery resources.

Monitoring and Adaptive Management

No specific monitoring plan will be developed for fish. However, any species observed during the open water and wetland mitigation monitoring investigations may be documented.

6.5.2 Essential Fish Habitat

Direct and indirect effects to EFH species is similar to what is described in Section 6.5.1. A Feasibility level Essential Fish Habitat Assessment has been prepared and is located in Appendix A.5.

Mitigation

Mitigation measures for EFH species are the same as discussed in Section 6.5.1.

Monitoring and Adaptive Management

No specific monitoring plan will be developed for EFH species. However, any species observed during the open water and wetland mitigation monitoring investigations may be documented.

6.5.3 Benthic Resources

Construction of the levee/floodwall and compensatory wetland mitigation could cause the direct mortality of aquatic macroinvertebrates that are not mobile enough to leave the area. Temporary increases in turbidity and suspended sediments near and downstream of the construction activities could cause direct mortality or indirect decreased reproductive success in benthic species over the short-term.

Recolonization of the wetland restoration area is expected after construction. The wetland restoration will aim to restore/enhance aquatic habitat for benthic resources.

Because the levee and marsh restoration will be occurring within the upper portions of the wetland complex, benthic resources within the Rahway River are not expected to experience any significant temporary and/or permanent adverse impacts.

Implementation of nonstructural measures within the project area will not have any adverse impacts on benthic resources.

Mitigation

The use of erosion and sediment control best management practices will minimize sedimentation and turbidity that can negatively impact benthic resources and their habitat. In addition, the in-water work restriction from 1 March through 30 June required by the NJDEP to protect fishery resources will provide similar protection to any benthic resources that also reproduce during this timeframe. The proposed wetland and open water mitigation will enhance foraging, resting and reproduction habitat for fishery resources.

Monitoring and Adaptive Management

No specific monitoring plan will be developed for benthic resources. However, any species observed during the open water and wetland mitigation monitoring investigations may be documented.

6.5.4 Birds

The construction of the recommended plan and associated mitigation will create short-term minor adverse impacts to migratory bird species from the clearing of vegetation as well as noise associated with construction activities. However, since bird species are highly mobile, they are expected to move away from the project area during construction. Furthermore, outside the breeding season these species do not permanently remain in any one location. Implementation of vegetation clearing restrictions will benefit ground and tree-dwelling migratory birds during the breeding season. Therefore, adverse impacts to migratory bird species are expected to be short term and minor, limited to the period of construction. Following construction, bird species are expected to resume their normal habits consistent with post-construction habitat availability in and within the vicinity of the project area.

Mitigation

In order to comply with the Migratory Bird Treaty Act, a clearing restriction of shrubs and trees from 1 April through 31 August will be implemented during construction to avoid adverse impacts to any potential nesting birds that are covered under this act. The proposed upland and wetland mitigation will benefit birds by restoring or enhancing foraging, shelter and nesting habitat will be restored through the re-establishment of native herbaceous, shrub and tree species.

Monitoring and Adaptive Management

No specific monitoring plan will be developed for birds. However, bird species observed during mitigation monitoring investigations may be documented.

6.5.5 Mammals

Construction activities associated with the recommended plan will result in the temporary disturbance of habitat (e.g., vegetation and tree removal). Construction activities also may cause the temporary displacement of these species due to increased human activity and habitat alterations. Shrub and tree-cutting restrictions implemented to protect migratory bird species will provide some protection for tree-dwelling mammal species.

Following construction, mammals are expected to resume their normal habits consistent with post-construction habitat availability in and within the vicinity of the project area. Given that the levee and nonstructural measures are located within developed areas already, the long-term impacts on local mammal populations will be minor.

Mitigation

The re-establishment of upland, riparian and wetland vegetation as described in sections 6.3.3 Wetlands and 6.4.1 Uplands and Riparian Corridor will provide foraging and cover habitat supportive of wildlife.

Monitoring

No specific monitoring plan will be developed for mammals. However, species observed during mitigation monitoring investigations may be documented.

6.5.6 Reptiles and Amphibians

The use of the area located within the footprint of the levee by reptilian and amphibian species is not well documented. Construction activities to replace the levee and mitigation may cause mortality of individuals or less mobile species that reside in the project area. More mobile species will be temporarily displaced from the area and are expected to relocate to other, undisturbed locations of the project area. Following construction, reptile and amphibian species are expected to resume their normal habits consistent with post-construction habitat availability in and within the vicinity of the project area.

Long-term impacts from the levee include effects on movement patterns of some amphibians and reptiles, and loss or modification of habitat. However, given that the levee is located in a developed area, the impacts will be minor.

Implementation of nonstructural measures within the project area will not have significant adverse temporary or permanent impacts on amphibian or reptile species.

Mitigation

The re-establishment of upland, riparian and wetland vegetation as described in Sections 6.3 and 6.4.1 will provide foraging and cover habitat supportive of reptiles and amphibians.

Monitoring and Adaptive Management

No specific monitoring plan will be developed for reptile and amphibian species. However, species observed during mitigation field surveys may be documented.

6.6 Threatened and Endangered Species

6.6.1 Federal, Threatened and Special Concern Species

USFWS Trust Species

Tree clearing activities associated with implementing nonstructural measures and the portion of levee/floodwall located in upland forest could potentially remove Indiana bat and northern long-eared bat summer roosting habitat. In order to avoid adverse impacts to both species, a tree clearing restriction will be implemented during construction. This is a standard protocol in this region that does not require formal consultation with the USFWS. Informal ESA Section 7 consultation was completed as part of the Fish and Wildlife Coordination Act (FWCA) RepAdherence to the 1 March through 31 August tree and shrub clearing restriction during construction will protect any bald eagles and eastern black rail within project area. ort. USFWS concurred with the proposed tree clearing restrictions that will be implemented during construction in their Final FWCA Report dated December 10, 2018. Refer to Appendix A.3 for further information.

Other Species

Adverse effects to the eastern black rail resulting from the recommended plan will be negligible. Based on available information of preferred habitat of the eastern black rail, the marsh and scrub shrub wetlands within the project area can be considered potentially supportive habitat.

However, this habitat is severely degraded due to the presence of non-native and invasive plant species such as phragmites. The restoration of native salt marsh and scrub shrub wetland plant species being proposed as part of compensatory mitigation will enhance eastern black rail habitat and therefore have a positive effect.

Regarding the little brown bat and the tricolored bat, tree clearing activities associated with implementing nonstructural measures and the portion of levee/floodwall located in upland forest could potentially remove summer roosting habitat. The tree clearing restriction proposed to protect Indiana and northern long-eared bat will also protect adverse impacts to both species.

Given that two active bald eagle nests are located within two miles of the project area and the documented sightings of bald eagle at the Hawk Rise Sanctuary directly across the river from the location of the proposed levee, it is presumed that the Rahway River and wetland complexes are used as foraging habitat. The noise and overall activity occurring during the construction of the levee may deter use of this area for foraging by bald eagle. The level of impact, however, is negligible as there are other segments of the river and larger tidal wetland complexes north and south of the levee project that can be used as alternate foraging locations. The proposed wetland restoration to compensate for the permanent wetland impacts related to the levee construction will serve to enhance foraging habitat.

NOAA-NMFS Trust Species

Surveys conducted by the NJDEP and the District within the Rahway River, as discussed in Section 3.5.1, did not identify the presence of shortnose sturgeon or Atlantic sturgeon. In addition, the District conducted finfish surveys in 2006, 2011, 2013, and 2014 within the Arthur Kill as part of the New York/New Jersey Harbor Deepening Project (USACE, October 2104)(USACE, November 2013)(USACE, January 2013)(USACE, September 2007). One of the sampling stations established for the surveys was located within the Arthur Kill near the confluence of the Rahway River. Based on the results of the surveys, no sturgeon were collected at either the sampling station near the Rahway River or at other sampling stations within the Arthur Kill.

Therefore, it is the District's position that neither Atlantic sturgeon nor shortnose sturgeon occur within the project area and that implementation of the recommended plan will have no effect on these species or their critical habitat. A No Effect Determination has been developed and is located in Appendix A.1. Formal consultation with NOAA-NMFS will not be required.

Mitigation

A tree clearing restriction extending from 1 April through 30 September will be implemented during construction to protect the Indiana bat and northern long eared bat. Alternatively, if clearing must occur within this timeframe, a presence/absence survey will be conducted prior to construction with results coordinated with USFWS. A preference to tree species that provide roosting habitat for Indiana bat and northern long eared bat will be given to the 0.15 acres of upland forest that will be temporarily impacted and restored after construction.

Regarding eastern black rail, as this species was not included on the official endangered and threatened species list obtained from USFWS for the project, no specific measures will be taken to avoid/minimize impacts to this species. However, the vegetation clearing restriction associated with Migratory Bird Treaty Act compliance will provide protection to this species. The District will conduct informal consultation with the USFWS during the PED phase to ensure that no changes related to the potential presence of this species within the project area has occurred.

Regarding American bald eagle, the District will coordinate with the USFWS prior to construction to determine if recommendations for avoiding disturbance at foraging areas and communal roost sites as outlined in the National Bald Eagle Management Guidelines will be required during construction.

The re-establishment of native vegetation within the project area and mitigation sites will restore bald eagle habitat.

As no NOAA-NMFS Trust Species occur within the project area, no mitigation measures are proposed.

Monitoring

No post construction monitoring will be conducted for Indiana bat and/or northern long-eared bat. No specific post construction monitoring plans for bald eagle will be developed although any observations of this species during mitigation monitoring field surveys may be documented.

6.6.2 State Endangered, Threatened and Special Concern Species

As state endangered, threatened and special concern species known to occur in the project area are bird species, the impacts associated with the project are similar to what was discussed in section 6.5.4 Birds.

Mitigation

Compliance with the Migratory Bird Treaty Act, shrub and tree clearing from 1 April through 31 August will minimize adverse impacts to state endangered, threatened and special concern species. The re-establishment of upland and wetland habitats as described in sections 6.4.1 and 6.4.2 will provide foraging and cover habitat supportive of wildlife.

Monitoring

No specific monitoring plan will be developed for state endangered, threatened or special concern species. However, bird species observed during mitigation monitoring field surveys may be documented.

6.7 Socioeconomics

The proposed action is not expected to adversely impact the socioeconomic environment of the area. During construction of the levee and floodwall, approximately five property owners within the project area may be unable to fully utilize their property. Additionally, they may be required to move or dissemble structures such as sheds and above ground swimming pools to

accommodate construction. Permanent easements will be required for maintenance, inspection and operational requirements. However, property owners will be compensated for the easement at its market value for the effect on the property. Refer to Appendix E for further description of properties impacted and compensation.

Long term benefits achieved by the project include flood risk management benefits such as reduced damage to property, protection of business and residential structures, improved public health and safety, reduced traffic delays and emergency access for the fire department, medical personnel and police protection.

6.8 Environmental Justice

As discussed in Section 3.7.2 Environmental Justice, Environmental Justice considerations are applicable to the cities of Rahway and Linden, the Borough of Carteret and the Township of Woodbridge.

The location of the levee is sited to maximize management of coastal storm risk to the community, with adjacent structures receiving the most coastal storm risk management benefits.

Participation in floodproofing and elevation is in all cases voluntary and serves as a measure to reduce the risk of loss of life and property damage due to flooding. Property owners who opt to receive nonstructural measures will be compensated at the fair market cost for the construction of the measures.

Notifications for public information meetings, the release of the Draft FR/EA were distributed to elected officials and were posted on the websites of each municipality.

No local community activist groups focused on Environmental Justice issues within the study area were identified during stakeholder and public coordination. Coordination with the elected officials have not raised any issues that would require an in depth analysis related to Environmental Justice concerns. In addition, the District did not receive any comments during the Draft FR/EA comment period regarding Environmental Justice concerns.

Therefore, there will be no significant and disproportionate adverse impacts to residents of the Borough of Carteret or cities of Rahway and Linden.

6.9 Hazardous Toxic and Radioactive Waste

Based upon the review of the existing databases, none of the sites on the KCS list and no Superfund sites are located within or adjacent to the footprint of the levee and floodwall. The remediation undertaken by Middlesex County as part of the reconstruction and upgrade to Joseph Medwick Park involved excavation of contaminated soil and capping with 10 inches of clean soil or impervious surfaces. Coordination between the District, its study sponsor NJDEP, and Middlesex County ultimately resulted in a commitment by Middlesex County to remediate the HTRW before the recommended plan would be constructed, which would allow USACE to recommend construction of the project to Congress. The construction of this project would not have an impact on HTRW within the park and environs. It is possible that unknown and

unreported sites may be identified as part of pre-construction engineering and design. Geotechnical investigations and soil testing will be conducted prior to any construction activities associated with the project features, as necessary.

According to USACE policy, no elevation or floodproofing can occur to structures with asbestos and/or asbestos-containing materials if the proposed actions may affect the asbestos and/or asbestos-containing material. Prior to any actions being conducted, the asbestos and/or asbestos containing material that may be disturbed by the elevation or floodproofing activity must be removed. For all structures proposed for nonstructural measures, an asbestos investigation will be conducted to confirm the presence/absence of damaged or friable asbestos or asbestos-containing materials. If damaged or friable asbestos or asbestos-containing materials are confirmed on a property and have been determined to be impacted by the implementation of nonstructural measures, the property owner will be obligated, at his/her cost and expense, to conduct all necessary response and remedial activities in compliance with all applicable local, state, and federal laws and regulations. Asbestos and asbestos-containing materials that would not be affected by implementation of the recommended nonstructural measures would not need to be removed prior to construction.

6.10 Cultural Resources

NEPA and Section 106 of the National Preservation Act of 1966 (NHPA), as amended, requires that all federal agencies consider the potential effects of their proposed undertakings on cultural and historic resources. The Area of Potential Effect (APE) is the geographic extent to which an undertaking may directly or indirectly cause changes in the character or use of historic properties (NHPA, 36 CFR 800.16[d]).

The APE for the recommended plan consists of the structures for which nonstructural measures are recommended and their immediate vicinity, the levee/floodwall alignment, the segment of Engelhard Avenue that will be raised and all staging, easement, and mitigation areas which are to be determined during the next phase of the project, the PED phase.

6.10.1 Nonstructural Measures

Elevations and floodproofing of structures has the potential to cause adverse effects to the structures as well as to associated outbuildings and archaeological sites that may exist within the APE. Impacts to historic districts are also possible should the nonstructural measures result in the loss of contributing resources or alter the historic character of a neighborhood.

There are no documented archaeological sites within the APE for the nonstructural measures associated with the proposed undertaking. Four historic districts are located within or adjacent to the APE for nonstructural measures. These are the Rahway River Parkway Historic District, the Lower Rahway/Main Street Historic District, the Union County Parks System Historic District and the Upper Rahway Historic Districts. Of the structures identified for treatments, thirteen have been documented as part of the Upper Rahway Historic District and one is within the Lower Rahway/Main Street Historic District.

The Rahway River Parkway is contained within the boundaries of the Union County Parks System Historic District. Several structures identified for nonstructural measures are located within a short distance from the District boundaries in what is potentially the historic viewshed of the Rahway River Parkway and Union County Parks System Historic Districts. The structures located along River Road, West Grand Ave, and Irving St are likely to lie within the viewshed.

Additional structures within the APE for nonstructural measures may be eligible for the National Register of Historic Places but have not been subject to architectural survey. Many of the documented historic structures within the APE were last evaluated in the 1980's and should be evaluated again to determine whether they have retained their qualifying characteristics or have been significantly altered or demolished in the intervening time resulting in a loss of integrity. The Upper Rahway Historic District and the Rahway River Parkway Historic District should be re-evaluated as well to determine the status of their contributing resources and to better define their physical and viewshed boundaries within the APE.

6.10.2 Levee/Floodwall and Road Raising

The alignment for the levee and floodwall runs along the right side of the Rahway River separating the River from nearby residential and commercial properties and certain Joseph Medwick Park facilities. There is one historic property recorded within the APE for the levee/floodwall, the Inch Lines Linear Multistate Historic District. The pipeline, which is underground, is a contributing element to the district. There are no additional archaeological sites or historic properties documented within the APE for the levee/floodwall.

A review of survey reports, including a 1998 inventory of the pipeline confirmed that there are no above-ground contributing elements to the historic district located within the APE. The closest above-ground element is the Linden Station (Station 27), located in Linden, NJ, approximately 1 mile northeast of the proposed levee (Berger 1998). The elements of the historic district that are expected to be encountered within the APE are the pipeline itself and associated components lying underground.

The 1998 inventory posited that large portions of the pipeline in the east have been replaced over the years as segments wore out or became damaged (Berger 1998). However, an archaeological monitoring survey completed in 2013 for replacement of a section of the pipeline in Linden, NJ referenced schematic maps provided by FERC that showed much of the pipeline was actually original (PAL). Confirmation of the status of the pipeline in that particular location was achieved through monitoring. In the end, the archaeologist performing the monitoring found that much of the pipeline and components had not been replaced and were, in fact, original. The results of the monitoring work in Linden suggests that there is potential for original below-ground pipeline and associated components to exist within the current APE.

Development of Joseph Medwick Park and remediation activities is likely to have disturbed certain historic and prehistoric deposits if they exist within the APE. Archaeological testing in 2010 along a portion of the levee alignment in association with park development revealed areas with high levels of disturbance within the first two to four feet (Maser Consulting 2010). However, there is potential for deeply buried prehistoric archaeological remains within the APE

for the levee as well as moderate potential for historic archaeological sites to exist based on the historical record and documentation from archaeological sites in the area.

6.10.3 Future Section 106 Compliance

As the project advances into the Pre-Construction, Engineering and Design phase additional architectural and archaeological investigations will be necessary to complete identification of significant resources within the APE. In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended and its implementing regulations, 36 CFR 800, a Programmatic Agreement has been prepared that serves as a binding agreement between the NJHPO and the District that outlines the activities and tasks that must be carried out to conclude identification of significant resources, determine adverse effects, and mitigate for those adverse effects.

The survey activities outlined in the Programmatic Agreement include carrying out archaeological and architectural investigations within the locations of project elements, and coordination and consultation with the NJHPO, interested parties and federally recognized tribes. The Programmatic Agreement also stipulates that, depending upon the results of the architectural and archaeological surveys, treatment plans or standard mitigation agreements will be prepared to outline the specific mitigation measures that will be taken to address adverse effects to structures and archaeological sites that cannot be avoided.

Treatment plans or mitigation agreements will be developed based on the results of the architectural and archaeological surveys as well as coordination with the NJSHPO and interested parties but may include:

- specialized design guidelines for historic structures receiving nonstructural measures to ensure that flood protection measures are consistent with the historic fabric of the buildings and to reduce cumulative impact to historic districts;
- HABS/HAER documentation of historic structures that are to be adversely affected by nonstructural measures;
- the design of the project elements along the River to fit the character of historic districts;
- monitoring during construction activities to ensure avoidance or minimization of adverse effects to archaeological sites or to buried historic features including possibly the Inch Lines Linear Multistate Historic District; and
- data recovery for archaeological sites that cannot be avoided.

6.11 Recreation

The implementation of the levee/floodwall will have mostly temporary adverse impacts to recreational use of Joseph Medwick Park. The proposed levee footprint is within the current alignment of a portion of the Medwick Park Trail. This segment of the trail will be closed off to the public during construction and will disconnect the northern end of the park from the southern end of the park throughout the duration of construction of the portion of the levee within the park. Upon completion of the project, recreational uses and activities of the affected parks will resume.

Implementation of the nonstructural flood risk management measures will not have any long term adverse impacts on recreation within the project area.

Mitigation

Specific mitigation measures that will be evaluated to reduce the limited short-term and long-term effects of the recommended plan on recreation include:

- Installing a footpath on the top of the levee to continue the current alignment of the Medwick Trail;
- Replacing the wildlife observation deck that is partially located within the levee and vegetation free zone footprint. The District will evaluate installing ramps from the levee to allow for equipment access on both sides of the levee. As part of the evaluation, the District will assess locating at least one of the ramps near the wildlife observation deck to facilitate access to the deck by park patrons.
- Planting native herbaceous, shrubs and trees within the park after construction, which include the restoration of 1.29 acres of low marsh, 1.13 acres of high marsh and 1.14 acres of deciduous scrub shrub wetland;
- Situating construction access and staging areas away from the park facilities such as the tennis courts and athletic fields to the greatest extent practicable. This evaluation will occur during the PED phase;
- Erecting temporary fences and other physical barriers to control movement through construction areas and maintain a safe distance for pedestrians; and
- Installing signage that informs residents and others using affected recreational spaces of the proposed action's purpose and closure duration.

6.11.1 Green Acres Program

Under the Green Acres program, lands obtained or developed with Green Acres funding and lands held by a local government for recreation and conservation purposes must permanently remain in use for recreation and conservation purposes. In general, lands subject to the rules of the program cannot be disposed of or diverted unless it can be demonstrated to the State that the modification will protect or enhance the use of the area. By definition in the Green Acres Rules, land that is used for purposes other than recreation and conservation is considered a "diversion" while a "disposal" is the selling, donating, or some other form of permanent transfer of possession of parkland.

Flood/storm risk management measures such as levees and floodwalls are typically considered as diversions under the Green Acres Rules. Joseph Medwick Park is encumbered by Green Acres restrictions. However, the proposed levee is a component of a coastal storm risk management project that provides regional benefits and will ultimately protect park facilities such as the tennis courts, athletic fields and playground up to the 1% coastal storm event. In addition, the mitigation measures described in Section 6.10 will minimize the permanent adverse impacts to the use of the park. Therefore, the levee/floodwall will not have significant long term adverse impacts to the park or contravene the intent of Green Acres regulations.

The District will maintain coordination with representatives from the Green Acres Program throughout all phases of the project to ensure compliance with the Green Acres rules. The nonstructural measures within the project area will not have any temporary or long term impacts to Green Acres lands.

Mitigation

Mitigation measures are discussed in Section 6.10 Recreation.

Monitoring and Adaptive Management

There are no post construction monitoring and adaptive management measure requirements associated with the mitigation of Green Acre resources.

6.12 Aesthetics and Scenic Resources

The construction the recommended plan will have short-term minor and long-term adverse impacts to aesthetic and scenic resources. In the short-term, the presence of construction equipment and active construction activities throughout the project area will result in minimal temporary impacts to each construction site's immediate aesthetics and scenic resources. In the long term, the levee will obscure views of the Rahway River and wetland complexes to park patrons and the eight homes that are located adjacent to the proposed levee. However, a footpath will be installed on the levee and the wildlife observation deck will be replaced to enable viewing of the river and wetlands. In addition, the aesthetics of the wetland complex will be enhanced through the proposed on-site mitigation of restoration low marsh habitat. The levee will be stabilized with grass to maintain a relatively natural appearance. Therefore, there are no significant adverse impacts to aesthetics and scenic resources.

The implementation of nonstructural measures within the project area is not expected to result in significant adverse impacts on the area's aesthetics and scenic resources.

Mitigation

Mitigation measures that will be implemented to minimize impacts to aesthetics include:

- Replanting disturbed areas outside of the 15 ft vegetation free zone associated with the floodwall/levee with native vegetation. The District will consider the use of tree stock ranging from 8-14 ft in height in lieu of saplings.
- Installation of a footpath on the levee to maintain access for viewing the river and wetland complexes.
- Stabilizing the levee with grass.

6.13 Coastal Zone Management

The recommended plan and associated mitigation measures are in compliance with all applicable policies. A Coastal Zone Management Statement of Compliance has been prepared and is located in Appendix A.

Mitigation

There are no specific mitigation measures required for Coastal Zone Management. The mitigation measures being proposed to compensate for impacts to wetland resources, public access, recreation and infrastructure are addressed in the applicable policies within the Coastal Zone Management Compliance Statement.

Monitoring and Adaptive Management

There are no monitoring and/or adaptive management requirements associated with Coastal Zone Management.

6.14 Transportation

Traffic will likely increase on local roads as a result of the transportation of construction equipment and materials and workers commuting to the levee and nonstructural measures project areas.

The impacts on transportation will not be concentrated in any one location for extended periods of time and will relocate to other areas within the levee alignment as construction progresses. These are short term and will end once construction is completed. The downstream segment of the levee project area consists of narrow, dead-end residential roads. The use of these streets by equipment and vehicles during construction of the levees will be minimized to the greatest extent practicable for safety and logistical reasons.

Long term positive impacts resulting from the levee includes a reduction in road closures due to flooding and clean-up of any debris deposited on roads during flood events.

Mitigation

In order to minimize impacts to traffic during construction, traffic control and operations strategies that may be implemented during construction may include:

- Preparing a comprehensive Construction Traffic Management Plan. This plan will be developed by the contractor in the Construction phase and will be coordinated with the appropriate municipal and/or county officials and affected property owners as necessary;
- Routing and scheduling construction vehicles to minimize conflicts with other traffic;
- Strategically locating localized staging areas to minimize traffic impacts; and
- Establishing detours and alternate routes when it is important to close the work area to perform certain construction tasks or when diverting traffic will substantially reduce traffic volumes.

6.15 Air Quality

The project will produce temporary localized emission increases from the diesel powered construction equipment working onsite. The localized emission increases from the diesel-powered equipment will last only during the project's construction period and then end when the project is over, thus any potential impacts will be temporary in nature.

As stated in the Air Quality Section (Section 3.14), Middlesex and Union Counties have been designated with the following attainment status with respect to the NAAQS for criteria pollutants: 'moderate' nonattainment area for the 2008 8-hour ozone standard, maintenance for the 2006 $PM_{2.5}$ standard, and Union County is in maintenance of the 1971 CO standard. The counties are part of a larger Ozone Transport Region. Ozone is controlled through the regulation of its precursor emissions, which include NOx and VOCs. VOCs are emitted at a fractional rate compared to NOx emissions. SO_2 is a precursor for $PM_{2.5}$. Because of these designations and since the project is a Federal Action taken by the USACE, this project triggers a General Conformity Review under 40 CFR §93.154. General Conformity ensures that Federal Actions do not have a negative impact on State Implementation Plans (SIPs). For the pollutants to be emitted as part of the project, the annual de minimis levels are: 100 tons for NOx, 50 tons for VOC, and 100 tons for CO, $PM_{2.5}$, and SO_2 (each pollutant separately). Projects that don't have any annual emissions exceeding these threshold levels are considered to be in conformity with the SIP.

The emissions associated with the project are estimated as part of the General Conformity Review and are summarized below, by calendar year.

POLLUTANTS IN TONS

CALENDAR YEAR	NO_X	VOC	SO_X	$PM_{2.5}$	CO
2019	17.0	0.3	0.0	0.3	2.2
2020	68.0	1.4	0.0	1.2	8.7
2021	56.7	1.2	0.0	1.0	7.3

The Project's General Conformity-related annual emissions are significantly below all of the de minimis levels. Therefore, by rule (40 CFR §93.153 (b)), the Project is considered de minimis and will have only a temporary impact around the construction activities with no long-term impacts and no negative effects on the applicable SIP. Documentation of the emissions calculations is included in Appendix A.7.

Mitigation

Because the impact on air quality will be less than significant, no mitigation measures will be required outside of existing air quality regulations. NJDEP outlines requirements applicable to construction, such as controlling fugitive dust and open burning. All persons responsible for any operation, process, handling, transportation, or storage facility that could result in fugitive dust will take reasonable precautions to prevent such dust from becoming airborne. Reasonable precautions and best management practices (BMPs) might include using water to control dust from disturbed areas. In addition, construction will be performed in full compliance with current New Jersey Air Pollution Control requirements (N.J.A.C. 7:27-1-34), with compliant practices and/or products. These requirements include the following:

- Control and Open Prohibition of Burning (N.J.A.C. 7:27-2.3B)
- Control and Prohibition of Air Pollution from Diesel-powered Motor Vehicles (N.J.A.C. 7:27-14.15)

This listing is not all-inclusive; the USACE and contractors will use BMPs during construction and comply with all applicable air pollution control regulations.

6.16 Noise

The implementation of the proposed action will result in an increase in short-term minor adverse impacts related to noise. The specific impact of construction activities on the nearby receptors will vary depending on the type, number, and loudness of equipment in use. Excavators and other heavy equipment, truck removal of excavated material, and the delivery of riprap and concrete to workspaces will be the primary sources of noise. Individual pieces of heavy equipment typically generate noise levels of 80–90 dBA at a distance of 50 ft (15 m). With multiple items of equipment operating concurrently, noise levels can be relatively high during daytime periods at locations within several hundred feet of active construction sites. The zone of relatively high noise levels typically extends to distances of 400–800 ft (122–244 m) from the site of major equipment operations. Locations more than 800 ft (244 m) from construction sites seldom experience substantial levels (greater than 62 dBA) of noise.

Property owners within the footprint and vicinity of the nonstructural measures and within the vicinity of the levee will experience appreciable amounts of noise from heavy equipment during construction. However, given the temporary nature of proposed construction activities and the limited amount of noise that heavy equipment would generate, this impact will be minor. In addition, limited truck and worker traffic may be audible at locations along haul roads and roadways approaching the construction area. These impacts also will be negligible. Levee construction and associated noise will not be concentrated in any one location for extended periods of time. Impacts to the noise environment will move from one area to another as construction progresses.

There will be no permanent or ongoing sources of noise from the proposed action. Noise will end with the construction phase; therefore, there will be no long-term or significant impacts on the noise environment.

Mitigation

Because the impact to the noise environment will be less than significant, no mitigation measures will be required. Construction activities will adhere to the applicable noise ordinances within the municipalities in which the construction is occurring.

6.17 Summary of Mitigation

The various mitigation measures being considered to avoid, minimize, reduce or compensate for the adverse environmental impacts expected from implementation of the proposed action are summarized in Table 6-1.

Table 6-1. Summary of Mitigation Measures
(spans three pages)

Land Use
- Disturbed areas will be restored and their use returned to pre-construction land uses.

Soils
- Implementation of Erosion and Sediment Control Best Management Practices (BMPs) during construction, including the installation of a cofferdam or temporary culvert diversion to install the floodwall drainage structure in Casey's Creek and to construct the floodwall over Casey's Creek.

Water Resources
- Implementation of Erosion and Sediment Control Best Management Practices (BMPs) during construction, including the installation of a cofferdam or temporary culvert diversion to install the levee drainage structure in Casey's Creek and to construct the floodwall over Casey's Creek.
- Restoration of 200 linear feet of tidal creek including 0.14 acres of mudflat habitat.
- Maintaining an open gate on the floodwall drainage structure in Casey's Creek during normal flows.

Wetlands
- Implementation of Erosion and Sediment Control BMPs including the use of wetland access/anti-tracking mats.
- Compensation of wetland habitat through restoration of:
  - 1.29 acres of low marsh habitat
  - 1.13 acres of high marsh habitat
  - 1.14 acres of deciduous scrub shrub wetland
- Restoration of 0.55 acres of low marsh habitat, 0.44 acres of high marsh habitat, 0.10 acres of scrub shrub wetland and 0.15 acres of upland forest subject to temporary impacts during construction.

Vegetation
- Restoration of 0.15 acres of upland forest vegetation temporarily impacted by construction activities.
- Establishment of a total of 3.56 acres of native vegetation through compensatory wetland mitigation.

Aquatic Resources and Wildlife
- Tree and shrub clearing restriction from 1 March through 31 August to comply with the Migratory Bird Treaty Act
- Tree clearing restriction from 1 April through 30 September to protect Federally listed endangered and threatened bat species.
- Re-establishment of native herbaceous, shrub and tree species in disturbed areas and compensatory mitigation areas.
- In-water work restriction from 1 March through 30 June to protect spawning fish species.
- Restoration of 200 linear feet of tidal creek including 0.14 acres of mudflat habitat.
- Restoration of 1.29 acres of high marsh wetland habitat.
- Restoration of 1.13 acres of low marsh wetland habitat.
- Restoration of 1.14 acres of deciduous scrub shrub habitat.

Cultural Resources
- The project has the potential to have an adverse impact on historic properties, however, additional investigation is required to determine what properties will be impacted. A Programmatic Agreement among the New York District and the New Jersey State Historic Preservation Office (NJSHPO) has been prepared that outlines the steps that will be taken to determine adverse effects and the appropriate mitigation measures in consultation with interested parties (see Appendix A). Some mitigation measures to be considered include HABS/HAER documentation of historic structures, archaeological data collection, replacing or providing substitute resources, monitoring during construction, and enhancement of historic districts through signage and public outreach.

Recreation
- Planting native herbaceous, shrubs and trees within Joseph Medwick Park after construction.
- Erecting temporary fences and other physical barriers to control movement through construction areas and maintain a safe distance for pedestrians
- Installing signage that informs residents and others using the effected recreational spaces of the proposed actions purpose and closure duration.
- Installing a footpath on top of the levee.
- Replacing the existing wildlife observation deck following construction of the levee.

Aesthetics and Scenic Resources
- Replanting disturbed areas with native herbaceous, shrub and tree material after construction.

Transportation
- Preparation of a Construction Traffic Management Plan.
- Routing and scheduling construction vehicles to minimize conflicts with other traffic
- Strategically locating localized staging areas to minimize traffic impacts; and
- Establishing detours and alternate routes when it is important to close the work area to perform certain construction tasks or when diverting traffic will substantially reduce traffic volumes.

Air Quality
- Because the air emissions are below de minimis levels for NO_x, VOC, $PM_{2.5}$ and SO_2, no specific mitigation is required. Construction will be performed in compliance with current New Jersey Air Pollution Control requirements (N.J.A.C. 7:27-1-34).

Noise
- Construction will occur within the timeframes allowed as per local noise ordinances.

6.18 Compensatory Mitigation

As discussed in Sections 6.3.2 Water Quality and Aquatic Habitat and 6.3.3 Wetlands, compensatory mitigation is being proposed for impacts to marsh, tidal creek and scrub-shrub wetland resources.

USACE guidance requires mitigation plans be selected based on an analysis that determines the most cost effective plan through an incremental cost analysis (ICA). Based on the ICA, the most cost effective plan identified the restoration of 1.29 acres of low marsh wetland, 1.13 acres of high marsh wetland and 1.14 acres of scrub shrub wetland.

Impacts to the tidal channel are estimated at 0.10 acre. Functional assessment models become imprecise in that they are unable to differentiate functional capacity indices/units between existing conditions and various mitigation alternatives with acreages this small. As a result, the District conducted a qualitative analysis to determine the resource value of the tidal channel as being intermediate value. Therefore, for cost estimation purposes, the District assumed creating 200 linear feet of tidal creek with 0.14 acres of mudflat. Refer to Appendix A.8 for additional details on the impact/mitigation assessment and A.9 for details on the CE/ICA analysis.

As Federal mitigation requirements do not establish a definitive monitoring duration, the District will follow the NJDEP requirements which mandate a minimum five year monitoring period. Surveys to assess compensatory mitigation success will occur in the spring and fall annually. The non-federal sponsor will be responsible for the monitoring. Monitoring is not to exceed ten years. Should success of the compensatory mitigation measures be determined in less than five years, monitoring will either cease or be continued by the non-federal sponsor at their cost. Refer to Appendix A.10 for additional details on the proposed mitigation, monitoring and adaptive management measures. First Cost, Monitoring and Adaptive Management Costs for the proposed compensatory mitigation are included in Table 6-2.

Table 6-2. Wetland Mitigation Cost Summary

Mitigation Feature	Cost
Construction	$2,912,000
Monitoring (5 years)	$142,850
Adaptive Management	$195,101

Chapter 7.0 Cumulative Effects*

The Council of Environmental Quality (CEQ) defines cumulative effects 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 or individual takes the action.

The cumulative impact analysis encompasses the Rahway River Basin. As stated in previous sections of the report, the Rahway River has experienced modifications related to the development of infrastructure and water supply. In addition to the cumulative impacts associated with those disturbances, the cumulative impacts analysis evaluates the impacts associated with past, present and foreseeable future actions listed in Tables 1-1, 1-2, and 1-3 in Chapter 1 of this report.

7.1 Land Use

The recommended plan will not contribute to significant adverse cumulative effects to land use. The recommended plan, when combined with other past, current and future flood and coastal storm risk management measures implemented in the basin will serve to protect current land uses.

7.2 Topography, Geology and Soils

The recommended plan will not contribute to significant adverse cumulative impacts to topography, geology and soils. The recommended plan and other actions within the Rahway River Basin will be required to prevent soil erosion through the preparation and implementation of an erosion and sediment control plan. In addition, any activities proposing to change the existing grade within the floodway and flood hazard area as defined by the NJ Flood Hazard Area Control Act must obtain a permit from the NJDEP and demonstrate that the action will not induce flooding to other properties. The recommended plan will provide a cumulative benefit of regional flood/coastal storm risk management within the Rahway River Basin when combined with changes in topography related to other past, current and future flood/coastal storm risk management projects,

7.3 Water Resources

The recommended plan, current and future actions as listed in Tables 1-1, 1-2, and 1-3 will be required to protect water quality in and adjacent to water bodies through the implementation the acquisition of water quality certifications, wetland permits that include mitigation requirements for water resource impacts, State Pollution Discharge Elimination Systems permits and implementation of erosion and sediment control BMPs. Therefore, the recommended plan will not contribute to adverse cumulative impacts to water resources.

7.4 Vegetation

The recommended plan will result in short-term minor and long-term moderate adverse impacts to upland and wetland vegetation within the project area. Short-term impacts include removal of vegetation within construction workspaces. Vegetation will be reestablished within these areas

after construction to minimize short term cumulative adverse impacts. The proposed mitigation discussed in previous sections of the report will minimize the recommended plans contribution to significant adverse cumulative impacts to vegetation.

7.5 Fish and Wildlife

The recommended plan is expected to have minor cumulative impacts to fish and wildlife resources. The proposed upland, wetland and open water mitigation discussed in previous sections of the report will minimize significant adverse cumulative impacts. In addition, actions taken by others that effect aquatic, wetland and riparian habitat are subject to permit mitigation requirements. Any mitigation actions taken by others in conjunction with any ecosystem restoration projects could improve fish and wildlife habitat throughout the watershed.

The recommended plan will not have significant adverse cumulative impacts to state and/or Federal endangered, threatened and special concern species that may occur in the project area. Nor will it have a significant adverse cumulative impact to Essential Fish Habitat species.

7.6 Socioeconomics and Environmental Justice

In general, the objective of the recommended plan and other flood risk management measures implemented within the Rahway Watershed is to provide a long term risk reduction to loss of life and property/infrastructure damages resulting from flood events.

The recommended plan will have no adverse cumulative impacts on the existing demographics, economy, housing and Environmental Justice communities in the geographical region analyzed for cumulative impacts. Increasing storm and flood risk management will reduce damage to property and infrastructure within the study area; thus implementation of the recommended plan is expected to benefit the local economy and housing in the long term.

All of the actions considered could produce positive cumulative socioeconomic impacts within the watershed by reducing flooding, which is disruptive to socioeconomic conditions.

7.7 Hazardous, Toxic and Radioactive Waste

The recommended plan will not contribute to the release and/or exposure of HTRW substances. All state and federally permitted actions, including the recommended plan, must implement measures such as erosion and sediment BMPs and/or an environmental protection plan to manage the risk of improper release, exposure and disposal of HTRW substances.

7.8 Cultural Resources

Cumulative impacts from nonstructural measures could potentially include adverse effects to historic districts from loss of multiple contributing historic properties or archaeological sites. If the construction of the levee leads to a loss of contributing elements of the Inch Lines Linear Multistate Historic District and other losses along the pipeline occur cumulative impacts to the District as a whole could be realized. As part of on-going consultation with the New Jersey State Historic Preservation Office and other consulting parties mitigation efforts will look to avoid, minimize, or mitigate for those cumulative effects. Activities to avoid, minimize, or mitigate for

cumulative effects may include design of project elements to conform to the defining characteristics of a historic district, HABS/HAER documentation to contribute to the general knowledge of a specific class of historic property or a district, and archaeological data recovery to document archaeological sites that could be lost as a result of the project.

7.9 Recreation

The recommended plan will not contribute significantly to adverse impacts to recreation. Rather, the recommended plan, combined with other flood and coastal storm risk management projects conducted by the USACE and others will protect recreational facilities and publicly owned open spaces. Measures to minimize adverse cumulative impacts to recreation include replanting disturbed areas with native herbaceous, shrub and tree material, including a footpath on top of the levee, and replacing the wildlife observation deck.

7.10 Aesthetics and Scenic Resources

Based on the location of the recommended plan and other actions listed in Tables 5-7, it is not anticipated that there will be significant, cumulative long-term impacts. Most impacts will be short-term effects resulting from construction activities. The timing of the implementation of the recommended plan and any other actions is such that it is not anticipated that construction noted actions will be concurrent.

7.11 Transportation

The recommended plan will not have any adverse cumulative impacts on transportation. Positive cumulative impacts resulting from the combination of the recommended plan and with past, actively occurring or future flood risk management actions will be the reduction in road closures and damage to transportation infrastructure due to flooding within the Rahway River watershed.

7.12 Air Quality

The recommended plan will not have any adverse cumulative impacts on air quality. Air emissions related to land-based construction activities are a short-term and local impact accounted for in New Jersey's State Implementation Plan (SIP). There are no operable parts of the completed project that will result in air emissions.

7.13 Noise

The recommended plan will introduce short-term increases in the noise environment from construction. These changes will have a negligible cumulative effect. There will be adverse cumulative impacts on the existing environment once construction is completed.

Chapter 8.0 Coordination & Compliance with Environmental Requirements

A public information meeting was held in May 2015 in order to inform regulatory agencies and the public of the feasibility study process and to solicit feedback. Meetings to discuss the preliminary coastal storm risk management alternatives were held with staff from the NJDEP Bureau of Flood Control and Dam Safety. A meeting was held in March 2017 with representatives from the New Jersey Green Acres Program to discuss the recommended plan (Refer to Appendix A.8).

The District coordinated with the USFWS New Jersey Field Office as it relates to the Fish and Wildlife Coordination Act and Section 7 of the Endangered Species Act. A Final Fish and Wildife Coordination Act Report was prepared December 2018 and is located in Appendix A.3. Informal consultation under Section 7 of the Endangered Species Act of 1973 was completed via the FWCA.

The District completed coordination with the NOAA-NMFS as it relates to Essential Fish Habitat on April 10, 2019. Correspondence between the District and the NOAA-NMFS is located in Appendix A.8. The EFH Assessment is located in Appendix A.5. A No Effect Determination regarding Endangered Species is located in Appendix A.1. Per NOAA-NMFS guidance, the District does not need to obtain concurrence from the agency on No Effect Determinations.

The District has consulted with the New Jersey State Historic Preservation Office (NJSHPO), Federally Recognized Tribes with significant cultural heritage in the region, and local historical organizations. The District has prepared a case report and Programmatic Agreement in accordance with NEPA and Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify cultural and historic resources and historic properties eligible for or listed on the NRHP within the study area and to mitigate for adverse effects resulting from the proposed project (Appendix A.4). The Programmatic Agreement is between the U.S. Army Corps of Engineers and the New Jersey State Historic Preservation Office. The Advisory Council on Historic Preservation, the Delaware Nation, Delaware Tribe of Indians, and the Shawnee and Eastern Shawnee Tribes of Oklahoma have been invited to review and participate in the Programmatic Agreement as well. The ACHP has opted not to participate in the agreement and the Delaware Nation has agreed to be a concurring party. Additional public involvement was conducted as part of the scoping period in the Spring of 2015 and public review of the draft EA and the Programmatic Agreement under NEPA.

The Notice of Availability initiating the 30 day review of the Draft Integrated FR/EA was posted on the study webpage, sent to affected municipalites for posting on their website and sent to interested parties. Public and agency comment period concluded June 30, 2017. The Notice of Availability was also sent to federal, state, local agencies, non-profit organizations and interested parties identified in the Distribution List located in Appendix A.12. Both the Notice of Availability and the Draft Integrated FR/EA were posted on the study webpage located on the District website. No comments were received from the public or municipal officials. Comments were received from the EPA on June 15, 2018 and the NJDEP Office of Permit Coordination and

Environmental Review on June 5, 2018. A matrix of comments received from the EPA and NJDEP and the District's responses are located in Appendix A.12.

A subsequent Public Notice was issued in June 2019 explaining the contamination issue at Medwick Park and that the state would perform additional investigations in support of potential full remediation of the site prior to implementation of the recommended plan. No comments were received from the public. The Public Notice is located in Appendix A.12.

The District received a conditional Water Quality Certificate and Federal Consistency Determination from the NJDEP on January 8, 2020 (Appendix A.11).

Table 8-1 summarizes the status of compliance of the study and project with federal laws and executive orders. Table 8-2 summarizes the status of compliance with New Jersey state laws.

Table 8-1. Compliance Status of Federal Laws and Executive Orders
(spans two pages)

Legislative Title and U.S. Code/Other		Compliance
Clean Air Act	42 U.S.C. §§ 7401-7671g	An air quality analysis was completed for the project. Based upon the completed analysis, the emissions from the project are considered to have an insignificant impact on the regional air quality, and according to 40 CFR 93.153 (f) and (g) the proposed project is presumed to conform to the SIP. A Record of Non-Applicability is located in Appendix A (Environmental Documentation).
Clean Water Act	33 U.S.C. §§ 1251 et seq.	A 404(b) Evaluation is located in Appendix A.2. A Conditional Water Quality Certification was obtained from NJDEP January 8, 2020 (Appendix A.11) The State of New Jersey assumed the 404 authority in 1993 and is the responsible administering authority. The Rahway River is a delegable waterway and is therefore under the jurisdiction of New Jersey. The District will submit a Freshwater Wetlands Individual Permit to NJDEP to fulfill the requirements of Section 404 of this act prior to initiating construction.
Coastal Zone Management Act	16 U.S.C. §§ 1451-1464	A CZM Compliance Statement has been prepared and is located in Appendix A.6. New Jersey is the administering authority for the CZMA. A conditional concurrence on the CZM compliance statement was obtained from NJDEP on January 8, 2020 and is located in Appendix A.11.
Endangered Species Act of 1973	16 U.S.C. §§ 1531 et seq.	Based on informal consultation with the U.S. Fish and Wildlife Service, the project area does not contain habitat supportive of any Federally listed

		Endangered and/or Threatened species. Refer to Official Species list in Appendix A.3. No endangered species under the jurisdiction of NOAA-Fisheries occur within the project area. A No Effect Determination is located in Appendix A.11.
Fish and Wildlife Coordination Act	16 U.S.C. § 661 et seq.	USACE completed coordination with the U.S. Fish and Wildlife Service. A FWCAR report prepared in February 2018 is included in Appendix A.3.
Magnuson Stevens Fishery Conservation and Management Act	38 U.S.C. § 1801 et seq.	Coordination of the EFH Assessment was completed in April 2019. An Essential Fish Habitat Assessment has been prepared and is included in Appendix A.5. Correspondence from NOAA-NMFS is located in Appendix A11.
National Environmental Policy Act of 1969	42 U.S.C. §§ 4321-4347	The signing of the Finding of No Significant Impact fulfills requirements of this act.
National Historic Preservation Act of 1966	16 U.S.C. §§ 470 et seq.	The District and the NJ State Historic Preservation Office (NJSHPO) have prepared a Programmatic Agreement to fulfill the requirements of this act. The Programmatic Agreement for the project is located in Appendix A (Environmental Documentation).
Executive Order 11990, Protection of Wetlands	May 24, 1977	Circulation of this report for public and agency review fulfills the requirements of this order.
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	April 21, 1997	Implementation of this project will reduce environmental health risks. Circulation of this report for public and agency review fulfills the requirements of this order.
Executive Order 13751 Safeguarding the Nation form the Impacts of Invasive Species	December 8, 2016	BMPs to prevent spread, proper disposal of invasive plant species during construction, replanting with native vegetation monitoring and adaptive management such as invasive species management until mitigation is determined to be successful. Refer to section 6.4.3 for additional information.

Table 8-2. Compliance Status with New Jersey State Laws

Legislative Title and Code/Date		Compliance
Flood Hazard Area Control Act – FHACA Rules	N.J.S.A 58:16A (N.J.A.C. 7:13)	The recommended plan is located within the flood hazard area and will require a FHACA Individual permit. The District coordination with the NJDEP during the study. Permits will be obtained during pre-construction engineering and design (PED) phase.
Freshwater Wetlands Protection Act Freshwater Wetlands Protection Rules	N.J.S.A. 13:9B (N.J.A.C. 7:7A)	The levee is impacting 0.57 acres of deciduous scrub shrub wetland. The State of New Jersey assumed the 404 authority in 1993 and is the responsible administrering authority. The District apply for an Individual Freshwater Wetland permit during the PED phase.
Waterfront Development Act - Coastal Zone Management Rules	N.J.S.A 12:5-3 (N.J.A.C. 7:7)	The recommended plan requires a Waterfront Development permit, an Individual Coastal Wetlands permit and a Water Quality Permit as promulgated by the CZM Rules. A statement of compliance with New Jersey's CZM policies is located in Appendix A.6. The Waterfront Development permit and Individual Coastal Wetland permit will be obtained during PED phase. A conditional Water Quality Certification and concurrence on the CZM compliance statement was obtained from NJDEP on January 8, 2020 and is located in Appendix A.11.
New Jersey Erosion and Sediment Control Act	N.J.S.A. 4:24-39 (N.J.A.C. 2:90-1.1)	An erosion and sediment control plan will be developed during the construction phase and will be submitted to the Union-Somerset and Freehold Soil Conservation Districts for approval.
New Jersey Pollution Disharge Elimination System Permit	N.J.S.A. 58:10A-58:12A-1 (N.J.A.C. 7:14A)	The SPDES permit will be applied for by the construction contractor once the E&S Plan is approved by the Union-Somerset and Freehold Soil Conservation Districts.
Green Acres Program	N.J.S.A. 13:8 (N.J.A.C. 7:36)	A portion of the levee/floodwall is located on lands acquired through Green Acres funding and will require approval from the Green Acres Program. Any required approvals/permits will be obtained in the PED phase.
Pesticide Control	N.J.S.A. 13:1F-1 (N.J.A.C. 7:30-9.3)	An aquatic pesticide permit to apply herbicide to manage invasive plant species as part of compensatory wetland mitigation will obtained during construction of the project. All necessary public coordination as required by the permit will be completed at the time.

Irreversible and Irretrievable Commitment of Resources

There are several resources, both natural and built, that would be expended during the construction and operation of the proposed project. These resources include the land area used to construct the levee/floodwall and implementation of nonstructural measures. Materials used for construction; energy in the form of gas and electricity consumed during construction and routine maintenance activities; and the human effort (time and labor) required to develop construct and maintain various project components. These resources are considered irretrievably committed because their reuse for some purpose other than the project would be highly unlikely. This commitment of resources and material has been weighed against the public purpose and need for the proposed action and would provide various social, environmental and economic benefits.

Chapter 9.0 Plan Implementation

9.1 Consistency with Public Law 113-2

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

- the specific requirements necessary to demonstrate that the project is technically feasible, economically justified and environmentally complaint;
- the specific requirements necessary to demonstrate resiliency, sustainability and consistency with the NACCS; and
- the costs and cost-sharing to support a Project Partnership Agreement (PPA).

Economics Justification and Environmental Compliance. The prior sections of this report demonstrate that the Recommended Plan is technically feasible. It also identifies the plan to be economically justified. The Environmental Assessment has been prepared to meet the requirements of NEPA and demonstrate that the plan is compliant with environmental laws, regulations, and policies and has effectively addressed any environmental concerns of resource and regulatory agencies.

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

The process used to identify the Recommended Plan was a risk management approach that included evaluation of the benefits and costs of an array of alternative solutions, both structural and non-structural, and took into account storm data, climate change, and rising sea levels consistent with NACCS.

Recognizing the federal government's commitment to ensure no inducement of development in the floodplain, pursuant to Executive Order 11988, this project will identify in the PPA the need for the non-federal sponsor to develop a Floodplain Management Plan, and a requirement for the sponsor to certify that measures are in place to ensure the project does not induce development within the floodplain. Compliance with Executive Order 11988 was documented in Chapter 5.6. The non-federal sponsor, NJDEP, is to prepare a Floodplain Management Plan designed to reduce the impacts of future flood events in the project area within one year of signing a PPA and to implement the plan not later than one year after completion of construction of the project.

9.2 Implementation Activities

Implementation will begin after Congress authorizes the project and appropriates funding for it and USACE executes a Project Partnership Agreement (PPA) with the non-federal sponsor in accordance with the local cooperation requirements in Section 9.4. Implementation will begin with pre-construction engineering and design (PED) and proceed to construction.

During PED, USACE will conduct additional technical investigations and analyses, prepare Design Documentation Reports, plans, specifications for each construction contract, and prepare an OMRR&R manual for the non-federal sponsor. The OMRR&R manual will describe project adaption-improvement actions that could address reductions in project performance due to observed climate change trends related to changes in sea levels and hydrology; the non-federal sponsor would be responsible for implementing these project adaption actions to address climate change effects.

A full geotechnical/geologic subsurface investigation is necessary to finalize the design of the proposed features. This investigation will include collecting borings, in-place permeability testing, rock strength tests, and soil classification tests. Appendix CIII: Geotechnical Engineering Appendix, contains more details on recommended geotechnical work.

Surveys and testing to detect whether HTRW is present in the project footprint will be conducted by the non-federal sponsor. The non-federal sponsor will be responsible for remediating any HTRW detected. USACE will continue to coordinate with NJDEP and Middlesex County regarding ongoing HTRW remediation.

Utility surveys will be conducted in the areas of the levee and floodwalls and road raising.

Additional hydraulic analyses will include testing the assumption of this study that nonlinearity with respect to the superimposition of tides and sea level change in hydraulic modeling is negligible. If significant nonlinearity is detected, hydrodynamic modeling shall be performed using tides and sea level change as starting conditions, and the modeling results will inform final designs.

The number and size of interior drainage features will be reassessed, focusing on the outlet for Casey's Creek.

Additional archaeological surveys will be conducted to complete USACE's identification of historic properties and archaeological sites in the project area. Surveys will be designed and carried out in accordance with the Programmatic Agreement between USACE and the NJSHPO contained in Appendix A.4: Cultural Resources.

The structures recommended for floodproofing, elevation, and buyouts will be surveyed, and a nonstructural implementation plan will be developed. Asbestos investigations, and response and remediation by property owners will occur, as described in Section 6.9.

During construction, USACE will provide construction management for activities from pre-award requirements through final construction contract closeout.

9.3 Implementation Schedule

Table 9-1 presents the implementation schedule that was used to estimate project costs. A Chief's Report will be signed because Public Law 113-2 funds are not available for construction of the recommended plan, requiring authority and appropriation for construction. There is a

possibility that Public Law 113-2 investigation funds could be used for Preconstruction Engineering and Design, contingent upon availability of remaining Public Law 113-2 investigation funds. The implementation schedule may vary depending on when Congress authorizes and appropriates federal funding for the project.

Construction is expected to take 52 months, and is estimated to occur from September 2024 to January 2029. The 52-month construction duration reflects the extent of the nonstructural plan. The recommended plan consists of the relocation of about 106 linear of observation deck, 2,200 linear feet of bike path, and the replacement of elements such as manholes, fire hydrants, utility poles, etc. related to the road raising of Engelhard Ave. It also consists of the construction of 2,520 linear feet of levees and 1,968 linear of floodwalls as well as nonstructural measures of 106 residential properties and four commercial properties. The productivity rate for each construction task are extracted from the MCACES, MII program. The construction tasks are imported into P6 for sequencing. It is assumed per engineering judgment that the relocation task will start right after mobilization followed by the construction of levees and floodwalls. However the nonstructural measures will start right after mobilization and work concurrent with the relocation as well as the construction of levees and floodwalls. The treatment of the nonstructural elements are on the critical path using two crews. Average duration for each treatment using one crew is about 28 days, which brings the construction schedule to 52 months with time considered for punchlist. The construction of the levee/floodwall will be completed by January 2028 and the construction of the nonstructural measures will be completed by December 2028. The midpoint of construction is May 2026.

Table 9-1. Recommend Plan Implementation Schedule

Event or Activity	Date
Chief's Report Signed	May 2020
PPA Executed	December 2021
Notice to Non-Federal Sponsor to Proceed with Real Estate Acquisition	December 2021
Begin Preparing Plans & Specifications and Request for Proposal	January 2022
USACE Receives Authorization for Entry for Construction from Non-Federal Sponsor	January 2024
USACE Certifies Real Estate for the Recommended Plan	February 2024
Advertise Construction Contract	March 2024
Begin Construction	September 2024
Complete Construction	January 2029

9.4 Local Cooperation Requirements

The non-federal sponsor, NJDEP, supports the recommended plan described in this report and intends to execute a PPA for the project once it is authorized and federal funding is appropriated. The letter of support for the project from NJDEP is in Appendix F.

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:

1. In coordination with the federal government, who shall provide 65 percent of the initial project cost,
   a. Provide 35 percent of the total nonstructural flood damage reductions costs and a minimum of 35 percent, but not to exceed 50 percent, of the total structural flood damage reduction costs and, as further specified below:
      i. Provide, during design, 35 percent of design costs allocated to nonstructural flood damage reduction and 35 percent of design costs allocated to structural flood damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;
      ii. Pay, during construction, a contribution of funds equal to five percent of total structural flood damage reduction costs;
      iii. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the Federal government to be required or to be necessary for the construction, operation, and maintenance of the project;
      iv. Pay, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total nonstructural flood damage reduction costs and at least 35 percent of total structural flood damage reduction costs;
   b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;
   c. Inform affected interests, at least annually, of the extent of risk management afforded by the structural flood damage reduction features;
   d. Participate in and comply with applicable floodplain management and flood insurance programs;
   e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12);
   f. 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 performance levels provided by the flood damage reduction features;
   g. Not use the project lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;
   h. Operate, maintain, repair, rehabilitate, and replace 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;

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

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

k. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of three 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;

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

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

n. 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, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

o. 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 1986, 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;

p. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601- 4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and

maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

q. 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

r. 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.

9.5 Cost Apportionment

Costs of implementing the recommended plan will be cost-shared 65% federal and 35% non-federal, in accordance with the local cooperation requirements in Section 9.3. The estimated project first cost, $71,929,000, is the constant dollar cost of the recommended plan at current (October 2019) price levels. The first cost will be used for project authorization. The estimated total project cost, $88,130,000, is the constant dollar cost fully funded with escalation to the estimated midpoint of construction, May 2026. The total project cost will be used in the PPA and is provided to the non-federal sponsor for financial planning. Table 9-2 shows how the costs of implementing the recommended plan will be apportioned between the federal government and the non-federal sponsor. The non-federal sponsor's lands lands, easements, right-of-ways, relocation, and disposal area (LERRDs) costs for the recommended plan are $10,550,000.

Table 9-2. Cost Apportionment for Implementation of the Recommended Plan

	Total	Federal	Non-Federal
First Cost	$71,929,000	$46,754,000	$25,175,000
Non-Federal Sponsor's LERRDs	$10,550,000	--	$10,550,000
Cash Contribution	$14,625,000	--	$14,625,000

The non-federal sponsor will be fully responsible for project OMRR&R costs, estimated at $232,000 per year.

Chapter 10.0 **Recommendations**

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

I recommend that the Recommended Plan for coastal storm risk management in the Rahway River Basin, New Jersey, as fully detailed in this final 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 Congress as proposals for authorization and/or implemention 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.

Thomas D. Asbery
Colonel, U.S. Army
District Engineer

Chapter 11.0 **References**

Amy S. Greene Environmental Consultants, Inc. March 11, 2014. Environmental Resource Inventory Report for Millburn Township, Essex County, New Jersey.

Bartoldus, C.E. Garbisch, and M. Kraus. 1994 Evaluation for Planned Wetlands, A Procedure for Assessment wsetland Functions and a Guide to Functional Design.

Borough of Carteret. 2012. Mayor Reiman joins with Middlesex County Board of Chosen Freeholders to inveil enhanced Joseph Medwick Park. Available at: https://www.carteret.net/news/mayor-reiman-joins-with-middlesex-county-board-of-chosen-freeholders-to-unveil-enhanced-joseph-medwick-park/

Federal Emergency Management Agency (FEMA). 2018. FEMA Fact Sheet: Mitigation Assessment Team Results – Hurricane Sandy. https://www.fema.gov/MAT-results-hurricane-sandy. Accessed 11 Dec 2019.

Intergovernmental Panel for Climate Change (IPCC). 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA (IPCC, 2007).

Miller, Thomas. December 2012. Ambient Biomonitoring Network, Raritan Water Region, Watershed Management Areas 7,8,9 and 10, Round 4 Benthic Macroinvertebrate Data, Volume 1 and 2.

National Audubon Society. Important Bird Areas, Arthur Kill Complex and Tributaries. Available at: http://www.audubon.org/important-bird-areas/arthur-kill-complex-and-tributaries . Accessed 14 March 2017

Natural Resources Conservation Service, United States Department of Agriculture (NRCS) . Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov. Accessed June 1 2016.

_____. February 2007. New Jersey Hydric Soil List. Available online at: http://soils.usda.gov/use/hydric/. Accessed June 1 2016.

_____. December 2012. Boonton Series Description.

_____. Soil Survey of Union County, New Jersey. 2002.

_____. January 2013a. Haledon Series Description.

_____. January 2013b. Hasbrouck Series.

_____. New Jersey Important Farmlands Inventory. Website accessed 12 July 2016. Available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/nj/soils/?cid=nrcs141p2_018875

_____. State Soil Data Access Hydric Soils List. Website accessed 14 March 2017. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd1316619.html

Montemarano, Justin J., Jason Havelin and Matthew Draud. 11 May 2016. Diet composition of the smooth dogfish (*Musteulus canin*) in the waters of Long Island, New York, USA.

Munafo, Kristin and Michael Allen. 2013. Biodiversity Inventory, Hawk Rise Sanctuary & Linden Landfill, 2013 Survey Results.

National Oceanic and Atmospheric Administration (NOAA). December 2012. BookletChart, Kill Van Kull and Northern Part of Arthur Kill, NOAA Chart 12333.

NOAA. 24 January 2013a. NOAA Water Level and Meteorological Data Report: Hurricane Sandy.

NOAA. 11 April 2013b. Tropical Cyclone Report: Hurricane Irene.

NOAA-NMFS. 2017a. Estimated Range of Shortnose Sturgeon. Accessed May 8, 2017. Available at: https://www.greateratlantic.fisheries.noaa.gov/protected/section7/listing/index.html

NOAA-NMFS.2017b. Estimated Range of Atlantic Sturgeon. Accessed May 8, 2017. Available at: https://www.greateratlantic.fisheries.noaa.gov/protected/section7/listing/index.html

NOAA-NMFS.2017c. Atlantic Sturgeon Proposed Critical Habitat. Accessed May 8, 2017. Available at: https://www.greateratlantic.fisheries.noaa.gov/protected/section7/listing/index.html

NOAA-NMFS.2017d. Shortnose Sturgeon Species Description. Accessed May 8, 2017. Available at: http://www.fisheries.noaa.gov/pr/species/fish/shortnose-sturgeon.html

NOAA-NMFS.2017e. Atlantic Sturgeon Species Description. Accessed May 8, 2017. Available at: http://www.fisheries.noaa.gov/pr/species/fish/atlantic-sturgeon.html

New Jersey Administrative Code (N.J.A.C.) October, 17, 2016. N.J.A.C. 7:9B Surface Water Quality Standards. Available at: www.nj.gov/dep/rules/rules/njac7_9b.pdf Accessed 28 October 2016.

New Jersey Department of Environmental Protection (NJDEP). September 2019. 2016 New Jersey Integrated Water Quality Assessment Report (Draft).

_____. 2016. Statewide Estuarine & Marine Waters (All coastal waterbodies except those under

Waterbody Specific Advisories). Available at: http://www.state.nj.us/dep/dsr/fishadvisories/marine.htm. Accessed 4 April 2017.

Rubino, Jennifer. January 12, 2017. News Article: "County Deer Management Program has begun" Available at: http://unionnewsdaily.com/headline-news/28833

Scarpa, Carissa. 2017. Cultural Resources Summary and Preliminary Case Report, Rahway River Basin, New Jersey Coastal Storm Risk Management Project.

Smith, Larissa, and Kathleen E. Clark. 2018. New Jersey Department of Environmental Protection, Divisions of Fish and Wildlife, New Jersey Bald Eagle Project, 2018.

United States Army Corps of Engineers (USACE). December 2004. Arthur Kill Channel – Howland Hook Marine Terminal 40'/41' Deepening-Mitigation Joseph Medwick Park, Carteret, New Jersey, Design Documentation Report.

_____. March 2004. Draft Environmental Assessment/Ecosystem Restoration Report, Rahway River, New Jersey, Section 1135 Project.

_____. November 2001. Rahway River Nekton Sampling Data Documentation. Spring and Fall Sampling Events.

_____. October 2014. 2013 New York and New Jersey Harbor Deepening Project, Migratory Finfish Report.

_____. November 2013. 2012 New York and New Jersey Harbor Deepening Project, Migratory Finfish Report.

_____. January 2013. 2011 New York and New Jersey Harbor Deepening Project, Migratory Finfish Report.

_____. January 2015. North Atlantic Coast Comprehensive Study. http://www.nad.usace.army.mil/CompStudy.aspx

_____. September 2007. 2006 New York and New Jersey Harbor Deepening Project, Migratory Finfish Report.

U.S. Coast Guard. April 2010. Final Environmental Assessment, Tremley Point Connector Road.

U.S. Fish and Wildlife Service, June 2017a. New Jersey Municipalities with Hibernation or Maternity Occurrence of Indiana bat or Northern long-eared bat.

_____. Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision. April 2007. U.S. Fish and Wildlife Service, Fort Snelling, MN.

_____. December 2015. Final Environmental Assessment, Final 4(d) Rule for the Northern Long-eared bat.

_____(2019a). October 11, 2019. U.S. Fish and Wildlife Service, Endangered Species Act Update.

_____(2019b). March 25, 2019. USFWS, Eastern black rail species profile. Available at: https://www.fws.gov/southeast/wildlife/birds/eastern-black-rail/#current-range-section. Accessed January 14, 2020.

United Water. June 2016 Available at: https://www.mysuezwater.com/sites/default/files/w_h16_rahway.pdf Accessed 17 July 2016.

Vile, John. September 2011. New Jersey Department, Bureau of Freshwater & Biological Monitoring. Fish IBI Report, 2010 Sampling, Round 3, Year 1 of 5, Volumes 1 and 2.

_____. March 2011. New Jersey Department, Bureau of Freshwater & Biological Monitoring. Fish IBI Report, 2009 Sampling, Round 2 Year 5 of 5, Volumes 1 and 2.

Bartoldus, C.C., Garbisch, E.W., and Kraus, M.L.: 1994, Evaluation for Planned Wetlands. Environmental Concern Inc., St. Michaels, Maryland, 310 pp.

Montemarano, Justin J., Jason Havelin and Matthew Draud. 11 May 2016

_____. State Soil Data Access Hydric Soils List. Website accessed 14 March 2017. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd1316619.html

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