US Army Corps of Engineers
Philadelphia District

New Jersey Department of
Environmental Protection

New Jersey Beneficial Use of Dredged Material for the Delaware River

Feasibility Report and Integrated Environmental Assessment

Volume I

10/18/2017

This page intentionally left blank

New Jersey Beneficial Use of Dredged Material for the Delaware River

Feasibility Report and Integrated Environmental Assessment

ABSTRACT: This Feasibility Report and Integrated Environmental Assessment presents the draft findings of a study to determine a coastal storm risk management plan for bayshore and flood-prone urban areas along the Delaware Estuary shoreline of New Jersey. The report describes the engineering, economic, social and environmental analyses that were conducted to develop a tentatively selected plan.

NOTE TO READER: To provide full and convenient access to the environmental, economic and engineering documentation prepared for the study, the Environmental Assessment has been integrated into this feasibility report in accordance with Engineering Regulation 1105-2-100.

This page intentionally left blank

New Jersey Beneficial Use of Dredged Material for the Delaware River Feasibility Study

Feasibility Report and Integrated Environmental Assessment

Executive Summary

1 Study Information

The purpose of this report is to analyze coastal storm risk management (CSRM) issues in various New Jersey communities, with the intent to beneficially use dredged material from Federal navigation channels within the Delaware River and Bay and to recommend measures to manage and reduce risk from coastal storms. The U.S. Army Corps of Engineers (USACE) and the Non-Federal Sponsor (New Jersey Department of Environmental Protection – NJDEP) entered into a feasibility cost share agreement (FCSA) on 27 February 2014.

This report was prepared in response to an October 26, 2005 resolution of the Committee on Environment and Public Works of the United States Senate, as well as the Disaster Relief Appropriations Act, 2013 (PL 113-2) which was passed in the aftermath of Hurricane Sandy (October 2012).

2 Problem

The primary problems identified in this study are shoreline erosion, waves, and storm surge caused by coastal storms, along with sea level change (SLC), which cause flood-related damages along the Delaware River/Bay shoreline of New Jersey. The shoreline is characterized by a flat, low-lying coastal plain with broad marshes and narrow barriers of sand along the bay beaches. The sand beach barrier is widest and most well-developed near the mouth of the bay (south of Villas), becoming less prevalent to the north. Based on the nature of the problem and overall characteristics of the study area, 33 specific CSRM problem areas were identified.

The nature of the CSRM problem and the study area characteristics also present the following opportunities:

- Minimize erosion, wave and storm-surge related damages to New Jersey communities located along and adjacent to the Delaware River and Bay/Estuary shoreline.
- Increase the resiliency of the New Jersey shoreline by reducing its vulnerability to flood and storm events.

- Beneficially use dredged material to minimize erosion, wave and storm-surge related damages and increase resiliency along the New Jersey shoreline.

Based on the characteristics of the study area and the associated problems, the study area was evaluated in two defined planning reaches within the Delaware Estuary, which includes the Delaware Bay and the tidal reach of the Delaware River. The “northern reach” is from the head of tide at Trenton, NJ down to the approximate river/bay boundary (around Alder Cove), while the “southern reach” extends south from the Alder Cove area (river/bay boundary) to the mouth of the Delaware Bay at Cape May Point, NJ.

3 Plans Considered

The primary planning objectives of this study are:

1. Improve coastal storm risk management (CSRM) for people, property and infrastructure along and adjacent to the New Jersey shoreline from 2022 to 2072, via the beneficial use of dredged material.

2. Increase the resiliency of coastal New Jersey, specifically along the Delaware Estuary shoreline, via the beneficial use of dredged material.

The original 33 problem areas were subjected to Cycle 1 screening to confirm that CSRM was the primary problem and that the use of dredged material was potentially feasible in a management measure for the problem area. The PDT formulated non-structural and structural measures, as well as natural and nature-based features (NNBF), for each problem area. In Cycle 2, the measures were compared against the planning objectives to see if they were in line with the study purpose.

The North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk (NACCS) criteria for assessing each measure’s CSRM Function were applied to determine if a measure met Objective 1. The CSRM Function was based on the measure’s ability to mitigate flooding, attenuate wave action and reduce shoreline erosion. Per the NACCS, if the selected measure received at least a “medium” ranking for one of these three criteria and dredged material was feasible to use for implementation of the measure, the PDT determined that the measure met Objective 1.

The NACCS criteria for assessing each measure’s resilience was applied to determine if a measure met Objective 2. Specifically, if the NACCS ranking indicated a “medium” or higher “adaptive capacity” for a selected measure, the PDT determined that the measure increased the shoreline resilience and met Objective 2. Adaptive capacity is defined as a measure’s ability to adjust through natural processes, operation and maintenance activities, or adaptive management, to preserve the measure’s function.

In order for measures to be carried forward for further analysis, they must have met one of the two study objectives.

In the northern planning reach, the No Action Plan and the Levee/Dike Plan were formulated in Penns Grove/Carneys Point and Pennsville. The alternative plans involving different forms of beach restoration were not formulated at Penns Grove/Carneys Point and Pennsville due to the lack of homogeneous sand dredged material sources close to the sites.

In the southern planning reach, the No Action Plan and the Levee/Dike Plan were formulated in Bivalve, Shellpile, Port Norris and Maurice River Twp. At Gandys Beach, Fortescue, Reeds Beach, Pierces Point, Del Haven and Villas, the No Action Plan and the Beach Restoration Plan were formulated. The Beach Restoration with Groin(s) Plan was also formulated at Gandys Beach and Fortescue. The Beach Restoration with Breakwater Plan was not formulated in the southern planning reach because the added breakwater cost greatly outweighed any added CSRM benefits. Per the NACCS, an estimated total first construction cost of a breakwater could be as high as $90,000,000 for a 10,000 feet stretch of shoreline. Given the limited size of the structural inventories of the communities in the southern reach, the potential CSRM benefits did not appear to offset the added cost.

Regarding the Beach Restoration with Groin(s), Breakwater, Living Shoreline & Wetland Plan, analysis indicated that the additional features, such as wetlands or living shorelines, would provide minimal additional CSRM compared to the added cost. For living shorelines, data from the NACCS indicated that they are generally applicable to relatively low current and wave energy environments. However, in the southern reach, the width of the bay (fetch) increases and allows wind to generate greater wave energy at the shoreline, so that waves create an additional risk mechanism beyond inundation alone. The additional damage mechanisms resulting from the combined effects of long-term and storm-related erosion, inundation and waves (analogous to the damage mechanisms experienced on the open ocean coast) minimize the potential effectiveness of living shorelines. The limited effectiveness coupled with a $1,415 cost per linear foot of living shoreline construction (as estimated in the NACCS) also limits the efficiency of the living shoreline feature. Per the NACCS, wetlands can slow the advance of storm surge somewhat and slightly reduce the surge landward. In addition, wetlands can dissipate wave energy; however, evidence suggests that slow-moving storms and those with long periods of high winds that produce marsh flooding reduce this benefit (Resio and Westerlink, 2008). This limited effectiveness coupled with a $2,593 cost per linear feet of wetland construction (as estimated in the NACCS) also limits the efficiency of the wetland feature.

Based on the aforementioned formulation and alternative plans in each planning reach, the final array of alternative plans includes the following:

1. No Action Plan
2. Levee/Dike Plan
3. Beach Restoration Plan
4. Beach Restoration with Groin(s) Plan

4 Tentatively Selected Plan

The TSP consists of beach restoration at Villas (South) and beach restoration with groin(s) at Gandys Beach and Fortescue.

For Gandys Beach, the proposed design template features a berm of 75 feet (ft) width at a height of +6 ft NAVD88 with a foreslope of approximately 130 ft length on a slope of 1V:10H extending bayward to a tie-in depth of -7 ft NAVD88. A new terminal groin structure is proposed for the northern end of Gandys Beach to offset the erosive nature of this portion of the bay. Over the last 25 years there has been demonstrated shoreline retreat at Gandys Beach. Currently, there is significant armoring of the Gandys shoreline using steel sheet piling, concrete sea wall and rubble armoring. The natural shoreline erosion has created conditions where the Delaware Bay has flanked the town and the proposed beach restoration will suffer unacceptable erosion rates without the use of a terminal groin.

For Fortescue, the proposed design template features a berm of 75 ft width at a height of +6 ft NAVD88 with a foreslope of approximately 100 ft length on a slope of 1V:10H extending bayward to a tie-in depth of -4 ft NAVD88. At Fortescue, the existing terminal groin at the northern edge of the community will be rehabbed and replaced as part of the recommended plan to reduce end losses and the associated renourishment frequency.

The terminal groins at Gandys and Fortescue will be comprised of a timber stem section that will prevent sediment migration. The timber stem will be comprised of sheeting, walers and piles. The timber stem will be anchored bayward by a rubble mound groin, comprised of armor stone and bedding stone.

At Villas (South), the proposed design template features a berm of 75 feet (ft) width at a height of +5 ft NAVD 88 with a foreslope of approximately 100 ft length on a slope of 1V:10H extending bayward to a tie-in depth -2 ft NAVD88. The berm is topped with a dune whose crest width is 25 ft at a height of +12 ft NAVD88. The dune transitions both bayward to the berm and landward to existing grade on a slope of 1V:5H.

Figure ES-1 - Design Template for Gandys Beach and Fortescue

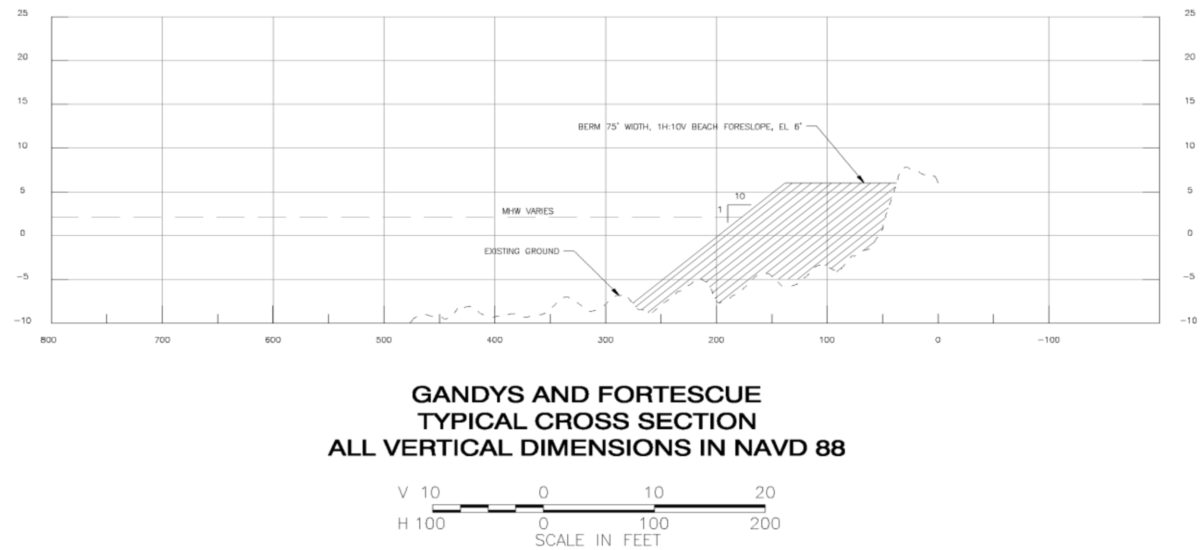
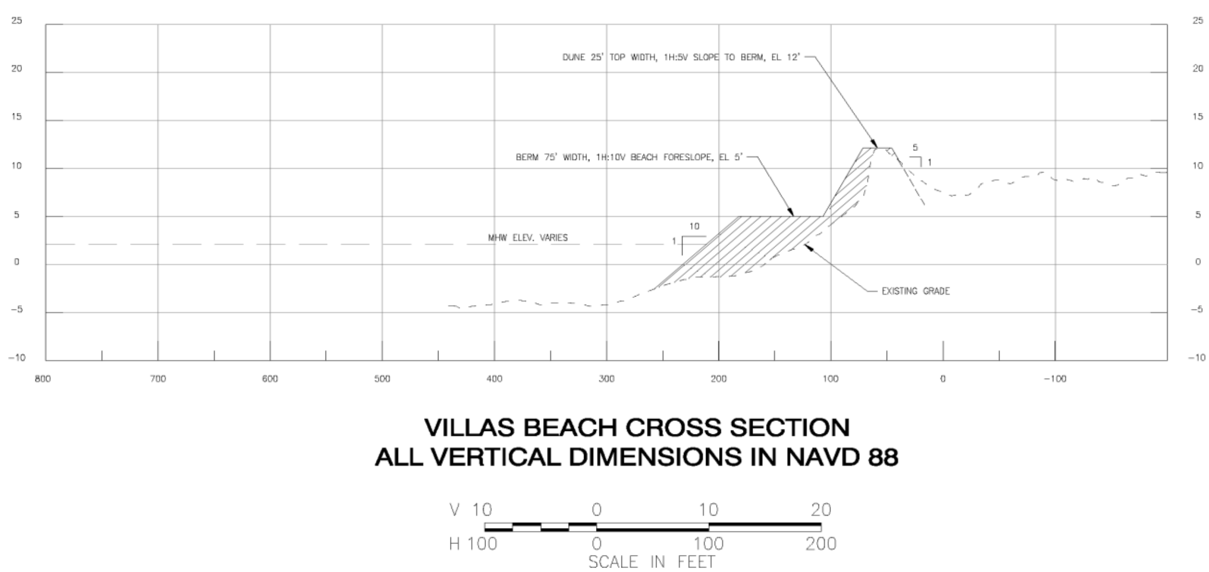


Figure ES-2 - Design Template for Villas (South)



Based on the volume projections for initial construction at each of the 3 placement locations, a total of approximately 700,000 cubic yards of dredged material would be required for initial construction. As referenced in Section 3.4, the proposed source area (Brandywine and Miah Maull reaches of the Delaware River Main Channel – designated Lower Reach E) is anticipated to have approximately 465,000 cubic yards of dredged material available annually that will need to be removed to maintain the 45 feet depth. The anticipated dredging cycle for Lower Reach E is every two years to remove and place 930,000 cubic yards (465,000 x 2) of dredged material. The projected quantity and dredging cycle were based on the feasibility report completed in support of the Delaware River Main Channel Deepening project (MCD). Actual dredged material quantities will be verified prior to construction; therefore, the PDT recognizes the possibility that there may be greater and/or lesser quantities available (than currently projected) at the time of construction. If there is less dredged material available than anticipated at the projected date of initial construction (2022), the Buoy 10 open water disposal site (located one mile east of the Delaware River Main Channel in Lower Delaware Bay) may serve as a back-up source for initial construction as it contains sand (approximately 750,000 cubic yards) previously dredged from Lower Reach E during operation and maintenance of the Delaware River, Philadelphia to the Sea navigation project. The PDT recognizes that the use of Buoy 10 as a back-up source would necessitate a benthic habitat assessment and ultimately a Supplemental Environmental Assessment (EA).

Varying volumes of dredged material are required at each of the placement locations, depending on the length of shoreline to be nourished and the existing beach profile. In order to maintain the integrity of design beachfill alternatives, beachfill nourishment must be included in the project design. If periodic nourishment was not performed throughout the life of the project, the longshore and cross shore sediment transport mechanisms, separate from storm induced erosion, would act to erode the design beach. An 8-year periodic nourishment cycle is anticipated to maintain optimal CSRM. This nourishment cycle is in line with the proposed operation and maintenance (O&M) dredging to be performed in Lower Reach E (the proposed project dredged material source area for the TSP); however, it will be further refined during plan optimization.

New Jersey Beneficial Use of Dredged Material for the Delaware River Feasibility Study

Feasibility Report and Integrated Environmental Assessment

Table of Contents

Figures

Tables

Appendices

This page intentionally left blank

1 STUDY INFORMATION

The purpose of this report is to analyze coastal storm risk management (CSRM) issues in various New Jersey communities, with the intent to beneficially use dredged material from Federal navigation channels within the Delaware Estuary. The U.S. Army Corps of Engineers (USACE) and the Non-Federal Sponsor (New Jersey Department of Environmental Protection – NJDEP) entered into a feasibility cost share agreement (FCSA) on 27 February 2014.

1.1 PROBLEM DESCRIPTION

Shoreline erosion, waves and storm surge caused by coastal storms, along with sea-level change (SLC), cause flood-related damages along the Delaware Estuary shoreline of New Jersey.

The overall objective of the planning study is to improve CSRM for New Jersey communities located along the Delaware Estuary area.

1.2 STUDY AUTHORITY

The study authorities for the New Jersey Beneficial Use of Dredged Material for the Delaware River Study (DMU) are the October 26, 2005 resolution of the Committee on Environment and Public Works of the United States Senate ("Resolution") and the Disaster Relief Appropriations Act, 2013 (PL 113-2).

The Resolution reads as follows:

> "Resolved by the Committee on Environmental and Public Works of the United States Senate, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Delaware River between Philadelphia, Pennsylvania and Trenton, New Jersey, and Philadelphia to the Sea, published as House Document 358, Eighty Third Congress, Second Session (1954), and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable in the interest of beneficial use of dredged material resulting from the aforementioned project, including transfer and transport facilities for the drying, rehandling, and transferring of dredged material, as it relates to comprehensive watershed and regional sediment management (RSM), ecosystem restoration, navigation, stream restoration, water quality, restoration of coal and other mined areas, cover material for sanitary landfills and other allied purposes."

In accordance with the Resolution, the project delivery team (PDT) reviewed the above-referenced report of the Chief of Engineers to determine if any modifications to the recommendations were warranted with regard to the beneficial use of dredged material. The feasibility study described herein was conducted to facilitate the review. Upon initiation of the study, CSRM was identified as an "other allied purpose" to be considered for the beneficial use of dredged material under this authority. As discussed further in this section, the passage of PL 113-2 further mandated a CSRM feasibility study for the subject study area.

Specifically regarding PL 113-2, a catastrophic storm (Hurricane Sandy) struck the Atlantic coastline, resulting in loss of life, severe damages to the coastline, widespread power outages, and damage to infrastructure, businesses and private residences. The storm also resulted in degraded coastal features, which increased the risks and vulnerability from future storms. Expected changes in sea level, an increased probability of extreme weather events, and other impacts of climate change are likely to increase those risks even further. In the aftermath of Hurricane Sandy and the subsequent passage of PL 113-2, Congress authorized supplemental appropriations to Federal agencies for expenses related to the consequences of Hurricane Sandy. Chapter 4 of PL 113-2 identifies those actions directed by Congress specific to USACE, including preparation of two interim reports to Congress, a project performance evaluation report, and a comprehensive study to address the flood risks of vulnerable coastal populations in areas affected by Hurricane Sandy within the boundaries of the North Atlantic Division of USACE. The Second Interim Report to Congress (dated 30 May 2013) states that PL 113-2 "provides supplemental appropriations to address damages caused by Hurricane Sandy and reduce future flood risk in ways that will support the long-term sustainability of the coastal ecosystem and communities, and reduce the economic costs and risks associated with large-scale flood and storm events."

This study was identified in the Second Interim Report to Congress as an "Ongoing Study" for reducing flooding and storm damage risks in the area affected by Hurricane Sandy. This CSRM study has been authorized by and conducted in accordance with the Resolution and PL 113-2 and its associated reports thereby formulating for CSRM via the beneficial use of dredged material.

PL 113-2 directed USACE to conduct a comprehensive study (the NACCS) to address the flood risks of vulnerable coastal populations in areas that were affected by Hurricane Sandy within the boundaries of the North Atlantic Division of the Corps. The NACCS was completed in January 2015 and provides a step-by-step approach, with advancements in the state of science and tools to conduct three levels of analysis. Tier 1 was a regional scale analysis (completed as part of the NACCS), Tier 2 was conducted at a State or watershed scale (conceptual Tier 2 evaluations were completed in each state and the District of Columbia), and Tier 3 would be a local-scale analysis that incorporates benefit-cost evaluations of CSRM plans.

Under the NACCS, more than 31,200 miles of coastal shoreline were delineated into 39 planning reaches based on State boundaries, shoreline types, geomorphic features, and extent of existing or planned risk management projects. Based on coordination with a diverse set of agencies, the NACCS considers population and supporting infrastructure, environmental and cultural resources, and existing and planned CSRM efforts. The study also considers existing and future inundation and SLC. Specifically, the NACCS identified the Delaware Bay shoreline as a high risk area requiring additional analysis.

1.3 PURPOSE AND SCOPE (PURPOSE AND NEED)

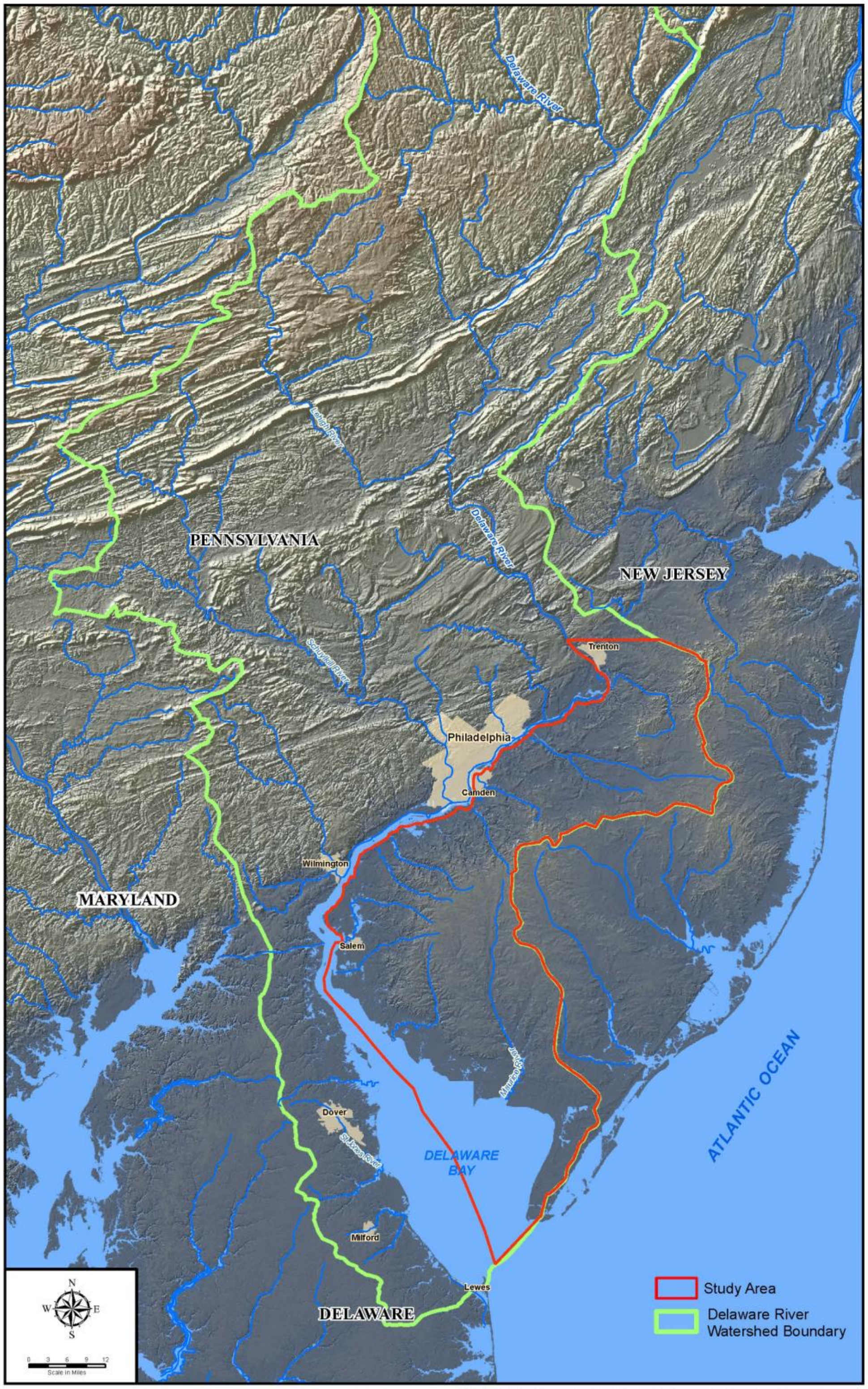
The purpose of this report is to present the findings of a feasibility investigation that was conducted to determine if there is a Federal interest and recommend a solution to identified CSRM problems at various New Jersey communities. The study investigated the feasibility of addressing CSRM problem(s) via the beneficial use of dredged material. CSRM alternatives utilizing dredged material were formulated, compared/evaluated against the without project condition and ultimately will be optimized in order to identify the National Economic Development (NED) plan. If screening does not indicate a viable opportunity to implement CSRM alternatives with dredged material in select problem areas, then other alternatives may be recommended for further analysis under another study authority.

1.4 LOCATION OF THE STUDY AREA

The study area is located within the Delaware River watershed, which lies within the State of New Jersey and the Delaware River itself. The north/south boundaries of the study area extend from Trenton, NJ to Cape May Point, NJ (Figure 1). The centerline of the Delaware Estuary represents the western study area boundary and it extends approximately 135 miles from the Atlantic Ocean upstream to the head of tide at Trenton, New Jersey.

The study area includes flood prone areas along the mainstem Delaware River and Delaware Bay, but also the tributaries of the Delaware which contribute to both tidal and fluvial flooding. Tributaries to the Delaware River and Bay within the study area include: Dennis Creek, Maurice River, Cohansey River, Stowe Creek, Alloway Creek, Salem River, Oldmans Creek, Raccoon Creek, Mantua Creek, Big Timber Creek, Cooper River, Pennsauken Creek, Rancocas Creek and Black Creek.

Figure 1 - Study Area



Path: E:\Planning_Projects2\Lower_Delaware_Watershed\MXD\Delaware_River_Study_Adj_Area_and_Watershed_NJ_11x17.mxd

This feasibility study evaluated coastal storm-related damages in New Jersey occurring in two defined planning reaches within the Delaware Estuary system. The "northern reach" is from the head of tide at Trenton, NJ down to the approximate river/bay boundary (around Alder Cove), while the "southern reach" extends south from the Alder Cove area (river/bay boundary) to the mouth of the Delaware Bay at Cape May Point, NJ. The northern reach includes four distinct zones of the tidal Delaware River watershed, as defined by the Delaware River Basin Commission (DRBC):

- Zone 2 – Zone 2 is the part of the Delaware River extending from the head of tidewater at Trenton, NJ to the Trenton/Morrisville Toll Bridge below the mouth of Pennypack Creek, including the tidal portions of the tributaries thereof (River Mile 133.4 to 108.4).
- Zone 3 – Zone 3 is the part of the Delaware River extending from the Trenton/Morrisville Toll Bridge to just below the mouth of Big Timber Creek (near Westville, NJ), including the tidal portions of the tributaries thereof (River Mile 108.4 to 95.0).
- Zone 4 – Zone 4 is the part of the Delaware River extending from just below the mouth of Big Timber Creek to where the Delaware state boundary line approaches the New Jersey shoreline, opposite of Marcus Hook, PA, including the tidal portions of the tributaries thereof (River Mile 95.0 to 78.8).
- Zone 5 – Zone 5 is the part of the Delaware River extending from the Delaware boundary line with the New Jersey shoreline to the south of Hope Creek Generating Station adjacent to Mad Horse Creek Wildlife Management Area, including the tidal portions of the tributaries thereof (River Mile 78.8 to 48.2).

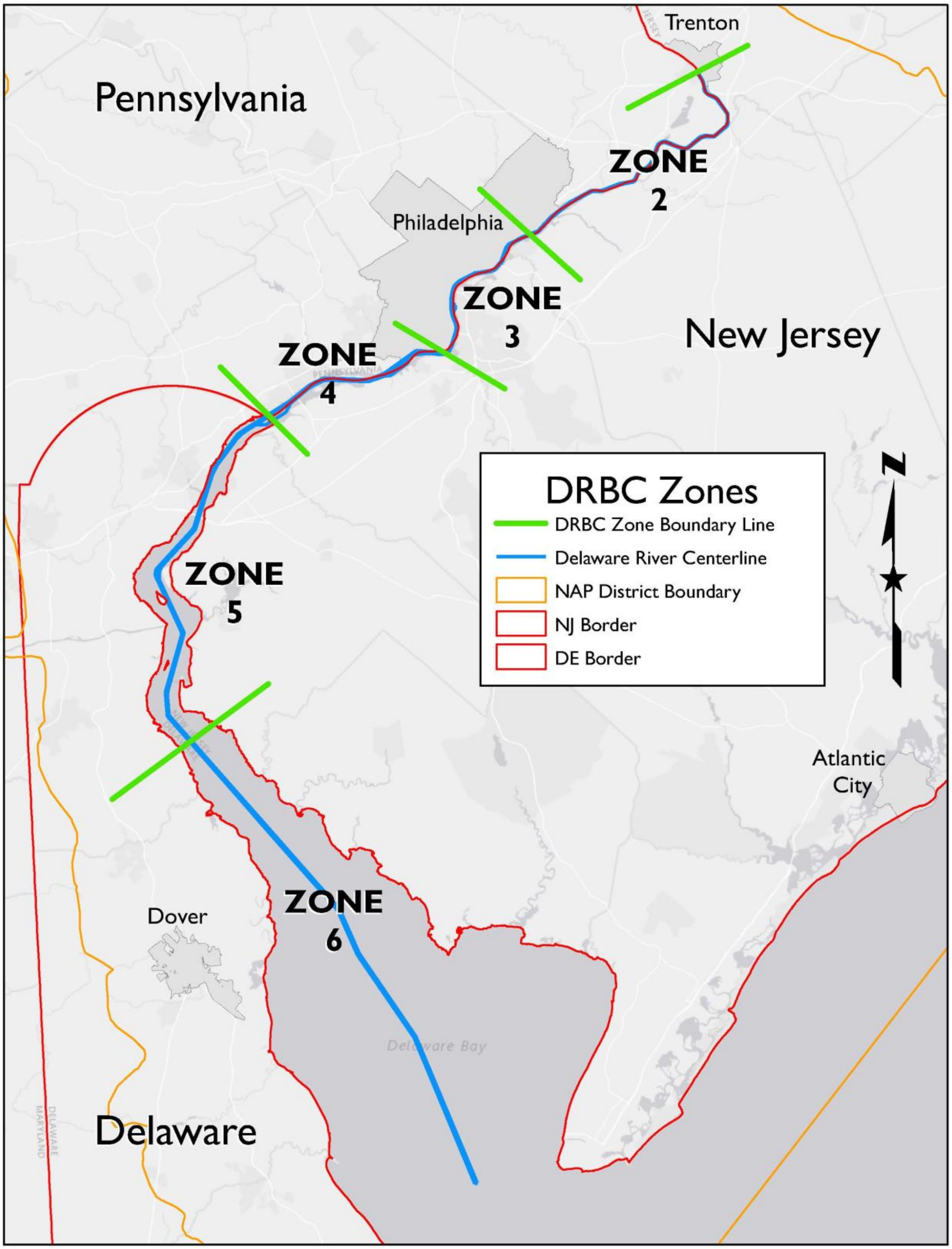
The southern reach includes Zone 6 extending from Madhorse Creek Wildlife Management Area south to the sea (Atlantic Ocean), including the tidal portions of the tributaries thereof (River Mile 48.2 to the Sea – River Mile 0) (Figure 2).

In the northern reach, the width of the waterway is relatively smaller and the principal CSRM damages are due to inundation related to coastal storm surge, as occurs during tropical storms, hurricanes or nor'easters. However, in the southern reach, the width of the bay (fetch) increases and allows wind to generate greater wave energy at the shoreline, so that waves create an additional risk mechanism beyond inundation alone. Due to the additional damage mechanisms, the southern reach experiences CSRM damages from the combined effects of inundation, waves and storm erosion, analogous to the damage mechanisms experienced on the open ocean coast.

Sediment composition and grain size also vary between the northern and southern reaches. Sediment deposition in the northern reach is dominated by fine-grained sediments, predominantly silts and clays. All dredged sediment from the navigation channel in the northern reach is placed in USACE upland CDFs, which contain hundreds of millions of cubic yards of sediment. In the southern reach, sediment deposition becomes progressively coarser southward such that shoaling in the southernmost 15 miles of the navigation channel consists of predominantly coarse-grained material. The nature of this sediment is discussed in more detail in Section 5.1.3. Traditionally, all sediment dredged from this reach has been either placed at Buoy 10 (approximately 1 mile east of the navigation channel) or brought north for placement at the Artificial Island CDF.

More recently, material from the MCD project was beneficially placed as beach fill at Oakwood Beach, Salem County, New Jersey (2014) and Broadkill Beach, Sussex County, Delaware (2015-2016).

Figure 2 - Delaware River Basin Commission (DRBC) Zones



1.5 PRIOR REPORTS AND EXISTING PROJECTS

The Philadelphia District has been responsible for the construction and maintenance of the Delaware River navigation channel since the late 19th Century, allowing deep-draft commercial vessels to call on the Port of Philadelphia and other regional port facilities. As a result, there are several existing Federal navigation projects which are maintained by USACE within the study area. There have also been several water resource studies previously conducted within the study area.

USACE Projects

Delaware River, Philadelphia to the Sea NJ, PA & DE: This project provides a channel from Allegheny Avenue, Philadelphia to deep water in Delaware Bay. It also provides six anchorages, dikes, and training works for the regulation and control of tidal flow. The project channel, previously maintained at a depth of 40 feet, was authorized for deepening to a depth of 45 feet mean lower low water (MLLW) by Congress in 1992. Construction of the deepened channel was initiated in 2010 and is scheduled for completion in 2018. Maintenance dredging of the 45 foot channel will be required and will be performed as needed based on shoaling conditions and project funding. It is expected that maintenance dredging of the project will occur on an annual basis. Federal maintenance dredging of the 40 foot channel has historically generated approximately 3,000,000 cubic yards of dredged material annually.

Delaware River, Philadelphia to Trenton, NJ & PA: This project provides for a channel and turning basins in the Delaware River from Allegheny Avenue in Philadelphia upstream approximately 30 miles to the Marine Terminal in Trenton, NJ. The project dimensions vary from 35 to 40 feet deep and 300 to 400 feet wide. The project is complete except for deepening the channel from 25 to 35 feet between Newbold Island and the Trenton Marine Terminal, which has been placed in the deferred category.

Schuylkill River: This project provides for a channel 6.5 miles long with depths of 22', 26', and 33' and widths of 200', 300', and 400'. Maintenance dredged material (last performed in 2008) is pumped directly to an upland disposal area by a cutter-head pipeline dredge.

Salem River: This project provides for an entrance channel 16' deep and 150' wide in the Delaware River across Salem Cove to the mouth thence 16' deep and 100' wide to the fixed highway bridge in Salem. It also provides for a cutoff between the mouth and Salem. The project length is approximately 5 miles.

Oakwood Beach: This CSRM project consists of a 50-feet wide berm that is 9,500 linear feet with 346,000 cubic yards of dredged material (from the Reedy Island Range of the Delaware River Main Channel), with periodic nourishment and the extension of five stormwater outfall pipes. The project was authorized by WRDA 1999, Title I, §101(b)(5), and was constructed as a Hurricane Sandy (PL 113-2) "authorized but unconstructed" (ABU) project in 2014.

USACE Studies and Reports

Delaware Bay Coastline, DE & NJ Feasibility Study (USACE, 1991): The Delaware Bay Coastline, DE & NJ Feasibility Study (1991) evaluated CSRM and ecosystem restoration problems along the Delaware Bay coastline in Delaware and New Jersey. The feasibility study evaluated seven interim study areas with four sites in New Jersey and three in Delaware. The study areas in New Jersey included the Maurice River area, the Villas and Vicinity, Reeds Beach to Pierces Point, and Oakwood Beach. Congress subsequently authorized the projects at Oakwood Beach, Reeds Beach–Pierces Point, and Villas, New Jersey.

Delaware River Main Stem and Channel Deepening Project - Environmental Impact Statement (1992); Supplemental Environmental Impact Statement (1997); Environmental Assessment (2009, 2011 and 2013): This project involves dredging as needed within the existing 40-foot Delaware River Federal navigation channel to deepen it to 45 feet from Philadelphia Harbor, Pa. and Beckett Street Terminal (Camden, NJ) along a 102.5-mile distance to deepwater in Delaware Bay. The deeper channel will provide more efficient transportation of containerized, dry bulk (steel and slag) and liquid bulk (crude oil and petroleum products) cargo to and from the Delaware River ports, with estimated net annualized benefits of more than $13 million to the U.S. economy.

Oyster and Water Quality Study for the Delaware River Main Channel Deepening Project (2000, 2012, 2013, 2014 and 2015): Data collection and scientific analysis of water quality and oyster beds in Delaware Estuary to assess possible hydrological changes due to channel deepening that may affect the biology and ecology of the estuarine system.

Delaware River Waterfront, PA (USACE, 2009): This reconnaissance study was initiated in 2009, and evaluates possible recommendations advisable in the interest of environmental restoration and protection, mitigation for previous activities and projects, riparian habitat improvement, water quality control, historic preservation, and other allied purposes, for the area extending from the Benjamin Franklin Bridge to the Poquessing Creek, including the tidal portions of tributary creeks in the reach of the Delaware River.

Delaware Bay Oyster Revitalization Project (USACE, 2005-2008): The native oyster population in the Delaware Bay is imperiled by disease. This project revitalized the natural oyster beds through shell planting/ transplanting over a four year period and has helped to maintain habitat diversity within the Bay. The study area includes all of the Delaware Bay, both New Jersey and Delaware. USACE's project efforts were completed in 2008 but additional shell plants by the Partnership for the Delaware Estuary and its collaborating partners have been conducted on a much smaller scale thereafter.

Delaware River Basin Comprehensive (USACE, 2006): This reconnaissance study was completed in May 2003. A FCSA was signed with the DRBC in July 2006. The objectives of this study were to: realize ecosystem restoration benefits gained by the effective restoration of habitat impacted by mining operations and wells, restore and protect the ecosystem and watershed; preserve open space and farmland; adopt sound land use planning practices; make infrastructure investments that do not promote sprawl; and invest in restoring public lands. The location of the study is within the Delaware River Basin, which is located in 28 counties in portions of New York, New Jersey, Delaware and Pennsylvania. The basin drains an approximate area of 12,765 square miles.

Biological Assessment (USACE, 2009): The BA evaluated potential impacts to Federally Listed Threatened and Endangered Species resulting from the Delaware River Main Stem and Channel Deepening Project. The BA included formal consultation with NMFS, pursuant to the Endangered Species Act.

Supplemental Biological Assessment (USACE, 2011): The Supplemental BA evaluated potential impacts to the New York Bight distinct population segment of Atlantic sturgeon (*Aciperser oxyrinchus oxyrinchus*) which is proposed for Federal Endangered Species Listing resulting from the Delaware River Main Stem and Channel Deepening Project. The Supplemental BA included formal consultation with NMFS, pursuant to the Endangered Species Act.

Delaware Estuary Salinity Monitoring Study (USACE, 2013): This study was completed in October 2013. The study provides hydrodynamic modeling capabilities for the Delaware Estuary to examine flow dynamics, salinity, and water quality. The study also collected population dynamics data for the Eastern Oyster and Atlantic and shortnose sturgeon, which have shown historically low populations along the Atlantic coast of North America. The model was used to assess the impacts of salinity variance to estuarine water users and the information gathered was useful to the States of New Jersey, Delaware and the DRBC in assessing low flow augmentation for the Delaware River and Bay.

Delaware River New Jersey, Delaware, and Pennsylvania Dredged Material Utilization and Beneficial Use Opportunities Expedited Reconnaissance Study (USACE, 2013): In response to the original study authorization from October 26, 2005, the Philadelphia District conducted this Expedited Reconnaissance Study. The purpose of this study was to examine beneficial use opportunities using maintenance dredged material from the Delaware River and its tributaries for multiple purposes. The findings of the expedited reconnaissance study indicated that there is Federal interest in further investigations of multiple-purpose beneficial sediment reuse opportunities through a feasibility study within New Jersey.

Reeds Beach and Pierces Point (USACE, 1998): This authorized, but unconstructed, ecosystem restoration project proposes to restore an 80-feet wide berm over 6,800 linear feet in Middle Township, Cape May County, NJ (along the Delaware Bay). The recommended plan entails a one-time placement of sand for horseshoe crab and shorebird habitat. A Limited Re-evaluation Report (LRR) was completed in 2006.

Villas and Vicinity (USACE, 1998): This authorized, but unconstructed, ecosystem restoration project proposes to restore an 80-feet wide berm over 29,000 linear feet in Middle and Lower Township, Cape May County, NJ (along the Delaware Bay). The recommended plan entails a one-time placement of sand for horseshoe crab and shorebird habitat. The project has not received funding since 2006. Hurricane Sandy struck the mid-Atlantic coastline in October 2012 causing widespread damage; therefore, this project may require a LRR.

1.6 PLANNING PROCESS AND REPORT ORGANIZATION

The planning process consists of six major steps: (1) Specification of water and related land resources problems and opportunities; (2) Inventory, forecast and analysis of water and related land resources conditions within the study area; (3) Formulation of alternative plans; (4) Evaluation of the effects of the alternative plans; (5) Comparison of the alternative plans; and (6) Selection of the recommended plan based upon the comparison of the alternative plans. The chapter headings and order in this report generally follow the outline of an Environmental Assessment (EA). Chapters of the report related to the six steps of the planning process as follows:

- Chapter 2, Problem Description and Objectives of the Proposed Action, covers the first step in the planning process (Specification of water and related land resources problems and opportunities).
- Chapter 3, Plans, is the heart of the report and is therefore placed before the detailed discussion of resources and impacts. It covers the third step in the planning process (Formulation of plans), the fourth step in the planning process (Evaluation of alternative plans), the fifth step in the planning process (Comparison of alternative plans) and the sixth step of the planning process (Selection of the recommended plan based upon the comparison of the alternative plans).
- Chapter 4, Affected Environment, covers the second step of the planning process (inventory, forecast and analysis of water and related land resources in the study area).
- Chapter 5, Effects on Environmental Resources, covers the fourth step of the planning process (Evaluation of the effects of the alternative plans).

This report was written in accordance with USACE Planning Modernization and meets the requirements, under the National Environmental Policy Act, as a full disclosure document of environmental effects of the proposed Federal agency actions. Information contained in the report demonstrates the decision-making process. For more information on the detailed analysis, please refer to the appendices.

2 PROBLEM DESCRIPTION AND OBJECTIVES OF THE PROPOSED ACTION

This chapter presents the results of the first step of the planning process, the specification of water and related land resources problems and opportunities in the study area. The chapter concludes with the establishment of planning objectives and planning constraints, which is the basis for the formulation of alternative plans.

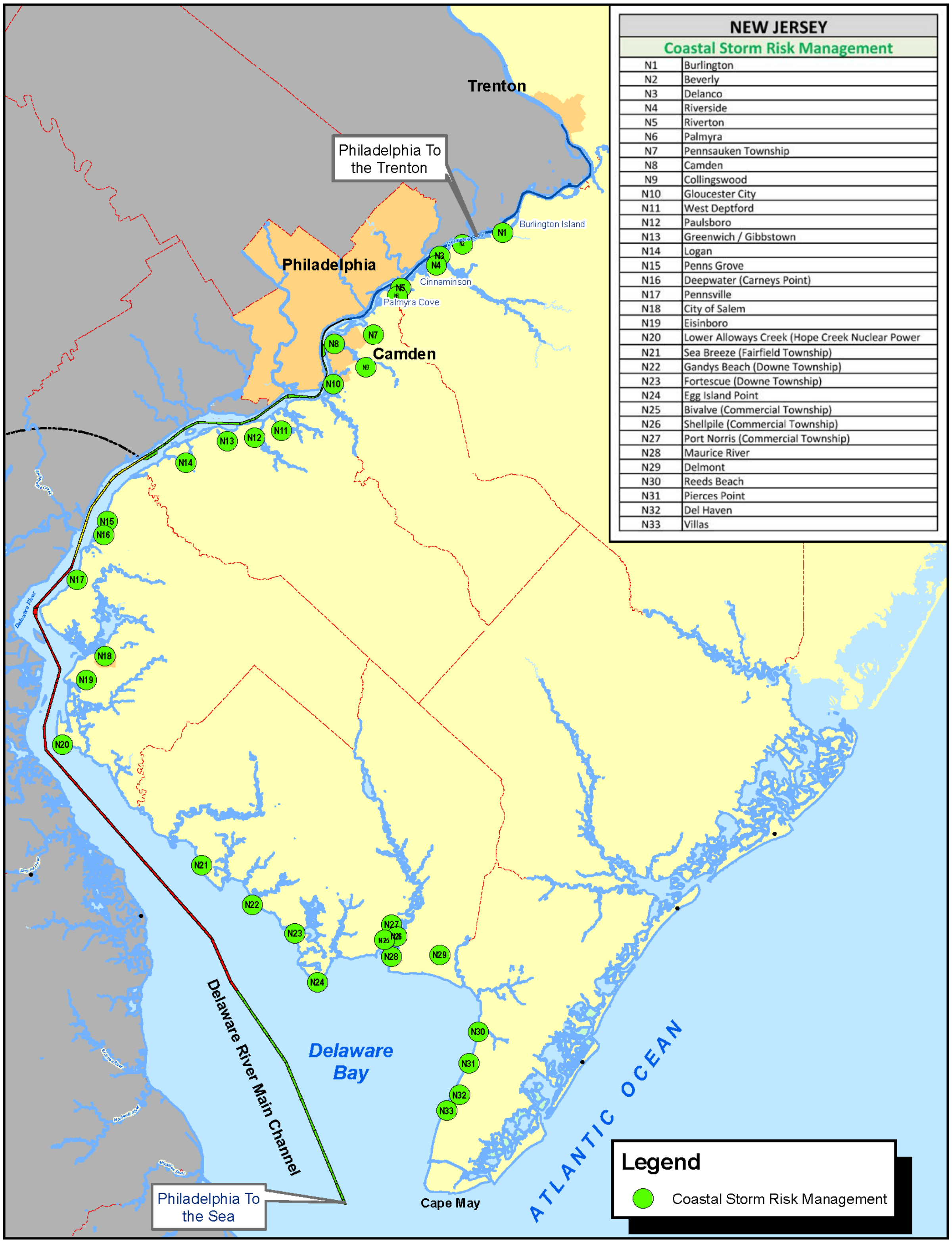
2.1 NATIONAL OBJECTIVES

The national or Federal objective of water and related land resources planning is to contribute to NED. In addition, it must be consistent with protecting the nation’s environment, pursuant to national environmental statutes, with applicable executive orders and with other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and in the rest of the nation as a result of reducing storm damages with the selected plan in place within the study area.

2.2 PUBLIC CONCERNS

As discussed in Section 1.2, the NACCS identified the Delaware River/Bay shoreline as a high risk area requiring additional analysis. Under the purview of the NACCS, there was significant coordination with state, county and local community agencies and representatives of non-profit organizations to identify specific flood-prone problem areas within New Jersey. The additional analysis and coordination under the NACCS identified the Delaware Bay shoreline as a “High Storm Impact” area from Hurricane Sandy. For the Delaware Bay shoreline in the state of New Jersey, 33 CSRM problem areas were identified extending from Burlington to Cape May Counties, as shown in Figure 3.

Figure 3 - CSRM Problem Areas



2.3 PROBLEMS AND OPPORTUNITIES

This section describes the needs in the context of problems and opportunities that can be addressed through water and related land resource management. The problems and opportunities are based upon the project conditions that are described in Chapter 4, Affected Environment.

The primary problems identified in this study are shoreline erosion, waves and storm surge caused by coastal storms, along with SLC, cause flood-related damages along the Delaware Estuary shoreline of New Jersey. The shoreline is characterized by flat, low-lying coastal plains with broad marshes and narrow barriers of sand along the bay beaches. The sand beach barrier is widest and most well-developed near the mouth of the bay (south of Villas), becoming less prevalent to the north.

The nature of the CSRM problem and the study area characteristics also present the following opportunities:

- Minimize erosion, wave and storm-surge related damages to New Jersey communities located along and adjacent to the Delaware Estuary shoreline.
- Increase the resiliency of the New Jersey shoreline by reducing its vulnerability to flood and storm events.
- Beneficially use dredged material to minimize erosion, wave and storm-surge related damages and increase resiliency along the New Jersey shoreline.

2.4 WITHOUT PROJECT CONDITIONS

As referenced above, the CSRM problem areas are located in DRBC Zones 2 through 6. The Delaware River region (comprised of DRBC Zones 2 through 5) is identified by DRBC as the Upper Estuary Watershed and includes Mercer, Burlington, Camden, Gloucester and Salem Counties. These counties are the more populated counties within the study area (located within both the New York and Philadelphia Metropolitan areas) and contain numerous industries. The area within and surrounding Trenton in Mercer County has a long history in the iron and steel industries, metals, rubber and ceramics. The residential communities in Burlington, Camden and Gloucester Counties are characterized by medium to high density single and multiple family urban homes with urban, bluff and wetland shoreline types, as defined by the NACCS. Specifically, Gloucester County transitions to a more rural and residential area with a patchwork of farmland, forests and communities. Salem County consists primarily of farmland interspersed with woodland and residential communities characterized by medium density single-family rural homes. The most populous communities within Salem County are Pennsville Township, Carneys Point Township and Penns Grove. A number of municipalities are working to preserve farmland within the county.

The Bay Region of the study area (DRBC Zone 6) includes bayshore communities in Cumberland (Sea Breeze, Gandys Beach, Fortescue, Egg Island Point, Bivalve, Shellpile, Port Norris, Maurice River and Delmont) and Cape May Counties (Reeds Beach, Pierces Point, Del Haven and Villas). The communities in Cumberland County consist of low density single-family rural homes with wetland and urban shoreline types, as defined by the NACCS. Bayshore communities in Downe Township were historically known for their commercial/recreational fishing and hunting traditions. These communities and their surrounding wetlands were severely flooded and eroded by Hurricane Sandy in October 2012.

Cape May County is the southernmost county in New Jersey that has consistently been a popular summer destination. Tourism is the county's single largest industry. Lower Township shares a shoreline on both the Atlantic Ocean and the Delaware Bay and is the largest municipality in the county. Small seasonal bungalows have been replaced along the Delaware Bay shoreline with medium to high density, large multi-story homes. Fishing and farming in surrounding areas continues to be an important economic factor.

2.4.1 Existing Coastal Storm Risk

The shorelines of the New Jersey Delaware Estuary are characterized by flat, low-lying coastal plains that are subject to inundation during storms, wave attack, as well as the ongoing effects of shoreline erosion and SLC. The Delaware Bay is 47 mi long and 27 mi wide measured at the widest point, making the area vulnerable to wave attack, erosion and flood damages from coastal and potentially fluvial sources. The shoreline consists of tidal marshes and sandy barriers or developed residential and commercial infrastructure. Public and private property at risk includes densely populated sections of the shoreline bordering the Delaware Estuary and associated tidal tributaries. Specifically, there are densely developed urban areas, private residences, businesses (including refineries and chemical plants), schools, infrastructure, roads and evacuation routes for coastal emergencies. Additionally, the study area includes undeveloped areas that provide ecological, fisheries and recreational benefits as well as ecosystem services. Dunes, beaches, marshes and estuarine ecosystems are quite fragile in some locations and are threatened by coastal storm events and the effects of climate change. In addition, there is an extensive network of private and state-preserved agricultural land in the study area.

Different regions of the Delaware Estuary exhibit differing flood and erosion problems. Developed residential areas incur frequent flood damages to homes and businesses from storm events while lesser developed regions incur excess inundation to natural habitat and farmland, incurring community and recreational access and economic losses due to flooding.

As referenced above, the northern planning reach has densely developed urban areas and businesses (including refineries and chemical plants). While much of the northern reach is developed with residential communities, industry is concentrated in Camden, Burlington and Mercer Counties. In the southern planning reach, the Delaware Bay shoreline (from the Cohansey River south to Cape May Point) is characterized by small residential communities interspersed with expansive salt marshes, narrow sandy beaches, dunes and low tide mud flats. The bay shoreline is not heavily developed and ownership along the bay shoreline is a mix of private, state and Federal lands. Approximately 52,000 acres of New Jersey bay wetlands are state-owned, most as Fish and Wildlife Management Areas (FWMA). New Jersey Wildlife Management Areas include: Mad Horse Creek, Dix, Nantuxent, Fortescue, Egg Island, Heislerville, Dennis Creek and Higbee Beach. The one Federally protected area is Cape May National Wildlife Refuge, a unit of the U.S. Fish and Wildlife Service (USFWS). Most of the beach areas, such as Fortescue, Reeds Beach and south of Reeds Beach, are accessible from roads. There is limited access to Moores Beach due to road washout at high tide. These areas incur frequent flood damages to home and businesses from storm events while lesser developed regions incur excess inundation to natural habitat, incurring community and recreational access and economic losses due to flooding. Erosion and flooding are the primary coastal hazards that lead to property and infrastructure damages. Coastal storms can occur at any time of the year and at varying levels of severity. Storm surge (i.e. over and above normal tidal action) inundates land areas with estuarine waters.

2.4.2 Historical Flooding

According to the National Climatic Data Center (NCDC), the following flood events were reported between January 1995 and December 2014:

- Burlington County: 33 days with flood events (5 with property damage totaling $5.36 million)
- Camden County: 26 days with flood events (3 with property damage totaling $1.35 million)
- Gloucester County: 25 days with flood events (3 with property damage totaling $1.8 million)
- Cumberland County: 18 days with flood events (2 with property damage totaling $11 million)
- Cape May County: 58 days with flood events (7 with property damage totaling $319 million)
- Salem County: 23 days with flood events (3 with property damage totaling $7.3 million)

Figure 4 - Reeds Beach – July 2005

Figure 5 - Pierces Point – July 2005

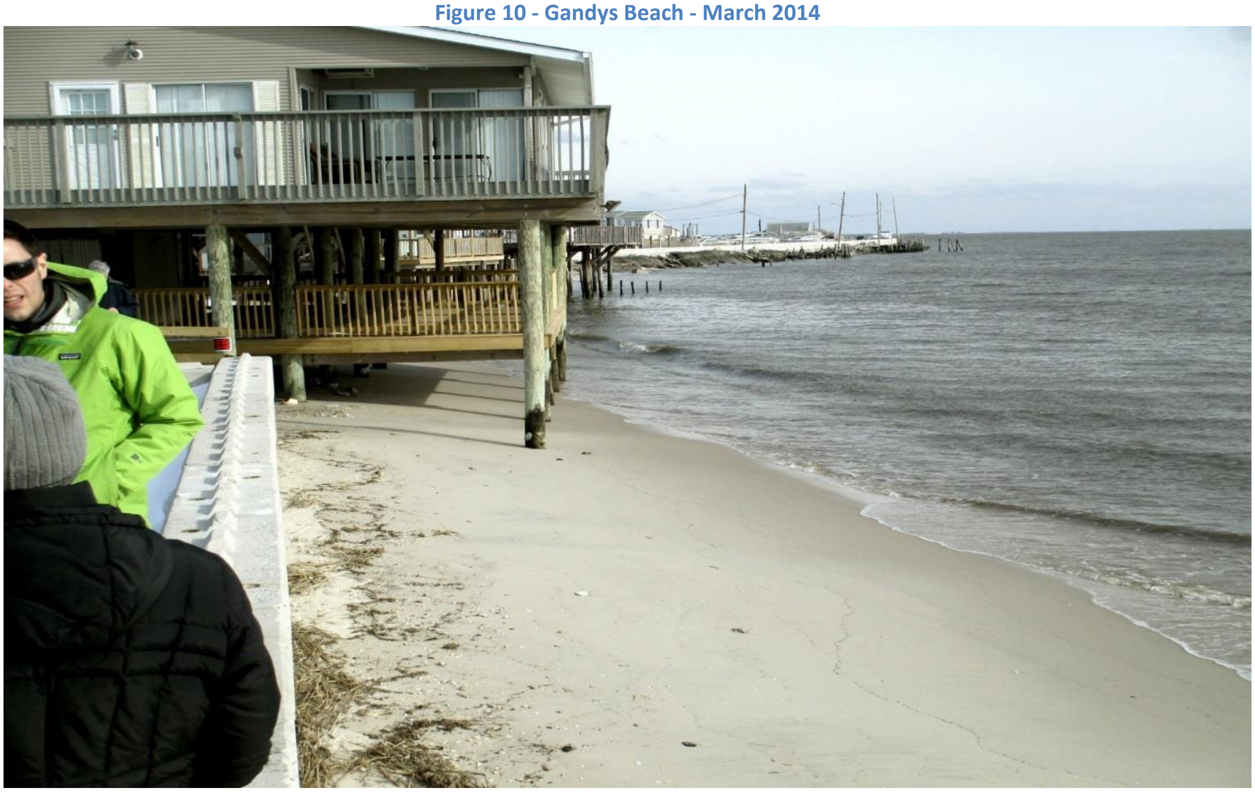
Figure 6 - Pierces Point – July 2005

Figure 7 - Reeds Beach – July 2005

Figure 8 - Villas - October 2012

Figure 9 - Fortescue - March 2014

Figure 10 - Gandys Beach - March 2014



2.4.3 Existing Coastal Storm Risk Management

USACE has evaluated potential CSRM along the Delaware Estuary shoreline since the early 1990s via the Delaware Bay Coastline, DE & NJ Feasibility Study (1991) as well as the Delaware River Basin Comprehensive (2006) feasibility study. In the northern reach, a CSRM project was constructed at Oakwood Beach in 2014. The project consists of a 50-feet wide berm that is 9,500 feet long with periodic nourishment and the extension of five stormwater outfall pipes. To date, no other Federal CSRM projects have been constructed within the study area. USACE is not aware of state and/or local CSRM projects within the study area.

2.4.4 Future Without Project Conditions

In August 1991, the Corps conducted a review of the Delaware Bay and its tributaries to determine the magnitude, location and effect of the shoreline erosion problems under the scope of the Delaware Bay Coastline – New Jersey and Delaware Reconnaissance Study. The study examined the New Jersey shoreline in Cumberland and Cape May Counties. Table 1 provides a summary of shoreline erosion trends in the aforementioned counties:

Table 1 - New Jersey Shoreline Erosion Rates

New Jersey	Minimum Shoreline Change Rate (ft/yr)	Maximum Shoreline Change Rate (ft/yr)	Average Shoreline Change Rate (ft/yr)
Arnolds Pt to Bayside	-2	-5	-3.5
Sea Breeze	-2	-5	-3.5
Fortescue	-1	-1	-1
Maurice River Cove	-3	-12	-7.5
East Pt to Thompsons Beach	Stable	Stable	Stable
Moores Beach	-2	-6	-4
Reeds Beach	-3	-3	-3
Green Creek to Villas	+1	+1	+1
Villas to Cape May Canal	-2	-2	-2

The minimum and maximum shoreline change rates listed on Table 1 were extracted from the 1991 Delaware Bay Coastline - New Jersey and Delaware Reconnaissance Study. The average of the minimum and maximum shoreline change rates was then calculated by the PDT. This table highlights that the New Jersey average shoreline change rates ranged from +1 ft/yr to -7.5 ft/yr in the area studied.

Assuming these trends continue and are potentially exacerbated by SLC, a significant amount of shoreline erosion will occur along the New Jersey shoreline. In addition to the ongoing effects of shoreline erosion and SLC, the Delaware Bay shoreline is vulnerable to flood-related damages from coastal storm events. Increased storm and erosion damage will continue to undermine the physiography supporting the existing structures and infrastructure in the developed areas and erode adjacent marsh and wetland habitat.

It is important to note that in the absence of a Federal project under this study authority, maintenance dredging is anticipated to continue throughout the Delaware Estuary with the majority of the dredged material disposal occurring in CDFs and/or Buoy 10 open water disposal site. As discussed in Section 3.4 and shown on Figure 11, the proposed source of material for this project is Lower Reach E (Miah Maull and Brandywine Ranges) of the Delaware Estuary main channel. The estimated future O&M dredging of Miah Maull and Brandywine is projected to be 465,000 cy/yr, with a dredging interval of 2 years. For the existing navigation project the dredged material disposal from Lower Reach E will be bottom dumping in Buoy 10 for approximately 10 more years (based on the current plans to expand the Buoy 10 footprint); however, after 10 years, the current plan is to take the material to the Artificial Island CDF for disposal. Section 3.5.1 provides further discussion on the future without project conditions and the potential economic impacts of such conditions.

2.4.5 Federal Interest

The Federal Government investigates prospective projects from a national point of view. When determining the need for Federal investment in a project, the primary analysis centers on significance of the problem and the benefits of possible solutions. In the case of this study, the focus is primarily on CSRM benefits. It is also in the Federal and non-Federal sponsor's interest to select a cost-effective plan, specifically one in which the benefits exceed costs. It is important to note that benefits can include non-monetary benefits such as reducing life-safety issues and improving the environmental quality. Federal interest in the project is identified when both requirements are satisfied.

Based on historical records, the identified problem areas experience significant flood-related damage every couple of years. It is within USACE and Federal interest to study the CSRM issues in this study area because there are significant flood damages that result in residential and commercial property loss. Impacts from frequent flooding in the past include significant economic costs. Developing a project that will reduce the frequency of these damages and protect human life is within the Federal interest and a primary mission of USACE.

2.5 PLANNING OBJECTIVES

The water and related land resource problems and opportunities identified in this study area are stated as specific planning objectives to provide focus for the formulation of plans and development of criteria. These planning objectives represent desired positive changes in the "without project" conditions. The base year, the year the project is assumed to be fully operational is 2022, and the period of analysis is through the year 2072. The planning objectives are as follows:

1. Improve CSRM for people, property and infrastructure along and adjacent to the New Jersey shoreline from 2022 to 2072, via the beneficial use of dredged material.

2. Increase the resiliency of coastal New Jersey, specifically along the Delaware Estuary shoreline, via the beneficial use of dredged material.

According to the NACCS, coastal resilience is a function of the shoreline's adaptive capacity. Adaptive capacity is defined as a measure's ability to adjust through natural processes, operation and maintenance activities, or adaptive management, to preserve the measure's function.

2.6 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in this study are as follows:

- CSRM must be achieved via the beneficial use of dredged material.
- Avoid inducing flood damages.
- Avoid conflicts with the existing engineering policies for CSRM projects.
- Do not formulate CSRM plans for a single private property.
- Avoid impacts to Threatened and Endangered Species.
- Avoid degradation to water quality.
- Avoid and/or minimize effects on cultural resources and historic structures, sites and features.
- The timing of maintenance dredging will control the availability of sand for placement.
- Existing topography for tying in dune alignment will impact CSRM benefits realized.

In addition to the aforementioned constraints, the following planning consideration was recognized during the formulation process: Limit extensive changes to local land use designations and zoning.

3 PLANS

This chapter describes the development of alternative plans that address the planning objectives, the comparison of those plans and the selection of a plan. It also describes the recommended plan and its implementation requirements.

3.1 PLAN FORMULATION RATIONALE

As referenced in Section 2, 33 CSRM problem areas were identified in the study area. As part of the alternative plan development, the PDT applied multiple rounds of screening to the 33 problem areas to determine which areas could be addressed by a Federal project, in accordance with the study objectives.

Each of the identified problem areas was screened by the PDT to better understand the nature and extent of the CSRM problems. Initially, the PDT posed the question as to whether CSRM was the primary problem at each location. CSRM was considered a primary problem at a location if the Composite Exposure Index (CEI), as calculated in the NACCS, was greater than 50%. In calculating the CEI, the NACCS defined exposure as the presence of people, infrastructure, and/or environmental and cultural resources affected by coastal storm risk hazards. Specifically, three exposure indices were combined to develop the CEI:

- Population Density and Infrastructure Index – the affected population and critical infrastructure
- Social Vulnerability Index – segments of the population that may have more difficulty preparing for and responding to natural disasters

- Environmental and Cultural Resources Index – important habitat and cultural and environmental resources that would be vulnerable to storm surge

Each index was multiplied by a relative weight and the results were summed to develop the total index. Population density and infrastructure were weighted 80%, while social vulnerability and environmental/cultural resources were each weighted 10%. The PDT chose to use the NACCS CEI as a Cycle 1 screening tool since the CEI was heavily weighted toward the impact of CSRM risks to people and infrastructure. While it was heavily weighted toward people and infrastructure, there were other metrics (social vulnerability and environmental/cultural indices) that contributed to the overall CEI; therefore, the PDT also applied best professional judgment to validate that the problem areas with greater than 50% CEI were predominantly inhabited by people and structures. If the problem area had a CEI greater than 50% and was subsequently validated by PDT best professional judgment, it was evaluated further to determine if dredged material would be a feasible CSRM measure in the problem area.

During Cycle 1 screening, a primary driver behind assessing the feasibility of using dredged material was determining the transport distance from the dredged material source area to the problem area(s). In addition, the amount of space and land available to place dredged material at the problem was considered, as well as the shoreline type at the problem area, per the NACCS. From there, potential sources of dredged material were identified:

- Confined Disposal Facilities (CDFs) – In the Delaware River Watershed, the predominant dredged material management practice has been to place material in upland CDFs after it is dredged from the channel. Sediment is then sequestered and managed in the CDF for an indefinite period of time. Within New Jersey, the PDT has identified 10 CDFs (Burlington Island, Cinnaminson, Palmyra Cove, National Park, Oldmans, Pedricktown North & South, Penns Neck, Killcohook and Artificial Island) that could serve as potential sediment sources for CSRM solutions. The New Jersey CDFs are located in the northern planning reach and may serve as a potential source for project areas in that portion of the watershed.
- Delaware Estuary Main Channel – The Delaware Estuary channel could also serve as a source area during O&M channel dredging, via a hopper dredge and associated piping/pumping of the dredged material to a potential project area. Depending on the type of material needed and the nature of the proposed project, dredging and piping/pumping from the main channel may serve as a potential source throughout the study area.
- Buoy 10 – Buoy 10 is an open water disposal site that is used for disposal of sandy dredged material. Buoy 10 is located in the southern planning reach near the mouth of the Delaware Bay and may be a viable sediment source for project areas in the lower portion of the study area.

If Cycle 1 screening indicated that CSRM was the primary problem and dredged material was a feasible measure, the problem area was carried forward for further analysis under this “Ongoing Study.” If CSRM was not the primary problem or dredged material was not considered a feasible measure, the problem area was screened out and recommended for further analysis under another authority. The results of the Cycle 1 screening are detailed in Table 2 below:

Table 2 - Problem Area Screening - Cycle 1

Cycle 1 Screening – NJ DMU		Question 1a: Is the CEI >50%? or Question 1b: Is the area at risk primarily inhabited by people and infrastructure?	Question 2: Is DM a feasible measure?	Carry Forward for Further Analysis under "Ongoing Sandy Study"
N1	Burlington	**Y**	**N**	**N**
N2	Beverly	**Y**	**N**	**N**
N3	Delanco	**Y**	**N**	**N**
N4	Riverside	**Y**	**N**	**N**
N5	Riverton	**Y**	**N**	**N**
N6	Palmyra	**Y**	**N**	**N**
N7	Pennsauken Township	**Y**	**N**	**N**
N8	Camden	**Y**	**N**	**N**
N9	Collingswood	**Y**	**N**	**N**
N10	Gloucester City	**Y**	**N**	**N**
N11	West Deptford	**Y**	**N**	**N**
N12	Paulsboro	**Y**	**N**	**N**
N13	Greenwich/Gibbstown	**Y**	**N**	**N**
N14	Logan	**Y**	**N**	**N**
N15	**Penns Grove**	**Y**	**Y**	**Y**
N16	**Deepwater (Carneys Point)**	**Y**	**Y**	**Y**
N17	**Pennsville**	**Y**	**Y**	**Y**
N18	City of Salem	Y	N	N
N19	Elsinboro	Y	N	Y
N20	Lower Alloways Creek	N	Y	N
N21	Sea Breeze (Fairfield Twp.)	**Y**	**N**	**N**
N22	**Gandys Beach (Downe Twp.)**	**Y**	**Y**	**Y**
N23	**Fortescue (Downe Twp.)**	**Y**	**Y**	**Y**
N24	Egg Island Point	**N**	**Y**	**N**
N25	**Bivalve (Commercial Twp.)**	**Y**	**Y**	**Y**
N26	**Shellpile (Commercial Twp.)**	**Y**	**Y**	**Y**
N27	**Port Norris (Commercial Twp.)**	**Y**	**Y**	**Y**
N28	**Maurice River Twp.**	**Y**	**Y**	**Y**
N29	Delmont	**N**	**Y**	**N**
N30	**Reeds Beach**	**Y**	**Y**	**Y**
N31	**Pierces Point**	**Y**	**Y**	**Y**
N32	**Del Haven**	**Y**	**Y**	**Y**
N33	**Villas**	**Y**	**Y**	**Y**

After the Cycle 1 screening, 20 sites were screened out from the initial 33 and recommended for further potential analysis under another authority. Specifically, the 14 problem areas spanning Burlington County to Gloucester County (N1 through N14) were screened out because majority of the shoreline in these areas appeared to be fairly hardened and protected with limited available space for the placement of dredged material. Penns Grove (N15) and Deepwater (Carneys Point – N16) were combined into one problem area, given their proximity to each other. The City of Salem (N18) was screened out because there was limited space for placement of dredged material. Elsinboro (N19) was screened out because the flood risks are currently being managed by the Federal Oakwood Beach, NJ flood and CSRM project.

Hope Creek Generating Station (HCGS) is the primary structure located at the Lower Alloways Creek problem area (N20). The Delaware River banks at HCGS are lined with heavy rip-rap, sheet piling and/or wood piling to protect the banks from erosion. Other sections of the river bank upstream of the property are similarly protected. Some areas further upriver are also protected by concrete structures to prevent erosion and lateral migration of the river. Lands consisting of tidal marsh are located to the north and east of the property. Based on the existing protection at N20 and the fact the FEMA floodplain mapping indicates the HCGS property is not in the 100-YR floodplain and only partially in the 500-YR floodplain, N20 was screened out.

Sea Breeze (N21), Egg Island Point (N24) and Delmont (N29) were screened out because CSRM was not considered to be the primary problem because the CEI was less than 50% and the areas were not primarily inhabited by people and infrastructure.

3.2 MANAGEMENT MEASURES

Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. Management measures are the building blocks of alternative plans and are defined as features or activities that can be implemented at a specific geographic site to address one or more planning objectives. The PDT formulated as many measures as possible, with the understanding that there would be at least one measure for each planning objective:

Non-Structural Measures:

1. Acquisition and Relocation – Buildings may be removed from vulnerable areas by acquisition (buy-out), subsequent demolition, and relocation of the residents. Often considered a drastic approach to storm damage reduction, property acquisition and structure removal are usually associated with frequently damaged structures. Implementation of other measures may be effective but if a structure is subject to repeated storm damage, this measure may represent the best alternative to eliminating risks to the property and residents.
2. Building Retrofit - Building retrofit measures include dry flood proofing or elevation of a structure. Dry floodproofing involves sealing flood prone structures from water with door and window barriers, small scale rapid deployable floodwalls, ring walls, or sealants. Elevation of structures is usually limited to residential structures or small commercial buildings. Whether a structure may be elevated depends on a number of factors including the foundation type, wall type, size of the structure, condition, etc.
3. Enhanced Flood Warning & Evacuation Planning - Flood warning systems and evacuation planning are applicable to vulnerable areas. Despite improved tracking and forecasting techniques, the uncertainty associated with the size of a storm, the path, or its duration necessitate that warnings be issued as early as possible. Evacuation planning is imperative for

areas with limited access, such as barrier islands, high density housing areas, elderly population centers, cultural resources, and areas with limited transportation options.

4. Flood Insurance - Residents that are uncertain about reducing risk to their belongings may be prone to attempt to remain in vulnerable areas during storm events, creating further risk. Knowing that personal property is insured, residents may be more comfortable with evacuating vulnerable areas at the approach of a storm.

Structural Measures:

1. Levees and Dikes – Levees and dikes are embankments constructed along a waterfront to prevent flooding in relatively large areas. They are typically constructed by compacting soil into a large berm that is wide at the base and tapers toward the top. If a levee or dike is located in an erosive shoreline environment, revetments may be needed on the waterfront side to reduce impacts from erosion, or in cases of extreme conditions, the dike face may be constructed entirely of rock. Levees may be constructed in urban areas or coastal areas; however, large tracts of real estate are usually required due to the levee width and required setbacks.
2. Beach Restoration - Beach restoration, also commonly referred to as beach nourishment or beachfill, typically includes the placement of sand fill to either replace eroded sand or increase the size (width and/or height) of an existing beach, including both the beach berm and dunes. Material similar to the native grain size is artificially placed on the eroded part of the beach.
3. Flood Wall(s) –
    a. Permanent Flood Wall - A flood wall is a concrete or sheet pile structure that parallels the channel on either side, rising above the surrounding floodplain (or above existing levees). Similar to a levee, a flood wall reduces the volume of water leaving the river channel.
    b. Rapid Deployment Flood Wall (RDFW) – A flood wall that is temporarily erected along the banks of a river or estuary, or in the path of floodwaters to prevent water from reaching the area behind the structure. After the storm or flood, the structure is removed. This category also includes permanently installed, deployable flood barriers that rise into position during flooding due to the buoyancy of the barrier material and hydrostatic pressure.
4. Shoreline Stabilization
    a. Seawalls/Bulkheads - Structures are often needed along shorelines to provide risk reduction from wave action or to stabilize and retain in situ soil or fill. Vertical structures are classified as either seawalls or bulkheads, according to their function, while protective materials laid on slopes are called revetments (USACE 1995). A bulkhead is primarily intended to retain or prevent sliding of the land, while reducing the impact of wave action is of secondary importance. Seawalls, on the other hand, are typically more massive structures whose primary purpose is interception of waves and reduction of wave-induced overtopping and flooding of the land structures behind. Note that under this definition seawalls do not include structures with the principal function of reducing

risk to low-lying coastal areas. In those cases a high, impermeable, armored structure known as a sea dike is typically required to prevent coastal flooding (USACE 2002).
   b. Revetments - Onshore structures with the principal function of reducing the impacts to the shoreline from erosion and typically consist of a cladding of stone, concrete, or asphalt to armor sloping natural shoreline profiles (USACE 2002). They consist of an armor layer, filter layer(s), and toe protection.
5. Storm Surge Barriers - Storm surge barriers reduce risk to estuaries against storm surge flooding and waves. In most cases the barrier consists of a series of movable gates that stay open under normal conditions to let the flow pass but are closed when storm surges are expected to exceed a certain level.
6. Groins - Groins are structures that extend perpendicularly from the shoreline. They are usually built to stabilize a stretch of natural or artificially nourished beach against erosion that is due primarily to a net longshore loss of beach material. The effect of a single groin is accretion of beach material on the updrift side and erosion on the downdrift side; both effects extend some distance from the structure.
7. Breakwaters - In general, breakwaters are structures designed to reduce risk to shorelines, beaches, or harbor areas from the impacts of wave action thereby reducing shoreline erosion and storm damage. Breakwaters are usually built as rubble-mound structures (USACE 2002) though they can be constructed from a variety of materials such as geotextile and concrete. The dissipation of wave energy allows sand to be deposited behind the breakwater. This accretion further reduces risk to the shoreline and may also widen the beach.

Natural and Nature-Based Features (NNBF): Per the NACCS, natural features are created and evolve over time through the action of physical, biological, geologic, and chemical processes operating in nature. Nature-based features are those that may mimic characteristics of natural features, but are created by human design, engineering, and construction to provide specific services such as coastal risk management. Nature-based features are acted upon by the same physical, biological, geologic, and chemical processes operating in nature, and as a result, generally must be maintained to reliably provide the expected level of service.

1. Living Shoreline - Living shorelines represent a shoreline management option that combines various erosion control methods and/or structures while restoring or preserving natural shoreline vegetation communities and enhancing resiliency. Typically, creation of a living shoreline involves the placement of sand, planting marsh flora; and, if necessary, construction of a rock structure on the shoreline or in the near shore (VIMS 2013b). Living shorelines can use a variety of stabilization and habitat restoration techniques that span several habitat zones and use a variety of materials. Specifically, living shorelines can be used on upland buffer/back shore zones, coastal wetlands and beach strand zones, and the subtidal water zone. Living shoreline materials may include sand fill, clean dredged material, tree and grass roots, marsh grasses, mangroves, natural fiber logs, rock, concrete, filter fabric, seagrasses, etc. (Maryland DNR, 2007).

2. Overwash Fans - Overwash is the landward transport of beach sediments across a coastal barrier feature. Large coastal storms and their associated high winds, waves, and tides can result in overwash of the beach and dune system. During storm conditions, elevated storm tides and high waves may erode beaches and dunes, and the eroded sand can be carried landward by surging water. The sand and water may wash over or break through the dunes, and spill out onto the landward side of the barrier island. This deposit is usually fan-shaped and therefore is known as an overwash fan (or washover fan) (Delaware Sea Grant, 2009). Engineered overwash fans would increase overall barrier island stability and back bay CSRM capacity by increasing its width/volume and providing a substrate suitable for wetland growth.
3. Reefs - Artificial reefs enhance the resilience of coastal areas by reducing the degradation and shoreline erosion that would occur during a storm event.
4. Wetlands - Coastal wetlands may contribute to coastal FRM wave attenuation and sediment stabilization. The dense vegetation and shallow waters within wetlands can slow the advance of storm surge somewhat and slightly reduce the surge landward of the wetland or slow its arrival time (Wamsley et al. 2010). Wetlands can also dissipate wave energy.

As previously referenced, the original 33 problem areas were subjected to Cycle 1 screening to confirm that CSRM was the primary problem and that the use of dredged material was potentially feasible in a management measure for the problem area. The PDT formulated structural and non-structural measures for each problem area. In Cycle 2, the measures were compared against the planning objectives to see if they were in line with the study purpose.

The NACCS criteria for assessing each measure's Storm Damage Reduction Function was applied to determine if a measure met Objective 1. The Storm Damage Reduction Function was based on the measure's ability to mitigate flooding, attenuate wave action and reduce shoreline erosion. Per the NACCS, if the selected measure received at least a "medium" ranking for one of these three criteria and dredged material was feasible to use for implementation of the measure, the PDT determined that the measure met Objective 1.

The NACCS criteria for assessing each measure's resilience was applied to determine if a measure met Objective 2. Specifically, if the NACCS ranking indicated a "medium" or higher "adaptive capacity" for a selected measure, the PDT determined that the measure increased the shoreline resilience and met Objective 2. Adaptive capacity is defined as a measure's ability to adjust through natural processes, operation and maintenance activities, or adaptive management, to preserve the measure's function.

In order for measures to be carried forward for further analysis, they must have met one of the two study objectives.

Table 3 - Objectives/Measures Matrix

Management Measure	**Non-Structural**	**Structural**	**NNBF**	**Objective 1:** Improve CSRM for people, property and infrastructure along and adjacent to the New Jersey shoreline from 2022 to 2072, via the beneficial use of dredged material.	**Objective 2:** Increase the resiliency of coastal New Jersey, specifically along the Delaware River/Bay shoreline, via the beneficial use of dredged material.	Management Measure Carried Forward for Further Analysis (Y/N)?
Levees and Dikes		X		Y	N	Y
Flood Wall 1. Permanent 2. RDFW		X		1. Permanent - N 2. RDFW - N	1. Permanent - N 2. RDFW - N	N
Shoreline Stabilization 1. Seawalls/Bulkheads 2. Revetments		X		1. Seawalls/Bulkheads - N 2. Revetments – N	1. Seawalls/Bulkheads - N 2. Revetments - N	N
Storm Surge Barriers		X		N	N	N
Beach Restoration 1. Dune & Berm 2. Dune 3. Berm 4. Perched Beach 5. Geotubes		X		Y	Y	Y
Groins		X		N	Y	Y
Breakwaters		X		N	Y	Y
Overwash Fan			X	N	Y	Y
Living Shoreline			X	N	Y	Y
Reef			X	N	Y	Y
Wetland			X	N	Y	Y
Acquisition and Relocation	X			N	N	N
Building Retrofit	X			N	N	N
Enhanced Flood Warning & Evacuation Planning	X			N	N	N
Flood Insurance	X			N	N	N

Non-Structural Measures

The non-structural measures were screened out because they did not meet at least one of the two study objectives. While acquisition had a high storm damage reduction function and adaptive capacity, it did not involve the use of dredged material. The same is true for the other three non-structural measures; therefore, they were not carried forward for further analysis.

Structural Measures

During the Cycle 2 screening, beach restoration met both study objectives; therefore, beach restoration measures were carried forward for further analysis. Per the NACCS, a well-designed beach restoration project reduces risk to the structures and population behind it by providing a buffer against the increased wave energy and storm surge generated during a coastal storm event. While it can function well as a stand-alone measure, beach restoration can be used in combination with other structural shoreline risk management measures, such as groins, breakwaters and reefs, in highly erosional areas. Groins, breakwaters and reefs were also carried forward for further analysis because they potentially enhance the functionality of beach restoration measures, thereby creating a more resilient shoreline.

According to the NACCS, levees and dikes contribute a low level of wave attenuation and little or no erosion reduction; however, the PDT believes they are a potentially effective method of CSRM in portions of the study area with more limited wave and erosion processes (northern planning reach).

Floodwall(s), shoreline stabilization and storm surge barriers were not carried forward for further analysis because they did not meet the study objectives.

Natural and Nature-Based Features (NNBF)

Three NNBF measures (living shorelines, overwash fans and wetlands) were also carried forward for further analysis because they met Objective 2. While these measures did not meet Objective 1, they did exhibit enough adaptive capacity to be considered resilient measures that meet Objective 2. Specifically, living shoreline creation involves the placement of sand, planting marsh flora, and if necessary, construction of a rock structure on the shoreline or in the near shore (VIMS 2013b). Per the NACCS, living shoreline materials may include sand fill, clean dredged material, tree and grass roots, marsh grasses, mangroves, natural fiber logs, concrete, filter fabric, seagrasses, etc. (Maryland DNR, 2007). They are generally applicable to relatively low current and wave energy environments in estuaries, rivers and creeks.

Engineered overwash fans would increase shoreline stability and resilience by increasing the shoreline width/volume and providing a substrate suitable for wetland/plant growth. Essentially, the engineered overwash fan would mimic the beneficial effects of natural overwash without the damages typically associated with overwash. Sandy sediment for the overwash fan could come from borrow sources and/or dredged material and be applied in a “thin layering” technique to mitigate for wetland erosion and the impacts of SLC on wetlands.

Wetlands can increase shoreline resiliency by contributing to coastal CSRM wave attenuation and sediment stabilization. The magnitude of these effects depends on the specific characteristics of the wetlands, including the type of vegetation, its rigidity and structure, as well as the extent of the wetlands and their position relative to the storm track. Sandy sediment is preferred in wetlands so that plant roots develop more effectively; however, wetlands can contain a higher percentage of fines than the beach region in front of them.

3.3 PLAN FORMULATION

During the development of the array of alternatives, the management measures that passed Cycle 2 screening were applied to the remaining 12 CSRM problem areas that passed Cycle 1 screening, as indicated on Table 4. Measures that were not beneficially using dredged material, but had the potential to augment or to be considered as a scale to work with beneficial use were included in the formulation process (groins, breakwater, reefs, etc.)

Table 4 - Measure Applicability by Problem Area

Problem Area	Beach Restoration	Groins	Breakwaters	Reef	Living Shoreline	Overwash Fans	Wetlands	Levees/Dikes	Shoreline Stabilization	Storm Surge Barrier
Penns Grove/Carneys Point								X		
Pennsville								X		
Gandys Beach	X	X	X		X		X			
Fortescue	X	X	X		X		X			
Bivalve								X		
Shellpile								X		
Port Norris								X		
Maurice River Twp.								X		
Reeds Beach	X	X	X		X		X			
Pierces Point	X	X	X		X		X			
Del Haven	X	X	X		X		X			
Villas	X	X	X		X		X			

Based on the characteristics of the study area and the associated problems, the remaining measures were combined to form alternative plans which were ultimately evaluated and compared in two defined planning reaches with the Delaware Estuary system. The northern reach is from the head of tide at Trenton, NJ down to the approximate river/bay boundary (around Alder Cove), while the southern reach extends south from the Alder Cove area to the mouth of the Delaware Bay at Cape May Point, NJ. The northern reach experiences damages primarily due to inundation related to storm surge, as occurs during tropical storms, hurricanes or nor'easters. As the width of the bay (fetch) widens moving south, the southern reach experiences damages from the combined effects of long term and storm-related erosion, inundation and waves; analogous to the damage mechanisms experienced on the open ocean coast.

In the northern planning reach, the No Action Plan and one action alternative (Levee/Dike Plan) were formulated based on the identified problems and shoreline characteristics of each problem area.

Table 5 - Northern Planning Reach Alternatives

Northern Planning Reach Alternatives						
CSRM Problem Area	No Action Plan	Levee/Dike Plan	Beach Restoration Plan	Beach Restoration with Groin(s) Plan	Beach Restoration with Breakwater Plan	Beach Restoration with Groin(s), Breakwater, Living Shoreline & Wetland Plan
Penns Grove/Carneys Point	X	X				
Pennsville	X	X				

As indicated on Table 5, the No Action Plan and the Levee/Dike Plan were formulated in Penns Grove/Carneys Point and Pennsville. The alternative plans involving different forms of beach restoration were not formulated at Penns Grove/Carneys Point and Pennsville due to the lack of homogeneous sand dredged material sources close to the sites.

In the southern planning reach, the No Action Plan, the Levee/Dike Plan, the Beach Restoration Plan and the Beach Restoration with Groin(s) Plan were formulated.

Table 6 - Southern Planning Reach Alternatives

Southern Planning Reach Alternatives						
CSRM Problem Area	No Action Plan	Levee/Dike Plan	Beach Restoration Plan	Beach Restoration with Groin(s) Plan	Beach Restoration with Breakwater Plan	Beach Restoration with Groin(s), Breakwater, Living Shoreline & Wetland Plan
Gandys Beach	X		X	X		
Fortescue	X		X	X		
Bivalve	X	X				
Shellpile	X	X				
Port Norris	X	X				
Maurice River Twp.	X	X				
Reeds Beach	X		X			
Pierces Point	X		X			
Del Haven	X		X			
Villas	X		X			

As indicated on Table 6, the No Action Plan and the Levee/Dike Plan were formulated in Bivalve, Shellpile, Port Norris and Maurice River Twp. At Gandys Beach, Fortescue, Reeds Beach, Pierces Point, Del Haven and Villas, the No Action Plan and the Beach Restoration Plan were formulated. The Beach Restoration with Groin(s) Plan was also formulated at Gandys Beach and Fortescue. The Beach Restoration with Breakwater Plan was not formulated in the southern planning reach because the added breakwater cost greatly outweighed any added CSRM benefits. Per the NACCS, an estimated total first construction cost of a breakwater could be as high as $90,000,000 for a 10,000 feet stretch of shoreline. Given the limited size of the structural inventories of the communities in the southern reach, the potential CSRM benefits did not appear to offset the added cost.

Regarding the Beach Restoration with Groin(s), Breakwater, Living Shoreline & Wetland Plan, analysis indicated that the additional features, such as wetlands or living shorelines, would provide minimal additional CSRM compared to the added cost. For living shorelines, data from the NACCS indicated that they are generally applicable to relatively low current and wave energy environments. However, in the southern reach, the width of the bay (fetch) increases and allows wind to generate greater wave energy at the shoreline, so that waves create an additional risk mechanism beyond inundation alone. The additional damage mechanisms resulting from the combined effects of long-term and storm-related erosion, inundation and waves (analogous to the damage mechanisms experienced on the open ocean coast) minimize the potential effectiveness of living shorelines. The limited effectiveness coupled with a $1,415 cost per linear foot of living shoreline construction (as estimated in the NACCS) also limits the efficiency of the living shoreline feature. Per the NACCS, wetlands can slow the advance of storm surge somewhat and slightly reduce the surge landward. In addition, wetlands can dissipate wave energy; however, evidence suggests that slow-moving storms and those with long periods of high winds that produce marsh flooding reduce this benefit (Resio and Westerlink, 2008). This limited effectiveness couple with a $2,593 cost per linear feet of wetland construction (as estimate in the NACCS) also limits the efficiency of the wetland feature.

Based on the aforementioned formulation and alternative plans in each planning reach, the final array of alternative plans includes the following:

1. No Action Plan
2. Levee/Dike Plan
3. Beach Restoration Plan
4. Beach Restoration with Groin(s) Plan

3.4 FINAL ARRAY OF ALTERNATIVES EVALUATION AND COMPARISON

After the final array of alternatives was formulated, the first task was to forecast the most likely with-project condition expected under each alternative plan. The criteria used to evaluate the alternative plans include: contribution to the Federal objective and the study planning objectives, compliance with environmental protection requirements, and the Principles & Guidelines' (P&G's) four evaluation criteria (completeness, effectiveness, efficiency and acceptability). The second task was to compare each with-project condition to the without-project condition and document the differences between the two. The third task was to characterize the beneficial and adverse effects of magnitude, location, timing and duration. The fourth task was to identify the plans that will be further considered in the planning process, based on a comparison of the adverse and beneficial effects and the evaluation criteria. The System of Accounts (National Economic Development, Environmental Quality, Regional Economic Development and Other Social Effects) was used to facilitate the evaluation and display of effects of alternative plans.

National Economic Development (NED) – Contributions to the NED account (increases in the net value of the national output of goods and services, expressed in monetary units) through the reduction in wave, erosion and inundation damages were measured with the following considerations: project cost, annual cost, total annual benefits, annual net benefits and benefit to cost ratio.

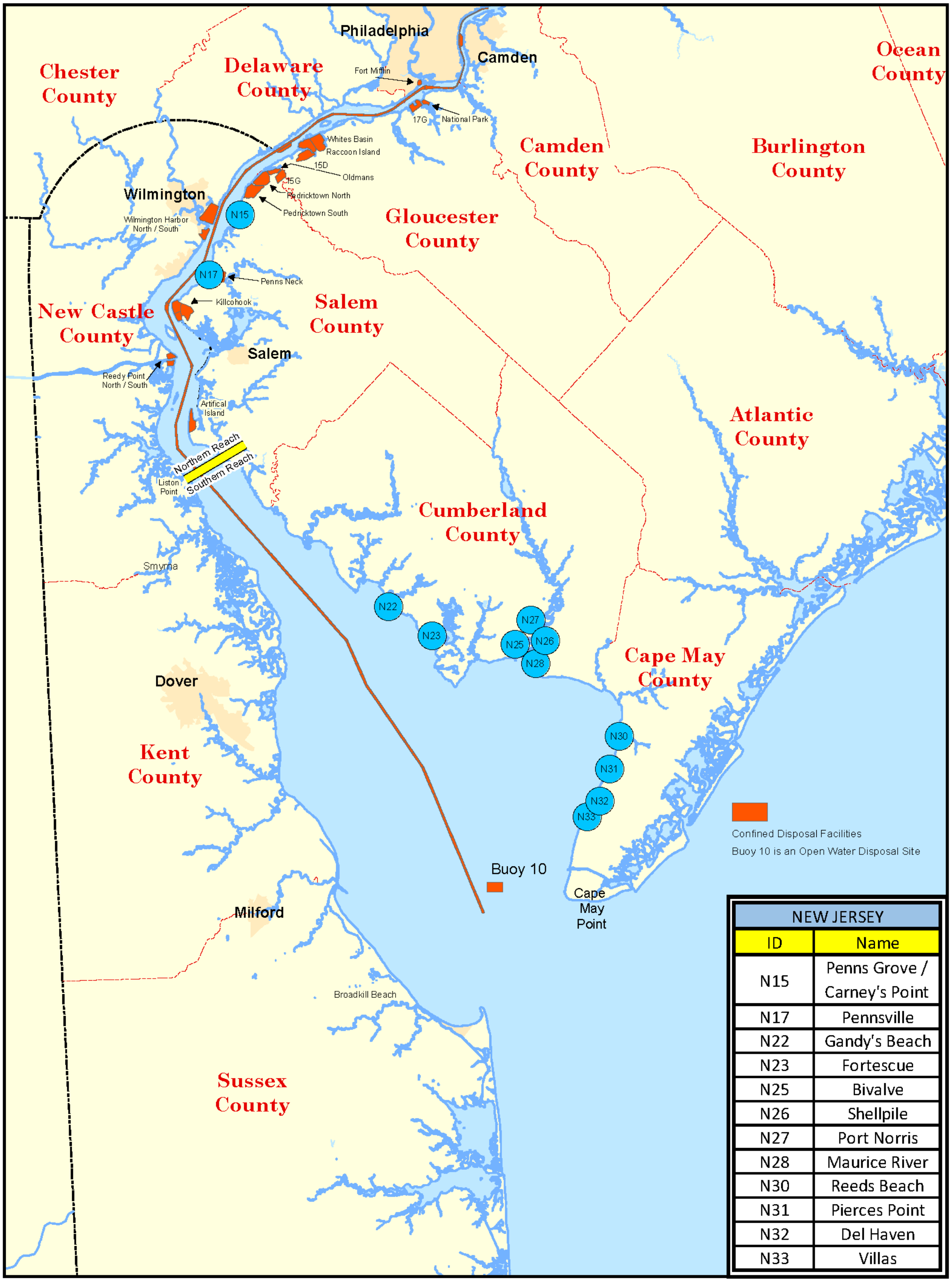
Regional Economic Development (RED) – The RED account registers changes in the distribution of regional economic activity that result from each alternative plan. Two measures of the effects of the plan on regional economies are used in the account: regional income and regional employment.

Environmental Quality (EQ) – Beneficial effects in the EQ account are favorable changes in the ecological, aesthetic and cultural attributes of natural and cultural resources. Adverse effects in the EQ account are unfavorable changes in the ecological, aesthetic and cultural attributes of natural and cultural resources.

Other Social Effects (OSE) – The OSE account is a means of displaying and integrating into water resource planning information on alternative plan effects from perspectives that are not reflected in the other three accounts. The categories of effects in the OSE account include the following: urban and community impacts; life, health and safety factors; displacement; long-term productivity; and energy requirements and energy conservation.

As previously referenced, the alternatives were evaluated in two defined planning reaches within the Delaware River/Bay system. The northern reach is north of the river/bay boundary (Alder Cove), while the southern reach extends south from the river/bay boundary to the mouth of the Delaware Bay. The northern reach includes DRBC Zones 2-5, while the southern reach includes DRBC Zone 6.

Figure 11 - Planning Reaches



NEW JERSEY	
ID	Name
N15	Penns Grove / Carney's Point
N17	Pennsville
N22	Gandy's Beach
N23	Fortescue
N25	Bivalve
N26	Shellpile
N27	Port Norris
N28	Maurice River
N30	Reeds Beach
N31	Pierces Point
N32	Del Haven
N33	Villas

3.4.1 Northern Reach Alternative Evaluation and Comparison

The without project conditions and associated problem(s) at each specified CSRM problem area as well as the availability of a suitable dredged material source area to help address the problem(s) greatly influenced the evaluation and comparison of alternatives, with respect to the NED account.

In the northern reach, the array of alternatives were evaluated and compared across 2 CSRM problem areas (Penns Grove/Carneys Point and Pennsville) under the NED account. In addition to the No Action Plan, the Levee/Dike Plan was formulated at each CSRM problem area. As indicated on Table 7, 7 potential dredged material source areas were considered for the Levee/Dike Plan at the 2 problem areas.

Table 7 - Levee/Dike Plan Dredged Material Source Areas - Northern Reach

Source Area	Distance from Penns Grove/Carneys Point CSRM Problem Area (Miles)	Distance from Pennsville CSRM Problem Area (Miles)
Buoy 10 Open Water Disposal Site	65	60
Lower Reach E of the Delaware Bay Main Channel	64	59
Artificial Island CDF	16	11
Killcohook CDF	9	3
Penns Neck CDF	5	1
Pedricktown South CDF	2	7
Pedricktown North CDF	3	8

In addition, a Value Engineering (VE) study was conducted to evaluate the viability of applying the Levee/Dike Plan to each problem area. The VE team consisted of the following technical disciplines: civil engineering, geotechnical engineering, hydrology and hydraulic engineering, cost engineering and planning. The Levee/Dike Plan was measured against the P&G's evaluation criteria and determined to have low efficiency and medium effectiveness. The low efficiency rating was based on the following:

- Anticipation of a high cost of levee construction offsets the potential for significant damage reduction.
- Silt, sand and organic material comprise the bulk of dredged material available for use; however, this material is unsuitable for levee construction without augmentation of the dredged material and additional imported impervious fill for the levee core.

A medium rating was assigned for the effectiveness because given the pervious nature of the available dredged material sources, the fill required for levee construction can only be partially supplied by dredged material. Levee core and possibly other sections would need to come from elsewhere, or be improved dredged material (e.g. soil mixing). The specified opportunity of dredged material utilization would not be well addressed, due to limited and/or lack of use of dredged material.

As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. This augmentation would add costs to an already expensive levee construction cost; therefore, given the lack of suitable levee construction material and elevated levee construction costs, Penns Grove/Carneys Point (N15) and Pennsville (N17) were screened out from further consideration under this study.

This page intentionally left blank

Table 8 - Northern Planning Reach Alternative Comparison

National Economic Development (NED)				
	No Action Plan	Levee/Dike Plan	Beach Restoration Plan	Beach Restoration with Groin(s) Plan
Project Cost vs. Project Benefits	While there is no project cost, the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	Per the NACCS parametric costs, levee construction costs are approximately $1,578 per linear foot. As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. The augmentation would add costs to an already expensive levee construction cost.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Environmental Quality (EQ)				
Physiography & Geology	Storms will continue to erode the shoreline undermining physiography supporting the existing infrastructure in the developed areas and continued erosion of adjacent wetlands.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Sediment Quality	Future maintenance dredging sand from the northern reach will be placed in CDFs located adjacent to DRBC Zones 2-5.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Vegetation & Wetlands	The majority of wetlands within the study area are estuarine intertidal emergent wetlands. The No Action Plan is expected to exacerbate the loss of shoreline vegetation and excessive inundation of neighboring wetlands.	In developed areas, the plan will have minimal effect. In wetland areas, the plan interrupts the hydrodynamic interface of tidal influx.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Planktonic & Benthic Organisms	With the No Action Plan, continued erosion reduces water quality which in turn adversely impacts planktonic and benthic organisms.	No impact.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Fish	Under the No Action Plan, adult fish occurring in the nearshore zone would not be impacted. However, with continued erosion of the shoreline, larval and juvenile fish stages are likely to be adversely impacted by water quality reduction.	No impact.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Wildlife	Under the No Action Plan, wildlife species would continue to incur further losses in	Levee/dike footprint reduces available habitat for wildlife.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the

	habitat quality and quantity due to ongoing flooding.		sites.	sites.
Threatened & Endangered Species	Under the No Action Plan, continued erosion and flooding will result in degraded habitat for species.	Levee/dike footprint reduces available habitat for threatened and endangered species.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Air Quality	No impact.	Temporary impact to air quality during construction and maintenance operations.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Noise	Normal noise levels created by traffic, businesses and industrial activities would continue under the No Action Plan.	Temporary elevation of noise levels during construction and maintenance operations.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Cultural Resources & Historic Properties	No impact.	No impact because this plan was not proposed in the northern planning reach.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Other Social Effects (OSE)				
Environmental Justice	No impact.	No impact because this plan was not proposed in the northern planning reach.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Quality of Life/Recreation	Continued erosion and flooding will have an adverse impact on ecosystem services and related recreation opportunities.	Potential CSRM combined with a potential recreational use of the levee crest may improve quality of life and recreation.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.
Regional Economic Development (RED)				
RED Impacts	Same as NED impacts.	Same as NED impacts.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.	Not evaluated in northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites.

Table 9 - Northern Planning Reach Alternative Evaluation

Contribution to Planning Objectives				
	No Action Plan	Levee/Dike Plan	Beach Restoration Plan	Beach Restoration with Groin(s) Plan
1. Improve CSRM for people, property and infrastructure along and adjacent to the New Jersey shoreline from 2022 to 2072, via the beneficial use of dredged material.	Erosion and storm-related damage will continue; therefore, the No Action Plan does not meet the objective.	While levees and dikes potentially could reduce impacts, this does not meet the objective because a cost-effective levee cannot be constructed with the available dredged material sources.	Not evaluated in northern planning reach.	Not evaluated in northern planning reach.
2. Increase the resiliency of coastal New Jersey, specifically along the Delaware River/Bay shoreline, via the beneficial use of dredged material.	Erosion and storm-related damage will continue to reduce the resiliency of coastal New Jersey; therefore, the No Action Plan does not meet the objective.	While levees and dikes potentially could reduce impacts and increase the resiliency of coastal New Jersey, this does not meet the objective because a cost-effective levee cannot be constructed with the available dredged material sources.	Not evaluated in northern planning reach.	Not evaluated in northern planning reach.
Response to Evaluation Criteria				
Completeness	This does not meet the completeness criteria because the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. The augmentation would add costs to an already expensive levee construction cost; therefore, the levee/dike plan will not provide a complete CSRM solution.	Not evaluated in northern planning reach.	Not evaluated in northern planning reach.
Effectiveness	This does not meet the effectiveness criteria because the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. The augmentation would add costs to an already expensive levee construction cost; therefore, the levee/dike plan will not provide an effective CSRM solution.	Not evaluated in northern planning reach.	Not evaluated in northern planning reach.
Efficiency	This does not meet the efficiency criteria. While there is no project cost, the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. The augmentation would add costs to an already expensive levee construction cost; therefore, the levee/dike plan will not provide an efficient CSRM solution.	Not evaluated in northern planning reach.	Not evaluated in northern planning reach.
Acceptability	This does not meet the acceptability criteria as State and local entities are generally supportive of improved CSRM.	The acceptability of the levee/dike plan is not known at this time as the aforementioned technical limitations of utilizing dredged material for levee construction prevented the levee/dike plan from being carried forward for further analysis.	Not evaluated in northern planning reach.	Not evaluated in northern planning reach.

This page intentionally left blank

3.4.2 Southern Reach Alternative Evaluation and Comparison

Under the NED account in the southern reach, the array of alternatives were evaluated and compared across 10 CSRM problem areas (Gandys Beach (N22), Fortescue (N23), Bivalve (N25), Shellpile (N26), Port Norris (N27), Maurice River Twp. (N28), Reeds Beach (N30), Pierces Point (N31), Del Haven (N32) and Villas (N33)).

Bivalve (N25), Shellpile (N26), Port Norris (N27), and Maurice River Twp. (N28) are located along the Maurice River in Cumberland County, NJ. The Levee/Dike Plan was evaluated in these problem areas. The Levee/Dike Plan was measured against the P&G's evaluation criteria and determined to have low efficiency and medium effectiveness, per the above-referenced VE study. The low efficiency rating was based on the following:

- Anticipation of a high cost of levee construction offsets the potential for significant damage reduction.
- Silt, sand and organic material comprise the bulk of dredged material available for use; however, this material is unsuitable for levee construction without augmentation of the dredged material and additional imported impervious fill for the levee core.

A medium rating was assigned for the effectiveness because given the pervious nature of the available dredged material sources, the fill required for levee construction can only be partially supplied by dredged material. Levee core and possibly other sections would need to come from elsewhere, or be improved dredged material (e.g. soil mixing). The specified opportunity of dredged material utilization would not be well addressed, due to limited and/or lack of use of dredged material.

Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. This augmentation would add costs to an already expensive levee construction cost; therefore, given the lack of suitable levee construction material and elevated levee construction costs, Bivalve (N25), Shellpile (N26), Port Norris (N27), Maurice River Twp. were screened out from further consideration under this study.

The remaining 6 southern reach problem areas (Gandys Beach (N22), Fortescue (N23), Reeds Beach (N30), Pierces Point (N31), Del Haven (N32) and Villas (N33)) are subject to CSRM damages from inundation, waves and erosion. Therefore, they were evaluated with Beach-fx. In order to accomplish the economic benefits analysis, Beach-fx required the application of the model SBEACH. SBEACH was used to simulate the without project condition profile response to a larger number of storm conditions in order to build the response database used by Beach-fx in the economic analysis. Based on the with-project design templates, estimated sand quantities for initial construction and periodic nourishment were determined within Beach-fx. Dredged material beach restoration source areas were identified and the costs associated with placing material from those source areas were also provided as inputs into Beach-fx.

For Gandys Beach, Fortescue, Reeds Beach, Pierces Point, Del Haven and Villas, the PDT focused the alternative evaluation and comparison to the Beach Restoration Plan and the No Action Plan. Due to the unacceptably high with-project end losses at Gandys Beach and Fortescue, the Beach Restoration with Groin(s) Plan was also formulated at these two locations.

For the southern reach, the PDT focused on dredged material source areas with predominantly sandy material and their associated distance from the placement locations.

Table 10 - Beach Restoration Dredged Material Source Areas – Southern Reach

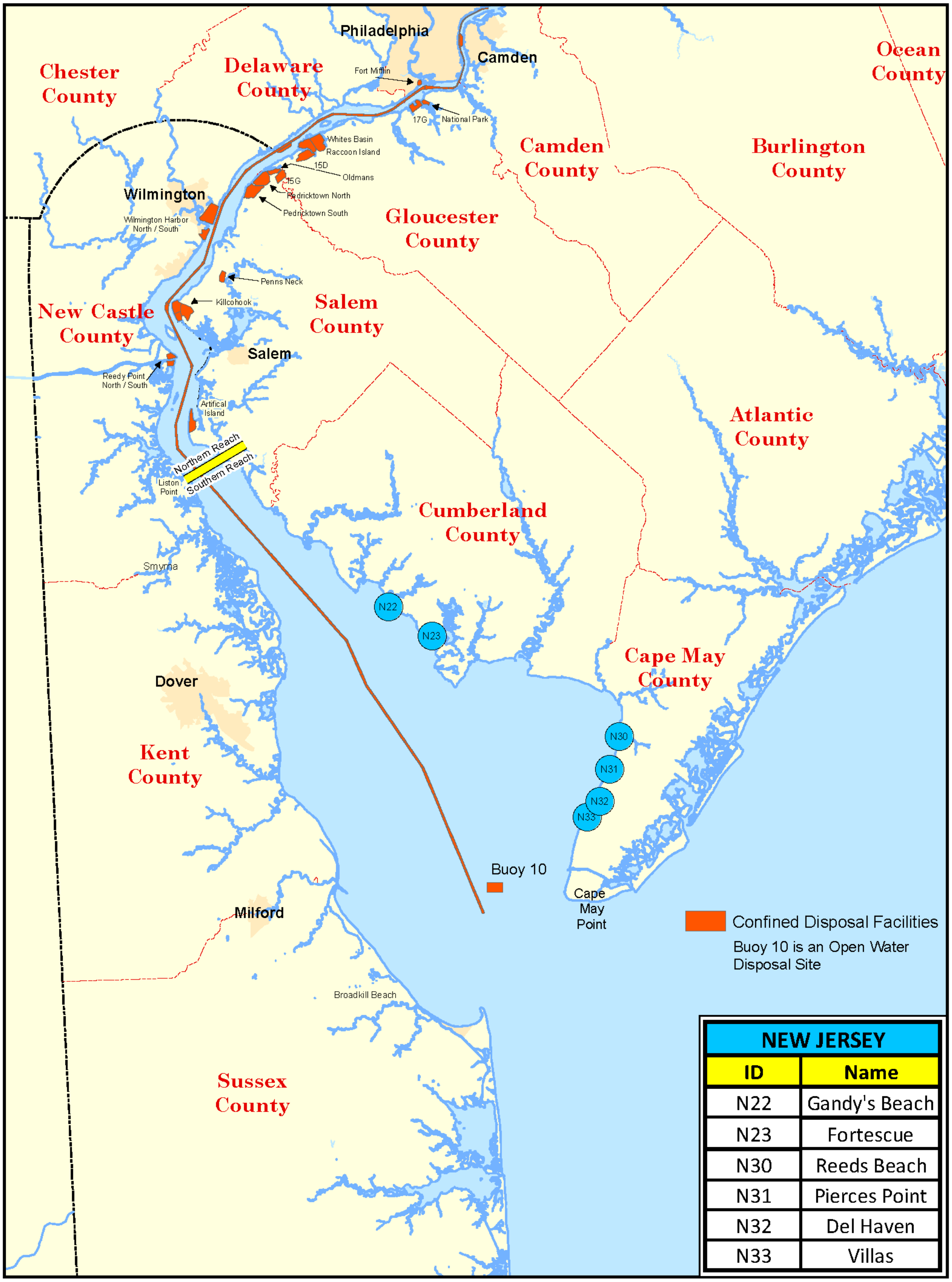
Source Area	Distance to Gandys Beach (Miles)	Distance to Fortescue (Miles)	Distance to Reeds Beach (Miles)	Distance to Pierces Point (Miles)	Distance to Del Haven (Miles)	Distance to Villas (Miles)
Buoy 10 Open Water Disposal Site	24	21	16	13	11	9
Lower Reach E of the Delaware Bay Main Channel	8	7	19	19	19	19

Geotechnical analysis of available dredged material for beach restoration further supported the selection of potential source areas with available sand: Lower Reach E (Miah Maull and Brandywine Ranges) of the main Delaware Estuary channel and the Buoy 10 open water disposal site. Lower Reach E and Buoy 10 were identified as potential source areas based on the following criteria:

- The sandy material in Lower Reach E and Buoy 10 has a similar grain size (approximately 0.30 – 0.50 mm) to the proposed beach destinations along the New Jersey shoreline.
- Buoy 10 currently contains approximately 750,000 cubic yards of sandy material that could be used for initial construction of the proposed beach destinations.
- Lower Reach E (which was deepened to 45 feet in 2015/2016) is anticipated to have approximately 465,000 cubic yards of dredged material available annually that will need to be removed to maintain the 45 feet depth. The sandy material from the Lower Reach E was used to construct a beach at Broadkill Beach.
- Prior to the deepening of Lower Reach E, sandy dredged material from this reach was placed in Buoy 10 for disposal.

Based on the projected quantities required for initial construction and periodic nourishment, Lower Reach E (Miah Maull and Brandywine Ranges) of the main Delaware River channel is the likely dredged material source for the CSRM project. Specifically, the proposed source area is anticipated to have approximately 465,000 cubic yards of dredged material available annually that will need to be removed to maintain the 45 feet depth. The anticipated dredging cycle for Lower Reach E is every two years to remove and place 930,000 cubic yards (465,000 x 2) of dredged material.

Figure 12 - Southern Reach Beach-fx Evaluation



NEW JERSEY	
ID	Name
N22	Gandy's Beach
N23	Fortescue
N30	Reeds Beach
N31	Pierces Point
N32	Del Haven
N33	Villas

Considering the proposed source area and the projected quantities for initial construction and periodic nourishment, the PDT determined that the likely project implementation would consist of a systematic and continuous dredging operation with one primary mobilization shared across each site. The PDT applied the systematic analysis to the six sites referenced above (Gandys Beach (N22), Fortescue (N23), Reeds Beach (N30), Pierces Point (N31), Del Haven (N32) and Villas (N33)). While the likely project implementation creates a system with non-separable dredge mobilization costs, the six sites do not appear to be hydraulically connected. Therefore, each site was incrementally justified with individual net benefits calculated for each site, rather than combining the net benefits for the six sites.

It is important to note that Villas (N33) was split into two sites (Villas North and Villas South) in the Beach-fx model, based on distinct differences in topo-bathymetric conditions and coastal processes. Villas North is characterized by a stable and mature dune system with historical shoreline changes of +0.5 ft/yr and a very shallow submerged beach profile effective at dissipating wave energy. In contrast Villas South is characterized by an eroding dune system (dune scarping was observed during site visit) with historical shoreline changes of -1.5 ft/yr and a relatively deep submerged profile that is not as effective at dissipating wave energy. The PDT decided that the differences in site conditions along Villas were significant enough to justify two separate sites. Villas South is able to function as a standalone project, independent of Villas North, because the primary damage driver at Villas South is erosion damages. In this case Villas North shoreline is stable or accreting and the No Action alternative at Villas North will not negatively impact the performance of beach restoration at Villas South.

Table 11 - Initial Southern Reach Economic Summary

Site	Average Annual Cost	Average Annual Benefits	Average Annual Net Benefits	Benefit-Cost Ratio
Gandys Beach	$1,023,314	$2,323,296	$1,299,982	2.3
Fortescue	$1,355,048	$2,736,996	$1,381,949	2.1
Reeds Beach	$1,287,143	$1,064,524	-$222,618	0.8
Pierces Point	$1,376,148	$682,885	-$693,263	0.5
Del Haven	$1,022,270	$534,413	-$487,857	0.5
Villas (North)	$1,188,301	$143,563	-$1,044,738	0.1
Villas (South)	$1,920,791	$2,058,775	$137,984	1.1

Gandys Beach, Fortescue, and Villas (South) had positive Average Annual Net Benefits (AANB) and a Benefit-Cost Ratio (BCR) above 1.0 over the 50-year project life. As each site must be independently justified for inclusion in the TSP, Reeds Beach, Del Haven, Pierces Point, and Villas (North) were screened from further consideration.

This page intentionally left blank

Table 12 – Southern Reach Alternative Comparison

National Economic Development (NED)			
	No Action Plan	Beach Restoration Plan	Beach Restoration with Groin(s) Plan
Project Cost vs. Project Benefits	While there is no project cost, the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	The benefits of beach restoration at Villas (South) are greater than the associated dredged material placement costs.	The benefits of beach restoration with groin(s) at Gandys Beach and Fortescue are greater than the associated dredged material placement costs. Despite the added initial construction cost associated with groins, the reduction in end losses and erosion provided by the groins adds benefit to the proposed project.
Environmental Quality (EQ)			
Physiography & Geology	Storms will continue to erode the shoreline, exposing the underlying peat and reducing available sandy beach habitat for wildlife. A loss of barrier beach could result in flood inundation to interior salt marshes, forests and neighboring farmland.	Beach restoration will help restore the natural bayfront physiography and geology. Also, beach nourishment using compatible grain size materials enhances habitat within the study area.	The construction of a hardened structure, such as a groin would not impact area geology, but would alter localized physiography of the beach by accumulating sand on the updrift side, stabilizing the beach but may cause erosion on the downdrift side. Groins at inlets (jetties) serve to reduce sand accumulation within the inlet.
Sediment Quality	Future maintenance dredging sand from the proposed project source area will be placed at Buoy 10 for approximately 10 more years. Beyond this, dredging sand from the proposed source area will be place at Artificial Island CDF. This future practice will contribute to increasing sediment deficit in the Delaware Bay as studies indicate that the bed of the bay has eroded at a rate that exceeds the average annual rate at which new sediment is supplied from the watershed.	Beach restoration will reduce the sediment deficit in the Delaware Estuary and improve the overall health of the estuary.	The construction of a hardened structure, such as a groin impedes longshore sediment transport within the beach/intertidal habitat interface. Groins located at inlets (jetties) serve to reduce sediment end losses on the beach and sedimentation in the inlet.
Vegetation & Wetlands	The majority of wetlands within the study area are estuarine intertidal emergent wetlands, with additional estuarine intertidal scrub-shrub and forested wetlands occurring intermittently. The No Action Plan is expected to exacerbate the loss of beach vegetation and excessive inundation of neighboring wetlands with erosion of the barrier beachfront.	Beach restoration will enhance reduction of risk to the adjacent wetlands and enable dune vegetation to establish with resultant higher berm and dune elevations.	The construction of a hardened structure, such as a groin would be located seaward of beach vegetation and wetlands. No adverse impact. Groins accumulate sand on the updrift beach side which may provide additional erosion protection for landward vegetation and wetlands.

Planktonic & Benthic Organisms	With the No Action Plan, low quality intertidal habitat would continue to exist due to severe erosion and exposed peat. Continued shoreline erosion elevates water turbidity which reduces primary productivity.	Beach restoration will involve the pumping of dredged material onto the beach above the mean high water line, thereby minimizing impacts to intertidal infaunal organisms. However, despite the resiliency of intertidal benthic fauna, the initial beachfill will result in some mortalities of existing benthic organisms.	The construction of a hardened structure, such as a groin would permanently reduce available shallow water soft bottom habitat in the structure footprint but adds to intertidal habitat diversity by providing hard bottom substrate for benthic macroinvertebrates.
Fish	Under the No Action Plan, adult fish occurring in the nearshore zone of the bay would not be impacted. However, with continued erosion of the barrier beaches, larval and juvenile fish stages are likely to be adversely impacted if area salt marshes incur lower habitat quantity and quality through loss of wetlands.	Beach restoration may temporarily adversely impact larval and juvenile fish by elevating turbidity levels within the nearshore zone. Beach restoration will not disrupt the natural shoreline transition zone from intertidal to beach berm and will have minimal to no impact on adult fish that can leave the impact area during construction.	Minor temporary impacts to fish during construction due to elevated turbidity. Groins provide habitat diversity through the creation of hard substrate in a soft bottom habitat for prey species and refugia from currents and for feeding.
Wildlife	Under the No Action Plan, wildlife species would continue to incur further losses in habitat quality and quantity due to ongoing flooding and erosion.	Beach restoration will provide added risk reduction to wildlife habitats along the bayshore and within interior wetlands, scrub shrub and forested areas.	The construction of a hardened structure, such as a groin provides a resting area for waterbirds and feeding sites for coastal birds of prey. Groins may impede movement by small mammals, spawning horseshoe crabs, and terrapins.
Threatened & Endangered Species	Under the No Action Plan, continued erosion and flooding will result in degraded habitat for species, including exposed underlying peat and scarped dunes.	Beach restoration can provide positive benefits to listed species by restoring preferred beach habitat and increased flood protection to interior wetlands, scrub shrub, and maritime forested habitats. Adverse impacts are avoided with environmental windows during placement operations.	The construction of a hardened structure, such as a groin would permanently reduce soft bottom habitat within the intertidal zone but provides erosion protection of beach habitat on the updrift side for beach foraging and nesting birds but impedes visual sight lines for foraging shorebirds. Groins at inlets accumulate sand on the updrift side, enlarging and elevating the beach, which is preferred by migratory shorebirds for predator avoidance.
Air Quality	Air quality is generally good in the Delaware Bay region.	Temporary impact to air quality during construction and maintenance operations.	Temporary impact to air quality during construction and maintenance operations.
Noise	Normal noise levels created by traffic, businesses and industrial activities would continue under the No Action Plan.	Temporary elevation of noise levels during construction and maintenance operations.	Temporary elevation of noise levels during construction and maintenance operations.
Cultural Resources & Historic Properties	The No Action Plan will have no impact on Cultural Resources and Historic Properties.	Due to the lack of a comprehensive survey of the Delaware bayshore, a Phase IA Archaeological Investigation will be conducted.	Due to the lack of a comprehensive survey of the Delaware bayshore, a Phase IA Archaeological Investigation will be conducted.
Other Social Effects			
Environmental Justice	The No Action Plan will have no impact on Environmental Justice	Beach restoration is not anticipated to result in any significant or negative human health or safety impacts. Also, it will not have a disproportionately high adverse effect on minority or low income populations and is in compliance with EO 12898.	Beach restoration with Groin(s) is not anticipated to result in any significant or negative human health or safety impacts. Also, it will not have a disproportionately high adverse effect on minority or low income populations and is in compliance with EO 12898.

Quality of Life/Recreation	Continued erosion and flooding will have an adverse impact on ecosystem services and related recreation opportunities.	Beach restoration will enhance ecosystem services to humans by providing erosion control, water quality enhancement, storm risk management and habitat provision for wildlife and recreation.	Beach restoration with Groin(s) will enhance ecosystem services to humans by providing erosion control, water quality enhancement, storm risk management and habitat provision for wildlife and recreation.
Regional Economic Development (RED)			
RED Impacts	Same as NED impacts.	Same as NED impacts.	Same as NED impacts.

Table 13 - Southern Reach Alternative Evaluation

Contribution to Planning Objectives				
	No Action Plan	Levee/Dike Plan	Beach Restoration Plan	Beach Restoration with Groin(s) Plan
1. Improve CSRM for people, property and infrastructure along and adjacent to the New Jersey shoreline from 2022 to 2072, via the beneficial use of dredged material.	Erosion and storm-related damage will continue; therefore, the No Action Plan does not meet the objective.	While levees and dikes potentially could reduce impacts, this does not meet the objective because a cost-effective levee cannot be constructed with the available dredged material sources.	By reducing erosion and storm-related damage to coastal New Jersey, this alternative meets the objective.	By reducing erosion and storm-related damage to coastal New Jersey, this alternative meets the objective.
2. Increase the resiliency of coastal New Jersey, specifically along the Delaware River/Bay shoreline, via the beneficial use of dredged material.	Erosion and storm-related damage will continue to reduce the resiliency of coastal New Jersey; therefore, the No Action Plan does not meet the objective.	While levees and dikes potentially could reduce impacts and increase the resiliency of coastal New Jersey, this does not meet the objective because a cost-effective levee cannot be constructed with the available dredged material sources.	By reducing erosion and storm-related damage to coastal New Jersey, this alternative meets the objective by creating a more resilience coastal New Jersey.	By reducing erosion and storm-related damage to coastal New Jersey, this alternative meets the objective by creating a more resilience coastal New Jersey.
Response to Evaluation Criteria				
Completeness	This does not meet the completeness criteria because the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. The augmentation would add costs to an already expensive levee construction cost; therefore, the levee/dike plan will not provide a complete CSRM solution.	This alternative meets the completeness criteria as it maximizes CSRM benefits with the use of dredged material.	This alternative meets the completeness criteria as the addition of the terminal groin at Gandys Beach and Fortescue increases the project sustainability by reducing diffusion losses.
Effectiveness	This does not meet the effectiveness criteria because the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. The augmentation would add costs to an already expensive levee construction cost; therefore, the levee/dike plan will not provide an effective CSRM solution.	This alternative effectively reduces erosion and storm-related damage to coastal New Jersey.	This alternative effectively reduces erosion and storm-related damages to coastal New Jersey. The addition of the terminal groin at Gandys Beach and Fortescue increases the project sustainability by reducing diffusion losses.
Efficiency	This does not meet the efficiency criteria. While there is no project cost, the No Action Plan does not provide CSRM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRM problem areas.	As referenced in the VE study, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability. The augmentation would add costs to an already expensive levee construction cost; therefore, the levee/dike plan will not provide an efficient CSRM solution.	The benefits at Gandys Beach, Fortescue and Villas (South) are greater than the associated dredged material placement costs.	The benefits at Gandys Beach, Fortescue and Villas (South) are greater than the associated dredged material placement costs and groin construction costs (at Gandys Beach and Fortescue).
Acceptability	This does not meet the acceptability criteria as State and local entities are generally supportive of improved CSRM.	The acceptability of the levee/dike plan is not known at this time as the aforementioned technical limitations of utilizing dredged material for levee construction prevented the levee/dike plan from being carried forward for further analysis.	State and local entities are generally supportive of beach restoration.	State and local entities are generally supportive of beach restoration; however, additional coordination may be necessary to explain the inclusion of terminal groins at Gandys Beach and Fortescue.

This page intentionally left blank

3.5 PLAN SELECTION

As referenced in Section 3.4, the project cost was compared against the benefits at each individual dredged material placement location in to determine the BCR and net benefits at each placement location.

The costs of transporting material to the DMU project site were compared against the Federal Standard practice of dredged material disposal at the least cost, environmentally acceptable disposal location (Buoy 10). The current Federal standard for dredged material disposal from the proposed TSP source area is dredging via a hopper dredge and bottom dumping at Buoy 10 (an open water disposal site located in southern planning reach adjacent to the mouth of the Delaware Bay). Buoy 10 is approaching full capacity. USACE is currently pursuing a revised water quality certificate (WQC) to expand the footprint of Buoy 10 and provide additional capacity, which will potentially extend Buoy 10's viability for dredged material disposal for approximately the first 10 years of the proposed project life. Beyond this 10 year threshold, the Federal standard will likely involve the placement of dredged material at Artificial Island CDF, located approximately 40 miles upstream from the dredged TSP source location.

For initial construction through the first 10 years of the project life, project costs are based on the difference between placement at the DMU project locations (with-project condition) and placement at Buoy 10 (without-project condition). As referenced above, the without project condition changes after year 10 due to limited capacity at Buoy 10; therefore, the with-project condition is compared against disposal at Artificial Island CDF for years 11 to 50 of the project. The likely project implementation would consist of a continuous dredging operation with one primary mobilization; therefore, the mobilization cost is shared by the six sites analyzed with Beach-fx in the southern reach.

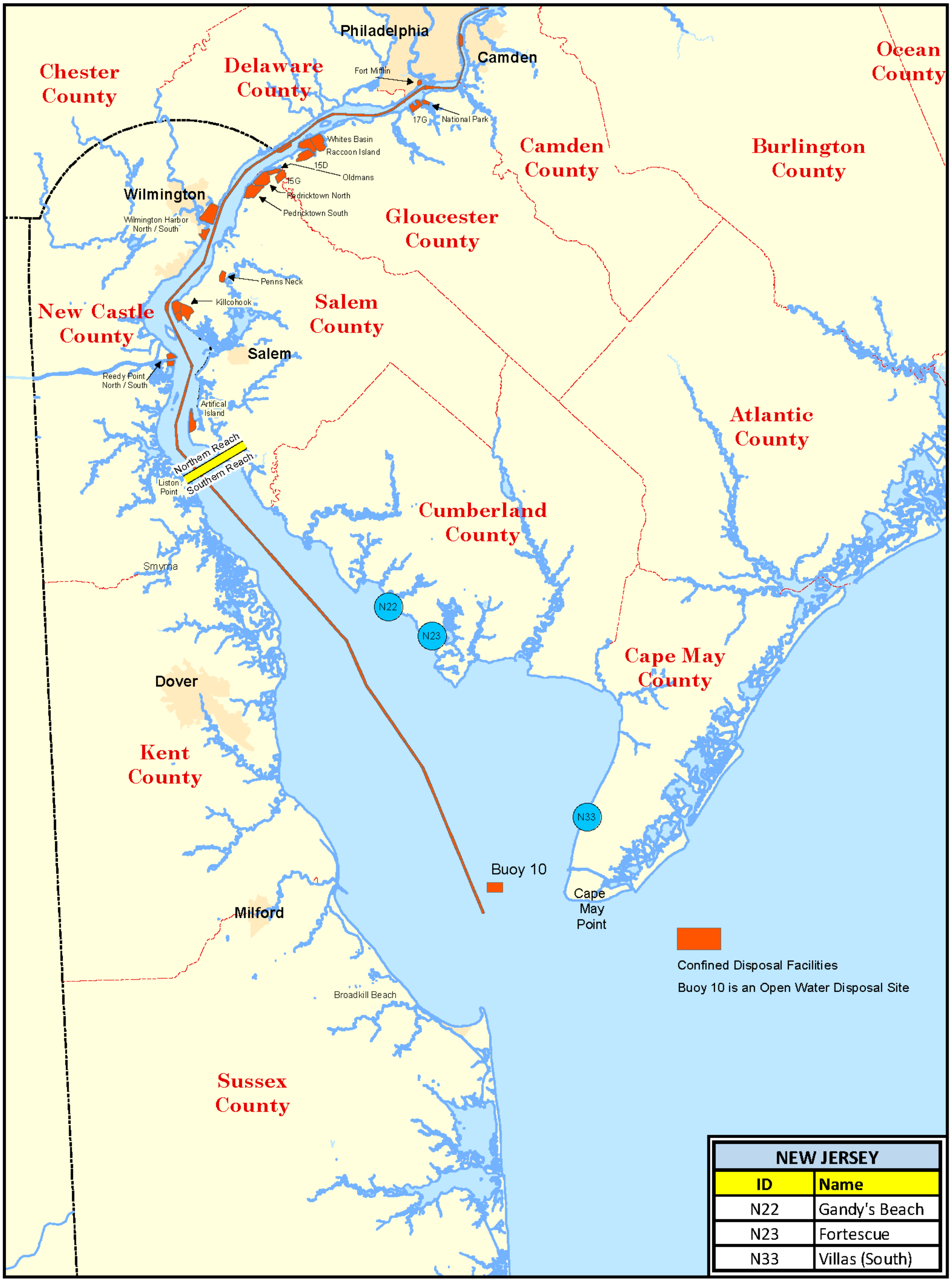
Throughout the 50-year project lifecycle, the dredged material unit placement cost is based on the difference between without project condition (dredged material placement via the Federal standard) unit placement costs and the with project condition (dredged material placement at the proposed DMU project location) unit placement costs. The difference between these unit placement costs are attributed to the DMU project. For example, if costs to place dredged material via the Federal Standard for the ongoing Delaware River – Philadelphia to the Sea Navigation Project are $10 per cubic yard, and the costs to transport the same material to a DMU project site for CSRM are $15 per cubic yard, then the cost to the navigation project is $10 per cubic yard and the only cost applied to the DMU project is the additional cost above the Federal standard, $5 per cubic yard.

The NED benefit categories included the following: reduction in damage to structures and content, local costs foregone, emergency costs foregone, and incidental recreational benefits.

3.5.1 Economic Summary

Current results indicate that the benefits of the TSP at each placement location are greater than the associated dredged material placement costs for Gandys Beach, Fortescue and Villas (South).

Figure 13 - TSP Overview



While the 3 individual dredged material placement sites have benefits exceeding costs, the placement sites will undergo an optimization process that will ultimately determine the final footprint of the recommended plan and its associated costs and benefits.

The project cost is summarized in Table 14:

Table 14 - Project Cost

Site	Initial Construction Cost	Periodic Nourishment Cost	Total Project Cost	Nourishment Cycle
Gandys Beach	$12,766,361	$14,199,791	$26,966,152	8 years
Fortescue	$15,964,212	$19,743,722	$35,707,934	8 years
Villas (South)	$19,663,366	$30,953,006	$50,616,372	8 years
Total	$48,393,939	$64,896,519	**$113,290,458**	-

Note: The cost values in Table 14 cover a 50-year period of analysis with a base year of 2022.

The TSP economic results are summarized on Table 15. The BCRs and associated net benefits listed in Table 13 are subject to change as the tentatively selected plan is optimized.

Table 15 – Summary of Costs & Benefits

Site	Average Annual Benefits (AAB)	Average Annual Costs (AAC)	Average Annual Net Benefits (AANB)	Benefit-Cost Ratio (2.875%)
Gandys Beach	$2,323,296	$991,518	$1,331,656	2.3
Fortescue	$2,736,996	$1,327,105	$1,409,891	2.1
Villas (South)	$2,058,775	$1,807,681	$251,094	1.1

Note: The cost and benefit values cover a 50-year period of analysis with a base year of 2022. The Federal discount rate is 2.875%.

3.5.1.1 Residual Risk

Damages prevented constitute the CSRM benefits of the TSP. Benefits are computed using the formula Without Project Damages – With Project Damages = CSRM Benefits. Residual Risk refers to the storm damage a study area can be anticipated to experience post project implementation. This is computed using Without Project Damages – CSRM Benefits = Residual Risk. Additional benefits, such as Benefits During Construction (BDC), Local Costs Foregone and Recreational Benefits may also be present, but were not quantified at this time. The table below provides a summary of damages prevented, which increase as residual risk decreases.

Table 16 - Summary of CSRM Damages Prevented

Site	Without Project Condition		With Project Condition		Damages Reduced		
	Total Damage	AAD	Total Damage	AAD	Total Damage	AAD	Residual
Gandys Beach	$66,303,539	$2,516,092	$5,080,528	$192,796	$61,223,011	$2,323,296	7.66%
Fortescue	$119,048,659	$4,517,669	$46,923,905	$1,780,672	$72,124,753	$2,736,996	39.42%
Villas (South)	$55,255,523	$2,096,841	$1,003,115	$38,066	$54,252,408	$2,058,775	1.82%
Total	**$240,607,721**	**$9,130,602**	**$53,007,548**	**$2,011,534**	**$187,600,172**	**$7,119,067**	**22.03%**

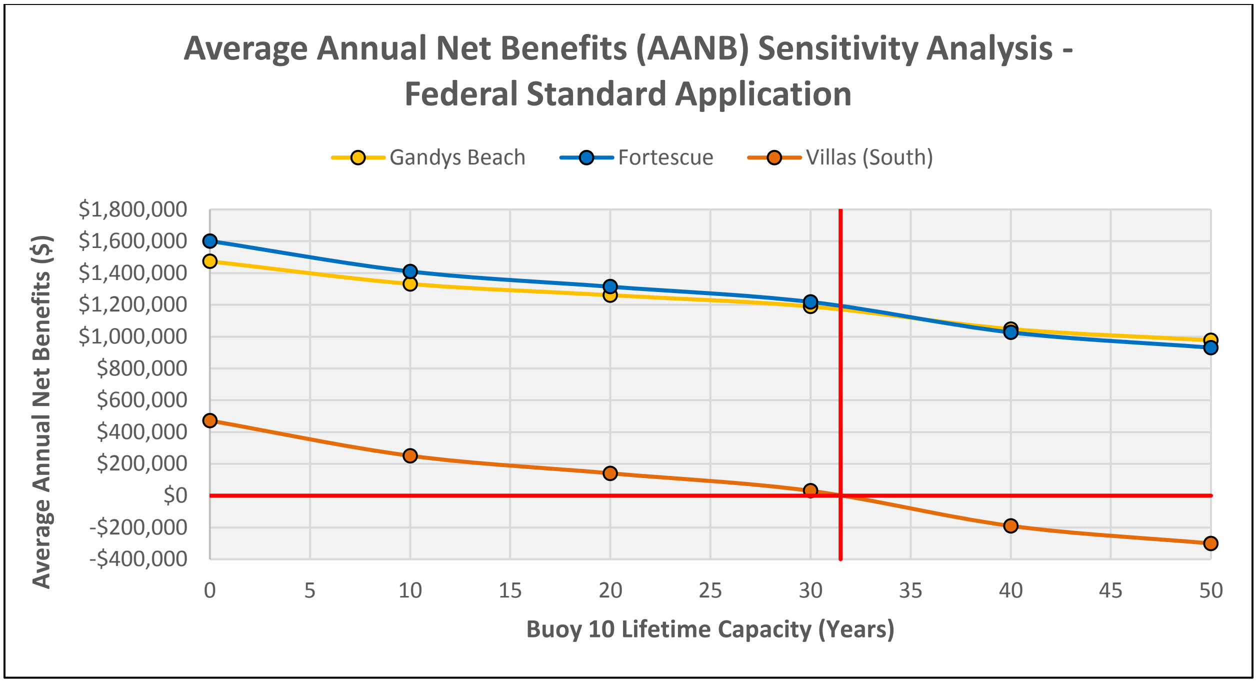
3.5.1.2 Risk & Uncertainty

As stated in Appendix A, Beach-fx is an event-based Monte Carlo life cycle simulation that uses historic storms to calculate damages over the course of a project life cycle. The model links the predictive capability of coastal evolution modeling with project area infrastructure information, structure and content damage functions, and economic valuations to estimate the costs and total damages under various CSRM alternatives while accounting for risk and uncertainty. The model output can then be used to determine the net benefits of each project alternative. Storm damage is defined as the ongoing monetary loss to contents and structures incurred as a direct result of wave attack, erosion, and inundation caused by a storm of a given magnitude and probability. The model also computes permanent shoreline reductions. These damages and associated costs are calculated over the project period of analysis based on storm probabilities, tidal cycle, tidal phase, beach morphology, and many other factors. Data on historic storms, beach survey profiles, and beach reactions to specific storm events can be found in the Engineering Appendix C.

For the Future Without Project (FWOP) Condition and Future With Project (FWP) Condition, the structure inventory and values are the same as the existing condition barring any structure that are deemed condemned by Beach-fx over the period of analysis.

As previously stated, the current Federal standard for dredged material disposal from the proposed TSP source area is dredging via a hopper dredge and bottom dumping at Buoy 10, which is approaching operational capacity. While it is expected that NJDEP will provide a revised WQC for Buoy 10 providing an additional 10 years of capacity, the PDT recognizes a degree of uncertainty related to the projected Buoy 10 capacity as the WQC has not been granted to date. Because the assumed Federal Standard impacts the NJ DMU study economics as project costs are based on the difference between placement at the DMU project locations (with-project condition) and placement at Buoy 10 and/or Artificial Island, an economic sensitivity analysis was conducted to evaluate the impact of the Federal Standard assumptions on the project economics. The results of the sensitivity analysis are summarized on the figure below:

Figure 14 – Economic Sensitivity Analysis



As indicated on the figure above, Gandys Beach and Fortescue have positive net benefits whether Buoy 10 is operational for up to 50 years or not operational at all. For Villas (South), net benefits become negative if Buoy 10 has greater than 31.5 years of operational capacity.

Damage Functions

Damage functions are user-defined curves that are applied within the model to determine the extent of storm-induced damages attributable to any specific combination of damage element type and foundation type. There are six types of damage functions which include erosion, inundation, and wave attack for both structure and content. For example, there is a specific set of six damage functions for single-family residential one story Damage Elements with a slab foundation and a separate, unique set of damage functions for single-family residential one story Damage Elements with a pile foundation. This analysis used a total of 48 damage functions to calculate storm-induced damages.

Damage is determined as a percentage of overall structure or content value using a triangle distribution of values, which looks at minimum, maximum and most likely value. For erosion functions, damage is dependent upon the extent to which a structure’s footprint has been compromised and for inundation and wave attack functions, damage is determined by the storm-surge heights in excess of first-floor elevation.

Damage Functions were developed using the NACCS Physical Depth Damage Function Summary Report.

Future Without Project Condition (FWOP) Damages

The FWOP net present value damages are a combination of the CSRM damages experienced at each individual project site. Damages are measured by both structure and content and averaged over 300 iterations. Values are in Present Worth using the FY2017 Federal Discount Rate. All results are currently shown at the Intermediate Relative Sea Level Change (RSLC) rate, but will include Historic (Low) and High rates post-optimization.

3.6 DESCRIPTION OF THE RECOMMENDED PLAN

3.6.1 Plan Components

The TSP consists of beach restoration at Villas (South) and beach restoration with groin(s) at Gandys Beach and Fortescue.

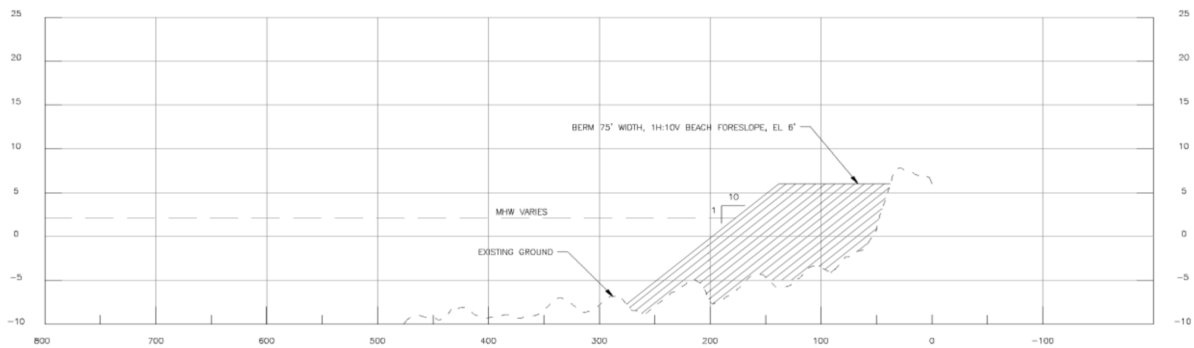
For Gandys Beach, the proposed design template features a berm of 75 feet (ft) width at a height of +6 ft NAVD88 with a foreslope of approximately 130 ft length on a slope of 1V:10H extending bayward to a tie-in depth of -7 ft NAVD88. A new terminal groin structure is proposed for the northern end of the Gandys Beach footprint to reduce longshore losses of sand from the proposed project area. Over the last 25 years there has been demonstrated shoreline retreat at Gandys Beach. Currently, there is significant armoring of the Gandys shoreline using steel sheet piling, concrete sea wall and rubble armoring. The natural shoreline erosion has created conditions where the Delaware Bay has flanked the town and the proposed beach restoration will suffer unacceptable erosion rates without the use of a terminal groin.

For Fortescue, the proposed design template features a berm of 75 ft width at a height of +6 ft NAVD88 with a foreslope of approximately 100 ft length on a slope of 1V:10H extending bayward to a tie-in depth of -4 ft NAVD88. At Fortescue, the existing terminal groin at the northern edge of the community will be rehabbed and replaced as part of the recommended plan to reduce end losses and the associated renourishment frequency.

The terminal groins at Gandys and Fortescue will be comprised of a timber stem section that will prevent sediment migration. The timber stem will be comprised of sheeting, walers and piles. The timber stem will be anchored bayward by a rubble mound groin, comprised of armor stone and bedding stone.

At Villas (South), the proposed design template features a berm of 75 feet (ft) width at a height of +5 ft NAVD 88 with a foreslope of approximately 100 ft length on a slope of 1V:10H extending bayward to a tie-in depth -2 ft NAVD88. The berm is topped with a dune whose crest width is 25 ft at a height of +12 ft NAVD88. The dune transitions both bayward to the berm and landward to existing grade on a slope of 1V:5H.

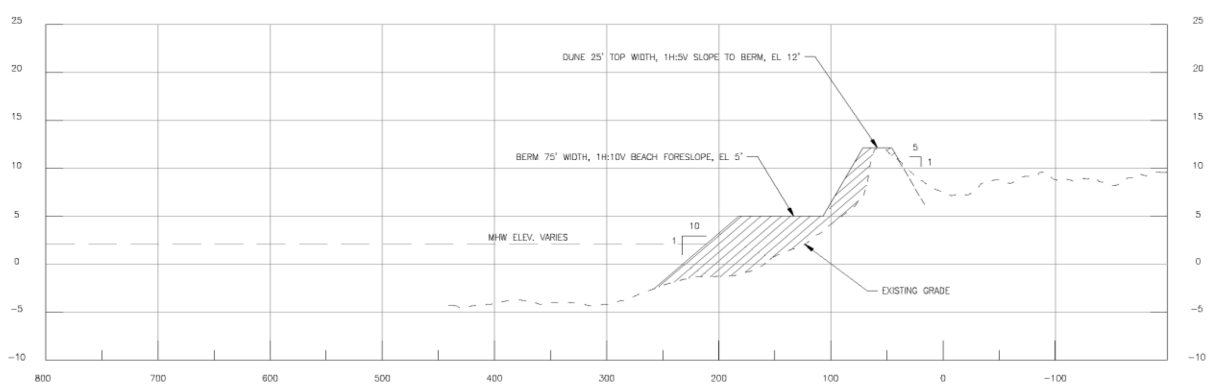
Figure 15 – Design Template for Gandys Beach & Fortescue



GANDYS AND FORTESCUE
TYPICAL CROSS SECTION
ALL VERTICAL DIMENSIONS IN NAVD 88

V 10 0 10 20
H 100 0 100 200
SCALE IN FEET

Figure 16 - Design Template for Villas



VILLAS BEACH CROSS SECTION
ALL VERTICAL DIMENSIONS IN NAVD 88

V 10 0 10 20
H 100 0 100 200
SCALE IN FEET

Based on the volume projections for initial construction at each of the 3 placement locations, a total of approximately 700,000 cubic yards of dredged material would be required for initial construction. As referenced in Section 3.4, the proposed source area (Lower Reach E) is anticipated to have approximately 465,000 cubic yards of dredged material available annually that will need to be removed to maintain the 45 feet depth. The anticipated dredging cycle for Lower Reach E is every two years to remove and place 930,000 cubic yards (465,000 x 2) of dredged material. The projected quantity and dredging cycle were based on the feasibility report completed in support of the MCD project. Actual dredged material quantities will be verified prior to construction; therefore, the PDT recognizes the possibility that there may be greater and/or lesser quantities available (than currently projected) at the time of construction. If there is less dredged material available than anticipated at the projected date of initial construction (2022), Buoy 10 may serve as a back-up source for initial construction as it contains sand (approximately 750,000 cubic yards) previously dredged from Lower Reach E during operation and maintenance of the Delaware River, Philadelphia to the Sea navigation project. The PDT recognizes that the use of Buoy 10 as a back-up source would necessitate a benthic habitat assessment and ultimately a Supplemental Environmental Assessment (EA).

Varying volumes of dredged material are required at each of the placement locations, depending on the length of shoreline to be nourished and the existing beach profile. In order to maintain the integrity of design beachfill alternatives, beachfill nourishment must be included in the project design. If periodic nourishment was not performed throughout the life of the project, the longshore and cross shore sediment transport mechanisms, separate from storm induced erosion, would act to erode the design beach. An 8-year periodic nourishment cycle is anticipated to maintain optimal CSRM. This nourishment cycle is in line with the proposed operation and maintenance (O&M) dredging to be performed in Lower Reach E (the proposed project dredged material source area for the TSP); however, it will be further refined during plan optimization.

3.6.2 Public Law 113-2 Requirements

This section has been prepared to address how the TSP contributes to the resiliency of the New Jersey shoreline; how it affects the sustainability of environmental conditions in the affected area; and how it will be consistent with the findings and recommendations of the NACCS.

Resiliency is defined in the February 2013 USACE-NOAA Infrastructure Systems Rebuilding Principles white paper as the ability to adapt to changing conditions and withstand, and rapidly recover from disruption due to emergencies. Sustainability is defined as the ability to continue (in existence or a certain state, or in force or intensity), with interruption of diminution.

3.6.2.1 Resiliency

One of the planning objectives of the NJ DMU is to "increase the resiliency of coastal New Jersey, specifically along the Delaware Estuary shoreline, via the beneficial use of dredged material." The formulated measures and alternatives have all been designed to enhance the resiliency of the coastal system, particular with regard to erosion and SLC.

In general CSRM projects, such as the NJ DMU, are engineered beaches that are designed, constructed and periodically nourished to reduce the risk of economic losses arising from coastal storms. The intent is to replicate the function of beaches in areas that were once part of natural, undeveloped systems that have subsequently experienced significant human development and utilization. Storms reduce the degree of storm risk management provided by the beach fill project; elevated water levels and larger-than-normal waves displace sand from the berm and dune portions of the engineered beach profile and transport it principally in the offshore direction. After the storm, normal tide and wave conditions return, typically resulting in onshore-directed sand transport that rebuilds at least a portion of the berm (i.e., beach). This natural recovery of the beach berm occurs over a period that may range from days to months. Natural rebuilding of the dune is a process that requires years to decades, given its dependence on wind transport and an adequate sand supply on the beach. In the period between the storm and the partial natural recovery, an increased level of storm damage risk exists due to the eroded condition of the project berm and dune relative to the level of risk associated with a constructed, fully maintained project. Consequently, repair of an engineered beach to its design dimensions is usually accomplished as a planned renourishment, which is included in the authorized period of analysis cycle, or as an emergency activity under the USACE Flood Control and Coastal Emergencies authority (PL 84-99), to restore the storm damage risk reduction function for which the project was authorized. This post-storm repair is necessary because the engineered beach may not otherwise fully recover to its authorized dimensions naturally, or at least not in a time frame that would minimize risks due to the deteriorated condition. In this regard, it is apparent that storm risk management projects involving beach replenishment possess intrinsic “resilience”, in light of the large volume of sediment that remains within the system after a major disturbance and the associated repair or replenishment that is included to restore the project design dimensions.

3.6.2.2 Sustainability/Adaptability

The NJ DMU recommended plan meets the economic, environmental and community sustainability goals for the fifty year length of the project. Economic principals are used in benefit calculations, plan formulation ranking and project justification by their contributions to the NED account. Environmental concerns are evaluated in the integrated EA and through coordination and review with various resource agencies. Social accounts are intrinsic in beach nourishment projects since they maintain habitat for beach patrons. The nexus of these three pillars indicates that the recommended plan is sustainable.

3.6.2.3 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 incorporates wherever possible sustainable coastal landscape systems that takes into account, future sea level and climate change scenarios. The process used to identify the TSP utilized the NACCS Risk Management framework that included evaluating alternative solutions and also considering future SLC and climate change.

3.6.3 Real Estate Requirements

Based on the information available, the current TSP requires two (2) types of easements/instruments for the combined projects. Currently, all mobilization and construction activities, including lay down and storage of contractor materials and equipment, is assumed to be located within the project area Limit of Construction for the entire project. Since at least one of the project areas may contain a private road leading to a portion of the project area, a Road/Access Easement (Standard Estate No. 11) is anticipated to be required for at least one area.

The standard Perpetual Beach Storm Damage Reduction Easement (Standard Estate No. 26) is required for the construction of the beach berm and dune system on the beachfront properties that are above the MHWL or that include riparian grants, including any owned by the local municipalities. Properties requiring Standard Estate No. 26 include parcels located below the MHWL currently subject to riparian grants. Easements must be acquired over the areas below the MHWL covered by riparian grants for construction, operation and maintenance work required by the non-Federal sponsor and the Government over the life of the project.

3.6.4 Environmental Compliance

Table 17 provides a summary of the environmental compliance status to date. Additional details regarding the environmental compliance are provided in Section 6.2.2.

Table 17 - Summary of Environmental Compliance

Item	Compliance
Anadromous Fish Conservation Act	N/A
Archaeological and Historic Preservation Act, as amended, 16 U.S.C. 469, et seq.	Pending
Clean Air Act of 1977, as amended, 42 U.S.C. 7609, et seq.	Full
Clean Water Act, as amended, (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Pending
Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990	Full
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Pending
Endangered Species Act, 16 U.S.C. 1531, et seq.	Pending
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Full
Farmland Protection Policy Act of 1981	N/A
Federal Water Project Recreation Act, 16 U.S.C. 460-12, et seq.	Full
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Pending
Land and Water Conservation Fund Act, 16 U.S.C. 460/ -460/-11, et seq.	N/A
Magnuson-Stevens Fishery Conservation and Management Act of 1976	Full
Marine Mammal Protection Act of 1972	Full
Marine Protection, Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	N/A
Migratory Bird Treaty Act and Migratory Bird Conservation Act	Pending
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full
National Historic Preservation Act, 54 U.S.C. 300101 et seq.	Pending
Rivers and Harbor Act, 33 U.S.C. 401, et seq.	Full
Submerged Lands Act of 1953	Full
Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970	N/A
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	N/A
Wild and Scenic Rivers Act, 16 U.S.C. 1271, et seq.	N/A
Executive Order 11988, Floodplain Management, May 24, 1977 (42 CFR 26951; May 25, 1977)	Full
Executive Order 11990, Protection of Wetlands, May 24, 1977 (42 CFR 26961; May 25, 1977)	Full
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994	Full
Executive Order 13045, Disparate Risks Involving Children	N/A

Note: The compliance categories used in this table were assigned based on the following:

- Full Compliance (Full) – Having met all requirements of the statute, Executive Order (EO) or other environmental requirements for the current stage of planning
- Pending indicates coordination ongoing and will be completed prior to signature of FONSI.

3.6.5 Environmental Operating Principles

The USACE Environmental Operating Principles were developed to ensure that Corps of Engineers missions include totally integrated sustainable environmental practices. The Principles provided corporate direction to ensure the workforce recognized the Corps of Engineers role in, and responsibility for, sustainable use, stewardship, and restoration of natural resources across the Nation and, through the international reach of its support missions.

Since the Environmental Operating Principles were introduced in 2002 they have instilled environmental stewardship across business practices from recycling and reduced energy use at Corps and customer facilities to a fuller consideration of the environmental impacts of Corps actions and meaningful collaboration within the larger environmental community.

The concepts embedded in the original Principles remain vital to the success of the Corps and its missions. However, as the Nation's resource challenges and priorities have evolved, the Corps has responded by close examination and refinement of work processes and operating practices. This self-examination includes how the Corps considers environmental issues in all aspects of the corporate enterprise. In particular, the strong emphasis on sustainability must be translated into everyday actions that have an effect on the environmental conditions of today, as well as the uncertainties and risks of the future. These challenges are complex, ranging from global trends such as increasing and competing demands for water and energy, climate and sea level change, and declining biodiversity; to localized manifestations of these issues in extreme weather events, the spread of invasive species, and demographic shifts. Accordingly, the Corps of Engineers is re-invigorating commitment to the Environmental Operating Principles in light of this changing context.

The Environmental Operating Principles relate to the human environment and apply to all aspects of business and operations. They apply across Military Programs, Civil Works, Research and Development, and across the Corps. The Principles require a recognition and acceptance of individual responsibility from senior leaders to the newest team members. Re-committing to these principles and environmental stewardship will lead to more efficient and effective solutions, and will enable the Corps of Engineers to further leverage resources through collaboration. This is essential for successful integrated resources management, restoration of the environment and sustainable and energy efficient approaches to all Corps of Engineers mission areas. It is also an essential component of the Corps of Engineers' 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 Corps 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 Corps, 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 Corps actions in a collaborative manner.

- Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

Over the past 50 years, there has been a progressive decline in the average annual volume of sediment removed from the Delaware Estuary system by dredging with no reductions in maintained depths or any significant reduction in dredging projects requiring maintenance. The Delaware Bay shoreline has incurred significant erosion and tidal flooding. Most shoreline erosion of the Delaware Bay is caused by waves generated by local winds. The beach berm is the primary feature. A gently sloped beach dissipates wave energy while dunes reduce the erosion impact of wind, buffer the effects of floodwaters, and provide a sediment source to adjacent salt marshes (Knutson, 1988; Rosen, 1980). The dune is the secondary feature that provides additional height to reduce storm surge overtopping. Dune vegetation provides additional protection against erosion forces of wind and waves. American beach grass (*Ammophila breviligulata*) is a natural dune plant species that increases stability of the dune. The Delaware Bay beaches, including the beaches fronting residential communities, provide an important stopover site for migratory birds that travel up and down the Atlantic Flyway, provide breeding habitat for Federally and State-listed threatened and endangered species, as well as for many neo-tropical migrating bird species. Diamondback terrapins and horseshoe crabs utilize these beaches for nesting and spawning, respectively.

Fringing marshes along the shorelines have experienced significant lateral retreat. Inadequate importation of suspended sediment (and confined upland placement of dredge material), SLC, frequent severe storms, ship wakes, and to some extent, land subsidence, are believed to be the main causal factors.

The above-referenced TSP will provide improved CSRM for the Delaware Bay shoreline by utilizing dredged material to alleviate shoreline erosion and flooding. This TSP supports the Corps Environmental Operating Principles by providing an economic and environmentally sustainable solution that enhances shoreline resilience and sustainability by placing dredged sediment in the estuary system.

There is a potential for this TSP to enhance resiliency and sustainability of the natural coastal environment by retaining sediment in the system, and thereby providing habitat protection and/or restoration as well as shoreline stabilization. Specifically, the importation and deposition of new sediments is essential to the long-term sustainability of coastal wetlands. Wetlands promote shoreline stabilization and a defense against more frequent/lower level flooding events. Due to land conversion and degradation, less than 5% of pre-settlement acreage of freshwater wetlands remains in the Delaware Estuary. The U.S. EPA estimates that 35% of Delaware Bay's rare species and 70-90% of the estuary's fish and shellfish depend on wetland habitats. These critical habitats are under constant threat of storm damage and inundation.

Tidal wetlands provide some of the most productive natural ecosystems in the world, and are widely recognized for their important ecological functions. The services they provide include flood protection for coastal communities, maintenance of water quality, habitat for hundreds of species of fish and wildlife, and carbon sequestration. Normally, tidal wetlands can build vertically (accrete) in order to compensate for subsidence and/or SLC. This accretion occurs through the accumulation of organic matter (peat) from autochthonous production as well as the importation and trapping of suspended sediments washing in with tidal or storm flows by salt marsh vegetation.

The loss of shoreline fringing wetlands has exacerbated flooding and erosion problems. Once inundated, long-term vegetation dies off leaving mudflats, eroded banks, and open water areas that can no longer accrete sediments and keep pace with SLC. A robust beach berm and dune serves to provide protection and sediment source to adjacent wetlands by reducing flooding. Coastal marshes provide naturally for greater resilience to future storm damage. In combination with utilizing dredged material to build up eroded shorelines, opportunities exist to establish "living shorelines," which serve to further reduce losses of tidal marshes. Fringing shellfish beds, such as oysters or mussels, serve as natural breakwaters to trap sediments and absorb wave energy. Oysters and mussels build their own habitats and provide habitat for other marine intertidal species, while armoring the substrate and binding to vegetation.

3.6.6 Contributions to the USACE Campaign Plan

The USACE Campaign Plan is comprised of four separate goals: 1 – Supporting the Warfighter, 2 – Transforming Civil Works, 3 – Reducing Disaster Risks, and 4 – Preparing for Tomorrow.

Transforming Civil Works will enable the Corps to deliver essential water resource solutions using effective transformation strategies through a systems-based watershed approach. The NJ DMU TSP enhances resiliency and sustainability of the natural coastal environment by retaining sediment in the system and improving CSRM and habitat protection along the New Jersey shoreline.

Reducing Disaster Risk will be achieved through the reduction in coastal storm risk offered by the protective dune and berm.

Preparing for Tomorrow contributions are through maintaining a commitment to the project through periodic nourishment and life cycle adaptive management while mitigating for increases in water levels and storm frequency.

4 AFFECTED ENVIRONMENT

The study area is located within the section of the Delaware Estuary watershed, which lies within the State of New Jersey and the Delaware River itself. The north/south boundaries of the study area extend from Trenton, NJ to Cape May Point, NJ (Figure 1). The centerline of the Delaware Estuary represents the western study area boundary and it extends approximately 135 miles from the Atlantic Ocean upstream to the head of tide at Trenton, New Jersey.

4.1 ENVIRONMENTAL SETTING OF THE STUDY AREA

The NJ DMU study area extends from the head of tide at Trenton, Mercer County to Cape May Point in Cape May County, New Jersey for a total of approximately 133.4 miles of the Delaware Estuary shoreline (Mercer, Burlington, Camden, Gloucester, Salem, Cumberland and Cape May Counties).

The Delaware Bayshore (Cumberland and Cape May Counties) can be naturally divided into three distinct geomorphic regions. From south to north (Cape May Point to Bidwell Creek), the Cape May peninsula extends approximately 16 miles. The southern end of the peninsula is comprised of a community of seasonal and year-round inhabitants. The two largest coastal communities (both in Lower Township, Cape May County) are North Cape May and Villas. The shore is characterized by low dunes fronted by a narrow strip of eroding coarse sand beach. Sand and mud flats are prevalent at low tide. The middle section of the peninsula comprises the northern part of Middle Township and all the bay shore of Dennis, Maurice, Downe, Lawrence, Fairfield and Greenwich Townships. Communities include Sunray, Del Haven, Highs Beach, Pierces Point and Reeds Beach. Further north, the communities of Moores and Thompsons Beach, and East Point are much smaller in size, containing a single row of homes with access roads that require frequent maintenance due to persistent overwashing during periods of high water. The Cape May Point State Park is located at the southern limit of the study area and is considered one of the foremost bird viewing areas along the eastern seaboard for migratory shorebirds. Erosion is a persistent problem along this stretch of shoreline. There are three wildlife management areas located along the Delaware Bay shoreline from south to north: Higbee Beach, Cape Island and Dennis Creek Wildlife Management Areas (WMAs). Just south of Dennis Creek WMA is the Cape May National Wildlife Refuge.

The middle region shoreline (north of Bidwell Creek to Nantuxent Cove – approximately 40 miles) consists predominantly of natural lands with salt marshes and interior maritime forests separating smaller distinct residential communities. These include from south to north: Heislerville WMA, Egg Island Fish and Wildlife Management Area (FWMA), the Nantuxent FWMA and the New Sweden WMA. The town of Fortescue and Gandys Beach are the two largest communities. Commercial businesses occur in the towns of Bivalve and Shellpile along the Maurice River mouth including seafood suppliers, marinas and the Rutgers University Haskin Shellfish Research Laboratory. The shoreline consists of a narrow strip of sandy beach with low to no vegetated dunes. The communities in this section are small, surrounded by wetlands and have very narrow sandy beaches. These are Dyer Cove, Gandys Beach, Money Island, Bay Point, Sea Breeze and Bay Side. The only exception is the town of Fortescue, which is much larger (>200 homes). Fortescue is a popular fishing community and contains a state-owned marina. The majority of the community is bulkheaded with little to no beach at high tide.

North of Nantuxent Cove, the upper bay region becomes narrower as it transitions into the lower Delaware River. The area up to the Hope Creek Generating Station (approximately 30 miles) continues to be predominantly natural undeveloped marsh and beach shoreline of the Dix WMA and Mad Horse Creek WMA. Just behind the beach, the irregular salt marsh coast continues to dominate the shoreline up the Delaware River to the mouth of the Salem River. This section lies in the southern part of Salem County and comprises the bay shore of Lower Alloway and Elsinboro Townships. Just north of the Salem River mouth is the Supawna Meadows National Wildlife Refuge. At the northern part of the bay in Elsinboro Township is the community of Oakwood Beach.

4.2 PHYSICAL ENVIRONMENT

4.2.1 Land Use

The Delaware River, which is fed by 216 tributaries, is the longest un-dammed river east of the Mississippi River. Approximately 15 million people, or about 5% of the U.S. population, rely on the waters of the Delaware River Basin for drinking and industrial use, and the Delaware River is only a one to two hour drive away for about 20% of the people living in the United States (Kaufman, 2011). The Delaware River is a principal corridor for commerce that has sustained the region since America's colonial period and reached a zenith during World War II and thereafter. Today, it continues to be a major port for national defense and economic interests. The Delaware Estuary has 64 municipalities bordering it. The Estuary supports the 4th largest urban center in the nation and contains the world's largest freshwater port. The Estuary also sustains a wealth of natural and living resources, extensive tidal marshes that sustain vibrant ecosystems and shoreline habitats for horseshoe crabs and migratory shorebirds, and both fresh water and salt water habitats for shellfish (Kreeger *et al.*, 2010). The beaches and marshes of the Delaware Bay provide many natural areas for recreational opportunities such as birding, fishing, kayaking, beachcombing and crabbing. Larger residential communities include: Oakwood Beach (Elsinboro), Fortescue, Reeds Beach, Pierces Point and Villas.

In January 2017, the state of New Jersey purchased 204 acres of wetlands and upland buffers along the Delaware Bay in Maurice River Township, Cumberland County for waterfowl and other wildlife habitat preservation using funding from USFWS' Coastal Wetlands Conservation Grant Program and NJDEP's Green Acres Program. The land will be added to the New Jersey Division of Fish and Wildlife's 7,231-acre Heislerville WMA. Ecotourism is a growing industry in New Jersey, particularly in the Delaware Bay region considering New Jersey's Atlantic Ocean coastline is more heavily developed. The bay region is home to the state's largest concentration of bald eagles and is a critical stopover area for migrating shorebirds.

4.2.2 Physiography and Geology

The area is primarily a broad flat area with marshes, sandy beaches and forest. Its most notable feature is the Pine Barrens, 760 square miles of protected forests and marshes, with predominant pitch pines and white oaks.

Geologically, the Delaware Estuary is situated near the border of two subdivisions: the Appalachian Piedmont province and the Atlantic Coastal Plain province. The Piedmont Plateau lies along the eastern edge of the Appalachian Mountains and runs from New Jersey to Alabama. The formations of the Piedmont Plateau consist primarily of Cambrian to Ordovician age, hard, crystalline rocks. They extend downward and toward the Atlantic Ocean, forming a platform that supports the Coastal Plain. The Piedmont Plateau borders the western side of the estuary between Philadelphia and Wilmington. The Coastal Plain physiographic province borders the entire eastern side of the Delaware Estuary. The formations of the coastal plain are much younger than those of the Piedmont, and are largely unconsolidated sediments. The Coastal Plain sediment layers are mainly comprised of sands and clays that dip to the southeast, and generally thicken oceanward. The older formations are at or near the surface in the vicinity of the estuary, and are progressively deeper towards the Atlantic Ocean. The unconsolidated sediments consist of pervious and impervious layers that form a series of aquifers and aquicludes.

4.2.3 Sediment Quality

Extensive sediment quality sampling and analyses have been conducted within the Delaware Estuary, primarily in association with the USACE Delaware River Main Stem Channel Deepening and Maintenance Dredging projects in the uppermost portions of the navigation project (USACE, 1992, 1997). Most of this sediment testing has occurred within the current project area reaches.

Sediment samples collected from the Main Stem Delaware River included bulk sediment analyses, elutriate sediment analyses, Toxicity Characteristic Leaching Procedure (TCLP) analyses, biological effects based sediment testing, and high resolution PCB congener analyses (USACE, 2009). The mean and range of contaminant concentrations were provided for each reach of the proposed project area. Mean contaminant concentrations fell within ranges considered to be background for soils and sediments in New Jersey. Maximum concentrations that exceed background appear to be in isolated samples, and are, therefore, limited in spatial distribution.

Due to concerns raised during the MCD Feasibility study regarding sediment chemical quality and the potential adverse effects on aquatic resources, bulk sediment and elutriate analyses were conducted (USACE, 1997). The majority of contaminant parameters evaluated were not detected in channel sediments. Bulk analysis did not identify high concentrations of organic contaminants: PCBs were detected in two samples (Bellevue and Liston Ranges); 4 pesticides (all below 0.1 ppm) were detected in the Bellevue, Liston and Mifflin Ranges; and polycyclic aromatic hydrocarbons (PAHs) were detected in several channel bends between Philadelphia Harbor and Artificial Island. Of the remaining volatile and semi-volatile organic contaminants evaluated, only methylene chloride, acetone, 2-butanone, styrene and phthalates were detected at quantifiable levels (all below 0.1 ppm). Heavy metals were found to be widely distributed throughout the MCD project area, with concentrations in predominantly sandy bay sediments lower than up-river sediments. The presence of heavy metals in channel sediments is attributed to the urban and industrialized nature of the upper estuary. Refer to the 1997 Supplemental EIS (USACE, 1997) for a more detailed discussion of the sediment quality analyses and potential impacts to human health and biological effects testing.

Two additional sets of bulk sediment data were collected from the channel (Versar, 2003, 2005). A total of 45 sediment cores were collected between Philadelphia and the Chesapeake and Delaware Canal and analyzed for inorganics, pesticides, PCBs, volatile and semi-volatile organic compounds. In these reaches of the river, the results were compared to Residential Direct Contact criteria developed by the State of New Jersey, and used to evaluate the quality of dredged material. The most common parameters detected in sediments were inorganic metals. Concentrations of inorganics in all 45 samples were below New Jersey residential criteria except for thallium and arsenic. Two samples had thallium concentrations (5.33 ppm and 7.24 ppm) above the residential criterion of 5 ppm. Two samples had arsenic concentrations (51.4 ppm and 37.4 ppm) above the residential criterion of 19 ppm. Thallium and arsenic, along with antimony, were the only inorganic parameters to exceed New Jersey criteria in previous sampling efforts. The most frequently detected organic parameters in the upper river were PAHs. PAHs are primarily formed through combustion of fossil fuels and are expected to be found in highly industrialized and populated regions (USACE, 2009).

A multi-agency Sediment Quality Committee compiled a database of 932 *in situ* bulk chemistry sediment samples in 2012 (RSMT, 2013). Samples were analyzed for the purpose of evaluating dredged material for use in aquatic habitat restoration. The data was evaluated for the following contaminants of concern (COC): arsenic, cadmium, cobalt, copper, lead, mercury, total chlordane, dieldrin, 4,4'-DDT/DDD/DDE, benzo(a)pyrene, total PCBs and total dioxin/furan. The Committee considered guidelines that are currently in use in the Delaware Estuary to evaluate sediment quality, including Pennsylvania, New Jersey and Delaware state regulatory criteria for the evaluation of fill (soil, dredged material, *etc*.) at upland sites; sediment quality guidelines used for ecological effects screening purposes; state and DRBC water quality criteria, state criteria used to develop fish advisories; and eco-effects data for toxicity, bioaccumulation, and community health indices.

Statistical analyses of the mean COC concentrations in each DRBC Water Quality Zone identified significant differences between DRBC zones. The Committee concluded that sediments suitable for "unrestricted" upland beneficial uses are usually interspersed among samples acceptable for "limited/restricted" upland beneficial uses throughout the Delaware Estuary. However, the data suggest that dredged material from DRBC Zone 6 (Delaware Bay) is most suitable for "unrestricted" upland beneficial use projects. Dredged material from DRBC Zones 2 through 5 and the tributaries appear to be suitable for either "unrestricted" or "limited/restricted" upland beneficial uses.

Explorations and test data from eleven (11) individual USACE and Philadelphia Regional Port Authority (PRPA) investigations were compiled into a single geotechnical data report by Gehagan & Bryant Associates, Inc. (GBA) dated October 2010. This GBA geotechnical report is included as Appendix C4 of this feasibility report. These investigations between Philadelphia and the sea were conducted between the early 1960s and 2010 for local project feasibility studies and the MCD. From this collection of data, it was estimated that most materials in the main channel of Reach E consisted of sandy materials. In 2012, GBA conducted a supplemental geotechnical subsurface investigation for USACE Philadelphia District and the PRPA. GBA collected vibracore samples of the riverbed sediment at 51 discrete locations in the main channel. An extensive geotechnical laboratory testing program was performed, results of which indicated the bulk of material encountered was sand. Results show that 92% of all samples were predominantly sand (sand fraction greater than 50%). Only 12% of grain size samples had silt and clay contents greater than 50%. The findings of this supplemental investigation essentially confirmed previous findings and assumptions regarding the sediment grain sizes in the channel.

Specifically, the Philadelphia District has placed sand dredged from Lower Reach E (the Brandywine and Miah Maull ranges of the Main Channel in DRBC Zone 6) in Buoy 10 approximately ten times between 1991 and 2012. In 2014, 11 sediment grab samples were collected in and around the Buoy 10 open water disposal site by the Philadelphia District. All samples were analyzed for grain size and ranged from 96.1% to 99.8% sand. The remaining component were shell fragments. Vibracores were collected from Buoy 10 in 2007 (Schnabel Engineering, 2007) for the Philadelphia District and again in 2014 and predominantly indicate similar results as the grab samples; however, there are some coarser sediments (gravel) in pockets approximately 7 to 10 feet below the surface that may reduce total available quantity. Materials with large grain sizes (>90% sand) are typically not contaminated and chemical testing is not required. The munitions and explosives of concern (MEC) screening process will prevent most of the coarser material from getting into the dredged material. The current estimate of sand remaining within the Buoy 10 boundaries is approximately 750,000 cy.

4.2.4 Climate and Climate Change

It is anticipated that the global mean sea level will rise within the next 100 years. To include the direct and indirect physical effects of projected future SLC on design, construction, operation and maintenance of coastal projects, USACE follows guidance provided in the form of Engineering Regulation (ER) 1100-2-8161 (developed with assistance of coastal scientists from the NOAA National Ocean Service and the U.S. Geological Survey), and Engineering Technical Letter (ETL) 1100-2-1 Procedures to Evaluate Sea Level Change: Impacts, Responses and Adaptation. Three estimates are required by the guidance; a Baseline (or “Low”) estimate, which is based on historic sea level rise and represents the minimum expected SLC, an intermediate estimate, and a high estimate representing the maximum expected SLC.

The Partnership for the Delaware Estuary (PDE) is a nonprofit organization that manages the Delaware Estuary Program, one of 28 estuaries recognized by the U.S. Congress for its national significance under the Clean Water Act. The PDE evaluated climate change effects within the Delaware Estuary (Kreeger *et al*., 2010).

SLC due to climate change has been predicted to be greater in the Mid-Atlantic Region than points north and south on the eastern seaboard. PDE’s Climate Adaptation Workgroup looked at the results of 14 different climate models to first test their accuracy in predicting past conditions for the region and averaged them together to postulate a locally relevant future scenario. The team then evaluated the vulnerabilities of the Delaware Estuary’s tidal wetlands, drinking water, and bivalve shellfish to changes in physical and chemical conditions associated with climate change. Some aspects of a changing climate may not be as severe here than in other watersheds while other changes may be more problematic.

For example, modest rises in temperature could lengthen growing seasons or boost productivity for some signature species and help them compete with invasive species or keep pace with SLC. PDE’s scientific team found that the length of the growing season is predicted to increase by about 15 days by mid-century, and by up to 30 days by 2100 for the Delaware Estuary. Additionally, approximately 20 fewer frost days per year are predicted by mid-century and 40 fewer frost days by the end of the century under a higher emissions scenario. The models show high confidence that average annual temperatures will increase by the end of the 21st century by 2-4 degrees C. More warming is expected in summer months. This conclusion is consistent with predictions by the Union of Concerned Scientists which estimated that Pennsylvania summer temperatures could increase by 2-7 degrees C, depending on the emissions scenario (UCS, 2008; Field *et al*., 2007).

Annual mean precipitation is predicted to increase by 7-9% by the end of the 21st century (median projection). Higher increases are expected during winter months (Najjar, 2009; GCRP, 2009). Three quarters of the models predict substantial increases in the frequency of extreme precipitation events including heavy precipitation and consecutive dry days. The U.S. Global Climate Research Program (GCRP) also predicted increases in extreme weather events and associated risks from storm surges (GCRP, 2009) (Table 18).

Table 18 - Delaware Estuary Watershed Climate Predictions: Present to 2100

Climate Condition		Model Evaluation: Biases & Issues	21st Century Prediction	Confidence Levels
Temperature	Monthly Mean	Slight cool bias in winter and summer	Warming: 1.9 – 3.7^{o}C median rise by late century; Substantially greater warming in summer months	High
	Inter-annual Variability	Slightly too much variability, but better with winter than summer		
	Intra-monthly Variability	Models' mean reproduces correctly, but there is a large spread among the individual models		
	Extreme Temp >80 F	Underestimates	Downscaled models show substantial increases	High
Precipitation	Monthly Mean	Wet bias in winter and spring and a dry bias in summer	Increase in Precipitation: 7 - 9% median increase by late century; Substantial increase in winter months	Medium
	Inter-annual Variability	Does not predict summer peak and winter minimum seen in observed conditions		
	Intra-monthly Variability	Mean reasonably captures, but too low in the summer		
Extreme Precipitation	Short Term Drought	Slight low bias	Substantial increases, but less than ¼ of models show declines	Medium
	Heavy Precipitation	Slight low bias		
Growing Season Length		Predicts accurately	Substantial increase by end of century	High
Number of Frost Days		Somewhat high	Substantial decline	High

The Delaware Estuary freshwater tidal region extends about 70 river miles, and the salinity in areas more seaward changes very gradually. This feature makes the Delaware Estuary unique among large American estuaries because of the array of ecosystem services supplied to human and natural communities tied to the extended salinity gradient, such as the supply of drinking water for people and rare natural communities (Kreeger *et al*., 2010). Increasing sea level may result in larger tidal volumes bringing salt water further up the estuary. Some of the salinity increase could be offset by anticipated increases in precipitation. Sea level rise could increase the tidal range in the Delaware system (Walters, 1992), similar to expectations for the Chesapeake Bay (Zhong *et al*, 2008).

The Mid-Atlantic region is anticipated to experience SLC greater than the global average (GCRP, 2009). Some regional variation in sea level results from gravitational forces, local land subsidence, wind, and water circulation patterns. Sea level is expected to increase in the region by approximately 10 cm over this century (Yin *et al*., 2009). Two other factors play prominent roles influencing SLC locally: land subsidence and sediment accretion. New Jersey has been subsiding since the last Ice Age, causing a steady loss of elevation. Subsidence is expected to continue through the next century at an average of 1-2 mm of land elevation loss per year (Engelhart *et al*., 2009). Sediment accretion is a natural process whereby suspended sediments within the Delaware River, Bay, and tributaries settle and accumulate along the shoreline such as on mudflats and in wetlands. Accretion cannot occur on developed surfaces where erosion typically occurs or if the system is sediment starved from diversion processes (such as dredging and upland placement operations). These factors play a significant role in either accelerating or decreasing the rate of SLC and loss of habitat. The net increase in sea level compared to the change in land elevation is the rate of relative sea level rise (RSRL). Kreeger *et al*. (2010) estimate relative sea level rise for the Delaware Estuary watershed by the end of the century at 0.8 to 1.7 m.

4.3 WATER RESOURCES

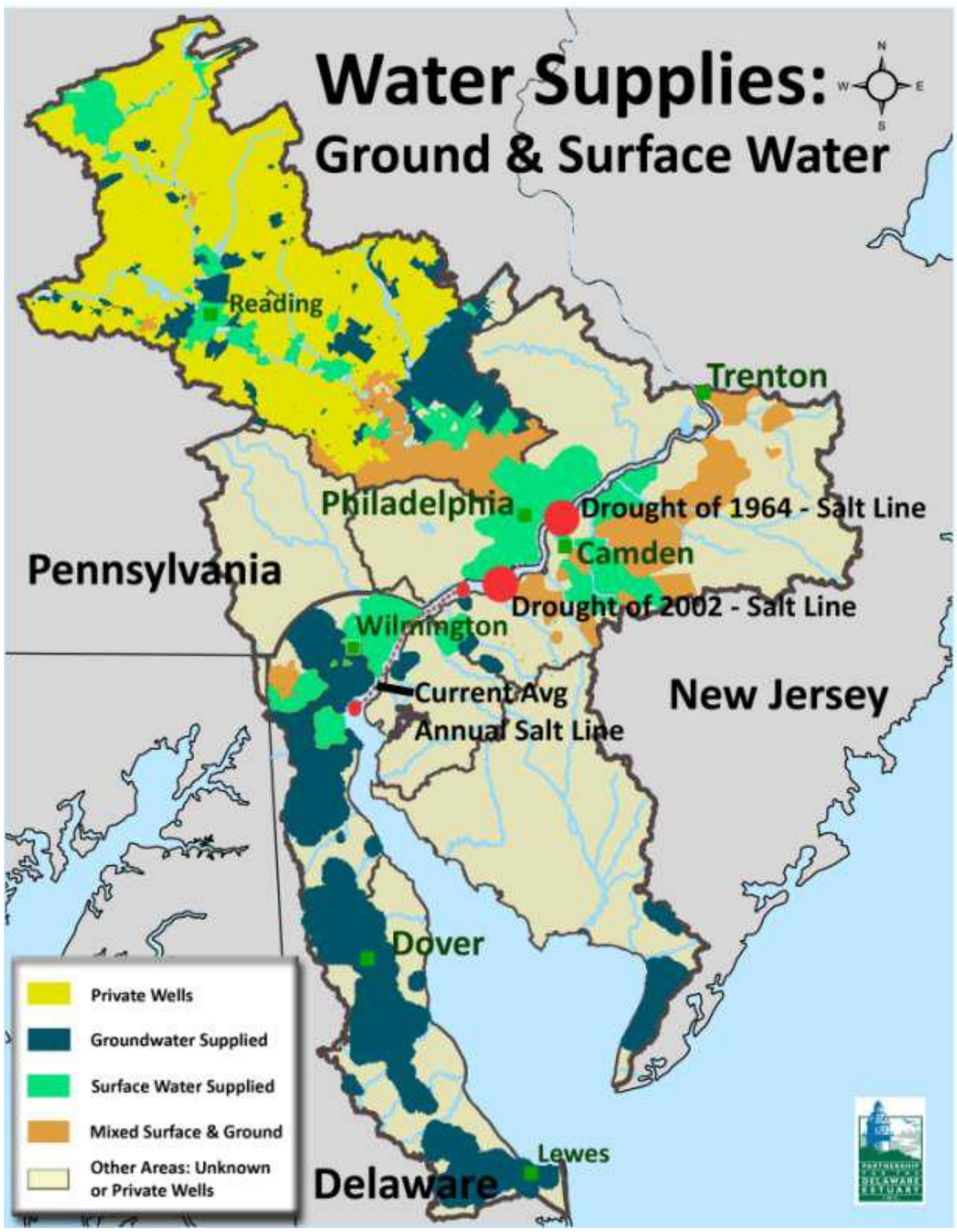
4.3.1 Groundwater Quality and Public Water Sources

Groundwater is contained within aquifers, which are porous geologic formations that store or transit groundwater. The 5 principal Coastal Plain aquifers are the Kirkwood-Cohansy aquifer system, the Atlantic City 800-foot sand, the Wenonah-Mount Laurel aquifer, the Englishtown aquifer, and the Potomac-Raritan-Magothy aquifer system. All but the Kirkwood-Cohansy are confined except where they crop out or are overlain by permeable surficial deposits. The aquifers are recharged directly by precipitation in outcrop areas, by vertical leakage through confining beds, and by seepage from surface water bodies (Sargent *et al.*, 1985).

As part of the U.S. Geological Survey's (USGS') National Water Quality Assessment Program (NAWQA), USGS hydrologists in New Jersey assess surface and groundwater quality in the state's coastal drainage basins. In New Jersey, the NAWQA Program is focusing on the effect of land use on shallow groundwater quality, spatial and temporal trends in groundwater quality, well vulnerability to contamination from various sources, toxic materials in surface water, storm water quality and the effects of interbasin surface water transfers on water quality.

More than 75% of the freshwater supply in the New Jersey Coastal Plain is from ground water. Water quality is satisfactory except for some local excessive iron concentrations (as much as 460 milligrams per liter) in several aquifers, including the Potomac-Raritan-Magothy, and occasional local contamination from saltwater intrusion or waste disposal. In the unconfined Kirkwood-Cohansey aquifer system, water is brackish or salty in some coastal areas. In confined aquifers, salinity generally increases with depth in the southern and southeastern parts of the Coastal Plain (Sargent, *et al*., 1985). Groundwater withdrawals in coastal areas have resulted in the landward movement of salty groundwater into aquifers that are used heavily for water supply. As a result, more than 120 wells in Cape May County alone have been abandoned since 1940. The USGS, in cooperation with Lower Township and the cities of Cape May and Wildwood, developed a groundwater flow model that can be used to estimate saltwater movement in coastal areas under various hypothetical groundwater withdrawal schemes. The estimates help water managers decide how best to distribute future withdrawals to minimize additional saltwater intrusion. Figure 17 shows a map of the watershed and service areas of community water supplies.

Figure 17 - Water Supplies: Ground & Surface Water



In New Jersey, approximately 40% of the drinking water supply is groundwater. Human activities are known to impact shallow groundwater quality. The quality of southern New Jersey's groundwater resources is generally good, although local problems exist. The Potomac and Magothy formations are usually high in iron. Agricultural and urban areas have higher concentrations of nutrients, especially nitrite plus nitrate, than undeveloped areas. The origin of the nitrite plus nitrate is believed to be primarily fertilizers and releases from manure management, although septic systems and leaking sewer systems likely contribute as well. A high chloride concentration is typical within two miles of Delaware Bay and within one mile of tidal streams (USACE, 1992). The most widespread groundwater quality problem in southern New Jersey has been saline encroachment.

4.3.2 Surface Water Quality

Nutrient monitoring is conducted by NJDEP within the Delaware Estuary. NJDEP (1999) has compiled over a decade worth of physical and nutrient monitoring in New Jersey State waters, including the lower Delaware Estuary. The report findings are that physical parameters of temperature, salinity and Secchi depth are typical of what would be expected in the freshwater riverine portion of the upper study area, the turbidity maximum zone of middle section of the study area (upper Delaware Bay) and in the lower bay where oceanic influences dominate many physical parameters. Spring temperatures typically vary from 10 – 20° C, while summer temperatures range from 20 - 25° C. Temperatures during the fall tend to be near 15° C. Many Delaware Estuary stations did not show a seasonal component to Secchi depth, but seasonal and often daily fluctuations for oxygen and nutrient levels. There were several stations spread throughout the estuary that occasionally failed to achieve the NOAA minimum dissolved oxygen standard (minimum 5.0 mg/L), particularly during the summer. Nutrient levels in the Delaware Estuary exhibit seasonal patterns and spatial distribution where both ammonia and phosphorous were higher in the summer and total nitrogen and nitrate were elevated in the fall. Nutrient levels were highest close to the shoreline, and are likely attributed to anthropogenic activities (NJDEP, 1999).

Advances in the treatment of municipal and industrial waste and changes in manufacturing and processing techniques over the past 40 years have led to improved surface water quality in many parts of the Delaware River Basin. One indication of this improvement is the return of shad runs to the Delaware River. The presence of toxic compounds, however, still leads to consumption advisories for many fish species, and nutrient loadings adversely affect water quality and the health of ecological communities. Many of the water-quality issues in the Delaware Estuary can be related to the high human population density and related activities associated with urban, industrial, and agricultural land use. Most concerns are related to human health (*i.e.* the quality of domestic water supply, the safety of water contact recreation, and the safety of eating game fish) and the health of ecological communities (USACE, 2009).

The proposed project area includes the lower portion of the Delaware Estuary. Surface water quality in these reaches varies from fair in the uppermost portions to good in the lower Delaware Bay region. The uppermost reach is considered a transition zone between urbanized upstream areas and rural Delaware Bay. These zone is also the transitional area between the freshwater habitats upstream and more saline areas downstream.

The DRBC is responsible for managing the water resources within the entire Delaware River Basin. Pursuant to Section 305(b) of the Clean Water Act, the DRBC prepares biennial assessments of water quality for the Delaware River. The DRBC considers all readily available data sets in its assessments, such as the U.S. Environmental Protection Agency (EPA) STORET database, the U.S. Geological Survey (USGS) NWIS database, the NOAA PORTS database, as a few examples. The reports provide an assessment of waters in the Delaware River and Bay for support of various designated uses in accordance with Section 305(b) of the Clean Water Act and identifies impaired waters, which consist of waters that do not meet DRBC Water Quality Regulations (18 CFR 410).

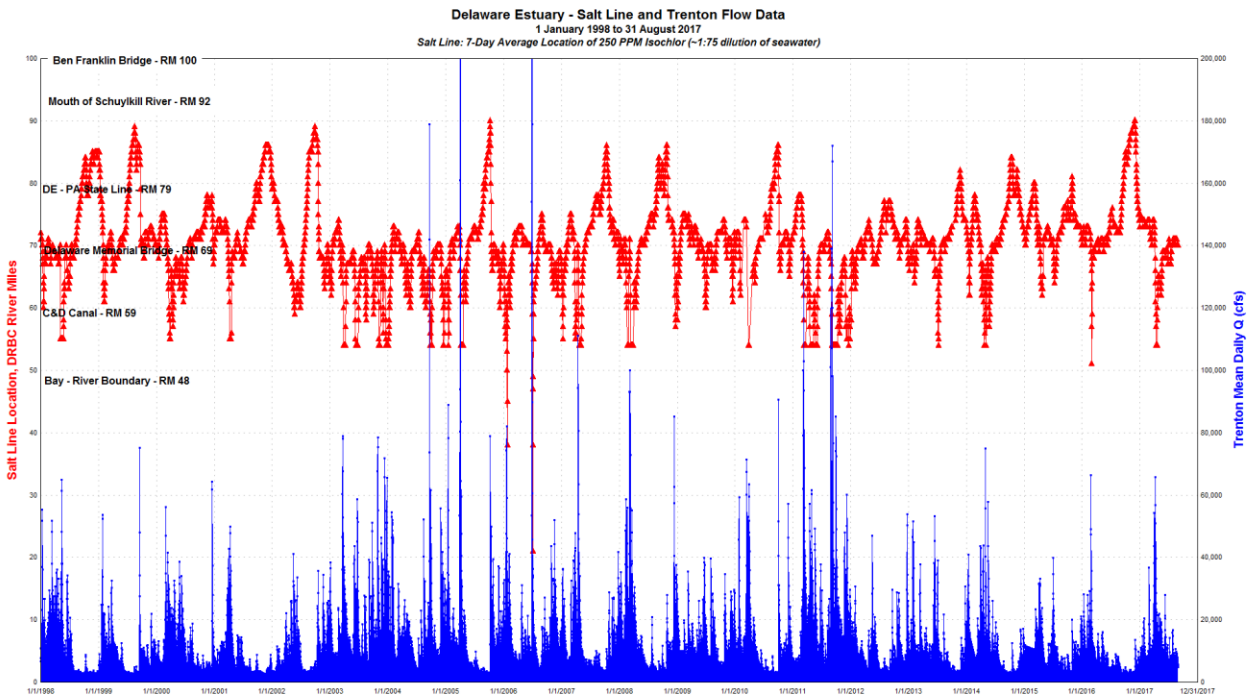
The composite aquatic life assessment for 2012 yields a result of "Not Supporting" for aquatic life (DRBC, 2012). It is important to note, however, that this result is largely driven by DRBC's requirement to categorize as not meeting criteria with 1 exceedance plus 1 confirmatory exceedance and based primarily on fewer than 10% exceedances of criteria. It has been extensively documented that water quality of the Delaware Estuary, particularly upstream in the tidal Delaware River, has greatly improved over the past 50 years since implementation of the 1961 Delaware River Basin Compact and the 1970s Federal Clean Water Act Amendments. Dissolved oxygen levels have increased while phosphorus and nitrogen levels have decreased (Kauffman *et al*., 2009).

Salinity. Salinity within Delaware Estuary waters is important for its effects on habitat suitability for living resources (fish, shellfish, plant life, *etc*.), and its impact on human uses of the water of the estuary (industrial and municipal water supply withdrawals, groundwater recharge, *etc*.). A longitudinal salinity gradient exists with salinity higher at the mouth and downbay and decreases in the upstream direction. The distribution of salinity in the Delaware Estuary exhibits significant variability on both spatial and temporal scales; at any given time, salinity reflects the opposing influences of freshwater inflow from tributaries (and groundwater) versus saltwater inflow from the Atlantic Ocean.

The four longitudinal salinity zones within the Delaware Estuary, starting at the bay mouth are: *polyhaline* (18 - 30 ppt) from the mouth of the bay to the vicinity of the Fortescue FWMA; *mesohaline* (5 - 18 ppt) from the Fortescue area north to the vicinity of the Cohansey River; *oligohaline* (0.5 - 5 ppt) from the Cohansey River area north to the vicinity of Riverfront Park near Bridgeport, and *fresh* (0.0 - 0.5 ppt) upriver. Although these zones are useful to describe the long-term average distribution of salinity in the estuary, the longitudinal salinity gradient is dynamic and subject to short and long-term changes caused by variations in freshwater inflows, tides, storm surge, weather (wind) conditions, *etc*. These variations can cause a specific salinity value (isohaline) to move upstream or downstream by as much as 10 miles in a day due to semi-diurnal tides, and by more than 20 miles over periods ranging from a day to weeks or months due to storm and seasonal effects on freshwater inflows.

The long-term average salt line location hovers in the vicinity of the Delaware Memorial Bridge (River Mile 69-70). From 1998 to the present, the salt line data (*i.e*. the 7-day average location of 250 ppm isochlor) shows that it has nearly reached as far north as River Mile 90 (the mouth of the Schuylkill River) about three times and has flushed downstream below RM 59 (the C&D Canal entrance) about five times, due to sustained high flows at Trenton, New Jersey (Figure 18).

Figure 18 - Delaware Estuary: Salt Line and Trenton Flow Data



4.4 BIOLOGICAL RESOURCES

4.4.1 Vegetation and Wetlands

In the upper reaches of the estuary, vegetation is predominantly riparian and includes emergent and forested wetland species such as American beech (*Fagus grandifolia*), American sycamore (*Platanus occidentalis*), black birch (*Betula lenta*), black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), boxelder (*Acer negundo*), common persimmon (*Diospyros virginiana*), eastern cottonwood (*Populus deltoids*), eastern red cedar (*Juniperus virginiana*), hackberry (*Celtis occidentalis*), hickory (*Carya* spp.), pin oak (*Quercus palustris*), red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), tuliptree (*Liriodendron tulipifera*), and willow (*Salix nigra*). Upland forests in this area are typically transitional and dominated by oak (*Quercus* spp.). Non-native flora, including common reed (*Phragmites australis*), mile-a-minute vine (*Persicaria perfoliatum*), and purple loosestrife (*Lythrum salicaria*) are also present.

As previously mentioned in Section 4.3.2, salinity is a key factor in the distribution of vegetation species in an estuarine environment. Plant location is dependent upon their salinity tolerance. Freshwater species tend to be located along the coastline as well as inland, while species that are more salt-tolerant occur in coastal areas down river and down bay. Historically, the Delaware River and all tidal tributaries were fringed with wetlands. The Delaware Estuary's large tidal freshwater prism runs from Trenton, New Jersey to around Carneys Point Township, New Jersey. Tidal wetlands provide essential spawning, foraging, and nesting habitats for both land and aquatic species. Wetlands absorb contaminants, nutrients, and suspended sediments from the water column, and help buffer the impact of storm surge and flooding. The values of these ecosystems went largely unrecognized in the past, and most of these wetlands on both shores have been eliminated through development. Losses are most severe in the urban corridor. Freshwater riverine wetland plant species commonly found upriver include arrow arum (*Peltandra virginica*), spikerush (*Eleocharis palustris*), pickerelweed (*Pontederia cordata*), blue flag (*Iris versicolor)*, American threesquare (*Scirpus americanus)* and common reed (*Phragmites australis*).

Wetlands are considered one of the most productive ecosystems in the world and play an important role in the maintenance of water quality. Dense vegetation filters sediment nutrients from the water and provides coastal resiliency to storms and erosion. Wetlands provide habitat and food for a variety of wildlife and tidal marshes in particular are vital as nursery areas for economically valuable fish and crustaceans. New Jersey has about 916,000 acres of wetland, most of which are the coastal plain. Forested wetlands are the most common and widely distributed wetlands in the state. Salt marshes are the most common wetlands in the coastal areas. Between the 1780s and 1980s, New Jersey lost about 39 percent of its wetlands. Wetlands have been drained primarily for crop production and pasturage and filled for housing, transportation, industrialization and landfills. In the Delaware Estuary, tidal wetlands are flooded twice daily by tides and this tidal fluctuation maintains their high productivity. Nontidal wetlands typically occur in freshwater zones such as lakes and upriver stream (https://www.aswm.org).

Representative wetland plant species follow the salinity gradient. Typical freshwater marsh species include common threesquare (*Scirpus americanus*), dotted smartweed (*Polygonum punctatum*), common spikerush (*Eleocharis palustris*), wild rice (*Zizania palustris*), pickerelweed (*Pontederia cordata*), and arrow arum (*Peltandra virginica*).   Saltwater marsh species include smooth cordgrass (*Spartina alterniflora*), salt hay (*Spartina patens*), spikegrass (*Distichlis spicata*), and marsh elder (*Iva frutescens*).

4.4.2 Planktonic and Benthic Organisms

The diversity of phytoplankton is high in the Delaware Estuary due to the presence of freshwater, brackish, and marine environments. Several hundred species occur along the length of the estuary. The most prominent are diatoms (Class Bacilliariophyceae) (Pennock and Herman, 1988). In the upper reaches of the estuary, phytoplankton have lower diversity and are limited by water quality (*i.e.* the area of higher anthropogenic influences and the turbidity maximum). Chlorophytes (green algae) and diatoms were the predominant groups (ANSP, 1981).   This phytoplankton community is indicative of an enriched and turbid system, while many of the species are considered pollution tolerant (*e.g*. *Phizoclonium*, *Oscillatoria*, and *Cladophoroglomata*). Upper estuary phytoplankton exhibit a period of accumulation during the summer months. In the middle estuary region, the accumulation peaks generally occur in spring, and transient blooms in September and November.   Despite lower turbidity and non-nutrient limiting conditions in the lower bay during summer months, chlorophyll concentrations remain relatively low. Small green and brown algae make up much of the summer phytoplankton population in the lower bay (Pennock and Harman, 1988).

Zooplankton occupy a critical position in the food web. These small drifting animals feed on phytoplankton and provide a large food source for larger aquatic animals. The ANSP (1981) found that the zooplankton found in the upper reaches of the project area consisted primarily of ciliates (Codonella) and heliozoan protozoa (Actinosphaerium, Staurophyra) and rotifers (Keratella). The zooplankton community in these upper portions of the estuary showed a high dominance of a few taxa and populations were not particularly abundant. In the lower more saline reaches, 30 different species of zooplankton have been identified, with more than 85% of them Copepods. Other common species include *Halicyclops fosteri*, *Eurytemora affinis*, and *Acaryia tonsa*. Mysid shrimp (*Neomysis americana*) also provide a significant food source for fish. Ecologically important crustaceans include the grass shrimp (*Palaemonetes* spp.), fiddler crab (*Uca* spp.), and blue crab (*Calinectes sapidus*). The wedge rangia (*Rangia cuneata*) is an important bivalve filter feeder in soft bottom habitats, and the coffee-bean snail (*Melampus bidentatus*) serves as a detrial/algal razer in marshes. Other abundant forms included crabs and shrimp larvae, mollusk larvae, barnacle larvae, and fish eggs and larvae (Pennock and Herman, 1988).

The distribution of benthic macroinvertebrates within the Delaware Estuary is determined by salinity, sediment type, and current velocity. In the upper reaches where waters are brackish to fresh, Oligochaeta and Hirundinea were the most abundant, although blue crabs have also been found in this stretch of the river (PECO, 1977). The ANSP (1981) concluded that the predominant macroinvertebrate fauna are sparse in this portion of the upper estuary, citing low species diversity due to the more industrialized character of the river. The species most dominant were amphipods (Gammarus); isopods (Cyathura, Chiridotea); and tubificid worms (Limnodrilus).

In contrast to the upper estuary, species diversity is greater, with more taxa contributing significantly to the biota, in the more saline bay region. Over 30 taxa of polychaetes, mollusks, and crustaceans were found. Important species include the polychaete *Sabellaria vulgaris*, the mysid shrimp Neomysus Americana, amphipods Unciola and Acanthohaustorius, and the snail Nassarius trivittatus. Decapod crustaceans in the lower bay include several species of crab (Ovalipes, Panopeus, Cancer, Libinia) and the sand shrimp (Crangon septemspinosa) (RMC, 1988).

Maurer *et al.* (1978) conducted a quantitative bay-wide survey (207 stations) of benthic invertebrates over two consecutive summers. A total of 169 species were collected and expectedly, the number of species and number of individuals increased with increasing salinity and sediment grain size. Species composition was similar to that in Chesapeake Bay and dominant species in other mid-Atlantic bight estuaries. They compared their results with other estuaries throughout the world and these relationships of species composition relative to salinity and sediment type were found to be similar.

A recent biological survey was performed by the Rutgers University Haskin Shellfish Research Laboratory from August to the end of October 2014 that utilized seines along the shoreline marsh and shallow water habitats at the Money Island/Gandys Beach Preserve and Nantuxent Creek. In this survey, several macroinvertebrate taxa were collected, which included: horseshoe crab, Atlantic mud crab (*Panopeus herbstii*), brown shrimp (*Penaeus aztecus*), grass shrimp (*Paleomonetes* spp.), sand shrimp (*Crangon septemspinosa*), and blue crab (*Callinectes sapidus*) (USFWS, 2014).

The Eastern oyster (*Crassostrea virginica*) is an important species both ecologically and economically that occurs in Delaware Bay from the mouth up to the upper portion of the bay where it narrows at Hope Creek Generating Station. Although oysters can tolerate a wide range of salinity, populations endure a trade-off such that in higher salinity environments of the lower bay, oysters experience faster growth but reduced survival due to disease and predation, whereas in the lower salinity region of the upper bay, oyster grow more slowly (Kraeuter *et al.*, 2007) but disease and predation pressure are lower (Munroe *et al.*, 2013). Oyster populations dropped significantly in the 1950s due primarily to the prevalence of an oyster disease (MSX). Populations recovered slightly during the 1970s and 1980s only to be hit again by a second disease (Dermo). Since 1989, the condition of the bay's oysters has deteriorated despite careful management and a limited controlled fishery.

Blue crabs have been reported to occur above Wilmington, DE but are more common in the higher salinity waters of the bay. The blue crab (*Callinectes sapidus*) inhabit nearshore coastal and estuarine habitats. Delaware Bay is the northernmost range of blue crab distribution (Helser and Kahn, 2001). Generally the crabs reside in shallow lower salinity waters in spring and summer and higher salinity deeper waters in winter.

One of the Delaware Estuary's notable species is the horseshoe crab (*Limulus polyphemus*). The crabs spend the bulk of their lives on the bay and ocean bottom but gather on bay beaches during the high tides of the full and new moons in May and June. Beach morphology (*i.e.* sediment type and grain size) affects oxygen, temperature and moisture gradients, which in turn, affect egg survivability. Horseshoe crabs appear to favor sandy beaches with a gentle slope (Botton and Loveland, 1987). In addition to the intertidal zone used for spawning, horseshoe crabs use the adjacent shallow waters and tidal flats as nursery habitat for juvenile life stages. Horseshoe crab eggs provide a critical food resource to migrating shorebirds, and are economically valued as bait for the American eel and conch fisheries, and in the manufacture of medical testing products.

4.4.3 Fish

The Delaware Estuary also supports over 200 fish species, both residents and migrants: freshwater species, freshwater species that occasionally enter brackish water; estuarine species that remain in the estuary their entire life cycle, anadromous and catadromous species passing through different salinity reaches of the estuary, marine species which regularly spend time in the estuary, marine species that utilize the estuary as a nursery and/or spawning area; and adventitious visitors of oceanic origin (ANSP, 1981). River herring (*Alosa* spp.) are anadromous species that live in the ocean but migrate upbay to spawn in freshwater reaches of the river. Some commercially and recreationally important fisheries include striped bass (*Morone saxatilis*), weakfish (*Cynoscion regalis*), summer flounder (*Paralichthys dentatus*), croaker (*Micropogonias undulates*), and menhaden (*Brevoortia tyrannis*)(McHugh, 1981).

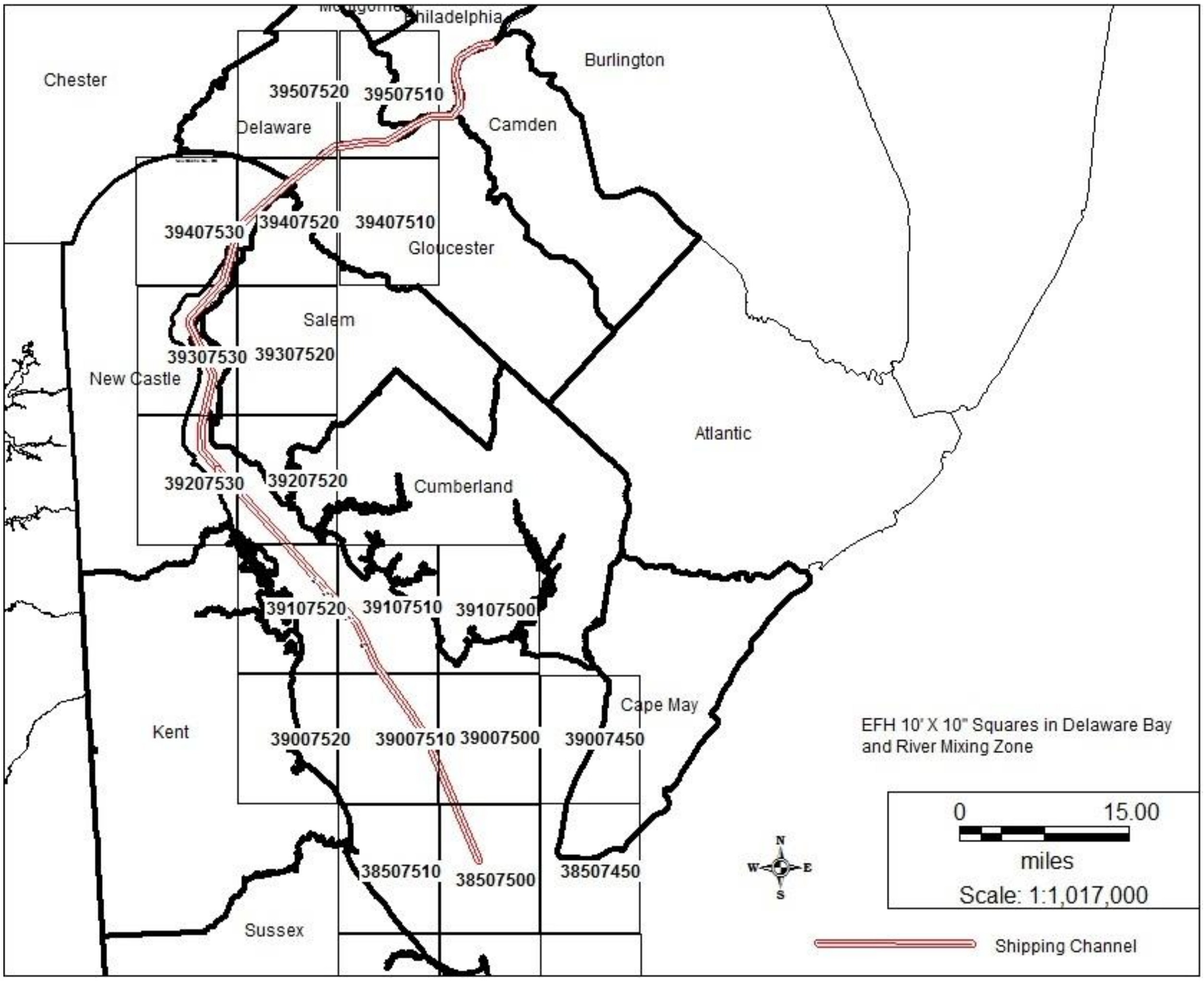
There are at least 31 species that are commercially harvested from the Delaware Estuary. Catadromous species, such as the American eel (*Anguilla rostrata*), spend their lives within the estuary, but migrate to the ocean to spawn. Species such as the spottail shiner (*Notropis hudsonius*) and the channel catfish (*Ictalurus punctatus*) are year-round residents of fresh and brackish waters and do not migrate to any significant degree to spawn. Species such as the Atlantic silverside (*Menidia menidia*) and bluefish (*Pomatomus saltatrix*) spend their lives in higher salinity waters and spawn in the bay. Atlantic menhaden (*Brevoortia tyrannus*) and the Atlantic croaker (*Micropogon undulates*) spawn offshore and use the bay as a nursery area.

Other notable fish inhabitants include several species of sharks skates, and rays including sand tiger (*Carcharias taurus*) and sandbar (*Carcharhinus* plumbeus) sharks, the cow-nosed stingray (*Rhinoptera* bonasus) and clear-nose skate (*Raja eglanteria*). The lower portion of the Delaware Bay has been designated as a Habitat Area of Particular Concern (HAPC) for sandbar shark. Pregnant females enter the bay between late spring and early summer, give birth and depart shortly after while neonates (young of the year) and juveniles (ages 1 and over) occupy nursery grounds until migration to warmer waters in the fall (Rechisky and Wetherbee, 2003). Neonates return to their natal grounds as juveniles and remain there during the summer. Tagging studies done by Merson and Pratt (2001) found that sandbar sharks use the southwestern portion of the bay as pupping grounds and the entire bay for summer feeding nursery area.

4.4.3.1 Essential Fish Habitat

Under provisions of the reauthorized Magnuson-Stevens Fishery Conservation and Management Act of 1996, the Delaware Estuary, spanning from the northern part of the state of Delaware south to the bay mouth, is designated as Essential Fish Habitat (EFH) for species with Fishery Management Plans (FMPs) and their important prey species. The area includes fifteen 10 minute x 10 minute squares. The map depicted in Figure 19 shows the locations within the Delaware Estuary that the National Marine Fisheries Service (NMFS) identifies as the mixing zone.

Figure 19 - Delaware Estuary Mixing Zone Essential Fish Habitat



The study area contains EFH for various life stages for 25 species of managed fish and shellfish. Table 19 presents the managed species and their life stage that EFH is identified for these fifteen 10 x 10 minute squares covering the potential affected area.

Table 19 - Summary of Essential Fish Habitat Designated Species & Their Life Stages

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Redfish (Sebastus fasciatus)	n/a				
Red Hake (Urophycis chuss)				X	

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Winter flounder (Pleuronectes americanus)	X	X	X	X	X
Windowpane flounder (Scopthalmus aquosus)	X	X	X	X	X
Atlantic sea herring *(Clupea harengus)*			X	X	
American plaice (Hippoglossoides platessoides)			X		
Bluefish (Pomatomus saltatrix)			X	X	
Long finned squid *(Loligo pealei)*	n/a	n/a			
Short finned squid *(Illex ilecebrosus)*	n/a	n/a			
Atlantic butterfish *(Peprilus tricanthus)*		X	X	X	
Summer flounder (Paralicthys dentatus)			X	X	
Scup (Stenotomus chrysops)			X	X	
Black sea bass (Centropristus striata)			X	X	
Surfclam (Spisula solidissima)	n/a	n/a			
Ocean quahog (Artica islandica)	n/a	n/a			
Spiny dogfish (Squalus acanthias)	n/a	n/a			
King mackerel (Scomberomorus cavalla)	X	X	X	X	
Spanish mackerel (Scomberomorus maculatus)	X	X	X	X	
Cobia (Rachycentron canadum)	X	X	X	X	

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Clearnose skate (*Raja eglantteria*)			X	X	
Little skate (Leucoraja erinacea)			X	X	
Winter skate (Leucoraja ocellata)			X	X	
Sand tiger shark (Carcharias taurus)		X neonates*		X	
Dusky shark (Carcharhinus obscurus)		X neonates*			
Sandbar shark (Carcharhinus plumbeus)		X neonates* (HAPC)	X (HAPC)	X (HAPC)	

Notes:

1.) N/A indicates species either have no data available on designated life stages, or those life stages are not present in the species reproductive cycle.
2.) Neonates* indicates sharks do not have a larval stage.

4.4.4 Wildlife

<u>Reptiles and Amphibians</u>. The American toad (*Bufo americanus*) and the leopard frog (*Rana pipens*) are amphibian residents of the study area. Reptiles include the common snapping turtle (*Chelydra serpentina)*, eastern garter snake (*Thamnophi sirtalis*), diamondback terrapin (*Malaclemys terrapin)* and smooth green snake (*Opheodrys vernalis*).

Across their range, diamondback terrapin (*Malaclemys terrapin)* populations are in decline (USFWS, 2016). The terrapin is native to New Jersey and inhabits coastal salt marshes of Delaware Bay and the Atlantic coast. New Jersey lists the diamondback terrapin as a species of concern, warranting special attention due to the evidence of decline. The USFWS lists the species as an Appendix II species under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The diamondback terrapin is the only North American turtle that lives exclusively in brackish waters associated with estuaries, coastal bays and salt marshes. Terrapins are heavily dependent on shoreline conditions to satisfy its habitat requirements. The terrapin spends most of its life in the water, but it must come ashore for nesting. Nesting normally occurs at bare or sparsely vegetated, unshaded, sandy areas above the level of the normal high tides (Palmer and Cordes, 1988; Roosenburg, 1990; Burger and Montevecchi, 1975). Nesting season extends from the beginning of June until the end of July, and terrapins often aggregate in the waters adjacent to the nesting beaches during the nesting season (Roosenburg, 1993).

The primary habitats of hatchlings and juveniles up to about the third year appear to be marshes and tidal flats (Roosenburg *et al.*, 2004; Draud *et al.*, 2004). At this stage, they avoid open water, but instead actively seek to hide under vegetation or debris in an apparent attempt to avoid being preyed upon (Lovich *et al.*, 1991; Burger, 1976; Pitler, 1985; Gibbons *et al.*, 2001). It appears necessary that such wetland habitat be located in proximity to the nesting sites, and most terrapin nesting studies have indeed reported the presence of adjacent marshes (Roosenburg 1991; Burger and Montevecchi, 1975; Feinberg and Burke, 2003; Butler *et al.*, 2004; Chambers, 2000; Szerlag and McRobert, 2006; Aresco, 1996).

<u>Birds</u>. Many species of birds common to the Delaware Estuary are inhabitants of the wetlands and tidewaters. Other species use wetlands and beaches during their migrations. The Delaware Estuary is situated on the Atlantic Flyway and an important migratory route for many species of shorebirds and waterfowl. Migratory shorebirds such as the ruddy turnstone (*Arenaria interpres*), short-billed dowitcher (*Limnodromus griseus*), semi-palmated sandpiper (*Calidris pussilla*), sanderlings (*Calidris alba*), and the imperiled red knot (*Calidrus canutus*) fly from southern Argentina each spring and stop at the Delaware Bay to rest and feed on amphipods, chironomids, and horseshoe crabs (Chipley *et al*., 2003). The total number of shorebirds counted in aerial surveys in Delaware Bay over a 6-week migration period from May to mid-June range from 250,000 to more than 1,000,000 birds. Birds observed in tidal marsh habitats are estimated at 700,000.

Neotropical songbirds also migrate in and out of the project area in the spring and fall. Species observed in 1990 included the red-bellied woodpecker (*Centurus carolinus*), blue jay (*Cyanocitta cristata*), tree swallow (*Iridoprocne bicolor*), versper sparrow (*Pooecetes gramineus*), American robin (*Turdus migratorius*) and eastern bluebird (*Sialia sialis*). Other species known to inhabit the area are the savannah sparrow (*Passerculus sandwichensis*), song sparrow (*Melospiza melodia*), mourning dove (*Zenaida macroura*), gray catbird (*Dumetella carolinensis*), northern mockingbird (*Mimus polyglottos*), redwinged blackbird (*Agelaius phoenicues*) and brown thrasher (*Toxostoma rufum*). Many of these birds remain to breed in the vast woodlands along the coast. The geographical location and the healthy, expansive upland edge of the wetlands of the lower estuary provide critical resting and feeding opportunities to neotropical migrants.

Waterfowl common to the area include mallard (*Anas platyrhynchos*), American black duck (*Anas rubripes*), northern pintail (*Anas acuta*), and wood duck (*Aix sponsa*). Canada geese (*Branta Canadensis*) and snow geese (*Chen caerulescens*) frequent the region during fall, winter, and spring. Saltmarshes are frequented by clapper rail (*Rallus longirostris*), seaside sparrow (*Ammodramus maritimus*), saltmarsh sparrow (*Ammodramus caudacutus*), redwinged blackbird (Agelaius phoeniceus)and willet (*Tringa* *semipalmata*). Wading bird species common to the area include the snowy egret (*Leucophoyx thula*), glossy ibis (*Plegadis falcinellus*), and great blue heron (*Ardea herodias*). Over a dozen raptors reside or migrate through the study area, such as the red-tailed hawk (*Buteo lineatus*), broad-winged hawk (*Buteo platypterus*), northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), osprey (*Pandion haliaetus*) and sharp-shinned hawk (*Accipiter striatus*). Typical owls include the barn owl (*Tyto alba*), great horned owl (*Bubo virginianus*) and long-eared owl (*Asio otus*).

Mammals. Many species of mammals inhabit the shoreline, tidal marshes and interior shrubland and forests. Common to the study area are white tail deer (*Odocoileus viiginianus*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*), striped skunk (*Mephitis mephitis*), river otter (*Lutra canadensis*), muskrat (*Ondatra zibethicus*), gray squirrel (*Sciurus carolinensis*), eastern chipmunk (*Tamia striatus*), eastern cottontail (Sylvilagus floridanus), Virginia opossum (Didelphis virginiana), white-footed mouse (*Peromyscus leucopus*), meadow vole (*Microtus pennsylvanicus*), and marsh rice rat (*Oryzomys palustris*).

4.4.5 Threatened and Endangered Species

Endangered species are those whose prospects for survival are in immediate danger because of a loss or change of habitat, over-exploitation, predation, competition or disease. Threatened species are those that may become endangered if conditions surrounding the species begin or continue to deteriorate. Species may be classified on a Federal or State basis. The USACE Philadelphia District coordinates with the USFWS and the NMFS regarding Federally-listed threatened and endangered species in the study area. Extensive bayshore shorelines, adjacent marshes and woodlands, and shallow and deep water habitats are prevalent within the study area, and provide habitat for several endangered and threatened animal species.

The Delaware Estuary is within the historic range of 22 Federally-listed threatened or endangered species: 17 animals and 5 plants (Table 20).

Table 20 - Delaware Estuary Threatened & Endangered Species

Status	Species
T	Bat, Northern long-eared (*Myotis septentrionalis*)
E	Piping Plover (*Charadrius melodus*)
T	Knot, red (*Calidris canutus rufa*)
T	Sea turtle, green: except where endangered (*Chelonia mydas*)
E	Sea turtle, hawksbill Entire (*Eretmochelys imbricata*)
E	Sea turtle, Kemp's ridley Entire (*Lepidochelys kempii*)
E	Sea turtle, leatherback Entire (*Dermochelys coriacea*)
E	Loggerhead Turtle (*Caretta caretta*)
E	Squirrel, Delmarva Peninsula fox Entire, except Sussex Co (*Sciurus niger cinereus*)
E	Sturgeon, shortnose Entire (*Acipenser brevirostrum*)
E	Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)
T	Turtle, bog (=Muhlenberg) northern (*Clemmys muhlenbergii*)
E	Whale, fin Entire (*Balaenoptera physalus*)
E	Whale, humpback Entire (*Megaptera novaeangliae*)
E	Whale, North Atlantic Right Entire (*Eubalaena glacialis*)
E	Sei Whale (*Balaenoptera borealis*)
E	Sperm Whale (*Physeter macrocephalus*)
T	Amaranth, seabeach (*Amaranthus pumilus*)
T	Beaked-rush, Knieskern's (*Rhynchospora knieskernii*)
E	Dropwort, Canby's (*Oxypolis canbyi*)
T	Pink, swamp (*Helonias bullata*)
T	Pogonia, small whorled (*Isotria medeoloides*)

On May 4, 2015, the USFWS designated the northern long-eared bat (*Myotis septentrionalis*) as a threatened species under the Endangered Species Act (ESA). In more recent years, the Federally-listed and State-listed endangered piping plover (*Charadrius melodus*) have been occasionally sited on sandy beaches of the lower bay but is not known to have nested along the bayshore. The Service proposed in 2006 to list the *rufa* subspecies of the red knot (*Calidris canutus rufa*) due to the high magnitude of imminent threats to the subspecies, and as of September 2013 the Service listed the red knot as a threatened species throughout its range, including New Jersey.

Piping plover. Outside of the study area, the oceanfront beaches of New Jersey support small breeding populations of the Federally threatened piping plover (*Charadrius melodus*). There are currently no known nesting areas on the Delaware Bay coastline. Cape May County possesses suitable habitat for breeding piping plovers but no nests have been observed at the NJDEP Fish and Wildlife observation stations closest to the proposed project since 2013: Cape May National Wildlife Refuge, Two-Mile Beach, the Coast Guard Loran Support Unit (Wildwood), Coast Guard Training Center (Cape May), Cape May City, Cape May Meadows, the Nature Conservancy refuge and Cape May Point State Park.

The Atlantic coast piping plover breeding population nests on wide, flat, sparsely vegetated barrier beach habitats. These habitats include abundant moist sediment areas that are associated with dune blowouts, washover areas, sand spits, unstable and recently closed inlets, ephemeral pools and sparsely vegetated dunes. Locations suitable for breeding are also limited because these ground nesting birds are especially sensitive to human-related disturbance and predation. In New Jersey the birds begin arriving in mid-March to set up territories and perform courtship behavior. Egg laying begins mid-April. The birds may re-nest one or more times if their nest is lost prior to hatching. Hatching takes place from mid-May to mid-July. Generally, the young would be completely fledged by September 1 and often earlier in July or August. Piping plover chicks are somewhat unusual in that they must leave the nest shortly after hatching in order to begin foraging for food. Since the chicks are flightless, suitable feeding areas must be located within a reasonable walking distance of the nest site. Feeding areas include the wet portion of the beach, wrack lines, moist washover areas, and shorelines and flats associated with coastal lagoons and ponds. If the vegetation is too dense, the chicks may be deterred from reaching the feeding areas. The wave overwash that occurs during storms can be beneficial by creating low moist feeding areas and by keeping the vegetation from becoming too dense (USFWS, 2016).

Red Knot. The Delaware Bay shoreline is known to be a major stopover site for the Federally threatened red knot, during their northward migration in the spring. The red knots perform an unusually long distance migration from their primary wintering areas in southern South America to their breeding areas in the Canadian Arctic. While the red knots normally feed primarily on small bivalves, their spring migration has evolved so that the Delaware Bay area has become their primary stopover location due to the extraordinary abundance of horseshoe crab eggs. The eggs are considered to be a key factor that allows red knots to gain sufficient body condition to complete the migration and accomplish their breeding activity. The reduced availability of horseshoe crab eggs at the Delaware Bay stopover due to commercial harvest of the crabs is believed to have been a primary cause for the decline of the red knot population that was observed in the early 2000s.

Cape May National Wildlife Refuge has a five-mile stretch along the Delaware Bay that serves as a major resting and feeding area for migratory shorebirds. The bayshore is second only to the Cooper River Delta in Alaska as a major shorebird staging area in North America. In addition to the threatened red knot, the arrival of more than 20 shorebird species coincides with the horseshoe crab spawning season in May and early June. Most of their time is spent feeding on horseshoe crab eggs which are available on the intertidal beaches, although they also make comparatively limited use of the exposed mud flats and pans within the adjacent marshes and impoundments for roosting. Red knots are relatively uncommon along Delaware Bay during the southward fall migration, which peaks in August (USFWS, 2016).

Sea turtles. There are five Federally-listed threatened or endangered sea turtles that occasionally enter the Delaware Estuary including the endangered Kemp's ridley turtle (*Lepidochelys kempii*), leatherback turtle (*Dermochelys coriacea*) and hawksbill turtle (*Eretmochelys imbricata*), and the threatened green turtle (*Chelonia mydas*) and loggerhead turtle *(Caretta caretta*). With the exception of the loggerhead these species breed further south from Florida through the Caribbean and the Gulf of Mexico. The loggerhead may have historically nested on coastal barrier beaches. No known nesting sites are within the project area.

Whales. There are six species of Federally-endangered whales that have been observed along the Atlantic coast that, on occasion, have traveled into the Delaware Bay. These include the sperm whale (*Physeter catodon*), fin whale (*Balaenoptera physalus*), humpback whale (*Megapter novaeangliae*), blue whale (*Balaenoptera musculus*), sei whale (*Balaenoptera borealis*) and North Atlantic right whale (*Balaena glacialis*). These are migratory animals that travel north and south along the Atlantic coast. All six species are also listed by the state of New Jersey.

Shortnose sturgeon. The shortnose sturgeon (*Acipenser bevirostrum*) is a Federally-listed endangered species, and occurs primarily in the upriver freshwater portion of the Delaware Estuary. Interbasin movements have been documented for shortnose sturgeon between the Delaware River and Chesapeake Bay via the C&D Canal (NMFS, 2011).

Atlantic sturgeon. In 2010, NMFS proposed to list three Distinct Population Segments (DPSs) of the Atlantic sturgeon (*Acipenser oxyrhinchus oxyrinchus*) in the Northeast Region. The New York Bight DPS, which includes Atlantic sturgeon whose range extends into coastal waters of Long Island, the New York Bight, and the Delaware Bay, from Chatham, MA to the Delaware-Maryland border of Fenwick Island, as well as wherever these fish occur in coastal bays, estuaries, and the marine environment from the Bay of Fundy, Canada to the Saint Johns River, FL. In 2012, NMFS issued rulings listing five DPS of Atlantic sturgeon as threatened or endangered under the ESA. All five of these DPS may occur within waters of the Delaware Bay. Atlantic sturgeon are anadromous, spending a majority of their adult life phase in marine waters, migrating upriver to spawn in freshwater reaches of the Delaware River, then migrating to lower estuarine brackish areas during juvenile growth phases. Adults migrate along the ocean coast of New Jersey and Delaware.

In addition to the Atlantic and shortnose sturgeons, sea turtles, and whales, the NMFS has jurisdiction over other listed species that are more likely to occur in the lower reaches of the estuary. Some marine mammals may be classified as threatened or endangered species, but all fall under the jurisdiction of the Marine Mammal Protection Act. The marine mammal species that are commonly encountered in the Delaware Estuary are bottlenose dolphin (*Tursiops truncatus*), harbor porpoise (*Phocoena phocoena*), harbor seal (*Phoca vitulina concolor*), and gray seal (*Halichooerus grypus*). Additional species not commonly sighted but which may incidentally utilize the estuary are pygmy sperm whale (*Kogia breviceps*), long-finned pilot whale (*Globicephala melaena*), harp seal (*Cystophora cristata*), and ringed seal (*Poca hispida*).

Raptors. Although the bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco* peregrines) have been recently removed from the Federal endangered species list, these raptors do occur in the project area. The bald eagle is still protected under the Bald and Golden Eagle Protection Act (BGEPA) and both birds are protected under the Migratory Bird Treaty Act (MBTA).

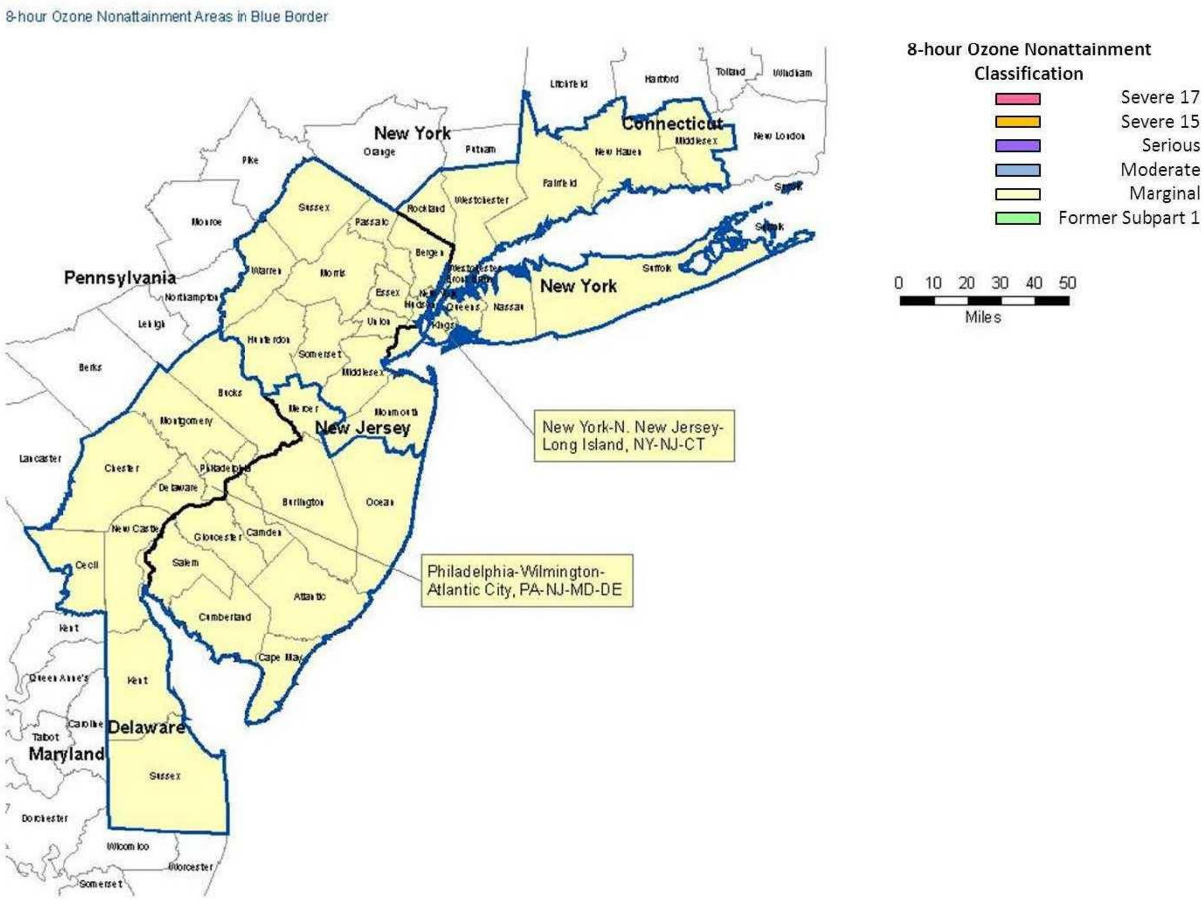
A list of state threatened and endangered species of New Jersey can be accessed at www.nj.gov/dep/fgw/tandespp.htm.

4.5 AIR QUALITY

Ambient air quality is monitored by the NJDEP Division of Air Quality and is compared to the National Ambient Air Quality Standards (NAAQS) throughout the state, pursuant to the Clean Air Act of 1970. Six principal "criteria" pollutants are part of this monitoring program, which include ozone (O3), carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), particulate matter (PM10 and PM 2.5), and lead (Pb). Sources of air pollution are broken into stationary and mobile categories. Stationary sources include power plants that burn fossil fuels, factories, boilers, furnaces, manufacturing plants, gasoline dispensing facilities, and other industrial facilities. Mobile sources include vehicles such as cars, trucks, boats, and aircraft. New Jersey air quality data from air monitoring sites can be accessed from www.njaqinow.net/. New Jersey air quality has improved significantly over the past 40 years, but exceeds the current standards for ozone throughout the state and for fine particles in urban areas. With the exception of Warren County, outside of the project study area, New Jersey has attained the sulfur dioxide, lead and nitrogen dioxide standards.

The Clean Air Act requires that all areas of the country be evaluated and then classified as attainment or non-attainment areas for each of the National Ambient Air Quality Standards. Areas can also be found to be “unclassifiable” under certain circumstances. The 1990 amendments to the act required that areas be further classified based on the severity of non-attainment. The classifications range from “Marginal” to “Extreme” and are based on “design values”. The design value is the value that actually determines whether an area meets the standard. For the 8-hour ozone standard for example, the design value is the average of the fourth highest daily maximum 8-hour average concentration recorded each year for three years. Their classification with respect to the 8-hour standard is shown in Figure 12. Ground-level ozone is created when nitrogen oxides (NOx) and volatile organic compounds (VOC’s) react in the presence of sunlight. NOx is primarily emitted by motor vehicles, power plants, and other sources of combustion. VOC’s are emitted from sources such as motor vehicles, chemical plants, factories, consumer and commercial products, and even natural sources such as trees. Ozone and the pollutants that form ozone (precursor pollutants) can also be transported into an area from sources hundreds of miles upwind. The project area is located within the 8-hour Ozone Nonattainment area shown in Figure 20. The entire state of New Jersey is in non-attainment and is classified as being “Marginal.”

Figure 20 - Non-Attainment Areas for Ozone



Greenhouse gases (GHG) trap heat in the atmosphere. Carbon dioxide is the most abundant GHG and enters the atmosphere through burning fossil fuels (coal, natural gas and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g. manufacture of cement). Carbon dioxide is removed from the atmosphere (or “sequestered”) when it is absorbed by plants as part of the biological carbon cycle. Methane is emitted during the production and transport of coal, natural gas and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills. Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substance (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons) (USEPA, 2016).

The largest source of GHG emissions from human activities in the United States is from burning fossil fuels for electricity, heat and transportation. The USEPA tracks total U.S. emissions and reports the total national GHG emissions and removals associated with human activities.

4.6 NOISE

Noise is of environmental concern because it can cause annoyance and adverse health effects to humans and animals. Communities adjacent to the Delaware Estuary shoreline are more extensively developed in the upper portion of the estuary along the Delaware River, primarily as residential and commercial properties. Noise in this area is mostly due to traffic along inland main road corridors. Vehicle traffic is minimal in the smaller bayshore communities, and more frequent in the larger bayshore communities such as Villas and Cape May Point. In the bay region of the estuary, roads are located further inland and noise generated is significantly less. Route 47 is the main road, a two-lane state road that traverses inland 75 miles from Camden County south through rural areas of Cumberland County and ends at Wildwood in Cape May County.

4.7 VISUAL AND AESTHETIC VALUES

Aesthetics refer to the sensory quality of the resources (sight, sound, smell, taste and touch) and especially with respect to judgment about their pleasurable qualities (Canter, 1993; Smardon *et al*., 1986). The aesthetic quality of the study area is influenced by the natural and developed environment. Aesthetic values are high in the study area due to the predominance of expansive salt marshes, open water, beaches and the presence of Delaware Bay maritime communities consisting of fishing boats, docks and related facilities. The presence of dilapidated structures damaged from erosion, flooding and damaged revetments along the shoreline may detract from the high aesthetic value of the area.

4.8 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

The PDT contracted with Environmental Data Resources, Inc. (EDR) to produce environmental database, mapping and aerial photograph searches for the proposed dredged material placement areas. Database searches were conducted for reports within a one mile radius of addresses located in the approximate centers of the proposed dredged material placement areas. Each notation for each database find was reviewed to determine which were considered closed by appropriate authority. In cases where the review was inconclusive, the result was considered to be open. The United States Geological Survey, public and private wells were considered to be open. Each remaining address for the database searches was then reviewed for distance from the beachfill area, up or downgradient of the beachfill area, and potential for impact to the planned nourishment of the beaches by pumping.

Facilities with potential HTRW impacts located within approximately ¼ mile of each dredged material placement location were subjected to further case review and evaluation for potential impacts to the proposed beachfill projects. No reported facilities were found to have the potential to adversely affect the proposed beachfill projects. The USACE project team has elected to have EDR continue to monitor the selected locations and EDR will provide updates electronically should any new environmental records become available.

4.9 CULTURAL RESOURCES

Background research shows no recorded historic properties eligible for or listed on the National Register of Historic Places (NRHP) within the area of potential effect (APE) for Gandys Beach and Fortescue.

There have been no archaeological field investigations conducted in the project areas; however, there have been several comprehensive studies that suggest that the beach area has moderate potential for significant archaeological resources at either Gandys Beach or Fortescue.

There have been no historic structures analyses conducted in the project areas; however, given the history of the region with early settlers who farmed salt hay, there is moderate potential for historic structures potentially eligible for the NRHP to exist within the project area. Preservation New Jersey named the village of Fortescue as one of the ten most endangered historic sites in New Jersey in 2014, even after the damage caused by Hurricane Sandy.

Background research for the APE for Villas shows that there are identified archaeological sites on the north and south extents of the project area. This indicates, as well as other comprehensive studies previously conducted, that the beach area at The Villas has a moderate to high potential for significant archaeological resources. Research has also found previously recorded historic structures that are eligible for or listed on the NRHP. The Judge Nathanial Foster house is listed on the NRHP, and 8 structures have been determined to be eligible for listing along Bayshore Drive.

4.10 SOCIOECONOMIC

New Jersey is the fourth smallest state but the most densely populated of the United States. Industry such as pharmaceuticals, chemical, telecommunications, shipping and food processing predominate the northern central portion of the state while in the proposed project area of southern New Jersey, tourism has developed into the dominant industry. Colloquially, South Jersey refers to the area in New Jersey within the influence of the Philadelphia metropolitan area, in contrast to the rest of New Jersey, located within the New York metropolitan area. South Jersey is a peninsula with residential communities, farmland, wetlands and the Pine Barrens.

The Delaware Estuary provides numerous economic benefits to the region. The Delaware River Port Complex (including docking facilities in Pennsylvania, New Jersey and Delaware) is the largest freshwater port in the world. According to testimony submitted to the U.S. House of Representatives subcommittee in 2005, the port complex generates $19 billion in annual economic activity. It is one of only 14 strategic ports in the nation transporting military supplies and equipment by vessel to support our troops overseas. The Delaware River and Bay are home to the third largest petrochemical port as well as five of the largest east coast refineries. Nearly 42 million gallons of crude oil are moved on the Delaware River on a daily basis. There are approximately 3,000 deep draft vessel arrivals each year and it is the largest receiving port in the United States for very large crude carriers (tank ships greater than 125,000 deadweight tons). It is the largest North American port for steel, paper and meat imports as well as the largest number of cocoa beans and fruit on the east coast. Over 65% of Chilean and other South American fruits imported into the United States arrive at terminal facilities in the tri-state port complex. Wilmington, Delaware is home to the largest U.S. banana importing port, handling over one million tons of this cargo annually from Central America. According to Rear Admiral Sally Brice-O'Hara, District Commander of the Fifth Coast Guard District, "The port is critical not only to the region, but also to the nation" (Kaufman, 2011).

Wetlands are ecologically and economically valuable to the state. Cranberry growing is a significant industry in New Jersey, as it is the third largest producer in the United States. There are more than 3,600 acres of cranberry bog wetlands in New Jersey. Fishing and aquaculture contribute $1 billion annually to the state's economy. Commercial fishing includes over 100 species of fish and shellfish, such as scallops, surf clams, blue crabs and herring. Hard clams and oysters account for the majority of the aquaculture.

The upper region of the Delaware Bay has large oyster beds that are stock-assessed by the Rutgers University Haskin Shellfish Research Laboratory for the state to manage a controlled fishery. Oysters have also been a valuable food source and part of the mid-Atlantic's cultural history for centuries. The New Jersey fishery for *C. virginica* landed an estimated 94,470 bushels of oysters in 2011, worth approximately 4.2 million in dockside value (Powell *et al.*, 2012).

Numerous seaside resorts and small towns are located along the New Jersey bayshore. In between and interior to these beach towns are tens of thousands of acres of tidal marshes, upland forests and undeveloped beaches. Tourism is growing along New Jersey's Delaware Bay shores as residents and visitors seek out the quieter, less developed coastal areas west of the Atlantic Ocean beaches. Primary interests include wildlife viewing, water recreation and special events or festivals (Schuster, 2016).

Environmental Justice. In accordance with Executive Order 12989 dated February 11, 1994 (Environmental Justice in Minority Populations), a review was conducted of the populations within the affected areas. The U.S. Environmental Protection Agency (USEPA) definition for Environmental Justice is: "the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies." The United States Census Bureau estimates the population of New Jersey to be 8,958,013 (2015) and comprised of 68.6% Caucasian, 13.7% African American, 8.3% Asian American and 9.4% other races. Hispanic or Latino members of the population (of any race) comprise 17.7% of the population. New Jersey is identified as one of the most ethnically diverse states in the country. The majority of the population resides in the counties surrounding New York City, Philadelphia and the eastern Jersey shore. The more southern and northwestern counties are less densely populated. Although New Jersey is the second wealthiest state (Lynn and Sheingold, 2015), more New Jersey residents are in poverty now than in the past 5 decades. Poverty rates remain disproportionately higher for blacks and Hispanics and the official poverty level is highest in Cumberland County. Low wage occupations employ proportionately far more workers in New Jersey but bring home a proportionately lower share of the state's total earnings. Average household income has declined by more for the lower income groups than the higher income groups over the period 2007 – 2014 (Legal Services of New Jersey, 2015).

5 EFFECTS ON SIGNIFICANT RESOURCES*

This section evaluates impacts that may occur as a result of the CSRM alternative plans, including the TSP. Impacts resulting from the O&M dredging activities (that will serve as the CSRM dredged material source) are fully evaluated in several NEPA documents specifically for the Delaware River Main Stem

Navigation Channel (see Section 1.5), and in the interest of brevity, are incorporated by reference instead of being presented in this report. In addition to the No Action Plan, viable alternatives considered during the alternative analysis included the Levee/Dike Plan, the Beach Restoration and the Beach Restoration with Groin(s) Plan.

5.1 PHYSICAL ENVIRONMENT

5.1.1 Land Use

The communities along the Delaware Estuary shoreline have a long history of economic activity provided by the waterway. The Delaware River continues to serve as a principal corridor for commerce as well as a major strategic port for national defense. The economies of the towns have changed over the years from ship building and oyster harvesting to primarily fishing, crabbing and tourism. The Delaware Estuary shoreline communities have changed from rural farmsteads to seasonal vacation destinations and year-round residential communities in the larger towns. The NJDEP, in partnership with private and Federal natural resource organizations, promotes the preservation of natural resources surrounding the communities along the bayshore and strives to increase the ecotourism to support these communities. In addition, the National Fish and Wildlife Foundation (NFWF) is initiating studies within the Delaware Bay region in support of programs and projects that will improve resilience by reducing communities' vulnerability to coastal storms, SLC and flooding events by strengthening natural ecosystems and the fish and wildlife habitat they provide.

The No Action Plan does not provide CSRM and will allow for continued erosional impacts and coastal storm risk to infrastructure. Levees and dikes are embankments of sediments to raise elevation in a linear fashion paralleling a water body and reduce flooding for the lands behind the structure. The Levee/Dike Plan was evaluated at 6 locations in the study area (Penns Grove/Carneys Point, Pennsville, Maurice River Township, Bivalve, Shellpile and Port Norris). This alternative was eliminated based on the grain size incompatibility of the source material and the cost of augmenting the material to meet USACE levee construction criteria.

The action alternatives entailing beach restoration would provide beneficial effects by establishing an added buffer beach to provide protection to upland infrastructure and populations against storms and flooding. Sand nourishment also creates additional habitat for beach flora and fauna, added inundation protection to interior wetlands and more opportunities for recreational activities. The TSP entails beach restoration at Villas, but also includes restoration of an existing terminal groin at Fortescue and construction of a new terminal groin at Gandys Beach. The terminal groin restoration/construction is intended to enhance the performance and longevity of the beach restoration project by reducing end losses. The addition of a groin to a beach nourishment plan is typical in areas where relatively higher beach erosion rates and losses occur. The TSP to provide CSRM with beach restoration will help the shoreline communities be resilient against future storms and help provide economic sustainability, recreational use and natural habitat restoration.

Generally, the proposed project would likely produce more favorable economic conditions than exist at present, although construction operations will produce some minor adverse effects on land use. These effects would primarily be temporary in nature, and land uses would continue as they had been under pre-construction conditions after placement operations and construction.

5.1.2 Physiography and Geology

Erosion and flooding are the primary coastal hazards that adversely impact the estuarine shoreline. Under the No Action Plan, tidal action and storms will continue to erode the shoreline, exposing the underlying peat and reducing available sandy beach habitat for wildlife and CSRM for developed stretches. A loss of barrier beach can also result in flood inundation to interior salt marshes, forests and neighboring farmland.

Stockton University's Coastal Research Center (CRC) conducts surveys at 31 sites along the Atlantic Ocean and Delaware Bay beaches of Cape May County as part of their Beach Profile Network (NJBPN). Four of these are located along the Delaware Bay shore: Reeds Beach in Middle Township, Villas in Lower Township, North Cape May in Lower Township and at the Higbee Beach State Park (Farrell *et al.*, 2016). The CRC conducted post-Hurricane Sandy surveys on 12 and 26 November 2012 (Hurricane Sandy made landfall on 29 October 2012) to evaluate severe beach erosion. Researchers compared shoreline and beach volume changes of the post-storm surveys with surveys taken at the same NJBPN pre-storm monitoring sites (19 October 2012). Between Reeds Beach and Cape May Point, the storm surge flooded the Delaware Bay with 4-foot waves. High water levels and waves pounded dunes and inundated low-lying areas with loss of some structures. Reeds Beach was hit hard due to the absence of a bluff and minimal dune system. Sand was pushed across the service road to Bidwell Creek and inland onto the salt marshes.

To the south, the bluff and sand dunes serve as a barrier. Some erosion of the dune occurred and moved the zero elevation position towards the bay. The berm/dune slope was reduced in gradient allowing sand to deposit on the terrace that extends over 1,000 feet into the bay from Villas to North Cape May. This wide terrace is the geological result of long, slow erosion of the bluff by bay waves. Higbee Beach is a natural area and suffered minimal bluff erosion and beach retreat (Farrell *et al.*, 2016).

Alternative plans that include a hardened structure (such as a groin) perpendicular to the beach will not impact the area geology, buy may alter the physiography of the beach. Groins deflect alongshore currents resulting in greater accumulation of transported sediments on the updrift side. Groins impede longshore sand transport, which may provide a benefit to navigation when positioned adjacent to inlets and may also provide additional CSRM for structures located on the updrift side of the groin. Erosion and extreme weather events will continue to be the primary drivers of flooding events.

The TSP involves the restoration of the berm and dune system at Villas fronting the developed sections of the bayshore to provide CSRM. The construction of terminal groins at two of the beaches (Gandys Beach and Fortescue) will provide added protection from erosion by restricting longshore transport from carrying sediments northwest, particularly at Fortescue where a hardened structure currently exists at the mouth of the inlet to reduce infilling. Beach nourishment restores the natural physiography and habitat that existed along the shoreline fronting these communities. In addition, beach nourishment using compatible grain size materials does not adversely impact the geology of the study area.

5.1.3 Sediment Quality

Delaware Estuary sediment quality is described in the 1992 EIS (USACE, 1992), 1997 SEIS (USACE, 1997), the 2009 EA (USACE, 2009), the 2011 EA (USACE, 2011) and the 2013 EA (USACE, 2013) for the MCD project. This information is incorporated by reference.

The 1997 SEIS (USACE, 1997) sediment quality data included bulk sediment analysis, elutriate sediment analysis, Toxicity Characteristic Leaching Procedure (TCLP) analysis, biological effects based sediment testing and high resolution PCB congener analysis for the MCD project. Based on a review by the EPA, the tests showed no toxicity or bioaccumulation of any significance. The USFWS commented that the results of the chemical analysis indicated that contaminated loads in the sediments tested are low. These chemical analyses investigated sediments extending approximately 102.5 river miles from Philadelphia to the mouth of the Delaware Bay. Chemical contaminants are more likely to occur in the upper reaches of the estuary where smaller grain size sediments are found (chemical constituents bind to smaller grain size sediments) than in the lower reaches of the Delaware Bay where the proposed beneficial use sediments occur.

This feasibility report focuses on sediment quality data for the Main Channel from the Miah Maull and Brandywine Ranges within lower Reach E only (the proposed maintenance dredged material source area for the TSP). The 1998 Inland Testing Manual (EPA-823-B-98-004) provides national guidance on the evaluation of dredged material under the Clean Water Act. It states that no chemical analysis is required if there is a "*reasonable assurance that the proposed discharge material is not a carrier of contaminants…For example, dredged material is most likely to be free of contaminants if the material is composed primarily of sand, gravel or other inert material and is found in areas of high current of wave energy [230.60(a)].*" For the MCD project, the sediments tested within this ranges exhibited large grain sizes and no contaminants were detected in these samples. The sediment grain size samples obtained in 2008 as part of the Delaware Estuary Program DEBI (Delaware Estuary Benthic Inventory) indicated that the percent sand in Lower Reach E was 81-100%.

Prior to the deepening operations in 2015, sediment grain size data for Reach E bottom sediments collected by USACE between 1991 and 2013 (176) samples were re-evaluated to identify the sub-reaches where economic loading would be permitted during dredging. Economic loading refers to the practice of filling a hopper dredge beyond overflow to achieve a higher density load (discussed in greater detail in Section 5.2.2). The 2013 EA (USACE, 2013) considered both the environmental effects of economic loading (*i.e.* turbidity) and the economic benefits and concluded that economic loading could be conducted in Delaware Bay with minimal adverse environmental impacts and significant economic benefits.

As indicated on Figure 21, Reach E was divided into 9 subsections. For sub-Reach E-7 through E-9 (the Miah Maull and Brandywine Ranges), the weighted average for coarse-grained material was estimated to be approximately 93 percent, with a confidence interval of 90 percent that another sample collected within E-7 through E-9 would be between 90 and 95 percent coarse grained material. Coarse grained material is defined as the portion of the sample that includes sand (passing the #4 to #200 screen) and gravel (passing the #3 to #4 screen) (USACE, 2013).

For the No Action Alternative, future maintenance dredging sand from Lower Reach E will be placed at Buoy 10 open water disposal site for approximately 10 more years. Beyond this, dredging sand from Lower Reach E will be placed at Artificial Island CDF, per the Federal Standard for the least-cost, environmentally acceptable disposal location. Although this is the least-cost method of disposing maintenance dredging material from lower Reach E, there is no significant economic or environmental benefit from this practice. Continued erosion of the beach and dune system will result in exposure of the underlying peat and clay layers.

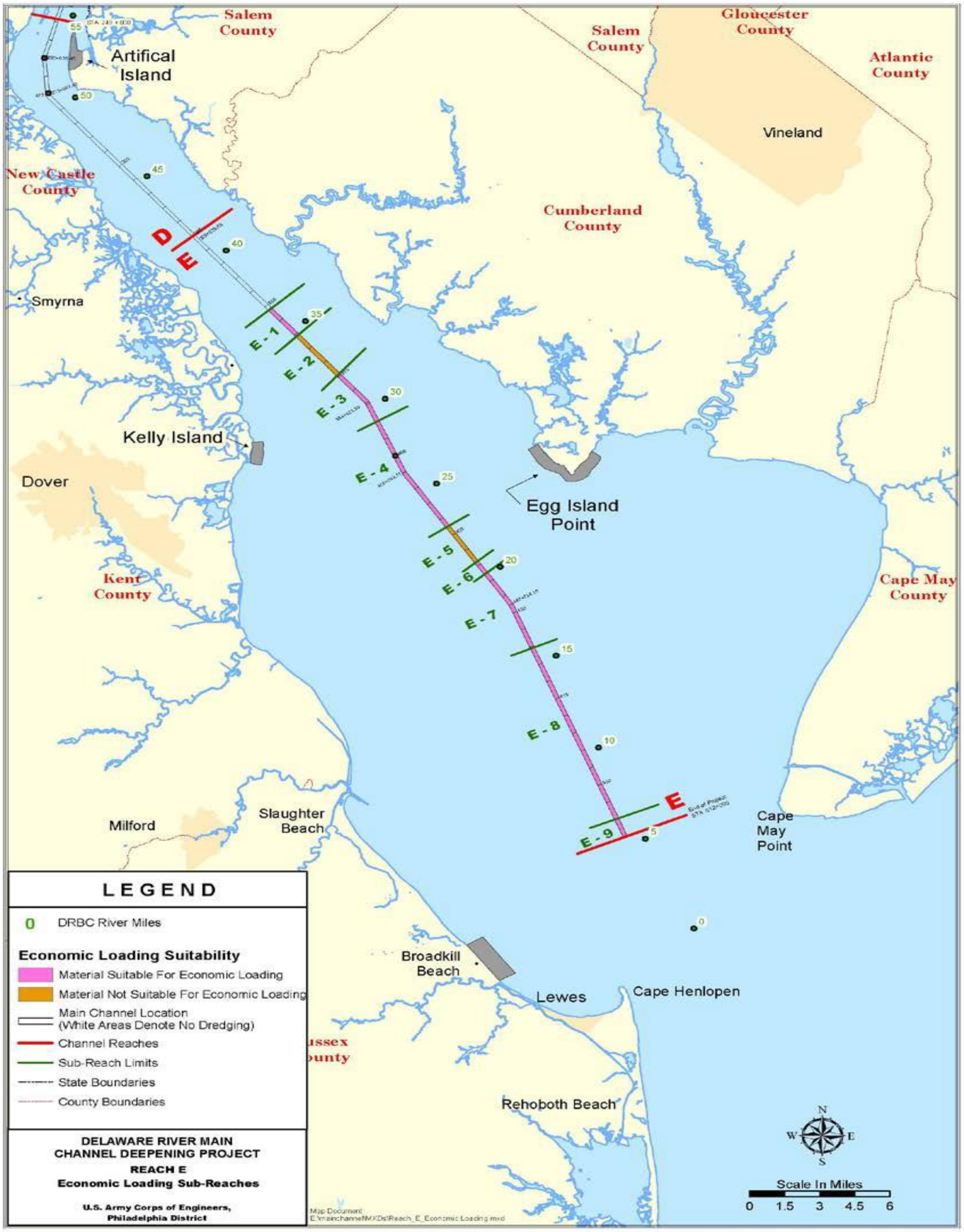
Sediments are a critical component of the estuarine system as they constitute the substrate for most hydraulic, geochemical and biogenic processes that affect the overall "health" of the estuary. The estuary acts as a sink for sediments eroded from the watershed above the head of tide. The most seaward portion of the estuary (the bay) is also a sink for sandy sediment transported in from the ocean primarily by tidal hydraulic processes.

The latest published sediment budget for the Delaware Estuary indicates that the bed of the estuary has eroded at a rate that exceeds the average annual rate at which new sediment is supplied from the watershed (*i.e.* upland fluvial input). Additionally, maintenance dredging coupled with disposal at CDFs is the principal mechanism by which sediment is removed from the estuary. Decreasing dredged quantities from the main channel over time (1937 – 2009) are indicative of this imbalance (Gebert and Searfoss, 2012).

Beach nourishment is not expected to impact sediment quality. Grain size of the source material is similar to that which occurs on the proposed placement beaches and materials with large grains sizes (>90% sand) do not require chemical analysis for contamination.

Under the TSP, the use of sand dredged from lower Reach E for beach nourishment will provide a tangible economic benefit (*i.e.* CSRM benefit) to the study area shoreline while restoring the sediments typical of a healthy sandy beach shoreline. The addition of rehabilitating the groin at the northernmost end of Fortescue and adding a new groin at Gandys Beach may impact sediment quality on the downdrift side of the groin by reducing deposition and potentially exacerbating erosion through the interference of longshore sediment transport, thereby exposing underlying peat and clay layers. The updrift side of the groin will receive increased deposition, thereby increasing the width of the beach fronting the community.

Figure 21 - Reach E Sub-Reaches



5.1.4 Climate and Climate Change

The U.S. Climate Change Science Program (USCCSP, 2009) evaluated coastal sensitivity to SLC and climate change scenarios, with a focus on the mid-Atlantic region. Sea level trends are recorded by tide stations, which measure the height of the water relative to a known land elevation (benchmark). The long-term tide gauge data recorded during the past century shows an average global sea level rise of approximately 1-2 mm/yr. Within the study region, the National Ocean Service (NOS) tide gage at Lewes, DE has measured an average rate of sea level rise of 3.4 mm/yr over a 97-year period of record. At the west end of the Cape May Canal, the NOS tide gage has measured 4.6 mm/yr of SLR over a 51-year period of record.

In accordance with ER 1100-2-8162, the direct and indirect effects of future SLC on the identified TSP were evaluated using the Beach-fx model. The historical rate of SLC was determined through the use of the online calculator provided by USACE at http://corpsclimate.us/ccaceslcurves.cfm. The future low rate of SLC was taken as a linear projection of this historical rate of change. Currently, the Beach-fx analysis utilizes only the intermediate curve rate; however, Table 21 provides a summary of the computed SLC that will ultimately be utilized in Beach-fx for each of the three SLC scenarios across the simulation period (2022 to 2072) in later phases.

Table 21 - Relative Sea Level Change (RSLC) Adjustments applied during Screening Level Assessments

NOAA Gage ID	Project Year	RSLC Adjustments [1]		
		USACE Low	USACE Int.	USACE High
8551910, Reedy Point, DE	2022	0.34	0.42	0.67
	2072	0.9	1.46	3.27
	2100	1.21	2.25	5.53
8557380, Lewes, DE	2022	0.33	0.41	0.66
	2072	0.88	1.45	3.25
	2100	1.19	2.23	5.51
8536110, Cape May, NJ	2022	0.37	0.45	0.71
	2072	1.00	1.57	3.37
	2100	1.35	2.38	5.67

[1] Calculated RSLC estimates from USACE Sea Level Change Curve Calculator (2017.55), http://www.corpsclimate.us/ccaceslcurves.cfm, using Published Rates for each gage, base year 2022, 50- and 100-yr planning horizons. Values in feet.

[2] Calculated RSLC estimates at the base year (2022) represent the RSLC between 1992 (the midpoint of the current National Tidal Datum Epoch of 1983-2001) and 2022.

While the economic analysis is limited to the 50-yr life cycle, SLC was also assessed on a 100-yr planning horizon, and used to qualitatively inform project performance (e.g. understanding future level of protection offered in 2100), and identify potential for adaptive management (e.g. increasing dune/berm height/width). SLC at 2100 will be used more quantitatively to guide optimization of proposed protections measures during later project phases.

Most erosion along the Delaware Bay shoreline is caused by waves generated by local winds, especially during storms. Wave exposed shorelines within estuaries and coastal bays are likely to see higher rates of erosion with SLC increases (Rosen, 1978; Stevenson and Kearney, 1996). SLC has this effect because it allows waves to impact the shoreline at a higher elevation (National Research Council, 2007). Erosion rates on non-ocean tidal shorelines may be significantly higher than on the more exposed ocean coast (French, 1990). One reason for this is that the non-ocean beaches lack exposure to the long period swell waves that return sand to ocean beaches (Nordstrom, 1980). Since erosion of estuarine and bay beaches is typically storm-driven (French, 1990), if the storm activity increases, this would compound the effect of rising sea level. The No Action Plan will have no impact on SLC. While SLC is believed to be an underlying driving force, there are many other factors that directly affect shoreline erosion including the material composition of the shoreline, bank height, supply of sandy material in the littoral zone, wave energy exposure, tidal range and human influences (Rosen, 1977 & 1980; Stevenson and Kearney, 1996; Perry, 2008). These factors often make it difficult to clearly discern the effect of SLC. Both beach restoration and beach restoration with a terminal groin are expected to reduce the adverse impacts of SLC on communities and beach habitat quality.

While there are many types of shorelines in estuaries, beaches tend to be the most common type and are prominent in the proposed project area. These beaches, which are smaller than on the ocean coast, may occur along the upland edge or so-called “fetch limited” barriers (Lewes *et al.*, 2005). Their presence also tends to reduce erosion of uplands and wetlands by absorbing wave energy. Beaches tend to be relatively resilient to SLC since they are able to migrate landward as the shoreline retreats and wetlands accrete sediment and build in elevation. However, the combination of SLC and increased storm activity could cause more of the sand to be lost offshore. Riverine sediment input to the estuary is a sediment source to the estuary shoreline; however, the Delaware Estuary is known to be in sediment deficit due to significant shoreline stabilization in the upper reaches and decades of removal of bottom sediments by dredging and placement into upland CDFs. Since bank erosion and riverine input may serve as an important sediment source to bay shorelines, beneficial use of dredged material serves to put sediment back into the system where the shoreline is sediment starved.

It is difficult to predict the impact of climate change on endangered species as there is significant uncertainty in the rate and timing of climate change as well as the effects it may have on the species. SLC could result in a reduction in available bird beach nesting habitat and increase the risk of nest inundation, and changes in abundance and distribution of forage species. Interior maritime forest habitat for passerine birds and wading birds is also at risk due to sea water inundation once barrier beaches are eroded. Changes in water temperature could lead to a northward shift in the sea turtle range; however, the anticipated change in sea temperatures within the next 50 years is not expected to be greater than 1.5 to 2.0 and not deemed significant enough to contribute towards shifts in range or distribution of sea turtles (NMFS, 2014) or warm enough for successful egg rearing. Sea turtle nesting north of Virginia is relatively rare and is not expected to occur in the project area.

Rising sea level may result in moving the salt line upstream, and potentially reducing available freshwater habitat for spawning, larvae and younger juvenile Atlantic sturgeon. Increased rainfall, as predicted by some climate models, may increase runoff and scour, thereby exacerbating poor water quality conditions but possibly counteracting a northern encroachment of the salt line. Atlantic sturgeon prefer water temperatures up to approximately 28 degrees C. Increased droughts (or increased withdrawals for human use) and low flow conditions are additional potential impacts unrelated to the proposed project that can impact all Atlantic sturgeon life stages by reducing suitable habitat and reducing water quality conditions.

Beaches in developed areas can become trapped between the development on the land side and rising sea level on the water side, leaving little room for normal landward migration and sediment dynamics (Defeo *et al.*, 2009). The net result of these effects will probably be a net reduction in beach habitat. Erosion on beaches fronting houses particularly affects estuarine beach dependent species such as shorebirds, terns, horseshoe crabs and diamondback terrapins. While CSRM is the primary driver of this feasibility study, the ancillary environmental benefits to returning dredged estuarine sediments to the system through beach nourishment are significant.

A study by Galbraith *et al.* (2002) illustrates the potential effect of SLC on prime migratory shorebird habitat. The study used the SLAMM version 4 to investigate the effect of SLC on beach and intertidal flat habitat at Delaware Bay and four other sites on the west and Gulf coasts known for their importance to migrating or wintering shorebirds. Delaware Bay supports the second largest spring concentration of migrating shorebirds in the Western Hemisphere and is a critical stopover site for the red knot. Under a conservative scenario where a global SLC of 0.34 m by 2100 is adjusted with tidal gage records, the model predicted a 20 percent loss of Delaware Bay beach and intertidal flat habitat by 2050 and a 57 percent loss by 2100 (USFWS, 2016). The proposed TSP to conduct beach nourishment where possible best mimics the natural shoreline habitat while affording additional defense against SLC. Although the proposed hardened structure (terminal groin) does not necessarily offer added defense against SLC, it reduces sand losses to the beach fronting the community by impeding longshore transport of sediments and enlarging the beach width that in turn adds to increased resiliency in the face of SLC. In combination with a terminal groin, beach nourishment lowers the risk of flooding to the developed bayshore communities by providing an elevated beach berm buffer while reducing the rate of sediment loss in highly erosional areas.

5.2 WATER RESOURCES

Under the No Action Plan, inundation of flood waters along with storm waves on the Delaware bayshore causes erosion during storms, thereby raising turbidity, reducing water quality and clarity, which is further exacerbated by additional losses of vegetated land cover. Turbidity is the measure of the cloudiness of the water caused by suspended matter such as clay, silt and organic matter, thereby blocking the passage of light within the water columns. Continued erosion of the sandy beach eventually results in exposing the underlying peat and clay layers which are repeatedly inundated with each flood event, causing continued degradation of water quality and reducing beach, intertidal and shallow water habitats.

Beach nourishment on sandy beaches typically results in a temporary nearshore impact (*i.e.* swash zone) to water quality as placement operations elevate turbidity. While larger sand particles settle out more quickly, finer sediments will remain suspended for longer periods, or even indefinitely in coastal turbulent waters (Adriaanse and Coosen, 1991). Suspended particles can interfere with the biological function of some organisms, such as feeding, respiration, reproduction and predator avoidance. High turbidity and silt loads in the water can have detrimental impacts on filter feeding organism associated with nearshore areas such as polychaetes, amphipods, isopods, decapods and mollusks. The longer duration of diminished light penetration can detrimentally affect the photosynthetic activity of phytoplankton, the primary producers of energy production. The NJDEP prefers that fill material be very similar to existing beach sand to ensure minimization of turbidity during construction. The proposed maintenance material dredged from Lower Reach E consists of predominantly large grained sand.

A robust dune and beach sand berm reduces turbidity as a result of the higher proportion of larger grain sizes of sand particles to fine silts and clays and settles more quickly from turbulence during storm events. A healthy beach and dune system is the first line of defense for bayfront infrastructure, including homes, roads and utilities. They are also the first line of defense to reduce inundation to adjacent marshes. Marsh vegetation has the capacity to improve and maintain water quality through filtration, nutrient uptake and sediment trapping capacities. Large tracts of healthy marsh are particularly important surrounding bayfront residential communities to serve to absorb surface water and accrete sediments.

Beach restoration with a terminal groin will provide the same CSRM benefits as beach nourishment alone, but a terminal groin adds longevity at two dredged material placement beaches where erosion rates are significantly higher. Physical and biological impairments to water quality can result from the placement operations due to increases in turbidity in the effluent run-off. Increased turbidity results from the resuspension of sediments during operations and is temporary, but as noted, can impact primary productivity and respiration of organisms in the immediate project area. Increased turbidity can also impact prey species' predator avoidance ability due to decreased clarity in the water column. Impacts to water quality at the placement sites can be minimized through the creation of a temporary sand dike surrounding the outfall pipe during pumping operations. Elevated turbidity will result temporarily during construction of the terminal groin at Gandys Beach and rehabilitation of the groin at Fortescue. Groins made with stone add heterogeneity to the intertidal habitat for benthic organisms and foraging fish. Increased suspended sediment in the water can reduce dissolved oxygen (Johnston, 1981). This can be more of a concern during summer months when water temperatures are warmer and less capable of holding dissolved oxygen (Hatin *et al.*, 2007). The nature, degree and extent of the suspended sediment plume in the water is controlled by a variety of factors including sediment particle size, solids concentration, dredge type, discharge rate, water temperature and hydrodynamic forces (*i.e.* waves, currents) causing horizontal mixing. The larger grain sizes of the proposed material source reduce the amount of time the material stays in suspension.

Turbidity levels decrease exponentially with increasing distance from the placement site due to settling and dispersion. Plume concentrations, particularly when the material is predominantly large grained sand particles, is expected to quickly return to background levels in most cases. The vast majority of re-suspended sediments resettle close to the construction site within one hour (Anchor Environmental, 2003). Overall, water quality impacts are anticipated to be minor and temporary.

Of the three major types of dredges available (hopper, cutter suction and mechanical), hopper dredges are the most likely to be used to dredge the Main Channel in lower Reach E because of the exposed conditions in the Delaware Bay and the relatively long distances between the Delaware River Federal channel and the dredged material placement sites. Impacts resulting from the dredging operations are thoroughly presented in the NEPA documentation for MCD navigation project (USACE, 1992, 1997, 2009).

Figure 22 - Hopper Dredge

Hopper dredges are self-propelled ships equipped with propulsion machinery, hoppers for dredged material storage and dredge pumps (Figure 22). Dredged material is hydraulically raised through trailing dragarms which "vacuum" water and sediment in contact with the channel bottom and discharge it into the hoppers. The material is stored in the hoppers through transportation to the placement site. While most hopper dredges are equipped with bottom doors or split hulls for release of material at open water sites, they can also be equipped for pump-out of material to the beach nourishment beneficial use sites.

As was previously mentioned in Section 5.1.3, the practice of filling a hopper beyond overflow to achieve a higher density load is referred to as economic loading. The result is fewer loads required to transport the same amount of dredged material, which decreases the overall operating time, and hence, the project cost. Economic loading is most effective when dredging coarse grained sediments or consolidated clay sediments due to higher settling velocities. Conversely, there is less potential for benefits from economic loading of fine-grained sediments due to lower settling velocities. The environmental effects of economic loading (*i.e.* turbidity) and the economic benefits are presented in the 2013 EA (USACE, 2013) for the deepening project of the Delaware Main Navigation Channel.

A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (PL 95-217), as amended, and a consistency determination under the Coastal Zone Management act are required from the state of New Jersey. Pursuant to Section 404 of the Clean Water Act, the impacts associated with the discharge of fill material into waters of the United States are discussed in Appendix D.

5.3 BIOLOGICAL RESOURCES

5.3.1 Vegetation and Wetlands

Over 300,000 acres of tidal wetlands provide breeding and nursery habitats for finfish and shellfish, and act as a natural flood and pollution control system along the shoreline of New Jersey. The majority of wetlands within the vicinity of the proposed project areas are estuarine intertidal emergent wetlands, with additional estuarine intertidal scrub-shrub and interior forested freshwater wetlands occurring intermittently. In the southern reach of the study area, coastal salt marshes are intertidal ecosystems occurring on soft sediments on which the vegetation is dominated by flowering plants, graminoids, forbs and low shrubs. Salt marshes develop between terrestrial and marine environments, resulting in biologically diverse communities adapted for harsh environmental conditions including desiccation, flooding, and extreme temperature and salinity fluctuations. These wetlands are characterized by a mix of marsh vegetation comprised of salt marsh cordgrass (*Spartina alterniflora*), salt grass (*Distichlis spicata*), salt hay (*Spartina patens*), and black needlerush (*Juncus roemerianus*). Common tree and shrub species include high tide bush (*Iva frutescens*), loblolly pine (*Pinus taeda*), Virginia pine (*P. virginiana*) and eastern red cedar (*Juniperus virginiana*). Marshes act as nurseries to a wide variety of organisms, some of which are notably threatened or marketed as important fisheries species (USFWS, 2016).

The No Action Plan is expected to exacerbate the loss of coastal vegetation and cause excessive inundation of neighboring wetlands with erosion of the barrier beachfront. The beach restoration alternatives will enhance protection of adjacent wetlands and enable dune vegetation to establish with the resultant higher berm and dune elevations. The proposed project may result in minimal short-term impacts to the vegetation that covers the existing dunes in areas where the fill will join the existing dune face. The proposed nourishment project will temporarily stabilize the beach and dune vegetative communities and prevent further erosion-related losses. The beach fill will furnish additional material to existing dune vegetation so the plants can collect and bind wind-blown and storm-driven sand into dune formations.

The addition of a hardened structure will produce a localized interference with the natural coastal processes that allow for the exchange between the berm/dune and adjacent salt marshes. The preferred plan entails planting American beach grass on the dune. Alternatives involving the construction of a perpendicular hardened structure are expected to lower the erosion rate but will also impede the natural transfer of sediments within the beach/intertidal habitat interface longitudinally, resulting in greater accretion of sediments updrift of the groin. The downdrift side of the proposed terminal groin at Fortescue has an inlet that will continue to accumulate a sediment delta at the inlet mouth due to tidal creek flow to the bay. These sediments provide a downdrift sand source to the shoreline to the north while sand on the updrift side of the terminal groins will accumulate sand fronting the nearby homes as a result of alongshore currents. These structures will not impact vegetation as they are located bayward of the dune vegetation line.

5.3.2 Planktonic and Benthic Organisms

With the No Action Plan, low quality intertidal habitat would continue to exist at the beach placement sites due to severe erosion and exposed peat that underlies the sand veneer. Infaunal organisms within the dredged material placement zone will be temporarily impacted by burial. By pumping dredged material onto the beach above the MHWL and constructing a temporary sand berm seaward of the placement pipe outfall, impacts to intertidal infauna can be minimized by reducing run-off and turbidity back into the bay. Despite the resiliency of intertidal benthic fauna that are adapted to high energy turbulent environments within the swash zone, the initial beachfill will result in some mortalities of infaunal species. The addition of a hardened structure (*i.e* groin) would permanently impact intertidal and beach habitat within the footprint as well as present a nearshore obstruction to alongshore sediment transport processes. Most of the organisms inhabiting these dynamic zones are highly mobile and respond to stress by displaying large diurnal, tidal and seasonal fluctuations in population densities (Reilly and Bellis, 1983). The ability of a nourished area to recover depends on grain size compatibility of the material pumped onto the beach (Parr and Lacy, 1978). Macrofaunal recovery is usually rapid after pumping operations cease. Recovery of the macrofaunal community may occur within one or two seasons because borrow material grain sizes are expected to be compatible with natural beach sediments.

Recolonization depends on the availability of larvae, suitable conditions for settlement, mobile organisms from nearby beaches, vertical migration of organisms through the placed material, and mortality. The benthic community can, however, be somewhat different from the original community. Dredged material pumping generates suspended sediments and increases turbidity. Recolonization of the benthic community can be rapid, typically taking from a few months to a few years (Brooks *et al*., 2006; Maurer *et al*., 1981a,b; 1982, Maurer *et al.,* 1986; Saloman *et al*., 1982; Van Dolah *et al*., 1984) through larval transport and settlement and based on seasonality and species' life history characteristics (Shull, 1997; Thrush *et al*., 1996; Zajac and Whitlatch, 1991). The groin adds heterogeneity to the intertidal environment of soft bottom habitat by providing hard substrate for sessile marine organisms to adhere to.

Larval recruitment and migration from adjacent, unaffected areas initially recolonize the disturbed area (Van Dolah *et al*., 1984; Oliver *et al*., 1977). Anderson *et al.* (2010) evaluated benthic organisms within Delaware Bay relative to major physical habitats of the seafloor, such as depth, sediment size, topography, and salinity. Salinity and sediment type were primary factors in benthic species composition. Annelids were the predominant benthic species inhabiting the project area as well as the

Delaware Bay as a whole. Some benthic studies have demonstrated only subtle changes in sediment characteristics with a slight shift in corresponding benthic community composition post-dredging (Scott, 2012). No long term effects are expected as salinity would not change and the benthic community that naturally exists in the area is present throughout the middle and lower bay region and dominated by species with opportunistic life histories that exhibit rapid recruitment capabilities.

Blue crabs. Adult blue crabs (*Callinectes sapidus*) migrate to higher salinity waters of the lower Delaware Bay in the December through March timeframe to overwinter. The crabs burrow into sediments of the deep channel as water temperatures decline and are not likely to be in the shallow waters of the project placement area during the cooler months of the year. During warmer months of the year, blue crabs are active within the shallow waters of the bay, but crabs in between molts have the mobility to move out of the area of disturbance at the placement sites.

Horseshoe crabs. Shallow water intertidal flats of Delaware Bay are prime spawning habitat for horseshoe crab (*Limulus polyphemus*). Shallow water areas with low wave action and sand or mud substrate are also important nursery areas for juvenile horseshoe crabs for their first two years. Horseshoe crab eggs and larvae are a food source for migratory birds and several fish species. The 17 phases of instars of the horseshoe crab are food for finfish, loggerhead turtles, American eels (*Anguilla rostrata*) and blue crabs.

A groin placed perpendicular to the shoreline may impede longshore transport of sediments but may also create improved spawning habitat on the updrift side by trapping sand and is unlikely to adversely impact horseshoe crab spawning. A terminal groin positioned perpendicular to the shoreline is less likely to adversely affect horseshoe crabs than breakwaters or bulkheads parallel with the shoreline that can trap horseshoe crabs. Botton and Loveland (1989) estimated that beach standings due to onshore structures cause mortality in 10 percent of adult horseshoe crab populations in Delaware Bay each year. Horseshoe crabs move in relation to beach slope and are capable of traveling along the length of the groin in both directions, although riprap can entrap horseshoe crabs (Shuster and Botton, 1985). Groins or jetties lying perpendicular to the shoreline can also benefit horseshoe crabs on spawning beaches by reducing the intensity of wave action (Maryland Department of Natural Resources, unpublished data, 1998). Beach restoration projects that reduce risk to developed areas provide habitat for horseshoe crab spawning.

In the lower Delaware Bay, migratory shorebird staging habitat was severely impacted by Hurricane Sandy in 2012 and to a lesser extent by subsequent nor'easter storms. Beach erosion has been a primary concern due to the loss of horseshoe crab spawning habitat along the thin veneers of coarse sandy bay beaches. Horseshoe crabs are dependent upon access to beaches for spawning, with preferred grain size sediment ranges and beach slope, both of which can be significantly impacted by flooding and erosion. During 2014 and 2015, habitat restoration efforts to restore horseshoe crab spawning habitat commenced and were funded by private wildlife-oriented organizations extending from Cape May County into Cumberland County. Other restoration efforts included marsh restoration on the Maurice River delta mudflats.

In addition to CSRM, beach nourishment of fronting bayshore communities will provide improved habitat for horseshoe crab spawning along the beach face for important migratory shorebird stopover sites. Restoring eroded beaches where horseshoe crabs spawn are important for both the crabs themselves and numerous other species that depend on the crabs for food. The current beach berm template is designed to have a suitable grain size (>0.3 mm) and slope (1H:10V), and is deep enough (>7 feet) to promote horseshoe crab spawning habitat.

5.3.3 Fish

Under the No Action Plan adult fish occurring in the nearshore zone of the bay are not likely to be adversely impacted as fish occurring in this area are habituated to high energy wave environments and elevated turbidity from waves. If erosion of the barrier beach continues, larval and juvenile fish stages are likely to be adversely impacted if adjacent salt marshes incur lower habitat quantity and quality through the potential loss of wetland vegetation from frequent flooding. Juvenile life stages rely on salt marshes as nursery areas. A robust berm and dune system is the first line of defense for salt marshes. Healthy productive wetlands also provide increased diversity of prey species for fish relative to barren mudflats. With the proposed placement project, larval and juvenile fish may be temporarily adversely impacted by elevated turbidity levels within the nearshore zone at the project site, but fish are motile and will likely leave the area temporarily. The beaches involving construction of a hardened structure would prolong the elevated turbidity levels during the construction period but will provide hard substrate for sessile encrusting organisms, and refugia for shallow water fish species and foraging species.

The marine habitat within the lower Delaware Bay has been designated as “Habitat Areas of Particular Concern” (HAPC) by the NMFS for the sandbar shark (*Carcharhinus plumbeus*). The lower estuary is important as a nursery and pupping grounds for their food source of benthic organisms along the Delaware Bay shorelines (Pratt, 1999). Potential impacts of the TSP may include, but not be limited to: changing the habitat characteristics, depth, profile, odor, turbidity and fauna of the nearshore area. Indirect and temporary adverse impacts include the loss of forage food items. Prey species, principally crabs and fish of many species, may be disrupted directly by the presence of physical activity in the area and indirectly by the covering of vulnerable food web organisms with sand. The NMFS recommends that dredging be avoided during the 1 May to 15 September period to prevent potential impacts to newborn and juvenile sharks. After this time period, the young sharks have reached a larger size where they could be more able to avoid the sand placement operations and likely to move into deeper waters. Since this environmental window, in combination with the Corps’ objective to avoid sensitive periods for other coastal species (*e.g.* horseshoe crab, blue crab), may result in an insufficient amount of remaining time necessary for the dredging and placement operations, the USACE will continue to coordinate the MCD maintenance dredging schedule with NJDEP and NMFS to determine how best to minimize or avoid potential adverse impacts to HAPC.

As mentioned previously, for beach restoration alternatives (including the TSP), a sand dike that is 200 to 300 feet in length is typically constructed with existing beach material above the MHWL to contain dredged material that is pumped landward of it. The dike will be long enough that most dredged material will drop out on the beach and not return to the bay as a slurry. As material is deposited along the beach, the dike may be repositioned seaward to contain the required tilling above the MHWL for that section of beach under construction. The slurry is also controlled by the dike along the shoreline. No dredged material will be hydraulically placed below the MHWL during any established restricted period. The dike will be extended down the beach as the area behind the dike is tilled and the dredge pipe is lengthened. The dredged material that has been deposited will be built into the dune and beach berm. It is expected that little of this material will be re-deposited by wave action during the spring/summer window period since weather and current conditions are generally mild. The dredge pipe will be placed on pontoons for a minimum of 1,000 feet, extending offshore to avoid disrupting young sandbar sharks mobility close to the shoreline.

The beach placement sites within the shallow intertidal areas will incur limited and short-term impacts on finfish. Most early developmental stages are typically found more often in tidal creeks and backwater areas. Most bottom dwelling and pelagic fishes in Delaware Bay are highly mobile and should be capable of avoiding turbidity impacts of the placement operations. Due to suspension of food particles in the water column, some finfish are attracted to the turbidity plume.

The primary impact to fisheries is the disturbance of benthic and epibenthic communities. As mentioned in Section 5.3.2, the loss of benthos smothered during berm construction temporarily disrupts food resources in the impact areas (Hackney *et al*., 1996). Rapid recolonization by macroinvertebrates typical of highly dynamic environments will occur in the short-term within the proposed sand placement sites. Depending on the time of year, benthos food resources can recolonize within a year via larval recruitment as well as from immigration of adults from adjacent, undisturbed areas (Burlas *et al*., 2001; Posey and Alphin, 2002; Byrnes *et al*., 2003). Recovery is most rapid if construction is completed before seasonal increases in larval abundance and adult activity in the spring and early summer (Herbich, 2000). Infaunal species will be permanently impacted within the footprint of the proposed terminal groin at Gandys Beach and to a lesser extent due to the proposed groin rehabilitation at Fortescue. Groins also present some positive attributes: the rock exterior will provide refugia from currents, interstitial spaces and hard structures for sessile fish prey species.

5.3.3.1 Essential Fish Habitat

Essential Fish Habitat (EFH) is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” and covers all habitat types utilized by a species throughout its life cycle. The Magnuson-Stevens Fishery Conservation and Management Act (Public Law 104-267) requires all Federal agencies to consult with NMFS on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect EFH.

Potential impacts to EFH under the No Action Plan and the beach nourishment alternatives (including beach restoration with a hardened structure) have been described in the previous sections in reference to water quality and benthic invertebrate prey species for both the intertidal and shallow water placement zones. Impacts from placement operations can impact EFH in several ways: smothering of eggs and larvae, the creation of higher suspended sediment levels in the water column, reduced feeding success for site-feeding fish and reduced water oxygen levels. All of these impacts are temporary in nature, occurring during and briefly after the construction period. Substrate conditions can often return to similar preconstruction conditions and the benthic community recovers through recolonization. Construction of groins reduces soft bottom habitat within the nearshore and intertidal zones but adds hard substrate for increased habitat heterogeneity for fish and attaching sessile organisms.

A review of EFH designations and the corresponding 10 ft x 10 ft squares, which encompass the project area was completed and coordinated with the NMFS. The following is an evaluation of the potential effects associated with this project on EFH species:

American plaice: No adverse effect is anticipated on adults as they are concentrated in oceanic deep water and not likely to be in the project area. Limited adverse effect is anticipated on juveniles as they would be expected to move away from the disturbance area. Impacts within the placement area will be minimized due to pumping of material onto the beach above the MHWL and reducing turbidity. Impacts to prey species in the intertidal zone will be temporarily impacted through burial but will recover through recolonization.

Atlantic butterfish: No adverse impacts are anticipated. All life history stages are pelagic and oceanic. Construction activities will take place on the bottom in the nearshore and intertidal zone. Elevated turbidity effects are temporary.

Atlantic sea herring: No adverse effect is anticipated as adults and juveniles occur in pelagic waters and are not likely to be in the project area during the temporary construction period. Eggs occur on bottom habitats of gravel, sand, cobble or shell fragments in depths ranging from 20 to 80 meters and a salinity range of 32-33 (oceanic waters) and are therefore not expected to be in the project area.

Black sea bass: No adverse effect is anticipated on juveniles and adults as this species occurs primarily in offshore areas with structure and they can avoid temporary impacts to the water column. Larvae are generally found on structural inshore habitat such as sponge beds. Black sea bass eggs are found from May through October on the Continental Shelf from southern New England to North Carolina and not within the intertidal zone.

Bluefish: No adverse effect on eggs and larvae as these occur in pelagic waters in deeper water than the project area and generally are not collected in estuarine waters. Juveniles and adults occur in mid-Atlantic estuaries from April through October. Temporary impacts to prey items may occur in the project area. Juveniles and adults are expected to move away from the project area during the temporary construction period. Elevated turbidity will be short-term.

Clearnose skate: Habitat for juveniles and adults is generally shallow soft bottoms or rocky, gravelly bottoms. Adults tend to move from shallow shores to deeper water in winter.

Impacts may occur to larvae though they are not likely to leave the project area during the construction period. Juveniles and adults are highly mobile. Temporary disruption of benthic food prey organisms may occur within the placement area.

Cobia: No adverse effect is anticipated for all life stages as they are all pelagic and construction activities will take place on the nearshore bottom. Cobia are not expected to occur in the project impact area.

Dusky shark: Neonates and early juveniles inhabit shallow coastal waters during summer months. No adverse impact is anticipated for neonates, juveniles or adults as these stages are expected to move out of the immediate impact area during the temporary construction period, particularly if placement activities occur predominantly off-season. Dredge material pumping at the placement site will occur above the high water line on the beach and proceeds in sections to minimize turbidity impacts to the nearshore environment.

King mackerel: No adverse effect on all life stages is anticipated as all life stages of this species are pelagic and the species is not expected to be in the area.

Little skate: Habitat consists of shallow coastal water over sand or gravel and up to 80 fathoms. Juveniles and adults are highly mobile. Larvae may be impacted by temporarily elevated turbidity. A temporary disruption to benthic food prey organisms may occur. Juveniles and adults of this species are likely to avoid the immediate impact area.

Red hake: No adverse effect is anticipated on adults as any that may occur in the Delaware Bay during the temporary construction period are anticipated to move away from the project area. In spring and summer, red hake move into waters less than 100 meters. They are most abundant between Georges Bank and northern New Jersey. Eggs are pelagic. During winter they tend to move into deeper waters offshore. Red hake are not frequently found in Delaware Bay's inshore waters.

Sandbar shark: Neonates and early juveniles are found in shallow coastal waters and use the Delaware Bay as a nursery area. Adults are highly migratory and mostly congregate offshore. Minimal adverse impact is anticipated for juveniles or adults as these stages are expected to move out of the construction area during the temporary construction period. If placement activities occur during the spring and summer pupping season, the dredge pipe will be floated on pontoons to avoid disrupting movements of young sandbar sharks. Sand is pumped onto the beach above the MHWL to minimize turbidity at the construction site.

Sand tiger shark: Neonates and early juveniles are found in shallow coastal waters and use the Delaware Bay. Adults are highly migratory and mostly congregate offshore. No adverse impact is anticipated for juveniles or adults as these stages are expected to move out of the construction area during the temporary construction period. If placement activities occur during the spring and summer, the dredge pipe will be floated on pontoons to avoid disrupting movements of young sharks. Sand will be pumped onto the beach above the MHWL to minimize turbidity at the construction site.

Scup: Eggs and larvae are abundant in estuaries from May through September in waters between 55 and 73 degrees F and salinities greater than 15 ppt**.** Juvenile and adults typically occur in estuaries and bays and migrate to coastal waters in summer. Older life history stages of the species would be expected to avoid the immediate placement area during temporary construction. Any increase in turbidity at the placement site will be minimal with pumping above the MHWL. Prey species composition may be temporarily impacted due to placement activities.

Spanish mackerel: The species makes seasonal migrations along the Atlantic coast. No adverse effect is anticipated for all life stages as they are all pelagic and not associated with bottom habitats and construction activities will take place on the bottom. The species is not anticipated to occur in the shallow waters of Delaware Bay.

Summer flounder: No adverse effect is anticipated on eggs and larvae because they are pelagic and generally collected at depths of 30 to 360 feet. No adverse effect is anticipated on juveniles and adults because they would be expected to move out of the construction. Impacts within the placement area are minimized due to pumping of material onto the beach above the MHWL and reducing turbidity. Impacts to prey species in the intertidal zone will be temporary. The predominant benthic community composition consists of dominant small taxa, such as polychates and small bivalves, species with fast recruitment rates.

Windowpane flounder: No adverse effect is anticipated on eggs and larvae as they are pelagic and work will be conducted on the bottom during the temporary construction period. Prey species composition may be temporarily impacted during placement operations. No adverse effect on juveniles and adults is anticipated in bottom habitats of the berm placement site as these life stages are anticipated to move away from the placement disturbance area during the temporary construction period. Pumping of material onto the beach will occur above the MHWL and thereby minimize turbidity and disruption of prey species composition.

Winter skate: habitat consists of shallow coastal water over sand or gravel and up to 80 fathoms. Juveniles and adults are highly mobile. Larvae may be impacted through suffocation. A temporary disruption to benthic food prey organism may occur.

In conclusion, of the species identified with Fishery Management Plans, and juvenile life history stages of highly migratory pelagics that may occur in the vicinity, the potential for adverse impacts to EFH is considered temporary and minimal. The egg and larval stages of winter flounder, which occur predominantly in inlets, are less likely to be impacted in the placement vicinities. The neonate stages of several shark species are predominately located in shallower coastal waters during summer months, and should be sufficiently mobile to leave the construction area. Potential impacts are further minimized if dredging can be conducted during the cooler, nonbreeding months of the year (*i.e*. fall and winter). The O&M dredging schedule for the Delaware River Main Channel Lower Reach E is predicated on storm events and shoaling rates and cannot be determined at this time. To protect juvenile shark species, the dredge pipe will be floated to avoid disruption of movements if placement operations occur between 1 May and 15 September, following procedures described by the NMFS. Based on the findings of the Field Evaluation of Hopper Dredge Overflow for the Delaware River (USACE, 2013) and sediment quality information provided (USEPA, 2002; and Hartwell and Hameedi, 2006), there is no evidence that temporarily elevated turbidity created from sediments greater than 90 percent coarse grained material adversely affects water quality or aquatic life. Therefore, the proposed beach restoration plan is not expected to have significant adverse effects on the EFH and HAPC shark species for the affected life stages.

At the beach placement site, the slurry of dredged material and water pumped onto the beach typically results in an increase in localized turbidity. The Atlantic States Marine Fisheries Commission (Greene, 2002) review of the biological and physical impacts of beach nourishment cites several studies on turbidity plumes and elevated suspended solids that drop off rapidly seaward of the sand placement operation. Other studies support this finding that turbidity plumes and elevated TSS levels are typically limited to a narrow area of the swash zone downcurrent of the discharge pipe (Burlas *et al*., 2001). Fish eggs and larvae are the most vulnerable to increased sediment in the water column and are subject to burial and suffocation. Juvenile fish and adults are capable of avoiding sediment plumes. Increased turbidity due to placement operations will temporarily affect fish foraging behavior and concentrations of food sources are expected to return to the nearshore zone once placement operations cease due to the dynamic nature of nearshore benthic communities (Burlas *et al*., 2001). Turbidity impacts are anticipated to be minimized by the placement of the dredge pipe above the MHWL during pump-out and development of the raised beach berm moving along the shoreline. Most shallow water coastal species will leave the area of disturbance at the immediate placement site.

The adverse impact on benthic organisms (including fish food prey items) in the placement areas is considered to be localized, temporary and reversible as benthic studies have demonstrated recolonization following placement operations within 13 months to 2 years. The construction of a hardened structure (*i.e.* a terminal groin as part of the TSP) permanently impacts bay bottom habitat within the footprint of the structure but also provides heterogeneity to the habitat in a shallow mud to sand soft bottom habitat. Authorized maintenance dredging within Reach E in the bay Main Channel will remove approximately 930,000 cubic yards of sandy material every 2 years. The Delaware Estuary is considered sediment starved due to a long history of extensive shoreline development in the upper riverine reaches and decades of dredging and placement into upland CDFs. It is beneficial to the estuarine fish and wildlife coastal habitats to keep the dredged material in the system by placing it on lower bay beaches rather than in CDFs.

5.3.4 Wildlife

Under the No Action Plan, wildlife species would continue to incur further losses in habitat quality and quantity due to ongoing flooding and erosion. Several mammals, reptiles, amphibians and birds utilize the beach and dune habitat of the proposed project areas. All of these species are mobile and expected to leave the immediate impact area temporarily during construction. The USFWS NJFO supports further investigation of providing CSRM to the New Jersey bayshore by beneficially using suitable dredged material and to expand opportunities to natural areas for the recovery of red knots and state-listed shorebirds, horseshoe crabs and marsh resiliency (USFWS, 2016).

The intent of the TSP is to meet the objective of minimizing storm impacts, while maximizing benefits to fish and wildlife resources, and minimizing any adverse effects associated with the plan. Beach nourishment restores beach habitat that is critical to all coastal wildlife, including horseshoe crabs, migratory shorebirds, waterbirds, diamondback terrapins and beach foraging animals. Specifically, the beach restoration plan will provide added protection to interior shrub and forested habitats adjacent to the bayshore communities. The beach restoration with groin plan will provide similar protection with added protection from sand losses. Inclusion of a hardened structure may result in a localized sand transport impediment in the nearshore intertidal zone, thereby incurring increased sediment accumulation on the updrift side of the groin and reduced sediments transported to the downdrift side of the groin. Both terminal groins proposed at Gandys Beach and Fortescue are positioned adjacent to inlets, which provide a sediment source to the downdrift side of the groins due to tidal river flow to the bay.

Widespread population declines of many songbird species are among the most critical issues in avian conservation today. Numerous studies have shown the critical role that maritime shrub, maritime red cedar woodland and maritime forested habitats play for migrating passerines, especially within adjacent natural lands such as Cape May National Wildlife Refuge and the Wildlife Management Areas, including habitat surrounding the Delmarva Peninsula bayshore communities (Mizarhi, 2006; Clancy and McAvoy, 1997; McCann *et al.*, 1993). Conservation of these habitats and the natural resources associated with them is essential to perpetuate the migratory songbird resources of North America.

<u>Birds</u>. Beach nourishment operations should have minimal effect on birds in the area. Most birds are seasonally transient, as well as highly mobile and can avoid the construction area due to the noise. Birds that use the beach for nesting and breeding are more likely to be adversely impacted under the No Action Plan as beach erosion continues. Beach nesting species are more likely to be adversely impacted by beach nourishment activities than those species that use the area for feeding and resting during migration if construction occurs during the nesting season. Birds may be temporarily displaced by dredges, pipelines and other equipment along the beach, or may avoid foraging along the shore if they are aurally affected (Peterson *et al.*, 2001). Seasonal restrictions or temporary exclusion fencing helps to reduce the potential for adverse impact for any construction alternative involving beach access by construction personnel and equipment, which have the potential to crush eggs or hatchlings or induce adults to abandon nest sites. Coarse sand or sand high in shell content can inhibit the birds' ability to extract food particles in the sand. Very fine sediments that temporarily reduce water clarity can also

decrease feeding efficiency of birds in the immediate area of construction for a short period of time (Peterson *et al.*, 2001). Sand historically dredged from the lower reaches of the Delaware Bay has been determined to be compatible with existing beach sand.

The species listed in the appendices of the USFWS NJFO Planning Aid Report (located in Appendix E) are protected under the Migratory Bird Treaty Act of 1918 (40 Stat. 755;16 U.S.C. 703-712), as amended and occur in the project area. Some of these species listed are considered Birds of Conservation Concern which are defined as species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq*.). Under the No Action Plan, erosion will continue and may result in beaches with undesirable exposed peat and clay or grain size less favorable to migratory shorebirds for feeding and resting (USFWS, 2016). Additionally, the No Action alternative doesn't restore a protective barrier beach berm and dune system that provides CSRM to neighboring salt marshes, scrub shrub, and interior forest habitats during severe coastal storm events.

Migratory shorebirds are heavily dependent on successful horseshoe crab spawning to fuel the remaining leg of their migration to arctic breeding grounds. A habitat suitability mapping study (Lathrop *et al.*, 2013) showed that Hurricane Sandy had a greater negative impact on horseshoe crab spawning habitat along the Delaware Bay shoreline than the prior 8 years of typical shoreline dynamics. It is possible that beach restoration can enhance or inhibit horseshoe crab spawning by changing grain size. The proposed TSP will provide sand grain size and slope that are within the preferred range for spawning horseshoe crabs. Adding sand to eroded beaches with compatible grain size renders bay beaches more favorable than existing conditions. Spawning horseshoe crabs will avoid beaches with exposed peat, which in turn, may reduce attraction of migratory shorebirds, including the red knot (an imperiled species that relies heavily on horseshoe crab eggs) (Botton *et al.*, 1988). Horseshoe crabs spawn on beaches fronting residential communities. In turn, residents and state environmental agencies promote seasonal beach use practices that avoid disturbance to migratory shorebirds, such as keeping dogs leashed and not disturbing concentrations of feeding shorebirds during the spring migration. Wide flat sandy, sparsely vegetated barrier beaches are the preferred nesting habitat for the piping plover. Beach nourishment activities can provide positive benefits to listed species by restoring preferred beach habitat.

Beach restoration involving the construction of a hardened structure can reduce available coastal foraging habitat within its footprint. The preferred plan of beach restoration with terminal groins at Gandys Beach and Fortescue is not likely to have a long-term adverse impact on these species. Beach nourishment may temporarily divert birds away during the construction period but offer longer term nesting opportunities for some shorebirds and colonial nesting waterbirds, particularly American oystercatcher (*Haematopus palliates*, state endangered) and black skimmer (*Rynchops niger*, state endangered). Terminal groins at the northern end of Gandys Beach and Fortescue will serve to retain sand fronting the communities. Red knots (*Calidris canutus rufa*) (Federally threatened and state endangered) will likely use these beaches in greater number for foraging (USFWS, 2016). The proposed dredged material source is projected to be compatible with existing beach sand characteristics. The inclusion of a groin at Gandys Beach and rehabilitation of an existing groin at Fortescue are not expected to adversely impact birds. Some species such as ruddy turnstones, terns and other species of shorebirds often congregate on groin structures for the benefit of the higher elevation above the beach for enhanced viewing capabilities of their surroundings and prey.

Reptiles. Across their range, diamondback terrapin (*Malaclemys terrapin*) populations are in decline. The state of New Jersey lists the diamondback terrapin as a species of greatest conservation need within their State Wildlife Action Plan. The USFWS lists the species as an Appendix II species under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The diamondback terrapin is the only North American turtle that lives exclusively in brackish waters associated with estuaries, coastal bays, and salt marshes. Terrapins are heavily dependent on shoreline conditions to satisfy their habitat requirements.

The terrapin spends most of its life in brackish waters of coastal salt marshes, but it must come ashore for nesting. Nesting normally occurs at bare or sparsely vegetated, unshaded, sandy areas above the level of the normal high tides (Palmer and Cordes, 1988; Roosenburg, 1990; Burger and Montevecchi, 1975). Diamondback terrapins are a state species of concern. Although species of concern are not protected under the ESA, the term commonly refers to species that are declining or appear to be in need of conservation.

In the study area, terrapin habitat is mostly associated with shoreline beaches although road shoulders, dikes, and tilled areas may occasionally be used. Coastal development, road kills and drowning in crab traps have resulted in significant declines of the species in New Jersey. The Terrapin Recovery/Conservation Project was initiated in 1989 and continues to address conservation needs of terrapins. The No Action Plan poses no benefits to diamondback terrapins as beach habitat would erode, reducing available suitable nesting habitat.

The TSP would provide improved nesting habitat for terrapins with an enlarged beach. Beach nourishment and the construction/repair of terminal groins are not expected to result in adverse impact to diamondback terrapins if construction occurs outside of the nesting season. Nesting season extends from the beginning of June until the end of July, and terrapins often aggregate in the waters adjacent to the nesting beaches during the nesting season (Roosenburg, 1993). Based on a study of a New Jersey population, the incubation period for the eggs is typically on the order of 70 to 80 days with a range between 61 and 104 days for individual terrapins (Burger, 1976; 1977). After hatching the terrapins remain in the nest for several days before they emerge.

Beach restoration that includes a hardened structure that runs parallel to the shoreline (such as a breakwater) can impede wildlife movement between the intertidal zone and the upper beach. Perpendicular hardened structures, such as the proposed terminal groins at Fortescue and Gandys Beach, do not impede terrapin access to the water from the beach and intertidal zone. However, nesting success can be inhibited in developed areas where predators such as dogs are more likely to occur (USFWS, 2016).

5.3.5 Threatened and Endangered Species

This section presents the potential impacts to threatened and endangered species and discusses the listed species life history requirements and measures taken by the USACE to minimize or avoid adversely impacting these species or their habitats. The No Action Plan will result in continued erosion of beaches and flood risk to bayfront communities. Eroded beaches, particularly those with exposed underlying peat and scarped dunes offer degraded habitat for wildlife in general.

The Federally listed species (threatened) under USFWS purview that may occur in the study area include the red knot (*Calidris canutus rufa*) and northern long-eared bat (*Myotis septentrionalis*). Section 7(a)(2) of the ESA requires every Federal agency to ensure that any action they authorize, fund or carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction of adverse modification of critical habitat.

Federally-listed threatened and endangered species under the jurisdiction of NMFS are known to occur in the vicinity of the study area. Pursuant to the ESA, the Corps is required to consult with NMFS on potential adverse effects to the species under NMFS purview that may result from implementing project activities.

<u>Northern long-eared bat</u>. A known maternity colony of the Federally-listed (threatened) northern long-eared bat occurs at the Supawna Meadows National Wildlife Refuge (Supawna NWR). This refuge was not evaluated as a potential project site. The species typically roosts underneath bark, crevices or hollows of both live and dead trees in summer. In winter, northern long-eared bats less predominantly hibernate in caves and abandoned mine portals. During the summer, this species typically roosts underneath bark or in crevices of both live and dead trees. Northern long-eared bats are also known to roost in structures such as buildings, barns, sheds or under eaves of windows (USFWS letter dated 2 February 2015). The USFWS has created a species-specific rule under authority of section 4(d) of the ESA that provides measures that are necessary and advisable for the conservation of the northern long-eared bat throughout its range, with the exception of removal from human dwellings by permitted individuals. The project site locations included in the TSP are beach habitat. The proposed plan will not impact surrounding saltmarsh vegetation, mature trees and buildings. The proposed project locations are not considered northern long-eared bat habitat; therefore, no impacts to the northern long-eared bat are anticipated.

<u>Red knot</u>. The final rule to list red knots as threatened under the ESA was 12 January 2015. Small numbers of red knots may occur in New Jersey year-round, while large numbers rely on Delaware Bay and Atlantic coast stopover habitats during the spring (May 1 through June 15) and fall (late-July through October) migration periods, respectively (USFWS, 2016). The shorebirds rely on these staging sites within the study area to feed and fuel the remaining leg of their >9,000 mile migration north to summer breeding grounds. Threats to the red knot include disturbance, reduced food availability at staging areas and loss of stopover habitat. Available records indicate that during spring migration red knots occur in the study area from Cohansey Point south to Cape May Canal (shoreline and marshes included) (USFWS, 2014).

The Corps is required to consult with USFWS for the protection of the red knot and its habitat pursuant to Section 7 of the ESA. USFWS has requested informal consultation by the USACE for activities related to the beneficial use of dredged material within the red knot foraging area. USFWS is currently preparing a proposed rule to designate critical habitat for the red knot. Portions of the study area may overlap with areas under consideration for proposed designation as critical habitat. To avoid delays or interruption of a project that might still be ongoing when the final critical habitat rule is published, USFWS recommends that the Corps request a conference opinion with USFWS for a project likely to adversely affect critical habitat, even if it may not rise to adverse modification. While consultation under Section 7 of the ESA is required when a proposed action may affect a listed species, a conference is required only if the proposed action is likely to jeopardize the continued existence of a proposed species or destroy or adversely modify proposed habitat. The conference process is discretionary for all other determinations besides jeopardy/adverse modification.

The No Action Plan is likely to impose adverse impacts on the red knot stopover habitat along the Delaware Bay as flooding and erosion of the beach will continue. The USFWS recommends that any activity that proposes to modify the beach, dune, mudflats, intertidal zone or marsh habitats adhere to a seasonal restriction extending from 15 April to 31 August to avoid impacts to horseshoe crabs. The horseshoe crab is not known to spawn beyond the western limits of Cumberland County (Lathrop *et al.*, 2006). The proposed TSP is not likely to result in adverse modification of critical red knot habitat. Beach nourishment is likely to improve eroded beach habitat utilized by red knots, although foraging areas will be reduced within the footprint of the groin. To avoid altering the preferred spawning beach profile for horseshoe crabs, dredged sand utilized will be similar to existing grain size dominated by coarse sandy sediments. The design template for the beach berm slope will be similar to that which occurs on beaches known for large horseshoe crab spawning congregations. The crabs spawn on bay beaches fronting residential development but will avoid spawning on beaches that have insufficient sand depth over peat (USFWS, 2016). The TSP will restore migratory bird foraging habitat and will provide both protection to human infrastructure while also decreasing the need for increased shoreline armoring or other structural stabilization that eliminates horseshoe crab habitat (USFWS, 2016).

<u>Piping plover</u>. A Federally-listed endangered species, the piping plover is a small migratory shorebird that may occur on Delaware Bay shorelines. There are no recent records of piping plovers present within the study area, most likely as a result of their development. As beach habitat evolves, either due to beach nourishment activities or storm washovers, wider beach berms may potentially attract piping plovers. USFWS does not cite the piping plover as a listed species expected to occur in the projected TSP project area.

<u>Bald eagles</u>. This species was removed from the Federal List of Endangered and Threatened Wildlife effective 8 August 2007. The bald eagle continues to be protected under the BGEPA and the MBTA. The bald eagle also remains a state-listed species under the New Jersey Endangered and Non-game Species Conservation Act (N.J.S.A. 23:2A *et seq.*), which carries protections under the state land use regulation program. These Federal and state laws prohibit take of bald eagles. There are several active nests of the bald eagle (*Haliaeetus leucocephalus*) within the Maurice River area and two active nests east of

Villas (USFWS, 2016). The No Action Plan and the TSP are not anticipated to result in any impact to bald eagles in the area.

Sea turtles. In the marine environment, several species of sea turtles are Federally listed as threatened or endangered under NMFS' jurisdiction and are known to migrate along the Atlantic Ocean coast, while some enter the Delaware Bay. These include the Loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempi*), Green sea turtle (*Chelonia mydas*), and the Leatherback turtle (*Dermochelys coriacea*). All are listed as endangered with the exception of the loggerhead turtle, which is listed as threatened. The No Action Plan is not expected to adversely affect sea turtles. The TSP is not anticipated to adversely affect sea turtle species on land as these species do not nest in the area. The furthest north that leatherbacks nest is southeastern Florida; Kemp's ridleys only nest in Mexico; and loggerheads nest as far north as Virginia. Nesting in the mid-Atlantic is generally rare. Sea turtles rarely frequent the intertidal and near shore shallow zone of the proposed construction area for the beach restoration alternatives. Sea turtles are capable of leaving the area during the temporary construction period.

Potential impacts near the construction area in the marine environment may result from elevated turbidity levels of the beach restoration alternatives that may impact foraging, migration or prey species, burial of prey species and noise due to project construction operations.

The loggerhead is the most abundant species of sea turtle in U.S. waters. They migrate north along the east coast as water temperatures warm in the spring and move back south in fall. They typically feed on benthic invertebrates in hard bottom habitats (NMFS and USFWS, 2008). Mansfield (2006) saw a decline from the 1980s to the 2000s in loggerhead spring residency in Chesapeake Bay and attributed it to significant declines in prey items such as horseshoe crabs and blue crabs. The Kemp's ridley is the least abundant of the world's sea turtle species. Suitable habitat occurs where there are available food resources (*e.g*. crabs, invertebrates), seagrass beds, oyster reefs, sandy and mud bottoms, and rock outcroppings (NMFS and USFWS, 2007). The Kemp's ridley utilizes Delaware Bay for foraging (Stetzar, 2002) but leave the area to migrate down the coast to the south Atlantic and Gulf of Mexico in fall. Green sea turtles are herbivorous and found in areas containing benthic algae and seagrasses. No sea grass beds occur in the proposed placement sites; therefore, green sea turtles will not use the areas for foraging. Seasonally, they are found in the Mid-Atlantic but are not common (Musick and Limpus, 1997; Morreale and Standora, 1998). Leatherback turtles have the widest distribution of all extant sea turtles species (from as far south as the Cape of Good Hope in Africa to as far north as Alaska and Norway. Leatherbacks feed in colder waters and primarily occur in open oceanic waters and considered rare in Delaware Bay.

In coordination with NMFS, USACE is required to have turtle deflector devices on the draghead of hopper dredges in lower Delaware Bay to reduce the risk of sea turtle entrainment. Although a NMFS-approved turtle monitor is not required on hydraulic cutterhead dredges, onboard observers are required on hopper dredges between 1 May and 15 November to monitor dredging activities. An observer trained in identifying biological material is also required to inspect the discharge basket on the beach. Sea turtles do not occur in the action area from December through April.

Atlantic Sturgeon. Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) are a long-lived (approximately 60 years), late maturing, estuarine-dependent anadromous species (Bigelow and Schroeder, 1953; Vladykov and Greeley, 1963; Dadswell, 2006; ASSRT, 2007). They can grow to over 14 feet in length and weigh up to 800 pounds (Pikitch *et al*., 2005). Spawning areas within the Delaware Estuary are not yet well defined, but believed to occur in flowing water above the salt line and below the fall line of the river (Shirey *et al*., 1999), well north of the proposed project placement areas. Larvae and young juveniles are believed to remain in the upper river portion of the estuary. Sub-adults and adults are more salt-tolerant and travel out of the Delaware Bay at the mouth to the Atlantic Ocean (Brundage and O'Heron, 2009), typically in late summer and early fall.

NMFS listed five Distinct Population Segments (DPSs) of Atlantic sturgeon under the ESA in 2012. Four were listed as endangered (New York Bight DPS, Chesapeake Bay DPS, Carolina DPS and South Atlantic DPS) and one was listed as threatened (Gulf of Maine DPS). The ESA also requires NMFS to designate critical habitat for listed species. Critical habitat is defined as specific areas within the geographical range occupied by the species that contain physical or biological features essential to their conservation. NMFS designated critical habitat from Maine to Florida for the Atlantic sturgeon on 16 August 2017. The final rule took effect on 18 September 2017. Approximately 340 miles of critical habitat was designated for the New York Bight DPS and includes the Delaware River.

The No Action Plan will not impact Atlantic sturgeon, and the species is not likely to be adversely impacted by beach placement operations of the beach restoration alternatives. The majority of impact studies conducted on the species assess potential dredging impacts, such as possible entrainment of cutterhead suction dredges or ship strikes by large vessels.

Burial of benthic invertebrate species will occur at the beach placement sites within the intertidal zone. Atlantic sturgeon are not expected to be in the shallow intertidal zone of the selected placement areas within the bay. Currently, numerous research activities are underway, involving NMFS and other Federal, State and academic partners, to obtain more information on the distribution, abundance and behavior of Atlantic sturgeon within the Delaware Estuary and other rivers of Mid-Atlantic Bight. The project is not expected to adversely impact Atlantic sturgeon as the species is not likely to occur in the shallow water nearshore and intertidal area of the bay where placement operations will occur. Additionally, the project locations are located south of the designated critical habitat of the Delaware River.

Shortnose sturgeon. Juvenile and adult shortnose sturgeon (*Acipenser brevirostrum*), an endangered species, generally remain in the freshwater portions of the Delaware River above the saltwater/freshwater interface, moving upstream in spring and summer and downstream during fall and winter. Telemetry data has shown, however, that shortnose sturgeon make localized coastal migrations, although not the significant marine migrations seen in Atlantic sturgeon. The NMFS concluded in their

B.O. (NMFS, 2015) that the presence of shortnose sturgeon is expected to be rare in the high salinity levels of Reach E, although an occasional shortnose sturgeon may occur in this reach between late April and mid-November.

Sturgeon are benthic feeders and are often found at or near the bottom in deeper waters while foraging and moving into rivers. However, information suggests that Atlantic sturgeon are up off the bottom while in offshore areas. Likewise, the species is not expected to travel in the shallower waters of the project's dredged material placement sites. The No Action Plan and the beach restoration alternatives, including the TSP, are not likely to adversely impact shortnose sturgeon.

Due to the possibility of encountering munitions and explosives of concern (MEC) or unexploded ordnance (UXO) within the lower Delaware Bay, screening is required on all dredges for beach nourishment projects by the USACE Philadelphia District. Beginning in 2007, dredges are outfitted with 1) a screening device placed on the dredge intake or in a pipeline section prior to reaching the dredge pump, and 2) a screen at the discharge end of the pipeline on the beach. The purpose of the screening is to prevent ordnance from being deposited on the beach by dredging. The screening device on the dredge intake prevents the passage of any material greater than 1.25 inches in diameter. The maximum allowable opening size is 1.25 inches by 6 inches. The screening device on the discharge end (on the beach) is designed to retain all items 0.75 inches in diameter and larger. Visual inspection of the screens and sand placement are performed at all times while material is being placed on the beach. Assuming use of a Hopper dredge, visual inspections of the interior and exterior of the beach basket are performed after each in-flow cycle. The use of munitions screens further reduces the likelihood of entrainment of fish or sea turtles (NMFS, 2014). No entrainment of Atlantic sturgeon, shortnose sturgeon or sea turtles has been observed in Reach E during the past dredging events in the May-November period. The reduced risk of entrainment in this reach is likely due to the width of the bay and the relatively small area, by comparison, of the dredging area to the known use of areas outside of the channel.

NMFS concluded in their most recent B.O. (NMFS, 2015) for the MCD project that no Atlantic or shortnose sturgeon are likely to be injured or killed during hopper dredging operations in Reach E.

As presented in Section 4.4.2, water quality impacts are anticipated to be minor and temporary at the placement locations. No information is available on the effects of TSS on sea turtles, but studies on the effects of turbid waters on fish suggest that concentrations of TSS can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton, 1993). Temporary turbidity plumes from beach placement operations may affect turtle behavior or turtle prey behavior but turtles are highly mobile and are likely to avoid areas of increased suspended solids.

Some marine mammals may be classified as threatened or endangered species, but all fall under the jurisdiction of the Marine Mammal Protection Act. The marine mammal species that are commonly encountered in the Delaware Estuary or traveling past the mouth of the Delaware Bay within the Atlantic Ocean are bottlenose dolphin (*Tursiops truncatus*), harbor porpoise (*Phocoena phocoena*), humpback whale (*Megatera novaeangliae*), harbor seal (*Phoca vitulina concolor*) and gray seal (*Halichooerus grypus*). Species not commonly sighted but could possibly utilize the lower estuary are pygmy sperm whale (*Kogia breviceps*), long-finned pilot whale (*Globicephala melaena*), fin whale (*Balaenoptera physalus*), northern right whale (*Eubalaena glacialis*), harp seal (*Cystophora cristata*) and ringed seal (*Poca hispida*).

Marine mammals would be expected to avoid dredging operations within the Delaware Bay. Section 7 of the ESA, as amended, requires Federal agencies to consult with the NMFS to ensure that the action carried out is not likely to jeopardize the continued existence of any endangered species or threatened species or adversely modify or destroy designated critical habitat. In the 2015 BO for the MCD, NMFS noted that although several whale species listed under their jurisdiction occur seasonally off the Atlantic coast of Delaware, and occasional transient right and humpback whales have been observed near the mouth of the Delaware Bay, no listed whales are known to occur in the proposed placement areas. The USACE Philadelphia District coastal dredging projects, as a rule, require the dredge and tender vessels to reduce transit speeds to 4 knots or less if any marine mammals, sea turtles or sturgeon are observed at the surface within 400 meters.

The USACE Philadelphia District has conducted formal Section 7 consultation with the NMFS several times for the MCD project and subsequent maintenance of the 45-foot channel. The MCD consultation encompassed the entire 100 river mile length of the deepening project, including Reach E where the present beneficial use of dredged material project dredging and placement operations are proposed.

Potential impacts due to dredging operations are evaluated in detail in NEPA reports prepared for the MCD project. In the most recent BO for the MCD project (November 2015), NMFS concluded that the proposed deepening is likely to adversely effect, but not likely to jeopardize the continued existence of endangered shortnose sturgeon, the threatened Gulf of Maine Distinct Population Segment (DPS) of Atlantic sturgeon, the threatened Northwest Atlantic DPS of loggerhead sea turtle or endangered Kemp's ridley sea turtle. The NMFS also concluded that the proposed action may affect, but is not likely to adversely affect endangered Carolina DPS of Atlantic sturgeon, endangered green sea turtles or endangered leatherback sea turtles. The BO specifies reasonable and prudent measures (RPMs) to be taken, necessary to minimize and monitor take of shortnose and Atlantic sturgeon and sea turtles. Since the proposed action to beneficially use dredged material from Reach E of the main channel within Delaware Bay is a modification to the original dredged material disposal plan, the USACE has re-initiated Section 7 consultation with NMFS. The USACE will abide by NMFS' RPMs and terms and conditions as specified through re-initiation of consultation.

5.4 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

Beach placement activities (i.e. the TSP or the beach restoration with hardened structure alternatives) are not expected to result in the identification and/or disturbance of HTRW, as it has been found that coarse-grained material like sand in a high-energy area is unlikely to be contaminated with HTRW (USACE, 1994). Although the potential is low, small caliber UXO may be encountered during dredging operations, although unlikely considering that this Reach of the channel has most recently been dredged previously in 2015/2016, during the MCD project. As a safety precaution, the Corps requires that a screen be placed over the drag head to effectively prevent any of the UXO from entering the hopper and also on the discharge pipe "basket" on the beach, before the sand is subsequently placed on the beach. In the event that UXO is encountered during dredging, the screening will all but eliminate the possibility of any UXO remaining on the new beach after construction.

The contractor would be responsible for proper storage and disposal of any hazardous material such as oils and fuels used during the dredging and beach nourishment operations. The U.S. EPA and U.S. Coast Guard regulations require the treatment of waste (*e.g*., sewage, gray water) from dredge plants and tender/service vessels and prohibit the disposal of debris into the marine environment. The dredge contractor will be required to implement a marine pollution control plan to minimize any direct impacts to water quality from construction activity.

As stated in Section 4.7, no reported HTRW-related impacts were found to have the potential to adversely affect either the No Action Plan or the proposed beachfill projects at the 3 dredged material placement locations.

5.5 AIR QUALITY

Air quality is generally good in the Delaware Bay region. No impacts to air quality would result from the No Action Plan. Emissions of criteria pollutants, greenhouse gases, and other hazardous air pollutants would result from the beach restoration alternatives, including the TSP, due to the operation of the dredge pumps and coupled pump-out equipment, dredge propulsion engines, tugs, barges, and support vessels used in the placement and relocation of mooring buoys. In addition, air emissions would result from bulldozers, trucks, and other heavy equipment used in the construction of the berm and dune. Carbon monoxide and particulate emissions at the project site, during construction, may be considered offensive; but are generally not considered far-reaching. Exhaust from the construction equipment will have an effect on the immediate air quality around the construction operation but should not impact areas away from the construction area. These emissions will subside upon cessation of operation of heavy equipment.

The 1990 Clean Air Act Amendments include the provision of Federal Conformity, which is a regulation that ensures that Federal Actions conform to a nonattainment area's State Implementation Plan (SIP) thus not adversely impacting the area's progress toward attaining the National Ambient Air Quality Standards (NAAQS). The study area of the Delaware Bay encompasses two counties: Cumberland and Cape May County, which are part of the Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE marginal areas that did not attain EPA's 2008 standards by 20 July 2015 (oxides of nitrogen NOx and volatile organic carbons VOCs).

There are two types of Federal Conformity: Transportation Conformity and General Conformity. Transportation Conformity does not apply to the proposed construction projects because they are not funded with Federal Highway Administration money and they do not impact the on-road transportation system. General Conformity typically applies to USACE beach projects, however, maintenance dredging activities are exempt from General Conformity review under 40 CFR Ch 1 Sec 93.153(c)(2)(ix): "*(c) The requirements of this subpart shall not apply to the following Federal actions: (2)(ix) Maintenance dredging and debris disposal where no new depths are required, applicable permits are secured, and disposal will be at an approved disposal site.*"

CEQ 2014 guidance on the consideration of greenhouse gases (GHGs) in NEPA reviews does not mandate mitigation, only consideration of climate change during the alternatives evaluation screening, and the effects of the proposed action on climate change. The No Action Plan would pose no impact on GHG. Maintenance dredging will continue to occur with or without the current proposed plan. However, the future implications of climate change will likely pose significant adverse effects in the study area on both coastal storm risk to communities and loss of beach habitat under the No Action scenario. The structural alternatives and the TSP would similarly pose impacts on GHG in the study area by contributing construction equipment emissions. All of the remaining CSRM alternatives respond to severe storm actions that erode beaches along the Delaware Bay shoreline. The degree to which the TSP impacts GHGs is dependent on the duration of the construction period (i.e. the amount of construction equipment emissions). Beach nourishment alone (Villas) would emit less emissions than beach nourishment with a terminal groin (Gandys Beach and Fortescue) since the latter requires additional equipment and duration of operations. Cumulative emissions are reduced because the current study intends to beneficially use sand that will be dredged during maintenance operations of the main navigation channel. Combining these projects reduces GHG emissions as the primary contributor: the dredge is mobilized once to accomplish two goals-maintenance dredging for navigation and coastal storm risk management on beaches. Additionally, the TSP entails dune grass planting which serves to reduce GHGs through carbon sequestering.

5.6 NOISE

No additional noise will result from the No Action Plan over existing and natural background noise levels. The TSP will generate additional noise at the dredged material placement sites as construction will consist of the sound of dredged material passing through pipes and discharging in a plume of water. Earth-moving equipment, such as bulldozers, will shape the newly deposited dredged material and produce engine noise in the nearby vicinity. Utilizing heavy earth-moving machinery fitted with approved muffling apparatus reduces noise and vibration impacts.

Several researches have examined the effects of human-related noise and activities on wildlife. Burger (1981) examined the direct and indirect effects on birds at a coastal bay refuge along the Atlantic coast. In a refuge, people are present daily for various activities such as birdwatching, fishing or walking. Burger noted that human activities involving rapid movements or close proximity to birds caused them to flush. Slow-moving or low consistent sounds, resulted in far less birds flushing. Fletcher and Busnel (1978) assembled a number of studies of noise impacts on a variety of species. For marine species, acoustical signaling is an important means of communication over long distances. Ship traffic is the predominant source of underwater noise, except under heavy sea conditions when natural noise predominates. As with human reactions, they found that abrupt loud noises (*i.e.* a sonic boom or siren) will cause wildlife alarm reactions more so than human-induced noises of a consistent pattern, such as repeating take-offs and landings at a busy airfield where wildlife (birds, rabbits, *etc.*) grow accustomed to the routine noises. Familiar anthropomorphic noises are also known to attract wildlife. In Norway and Sweden, steam-engines attracted elk to the railroad lines, while bison were attracted to railway engines in the U.S. This necessitated the fitting of cow-catchers on the train engines. At sea, some porpoise and dolphin species are attracted to moving ships. The researchers concluded that many animal species acclimate to continuous and intermittent sounds of 100 dB or less.

Popper and Hastings (2009) evaluated multiple studies conducted on the effects of pile driving noise on the health and well-being of fish. Unlike the low continual hum of dredging, underwater pile driving sounds are characterized by multiple rapid increases and decreases in sound pressure over a very short period of time. Fish mortality has been observed in areas of pile-driving, with a number of fish showing bleeding and damage to the swim bladder. In controlled studies of exposing caged fish to pile-driving noise (Abbott *et al.*, 2005; Ruggerone *et al.*, 2008; Nedwell *et al.*, 2006) results showed no difference in mortality or pathology or behavioral differences in fish. Other researches address noise impacts to marine mammals as well as fish and have documented that sounds can adversely impact behavior, hearing and physiology, depending on distance from the sound source (Popper, 2003; Popper *et al.*, 2004; Popper and Hastings, 2009; Houghton and Mundy, 1987; Goertner *et al.*, 1994; Govoni *et al.*, 2008).

Based upon data collected by Reine *et al*. (2014) for dredging operations, sediment removal and the transition from transit to pump-out produce the highest sound levels from larger suction dredges at an estimated source level (SL) of 172 decibels (dB) at 3 feet. The sediment removal operation will occur 6-7 miles offshore in the bay's center. The two quietest activities would be seawater pump-out (flushing pipes) and transiting (unloaded) to/from the placement site, with expected SLs of approximately 159 and 163 dB at 3 feet, respectively. Based upon attenuation rates observed by Reine *et al*. (in prep.), it would be expected that at distances approximately 1.6-1.9 miles from the source, underwater sounds generated by the dredges would attenuate to background levels. However, similar to in-air sounds, wind (and corresponding sea-state) would play a role in dictating the distance to which project-related underwater sounds would be above ambient levels and potentially audible to nearby receptors. Underwater noise levels exceeding 160 dB could harass marine mammals.

5.7 CULTURAL RESOURCES

Due to the moderate potential for significant archaeological sites at both Gandys Beach and Fortescue, steps should be taken in order to minimize potential impacts. Field inspection involving a systematic pedestrian survey that includes field collection and feature recordation of the tidal zone and shoreline within the APEs is recommended. If sites are found, steps should be taken in order to minimize project impacts during construction. Monitored construction of the project will ensure a No Adverse Effect to significant archaeological sites and ultimately serve to protect these sites from further erosion.

The towns of Gandys beach and Fortescue may have historic structures, and may be determined as historic districts. A full historic architectural assessment needs to be completed in order to determine if the projects will impact historic properties, either directly or visually.

The Villas will require a more in depth analysis of both archaeological and historic structures to determine if the project will have an adverse effect. A comprehensive Phase IA/B is needed for archaeology, and an historic architectural assessment will need to be conducted to determine if the project will have any impact to historic structures at the Villas.

5.8 SOCIOECONOMIC RESOURCES

Erosion and flooding are the primary coastal hazards that adversely impact the estuarine shoreline and lead to the loss of lives or damage to property and infrastructure in developed coastal areas. One of the greatest threats from coastal storms is flooding caused by storm surge. Coastal flooding is the inundation of land along the estuarine or oceanic shoreline by seawaters above the normal tidal range, resulting in significant economic loss through the destruction of buildings, roads, infrastructure, natural resources and wildlife habitats.

For the No Action Plan, future maintenance dredging sand from Lower Reach E will be placed at Buoy 10 open water disposal site for approximately 10 more years, based on the projections for additional capacity. Beyond this, dredging sand from Lower Reach E will be placed at Artificial Island CDF, per the Federal Standard for the least-cost, environmentally acceptable disposal location.

The No Action Plan is likely to have an adverse impact on the local economy, social structures and quality of life within the local bayshore communities. Failure to restore and maintain coastal beaches which reduce risk to homes and adjacent wetlands will likely result in increases in damages from storm surges. Flood-related damages to infrastructure and nearby croplands will continue to occur. Crops typically have a low tolerance to salinity so if salinity intrusion of floodwaters continues to occur during significant storm events, interior field productivity and quality would decrease. Mature stands of trees may also die due to saltwater intrusion. Conversion of emergent marsh to large un-vegetated open water and mud flat due to overly frequent inundation would result in a diminished capacity of the surrounding areas to support fish and wildlife populations. Wildlife-dependent recreational activities in state wildlife refuge lands located behind the narrow barrier bayfront beaches, such as hunting, fishing, wildlife observation and general enjoyment of natural spaces would be adversely affected with the continued loss of wetlands and habitat diversity through erosion and inundation.

The TSP will provide more resilient beaches that would reduce risk to the residential communities, adjacent salt marshes, interior freshwater wetlands, forests and pond habitats for wildlife. The inclusion of a hardened structure (terminal groin) was found to be necessary at Gandys Beach and Fortescue based on their geographic orientation, longshore sediment transport and the communities' proximity to inlets. Local long-term beneficial impacts to the socioeconomic environment would be realized from the placement of dredged material to create a robust beach berm and dune system. Ecosystem services to humans provided by beach restoration include erosion control, water quality enhancement, storm protection, habitat provision for wildlife and recreation.

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. All interested parties and residents have equal access to the current report review and comment process. Appropriate measures will be taken to ensure consistency with local, regional, state and Federal regulations. All of the alternative plans, including the TSP, would achieve the same degree of protection from environmental and health hazards for all races, ethnicities and income levels. Implementation of the TSP is not anticipated to result in any significant or negative human health or safety impacts. None of the alternatives will have a disproportionately high adverse effect on minority or low income populations. The TSP is in compliance with EO 12898. The project would generally have beneficial social and economic effects and would generally affect all persons equally.

Protection of Children. Appropriate measures will be taken to ensure the protection of children by assessing the health and safety risks of the proposed project that could disproportionately affect children. Appropriate safety buffer zones will be established around construction activities with effective fencing and other barriers.

5.9 CUMULATIVE IMPACTS

Cumulative impacts are defined in 40 CFR 1508.7 as those effects that result from:
…the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Table 22 summarizes the impact of cumulative actions by identifying the past, present and reasonably foreseeable future condition of the various resources which are directly or indirectly impacted by the proposed action and its alternatives. The table also illustrates the with-project and without-project condition (the difference being the incremental impact of the project). Also illustrated is the future condition with any reasonable alternatives (or range of alternatives).

Unavoidable Adverse Environmental Impacts. Unavoidable adverse environmental impacts associated with beach placement operations include temporary loss (burial) of benthic organisms in the beach, intertidal and shallow nearshore zone. Temporary water quality impacts result from the suspension of sediments during pump out. Species of relatively non-motile infaunal invertebrates that inhabit the placement area will be buried. Motile organisms such as fish and crabs should be able to escape. Many of those species that are not able to escape the construction area are expected to recolonize after project completion from adjacent similar habitat.

Impacts attributed to the construction of a terminal groin at Gandys Beach and the rehabilitation of the terminal groin at Fortescue include a permanent loss of benthic organisms within the groin footprint, temporary water quality impacts during construction and the reduction of alongshore currents with an accumulation of material on the updrift side of the groin. The addition of a terminal groin increases habitat heterogeneity within a soft bottom habitat by providing a hardened structure for sessile encrusting organisms to adhere to as well as provide refugia and foraging habitat for fish within the intertidal and nearshore shallow water zones.

In Delaware Bay, dredged material from Miah Maull and Brandywine Ranges is predominantly coarse to medium grained clean sand and will be used for beneficial purposes for beach nourishment to reduce flood risks and to enhance wildlife habitat and recreational use. While there would be environmental disturbance during construction, the completed projects will create more productive healthy coastal habitat and CSRM to communities.

Table 22 - Impacts of Cumulative Actions

	Past (baseline condition)	Present (existing condition)	Future without project	Future with Proposed Action
Sand Resources	Historically, the bay shoreline was larger in the past, extending several hundred feet further seaward in the project area. The losses have accelerated since 1937.	The beaches have experienced erosion with each significant storm event. The estuary is "sediment-starved" due to heavy shoreline development in the upper estuary and decades of dredged material placement in CDFs.	Material from Lower Reach E navigational channel will continue to be periodically dredged, and the material will be placed overboard at Buoy 10 and once filled, at the Artificial Island CDF. Bulkheads or seawalls may be required to protect bayfront residences in the project area.	High quality sand dredged from the navigation channel in Lower Reach E will be deposited onto Bayfront developed beaches to reduce flood risk and coastal erosion. The TSP does not pose adverse impact to existing shoreline stabilization features.
Fish and Wildlife Species	More abundant and widespread prior to development.	Some species have continued to suffer with loss of habitat from erosion (*e.g.* horseshoe crabs, migratory shorebirds).	Increased erosion in the future without project condition will cause beach habitat to continue to erode.	Individuals may be temporarily affected by dredging and placement activities; improved coastal habitat is sustained for life of project. The TSP poses positive impacts through restoration of natural beach habitat.
Water Quality	Pristine prior to development and farming runoff. Subsequent decline in water quality.	Water quality has improved since the 1970s but still some degradation due to anthropogenic actions.	No change to present condition; no known projects in the vicinity that would cause a decline in water quality.	Temporary increases in local turbidity due to construction; no long-term change; no adverse impacts to overall water quality.

Short Term Uses of the Environment and Long-Term Productivity. The Delaware River port complex is considered to be the world's busiest freshwater port. The navigation channel requires periodic dredging in areas that shoal. These periodic dredging events play a significant role in keeping the ports competitive with others in the United States. Future maintenance dredging sand taken from the navigation channel in lower Reach E would be placed at the Buoy 10 open water disposal site. Buoy 10 is estimated to be at or near capacity; however, USACE intends to expand the footprint and gain an additional 10 years capacity via a revised Water Quality Certificate from NJDEP. Once Buoy 10 is filled to capacity, future maintenance dredging sand would need to be transported and disposed at the nearest CDF (Artificial Island) located approximately 40 miles to the north. Placement at either Buoy 10 or Artificial Island provides no economic or environmental benefits to the proposed beach placement sites. However, beneficial use of the high quality clean sand dredged from Lower Reach E placed on eroding beaches provides substantial economic and environmental benefits.

Short-term use of the natural environment would be to achieve long-term productivity of the Delaware River ports and increased CSRM to Bayfront communities. Dredging and placement operations both place some stress on the aquatic environment (*i.e.* elevated turbidity and loss of benthic resources) with limited long-term effects.

Irreversible and Irretrievable Commitments of Resources.
An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost permanently. An irretrievable commitment of resources is one in which opportunities to use or enjoy the resources as they presently exist are lost for a period of time due to decisions to mandate the resource for another purpose. Beach placement operations would involve utilization of time and fossil fuels, which are irreversible and irretrievable. Adverse environmental impacts associated with placement operations are short-term in nature and will subside after construction is completed. Placement of dredged material at the beneficial use sites is not irreversible. The project would provide added CSRM to Bayfront communities from severe storm events but is not irreversible as storms will continue to occur, and in combination with SLC, continue to erode the shoreline.

6 PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION*

6.1 Public Involvement Program

To announce the scoping phase of the feasibility study, a NEPA scoping letter was issued on 24 November 2014. The recipients were informed of the purpose and scope of the feasibility study and were invited to provide input to the feasibility, including the scoping of the environmental issues that should be addressed throughout the study. Following the 31 March 2015 Alternatives Milestone meeting an additional NEPA scoping letter was issued on 27 April 2015.

6.2 Institutional Involvement

6.2.1 Agency Coordination

This feasibility study has been coordinated with the following agencies: the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the U.S. Environmental Protection Agency (EPA), and the New Jersey Department of Environmental Protection (NJDEP).

6.2.2 Compliance with Environmental Requirements

This section provides detailed discussion of agency coordination and associated environmental requirements.

6.2.2.1 National Environmental Policy Act of 1969 (NEPA)

This feasibility report documents alternative plans evaluated and the effects of the alternative plans, including the TSP, and contains an integrated Environmental Assessment. It will be subject to public review and comment for a 45-day period. This public coordination and environmental impact assessment complies with the intent of NEPA. The TSP is in compliance with the National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321, *et seq*. P.L. 91-190.

6.2.2.2 Endangered Species Act of 1973

The TSP falls under the scope of the 20 November 2015 Biological Opinion Re-initiation – Deepening of the Delaware River Federal Navigation Channel (NMFS, 2015). Consultation was reinitiated on 16 August 2016 with NMFS with the submittal of a Biological Assessment for the modification to beneficially use the dredged material from Lower Reach E to place on the Bayfront beaches identified in the TSP for this study. The project will adhere to the reasonable and prudent measures (RPMs) provided in the Biological Opinion (NMFS, 2017) and terms of conditions necessary to minimize impacts to shortnose and Atlantic sturgeon, sea turtles and whales. Pursuant to section 4(d) of the ESA, the project will not impact designated critical habitat for the New York Bight DPS of Atlantic sturgeon.

Coordination with the USFWS New Jersey Field Office (NJFO) was initiated on 24 November 2014. Consultation has been re-initiated and will be completed with USFWS review of the draft report. Coordination with USFWS will be finalized prior to construction. This feasibility study is in compliance with the Endangered Species Act of 1973, as amended, 16 U.S.C. 1531, *et seq.* P.L. 93-205.

6.2.2.3 Fish & Wildlife Coordination Act of 1958

Coordination with the USFWS for FWCA reports was initiated on 15 July 2015. The scope of work was finalized on 11 September 2015. A Planning Aid Report was received from USFWS on 08 July 2016. A final 2(b) report will be completed by the USFWS and submitted to USACE prior to finalization of the feasibility report and integrated environmental assessment. The feasibility study is in compliance with the Fish & Wildlife Coordination Act of 1958.

6.2.2.4 National Historic Preservation Act of 1966 (INTER ALIA)

The TSP is in compliance with Section 106 of the National Historic Preservation Act, as amended (P.L. 89-665). As part of the requirements and consultation process contained within the National Historic Preservation Act implementing regulations of 36 CFR 800, this TSP is also in compliance.

6.2.2.5 Clean Water Act of 1972

A Section 401 water quality certification application will be submitted to the New Jersey Department of Environmental Protection (NJDEP) and USACE will obtain this certification prior to construction. All state water quality requirements would be met. A Section 404(b)(1) evaluation is included in this report. The feasibility study is in compliance with the Clean Water Act of 1972.

6.2.2.6 Clean Air Act of 1972

The short-term impacts from the construction equipment associated with the TSP will not significantly impact air quality. The requirements of this rule are not applicable to this TSP because the project is exempt from the General Conformity requirement under 40 CFR Ch. 1 Sec. 93.153(c)(2)(ix) for maintenance dredging activities.

6.2.2.7 Coastal Zone Management Act of 1972

Coordination with the NJDEP requires Federal agencies to follow the state's coastal management policies to obtain Federal consistency under the Coastal Zone Management Act (CZMA). USACE has determined that the TSP is consistent with the CZMA concerning acquisition of a Section 401 Water Quality Certificate and other state authorizations. The draft feasibility report and integrated EA and Section 404(b)(1) Evaluation have been submitted to the state in lieu of a summary of environmental impacts to show consistency with the CZMA. A Federal consistency determination in coordination with 15 CFR 930 Subpart C will be obtained from the NJDEP prior to construction. Based on the information contained in the scoping notice and comments provided by their reviewing agencies, the state had no objections to the proposed activities.

6.2.2.8 Farmland Protection Policy Act of 1981

No prime or unique farmland would be impacted by implementation of this TSP. This Act is not applicable to this project.

6.2.2.9 Wild and Scenic River Act of 1968

No designated Wild and Scenic river reaches would be affected by project-related activities. This Act is not applicable to this project.

6.2.2.10 Marine Mammals Protection Act of 1972

USACE does not anticipate the take of any marine mammals during any activities associated with the TSP. Should a hopper dredge be utilized, a trained government-certified sea turtle and marine mammal observer will be stationed on the dredge during all water-related construction activities. Appropriate actions will be taken to avoid adverse effects to listed and protected marine mammal species during project construction, including all terms and conditions and reasonable and prudent measures provided by NJDEP and NMFS. Therefore, this project is in compliance with this Act.

6.2.2.11 Estuary Protection Act of 1968

In the Estuary Protection Act of 1968, Congress declared that "many estuaries in the United States are rich in a variety of natural, commercial and other resources, including environmental natural beauty, and are of immediate and potential value to the present and future generations of Americans." This Act is intended to protect, conserve and restore estuaries in balance with developing them to further the growth and development of the Nation. The TSP proposes to beneficially use sand material dredged from the Delaware River Main Channel to restore eroded Bayfront barrier beaches. No development will occur. The project will provide a positive benefit to the Delaware Estuary by keeping the dredged sand within the lower estuarine system and will provide a sand source to neighboring undeveloped beaches through natural longshore transport processes. Therefore, this TSP is consistent with the purposes of this Act.

6.2.2.12 Federal Water Project Recreation Act

This Act provides funds for land acquisition or directs non-Federal agencies to administer project land and water areas for recreation and fish and wildlife enhancement. In addition, while investigating and planning a federal navigation, flood control reclamation, hydroelectric or multiple-purpose water resource project, full consideration must be given to the opportunities when the project affords for outdoor recreation and fish and wildlife enhancement. This TSP is consistent with the purposes of this Act.

6.2.2.13 Magnuson-Stevens Fishery Conservation and Management Act of 1976

Coordination with NMFS to initiate consultation under the Magnuson-Stevens Fishery Conservation and Management Act began on 22 December 2014. An Essential Fish Habitat Assessment was prepared for the Delaware River Main Channel Deepening Project (the dredged material source) as well as for the current EA (beneficial use placement areas). NMFS identified fish species with Essential Fish Habitat Management Plans; identified ESA species and recommended avoiding sturgeon spawning habitat in the upper Delaware River. NMFS advised that general time of year restrictions could be revised upon review of the draft feasibility report and environmental assessment description of the TSP and its potential impacts. The TSP is being coordinated with NMFS and is in compliance with the Act.

6.2.2.14 Submerged Lands Act of 1953

The project would occur on submerged lands of the State of New Jersey. The project is being coordinated with the State and is in compliance with the Act.

6.2.2.15 Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990

The Coastal Barrier Resources Act (CBRA) and the Coastal Barrier Improvement Act of 1990 (CBIA) limit Federally subsidized development within CBRA System Units to limit the loss of human life by discouraging development in high risk areas, to reduce wasteful expenditures of Federal resources and to protect the natural resources associated with coastal barriers. No CBRA System Units will be impacted by the proposed TSP beneficial use sites. The TSP is in compliance with the Coastal Barrier Resources Act.

6.2.2.16 Rivers and Harbors Act of 1899

The Rivers and Harbors Act addresses river and harbor projects and activities within navigable waters. The proposed action will beneficially use dredged material from the bay portion of the authorized Philadelphia to the Sea Delaware River Navigation Channel to place on Bayfront beaches rather than disposal at Buoy 10 or an upland CDF. The TSP is in compliance with this Act.

6.2.2.17 Anadromous Fish Conservation Act

This Act authorizes the Secretaries of the Interior and Commerce to enter into cooperative agreements with the states and other non-Federal interests for conservation, development and enhancement of anadromous fish and to contribute up to 50 percent as the Federal share of the cost of carrying out such agreements. As this project is not receiving funding for these purposes, this Act does not apply.

6.2.2.18 Migratory Bird Treaty Act and Migratory Bird Conservation Act

Migratory birds would be minimally affected by dredging at the proposed sand source locations. USACE will include the standard migratory bird protection requirements in the project plans and specifications and will require the contractor to abide by those requirements. USACE will comply with all reasonable and prudent measures as advised by the USFWS. Nourishment activities at the beach placement sites will be monitored during the nesting season to protect nesting migratory birds. If nesting activities occur within the construction area, appropriate buffers will be placed around nests to ensure their protection. The TSP is in compliance with these Acts.

6.2.2.19 Marine Protection, Research and Sanctuaries Act (Ocean Dumping Act)

The term "dumping" as defined in the Act (3[33 U.S.C. 1402](f)) does not apply to the disposal of material for beach nourishment or to the placement of material for a purpose other than disposal. The disposal activities addressed in this EA have been evaluated under Section 404 of the Clean Water Act.

6.2.2.20 Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970

The purpose of this Act (PL 91-646) is to ensure that owners of real property to be acquired for Federal and Federally assisted projects are treated fairly and consistently and that persons displaced as a direct result of such acquisition will not suffer disproportionate injuries as a result of projects designed for the benefit of the public as a whole. No acquisition of real property was considered. Therefore, this project does not involve any real property acquisition or displacement of property owners or tenants. Therefore, this Act is not relevant to this project.

6.2.2.21 Executive Order 11990, Protection of Wetlands

No wetlands would be affected by the TSP. The plan is in compliance with the goals of this Executive Order.

6.2.2.22 Executive Order 11988, Floodplain Management

Executive Order 11988 requires federal agencies to avoid, to the extent possible, the long and short term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities.

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

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).** The proposed action is within the base floodplain; however, the project is designed to reduce damages to property and infrastructure located landward of the proposed project.
2. **If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or location of the action in the base flood plain.** Chapter 3 of this document presents an analysis of potential alternatives. Practicable measures and alternatives were formulated and evaluated against Corps of Engineers guidance, including non-structural measures.
3. **If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.** There has been extensive coordination with pertinent Federal, State and local agencies. The draft report was released for public review on 18 October 2017.
4. **Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.** The anticipated impacts associated with the TSP are summarized in Chapter 5 of this report. Beneficial use of dredged material (consisting of predominantly coarse to medium-grained clean sand) for placement on sandy beaches along the Delaware Bay will not only reduce flood risks, but will restore or enhance the natural bayshore habitat. The nourished sandy beach will reduce damages to fish, wildlife and other natural resources within this coastal barrier system through restoration of habitat lost to erosion.
5. **If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.** The project provides benefits solely for existing and previously approved development, and is not likely to induce development.
6. **As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the No Action Alternative.** There is no mitigation to be expected for the selected plan. The project will not induce development in the flood plain and the project will not negatively impact the natural or beneficial flood plain values. Chapter 3 of this report summarizes the alternative identification, screening and selection process. The No Action Alternative was included in the plan formulation phase.
7. **If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.** The Draft Feasibility Report and Integrated Environmental Assessment was provided for public review on 18 October 2017. Each comment received will be addressed and, if appropriate, incorporated into the Final Report. A record of all comments received will also be included in the Pertinent Correspondence Appendix.
8. **Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.** The recommended plan is the most responsive to all of the study objectives and the most consistent with the executive order.

6.2.2.23 Executive Order 12898, Environmental Justice

On February 11, 1994, the President of the United States issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. The Executive Order mandates that each Federal agency make environmental justice part of the agency mission and to address, as appropriate, disproportionately high and adverse human health or environmental effects of the programs and policies on minority and low-income populations.

The TSP is expected to result in coastal storm risk management benefits to residents of all socioeconomic status. The beneficial effect of a wider, more sustainable beach and dune would benefit all members of the public who are able to obtain transportation to access the beach. The storm damage reduction benefits are primarily benefiting the landowners in this area. There are no disproportionate adverse impacts to minority or low income populations resulting from the implementation of the TSP.

6.2.2.24 Executive Order 13045, Disparate Risks Involving Children

On April 21, 1997, the President of the United States issued Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*. The Executive Order mandates that each Federal agency make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and ensure that its policies, programs, activities and standards address disproportionate risks to children that result from environmental health risks or safety risks. As the TSP does not affect children disproportionately from other members of the population, the proposed action would not increase any environmental health or safety risks to children.

7 LIST OF PREPARERS

The project delivery team (PDT) prepared the report and consisted of the following people:

Table 23 – Project Delivery Team

Name	Discipline
Scott Sanderson	USACE – Project Manager
Barbara Conlin	USACE – Environmental Coordinator
Preston Oakley	USACE – Economics
Robert Hampson	USACE – Hydrology & Hydraulics
Nicole Minnichbach	USACE – Cultural Resources
Patrick Falvey	USACE – Civil Design
Derek Martowska	USACE – Geotechnical Engineering
William Harris	USACE – GeoEnvironmental
Alfredo Montes	USACE – Cost Engineering
Heather Sachs	USACE – Real Estate
Steve Long	USACE – GIS & Floodplain Management
William Dixon	NJDEP – Non-Federal Sponsor
Glenn Golden	NJDEP – Non-Federal Sponsor
Robert VonBriel	NJDEP – Non-Federal Sponsor

8 IMPLEMENTATION REQUIREMENTS

8.1 Institutional Requirements

The completion of the feasibility study and recommendation by the District Engineer are the first steps toward implementing the design and construction of the CSRM project along the New Jersey shoreline of the Delaware Bay. Upon approval by USACE's ASA (CW), the project will be considered for design and construction with funding made available through P.L. 113-2 and/or a Water Resources Development Act (WRDA).

Upon receipt of Federal construction funds, USACE and the non-Federal sponsor would enter into a Project Partnership Agreement (PPA). This PPA would define the Federal and non-Federal responsibilities for implementing, operating and maintaining the project. The Total Project Cost (Fully Funded) of the CSRM project will be cost-shared 65% by the Federal government and 35% by the non-Federal sponsor. The non-Federal sponsor (NJDEP) must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

- Provide a minimum of 35% of initial project costs assigned to coastal and storm damage reduction, plus 100% of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits, and 50% of periodic nourishment costs assigned to coastal and storm damage reduction, plus 100% of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do provide public benefits, and as further described below:
    - Provide, during design, 35% of design costs allocated to coastal and storm damage reduction in accordance with the terms of the PPA entered into prior to commencement of design work for the project;
    - Provide all lands, easements, rights-of-way, including suitable borrow areas, and perform or assure performance of all relocations, including utility relocations, as determined by the Federal government to be necessary for the initial construction, periodic nourishment or operation and maintenance of the project;
    - Provide, during construction, any additional amounts necessary to make its total contribution equal to 35% of initial project costs assigned to coastal and storm damage reduction plus 100% of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;
- Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be required for the construction, operation, and maintenance of the project.
- Coordinate all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction, operation, or maintenance of the project.
- Coordinate mitigation and data recovery activities associated with historic preservation, that are in excess of one percent of the total amount authorized to be appropriated for the project.
- Operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and any specific directions prescribed by the government in the Operations, Maintenance, Replacement, Repair and Rehabilitation (OMRR&R) manual and any subsequent amendments thereto.
- Provide the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls for access to the project for the purpose of inspection, and, if necessary after failure to perform

by the non-Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal government shall operate to relieve the non-Federal project partner of the responsibility to meet the non-Federal project partner's obligations, or to preclude the Federal government from pursuing any other remedy at law or equity to ensure faithful performance.

- Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors.
- Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project 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 codes of Federal regulations (CFR) Section 33.20.
- As between the Federal government and the non-Federal project partners, the non-Federal project partner shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.
- Comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the uniform regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.
- 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 issue pursuant thereto, as well as Army regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted of Conducted by the Department of the Army.
- Participate in and comply with applicable Federal flood plain management and flood insurance programs and comply with requirements in Section 402 of the Water Resources Development Act of 1986, as amended.
- Not less than once each year inform affected interests of the extent of protection afforded by the project.
- Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the protection provided by the project.

- Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might hinder its operation and maintenance, or interfere with its proper function, such as any new development on the project lands or the addition of facilities which would degrade the benefits of the project.
- Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.
- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides the Secretary of the Army shall not commence the construction any water resources project or separable element thereof, until the non-Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.
- At least twice annually and after storm events, perform surveillance of the Line of Protection and determine any physical variances from the project design section and provide the results of such surveillance to the Federal government.
- Inform affected interests, at least annually, of the extent of protection afforded by the structural flood damage reduction features.
- 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.
- 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.

8.2 Implementation Schedule

Before design and construction may be initiated, the report must be approved and submitted to the Office of Management & Budget. Further, the PPA must be executed by USACE and the non-Federal sponsor. The following provides the current schedule for study approval and PPA execution:

Final Feasibility Report & Integrated EA to Corps Higher Authority for Approval	June 2018
Chief's Report submitted to ASA (CW)	February 2019
ASA (CW) Final Feasibility Report & Integrated EA Approval	August 2019
ASA (CW) submits report to OMB	August 2019
Final Report to Congress	August 2019
Start Plans and Specifications (Design Phase)	March 2020
Execute PPA with non-Federal Sponsor	March 2020
Finalize Plans and Specifications for Contract	November 2020
Real Estate Certification for Contract	February 2021

Ready to Advertise Contract	March 2021
Award Construction Contract with Notice to Proceed	October 2021
Complete Project Construction	June 2022

8.3 Cost Apportionment

As referenced above in Table 14 of Section 3.5.1, the total project cost is approximately $113,000,000. The cost sharing is 65% Federal and 35% non-Federal, which includes cash and credits associated with obtaining the required lands, easements, rights-of-way, and relocations (LERR). OMRR&R is a 100% non-Federal responsibility and is included in the calculation of annualized project costs for economic purposes. The Federal government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-Federal partner.

The non-Federal partner is responsible for all LERR costs and all OMRR&R costs.

Table 24 – Estimated Schedule of Federal and Non-Federal Expenditures

	Non-Federal Sponsor Contribution	Federal Contribution	Total Project Cost
LERRD	$7,986,835	N/A	$7,986,835
Cash	$31,664,825	$73,638,798	$105,303,623
Total	$39,651,660	$73,638,798	**$113,290,458**

8.4 Environmental Requirements

Requirements for Section 404 of the Clean Water Act of 1972, as amended, will be met prior to any construction activity. The completed 404(b)(1) guidelines form is included in Appendix D.

A Section 401 Water Quality Certification and a consistency determination under the Coastal Zone Management Act will be obtained from the State of New Jersey prior to project construction.

Requirements for the Endangered Species Act will be met with both USFWS and NMFS prior to construction. Coordination with the resource agencies has occurred. For NMFS, compliance was received under the Delaware River Main Channel Deepening Project Biological Opinion (BO).

8.5 Views of Non-Federal Sponsor

The NJDEP fully supports the TSP and its associated implementation requirements. While this TSP improves coastal protection along New Jersey's Delaware Bay shoreline, NJDEP requests that USACE continue to look at maximizing opportunities for coastal resilience in New Jersey's Delaware Bay. Specifically, NJDEP is aware that communities such as Reeds Beach, Pierces Point and Del Haven were not incrementally justified; however, they were economically justified when evaluated as components of a systematic solution, based on a continuous dredged material placement operation across 6 sites (Gandys Beach, Fortescue, Reeds Beach, Pierces Point, Del Haven and Villas). NJDEP recognizes that the TSP will undergo optimization and requests that the aforementioned systematic-benefits and their associated regional economic and social impacts be strongly considered before finalization of the recommended plan.

9 REFERENCES

Abbott, R., J. Reyff and G. Marty, 2005. Final Report: Monitoring the Effects of Conventional Pile Driving on Three Species of Fish. Richmond, CA: Manson Construction Company.

Adriannse, L.A. and J. Coosen, 1991. Beach and Dune Nourishment and Environmental Aspects. Coastal Engineering 16: 129-146.

Allen, K.O. and J.W. Hardy, 1980. Impacts of Navigation Dredging on Fish and Wildlife: A Literature Review. U.S. Fish and Wildlife Service. Biological Service Program. FWS: OBS-80/07. 81 pp.

Amos, W., 1966. The Life of the Seashore. New York: McGraw-Hill, Inc.

Atkins Global, 2009. Management Plan for the Delaware Bay Beaches.

Aresco, M.J., 1996. *Malaclemys terrapin terrapin* Reproduction and Nest Predation. Herpetological Review 27(2): 77.

Bohlen, W.F., 1978. Factors Governing the Distribution of Dredged Suspended Sediments. Proceedings of the 16th Coastal Engineering Conference, American Society of Civil Engineers. West Germany.

Botton, M. and R. Loveland, 1989. Reproductive Risk: High Mortality Associated with Spawning by Horseshoe Crabs (*Limulus Polyphemus*) in Delaware Bay, USA, Mar. Biol. 101: 143-151.

Botton, M.L. and R.E. Loveland, 1987. Orientation of the Horseshoe Crab (*Limulus polyphemus*) on a Sandy Beach. Biol. Bull. (Woods Hole) 173: 289-298.

Burger, J., 1981. The Effect of Human Activity on Birds at a Coastal Bay. Biological Conservation, Vol. 21, Issue 3, pg 231-241.

Burger, J., 1976. Behavior of Hatchling Diamondback Terrapins (*Malaclemys Terrapin*) in the Field. Copeia 1976(4): 742-748.

Burger, J. and W.A. Montevecchi, 1975. Nest Site Selection in the Terrapin *Malaclemys Terrapin*. Copeia 1975(1): 113-119.

Bushek, D., S. Ford and S.E. Burt, 2012. Long-term Patterns of an Estuarine Pathogen Along a Salinity Gradient. J. Mar. Res. 70: 225-251.

Butler, J.A., C. Broadhurst, M. Green, and Z. Mullin, 2004. Nesting, Nest Predation and Hatchling Emergence of the Carolina Diamondback Terrapin, *Malaclemys Terrapin Centrata*, in Northeastern Florida.

Caudill, J. and E. Henderson, 2005. Banking on Nature 2004: The Economic Benefits to Local Communities of National Wildlife Refuge Visitation. U.S. Department of the Interior, Fish and Wildlife Service, Division of Economics, Washington DC. Pp 345-349.

Chambers, R.M., 2000. Population Study of Diamondback Terrapins of the Lower Housatonic River. Pp. 14.

Chipley, R.M., G.H. Fenwick, J.J. Parr, and D.N. Pashley, 2003. The American Bird Conservancy Guide to the 500 Most Important Bird Areas in the United States. American Bird Conservancy, New York.

Coxe, R., 2009. Guide to Delaware Vegetation Communities. 442 pp.

Curtis, L., 1975. Distribution of *Sabellaria vulgaris* Verrill (Polychaeta: Sabellaridae) on a Sandflat in Delaware Bay. Chesapeake Science 16:14-19.

Curtis, L., 1973. Aspects of the Life Cycle of *Sabellaria vulgaris* Verrill (Polychaeta: Sabellaridae) in Delaware Bay. Ph.D. Dissertation, University of Delaware, Newark, DE.

Delaware Estuary Regional Sediment Management Workgroup, 2013. Delaware Estuary Regional Sediment Management Plan: A Comprehensive Long-term Master Plan to Identify a New Sediment Management Program, Procedures and Management Practices with Regionally-targeted Goals, Objectives and Strategies.

DNREC, 2012. Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware. Delaware's Sea Level Rise Advisory Council.

DNREC, 1997. Summary of the Delaware 1999 Rate-of-Progress Plan for Kent and New Castle Counties for Demonstrating Progress Toward Attainment of the National Ambient Air Quality Standard for Ozone.

Draud, M., M. Bossert, and S. Zimnavoda, 2004. Predation on Hatchling and Juvenile Diamondback Terrapins (*Malaclemys Terrapin*) by the Norway Rat (*Rattus Norvegicus*). Journal of Herpetology 38(3): 467-470.

DRBC, 2014. Delaware River and Bay Water Quality Assessment. 88 pp.

DRBC, 2012. Delaware River and Bay Water Quality Assessment.

Dubois, S., C. Retiere, and F. Olivier, 2002. Biodiversity Associated with *Sabellaria alveolata* (Polychaeta: Sabellaridae) Reefs: Effects of Human Disturbances. Journal of the Marine Biological Association (United Kingdom) 82(05): 817-826.

Engelhart, S.E., B.P. Horton, B.C. Douglas, W.R. Peltier, T.E. Tornqvist, 2009. Spatial Variability of Late Holocene and 20th Century Sea-Level Rise along the Atlantic Coast of the United States. Geology 37, 1115-1118.

Farrell, S.C., S. Hafner, K. McKenna, C. Robine, B. Smith, N. DiCosmo, M. Gruver, A. Ferencz, C. Tracey, H. Pimpinelli, 2016. The New Jersey Network: Annual Report on Monitoring New Jersey Beaches, Spring 2014 through Fall 2015. NJDEP, Bureau of Coastal Engineering, Toms River, NJ 166 pp.

Feinberg, J.A. and R.L. Burke, 2003. Nesting Ecology and Predation of Diamondback Terrapins, *Maleclemys Terrapin*, at Gateway National Recreation Area, New York. Journal of Herpetology 37(3): 517-526.

Fletcher, J.L. and R.G. Busnel, 1978. Effects of Noise on Wildlife. Academic Press, New York.

French, G.T., 1990. Historical Shoreline Changes in Response to Environmental Conditions in West Delaware Bay. MS Thesis submitted to University of Maryland.

GCRP, 2009. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [James G. Titus (Coordinating Lead Author), Eric K. Anderson, Donald R. Cahoon, Stephen Gill, Robert E. Thieler, Jeffress S. Williams (Lead Authors)]. U.S. Environmental Protection Agency, Washington D.C., USA. Walters, 1992.

Gebert, J.A. and R. Searfoss, 2012. Chapter 4 Sediments. Technical Report, Delaware Estuary and Basin, PDE Report #12-01.

Gehagan & Bryant Associates, Inc., 2013. Delaware River Main Channel Deepening Project, Supplemental Geotechnical Subsurface Investigation, Reach E – Stations 350+000 to 515+000, Final Report. Gehagan & Bryant Associates, Inc., Baltimore, MD.

Gibbons, J.W., J.E. Lovich, A.D. Tucker, N.N. Fitzsimmons, and J.L. Greene, 2001. Demographic and Ecological Factors Affecting Conservation and Management of the Diamondback Terrapin (*Malaclemys Terrapin*) in South Carolina. Chelonian Conservation and Biology 4(1): 66-74.

Goertner, J.F., M.L. Wiley, G.A. Young and W.W. McDonald, 1994. Effects of Underwater Explosions on Fish Without Swimbladders. Naval Surface Warfare Center Report NSWC TR88-114. Fort Belvoir, VA: Defense Technical Information Center.

Gore, R., L. Scotto, and L. Becker, 1978. Community Composition, Stability, and Trophic Partitioning in Decapod Crustaceans Inhabiting some Subtropical Sabellariid Worm Reefs. Bulletin of Marine Science 28: 221-248.

Govoni, J.J., M.A. West, L.R. Settle, R.T. Lynch and M.D. Greene, 2008. Effects of Underwater Explosions on Larval Fish: Implication for a Coastal Engineering Project. Journal of Coastal Research 24, 228-233.

Helser, T.E. and D. Kahn, 2001. Stock Assessment of Delaware Bay Blue Crab (*Callinectes sapidus*) for 2001. Department of Natural Resources and Environmental Control, Dover, Delaware.

Houghton, J.P. and D.R. Mundy, 1987. Effects of Linear Explosive Seismic Energy Releases on Fish in Alaska's Transition Zones. Contract Report 06793-004-020; Anchorage, AK: Alaska Oil and Gas Association.

http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml

Kaufman, G.J., 2011. Socioeconomic Value of the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania, The Delaware River Basin an Economic Engine for Over 400 Years. University of Delaware, Newark, DE.

Knutson, P.L., 1988. Role of Coastal Wetlands in Energy Dissipation and Shore Protection. In Ecology of Wetlands, edited by D.D. Hook. Timber Press, Portland, OR: 161-174.

Krauter, J.N., S. Ford and M. Cummings, 2007. Oyster Growth Analysis: A Comparison of Methods. J. Shellfish Res. 26: 479-491.

Kreeger, D., J. Adkins, P. Cole, R. Najjar, D. Velinsky, P. Conolly, and J. Kraeuter, 2010. Climate Change and the Delaware Estuary: Three Case Studies in Vulnerability Assessment and Adaptation Planning. Partnership for the Delaware Estuary, PDE Report No. 10-01. 1-117 pp.

Kryter, K.D., 1985. The Handbook of Hearing and the Effects of Noise (2nd ed.). Academic Press, Orlando, Florida.

Lathrop, R.G. Jr., M. Allen and A. Love, 2006. Mapping and Assessing Critical Horseshoe Crab Spawning Habitats of Delaware Bay. Center for Remote Sensing & Spatial Analysis, Rutgers University, New Brunswick, New Jersey. 37 pp.

Lewes, D.A., J.A. Cooper, and O.H. Pilkey, 2005. Fetch-limited Barrier Islands of Chesapeake Bay and Delaware Bay. Southeastern Geology 44(1): 1-17.

Lovich, J.A., D. Anton, D.E. Kling, and W. Gibson, 1991. Behavior of Hatchling Diamondback Terrapins (*Malaclemys Terrapin*) Release in a South Carolina Salt Marsh.

Lynn, K. and D. Sheingold, 2015. Incomes Up, Poverty Down in NJ – But Only Slightly. North Jersey Media Group. 17 September 2015 Publication.

Maurer, D., L. Watling, P. Kinner, W. Leathem and C. Wethe, 1978. Benthic Invertebrate Assemblages of Delaware Bay. Marine Biology Vol. 45: pp 65-78.

McHugh, J.L., 1981. Marine Fisheries of Delaware. NOAA, Fish. Bull. 79: 575-599.

Merson, R.R. and H.L. Pratt, Jr., 2001. Distribution, Movements and Growth of Young Sandbar Sharks (*Carcharhinus plumbeus*) in the Nursery Grounds of Delaware Bay. Envir. Bio. of Fishes 61: 13-24.

Munroe, D., A. Tabatabai, I. Burt and J. Wilkin, 2013. Oyster Mortality in Delaware Bay: Impacts and Recovery from Hurricane Irene and Tropical Storm Lee. Estuarine Coastal and Shelf Science 135: 209-219.

Najjar, R., 2009. Analysis of Climate Simulations for Use in the “Climate-Ready Adaptation Plan for the Delaware Estuary.” An Interim Report to the Partnership for the Delaware Estuary. 18 pp.

National Research Council, 2007. Mitigating Shoreline Erosion along Sheltered Coasts. National Academies Press: Washington, D.C.

Nedwell, J.R., A.W.H. Turnpenny, J.M. Lovell and B. Edwards, 2006. An Investigation into the Effects of Underwater Piling Noise on Salmonids. Journal of the Acoustical Society of America 120, 2550-2554.

New Jersey Legal Services, 2015. Poverty Benchmarks: The Annual Overview of New Jersey’s Progress Against Poverty. 141 pgs.

NMFS, 2011. Endangered Species Act, Biological Opinion for the U.S. Army Corps of Engineers, Philadelphia District Deepening of the Delaware River Federal Navigation Channel (Reinitiation). National Marine Fisheries Service F/NER/2011/00574.

NOOA, 2009. NOAA Tides & Currents, Sea Level Trends.

Palmer, W.M. and C.L. Cordes, 1988. Habitat Suitability Index Models: Diamondback Terrapin (nesting) Atlantic Coast. U.S. Fish and Wildlife Service, Biological Report 82(10.151). 18p.

PECO, 1977 (Philadelphia Electric Company) Chester Generating Station 316(b) Report.

Pennock, J.R. and S.S. Herman, 1988. Plankton. Pages 55-69 in T.L. Bryant and J.R. Pennock, Eds. The Delaware Estuary: Rediscovering a Forgotten Resource. University of Delaware Sea Grant College Program, Newark, DE 144 pp.

Pitler, R., 1985. *Malaclemys Terrapin Terrapin* (Northern Diamondback Terrapin) Behavior. Herpetological Review 16(3): 82.

Popper, A.N. and M.C. Hastings, 2009. The Effects on Fish of Human-generated (Anthropogenic) Sound. Integrative Zoology (in press).

Popper, A.N., J. Fewtrell, M.E. Smith and R.D. McCauley, 2004. Anthropogenic Sound: Effects on the Behavior and Physiology of Fishes. MTS J. 37:35-40.

Popper, A.N., 2003. Effects of Anthropogenic Sound on Fishes. Fisheries 28, 24-31.

Powell, E.N., K.A. Ashton-Alcox and D. Bushek, 2012. Report of the 2012 Stock Workshop (14th SAW) for the New Jersey Delaware Bay Oyster Beds. Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ 155 pg.

Psuty, N.P., A. Spahn, S. Grogan, J. Greenberg, R.T. Fullmer, and B. Kempf, 2014. Shoreline Change along Prime Hook National Wildlife Refuge: Annual Monitoring Report, 2011-2014. U.S. Fish and Wildlife Service, Hadley, MA.

Psuty, N.P., M. Duffy, J.F. Pace, D.E. Skidds, and T.M. Silveria, 2010. Northeast Coastal and Barrier Geomorphological Monitoring: Part I - Ocean Shoreline Position. Natural Resources Report NPS/NCBN/NRR-2010/185. National Park Service, Fort Collins, CO.

Rechisky, E.L. and B.M. Wetherbee, 2003. Short-term Movement of Juvenile and Neonate Sandbar Sharks (Carcharhinus Plumbeus) on Their Nursery Grounds in Delaware Bay. Envir. Bio. Of Fishes 61: 13-24.

Richardson, W.J., C.R. Greene Jr., C.L. Malme and D.H. Thomson, 1995. Marine Mammals and Noise. Academic Press, New York.

RMC Environmental Services, 1988. Comprehensive Navigation Study, Delaware River, Philadelphia to the Sea. Benthic Community Analysis of Selected Localities within the Delaware River and Bay. Prepared for the U.S. Army Corps of Engineers, Philadelphia District. 60 pp.

Roosenburg, W.M., T.A. Radzio, and P.E. Allman, 2004. Terrapin Monitoring at Poplar Island 2003.

Roosenburg, W.M., 1993. Final Report, the Chesapeake Bay Diamondback Terrapin Investigations 1992. Chesapeake Research Consortium, CRC Publication Number 146.

Roosenburg, W.M., 1990. Final Report, Chesapeake Diamondback Terrapin Investigations for the Period 1987, 1988 and 1989. Chesapeake Research Consortium, CRC Publication Number 133.

Rosen, P.S., 1980. Erosion Susceptibility of the Virginia Chesapeake Bay Shoreline. Marine Geology 34: 45-50.

Rosen, P.S., 1978. A Regional Test of the Bruun Rule on Shoreline Erosion. Marine Geology 26: M7-M16.

Rosen, P.S., 1977. Increasing Shoreline Erosion Rates with Decreasing Tidal Range in the Virginia Chesapeake Bay. Chesapeake Science 18(4): 383-386.

Ruggerone, G.T., S.E. Goodman and R. Miner, 2008. Behavioral Response and Survival of Juvenile Coho Salmon to Pile Driving Sounds. Seattle, WA: Natural Resource Consultants, Inc. for Port of Washington.

Sargent, B. Pierre, George M. Farlekas, and Otto S. Zapecza, 1985. New Jersey Ground-Water Resources.

Schnabel Engineering, 2007. Geotechnical Data Report Vibrational Coring Cape May Villas, Cape May, New Jersey for the U.S. Army Corps of Engineers. Contract #W912BU-05-D-001. Schnabel Engineering, 510 East Gay Street, West Chester, Pennsylvania 19380.

Schuster, E., 2016. Delaware Bayshore Tourism Survey Results, Cumberland County, NJ. The Nature Conservancy.

Schuster, E. and M. Botton, 1985. A Contribution to the Population Biology of Horseshoe Crabs (*Limulus Polyphemus*) in Delaware Bay. Estuaries 8: 363-372.

Scott, L.C., 2014. Benthic Community Resource Monitoring and Assessment for the Lower Delaware Bay Prime Hook National Wildlife Refuge Dune Breach Repair Project, DE. Prepared for U.S. Army Corps of Engineers, Philadelphia District by Versar, Inc., Columbia, MD.

Sexton, N.R., S.C. Stewart, L. Koontz, P. Ponds, and K.D. Walters, 2007. Visitor and Community Survey Results for Prime Hook National Wildlife Refuge: Completion Report. U.S. Geological Survey, Biological Resources Discipline, Open-File Report 2007-1239. 63 pp.

Southwick Associates, 2011. The Economics Associated with Outdoor Recreation, Natural Resources Conservation and Historic Preservation in the United States. The Fish and Wildlife Foundation, Fernandina Beach, FL. 33 pp.

Szerlag, S. and S.P. McRobert, 2006. Road Occurrence and Mortality of the Northern Diamondback Terrapin. Applied Herpetology 3: 27-37.

The Academy of Natural Sciences of Philadelphia, 1981. Biological Effects of the Proposed Bulkhead for the Scott Paper Company, Chester, PA, Report No. 81-19D. 200 pp.

Tiner, R.W., N.A. Biddle, A.D. Jacobs, A.B. Rogerson, and K.G. McGuckin, 2011. Delaware Wetlands: Status and Changes from 1992 to 2007. Cooperative National Wetlands Inventory Publication. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA and the Delaware Department of Natural Resources and Environmental Control, Dover, DE 35 pp.

UCS, 2008. Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State. Union of Concerned Scientists, Cambridge MA. 54 pp.

USACE, 2015. North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk

USACE, 2013. Final Environmental Assessment, Delaware River Main Channel Deepening Project, Delaware Bay Economic Loading, Mechanical Dredging and Placement of Dredged Material at the Fort Mifflin Confined Disposal Facility, U.S. Army Corps of Engineers, Philadelphia District.

USACE, 2011. Final Environmental Assessment, Delaware River Main Channel Deepening Project, U.S. Army Corps of Engineers, Philadelphia District.

USACE, 2011. A Supplemental Biological Assessment for Potential Impacts to the New York Bight Distinct Population Segment of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) which is Proposed for Federal Endangered Species Listing Resulting from the Delaware River Main Stem and Channel Deepening Project, U.S. Army Corps of Engineers, Philadelphia District.

USACE, 2009. Delaware River Main Stem and Channel Deepening Project, Environmental Assessment, U.S. Army Corps of Engineers, Philadelphia District.

USACE, 1997. Delaware River Comprehensive Navigation Study, Main Channel Deepening Project (Pennsylvania, New Jersey, and Delaware), Final Supplemental Environmental Impact Statement, U.S. Army Corps of Engineers, Philadelphia District.

USACE, 1992. Delaware River Comprehensive Navigation Study, Main Channel Deepening, Final Interim Feasibility Study and Environmental Impact Statement, U.S. Army Corps of Engineers, Philadelphia District.

USACE, 1980. Final Environmental Impact Statement: Commercial Soil and Gravel Dredging, Allegheny River, PA (Mile 0 to Mile 62.2). Pittsburgh, PA.

USEPA/USACE, 1998. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual (Inland Testing Manual). Prepared by the Environmental Protection Agency Office of Water, Office of Science and Technology, Washington, D.C. and Department of the Army United States Army Corps of Engineers Operations, Construction and Readiness Division, Washington, D.C.

USEPA, 2016. Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2014.

USFWS, 2016. Planning Aid Report, Dredged Material Utilization Study for the Delaware River and Bay Shoreline, Kent, New Castle, and Sussex Counties, Delaware. USFWS, Ecological Services, Region 5, Chesapeake Bay Field Office, Annapolis, Maryland.

USFWS, 2015. Prime Hook National Wildlife Refuge Environmental Assessment.

USFWS, 2014. Final Environmental Assessment for the Gandys Beach/Money Island Living Shorelines Project, 33 pp.

USFWS, 2014. Rufa Red Knot Background Information and Threats Assessment. Supplement to Endangered and Threatened Wildlife and Plants: Final Threatened Status for the Rufa Red Knot (*Calidris canutus rufa*). New Jersey Field Office, Pleasantville, New Jersey. 383 pp.

USGS, 2012. Prepared Under a Mission Assignment with the Federal Emergency Management Agency Open File Report 2013-1043, U.S. Department of the Interior, U.S. Geological Survey: Monitoring Storm Tide and Flooding from Hurricane Sandy along the Atlantic Coast of the United States (by Brian E. McCallum, Shaun M. Wicklein, Robert G. Reiser, Ronald Busciolano, Jonathan Morrison, Richard J. Verdi, Jaime A. Painter, Eric R. Frantz, and Anthony J. Gotvald).

Versar, Inc., 2005. Delaware River Philadelphia, Pennsylvania to New Castle, Delaware Chemical Analysis of Dredged River Sediments. Prepared for USACE, Philadelphia District. Contract No. DACW61-00-D-0009 Task Order No. 0076.

Versar, Inc., 2003. Chemical Analysis of Maintenance Dredge Material from the Marcus Hook, Deepwater Point, and New Castle Navigational Ranges. Prepared for USACE, Philadelphia District. Contract No. DACW61-00-D-0009 Task Order No. 0045.

Versar, Inc., 2001a. Pre-Construction Oyster, Water Quality, and Sediment Monitoring Study for the Delaware River Main Channel Deepening Project 2000/2001. Prepared for USACE, Philadelphia District. Contract No. DACW61-95-D-0011 Task Order No. 0086.

Versar, Inc., 2001b. Near-Field Water Quality Modeling of Dredging Operations. Prepared for USACE, Philadelphia District. Contract No. DACW61-00-D-0009 Task Order No. 0026.

Weber, T., 2007. Ecosystem Services in Cecil County's Green Infrastructure. The Conservation Fund, Annapolis, MD.

Weisberg, S.B., P. Himchak, T. Baum, H.T. Wilson, and R. Allen, 1996. Temporal Trends in Abundance of Fish in the Tidal Delaware River. Estuaries 19(3): 723-729.

Wells, H., 1970. *Sabellaria* Reef Masses in Delaware Bay. Chesapeake Science 11: 258-260.

Yin, J.J., M.E. Schlesinger, R.J. Stouffer, 2009. Model Projections of Rapid Sea-Level Rise on the Northeast Coast of the United States. Nature Geosci. 2, 262-266.

Zimmer, B.J. and S. Groppenbacher, 1999. New Jersey Ambient Monitoring Program Report on Marine and Coastal Water Quality 1993-1997. Bureau of Marine Water Monitoring, Leeds Point, NJ: 112 pg.

Zhong, L., Li, M., Foreman, M.G.G., 2008. Resonance and Sea Level Variability in Chesapeake Bay. Continental Shelf Research 28, 2565-2573.

10 RECOMMENDATIONS

A tentatively selected plan (TSP) was developed to reduce damages due to shoreline erosion, waves and storm surge caused by coastal storms, along with SLC, along the Delaware Estuary shoreline of New Jersey. The TSP consists of beach restoration at Villas (South) and beach restoration with terminal groin(s) at Gandys Beach and Fortescue. Specific project details are presented in Section 3.6 of this report.

In making the above-reference recommendation, USACE has given consideration to all significant aspects in the overall public interest, including environmental quality, social effects, economic effects, engineering feasibility, and compatibility of the TSP with policies, desires, and capabilities of the State of Delaware and other non-Federal interests. USACE has evaluated several alternative plans for the purpose of coastal storm risk management. A TSP has been identified that is technically sound, economically cost-effective over the 50-year period of analysis, socially and environmentally acceptable, and has support from the non-Federal sponsor.

The selected plan has primary benefits based on coastal storm risk management and provides average annual total net benefits in accordance with the table below:

Table 25 - Summary of Costs & Benefits

Site	Average Annual Benefits (AAB)	Average Annual Costs (AAC)	Average Annual Net Benefits (AANB)	Benefit-Cost Ratio (2.875%)
Gandys Beach	$2,323,296	$991,518	$1,331,656	2.3
Fortescue	$2,736,996	$1,327,105	$1,409,891	2.1
Villas (South)	$2,058,775	$1,807,681	$251,094	1.1

Note: The cost and benefit values cover a 50-year period of analysis with a base year of 2022.
The Federal discount rate is 2.875%.

The TSP reflects information available at the time and current USACE policies governing formulation of coastal storm risk management projects. This plan will be subject to optimization and may be modified before finalization of the feasibility report. The project sponsor, interested Federal and non-Federal agencies, and other parties will be advised of any such modifications.