

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

Feasibility Report and Integrated Environmental Assessment

Executive Summary

1 Study Information

In October 2005, the Committee on Environment and Public Works of the United States Senate passed a resolution (“Resolution”) authorizing the U.S. Army Corps of Engineers (USACE) to review the report of the Chief of Engineers for two Federal navigation projects (1. Delaware River between Philadelphia, Pennsylvania and Trenton, New Jersey; and 2. Delaware River Philadelphia, Pennsylvania to the Sea) to determine if there were any opportunities for the beneficial use of dredged material resulting from the aforementioned navigation projects. The current standard practice for the above-referenced navigation projects is to dispose of dredged material via the least cost environmentally acceptable disposal location (Federal Standard), not beneficial use.

Pursuant to the Resolution, USACE undertook a Reconnaissance Study to look at the beneficial use of dredged material for a variety of purposes, including ecosystem restoration, flood risk management and navigation. In 2012, the “Delaware River New Jersey, Delaware and Pennsylvania Dredged Material Utilization and Beneficial Use Opportunities Expedited Reconnaissance Study” (Reconnaissance Study) was completed. It was recommended that the Reconnaissance Study proceed to the feasibility phase.

In January 2013, Congress passed the Disaster Relief Appropriations Act, 2013 (PL 113-2) in the aftermath of Hurricane Sandy (October 2012). In PL 113-2, Congress directed USACE to prepare and submit “an interim report identifying...any project under study by the Corps for reducing flood and storm damage risks in the affected area” and also appropriated \$29,500,000 for the Secretary of the Army to “expedite and complete ongoing flood and storm damage reduction studies in areas that were impacted by Hurricane Sandy in the North Atlantic Division of the United States Army Corps of Engineers.” At the time PL 113-2 was passed, this study was between the reconnaissance and feasibility phases. Accordingly, it was identified as a “project under study” in the interim report submitted to Congress and was an “ongoing study” eligible for a portion of the funds appropriated by Congress in PL 113-2 to continue to the feasibility phase. Therefore, this feasibility study and report¹, which looks at

¹ 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.

beneficially using dredged material for coastal storm risk management (CSRМ) benefits in various New Jersey communities, was prepared in response to both the 2005 Resolution and PL 113-2.

2 Problem

The primary problems identified in this study are damages along the Delaware Estuary shoreline (which includes the Delaware Bay and the tidal reach of the Delaware River) caused by erosion, wave attack and inundation due to coastal storms, along with rising water levels due to relative sea level change (RSLC). 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 CSRМ problem areas were identified.

The nature of the CSRМ problem and the study area characteristics presents the opportunity to beneficially use dredged material to reduce vulnerability to coastal storms by minimizing erosion, wave and storm-related damages to New Jersey communities and increase resiliency along the Delaware Estuary 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. 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.

3 Plans Considered

The primary planning objectives of this study are:

1. Improve CSRМ for people, property and infrastructure along and adjacent to the Delaware Estuary shoreline in New Jersey 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 two rounds of screening to confirm that CSRМ was the primary problem and that the use of dredged material was potentially feasible in a management measure for the problem area.

Each of the identified problem areas was screened to better understand the nature and extent of the CSRМ problems. Initially, the USACE posed the question as to whether CSRМ was the primary problem at each location. CSRМ was considered a primary problem at a location if the Composite Exposure Index (CEI), as calculated in the North Atlantic Coast Comprehensive Study (NACCS), was greater than 50%.

Although a myriad of factors or criteria can be used to identify exposure, the NACCS CEI focused on the following categories and criteria, as emphasized in PL 113-2: population density and infrastructure, social vulnerability and environmental and cultural resources.

- Population Density and Infrastructure – Population density includes identification of the number of persons within an areal extent across the study area; infrastructure includes critical infrastructure that supports the population and communities. These factors were combined to reflect the overall exposure of the built environment.
- Social Vulnerability Characterization – Social vulnerability characterization includes certain segments of the population that may have more difficulty preparing for and responding to coastal flood events.
- Environmental and Cultural Resources – The environmental and cultural resources exposure captures important habitat and cultural resources that would be affected by storm surge, winds and erosion.

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%, social vulnerability was weighted at 10% and environmental/cultural resources were weighted at 10% of the total CEI. The USACE chose to use the NACCS CEI as a screening tool since the CEI was heavily weighted toward the impact of CSRM risks to population and infrastructure. The CEI was selected as an initial screening tool because this CSRM study was conducted under the flood risk management business line where the primary planning objective was improved CSRM for people, property and infrastructure, not ecosystem restoration.

While the CEI was heavily weighted toward people and infrastructure, there were other metrics (social vulnerability and environmental/cultural indices) that contributed to the overall CEI. The social vulnerability characterization was completed using the U.S. Census Bureau 2010 Census Demographic Summary Profile data (Census, 2011). The overarching goal was to quantify areas where the population is more at risk to storm impacts. After considering the Census data, it was determined that age, income and inability to speak English were important factors in social vulnerability. The environmental and cultural resources characterization was intended to capture important habitat, and environmental and cultural resources that would be vulnerable to storm surge, winds and erosion. Environmental and cultural resources were evaluated via data from national databases; such as National Wetlands Inventory and The Nature Conservancy (TNC) Ecoregional Assessments; data provided from USFWS (including threatened and endangered species habitat and important sites for bird nesting and feeding areas); shoreline types; and historic and national monuments.

The USACE applied the CEI as a screening tool to focus this feasibility study on problem areas that could be addressed within the flood risk management business line. If the problem area had a CEI greater than 50% and was subsequently validated by best professional judgment, the USACE further evaluated

the problem area under the flood risk management business line, specifically to determine if dredged material would be a feasible CSRM measure in the problem area.

During the initial round of 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 area(s) was considered, as well as the shoreline type at the problem area (as defined by 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 sequestered and managed in the CDF for an indefinite period of time.
 - Within New Jersey, the USACE 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.
 - 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.
- 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 the first round of 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 “Project Under 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. After the first round of screening, 20 sites were screened out from the initial 33 and recommended for further analysis under another authority.

The USACE formulated non-structural and structural measures, as well as natural and nature-based features (NNBF), for each problem area. In the second round of screening, the measures were

compared against the planning objectives to see if they were in line with the study purpose. In order for measures to be carried forward for further analysis, they must have met one of the two study objectives.

The NACCS criteria for assessing each measure's CSR Function were applied to determine if a measure met Objective 1. The CSR 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 USACE 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 USACE 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 the northern planning reach, the No Action Plan and a 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 a 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 a Beach Restoration Plan were formulated. A Beach Restoration with Groin(s) Plan was also formulated at Gandys Beach and Fortescue. A Beach Restoration with Breakwater Plan was not formulated in the southern planning reach because the added breakwater cost greatly outweighed any added CSR benefits. Per the NACCS, an estimated total first construction cost of a breakwater could be as high as \$613 per linear foot plus an estimated \$4,000,000 mobilization/demobilization cost. Given the limited size of the structural inventories of the communities in the southern reach, the potential CSR benefits did not appear to offset the added cost.

Regarding a Beach Restoration with Groin(s), Breakwater, Living Shoreline & Wetland Plan, analyses indicated that additional features, such as wetlands or living shorelines, would provide minimal additional CSR benefits compared to the added cost. For living shorelines, data from the NACCS indicates that they are generally applicable to relatively low current and wave energy environments in estuaries, rivers, and creeks with water depths less than 5 feet MLLW. Areas exposed to larger waves do not benefit significantly from a living shoreline application since the marsh vegetation and underlying soils would likely be eroded. NACCS also indicates that living shorelines are more effective at shorelines with existing vegetation as opposed to exposed beach areas. An essential component of a living shoreline is constructing a rock structure (breakwater/sill) offshore and parallel to the shoreline to reduce wave energy that would impact the wetland area and cause erosion of the substrate and damage

or removal of the tidal plants. Typically, the rock structure is designed with a crest elevation at or slightly above MHW that is effective at reducing wave energy under normal conditions but allows waves under severe storm events to pass over the stone structure and impact the shore. Therefore, living shorelines are typically more effective at reducing long-term erosion than short-term storm driven erosion.

In the southern reach, the width of the bay (fetch) increases resulting in greater wind-generated wave energy at the shoreline. The greater wave conditions in the southern reach require a substantial rock structure associated with any living shoreline that would look and function similarly to a breakwater. Living shorelines in the southern reach are expected to have limited effectiveness at many of the sites since the most vulnerable houses are often located on or directly behind a sandy beach with significant wave exposure and potential for storm-driven erosion. As discussed above living shorelines have limited effectiveness at reducing short-term storm driven erosion since the waves pass over the rock structure and may require a substantial beach buffer behind the rock structure to prevent erosion damages. Due to these reasons coupled with a construction cost of \$1,415 per linear foot (as estimated in the NACCS) living shoreline measures were screened out of the southern reach.

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 Environmental Considerations

The 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).

A larger and more robust beach berm will provide a buffer that protects infrastructure but increases the beach berm size that in turn also protects adjacent salt marshes from inundation. The beneficial effect to the project area due to sand nourishment is restoration of sandy beach habitat primarily for horseshoe crabs, migratory shorebirds, foraging mammals, and nesting diamondback terrapins.

Healthy saltmarshes provide habitat for fish, waterbirds, birds of prey, amphibians, reptiles, and mammals. Construction and rehabilitation of the proposed terminal groins will displace some intertidal and subtidal habitat within the groin footprints but also provide interstitial spaces for marine organisms and refugia from currents. The proposed project would likely produce more favorable environmental conditions than exist at present by supplementing a sand source to eroded beaches and reducing wave energy. However, construction activities will produce some temporary adverse effects such as noise, elevated turbidity, and preclude access for species. Dredged material placement of sand would disrupt some infaunal and epifaunal organisms through burial. Noise generated during construction would cause short-term minor adverse effects to shorebirds as they would likely leave the immediate area during construction but return after completion of the project. The construction and rehabilitation of terminal groins will permanently displace soft bottom habitat within their footprints and reduce longshore sediment transport downdrift.

Two Federally listed species (threatened) under USFWS purview that may occur in the study area are the red knot (*Calidris canutus rufa*) and northern long-eared bat (*Myotis septentrionalis*). The proposed project locations are not considered northern long-eared bat habitat; therefore, no impacts to the northern long-eared bat are anticipated. 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 and fall (late-July through October) migration periods, respectively (USFWS, 2016).

In consultation with the USFWS, USACE has committed to extending initial construction over a 3 year period to accommodate seasonal restrictions recommended by USFWS for the red knot and also minimize impacts to spawning horseshoe crabs. In consultation with the NMFS, USACE will float the dredge pipe within the nearshore zone to minimize adverse impacts to sandbar sharks during their pupping season. Water quality impacts at the construction beaches will be minimized by reducing runoff and turbidity by creating a small temporary sand berm and pumping above the MHWL. USACE will track LST downdrift of the groin post initial construction to employ adaptive management during periodic nourishment cycles and determine future nourishment quantities and placement locations. USACE will re-initiate ESA Section 7 consultation if new information arises that could cause effect to listed species and prior to nourishment cycles.

5 Recommended Plan

The recommended plan consists of beach restoration at Villas (South) and beach restoration with groin(s) at Gandys Beach and Fortescue. Dune elevations and berm widths from the plan optimization are presented in Table ES-2. Berm elevations were selected to match the natural berm elevations in the study area.

Figure ES- 1: Recommended Plan Dredged Material Placement Sites



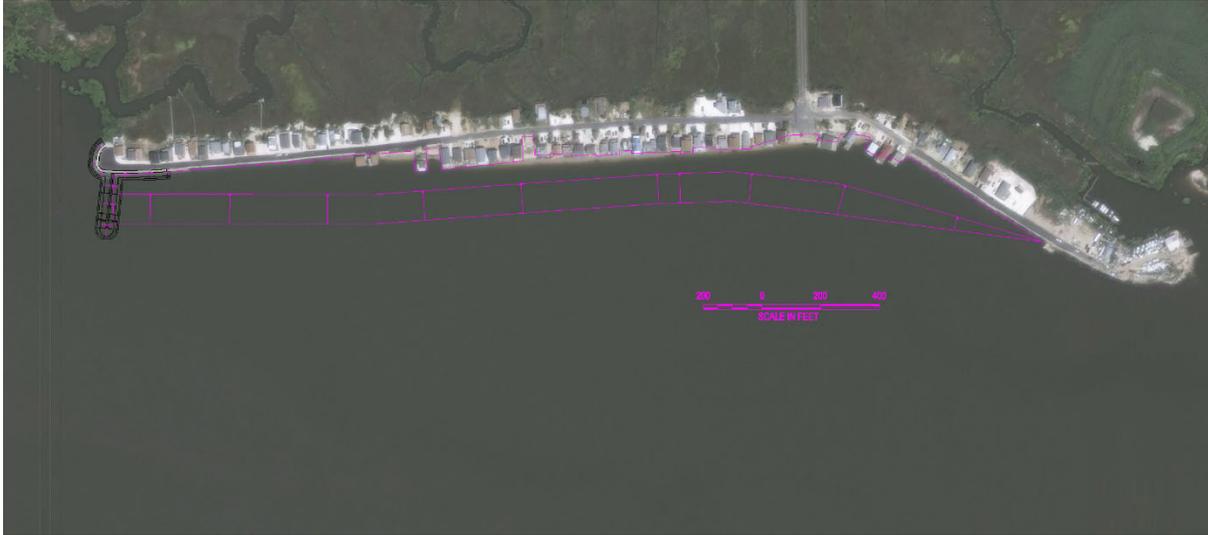
Gandys Beach

At Gandys Beach, the recommended plan calls for a berm only beachfill with the parameters shown on Table ES-2. The full width of the design extends in front of all currently developed property bayward of Cove Road. 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 high with-project end losses without the use of a terminal groin. The design will tie into a terminal groin at the northwest end of Gandys Beach that will be constructed as part of the plan and the southeastern end will taper to the existing shoreline. Beachfill alternatives were evaluated and compared at Gandys Beach with and without a terminal groin. Analytical shoreline change modeling of beach restoration at Gandys Beach shows that the beach template would be unstable without a terminal groin due to severe end losses of the fill. The rate at which the beachfill would erode would be so high that excessively frequent periodic nourishment would be required to maintain the project shoreline. Attempts to extend the periodic nourishment interval by increasing the fill volume would increase the project width and its perturbative effect on the shoreline alignment. This in turn would increase the beachfill loss rate so that the increased fill volume would do little to decrease the periodic nourishment frequency (Bodge 2003). Over a 50-year project life, the cumulative savings on periodic nourishments are expected to greatly exceed the initial cost of the terminal groin.

As discussed further in Section 5.3.5, USFWS and TNC expressed concern that the proposed terminal groin at Gandys Beach would further exacerbate the ongoing erosion of the TNC Gandys Beach Preserve (and associated red knot habitat in and adjacent to the Preserve) shoreline downdrift of the proposed groin. USACE held several conference discussions and a site visit in collaboration with USFWS and TNC to address their concerns with respect to the proposed Gandys Beach groin plan's effects on the Gandys Beach Preserve and associated red knot habitat. As a result of the continued coordination with USFWS and TNC, the terminal groin was optimized and refined to allow for transport over the groin at high tide at about mean sea level. Specifically, the groin will also include two layers of armor stone in order to increase the permeability of the structure to longshore sediment transport (LST) of sand. The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004).

USACE anticipates that periodic nourishment of the proposed beach over the project life will not only create and maintain sandy beach habitat in the Gandy Beach project area, but will also allow transport of sediment to the northwest into the TNC Preserve, which is sand-starved under existing conditions. It is expected that the nourishment of Gandys Beach will restore the two natural processes, upland beach erosion and LST, primarily responsible for providing sediment to bay beaches.

The groin will tie into the existing rubble revetment. From the tie-in, the groin will extend approximately 234 feet bayward and will consist of layers of armor stone, core stone and marine mattress.



Gandys Beach

Fortescue

For Fortescue, the recommended plan calls for a berm only beachfill with the parameters shown on Table ES-2. The full width of the design extends in front of all developed structures bayward of Delaware and Jersey Avenue. There is an existing timber groin currently separating the Fortescue beach area from Fortescue Creek. While the timber groin provides this separation, it is too short to retain the proposed beachfill at Fortescue. The proposed groin will be a rubble mound structure which is parallel to the existing groin and will extend 270 feet bayward (120 feet beyond than the bayward extent of the existing timber groin) to limit end losses of the planned beachfill. The proposed groin will tie into the existing shoreline and will be located approximately 30 feet east of the existing timber groin in order to allow for the timber groin to serve as a cofferdam during construction of the proposed rubble mound groin. The design beachfill will tie into the rubble mound groin at the northwest end of Fortescue (adjacent to the existing timber stem stone groin and Fortescue Creek) and the southeastern end will taper to the existing shoreline.



Fortescue

Villas (South)

At Villas (South), the recommended plan calls for a dune and berm beachfill with the parameters shown in Table ES-2. The design will tie into the existing shoreline at Francis Avenue and extend north to West Greenwood Avenue. The design will utilize tapers at each end to tie the beachfill into existing conditions.



Villas (South)

Table ES- 1: Summary of Recommended Plan Beachfill Dimensions

Location	Villas South	Gandys Beach	Fortescue
Length of Design Dune/Berm (feet)	7,442	2,507	4,564
Length of Dune (feet)	7,442	N/A	N/A
Southern Taper (feet)	1,000	786	1,251
Northern Taper (feet)	1,072	0	0
Length of Shoreline (feet)	9,514	3,293	5,815
Groin	None	NW End	NW End
Dune Height (feet NAVD88)	12	N/A	N/A
Dune Width (feet)	25	N/A	N/A
Berm Height (feet NAVD88)	5	6	6
Design Berm Width (feet)	30	30	30
Advance Berm Width (feet)	20	45	45
Total Berm Width (feet)	50	75	75

The proposed dredged material source area is the O&M dredged material to be taken from Miah Maul and Brandywine Ranges of Lower Reach E (Lower Reach E) of the Delaware River Main Channel. 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. Actual dredged material quantities will be verified prior to construction; therefore, the USACE 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 nourishment (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 USACE 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).

As the final beach restoration designs for Gandys Beach, Fortescue and Villas (South) were further refined, the estimated total nourishment quantity increased to approximately 1,147,900 cubic yards. Considering the proposed source area and the projected quantities for nourishment and periodic renourishment, the USACE revised the likely project implementation plan as explained below. In addition, because the Delaware DMU period of analysis overlaps a large portion of the New Jersey DMU period of analysis, the USACE assumed that available dredged material would need to be distributed to each project over each overlapping period of analysis.

In addition, based on the USFWS recommended environmental window associated with horseshoe crab spawning and migratory red knot foraging in the proposed project vicinity (15 April through 31 August), the USACE did not assume one continuous project construction operation for initial construction. The environmental window necessitated the USACE to assume initial construction to occur in three phases. Phase One (2021) will involve the construction of the terminal groins at Gandys Beach and Fortescue outside of the aforementioned environmental window. After the environmental window and based on the projected dredged material quantity limitations discussed above, Gandys Beach and Fortescue would be nourished as part of Phase Two (2022) of initial construction. Villas (South) is projected for nourishment in 2028, during the first periodic renourishment cycle of Gandys Beach and Fortescue.

In order to maintain the integrity of design beachfill alternatives, periodic renourishment must be included in the project design. If periodic nourishment was not performed throughout the life of the project, longshore and cross shore sediment transport mechanisms would act to erode the design beach. A 6-year periodic renourishment cycle is anticipated to maintain optimal CSR. This nourishment cycle coincides with the proposed operation and maintenance (O&M) dredging to be performed in Lower Reach E.

As discussed later in Section 3.5.1.2, there area economic risk and uncertainty drivers that affected the plan formulation. In addition, risk-informed decision making was applied in other areas of the plan formulation. There are two issues that appear to present the greatest risk and uncertainty for project implementation: quantity of available dredged material and sediment compatibility. As referenced earlier in this section, 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. USACE recognizes that the aforementioned shoaling rate and associated dredging cycle is based on an estimate and will need to be confirmed with post-deepening surveys.

Regarding sediment compatibility, a beachfill compatibility analysis is typically conducted to statistically compare the existing or “native” beach sand grain size to the intended borrow material that will be placed on that site. A resulting overfill factor is calculated and is greater than 1.0 when the borrow material is considerably smaller than the native materials. Due to several factors, a more general comparison needs has been applied to this project, as discussed further in Section 3.5.1.2. Determining the true “native” grain size characteristics of the placement sites is difficult due to limited available data and the fact that most of these beaches have been supplemented with numerous fills of varying materials through previous CSRMs efforts (dredging events and truck fill operations).

6 Real Estate Requirements

Based on the information available, the recommended plan requires two (2) types of easements 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) may be required for at least one area.

It is the District’s opinion that the federal navigation servitude may be invoked for construction of the proposed CSRMs project below MHW. Therefore, since the State of New Jersey owns all submerged lands below the MLLW and the Federal government may invoke the federal navigational servitude over lands between MHWL and MLLW, no authorization for entry will be required from the NFS and no credit for reimbursement will be afforded the NFS for these areas.

The standard Perpetual Beach Storm Damage Reduction Easement (Standard Estate No. 26) is required for the construction of the beach berm and/or dune system and terminal groins 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 also 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 of the project required by the non-Federal sponsor over the life of the project.

Between the three sites in the recommended plan, a total of 158 easements are required, adding approximately \$6,368,520 of LERRD related costs to the project.

Table ES- 2: Summary of Real Estate Requirements

Project Area	<u>Easements Required</u>		<u>Easements In-Hand</u>		<u>Outstanding Easements</u>	
	HSDR	Road	HSDR	Road	HSDR	Road
Gandys Beach	43	1	0	0	43	1
Fortescue	62	1	2	0	60	1
Villas (South)	57	0	2	0	55	0
TOTALS:	162	2	4	0	158	2

PERTINENT DATA

Item	Gandys Beach	Fortescue	Villas (South)	Total
Volume of Nourishment Fill	213,700 cubic yards	331,400 cubic yards	486,100 cubic yards	1,147,900 cubic yards
Volume of Renourishment Fill	49,200 cubic yards	67,500 cubic yards	62,800 cubic yards	179,500 cubic yards
Renourishment Interval	6 years	6 years	6 years	6 years
Length of Fill	2,507 feet	4,564 feet	7,442 feet	N/A
Width of Berm	75 feet	75 feet	50 feet	N/A
Berm Slope	1V:10H	1V:10H	1V:10H	N/A
Dune Crest	N/A	N/A	12 feet NAVD88	N/A
Dune Slope	N/A	N/A	1V:5H	N/A
Groin Construction Costs – 2021*	\$8,226,000	\$6,405,000	N/A	\$14,631,000
Nourishment Costs – 2022 (Gandys Beach and Fortescue)*				\$58,091,000
Nourishment Costs – 2028 (Villas South)*				\$51,550,800
Periodic Renourishment Costs – 2028 (Gandys Beach and Fortescue)*				\$22,093,200
Periodic Renourishment Costs – 2034 through 2072*				\$142,196,000
Average Annual Costs				\$5,912,633
Average Annual Benefits	\$2,548,718	\$3,015,329	\$2,692,323	\$8,256,370
Average Annual Net Benefits				\$2,343,737
Benefit Cost Ratio				1.4
Estimated Project Cost (October 2019 Price Level)				\$288,561,000

1. * Indicates costs include PED, Lands & Damages and Construction Management
2. Nourishment and renourishment costs shared across the sites in the recommended plan as they are based on a single dredge mobilization with continuous operation to each site.

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1 STUDY INFORMATION

The purpose of this report is to reduce the risk of damages from coastal storms through the beneficial use of dredged material from Federal navigation channels within the Delaware Estuary. The USACE and the non-Federal Sponsor (NJDEP) entered into a feasibility cost share agreement (FCSA) on 27 February 2014.

1.1 PROBLEM DESCRIPTION

The primary problems identified in this study are damages along the Delaware Estuary shoreline caused by erosion, wave attack and inundation due to coastal storms, along with rising water levels due to RSLC.

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

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 USACE undertook a Reconnaissance Study to review 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. In 2012, the USACE completed the “Delaware River New Jersey, Delaware and Pennsylvania Dredged Material Utilization and Beneficial Use Opportunities Expedited Reconnaissance Study” (Reconnaissance Study). The Reconnaissance Study looked at the beneficial use of dredged material for a variety of purposes, including ecosystem restoration, flood risk management, and navigation. It was recommended that the Reconnaissance Study proceed to the feasibility phase.

In January 2013, Congress passed the Disaster Relief Appropriations Act (PL 113-2) in response to Hurricane Sandy, a catastrophic storm that 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. In Chapter 4 of Title X PL 113-2, Congress directed USACE to prepare “an interim report identifying...any project under study by the Corps for for reducing flood and storm damage risks in the affected area” and to submit that interim report“ to the appropriate congressional committees by May 1, 2013.” As it was recommended that the Reconnaissance Study proceed to the feasibility phase, the Delaware Dredged Material Utilization, DE study was identified as a “project under study” in the interim report submitted to Congress. Congress also appropriated \$29,500,000 in PL 113-2 for the Secretary of the Army to “expedite and complete ongoing flood and storm damage reduction studies in areas that were impacted by Hurricane Sandy in the North Atlantic Division of the United States Army Corps of Engineers.” At the time PL 113-2 was passed, the feasibility study had not commenced and was an “ongoing flood and storm damage reduction study” between the reconnaissance and feasibility phases. Therefore, PL 113-2 provided the appropriation of funding to conduct the feasibility study.

The Resolution directs USACE to determine whether any modifications of the recommendations in the previous Chief’s Report “are advisable in the interest of beneficial use 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.” Upon initiation of the feasibility study, CSRSM was identified as an “other allied purpose,” for which dredged material could be used beneficially. Although the resolution does not define the term “allied purpose,” the word “allied” is defined to mean “having or being in close association” and “related especially through common purpose and qualities.” Given that the title of the resolution is “Beneficial Use of Dredged Material on the Delaware River, Delaware, New Jersey, and Pennsylvania,” an “allied purpose” means any purpose for which dredged material could be beneficially used in those states under the authority of USACE. Therefore, the feasibility study was conducted pursuant to the authorities in both the Resolution and PL 113-2.

1.3 PURPOSE AND SCOPE (PURPOSE AND NEED)*

As referenced above, the USACE undertook a Reconnaissance Study to review 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. In 2012, the USACE completed the Reconnaissance Study looking at the beneficial use of dredged material for a variety of purposes, including ecosystem restoration, flood risk management and navigation. It was recommended that the Reconnaissance Study proceed to the feasibility phase. The feasibility study described herein was conducted in accordance with that recommendation and to further facilitate the review requested by Congress in the Resolution. Upon initiation of the study, CSRSM was identified as an “other allied purpose” to be considered for the beneficial use of dredged material as authorized by the Resolution. The passage of PL 113-2 further mandated a CSRSM feasibility study for the subject study area; therefore, this study did not evaluate the other potential beneficial use opportunities (ecosystem restoration,

navigation, stream restoration, water quality, restoration of coal and other mined areas, cover material for sanitary landfills) discussed in the October 2005 Senate Resolution.

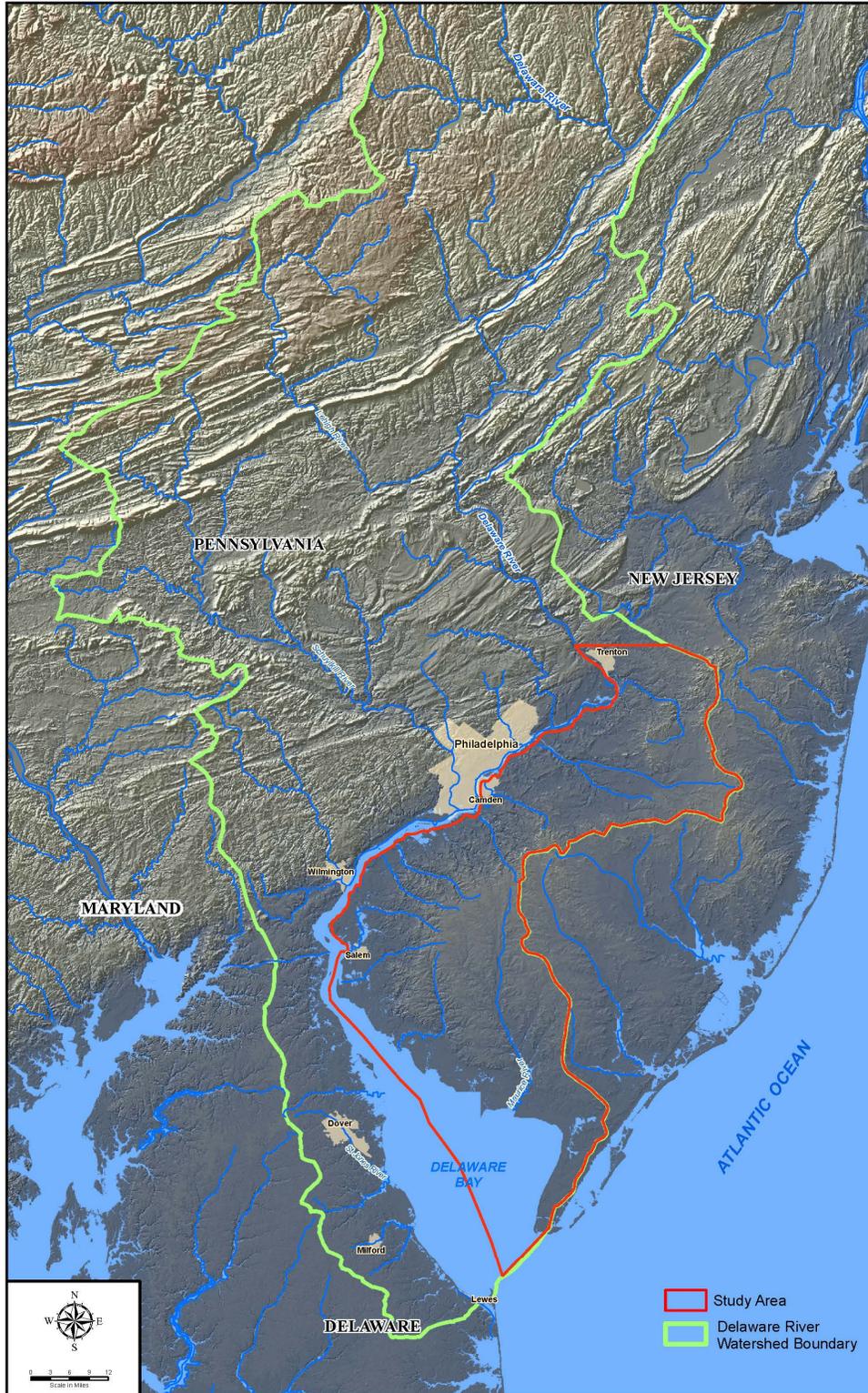
The purpose of this report is to present the findings of a feasibility investigation that was conducted to determine if there is a Federal interest and recommend a solution to identified CSRMs at various New Jersey communities. The study investigated the feasibility of addressing CSRMs via the beneficial use of dredged material. The purpose of this feasibility study is to determine feasible ways to beneficially use material to reduce the risk of damages along the Delaware Estuary shoreline caused by erosion, wave attack and inundation due to coastal storms, along with rising water levels due to RSLC. CSRMs alternatives utilizing dredged material were formulated, compared/evaluated against the without project condition and were optimized in order to identify the National Economic Development (NED) plan. If a viable opportunity to implement CSRMs alternatives with dredged material was not identified in select problem areas, then other alternatives were recommended for further analysis under another study authority.

1.4 LOCATION OF THE STUDY AREA

The study area is located within the New Jersey portion of the Delaware River watershed. 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_Projects\2Lower_Delaware_Watershed\400\Delaware_River_Study_Area_and_Watershed_NU_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 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).

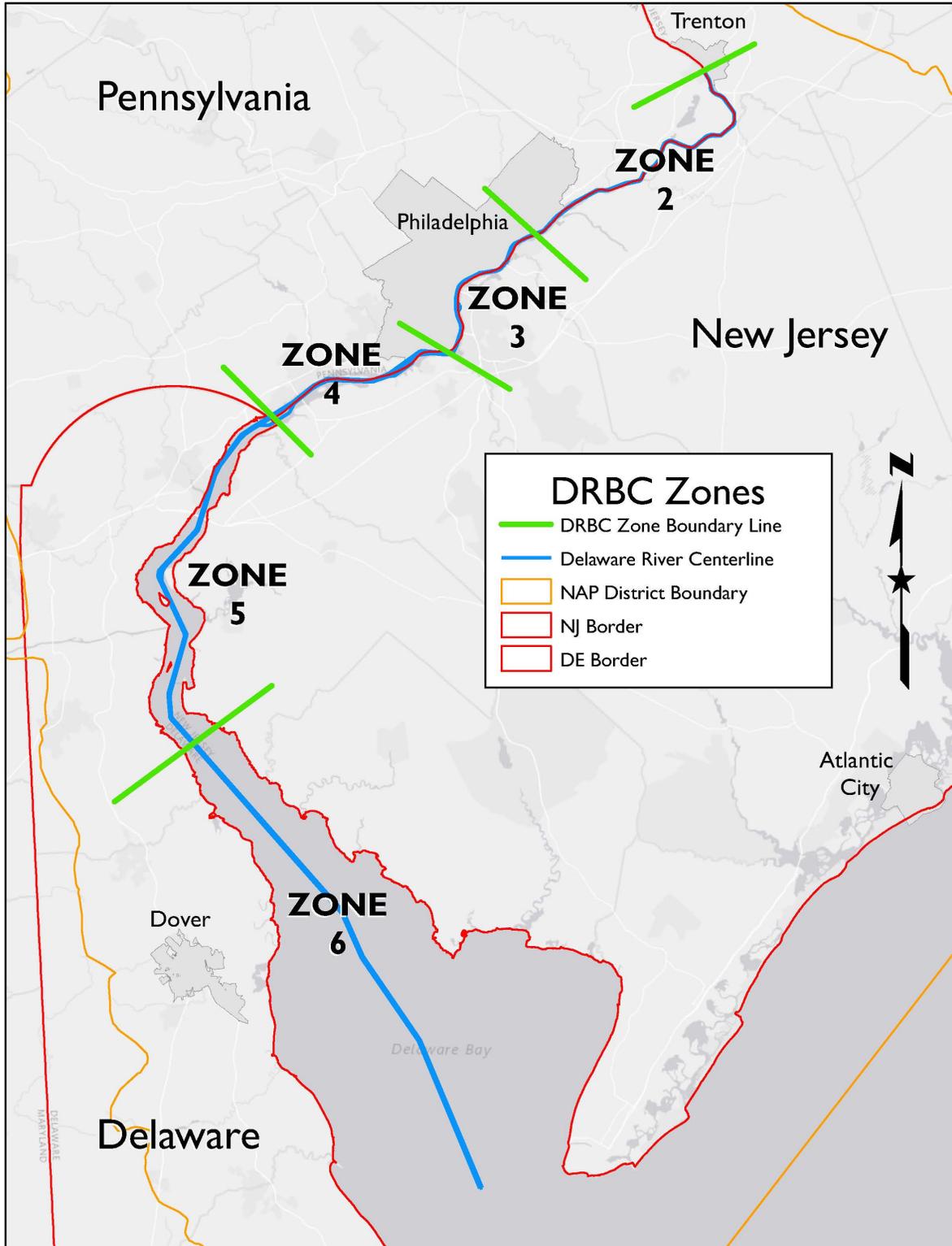
In the northern reach, the width of the waterway is relatively small and the principal CSRMs are due to inundation related to coastal storm surge, as occurs during tropical storms, hurricanes or nor’easters. The northern reach is characterized as a low wave energy environment although tidal currents and boat wake can be significant at exposed locations in close proximity of the main channel. 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 CSRMs from the combined effects of inundation, waves and storm erosion.

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 for maintenance dredging 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 Delaware River Main Channel Deepening (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) in 1992. Construction of the deepened channel was initiated in 2010 and is scheduled for completion in 2019. 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 cutterhead 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 CSRSM project consists of a 50-foot 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 evaluated CSRSM 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 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 deep water 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.

Reeds Beach and Pierces Point (USACE, 1998): This authorized, but unconstructed, ecosystem restoration project proposes to restore an 80-foot 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. The LRR updated the Delaware Bay Coastline, DE & NJ, Reeds Beach and Pierces Point, NJ Final Integrated Feasibility Report and Environmental Assessment, dated July 1998 (Addendum dated February 1999). The recommended plan consisted of beach fill (berm) at two contiguous locations, Reeds Beach and Pierces Point, New Jersey. The berm-only alternative was the sponsor's preferred design alternative. The feasibility report explained that, "In keeping with current Corps guidelines, a less optimal plan can be chosen as the selected plan if desired by the local sponsor as long as the sponsor preferred plan remains justified. It was previously demonstrated that the berm-only plan provided an incrementally justified amount of habitat improvement and can be constructed without any associated impacts which would adversely affect its implementability." Berm restoration was to be accomplished by beach nourishment. This plan required approximately 249,000 cubic yards of sand.

Villas and Vicinity (USACE, 1998): This authorized, but unconstructed, ecosystem restoration project proposes to restore an 80-foot 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.

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 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.

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.

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 (*Acipenser 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.

North Atlantic Coast Comprehensive Study (USACE, 2015): PL 113-2 directed USACE to conduct a comprehensive study (the NACCS) to address 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 CSRMs. 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 CSRMs efforts. The study also considers existing and future inundation and RSLC. Specifically, the NACCS identified the Delaware Bay shoreline as a high risk area requiring additional analysis.

Delaware Beneficial Use of Dredged Material for the Delaware River Feasibility Report and Integrated Environmental Assessment (USACE, 2018): The feasibility report and integrated EA evaluated CSRMs issues in various Delaware communities, with the intent to beneficially use dredged material from the Federal navigation channels within the Delaware Estuary. Seven communities (Pickering Beach, Kitts Hummock, Bowers Beach, South Bowers Beach, Slaughter Beach, Prime Hook Beach and Lewes Beach) were identified as dredged material placement sites for CSRMs.

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 1.5, PL 113-2 directed USACE to conduct a comprehensive study 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, completed in January 2015, identified the Delaware Bay shoreline as a high risk area requiring additional analysis.

As part 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 and Figure 4.

Figure 3 – Northern Planning Reach CSRM Problem Areas

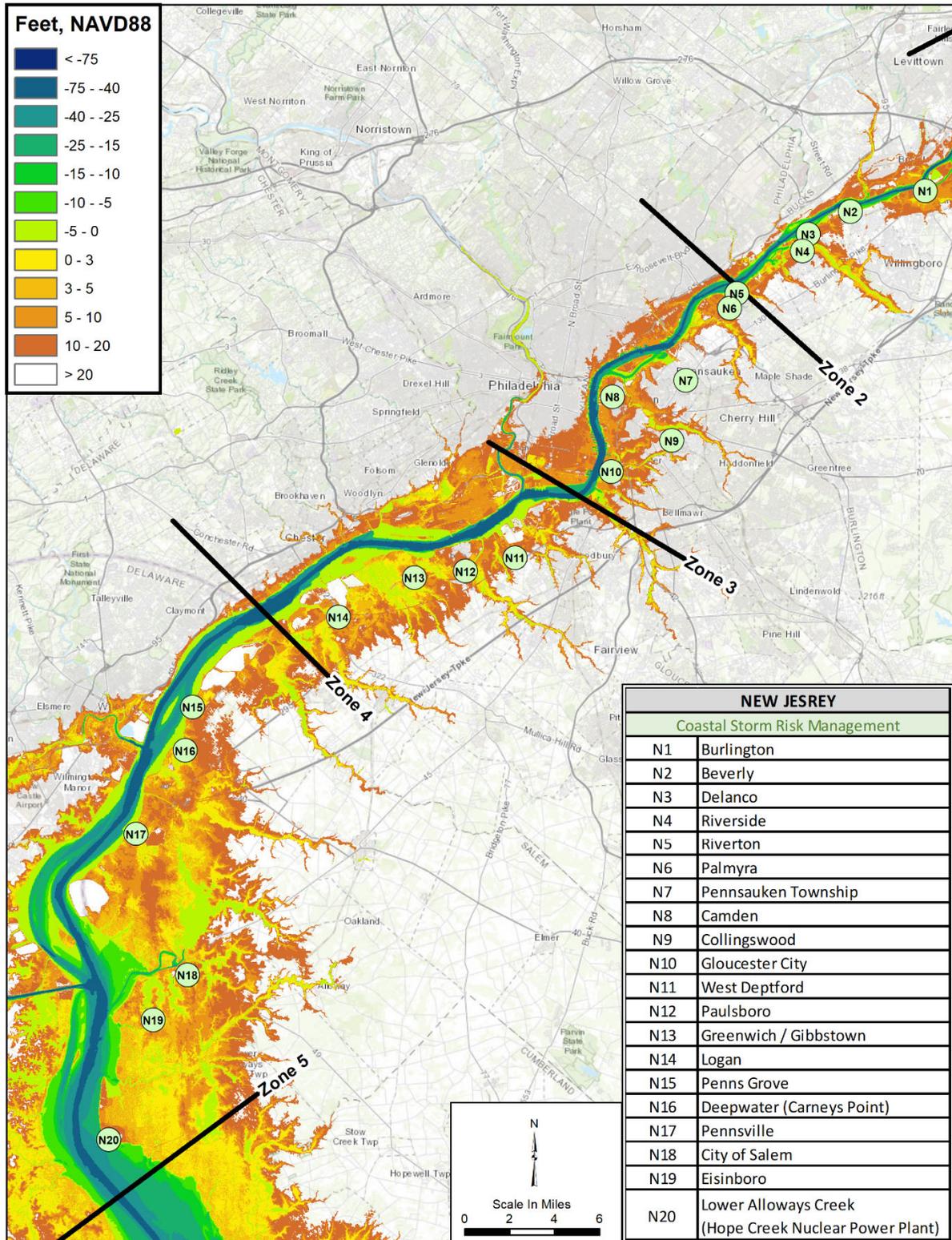
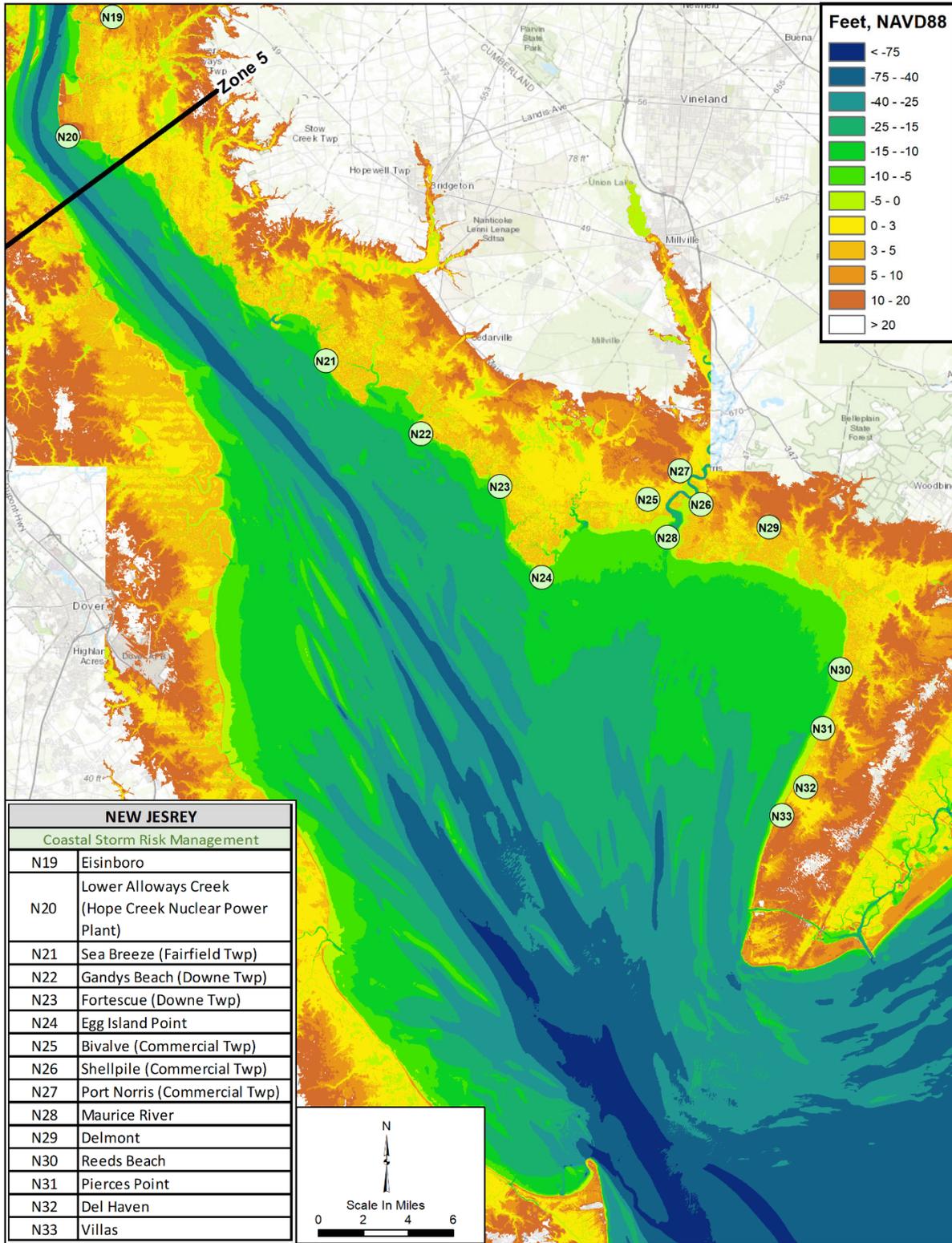


Figure 4 - Southern Planning Reach CSRM Problem Areas



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 damages along the Delaware Estuary shoreline caused by erosion, wave attack and inundation due to coastal storms, along with rising water levels due to RSLC. 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.

The nature of the CSRSM problem and the study area characteristics also present the opportunity to beneficially use dredged material to reduce vulnerability to coastal storms by minimizing erosion, wave and storm-surge related damages to New Jersey communities and increase resiliency along the Delaware Estuary shoreline.

2.4 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

The CSRSM 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 (Cumberland County) 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 continue to be an important economic factors.

The original intent was to use the two stage-probability curves generated by the NACCS numerical modeling as inputs to the HEC-FDA model to estimate the economic benefits of a CSRSM project at the problem areas. However, after further analysis, the PDT divided the study area into two planning reaches (northern reach and southern reach) based on the differing characteristics of the waterway in each reach.

In the northern reach, the width of the waterway is relatively small and the principal CSRSM damages are due to inundation related to coastal storm surge, as occurs during tropical storms, hurricanes or nor'easters. The northern reach is characterized as a low wave energy environment although tidal currents and boat wake can be significant at exposed locations in close proximity of the main channel. 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 CSRSM damages from the combined effects of inundation, waves and storm erosion. As qualitative screening (supported by a Value Engineering study) ruled out the CSRSM problem areas in the northern planning reach (riverine portion of the study area), it became apparent that HEC-FDA was not the appropriate model to evaluate the sites in the southern reach. As discussed in the Economics Appendix, the certified USACE model Beach-fx version 1.1 was used to evaluate with and without project conditions. This model employs event-based Monte Carlo life cycle simulation software to estimate erosion, wave, and inundation damages in the With- and Without-Project conditions.

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 RSLC. The Delaware Bay is 47 miles long and 27 miles wide measured at the widest point. 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 FWMAs 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 homes 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.

Specifically, Cumberland County, NJ (where Gandys Beach and Fortescue are located) has an estimated permanent population of 157,035 (2015 U.S. Census Bureau American Community Survey) with populations centered in the City of Bridgeton, the City of Vineland, and the City of Millville. The county population has increased 7.24% over the past 15 years. In total, Cumberland County has an estimated 56,216 housing units with a median value of \$162,400. Median household income is \$49,984 with a per capita income of \$22,417. 17.9% of persons in Cumberland County fall below the poverty line. Demographically, the county is predominantly Caucasian (48.5%) and Hispanic (28.6%) with African-American (18.6%), Asians (1.3%), and Other (3.0%) comprising the remainder of the county population. By value of sales, Cumberland County's largest business sectors are Retail Trade, and Transportation and Warehousing.

Villas is located in Cape May County, which has an estimated permanent population of 95,805 (2015 U.S. Census Bureau American Community Survey) with populations centered in the Lower Township, Middle Township, and Ocean City. The county has experienced a decrease in population of -6.37% over the past 15 years. In total, Cape May County has an estimated 98,747 housing units with a median value of \$299,700. Median household income is \$57,637 with a per capita income of \$33,028. 10.4% of persons in Cape May County fall below the poverty line. Demographically, the county is predominantly Caucasian (85.9%) with Hispanic (7.0%), African-American (4.6%), Asians (1.1%), and Other (1.4%) comprising the remainder of the county population. By value of sales, Cape May County's largest business sectors are Retail Trade, and Accommodation and Food Services.

At Gandys Beach and Fortescue the average upland elevation is approximately + 6.5 ft NAVD88 compared to the beach berm which is at +6 ft NAVD88. The upland elevation ranges from 8 to 14 feet NAVD88 at Villas, with a beach berm elevation of +5 ft NAVD88. Representative profiles for these and other CSRM problem areas are highlighted on Figure 14.

As referenced above, the Delaware bayfront communities are subject to long-term and storm-induced erosion, wave attack and inundation. Regarding long-term shoreline erosion, the USACE (1991) and G.T. French (1990) conducted a review of the Delaware Bay and its tributaries to determine the magnitude, location and effect of the shoreline erosion problems. In addition to the prior studies, a new shoreline change analysis was completed at Villas and Del Haven using long profile survey data from 1995 and LIDAR data from 2014. Del Haven and the northern portion of Villas were found to be stable, with accretion in northern Villas; however, the southern part of Villas had a long-term shoreline change rate of -1.5 ft/yr. In 2016, a shoreline change analysis was conducted at Gandys Beach using historical aerials from 1930 and 2013. Shoreline change rates were calculated based on the distance from the observed shoreline from a fixed baseline. The average shoreline change rate along Gandys Beach was found to be -2.5 ft/yr. The above-referenced USACE shoreline study (1991) evaluated shoreline change data between 1940 and 1978. Specifically, at Fortescue the estimated shoreline change rate was found to be -1 ft/yr; however based on historical beach fill operations that occurred at Fortescue during this same time period, the estimated long-term shoreline change rate is more like -2.5 ft/yr.

Waves within the Delaware Bay may be generated by local winds or propagate from the ocean through the mouth of the Bay. The sites under consideration in the southern planning reach are sheltered from ocean waves propagating through the mouth of the Bay; therefore, they are primarily exposed to locally generated waves. However, the wave directions at each site will vary based on the prevailing open water fetch direction and lengths.

2.4.2 Historical Flooding

According to the National Climatic Data Center (NCDC), the following coastal flood events resulted in damage to various New Jersey counties between January 1995 and December 2014:

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

Figures 5 through 11 provide an indication of the potential vulnerability of some of the communities in the southern planning reach, as many structures are close to the bayshore edge.

Figure 5 - Reeds Beach – July 2005



Figure 6 - Pierces Point – July 2005



Figure 7 - Pierces Point – July 2005



Figure 8 - Reeds Beach – July 2005



Figure 9 - Villas - October 2012



Figure 10 - Fortescue - March 2014



Figure 11 - Gandys Beach - March 2014



2.4.3 Existing Coastal Storm Risk Management

USACE has evaluated potential CSRMs 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 CSRMS project was constructed at Oakwood Beach in 2014. The project consists of a 50-foot wide berm at +6 ft NAVD88 that is 9,500 feet long with periodic nourishment and the extension of five stormwater outfall pipes. To date, no other Federal CSRMS projects have been constructed within the study area. USACE is not aware of state and/or local CSRMS projects within the study area.

2.4.4 Future Without Project Conditions

For the future without project 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. This conservative approach neglects any increase in potentially damageable assets accrued from future development even though Cumberland County and Cape May County have seen structure assessment values increase in recent years. Use of the existing inventory is preferable due to uncertainty and limitations in projecting future development.

Numerous studies have been conducted along the Delaware Bay and its tributaries to determine the magnitude, location and effect of the shoreline erosion. It is evident from Table 1 that there is fairly good agreement between previously reported shoreline change rates and more recent analyses by the Stockton College Coastal Research Center (2016) and USACE (2016). The greatest uncertainty appears to be at Reeds Beach, with reported values ranging between -3 ft/yr and 0 ft/yr. However, the more recent analyses show that the shoreline at Reeds Beach has been stable with shoreline change rates up to -1 ft/yr.

Recommended Future Without Project shoreline change rates for the NJ DMU project (Table 3) are a synthesis of all the available shoreline change data in study area with greater emphasis on newer data.

Table 1 - Historical Shoreline Change Rates (ft/yr) from Prior Studies – Cape May County

Location	USACE 1960	USACE 1991	FEMA 1993	USACE 1998a	USACE 1998b	CRC 2016	USACE ² 2016
	1842 to 1957	1842 to 1957	1842 to 1986	1943 to 1995	1842 to 1994	1995 to 2016	1995 to 2014
Goshen Creek	-3.0 ¹	-3					
Reeds North							
Reeds South	-0.2	0	-2		-1		
Pierces Point							
Del Haven	+1.0	+1	0	-0.6			-0.1
Villas North							
Villas South	-2.3	-2	-2	-1.4		+1.5	-0.9
North Cape May							

¹Shoreline change reported for Reeds Beach to Goshen Creek

²Analysis conducted by Philadelphia District in support of this study

Table 2 - Historical Shoreline Change Rates (ft/yr) from Prior Studies – Downe Township

Location	USACE 1991	HMM 2016	USACE ² 2017
	1943 to 1995	1930 to 2013	1943 to 1995
Gandys Beach		-2.5	
Fortescue	-1		-2.5 ¹

¹Shoreline change rate in absence of past beach fill activities

²Analysis conducted by Philadelphia District in support of this study

As noted on Table 2, observed shoreline changes at Fortescue were adjusted based on past beach fill activities to determine what the shoreline change rate would likely have been in the absence of these activities.

Table 3 - Recommended FWOP Shoreline Change Rates (ft/yr)

Location	Characterization	Shoreline Change (ft/yr)
Gandys Beach	Moderate Erosion	-2.5
Fortescue	Moderate Erosion	-2.5
Reeds Beach	Stable to Low Erosion	-1
Pierces Point	Stable to Low Erosion	-1
Del Haven	Stable	0
Villas North	Stable to Accretion	+0.5
Villas South	Moderate Erosion	-1.5

In the future without project conditions these erosion trends are expected to continue, or be exacerbated by RSLC, resulting in significant shoreline retreat and narrowing of existing beaches and dunes, and reduction in the existing beaches' ability to dissipate storm induced waves, erosion, and

flooding. Increased storm-induced wave, erosion, and flooding damages are expected to undermine the physiography supporting the existing structures and infrastructure in the developed areas and 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 as the footprint of Buoy 10 was permitted to expand, based on the January 2018 Coastal Zone Management Act Consistency Determination (CZM) and Water Quality Certificate (WQC). 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 the significance of the problem and the benefits of possible solutions. In the case of this study, the focus is primarily on CSRSM 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 the costs. It is important to note that benefits can include non-monetary benefits such as reducing life-safety issues and improving the environmental quality.

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 CSRSM 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 CSRSM for people, property and infrastructure along and adjacent to the Delaware Estuary shoreline in New Jersey 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.

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:

- CSRMs must be achieved via the beneficial use of dredged material.
- Avoid conflicts with the existing engineering policies for CSRMs projects.
- Do not formulate CSRMs plans for a single private property as well as a single entity.
- Avoid impacts to Threatened and Endangered Species.
- The timing of maintenance dredging will control the availability of sand for placement.

In addition to the aforementioned constraints, the following planning considerations were recognized during the formulation process:

- Limit extensive changes to local land use designations and zoning.
- Avoid inducing flood damages.
- Existing topography for tying in dune alignment will impact CSRMs benefits realized.
- Avoid and/or minimize effects on cultural resources and historic structures, sites and features.
- Avoid degradation to water quality.

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 CSRMs problem areas were identified in the study area. As part of the alternative plan development, the USACE 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 USACE to better understand the nature and extent of the CSRMs problems. Initially, the USACE posed the question as to whether CSRMs was the primary problem at each location. CSRMs was considered a primary problem at a location if the Composite Exposure Index (CEI), as calculated and reported in the NACCS, was greater than 50%. Although a myriad of factors or criteria can be used to identify exposure, the NACCS CEI focused on the following categories and criteria, as emphasized in PL 113-2: population density and infrastructure, social vulnerability and environmental and cultural resources:

- Population Density and Infrastructure – Population density includes identification of the number of persons within an areal extent across the study area; infrastructure includes critical infrastructure that supports the population and communities. These factors were combined to reflect the overall exposure of the built environment.
- Social Vulnerability Characterization – Social vulnerability characterization includes certain segments of the population that may have more difficulty preparing for and responding to coastal flood events.
- Environmental and Cultural Resources – The environmental and cultural resources exposure captures important habitat and cultural resources that would be affected by storm surge, winds and erosion.

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%, social vulnerability was weighted at 10% and environmental/cultural resources were weighted at 10% of the total CEI. The USACE chose to use the NACCS CEI as a screening tool since the CEI was heavily weighted toward the impact of CSRMs to population and infrastructure. The CEI was selected as an initial screening tool because this CSRMs study was conducted under the flood risk management business line where the primary planning objective was improved CSRMs for people, property and infrastructure, not ecosystem restoration.

While the CEI was heavily weighted toward people and infrastructure, there were other metrics (social vulnerability and environmental/cultural indices) that contributed to the overall CEI. The social vulnerability characterization was completed using the U.S. Census Bureau 2010 Census Demographic Summary Profile data (Census, 2011). The overarching goal was to quantify areas where the population is more at risk to storm impacts. After considering the Census data, it was determined that age, income and inability to speak English were important factors in social vulnerability. The environmental and cultural resources characterization was intended to capture important habitat, and environmental and cultural resources that would be vulnerable to storm surge, winds and erosion. Environmental and cultural resources were evaluated via data from national databases; such as National Wetlands Inventory and The Nature Conservancy (TNC) Ecoregional Assessments; data provided from USFWS (including threatened and endangered species habitat and important sites for bird nesting and feeding areas); shoreline types; and historic and national monuments

The USACE applied the CEI as a screening tool to focus this feasibility study on problem areas that could be addressed within the flood risk management business line. If the problem area had a CEI greater than 50% and was subsequently validated by best professional judgment, the USACE further evaluated the problem area under the flood risk management business line, specifically to determine if dredged material would be a feasible CSRMs measure in the problem area.

During the first round of 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 area was considered, as well as the shoreline type at the problem area, as reported in 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 USACE 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 the first round of 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 “Project Under 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 first round of screening are detailed in Table 4 below:

Table 4 - Problem Area Screening

First Round of Screening – NJ DMU		Question 1a: Is CSRM the primary problem?	Question 2: Is DM a feasible measure?	Carry Forward for Further Analysis under “Project Under 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 first round of 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. 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 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 USACE 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 flood proofing 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 placed on the eroded part of the beach. It is important to note that beach restoration has been evaluated as a structural measure as it is a structural element requiring construction or assembly on-site; however, it is also considered a natural and nature-based feature (NNBF), as indicated on Table 5.
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.
- 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) (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 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 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 USACE formulated structural and non-structural measures for each problem area. In the second round of screening, 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 Coastal Storm Risk Management Function was applied to determine if a measure met Objective 1. The Coastal Storm Risk Management 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 USACE determined that the measure met Objective 1.

USACE used criteria from the NACCS to assess each measure's resilience 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 USACE determined that the measure increased the shoreline resilience and met Objective 2.

In order for measures to be carried forward for further analysis, they must have met one of the two study objectives, as shown on Table 5.

Table 5 - Objectives/Measures Matrix

Management Measure	Non-Structural	Structural	NNBF	Objective 1: Improve CSRM for people, property and infrastructure along and adjacent to the Delaware Estuary shoreline in New Jersey from 2022 to 2072, via the beneficial use of dredged material.	Objective 2: Increase the resiliency of coastal New Jersey, specifically along the Delaware Estuary 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	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 CSRM 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 second round of 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. Nearshore berms and nearshore placement of dredged material were not evaluated as beach restoration methodologies in this study, as traditional beach nourishment (i.e. berm) was considered the most effective approach to maintain the design profile; however, as the project progresses, nearshore placement of sediment may be evaluated during periodic nourishment operations as an alternative approach to maintain the design profile.

While beach restoration 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 and breakwaters were also carried forward for further analysis because they potentially enhance the functionality of beach restoration measures, thereby creating a more resilient shoreline. In addition, groins and breakwaters could potentially be constructed with dredged material via geotubes for the sand or with the rock that is blasted and removed from the navigation project's channel.

According to the NACCS, levees and dikes contribute a low level of wave attenuation and little or no erosion reduction; however, the USACE believes they are a potentially effective method of CSRMs 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 involve the beneficial use of dredged material as stipulated in the study objectives.

Natural and Nature-Based Features (NNBF)

Three NNBF measures (living shorelines, reefs, overwash fans and wetlands) were also carried forward for further analysis because they met Objective 2. These NNBF measures would be expected to help reduce CSRMs problems, particularly erosion and wave damages; however, the effect is expected to be relatively small, especially for large storms; therefore, the USACE determined that these measures did not meet Objective 1. However, 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 RSLC 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.

Reefs can enhance the resilience of coastal areas by reducing the degradation and shoreline erosion that would occur during a storm event. Reef sites may be developed using natural materials such as oyster shells, clam shells, or rock.

3.3 PLAN FORMULATION

During the development of the array of alternatives, the management measures that passed the second round of screening were applied to the remaining 12 CSRM problem areas that passed the initial round of screening, as indicated on Table 6.

Table 6 - Measure Applicability by Problem Area (Second Round of Screening)

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

As Table 6 shows, beach restoration was considered as a potential measure at 6 problem areas (Gandys Beach, Fortescue, Reeds Beach, Pierces Point, Del Haven and Villas) based on the existing presence of beaches at each community, that are subject to varying degrees of long-term and storm-induced erosion. In addition, groins and breakwaters were considered as potential measures at these 6 problem areas. After the second round of screening, the USACE carried groins and breakwaters forward for further consideration at these 6 problem areas based on their potential to reduce the effects of long-term and storm-induced erosion.

In the northern (more riverine) reach, levees/dikes were considered at Penns Grove/Carneys Point and Pennsville because they were considered to be potentially more effective at mitigating flood inundation in a more riverine environment. Levees/dikes were considered for 4 Cumberland County problem areas (Bivalve, Shellpile, Port Norris and Maurice River Twp.) located in the southern (Bay) reach because each community was located along the Maurice River (upriver from the outlet to the Delaware Bay) where levees/dikes were considered to be more effective.

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.

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, as summarized on Table 7.

Table 7 - 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 7, 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 8 - 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 8, 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 \$613 per linear foot plus an estimated \$4,000,000 mobilization/demobilization cost. 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, analyses indicated that the additional features, such as wetlands or living shorelines, would provide minimal additional CSRM benefits compared to the added cost. For living shorelines, data from the NACCS indicates that they are generally applicable to relatively low current and wave energy environments in estuaries, rivers, and creeks with water depths less than 5 feet MLLW. Areas exposed to larger waves do

not benefit significantly from a living shoreline application since the marsh vegetation and underlying soils would likely be eroded. NACCS also indicates that living shorelines are more effective at shorelines with existing vegetation as opposed to exposed beach areas. An essential component of a living shoreline is constructing a rock structure (breakwater/sill) offshore and parallel to the shoreline to serve as risk management from wave energy that would impact the wetland area and cause erosion of the substrate and damage or removal of the tidal plants. Typically, the rock structure is designed with a crest elevation at or slightly above MHW that is effective at reducing wave energy under normal conditions but allows waves under severe storm events to pass over the stone structure and impact the shore. Therefore, living shorelines are typically more effective at reducing long-term erosion than short-term storm driven erosion.

In the southern reach, the width of the bay (fetch) increases resulting in greater wind-generated wave energy at the shoreline. The greater wave conditions in the southern reach require a substantial rock structure associated with any living shoreline that would look and function similarly to a breakwater. Living shorelines in the southern reach are expected to have limited effectiveness at many of the sites since the most vulnerable houses are often located on or directly behind a sandy beach with significant wave exposure and potential for storm-driven erosion. As discussed above living shorelines have limited effectiveness at reducing short-term storm driven erosion since the waves pass over the rock structure and may require a substantial beach buffer behind the rock structure to prevent erosion damages. Due to these reasons coupled with a construction cost of \$1,415 per linear foot (as estimated in the NACCS) living shoreline measures were screened out of the southern reach.

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

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.

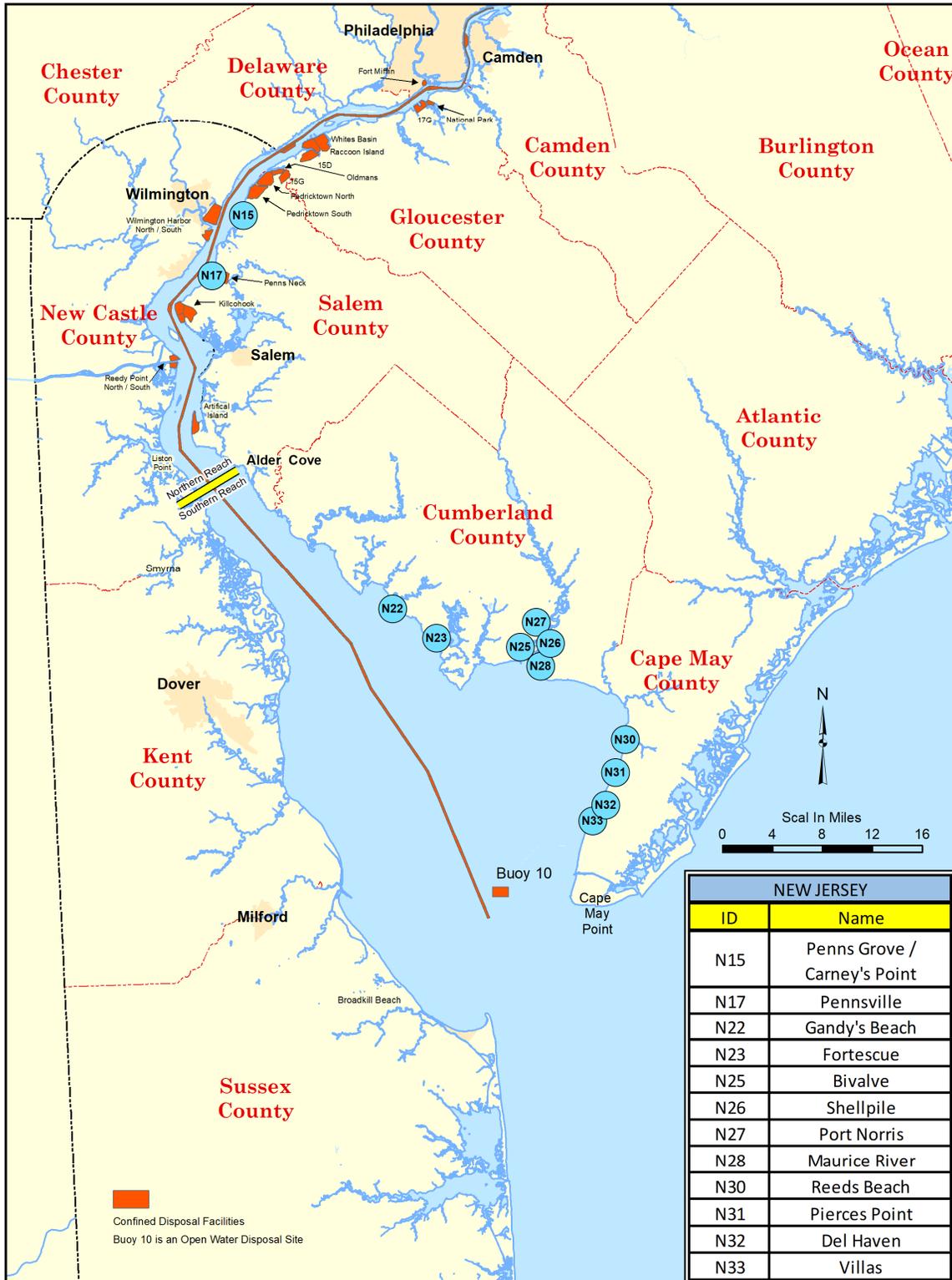
Regional Economic Development (RED) – The RED account registers changes in the distribution of regional economic activity that result from each alternative plan. Two measures of the effects of the plan on regional economies are used in the account: regional income and regional employment.

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 (as shown on Figure 12) within the Delaware Estuary 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 12 - Planning Reaches



3.4.1 Northern Reach Alternative Evaluation and Comparison

The without project conditions and associated problem(s) at each specified CSRМ 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 CSRМ 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 CSRМ problem area. Given the developed nature of the shoreline and the lack of space for beaches, beach restoration was not evaluated at these northern planning reach locations. As indicated on Table 9, 7 potential dredged material source areas were considered for the Levee/Dike Plan at the 2 problem areas.

Table 9 - Levee/Dike Plan Dredged Material Source Areas - Northern Reach

Source Area	Distance from Penns Grove/Carneys Point CSRМ Problem Area (Miles)	Distance from Pennsville CSRМ 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. While some of the VE study recommendations were different than the conclusions of the feasibility report, the purpose of the VE study was to support the plan formulation and offer other potential strategies and solutions. The VE study was conducted at a point in the feasibility process where select Beach-fx modeling results were not yet available to verify planning assumptions.

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.

While the northern reach sites and their associated alternatives were screened out via the NED Account, the other 3 accounts supported the evaluation and comparison of alternatives as highlighted on Tables 10 and 11.

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Table 10 - 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 CSRSM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRSM 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)				
Land Use	There will be continual erosional impacts and coastal storm risk to infrastructure. Continued erosion of the narrow sandy beaches along the bay coastline will leave adjacent salt marshes, farmland and residential communities (e.g. homes and roadways) vulnerable to frequent inundation, flooding and loss of vegetation. Adverse effects to land use include diminished aesthetic quality of bay beach communities and adjacent saltmarshes, recreational opportunities and habitat availability as the remaining beach berms continue to erode under current and future storm conditions.	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.
Physiography & Geology	Storms will continue to erode the shoreline undermining physiography supporting the existing infrastructure in the developed areas and continued exposure of adjacent wetlands to flooding.	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. This future practice will contribute to an increasing	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 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.			
Climate and Climate Change	Wave exposed shorelines within estuaries and coastal bays are likely to see higher rates of erosion with RSLC 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).	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.
Water Resources	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.	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 with erosion of the barrier beachfront.	In developed areas, the plan will have minimal effect. In wetland areas, the plan interrupts the hydrodynamic interface of tidal influx.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, beach restoration maintains the hydrodynamic interface of the tidal shoreline, providing nutrients/sediment source to adjacent wetlands.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, 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	No impact.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, beach restoration involves the pumping of dredged material onto the beach above	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, the construction of a hardened structure, such as a groin would permanently reduce available

	reduces primary productivity.		the mean high water line, thereby reducing 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.	shallow water soft bottom habitat in the structure footprint but adds to the intertidal habitat diversity by providing hard bottom substrate for benthic macroinvertebrates.
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 if salt marshes incur lower habitat quantity and quality through loss of wetlands.	No impact.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, 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.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, minor temporary impacts to fish may occur 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.	Levee/dike footprint reduces available habitat for wildlife.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, beach restoration provides added risk management to wildlife habitats along the bayshore and within interior wetlands, scrub shrub and forested areas.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, 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.	Levee/dike footprint reduces available habitat for threatened and endangered species.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, beach restoration can provide positive benefits to listed species by restoring preferred beach habitat and increased flood risk management to interior wetlands, scrub shrub and maritime forested habitats. Adverse impacts are avoided with environmental windows during placement operations.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, the construction of a hardened structure, such as a groin permanently reduces 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 the 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	The No Action Plan will have no impact on Air Quality.	Temporary impact to air quality during construction and maintenance operations.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, there may be	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, there may be

			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	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, there may be temporary elevation of noise levels during construction and maintenance operations.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, there may be temporary elevation of noise levels during construction and maintenance operations.
Visual and Aesthetic Value	Under the No Action Plan, beaches will continue to erode due to tidal and storm action. Exposed peat reduces the appearance and recreational value of the shoreline. Scarping of the beach slope by storm-induced waves and erosion can often render the beach inaccessible and reduces the available habitat and quality for beach nesting birds, foraging migratory shorebirds and other wildlife.	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.
HTRW	No reported HTRW-related impacts were found to have the potential to adversely effect the No Action Plan.	No reported HTRW-related impacts were found to have the potential to adversely effect the Levee/Dike Plan.	No reported HTRW-related impacts were found to have the potential to adversely effect the Beach Restoration Plan.	No reported HTRW-related impacts were found to have the potential to adversely effect the Beach Restoration with Groin(s) Plan.
Cultural Resources & Historic Properties	Under the No Action Plan, no direct adverse effects to historic properties are anticipated. However, the continued sea level rise and lack of additional protection from storm related wave action would likely result in the deterioration of historic properties leading to their loss of integrity and/or degradation.	With the proposed Levee/Dike plan there is the potential for impacts to historic properties such as prehistoric and historic archaeological sites, due to construction activities. There is also the potential for impacts to the historic viewshed of existing historic structures or historic districts. However, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	There is a potential for impacts to historic properties such as prehistoric and historic archaeological sites with the beach restoration plan; however, these impacts could be minimized through best management practices for sand placement along with an archaeological monitoring plan. However, this alternative was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the site sites.	There is a potential for impacts to historic properties such as prehistoric and historic archaeological sites with groin construction activities along with the potential to impacts submerged historic resources such as shipwrecks. There is also the potential for impacts to the historic viewshed of existing historic structures or historic districts. There is a potential for impacts to archaeological sites with the beach restoration plan; however, these impacts could be minimized through best management practices for sand placement along with an archaeological monitoring plan. However, this alternative was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the site sites.

Other Social Effects (OSE)				
Environmental Justice	The No Action Plan will have no impact on Environmental Justice.	This plan will have no impact on Environmental Justice.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, 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.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, 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.	Potential flood risk management combined with a potential recreational use of the levee crest may improve quality of life and recreation.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, beach restoration enhances ecosystem services to humans by providing erosion control, water quality enhancement, storm risk management and habitat provision for wildlife and recreation.	Although it was not evaluated in the northern planning reach due to the lack of homogeneous sand dredged material sources close to the sites, beach restoration with groin(s) enhances 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	While there is no project cost, the No Action Plan does not provide RED benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRMs problem areas.	As reference 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.	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 11 - 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 Estuary 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. Since the dredged material does not appear suitable for levee construction, this alternative will not ensure the realization of the planned effects; therefore, the levee/dike plan was screened out and 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 was screened out and 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 was screened out and 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. Coordination with Federal agencies, including USEPA, USFWS and NMFS is ongoing to help assess the acceptability of the proposed project.	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.

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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 CSRMs 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. (N28) were screened out from further consideration under this study.

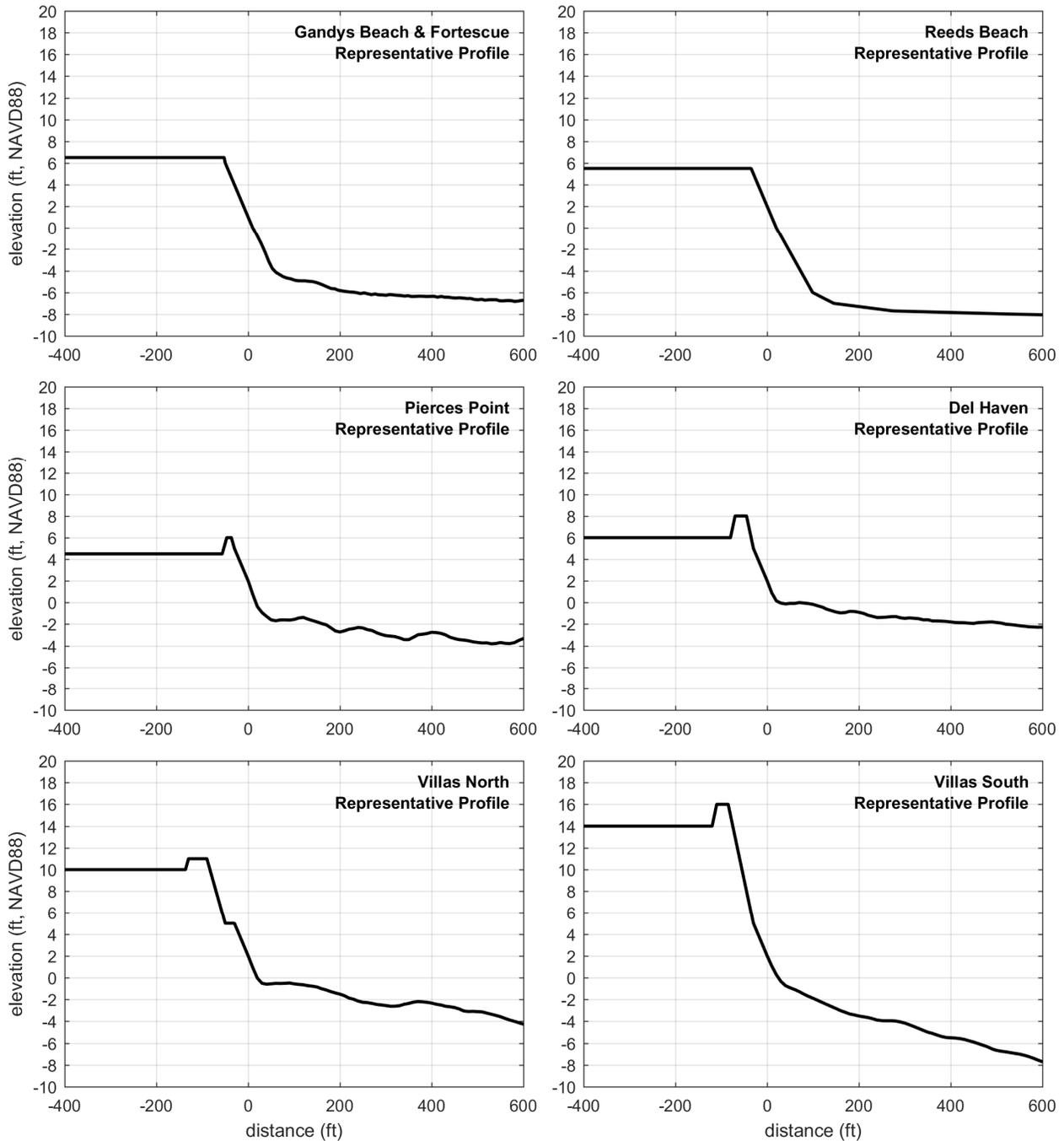
The remaining 6 southern reach problem areas (Gandys Beach (N22), Fortescue (N23), Reeds Beach (N30), Pierces Point (N31), Del Haven (N32) and Villas (N33)) are subject to CSRMs damages from inundation, waves and erosion. Therefore, they were evaluated with Beach-fx and are highlighted on Figure 13.

Figure 13 - Southern Reach Beach-fx Evaluation



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.

Figure 14 - Representative Without Project Profiles for Modeled Locations



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 USACE focused the alternative evaluation and comparison to the Beach Restoration Plan and the No Action Plan. In order to reduce rapid with-project end losses of the placed sand at Gandys Beach and Fortescue, the Beach Restoration with Groin(s) Plan was also formulated at these two locations.

As previously discussed, additional features, such as wetlands or living shorelines, would provide minimal additional CSRMs compared to the added cost. For living shorelines, data from the NACCS indicates that they are generally applicable to relatively low current and wave energy environments in estuaries, rivers, and creeks with water depths less than 5 feet MLLW. Areas exposed to larger waves do not benefit significantly from a living shoreline application since the marsh vegetation and underlying soils would likely be eroded. NACCS also indicates that living shorelines are more effective at shorelines with existing vegetation as opposed to exposed beach areas. An essential component of a living shoreline is constructing a rock structure (breakwater/sill) offshore and parallel to the shoreline to serve as risk management from wave energy that would impact the wetland area and cause erosion of the substrate and damage or removal of the tidal plants. Typically, the rock structure is designed with a crest elevation at or slightly above MHW that is effective at reducing wave energy under normal conditions but allows waves under severe storm events to pass over the stone structure and impact the shore. Therefore, living shorelines are typically more effective at reducing long-term erosion than short-term storm driven erosion.

In the southern reach, the width of the bay (fetch) increases resulting in greater wind-generated wave energy at the shoreline. The greater wave conditions in the southern reach require a substantial rock structure associated with any living shoreline that would look and function similarly to a breakwater. Living shorelines in the southern reach are expected to have limited effectiveness at many of the sites since the most vulnerable houses are often located on or directly behind a sandy beach with significant wave exposure and potential for storm-driven erosion. As discussed above living shorelines have limited effectiveness at reducing short-term storm driven erosion since the waves pass over the rock structure and may require a substantial beach buffer behind the rock structure to prevent erosion damages. Due to these reasons coupled with a construction cost of \$1,415 per linear foot (as estimated in the NACCS) living shoreline measures were screened out of the southern reach.

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 foot of wetland construction (as estimated in the NACCS) also limits the efficiency of the wetland feature.

According to the NACCS, the typical breakwater layout consists of breakwater segments of 300 feet (with 400 feet gaps between segments) and breakwaters located 500 feet seaward of the design shoreline. While breakwaters reduce wave energy and coastal erosion, they have minimal impact on inundation. In addition, based on the aforementioned design template and parametric costs in 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 size of the structure inventories of the communities in the southern reach, this added breakwater cost will greatly outweigh any added CSRMs benefits.

In accordance with ER 1100-2-8162, potential effects of RSLC on overall water levels were analyzed for each study location, over a 50-yr economic analysis period and a 100-yr planning horizon. A RSLC may be composed of both an absolute mean sea level change component and a vertical land movement change component. Historical sea level measurements at NOAA tide stations record the observed RSLC over time and capture the combined effect of absolute mean sea level change and vertical land movement. Historical RSLC and USACE SLC scenarios for this study are based on NOAA tidal records at Lewes, DE (Figure 15). Lewes, DE was selected over Cape May, NJ because the tidal record length at Lewes, DE is several decades longer than Cape May, NJ. Table 12 presents RSLC projections for the three USACE scenarios: Low/Historical, Intermediate, and High. A graphical display of the three RSLC scenarios over the 100-yr planning horizon is presented in Figure 16.

Table 12 – RSLC Adjustments Applied During Screening Level Assessments

Year	USACE - Low (ft, MSL¹)	USACE - Int (ft, MSL¹)	USACE - High (ft, MSL¹)
1992	0.0	0.0	0.0
2020	0.3	0.4	0.6
2045	0.6	0.8	1.6
2070	0.8	1.4	3.1
2095	1.1	2.0	5.0
2120	1.3	2.8	7.4

¹Mean Sea Level based on National Tidal Datum Epoch (NTDE) of 1983-2001

Figure 15 – Historical RSLC at Lewes, DE

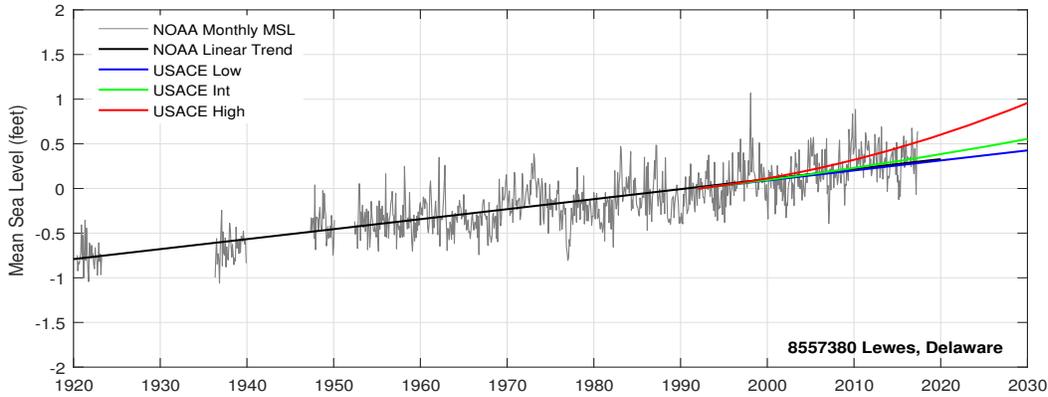
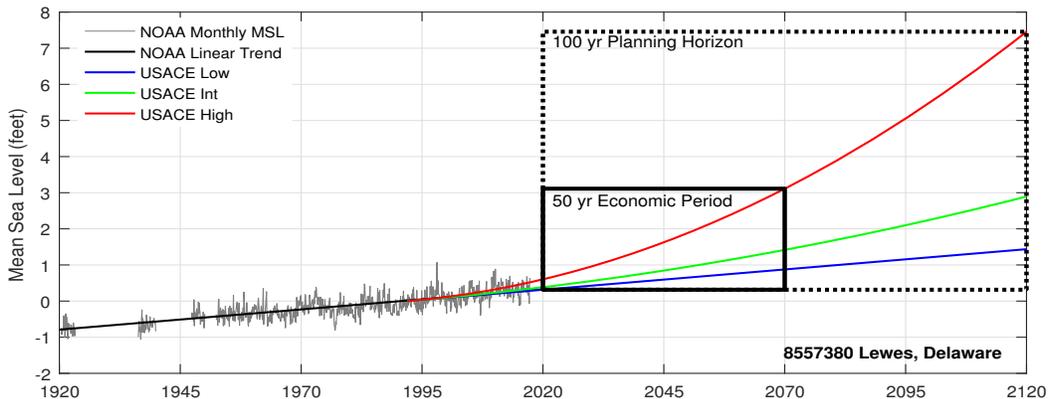


Figure 16 – RSLC Projections at Lewes, DE

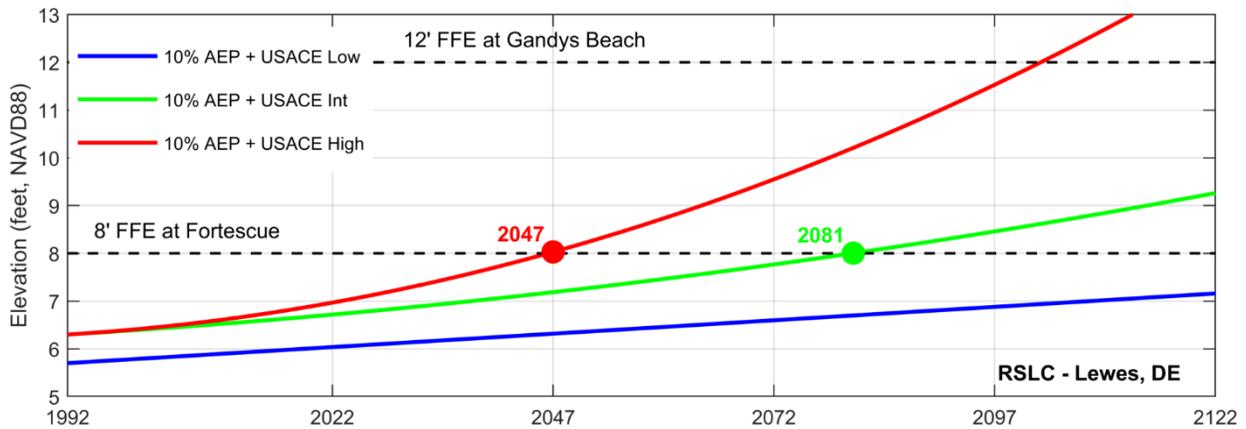


While the economic analysis is limited to the 50-yr life cycle, RSLC was also assessed on a 100-yr planning horizon, and used to qualitatively inform project performance (e.g. understanding future level of protection offered in 2100), and identify potential for adaptive management (e.g. increasing dune/berm height). For the 50-yr life cycle, the economic evaluation in Beach-fx supports the conclusion that the project has positive net benefits at all placement locations for the three RSLC curves. It is relatively easy to adapt the dune and berm restoration alternatives to RSLC, as additional sediment can be included in each renourishment operation to offset losses from RSLC. The natural berm elevation will rise in concert with the rising sea surface. The dune elevation will also need to be raised in response to RSLC to maintain the design performance. For the 100-year planning horizon, the proposed project remains sustainable for the intermediate and low RSLC curves; however, the project would not be

sustainable for the high RSLC curve as back-bay flooding would compromise the benefits of beach restoration to the communities.

Specifically in Fortescue and Gandys Beach back-bay flooding, with RSLC, will eventually compromise the benefits of beach restoration to the communities. Villas South is only exposed to flooding on one side (Delaware Bay) and has relatively high ground elevations (10 to 14 feet NAVD88). Potentially unsustainable damages to the structures at Fortescue will begin to occur when back-bay flood elevations exceed First Floor Elevations (FFE). Water elevations for the 10% AEP will exceed the median FFE at Fortescue (8 feet NAVD88) with 1.7 feet of RSLC. A RSLC of 1.7 feet is projected to occur by year ~2200, 2081, and 2047 in the USACE Low, Intermediate, and High SLC scenarios, respectively. The structures in Gandys Beach are not as vulnerable to back-bay flooding with a median FFE of 12 feet NAVD88, but the only road in town is vulnerable to nuisance flooding. Road elevations in Gandys Beach and Fortescue are at approximately 5 feet NAVD88 and will also experience daily tidal flooding (MHHW) with about 1.7 feet of RSLC, as indicated on Figure 17. Please see Appendix C-1 for further details on RSLC and its impacts on the project sustainability.

Figure 17 – RSLC Projections for the 10% AEP



As the feasibility study focused on the No Action Plan, the Beach Restoration Plan and the Beach Restoration with Groin(s) Plan in the southern reach, the USACE focused on dredged material source areas with predominantly sandy material and their associated distance from the placement locations, as highlighted on Table 13.

Table 13 - 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	25	25	9	9	9	9
Lower Reach E of the Delaware Bay Main Channel	13	13	20	20	20	20

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 (as indicated on Table 14) 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 a Delaware shoreline community adjacent to Prime Hook 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 nourishment and periodic renourishment, Lower Reach E (Miah Maull and Brandywine Ranges) of the main Delaware River channel is the likely dredged material source for the CSRSM 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.

Table 14 – Grain Size Comparison

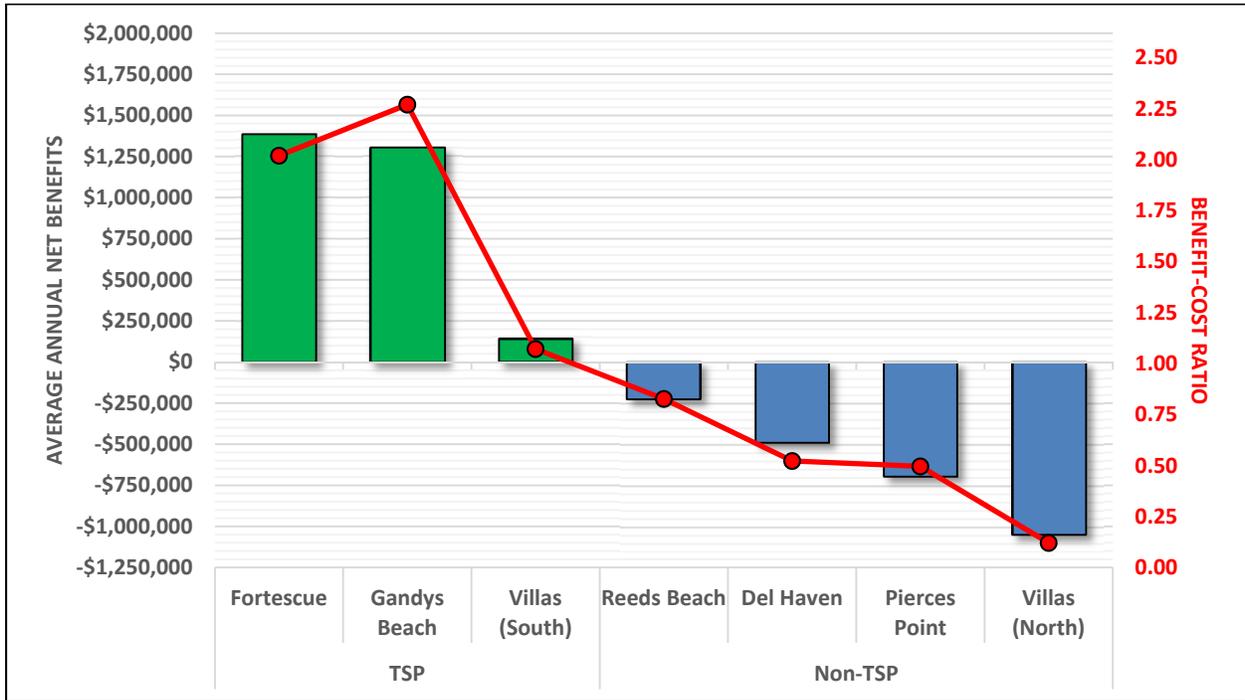
	Previously Dredged Sediment – Lower Reach E	Gandys Beach	Fortescue	Villas (South)
Average Grain Size (mm)	0.60	0.82	0.50	0.31

Notes:

1. Lower Reach E Average Grain Size based on sediment samples taken from Buoy 10.
2. In-situ grain sizes for Gandys Beach, Fortescue, and Villas (South) were estimated from past field investigation findings.
3. Each of these site has been subject to long-term erosion and prior restoration efforts; thus, the grain size findings are not indicative of natural material and would be expected to vary widely based on sampling locations and dates.

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 USACE 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 Plan at Villas North will not negatively impact the performance of beach restoration at Villas South.

Figure 18 – TSP Average Annual Net Benefits and Benefit-Cost Ratio Summary



At the time of the draft feasibility report release (October 2017), 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 period of analysis. As each site must be independently justified for inclusion in the recommended plan, Reeds Beach, Del Haven, Pierces Point, and Villas (North) were screened from further consideration.

As the final beach restoration designs for Gandys Beach, Fortescue and Villas (South) were further refined, the estimated total quantity increased to approximately 1,147,900 cubic yards for initial construction (nourishment). Considering the proposed source area and the projected quantities for nourishment and periodic renourishment, the USACE revised the likely project implementation plan as explained below. In addition, because the Delaware DMU period of analysis overlaps a large portion of the New Jersey DMU period of analysis, the USACE assumed that available dredged material would need to be distributed to each project over each overlapping period of analysis, as highlighted on Table 16.

In addition, based on the restrictive environmental window associated with the migratory red knot bird (15 April through 31 August), the USACE did not assume one continuous project construction operation for initial construction. The environmental window necessitated the USACE to assume initial construction to occur in three phases. Phase One (2021) will involve the construction of the terminal groins at Gandys Beach and Fortescue outside of the aforementioned environmental window. After the environmental window and based on the projected dredged material quantity limitations discussed above, Gandys Beach and Fortescue would be nourished as part of Phase Two (2022) of initial construction. Villas (South) is projected for nourishment in 2028, during the first periodic renourishment cycle of Gandys Beach and Fortescue.

Table 15 – Nourishment & Periodic Renourishment Quantities

Year	Dredged Material Placement Quantity – DE DMU (cubic yards)	Dredged Material Placement Quantity – NJ DMU (cubic yards)	Dredged Material Placement Quantity – Total (cubic yards)	Notes
2020 (DE DMU Base Year)	731,000		731,000	Nourishment – Lewes Beach, Prime Hook Beach and Slaughter Beach
2022 (NJ DMU Base Year)		545,100	545,100	Nourishment – Gandys Beach and Fortescue
2024				
2026	894,000		894,000	Nourishment – South Bowers Beach, Bowers Beach, Kitts Hummock and Pickering Beach Periodic Renourishment – Lewes Beach, Prime Hook Beach and Slaughter Beach
2028		602,800	602,800	Nourishment – Villas South Periodic Renourishment – Gandys Beach and Fortescue
2030				
2032	414,000		414,000	Periodic Renourishment (DE DMU)
2034		179,500	179,500	Periodic Renourishment (NJ DMU)
2036				
2038	414,000		414,000	Periodic Renourishment (DE DMU)
2040		179,500	179,500	Periodic Renourishment (NJ DMU)
2042				
2044	414,000		414,000	Periodic Renourishment (DE DMU)
2046		179,500	179,500	Periodic Renourishment (NJ DMU)
2048				
2050	414,000		414,000	Periodic Renourishment (DE DMU)
2052		179,500	179,500	Periodic Renourishment (NJ DMU)
2054				
2056	414,000		414,000	Periodic Renourishment (DE DMU)
2058		179,500	179,500	Periodic Renourishment (NJ DMU)
2060				
2062	414,000		414,000	Periodic Renourishment (DE DMU)
2064		179,500	179,500	Periodic Renourishment (NJ DMU)
2066				
2068	414,000		414,000	Periodic Renourishment (DE DMU)
2070		179,500	179,500	Periodic Renourishment (NJ DMU)
2072				

1. Major rehabilitation is not needed as the required major rehabilitation quantity is less than the periodic nourishment quantity, as further discussed in Appendix C-1.
2. The quantities listed on Table 15 represent projected pay quantities required to construct and maintain the beach profile

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 Miah Maull and Brandywine ranges is dredging via a hopper dredge and bottom dumping at Buoy 10 (an open water disposal site located in the southern planning reach adjacent to the mouth of the Delaware Bay). Buoy 10 is approaching full capacity. In 2017, Buoy 10 was estimated to be at or near capacity; however, the USACE requested and received from NJDEP a permit to expand the footprint and gain an approximate 10 years of additional capacity. A new CZM and WQC were received on 24 January 2018. 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 dredge location.

For nourishment through the first 8 years of the period of analysis, project costs are based on the difference between the 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 8 due to limited capacity at Buoy 10 (even with the expanded footprint); therefore, the with-project condition is compared against disposal at Artificial Island CDF for years 9 to 50 of the project. As discussed above, nourishment will be completed in two phases with the initial phase (Gandys Beach and Fortescue) completed in 2022 and the final phase (Villas South) completed in 2028 (concurrent with the periodic renourishment of Gandys Beach and Fortescue). Therefore, the mobilization cost for the 2022 nourishment is shared by 2 sites (Gandys Beach and Fortescue), while the 2028 nourishment/periodic renourishment mobilization cost will be shared by all 3 sites in the southern reach.

An overall summary of the southern reach alternative(s) comparison and evaluation is highlighted on Tables 16 and 17, respectively.

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Table 16 - Southern 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 CSRSM benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRSM 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.	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 rapid end losses and erosion provided by the groins adds benefit to the proposed project.
Environmental Quality (EQ)				
Land Use	There will be continual erosional impacts and coastal storm risk to infrastructure. Continued erosion of the narrow sandy beaches along the bay coastline will leave adjacent salt marshes, farmland and residential communities (e.g. homes and roadways) vulnerable to frequent inundation, flooding and loss of vegetation. Adverse effects to land use include diminished aesthetic quality of bay beach communities and adjacent saltmarshes, recreational opportunities and habitat availability as the remaining beach berms continue to erode under current and future storm conditions.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	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. CSRSM with beach restoration and beach restoration with groin(s) will help the shoreline communities be resilient against future storm and help provide economic sustainability, recreational use and natural habitat restoration.	The terminal groin restoration/construction is intended to enhance the performance and longevity of the beach restoration project by reducing rapid end losses of the placed sand. The addition of a groin to a beach restoration plan is typical in areas where relatively high beach erosion rates and losses occur. CSRSM with beach restoration and beach restoration with groin(s) will help the shoreline communities be resilient against future storm and help provide economic sustainability, recreational use and natural habitat restoration.
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.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	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 the physiography of the beach by accumulating sand on the updrift side and helping to stabilize the beach. The terminal groin at Gandys Beach may cause erosion on the downdrift side; however, it will be a rubble-mound structure designed to function as a cross-shore beach template (or brace), rather than as a block (or "dam") to longshore transport (Basco & Pope, 2004). The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004). The terminal groin at Fortescue (adjacent to the inlet at Fortescue Creek) will serve to reduce sand accumulation within the inlet.
Sediment Quality	Future maintenance dredging sand	Available dredged material does not	Beach restoration will reduce the sediment deficit in the	Groins located at inlets (jetties) serve to reduce sediment end losses

	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 placed 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.	appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Delaware Estuary, thereby improving the overall health of the estuary. The dredged material is predominantly sand and is not considered chemically contaminated. Beach restoration will not adversely impact sediment quality.	on the beach and sedimentation in the inlet. The dredged material is predominantly sand and is not considered chemically contaminated. Beach restoration with groin(s) will not adversely impact sediment quality.
Climate and Climate Change	Wave exposed shorelines within estuaries and coastal bays are likely to see higher rates of erosion with RSLC increases (Rosen, 1978; Stevenson and Kearney, 1996). RSLC 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).	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Beach restoration and beach restoration with groin(s) are expected to reduce the adverse impacts of RSLC on communities and beach habitat quality.	Beach restoration and beach restoration with groin(s) are expected to reduce the adverse impacts of RSLC on communities and beach habitat quality.
Water Resources	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.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Beach restoration on sandy beaches typically results in a temporary nearshore impact (<i>i.e.</i> 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). A robust dune and 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 berm 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 communities to serve to absorb surface water and accrete sediments.	Beach restoration with groin(s) will provide the same benefits as beach restoration alone, but a terminal groin adds longevity to beaches where erosion rates are significantly higher.
Vegetation & Wetlands	The majority of wetlands within the study area are estuarine intertidal emergent wetlands, with additional	Available dredged material does not appear to be suitable for USACE levee construction and would require	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

	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.	augmentation to improve its suitability.		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.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	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. There will be a temporary increase in turbidity during placement operations that may adversely impact planktonic and benthic organisms during construction. Despite the resiliency of intertidal benthic fauna, the initial beachfill will result in some mortalities of existing benthic organisms through burial.	The construction of a hardened structure, such as a groin would permanently reduce available shallow water soft bottom habitat in the structure footprint but add to intertidal habitat diversity by providing hard bottom substrate for benthic macroinvertebrates. There will be a temporary increase in turbidity during groin construction.
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 shoreline, 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.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	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.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Beach restoration will provide added risk management to wildlife habitats along the bayshore, interior shrub and within interior wetlands, scrub shrub and forested areas.	The construction of a hardened structure, such as a groin provides a resting area for shorebirds and feeding sites for coastal birds of prey. Groins provide interstitial spaces for marine macroinvertebrates as wildlife prey species.
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.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	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. With the No Action Plan there is no impact to air quality.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Temporary impact to air quality during construction and maintenance operations from increased emissions from construction equipment.	Temporary impact to air quality during construction and maintenance operations from increased emissions from construction equipment.
Noise	Normal noise levels created by traffic, businesses and industrial activities would continue under the No Action Plan.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Temporary elevation of noise levels during construction and maintenance operations.	Temporary elevation of noise levels during construction and maintenance operations.
Visual and Aesthetic Value	Under the No Action Plan, beaches will continue to erode due to tidal and	Available dredged material does not appear to be suitable for USACE levee	Beach restoration restores eroded beaches to a natural slope. Impacts to aesthetics will occur during construction operations	Construction of a terminal groin at Gandys Beach and Fortescue may take approximately 7 months. The presence of construction

	storm action. Exposed peat reduces the appearance and recreational value of the shoreline. Scarping of the beach slope by storm-induced waves and erosion can often render the beach inaccessible and reduces the available habitat and quality for beach nesting birds, foraging migratory shorebirds and other wildlife.	construction and would require augmentation to improve its suitability.	for approximately 7 months (for initial construction) and approximately 7 months for subsequent periodic nourishments. However, beach nourishment is conducted in sections, rendering approximately 800-1,000 linear feet of beachfront inaccessible to beach users for a few days at a time, until that section is complete and construction proceeds to the next section of beach.	equipment and associated noise will impact the aesthetic value at these locations temporarily. Groins commonly occur in coastal areas and may or may not be considered unsightly. Groins offer additional recreational use for sitting or fishing and are often observed to have shorebirds resting on them, such as terns and gulls.
HTRW	The No Action Plan will not identify or disturb potential HTRW.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	Beach restoration is not expected to identify or disturb potential HTRW. Sand is unlikely to be contaminated. Draghead screens on the dredged and beach discharge basket screen inspections prevent any potential UXO from being deposited on the beach.	Beach restoration with groin(s) is not expected to identify or disturb potential HTRW. Sand is unlikely to be contaminated. Draghead screens on the dredged and beach discharge basket screen inspections prevent any potential UXO from being deposited on the beach.
Cultural Resources & Historic Properties	Under the No Action Plan, no direct adverse effects to historic properties are anticipated. However, the continued sea level rise and lack of additional protection from storm related wave action would likely result in the deterioration of historic properties leading to their loss of integrity and/or degradation.	With the proposed Levee/Dike plan there is the potential for impacts to historic properties such as prehistoric and historic archaeological sites, due to construction activities. There is also the potential for impacts to the historic viewshed of existing historic structures or historic districts. However, available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	There is the potential for impacts to historic properties in all three areas related to the beach restoration plan. Such impacts can result from either direct impacts or indirect impacts to known and currently unknown resources that exists within the APE. Potential impacts to the resources include potential direct impacts to archaeological resources on or near the shoreline, submerged archaeological resources such as shiwrecks and inundated prehistoric archaeological sites, and viewshed impacts to historic structures. The District will work in coordination with the NJSHPO, the Tribes and other consulting parties to avoid, minimize, or mitigate any determined adverse effects.	There is the potential for impacts to historic properties related to the beach restoration with groin(s) plan. Such impacts can result from either direct impacts or indirect impacts to known and currently unknown resources that exists within the APE. Potential impacts to the resources include potential direct impacts to archaeological resources on or near the shoreline, submerged archaeological resources such as shiwrecks and inundated prehistoric archaeological sites, and viewshed impacts to historic structures. The District will work in coordination with the NJSHPO, the Tribes and other consulting parties to avoid, minimize, or mitigate any determined adverse effects.
Other Social Effects				
Environmental Justice	The No Action Plan will have no impact on Environmental Justice	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	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.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability.	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)				
Jobs	While there is no project cost, the No Action Plan does not provide RED benefits and will allow for increasing erosional impacts and coastal storm risk, thereby providing little or no employment benefits to the areas.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability	Regionally, the benefits of beach restoration could benefit the local economy by providing consistent CSRSM benefits to the areas.	Regionally, the benefits of beach restoration with groin(s) could benefit the local economy by providing consistent CSRSM benefits to the areas.

Income	While there is no project cost, the No Action Plan does not provide RED benefits and will allow for increasing erosional impacts and coastal storm risk, thereby providing little or no income-related benefits to the areas.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability	Regionally, the benefits of beach restoration could benefit the local economy by providing consistent CSRМ benefits to the areas.	Regionally, the benefits of beach restoration with groin(s) could benefit the local economy by providing consistent CSRМ benefits to the areas.
Tax Base	While there is no project cost, the No Action Plan does not provide RED benefits and will allow for increasing erosional impacts and coastal storm risk, thereby providing little or no benefits to the area tax base.	Available dredged material does not appear to be suitable for USACE levee construction and would require augmentation to improve its suitability	Regionally, the benefits of beach restoration could benefit the local economy by providing consistent CSRМ benefits to the areas.	Regionally, the benefits of beach restoration with groin(s) could benefit the local economy by providing consistent CSRМ benefits to the areas.

Table 17 - 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 CSRMs 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 Estuary 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 resilient coastal New Jersey.	By reducing erosion and storm-related damage to coastal New Jersey, this alternative meets the objective by creating a more resilient coastal New Jersey.
Response to Evaluation Criteria				
Completeness	This does not meet the completeness criteria because the No Action Plan does not provide CSRMs benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRMs 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. Since the dredged material does not appear suitable for levee construction, this alternative will not ensure the realization of the planned effects; therefore, the levee/dike plan was screened out and will not provide a complete CSRMs solution.	This alternative meets the completeness criteria as it provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.	This alternative meets the completeness criteria as the addition of the terminal groin at Gandys Beach and Fortescue provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
Effectiveness	This does not meet the effectiveness criteria because the No Action Plan does not provide CSRMs benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRMs 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 was screened out and will not provide an effective CSRMs 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 CSRMs benefits and will allow for increasing erosional impacts and coastal storm risk to the identified CSRMs 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 was screened out and will not provide an efficient CSRMs solution.	The benefits at Gandys Beach, Fortescue and Villas (South) are greater than the associated dredged material placement costs.	The benefits at Gandys Beach and Fortescue and 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 CSRMs. Coordination with Federal agencies, including USEPA, USFWS and NMFS is ongoing to help assess the acceptability of the proposed project.	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. Coordination with Federal agencies, including USEPA, USFWS and NMFS is ongoing to help assess the acceptability of the proposed project.	State and local entities are generally supportive of the beach restoration with groin(s). Coordination with Federal agencies, including USEPA, USFWS and NMFS is ongoing to help assess the acceptability of the proposed project.

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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 to determine the BCR and net benefits at each placement location.

3.5.1 Economic Summary

The primary NED benefit categories considered in this study included the following: reduction in damage to structures and content and local costs foregone. With only Fortescue and Gandys Beach included in the recommended plan, the total AANBs are \$1,632,000 with a 1.5 BCR. By adding Villas (South) dune and berm construction to the recommended plan, the AABs increase by \$2,517,326 with only a \$1,790,094 increase in AAC. This results in a net increase of \$727,233 to AANBs for the recommended plan and sets the three sites (Gandys Beach, Fortescue and Villas (South)) as the three communities in the recommended plan.

The location of the 3 sites in the recommended plan are shown on Figure 19.

Figure 19 – Recommended Plan Dredged Material Placement Sites



Table 18 provides a summary of the estimated costs associated with the recommended plan. For cost estimating purposes, USACE completed a cost and schedule risk analysis (CSRA) regarding the risk findings and recommended contingencies to be applied the estimated project cost. In compliance with ER 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based study was conducted. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

Table 18 - Summary of Estimated Costs for the Recommended Plan

COSTS FOR THE RECOMMENDED PLAN	
Period of Analysis	2022 to 2072 (50 Years)
Price Level	FY2020 (October 2019)
Discount Rate	2.75%
Base Year	2022
Initial Construction Costs	\$124,272,800
Interest During Construction	\$2,931,290
Periodic Nourishment Costs	\$164,289,000
Lands & Damages	\$6,530,000
Planning, Engineering & Design	\$27,319,000
Construction Management (E&D, S&A)	\$17,790,000
TOTAL AVERAGE ANNUAL COSTS	\$5,912,633

Notes:

1. Major rehabilitation costs are not included due to the required major rehabilitation quantity (12,400 cubic yards) being less than the periodic nourishment quantity of 179,500 cubic yards
2. Mid-point of construction is 2022 Q2
3. OMRR&R (which includes routine operation and maintenance of the project) is the responsibility of the non-Federal sponsor

Project monitoring costs will include beach profile surveys, surveys of borrow areas, sediment sampling of the beach and borrow areas, aerial photography and tidal data collection. The field data will be regularly analyzed to support engineering and design of ongoing nourishment. The proposed monitoring program will begin with initial construction and continue through the period of analysis. The monitoring program includes environmental and physical monitoring.

Table 19 summarizes the individual costs and benefits associated with each dredged material placement site in the recommended plan.

Table 19 - Summary of Costs & Benefits

FY2020	AAD Without Project	AAD With Project	AAD Reduced	Land Loss Reduced	Total AAB
Fortescue	\$4,864,669	\$1,883,795	\$2,980,873	\$34,456	\$3,015,329
Gandys Beach	\$2,713,966	\$165,248	\$2,548,718	\$0	\$2,548,718
Villas (South)	\$2,286,587	\$49,697	\$2,236,890	\$455,433	\$2,692,323
SUBTOTAL	\$9,865,222	\$2,098,741	\$7,766,481	\$489,889	\$8,256,370
AAC	-	-	-	-	\$5,912,633
AANB	-	-	-	-	\$2,343,737
AANB (Round)	-	-	-	-	\$2,344,000
BCR	-	-	-	-	1.4

Note: The cost and benefit values cover a 50-year period of analysis with a base year of 2022.

3.5.1.1 Residual Risk

CSRM benefits for the study included Structure Damages avoided, Content Damages avoided, and ancillary Navigation cost savings. Benefits are computed using the formula *Without Project Damages – With Project Damages + Navigation Savings = CSRM Benefits*. No other benefit categories (e.g. Recreation) were found to be significant contributors to overall 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*.

The recommended plan reduces 79.7% of damages in the study area. For this particular study area, the proposed plan is expected to significantly reduce erosion and wave attack damages with only minimal reduction to inundation damage due to the presence of back bay flooding. Specifically, Fortescue experiences greater inundation impacts than the other study locations and in turn Fortescue also experiences the highest residual risk (approximately 39%) post construction.

3.5.1.2 Risk & Uncertainty

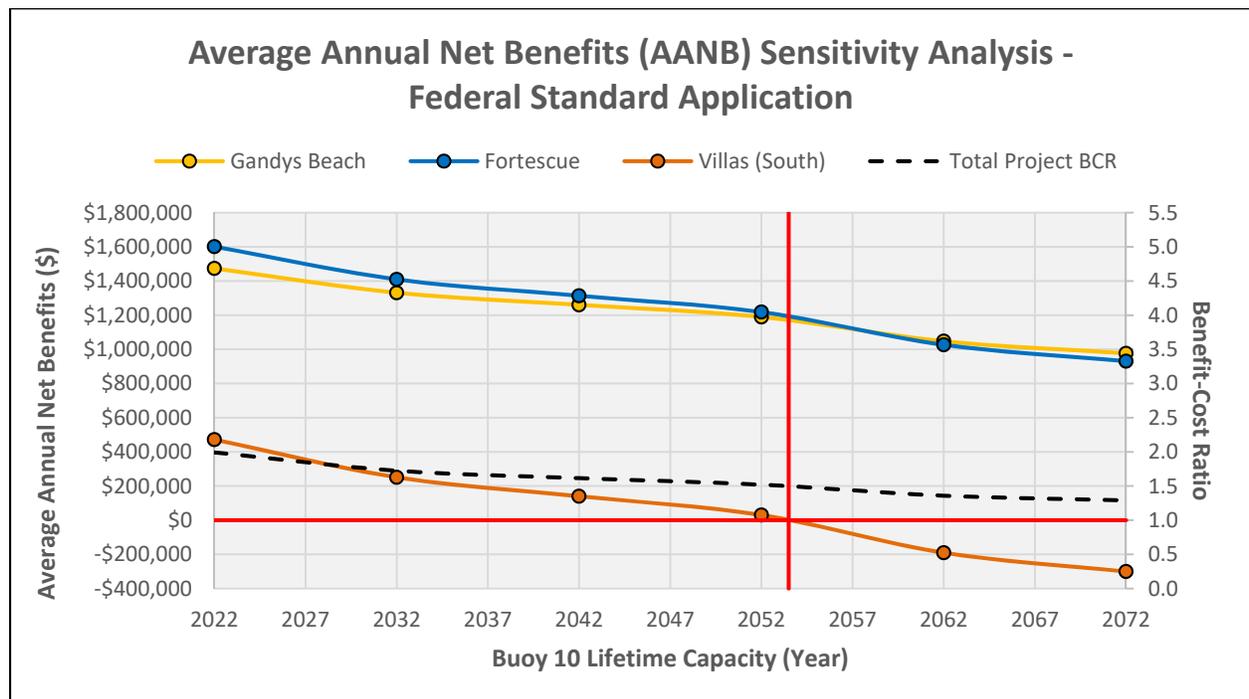
As stated in Appendix A, Beach-fx is an event-based Monte Carlo life cycle simulation that uses historic storms to calculate damages over the course of a project life cycle. The model links the predictive capability of coastal evolution modeling with project area infrastructure information, structure 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 condition and future with project 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. This conservative approach neglects any potential increase in value accrued from future development in the study area; however, use of the existing inventory is preferable due to uncertainty and limitations in projecting future development.

As previously stated, the current Federal standard for dredged material disposal from the proposed recommended plan source area is dredging via a hopper dredge and bottom dumping at Buoy 10, which is approaching operational capacity. In 2017, Buoy 10 was estimated to be at or near capacity; however, the USACE requested and received from NJDEP a permit to expand the footprint and gain approximately 10 years of additional capacity. A new CZM and WQC were received on 24 January 2018. While the NJDEP permit provides approximately an additional 10 years of additional capacity, the USACE recognizes a degree of uncertainty related to the projected Buoy 10 capacity. 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.

To evaluate the relative risk of this assumption, the total project Average Annual Net Benefits are calculated with a range of scenarios regarding the lifetime capacity of Buoy 10. Ranging from 0 years capacity (all maintenance dredged material is transported to Artificial Island in the without project condition) to 50 years capacity (dredged material is transported to Buoy 10 in the without project condition). The results of the sensitivity analysis are summarized on Figure 20:

Figure 20 - Economic Sensitivity Analysis



As indicated on Figure 19, the Total Project Average Annual BCR/Net Benefits remain positive even if the study never applies the Artificial Island Federal Standard. However, while Gandy's Beach and Fortescue remain justified in all scenarios, Villas (South) is only justified if Buoy 10 reaches capacity at 2054 (Project Year 32) or earlier. As current projections depict Buoy 10 to reach capacity in Year 8, forecasts would need to be underestimating future capacity conditions by 300% in order to jeopardize project justification at Villas (South).

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 Damages

The future without project condition 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, as described in greater detail in the Economics Appendix.

In addition to the economic risk and uncertainty drivers referenced above, risk-informed decision making was applied in other areas of the plan formulation. There are two issues that appear to present the greatest risk and uncertainty for project implementation: quantity of available dredged material and sediment compatibility. Based on the analysis completed for the feasibility report in support of the Delaware River Main Channel Deepening project, 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. USACE recognizes that the aforementioned shoaling rate and associated dredging cycle is based on an estimate and will need to be confirmed with post-deepening surveys.

Regarding sediment compatibility, a beachfill compatibility analysis is typically conducted to statistically compare the existing or "native" beach sand grain size to the intended borrow material that will be

placed on that site. A resulting overfill factor is calculated and is greater than 1.0 when the borrow material is considerably smaller than the native materials. Due to several factors, a more general comparison needs has been applied to this project. Determining the true “native” grain size characteristics of the placement sites is difficult due to limited available data and the fact that most of these beaches have been supplemented with numerous fills of varying materials through previous CSRM efforts (dredging events and truck fill operations). The average grain size for Gandys Beach and Fortescue is based on sediment samples collected at each site in September 2016, while the average grain size for Villas (South) is based on geotechnical analysis of beach samples collected in 1995. Determining the exact grain size characteristics of the proposed borrow material to be utilized is also difficult, as the dredged materials to be utilized are shoaling in to the deepened Delaware River navigation channel as this report is being prepared. However, it is with a high level of confidence that those shoaling sands will be very similar to the maintenance materials that have been dredged from the channel and placed at the Buoy 10 site over the past several decades. Seven vibracores from the Buoy 10 site were retrieved and detailed sieve analyses show that the average grain size of these materials is anticipated to be very similar to the sands that historically have existed at and near the proposed placement sites as demonstrated in Table 14. Logically, an average overfill factor of 1.0 can be applied to all fill quantities for these fill locations.

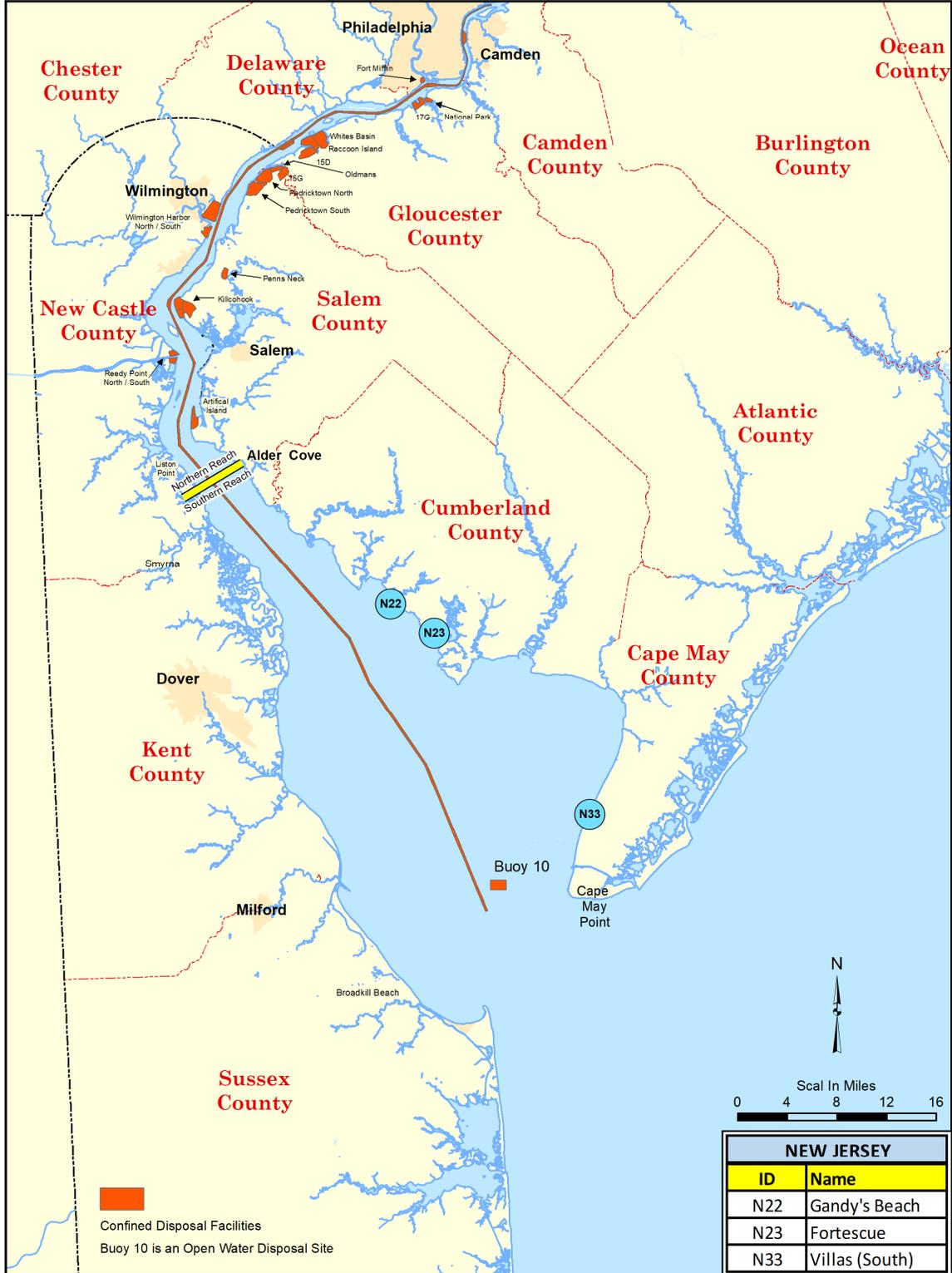
3.6 DESCRIPTION OF THE RECOMMENDED PLAN

3.6.1 Plan Components

The recommended plan consists of beach restoration at Villas (South) and beach restoration with groin(s) at Gandys Beach and Fortescue. Dune elevations and berm widths from the Beach-fx optimization are presented in Table 20. Berm elevations were selected to match the natural berm elevations in the study area.

Based on the USFWS recommended environmental window associated with horseshoe crab spawning and migratory red knot foraging in the proposed project vicinity (15 April through 31 August), the USACE did not assume one continuous project construction operation for initial construction. The environmental window necessitated the USACE to assume initial construction to occur in three phases. Phase One (2021) will involve the construction of the terminal groins at Gandys Beach and Fortescue outside of the aforementioned environmental window. After the environmental window and based on the projected dredged material quantity limitations discussed above, Gandys Beach and Fortescue would be nourished as part of Phase Two (2022) of initial construction. Villas (South) is projected for nourishment in 2028, during the first periodic renourishment cycle of Gandys Beach and Fortescue.

Figure 21 – Recommended Plan Dredged Material Placement Sites



Gandys Beach

At Gandys Beach, the recommended plan calls for a berm only beachfill with the parameters shown on Table 20. The full width of the design extends in front of all currently developed property bayward of Cove Road. 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 high with-project end losses without the use of a terminal groin. The design will tie into a terminal groin at the northwest end of Gandys Beach that will be constructed as part of the plan and the southeastern end will taper to the existing shoreline. Beachfill alternatives were evaluated and compared at Gandys Beach with and without a terminal groin. Analytical shoreline change modeling of beach restoration at Gandys Beach shows that the beach template would be unstable without a terminal groin due to severe end losses of the fill. The rate at which the beachfill would erode would be so high that excessively frequent periodic nourishment would be required to maintain the project shoreline. Attempts to extend the periodic nourishment interval by increasing the fill volume would increase the project width and its perturbative effect on the shoreline alignment. This in turn would increase the beachfill loss rate so that the increased fill volume would do little to decrease the periodic nourishment frequency (Bodge 2003). Over a 50-year project life, the cumulative savings on periodic nourishments are expected to greatly exceed the initial cost of the terminal groin.

As discussed further in Section 5.3.5, USFWS and TNC expressed concern that the proposed terminal groin at Gandys Beach would further exacerbate the ongoing erosion of the TNC Gandys Beach Preserve (and associated red knot habitat in and adjacent to the Preserve) shoreline downdrift of the proposed groin. USACE held several conference discussions and a site visit in collaboration with USFWS and TNC to address their concerns with respect to the proposed Gandys Beach groin plan's effects on the Gandys Beach Preserve and associated red knot habitat. As a result of the continued coordination with USFWS and TNC, the terminal groin was optimized and refined to allow for transport over the groin at high tide at about mean sea level. Specifically, the groin will also include two layers of armor stone in order to increase the permeability of the structure to longshore sediment transport (LST) of sand. The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004).

USACE anticipates that periodic nourishment of the proposed beach over the project life will not only create and maintain sandy beach habitat in the Gandy Beach project area, but will also allow transport of sediment to the northwest into the TNC Preserve, which is sand-starved under existing conditions. It is expected that the nourishment of Gandys Beach will restore the two natural processes, upland beach erosion and LST, primarily responsible for providing sediment to bay beaches.

The groin will tie into the existing rubble revetment. From the tie-in, the groin will extend approximately 234 feet bayward and will consist of layers of armor stone, core stone and marine mattress.



Gandys Beach

Fortescue

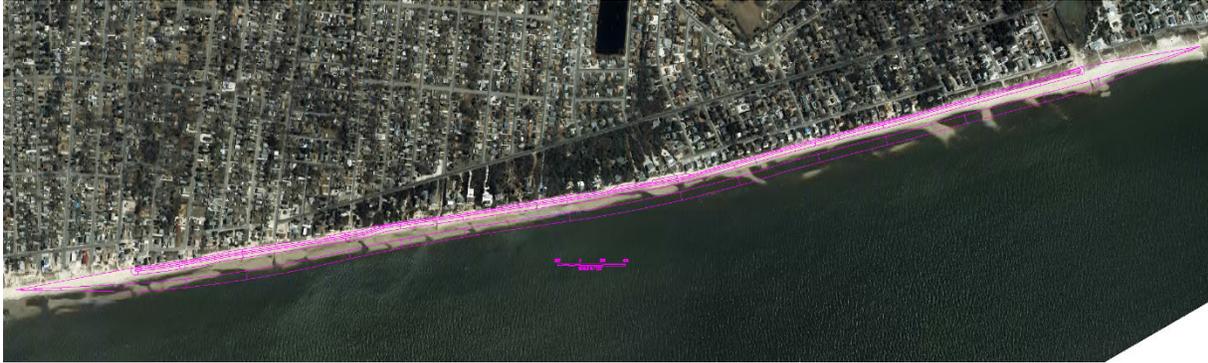
For Fortescue, the recommended plan calls for a berm only beachfill with the parameters shown on Table 20. The full width of the design extends in front of all developed structures bayward of Delaware and Jersey Avenue. There is an existing timber groin currently separating the Fortescue beach area from Fortescue Creek. While the timber groin provides this separation, it is in poor condition and will be too short to effectively limit sediment transport into Fortescue Creek. The proposed groin will be a rubble mound structure which is parallel to the existing groin and will extend 270 feet bayward (120 feet beyond than the bayward extent of the existing timber groin) to limit end losses of the planned beachfill. The proposed groin will tie into the existing shoreline and will be located approximately 30 feet east of the existing timber groin in order to allow for the timber groin to serve as a cofferdam during construction of the proposed rubble mound groin. The design beachfill will tie into the rubble mound groin at the northwest end of Fortescue (adjacent to the existing timber stem stone groin and Fortescue Creek) and the southeastern end will taper to the existing shoreline.



Fortescue

Villas (South)

At Villas (South), the recommended plan calls for a dune and berm beachfill with the parameters shown in Table 20. The design will tie into the existing shoreline at Francis Avenue and extend north to West Greenwood Avenue. The design will utilize tapers at each end to tie the beachfill into existing conditions.



Villas (South)

Table 20 - Summary of Recommended Plan Beachfill Dimensions

Location	Villas South	Gandys Beach	Fortescue
Length of Design Dune/Berm (feet)	7,442	2,507	4,564
Length of Dune (feet)	7,442	N/A	N/A
Southern Taper (feet)	1,000	786	1,251
Northern Taper (feet)	1,072	0	0
Length of Shoreline (feet)	9,514	3,293	5,815
Groin	None	NW End	NW End
Dune Elevation (feet NAVD88)	12	N/A	N/A
Dune Width (feet)	25	N/A	N/A
Berm Elevation (feet NAVD88)	5	6	6
Design Berm Width (feet)	30	30	30
Advance Berm Width (feet)	20	45	45
Total Berm Width (feet)	50	75	75

Table 21 - Pertinent Data

Item	Gandys Beach	Fortescue	Villas (South)	Total
Volume of Nourishment Fill	213,700 cubic yards	331,400 cubic yards	486,100 cubic yards	1,147,900 cubic yards
Volume of Renourishment Fill	49,200 cubic yards	67,500 cubic yards	62,800 cubic yards	179,500 cubic yards
Renourishment Interval	6 years	6 years	6 years	6 years
Length of Fill	2,507 feet	4,564 feet	7,442 feet	N/A
Width of Berm	75 feet	75 feet	50 feet	N/A
Berm Slope	1V:10H	1V:10H	1V:10H	N/A
Dune Crest	N/A	N/A	12 feet NAVD88	N/A
Dune Slope	N/A	N/A	1V:5H	N/A
Groin Construction Costs – 2021*	\$8,226,000	\$6,405,000	N/A	\$14,631,000
Nourishment Costs – 2022 (Gandys Beach and Fortescue)*				\$58,091,000
Nourishment Costs – 2028 (Villas South)*				\$51,550,800
Periodic Renourishment Costs – 2028 (Gandys Beach and Fortescue)*				\$22,093,000
Periodic Renourishment Costs – 2034 through 2072*				\$142,196,000
Average Annual Costs				\$5,912,633
Average Annual Benefits	\$2,548,718	\$3,015,329	\$2,692,323	\$8,256,370
Average Annual Net Benefits				\$2,343,737
Benefit Cost Ratio				1.4
Estimated Project Cost (October 2019 Price Level)				\$288,561,000

Notes:

1. * Indicates costs include PED, Lands & Damages and Construction Management
2. Nourishment and renourishment costs shared across the sites in the recommended plan as they are based on a single dredge mobilization with continuous operation to each site.

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 Delaware River Main Channel Deepening project. Actual dredged material quantities will be verified prior to construction; therefore, the USACE 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 nourishment (2022), Buoy 10 may serve as a back-up source for nourishment 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 USACE 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).

Nourishment quantities (1,147,900 cy) exceed the projected quantity assumed to be available from each dredging cycle. In addition there is a restrictive environmental window associated with the migratory red knot bird (15 April through 31 August). Based on the nourishment quantities and the restrictive environmental window, the USACE assumes nourishment will occur in three phases. Phase One (2021) will involve the construction of the terminal groins at Gandys Beach and Fortescue outside of the aforementioned environmental window. After the environmental window and based on the projected dredged material quantity limitations discussed above, Gandys Beach and Fortescue would be nourished as part of Phase Two (2022) of initial construction. Villas (South) is projected for nourishment in 2028, during the first periodic renourishment cycle of Gandys Beach and Fortescue.

In order to maintain the integrity of design beachfill alternatives, periodic renourishment must be included in the project design. If periodic renourishment is not performed throughout the life of the project, longshore and cross shore sediment transport mechanisms would act to erode the design beach. A 6-year periodic nourishment cycle is anticipated to maintain optimal CSR. This nourishment cycle coincides with the proposed operation and maintenance (O&M) dredging to be performed in Lower Reach E. At this time, traditional beach nourishment (i.e. berm) is considered the likely methodology for periodic renourishment; however, nearshore placement may be considered as the project progresses. However, while in some cases nearshore placement may be considered a lower cost option, given the shallow nature of the Delaware Bay, the reduction in transport distance would be relative small and it is unlikely that the cost per cubic yard of sand for nearshore placement would be significantly different than the cost of traditional beach nourishment.

3.6.2 Public Law 113-2 Requirements

P.L. 113-2 directed USACE to conduct a comprehensive study to address the flood risks of vulnerable coastal populations impacted by Hurricane Sandy within the borders of the North Atlantic Division. That comprehensive study is the NACCS. This section has been prepared to address how the recommended plan 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), without interruption or 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 RSLC.

In general, CSRMs 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 principles 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. Community sustainability, as known as 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 recommended plan utilized the NACCS Risk Management framework that included evaluating alternative solutions and also considering future RSLC and climate change.

Recognizing the Federal government's commitment to ensure no inducement of development in the floodplain pursuant to Executive Order 11988, this project will identify in the Project Partnership Agreement (PPA) the need for the non-Federal sponsor to develop a floodplain management plan and a requirement for the sponsor to certify that measures are in place to ensure that the project does not induce development within the floodplain.

3.6.3 Real Estate Requirements

Based on the information available, the recommended plan requires two (2) types of easements 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) may be required for at least one area.

It is the District opinion that navigation servitude may be invoked for construction of the proposed CSRSM project below the MHWL. Therefore, although the State of New Jersey owns all lands below the MLLW and the Federal government has navigational servitude over lands between MHWL and MLLW, no authorization for entry will be required from the NFS and no credit for reimbursement will be afforded the NFS for construction of the project in these areas.

The standard Perpetual Beach Storm Damage Reduction Easement (Standard Estate No. 26) is required for the construction of the beach berm and/or dune system and terminal groins 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 also include parcels located below the MHWL currently subject to riparian grants. Easements must be acquired over the areas below the MHWL for operation and maintenance of the projects required by the non-Federal sponsor over the life of the project.

Between the three sites in the recommended plan, a total of 158 easements are required, adding approximately \$6,530,000 of LERRD related costs to the project.

3.6.4 Environmental Compliance

Table 22 provides a summary of the environmental compliance status to date. Additional details regarding the environmental compliance are provided in Section 6.2.2.

Table 22 - Summary of Environmental Compliance

Item	Compliance
Anadromous Fish Conservation Act	N/A
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.	Full
Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990	Full
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Full
Endangered Species Act, 16 U.S.C. 1531, et seq.	Full
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.	Full
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	Full
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full
National Historic Preservation Act, 54 U.S.C. 300101 et seq.	Full
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	Full*
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
- *Non-Federal Sponsor will be required to comply with this Act when acquiring any real property interests needed for operation and maintenance of the project

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.

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, RSLC, frequent severe storms, ship wakes, and to some extent, land subsidence, are believed to be the main causal factors.

The above-referenced recommended plan will provide improved CSRMs for the Delaware Bay shoreline by utilizing dredged material to alleviate shoreline erosion and flooding. This recommended plan 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. Specifically, implementation of this recommended plan may potentially change the overall sediment management practices for the watershed, as it will achieve the same navigation benefits as the current dredged material management practices, but may provide the added benefit of retaining sediment in an estuary.

There is a potential for this recommended plan to enhance resiliency and sustainability of the natural coastal environment by retaining sediment in the system, and thereby providing 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. 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.

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.

This project transforms Civil Works by enabling the Corps to deliver essential water resource solutions using effective transformation strategies through a systems-based watershed approach. The NJ DMU recommended plan enhances resiliency and sustainability of the natural coastal environment by retaining sediment in the system and improving CSRSM 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 renourishment 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 Delaware Estuary watershed within the State of New Jersey and the Delaware Estuary. 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 study area includes flood prone areas along the Delaware River and Delaware Bay in NJ, and also the tidal reaches of the tributaries within this part of the estuary that contribute to tidal and fluvial flooding. These 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.

For discussion purposes, the Delaware Bayshore (Cumberland and Cape May Counties) can be naturally divided into three distinct geomorphic regions. The southernmost region (from south to north, Cape May Point to Bidwell Creek, the Cape May peninsula extends approximately 16 miles – Figure 22). 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. The southern end of the peninsula is comprised of communities 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. Further north and west along the peninsula are the bayshore Townships of Dennis, Maurice, Downe, Lawrence, Fairfield and Greenwich. Communities include Sunray, Del Haven, Highs Beach, Pierces Point and Reeds

Beach just north of Bidwell Creek. North of these communities are Moores Beach, Thompsons Beach and East Point. There are three wildlife management areas located in the southern region along the Delaware Bay shoreline: Higbee Beach, Cape Island and Dennis Creek Wildlife Management Areas (WMAs).

Figure 22 - South Region-Cape May Point to Bidwell Creek



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 (Figure 23). 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.

Figure 23 - Middle Region-Bidwell Creek to Nantuxent Cove



North of Nantuxent Cove, the upper bay region becomes narrower as it transitions into the lower Delaware River (Figure 24). 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 bayshore 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.

Figure 24 - North Region-Nantuxent Cove to Salem River



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 (Philadelphia) 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.

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. In 2015-2016 the USFWS New Jersey Field Office, in collaboration with The Nature Conservancy (TNC) implemented a living shoreline project northwest of Gandys Beach to provide erosion protection to 2,700 acres of wetlands, upland forest, and beach habitat for spawning horseshoe crabs and foraging migratory shorebirds. Shell bag and oyster castle breakwaters were placed in the shallow inshore waters approximately 1,500-2,000 feet northwest of the community of Gandys Beach. 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. At Wilmington, the Piedmont shifts to the west of the estuary, eventually running through Baltimore, Maryland and Washington D.C. The Coastal Plain physiographic province borders the entire eastern side

of the Delaware Estuary, as well as the western side of the estuary below Wilmington. 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 (MCD) 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. 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

The climate within the study area is considered subtropical which generally produces mild summer and winter seasons with only a few short hot, humid periods in summer, and cold, windy periods in winter. The summer weather is dominated by maritime tropical air masses which remain stable for several days at a time, creating high pressure systems. Spring and fall are milder and are dominated by quickly changing air masses. The mean annual temperature is in the range of 55 to 57 degrees Fahrenheit. The annual precipitation for the area is about 45 inches, with the average monthly rainfall amounting to three or more inches. Temporary droughts are not uncommon. Continental polar air masses in the winter produce rapidly moving fronts and intense weather patterns. The area is susceptible to strong beach eroding storms as a result of these weather patterns. Nor'easters are the more frequent storm type, originating in a low pressure area as an offshore air mass that rotates counterclockwise with winds blowing northeast-to-southwest over the region. Hurricanes average about once every 5.5 years.

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).

RSLC 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 RSLC. 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).

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 23).

Table 23 - Delaware Estuary Watershed Climate Predictions: Present to 2100

Climate Condition		Model Evaluation: Biases & Issues	21 st Century Prediction	Confidence Levels
Temperature	Monthly Mean	Slight cool bias in winter and summer	Warming: 1.9 – 3.7°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	<u>Substantial increases</u> , but less than ¼ of models show declines	Medium
	Heavy Precipitation	Slight low bias		
Growing Season Length		Predicts accurately	<u>Substantial increase</u> 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, 1997), similar to expectations for the Chesapeake Bay (Zhong *et al.*, 2008).

Some regional variation in sea level results from gravitational forces, local land subsidence, wind, and water circulation patterns. Two other factors play prominent roles influencing RSLC 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. These factors play a significant role in either accelerating or decreasing the rate of RSLC 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.

It is anticipated that the global mean sea level will continue to rise over the next 100 years. To include the direct and indirect physical effects of projected future RSLC 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 RSLC, an intermediate estimate, and a high estimate representing the maximum expected RSLC.

4.3 WATER RESOURCES

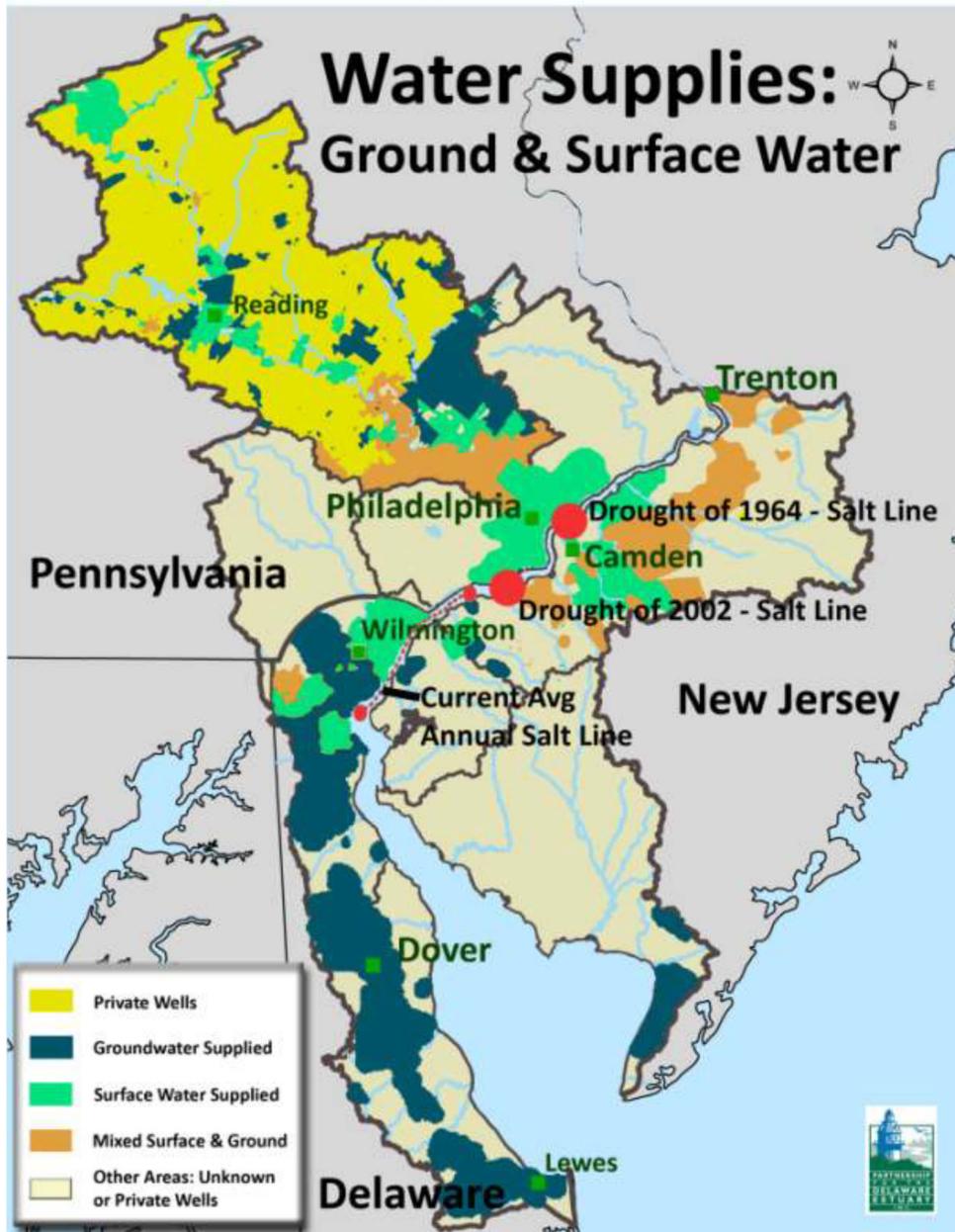
4.3.1 Groundwater Quality and Public Water Sources

Groundwater is contained within aquifers, which are porous geologic formations that store or transit groundwater. The 5 principal Coastal Plain aquifers are the Kirkwood-Cohansey 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-Cohansey 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 25 shows a map of the watershed and service areas of community water supplies.

Figure 25 - 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 the 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. This 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).

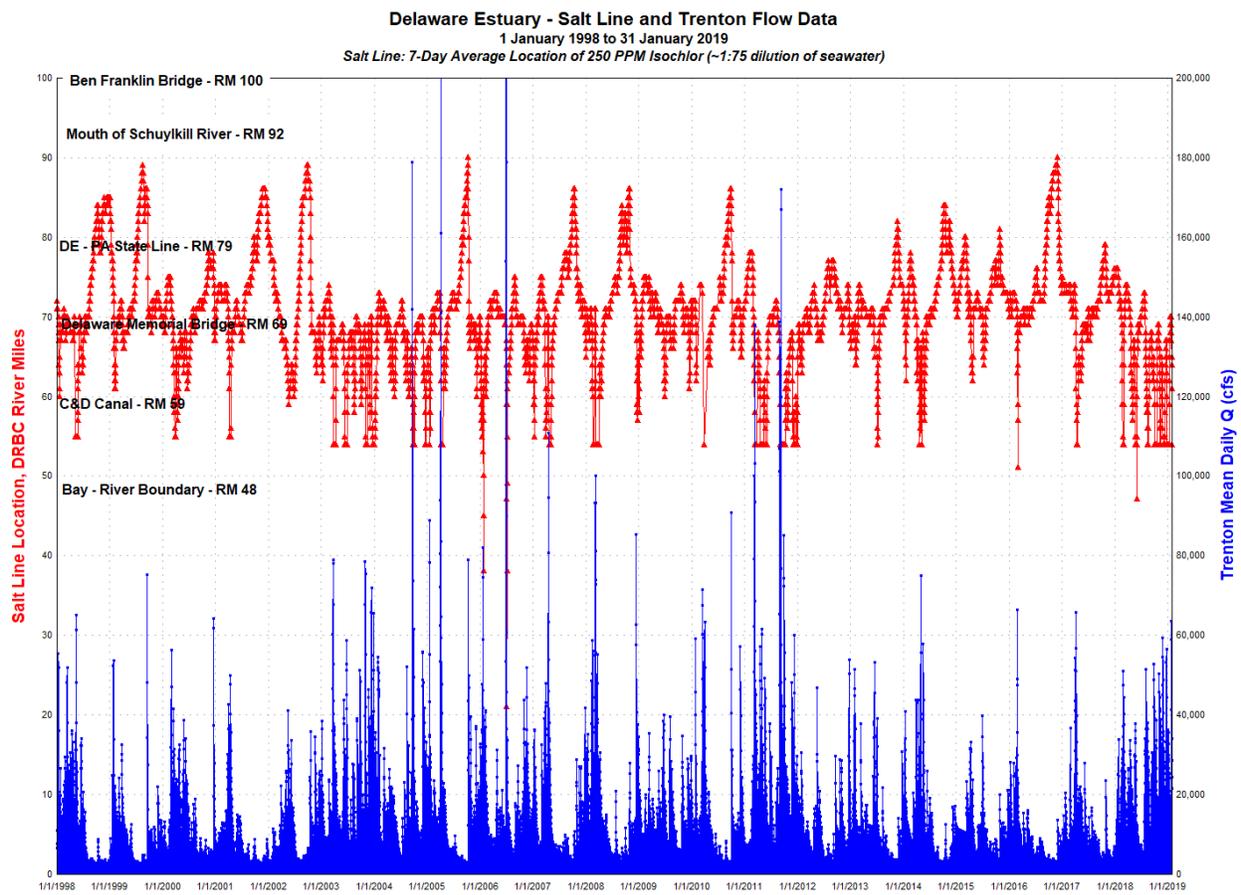
The composite aquatic life assessment for 2012 yields a result of “Not Supporting” for aquatic life (DRBC, 2012). It is important to note, however, that this result is largely driven by DRBC’s requirement to categorize as not meeting criteria with 1 exceedance plus 1 confirmatory exceedance and based 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 (RM 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 twenty times, due to sustained high flows at Trenton, New Jersey (Figure 26).

Figure 26 - 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 downriver 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 Bacillariophyceae) (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*, *Staurephyra*) 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 *Acarya 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 detrital/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 *Neomysis 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).

The sandbuilder worm (*Sabellaria vulgaris*) occurs along temperate shorelines, including in the mid-Atlantic, but only in dense, reef-like structures in the lower portion of the Delaware Estuary (Brown and Miller, 2011). Similar to oysters, sabellarid tube-building worms create structural habitat for a variety of benthic invertebrates, higher diversity than surrounding sediments, and provides an additional stabilizing force along beaches (Wells, 1970; Gore *et al.*, 1978; Dubois *et al.*, 2002).

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 (*Palaemonetes* 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 (*Callinectes sapidus*) commonly occur in Delaware Bay, but have been reported to occur above Wilmington, DE but are more common in the higher salinity waters of the bay (Helser and Kahn, 2001). The blue crab inhabit nearshore coastal and estuarine habitats. 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

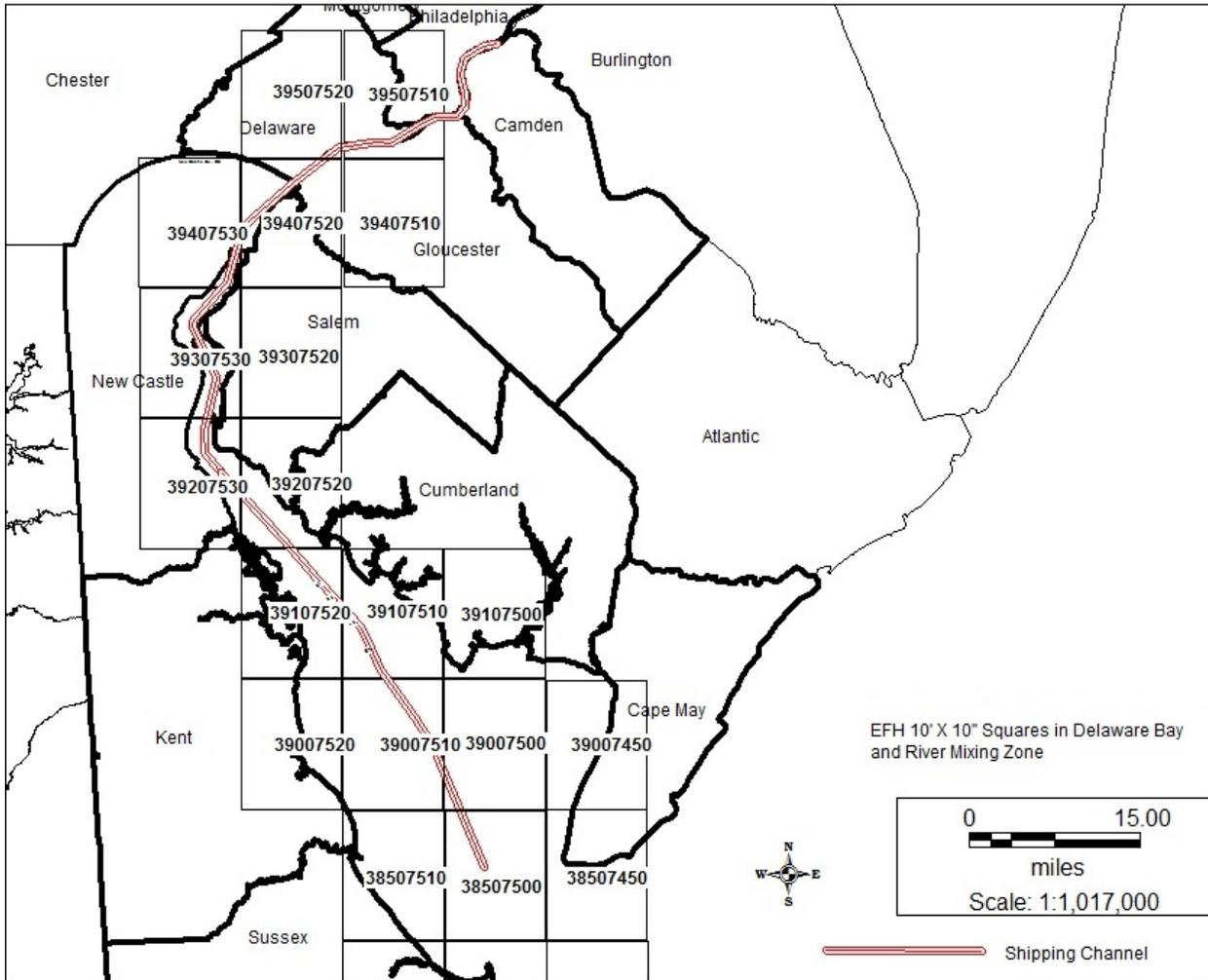
reaches of the estuary, marine species which regularly spend time in the estuary, marine species that utilize the estuary as a nursery and/or spawning area; and adventitious visitors of oceanic origin (ANSP, 1981). River herring (*Alosa* spp.) are anadromous species that live in the ocean but migrate 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 (MSA), 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. EFH regulation 50 CFR 600.905 mandates the preparation of EFH assessments. The map depicted in Figure 27 shows the locations of the 10 minute x 10 minute squares within the Delaware Estuary identified by the National Marine Fisheries Service (NMFS) as EFH.

Figure 27 - Delaware Estuary Mixing Zone Essential Fish Habitat



The study area contains EFH for various life stages for 18 managed fish species (NMFS letter dated 16 October 2017). Table 24 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 24 - Summary of Essential Fish Habitat Designated Species & Their Life Stages

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Red Hake (<i>Urophycis chuss</i>)				X	
Winter flounder (<i>Pleuronectes americanus</i>)	X	X	X	X	X

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Windowpane flounder (<i>Scophthalmus aquosus</i>)	X	X	X	X	X
Atlantic sea herring (<i>Clupea harengus</i>)			X	X	
Bluefish (<i>Pomatomus saltatrix</i>)			X	X	
Atlantic butterfish (<i>Peprilus tricanthus</i>)		X	X	X	
Summer flounder (<i>Paralichthys dentatus</i>)			X	X	
Scup (<i>Stenotomus chrysops</i>)			X	X	
Black sea bass (<i>Centropristus striata</i>)			X	X	
King mackerel (<i>Scomberomorus cavalla</i>)	X	X	X	X	
Spanish mackerel (<i>Scomberomorus maculatus</i>)	X	X	X	X	
Cobia (<i>Rachycentron canadum</i>)	X	X	X	X	
Clearnose skate (<i>Raja eglanterra</i>)			X	X	
Little skate (<i>Leucoraja erinacea</i>)			X	X	
Winter skate (<i>Leucoraja ocellata</i>)			X	X	
Sand tiger shark (<i>Carcharias taurus</i>)		X neonates*		X	
Dusky shark (<i>Carcharhinus obscurus</i>)		X	X		

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Sandbar shark (<i>Carcharhinus plumbeus</i>)		X *			

Notes:

- 1.) Neonates* indicates sharks and skates do not have a larval stage.

4.4.4 Wildlife

Reptiles and Amphibians. 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 (*Thamnophis 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).

Birds. 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 pusilla*), 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*), vesper 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 phoeniceus*) 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 virginianus*), 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 (*Tamias 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 25).

Table 25 - Delaware Estuary Threatened & Endangered Species

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

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).

Eastern Black Rail. The USFWS published a proposed rule in the Federal Register in 2018 to list the eastern black rail (*Laterallus jamaicensis jamaicensis*), a small, secretive marsh bird, as a threatened species under the ESA (USFWS, 2019). The black rail is also listed as endangered by the state of New Jersey. The migratory black rail is known to occur in as many as 36 states and multiple territories in the Caribbean and Central and South America. The species is rare along the Atlantic Ocean and Delaware Bay coasts.

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 proposed 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 (*Megaptera 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 brevirostrum*) 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 oxyrinchus oxyrinchus*) in the Northeast Region. The New York Bight DPS 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 (*Halichoerus 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.

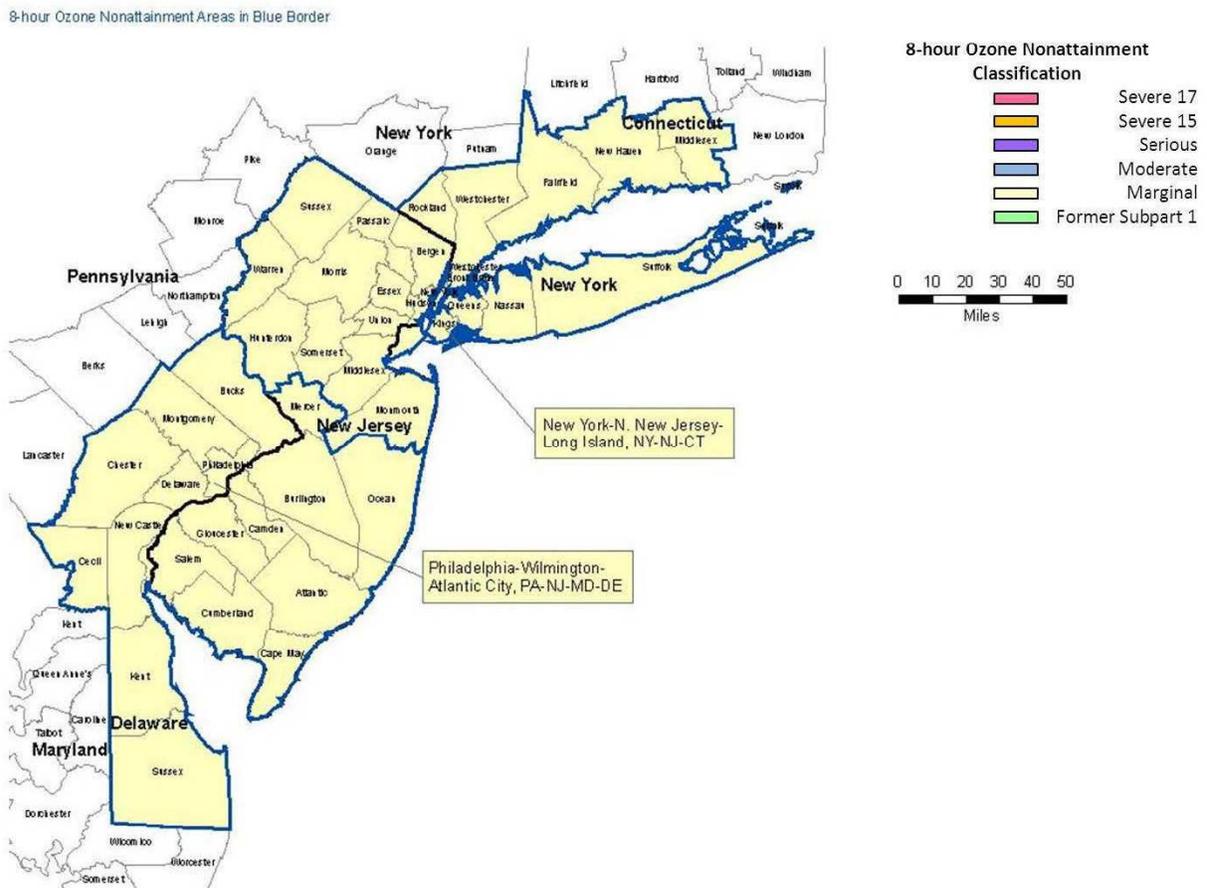
4.5 AIR QUALITY

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.njairnow.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 28. The entire state of New Jersey is in non-attainment and is classified as being “Marginal.”

Figure 28 - 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 lower. 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.

In-water noises occur in the Delaware River and Bay. The predominant noises are anthropomorphic and occur primarily in the upper regions of the estuary (where the river is more heavily industrialized) and in the shipping channel and lower bay anchorage. The Delaware Estuary is home to the fifth largest port complex (Delaware River Port Complex) in the United States in terms of total waterborne commerce. A study conducted by BOEM at a site offshore of Delaware Bay (Martin *et al.*, 2014) noted that ambient noise due to shipping is prevalent and relatively consistent, in the frequency range of 20-500 Hz. However, the study also showed that an increased energy in a particular frequency band was attributed to striped cusk-eel sounds; therefore, the primary cause of seasonal variation in sound levels at their study site was biological activity. The sounds produced by marine animals are many and varied. Marine mammals produce sounds over a wide frequency range, from less than 10 Hz to over 100,000 Hz, depending on the species. Many fishes, such as the oyster toadfish and some marine invertebrates, such as snapping shrimp, also produce sounds.

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 southern planning reach of 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. Eroded, scarped sandy beaches with exposed underlying peat also detracts from the natural aesthetic quality of the shoreline.

4.8 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

The USACE 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

The USACE initiated project consultation in 2016 with the New Jersey State Historic Preservation Office (NJSHPO), and has been in continued consultation. The USACE has also reached out to the federally recognized Tribes to provide them with information on the project, as well as to invite them to provide comments or to share their concerns regarding the project. The Tribes contacted included the following: the Delaware Nation, the Delaware Tribe of Oklahoma, the Eastern Shawnee Tribe of Oklahoma, the Oneida Indian Nation, the Seneca Nation of Indians, the Stockbridge-Munsee Band of Mohican Indians, and the St. Regis Mohawk Tribe. With the exception of the Stockbridge-Munsee Band of Mohican Indians, there were no comments from the Tribes; however, the Stockbridge-Munsee Band of Mohican Indians indicated that based on the mapping, they didn't have any areas of interest in the project area and didn't need to consult.

As stated in Section 3.1, 33 CSRSM problem areas were identified across two planning reaches (northern and southern) in the NJ DMU study area. The NACCS CEI was used as a preliminary screening tool to assess whether CSRSM was the primary problem to address at each problem area, per the planning objectives. The USACE conducted archival and database research. Existing information was gathered from various sources including previous investigations, reference books and periodicals, LUCY (the New Jersey Cultural Resources GIS online database), and personal communications with reviewers at the NJSHPO. Utilizing these data, a prehistoric and historic context is provided below.

PREHISTORIC CONTEXT

Archaeologists recognize a sequence of regional cultural traditions in the eastern United States that can be viewed as responses to both continuity and change within environmental and cultural systems. Three major cultural patterns and time periods have been identified: Paleoindian, Archaic, and Woodland.

Human occupation of the Middle Atlantic region began at the end of the Pleistocene epoch by highly mobile groups of hunter-gatherers described as Paleoindians (ca. 12,000 – 10,000 BP). Theories of the earliest peopling of North America are divided between Clovis-first and pre-Clovis settlers. The Clovis subperiod is distinguished by the manufacture of fluted, lanceolate-shaped spear points that have been found from the Great Plains to the eastern seaboard. The earliest Clovis occupations in the Middle Atlantic region date to around 10,950 radiocarbon years before the present (RCYBP, or simply, BP), represented by the Shawnee-Minisink Site on the Delaware River in Monroe County, Pennsylvania (Marshall 1985). Mammoths, mastodons, bison antiquus, giant beaver and other Pleistocene megafauna were important elements of Paleoindian subsistence and material culture, but represented only one end of the dietary spectrum. Paleoindian groups practiced a range of subsistence strategies, including hunting big and small game, fishing, and collecting plants. For example, fish bones and seeds of hackberry and blackberry were recovered from Paleoindian levels at Shawnee-Minisink (Dent 1991:125). By the late Paleoindian period, megafauna extinctions were widespread across the continent, caused by climate change, hunting overkill, or a combination of the two phenomena (Boulianger and Lyman 2014; Haynes 2009; Martin and Klein 1984).

Cultural deposits dating up to several thousand years earlier than Clovis have been reported from the Meadowcroft Site in western Pennsylvania (Adovasio et al. 1999) and the Cactus Hill Site in Virginia (MacAvoy and MacAvoy 1997), although these early dates are rare and remain controversial. One Paleoindian site is known in the Musconetcong River Valley in New Jersey (Kraft 1973), though there are no associated radiocarbon dates. The Paleoindian period is considered to end around 10,000 BP.

Additional recorded Paleoindian artifacts from New Jersey may be characterized as isolated finds of fluted spear points. The Turkey Swamp Site, located approximately 50 miles southeast of the Project in Monmouth County, yielded several unfluted, large triangular points that, according to their excavators, bore the hallmark of late-Paleoindian culture (Cavallo 1981). Radiocarbon assays associated with these points, however, indicated an Early Archaic occupation (Kraft 1986:48).

The adaptive strategies of groups during the Early Archaic subperiod (ca. 10,000 to 8000 BP) was more a continuation of established late Paleoindian broad-spectrum subsistence practices than a dramatic shift to new routines. Bands remained nomadic but appear to have exploited more restricted territories than their Paleoindian predecessors, making more repetitive visits to fewer strategic locations. The addition of ground-stone implements to toolkits suggests that nuts and seeds had become an important component of Early Archaic diets. These adaptive modifications in subsistence practices were probably

responses to increasingly dry conditions throughout the period. Climatic warming led to forest closure after 10,000 BP and increasing dominance of northern hardwoods over Boreal conifers, producing a more favorable habitat for such species as white-tailed deer and elk. (Davis 1983, Snow 1980). Early Archaic sites in the state cluster along the Upper Delaware River Valley and across the coastal plain in southern and central New Jersey (Kraft 1986; Mounier 1982).

During the Middle Archaic subperiod (ca. 8000 to 4500 BP), indigenous peoples lived in more widely distributed locations but settlement was still located along major waterways, falls, and lakes, and groups had developed a reliance on aquatic resources. Rising sea levels by this period had opened rivers to anadromous and catadromous fish, permitting people to fish and exploit spring and autumn spawning runs at inland locations. Soil horizons containing non-diagnostic lithic debris dating to the late Middle Archaic were identified from Site 28-Me-1-D at the Abbott Farm Complex near Trenton, approximately 35 miles south of the Project (Wall et. al. 1996b). Middle Archaic components have been identified at several sites along the upper Delaware River, including Harry's Farm and Miller Field in New Jersey and Faucett, and Shawnee-Minisink in Pennsylvania (Kraft 1986:56; Kinsey 1972; McNett 1985).

The Late Archaic subperiod (ca. 4500 to 3300 BP) appears to be characterized by increased population (as evidenced by larger and more numerous sites), the onset of long-distance trade networks, and an increased focus on riverine settings for site locations. These factors appear related to increased environmental stress caused by a shift toward a warmer, drier climate. Piles of shellfish refuse, or middens, appeared in the lower-Hudson River and lower-Delaware River during this period, and freshwater shellfish were probably exploited along the middle Delaware River and other inland drainages (Kraft 1986:78). The manufacture and use of small notched point and narrow stemmed point types became common over broad regions of the Eastern Woodlands, tool styles that are found in the archeological record for extended periods. Ceremonialism grew in importance, indicated by more elaborate, formalized burial practices and the presence of exotic raw materials as symbols of enhanced status and rank (Fiedel 1992).

The Early Woodland subperiod (c. 3000 to 2000 BP) marks the inception of widespread ceramic vessel use, an important technological advance that revolutionized food preparation and storage strategies. While carved steatite vessels were a precursor of this new technology, steatite was a heavy material and geographically restricted in its availability. Not only could ceramic vessels be manufactured anywhere there was clay, but its portability and plasticity of forms encouraged the transport of food and the storage of surpluses. Several lines of evidence suggest that Early Woodland population levels in the Northeast declined compared with Late Archaic levels, perhaps a response to climatic cooling that adversely affected game numbers and flora availability (Fiedel 2001). This population decline may have been a critical factor in the adoption of ceramics and shellfish collecting as a means of increasing food supply through labor-intensive, productive activities. Excavations at Site 28-Me-1D near the Delaware River at Trenton revealed a cluster of Early Woodland hearths and stone-boiling features, interpreted to have functioned as fish processing stations (Wall et. al. 1996b:363-365). Upper Delaware River sites displaying Early Woodland occupations include the Orient Phase at Harry's Farm and Miller Field, and Adena-Middlesex Phase at the Rosenkrans site (Kraft 1986:90-93).

The Middle Woodland subperiod marks the appearance of the first truly large shellfish middens that occur in southern coastal New England and Long Island (Bernstein 1993), and Cross noted that shellfishing along the New Jersey coast had become a major economic enterprise during this period. The expansion of the resource base is paralleled by an increase in the number of storage pits noted in the archaeological record (DeBoer 1988, Snow 1980:282). During this period, settlement patterns have a decidedly riverine and coastal focus (Kraft 1986:105-107, Williams and Thomas 1982:122). Large lithic workshops and anadromous fish processing camps from this period were excavated at the Abbott Farm Complex near Trenton (Cavallo 1987, Wall and Stewart 1996). Stewart (1998:258) has suggested that the distribution of Abbott zone-decorated ceramics between the Schuylkill River, lower Hudson River and the northern Jersey coastline, correlates with linguistic and social territories during the Middle Woodland. Fox Creek and Kipp-Island phase occupations have been associated with archaeological remains found on Minisink Island in the middle Delaware River (Kraft 1986:107-113).

Important cultural adaptations during the Late Woodland period (ca. 1000 to 400 BP) have been archaeologically recognized on a wide scale in New Jersey, and include the tending of cultigens (maize, beans, and squash), decrease in residential mobility, and use of the bow and arrow as a new and highly efficient hunting (and warring) weapon. These adaptations are perhaps all related to the region's population rise, with increased competition for resources and an intensification of local ethnic identity. Inhabitants of New Jersey during this period were members of the Algonquian language group, divided between Munsee dialect-speakers north of the Raritan River, and Unami-speakers to the south. The material culture of the Munsee includes the earlier Pahaquarra Phase, characterized by collarless, cord-marked ceramic vessels. The later Minisink Phase featured collared vessels with incised geometric designs. Pahaquarra and Minisink vessels have been recovered at the Minisink Island, Harry's Farm, and Miller Field sites along the middle section of the Delaware River, located approximately 25 to 28 miles north of the Project (Kraft 1986). The related Unamis constructed conical-shaped vessels with cord-marked surface treatment, a trait shared with groups from the Delmarva Peninsula (Kraft 1986; Wall and Stewart 1996).

HISTORIC CONTEXT

European Intrusion A.D. 1500 – A.D. 1700

At the time of contact between European and American Indians, it appears that the entire region now identified as New Jersey, eastern Pennsylvania, southern New York, and the northern portions of Delaware and Maryland, was homeland to the ancestral Lenni Lenape, or Delaware Indians, as the Lenape came to be known by the Europeans. While Lenape artifacts and general settlement patterns were similar to those of the Iroquois, the cultures differed linguistically. The Lenape spoke Algonkian. They also differed in terms of sociopolitical organization. At the time of contact, the Lenape could not be described as a tribe in the strict sense, but lived as loosely structured autonomous bands of lineages and resided in small settlements dispersed across the landscape.

For the 17th century, there is archaeological evidence of contact between Europeans and Lenape in northwestern, central, and southwestern New Jersey. It is sometimes difficult, however, to distinguish

between Late Woodland and early Contact Period sites. This is, in large part, because often only a limited number of European produced items are included in predominantly American Indian-produced assemblages of artifacts. In turn, this appears to be part of the reason that so few Contact period sites have been identified.

Colonial settlers of New Jersey also often valued the areas occupied by the Lenape for settlement. This is largely due to the similarities in subsistence between the two groups. Both usually farmed and, as stated above, the floodplains bordering major rivers contained the most productive land. The rivers yielded high densities of fish, which were useful to both groups. In addition, the earliest transportation routes available to Colonists were rivers, navigable streams, and Indian trails.

As Colonists increasingly occupied the area, most of the American Indian population was forced westward. The 17th and 18th centuries saw a drastic change in demography in New Jersey; by 1740, there were relatively few sites still occupied just by Lenape. While at 1600, most of the state was occupied by Lenape Indian societies; by 1800, no recognizable separate American Indian societies remained, based on present knowledge. This does not mean that Lenape Indians no longer lived in New Jersey. However, by 1800, the Lenape occupied the state as individuals who were part of the larger colonial society. The degree and time of cultural assimilation varied considerably. For example, in some areas such as Monmouth County, the Sand Hill Lenape continued to be culturally identifiable into the 19th and 20th centuries. Many people tracing their ancestry to the Lenape continue to live in the state today.

Initial Colonial Settlement

The historic period of New Jersey began with the first European explorers, including Giovanni di Verrazano in 1524, Lord de la Warre in 1608, Hendrik Hudson in 1609, and Cornelis Jacobse Mey in 1610. Settlement of New Amsterdam (now lower Manhattan) soon followed, and it became the center of a colony known as "New Netherland." Within a generation, the Dutch began expanding into northeastern New Jersey (now Hudson and Bergen Counties). In the Delaware River and Bay (so named by de la Warre), English, Dutch, Swedes and Finns soon settled, although the Swedes and Finns gained a temporary hegemony and called their province "New Sweden." In 1655, New Sweden was annexed by New Netherland, and in 1664, during one of the Anglo-Dutch wars of that era; an English force seized New Netherland in the name of King Charles II of England. In 1664, the Duke of York (King Charles II's brother) sold New Jersey to two of his supporters, Lord John Berkley and Sir George Cartaret, who in turn divided the colony into East and West Jersey along a poorly established and unsurveyed line (Cushing and Sheppard 1883).

The first permanent settlement in New Jersey by Europeans was at Bergen (Jersey City) by the Dutch in 1660. Old Bergen County continued to attract the Dutch and those associated with them (Flemings, Huguenots, Germans, Scandinavians). In 1664, when Dutch colonial rule ended and was superseded by the English, New Englanders began to move into the areas south of Bergen and in the mid-1670s, Quakers of English origin began to settle the southwestern portion of the state. Joining them were the Swedes and Finns, who had been residents in Pennsylvania.

Berkley, who laid claim to West Jersey, sold his claim in 1673 to two Quakers, John Fenwick and Edward Byllynge. Shortly after the sale of West Jersey, Cartaret obtained a more defined treaty that divided East and West Jersey on a diagonal border that traveled from Little Egg Harbor in the Southeast to the 41st parallel in the northwest along the Delaware River. While these land disputes concerned areas of the New World, the majority of the land owners remained in England. Fenwick did not leave England to settle in West Jersey until 1677 with additional Quaker settlers following into the early 1680s. It was during this time that the many of the municipal boundaries in the southern part of New Jersey were established (Peaslee 1944).

Cumberland County and the Maurice River Valley

European settlement of Cumberland County and the Maurice River Valley began in 1691, with the surveying of large tracts of land by John Worlidge and John Budd. Jeremiah Wasse was granted 10,000 acres on the west side of the river and Robert Squibb received 200,000 on the east side (Ward 1930). These original tracts were soon divided and sold to settlers, who were sufficient in numbers by 1700s to warrant the appointment of a constable for this region.

By the third quarter of the 18th century, half of the population of Cumberland County lived to the west of the Cohansey River, with most residents pursuing an agricultural existence. Residents in the Lower Maurice River area and along the coasts of Delaware Bay were chiefly involved in fishing, lumbering, and in the shipment of goods across the river and downstream into the Delaware Bay.

Prior to the Revolution, semi-processed raw materials, notably lumber and iron, and some agricultural produce were being transported from the Maurice River area to markets in the lower Delaware Valley on a regular basis both by water and by land. The principal port community in Cumberland County during this period was Mauricetown, which was situated on the west bank at the head of the marsh and salt hay meadows. Two major regional routes passed through the Maurice River drainage linking Cape May with Delaware Valley towns like Philadelphia, Wilmington and Burlington.

The colonial cultural landscape of Cumberland County was dominated by the Maurice River, navigable as far upstream as the Millville area and by the regional road network. Apart from the salt hay meadows along the river banks, only limited acreage was under cultivation. The interior areas were mostly being exploited for lumber and bog iron, resulting in a scattered network of sawmills, forges and furnaces (Wacker and Trindell 1975).

During the Revolutionary War, Cumberland and Salem Counties were relied upon heavily as a source of food and raw materials for Washington's troops. General Washington went so far as to declare that if it were not for the provisions sent by these two counties in the winter of 1778, he would not have had any army to continue to the war (Cunningham 1978). Only one Revolutionary War era military action took place in Cumberland County. This occurred in August, 1781 at the mouth of the Maurice River at Dallas Ferry (near present day Port Norris). During the "Battle of Dallas' Landing" a group of British Tories was caught boarding a ship docked near the ferry landing. The raiders were killed and the ship was supposedly burned and buried on the riverbank (MAAR Assoc. Inc. 1986).

Following the Revolutionary War, a number of new communities were established along the Maurice River and the Delaware Bay coast. The village of Dividing Creek was settled in the early 19th century and by 1810 was sufficiently developed to warrant the creation of a post office. The villages of Fortescue and Gandy's Beach were founded between 1776 and 1810 along with other villages along the Lower Maurice River. Port Elizabeth was founded in 1785 and by 1800 was an important focus of local glass manufacture. Fortescue was named after John Fortescue who owned the land prior to the war. By the beginning of the 19th century, the population of Cumberland County had grown to more than 8,000 (Cushing and Sheppard 1883).

Early 19th century Cumberland County economic stimulus was provided by the iron, lumber and glass industries which were to some extent interconnected. Up until the 1840s there was a throbbing iron industry in the region based on the extraction of bog ore. The Cumberland Nail and Iron Company in Bridgeton, and the R.D. Wood and Company in Millville were both established in 1814. Unfortunately the bog ore deposits were of limited capacity and not conducive to large scale production. By mid-century, Pennsylvania's vast supply of magnetite ores were being brought into production using the new, cheaper anthracite coal as fuel, which spelled the end of the charcoal-fired forges and furnaces of southern New Jersey (Cushing and Sheppard 1883).

As early as the second decade of the 18th century the oyster beds of the Delaware Bay were recognized as a valuable resource that needed to be carefully husbanded. In 1719, the colonial legislature enacted the first regulatory laws designed to prevent the plundering of the oyster beds. In 1775, the legislature forbade local lime burners from harvesting the oyster shells for crude lime to be used in fertilizer and mortar. By the early 19th century oystermen from New England were bringing wooden dredges equipped with iron teeth to the Chesapeake and Delaware Bays. These new dredges were typically dragged behind schooners so that the iron teeth would comb the bay floor cooping the oysters into mesh bags. This was much more efficient method of mining the oyster beds than the traditional manual usage of tongs and rakes. Dredging was further improved after the Civil War when all components of the dredge, including the frame and the mesh bag were made entirely of iron (Rofls 1971).

By the mid-19th century the Maurice River Cove was widely acknowledged as an excellent location for the cultivation of oysters. In 1865, special legislation authorized the board of chosen freeholders of Cumberland County to utilize the Maurice River Cove for the specific purpose of transplanting oyster from their natural seed beds. These were relocated to the northwest of the cove and extending along the eastern shore from above Egg Island Point to Arnolds Point. The board of commissioners was further granted the right to subdivide the Maurice River Cove and lease the land yearly to the highest bidders (Mints 1976).

By 1889, the beginnings of the new oystering village of Maurice River had been established in the form of two oyster houses. Within the next year the wharf was extended and four more oyster houses were built. All of Maurice River's oyster processing houses were designed and built by the railroad to facilitate the most efficient and productive use of the transportation system. In 1904, the Central Railroad of New Jersey, the predecessor of the New Jersey Southern Railroad, contracted for the construction of new oyster shipping sheds for Long Reach.

Cape May County and Southern New Jersey Bayshore

Cape May County is named after Cornelius Jacobson Mey, a Dutch sea captain who explored the Delaware Bay and River in the first quarter of the 17th century. Following his return to Holland, the bay was named New Port Mey and the southern point of New Jersey became known as Cape Mey. In 1630, directors of the Dutch West Indian Company purchased 12 miles of land from the Lenni Lenape, located along the Delaware Bay Shoreline stretching north from Cape May Point. Three years later, Pieterzen DeVries was sent to the newly acquired lands to set up a whaling station. In the following spring of 1634 DeVries abandoned his whaling enterprise in favor of fur trading (Liebknecht 2004).

By 1676 all of New Jersey had fallen under the control of the English and was formally divided into the provinces of East and West Jersey. The Cape May peninsula lay within the West Jersey and was set off to William Penn. The first permanent settlement in the Cape May area did not take place until approximately a decade later when the principal landholder was Dr. Daniel Coxe of London. Coxe organized the establishment of a Whaling town known as New England Town. Coxe established an English governing headquarters, known as Coxehall, near the current study area (Liebknecht 2004).

New England Town was also known as Cape May Town and sometimes as Portsmouth. Cape May Town was populated primarily by English settlers coming from Connecticut and Long Island. French Huguenots and a number of African Slaves made up the remainder of the population. The whaling industry survived at this location for several years. By the end of the 17th century the whale population near the bay had diminished, forcing the whalers to travel farther out to sea.

After the failure of the whaling industry, incoming settlers of the Cape May peninsula acquired land from the agents of Daniel Coxe or from the West Jersey Society and eked out an existence through farming and fishing. In 1697 construction of a highway from Burlington to Cape May was authorized. Completed in 1707 at the expense of the County, the road was known as the King's Highway. To pay for the cost of the King's Road, the county initiated a toll to be collected at several locations. Cape May Court House was one of these toll collection points. Some of the local farmers resented the toll and decided to build their own free road and named it "Shun-Pike". Portions of this road still exist and retain the name Shunpike Road (Liebknecht 2004).

Thomas Budd, in 1685, noted that the marshes along the Delaware Bay could be drained for agricultural purposes. By the 18th Century this was a common practice. Waterways through the meadowlands usually did not provide ample drainage and consequently the marshes remained stagnant. Once lands were drained, the value of the meadows increased. Salt hay was cultivated during the late summer and early fall. Salt hay farming remained profitable until the second quarter of the 20th Century (Louis Berger & Assoc., Inc. 1995).

As the 18th century progressed, communities continued to develop along the Bayshore and the King's Highway. These early settlements were often named after their original owners, a prominent landowner or after the waterways that they were situated near. Communities along the bay were linked

by way of the Nay Shore Road (present-day NJ Route 47), a road that is said to have evolved from a Native American Trail (Hunter Research, Inc. 1996).

By the middle of the 19th century, lower Cape May County became recognized as a major vacation area. In the early 1800s, hotel owners placed advertisements in Philadelphia newspapers in an attempt to lure potential travelers to the region.

Previous Investigations

Delaware River Main Channel Project

Various cultural resources investigation, both terrestrial and marine, have been conducted at various times for the Delaware Main Channel, its proposed upland CDFs and the Delaware Main Channel Deepening project. The most recent evaluation of the proposed sand sources can be found discussed in the Delaware River Main Stem and Channel Deepening Project – Environmental Impact Statement (1992); Supplemental Environmental Impact Statement (1997); Environmental Assessment (2009, 2011 and 2013). The use of sediments within the ten upland CDFs and within the footprint of the Delaware Main Channel will have No Effect on historic properties eligible for or listed on the NRHP. NEPA documents related to the Delaware Main Channel can be found at the following link: <https://www.nap.usace.army.mil/Missions/Civil-Works/Delaware-River-Main-Channel-Deepening/Project-Reports>.

Delaware Bay Shoreline Studies

Several shoreline and near shore investigations were also conducted in conjunction with other USACE civil works projects, such as storm damage assessment and ecosystem restoration projects.

In 1979, Gilbert/Commonwealth produced a cultural resources overview and sensitivity analysis for the Delaware River and Bay for the USACE. No specific resources were identified within the current study area; however, the shoreline portion of the project area was identified as having a medium sensitivity for containing archaeological sites (Gilbert/Commonwealth 1979).

In 1992, a similar overview study was also conducted for the USACE by GAI Consultants, Inc. A comprehensive inventory was prepared of all documented archaeological, historical, and maritime sites in along the Delaware Bay and an adjacent tow-mile inland corridor from Cape May Point to the Salem River, New Jersey and from Cape Henlopen to the Chesapeake and Delaware Canal in Delaware. The report located 198 archaeological sites in New Jersey, with a focus along stream and river terraces and elevated areas within and bordering marshes and stream confluences which provided both resources and important transportation routes, and marshlands.

Several cultural resources investigation have been conducted in the Lower Maurice River area, which includes Bivalve, Shellpile, Port Norris, and Maurice Township, and is located near both Gandy's Beach and Fortescue. The investigation was conducted on both sides of the river with a total of 930 acres assessed. The occurrence of prehistoric sites tend to be clustered along the margins of the waterway in upland terrain with adjoining tidal waterways and wetlands. It also notes that culturally significant sites

that have been inundated due to sea level rise may be compromised or destroyed by inundation. (MAAR Assoc., Inc. 1986, 1987).

A Phase I investigation was conducted by Hunter Research in 1996 in connection with the shoreline stabilization and dredging work proposed for the Lower Maurice River and Maurice River Cove for the USACE Philadelphia District. The study involved a combination of geomorphological analysis and paleographic reconstruction, historical research, prehistoric and historical archaeological investigation, and underwater archaeological survey using magnetic, acoustic and bathymetric remote sensing equipment. Numerous prehistoric sites are known along the Maurice River Drainage on upland terraces; however, their model predicts the near shore zone as having a low potential for prehistoric data and intact prehistoric sites (Hunter Research, Inc. 1996a).

A Phase I Submerged and Shoreline Cultural Resources investigation was conducted by Hunter Research in 1996. Two proposed sand borrow areas and a six-mile segment of tidal zone and shoreline between Norbury's Landing and the Cape May Canal. Although no known prehistoric resources, previous investigations still place the shoreline and near shore areas as having moderate potential for intact archaeological resources. A single underwater remote sensing target was identified in one of the two proposed offshore sand borrow areas. The fact that the target produced only an acoustic anomaly suggests that it derives from a pile of rock rather than a shipwreck or cultural feature. However, the marine remote-sensing investigation does point to the potential for submerged historic properties within the nearshore and just offshore areas within Delaware Bay (Hunter Research, Inc. 1996b).

A phase I cultural resource investigation was conducted along two segments of the Delaware Bay shoreline in Middle Township, Cape May County, New Jersey; more specifically along the beachfront tidal zone within the communities of Reeds Beach and Pierces Point. This project was undertaken in connection with a program of beach nourishment and shoreline erosion control planned by the USACE Philadelphia District. The study was able to use ongoing geomorphological and prehistoric research by Rutgers University and Richard Stockton College in the Kimbles Beach vicinity, roughly midway between Reeds Beach and Pierces Point. The work at Kimbles Beach has opened an important window on the prehistory of the Lower Delaware Bay, demonstrating that where the result of coastal and standard archaeological depositional processes has not been subsequently reduced by coastal erosion, there is a real potential for the survival of prehistoric archaeological deposits. However, no evidence of prehistoric occupation were found within the tidal zone along the shoreline at either Reeds Beach or Pierces Point.. Potential for intact cultural deposits still exists based on the soil profiles collected. . Three historic architectural resources were identified at Pierces Point are potentially eligible for inclusion in the NRHP. These are an oyster boat beacon and two early cottages at 127 and 129 Pierces Point Road. Provided no staging areas are located in close proximity to these structures, none of these properties would be affected by the proposed beach restoration for Reeds Beach and Pierces Point (Hunter and Tvaryanas 1999).

A Phase I/II cultural resources investigation was conducted at the Cape May Villas, Norbury's Landing to Pierce's Point in Middle Township, Cape May County, New Jersey by Hunter Research in 2004. The Area of Potential Effect included the beachfront tidal zone between the communities known as Pierce's Point

and Norbury's Landing in connection with a program of beach nourishment and shoreline erosion control. No conclusive evidence was found for intact prehistoric archaeological deposits due to wave action; however, a scatter of thermally altered rock has been given the designation of 28CM55 (Liebknecht 2004).

In respect to historic archaeological deposits, two features consisting of buried barrels and light artifact scatters were identified. Given the degree to which these resources have been affected by beach erosion, neither was considered archaeologically significant. The third resource encountered was a sluice gate system consisting of a buried, hollow log, pilings and timbers. The sluice system is considered eligible for listing on the NRHP under Criterion C, because of its function and design embody the distinctive characteristics of a type, period and method of sluice construction integrally tied to the common historic practice of reclaiming tidal marshes in southern New Jersey for agricultural pursuits. Four historic architectural resources were identified as potentially eligible for inclusion on the NRHP. These are a series of three cottages at 30 High's Beach Road and the Rutgers Cape Shore Laboratory complex (Liebknecht 2004).

Archaeological Sites and Historic Properties

The USACE conducted background and database investigation compiled a list of recorded eligible and potentially eligible historic properties within one mile of the study areas.

Northern Planning Reach Study Area

The study area for the Northern Planning Reach include the No Action Plan and the Levee/Dike plan for Penns Grove, Carney's Point and Pennsville.

Penns Grove

Below-Ground

The central portion of Penns Grove is included in the NJSHPO archaeological sensitivity grid indicating NR eligible sites are identified.

Above-Ground

One historic structure is located in the study area. The Leap House, located at 193 West Main Street, is individually eligible for the NRHP and was assessed as part of the Salem County Historic Resources Survey for Penns Grove Borough.

Carney's Point

Below-Ground

The northern portion of Carney's Point is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above-Ground

The DuPont Chamberworks Facility and Deepwater Village Historic District is eligible for listing on the NRHP is located near the shoreline of Delaware Bay.

Pennsville

Below-Ground

The northern portion of Pennsville is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above-Ground

The Deepwater Electric Generating Station, located in the northern portion of the Pennsville study area, is individually eligible for listing on the NRHP. The Delaware Memorial Bridge across the Delaware River at the northernmost section of Pennsville is also individually eligible for listing on the NRHP. No other historic structures have been identified; however, the Second Presbyterian Church Graveyard is individually eligible for listing on the NRHP.

Southern Planning Reach Study Area

The study area for the Southern Planning Reach include the No Action Plan, the Levee/Dike Plan (Bivalve, Shellpile, Port Norris and Maurice River Township), the Beach Restoration Plan (Gandys Beach, Fortescue, Reeds Beach, Pierces Point, Del Haven and the Villas), and the Beach Restoration with Groin(s) Plan (Gandys Beach and Fortescue).

Fortescue

Below-Ground

The Fortescue study area is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above-Ground

Although there has been no structure inventory or evaluation, based on the number of structures in the village that relate to its 19th century fishing origins, Preservation New Jersey named Fortescue as one of the ten most endangered historic sites in New Jersey in 2014, even after the damage caused by Superstorm Sandy. . There is an existing timber stem stone groin at the northwest end of Fortescue that will need to be assessed for its potential for listing on the NRHP.

Gandy's Beach

Below-Ground

The Gandy's Beach study area is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above-Ground

There have been no historic structures analyses conducted in the Gandys Beach portion of the study area; however, given the history of the region with early settlers who fished and farmed both oysters and salt hay, there is moderate to high potential for historic structures potentially eligible for the NRHP may exist within this portion of the study area.

Bivalve/ Shellpile

Below-Ground

The Bivalve/shellpile study area is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above-Ground

There are 12 historic structures located in Bivalve/Shellpile study area that are eligible for listing on the NRHP. The Bivalve Oyster Packing Houses and docks are located along the southern portion of the Maurice River are listed on the NRHP. Roughly bounded by Route 533 from the north, High Street from the East, Maurice River and Delaware Bay from the South and Indian Creek from the west is the NR eligible Berry-Gibson Salt Hay Farm.

Port Norris

Below-Ground

The Port Norris study area is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above- Ground

The Port Norris Maritime Historic District includes over 50 properties both individually eligible and/or contributing to the Historic District.

Maurice River Township

Below-Ground

There are at least 60 known prehistoric sites between the mouth of the Maurice River and Unin Lake, North of Millville. The Maurice River Township study area is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above-Ground

The Maurice River Lighthouse is listed on the NRHP is within the Maurice River Township Study area and is located on the east bank of the Maurice River where it meets Delaware Bay.

Reeds Beach/Pierces Point

Below-Ground

A Phase I Cultural Resources Investigation was conducted along the shore and nearshore of Reeds Beach and Pierces Point. Although no artifacts were found within the tidal zone along the shoreline at either Reeds Beach or Pierces Point, the potential for intact cultural deposits still exists based on the soil profiles collected.

Above-Ground

Historic architectural field survey has identified a number of buildings which are likely to be in excess of 50 years of age along the shoreline in both Reeds Beach and Pierces Point. The buildings located at 127 and 129 Pierces Point Road are considered eligible for listing on the NRHP under Criterion C. The timber and plank structure identified as being an oyster fleet navigational beacon is also potentially eligible for listing on the NRHP.

Del Haven

Below-Ground

The Del Haven study area is included in the NJSHPO archaeological sensitivity grid indicating there are sites identified that may be eligible for listing on the NRHP.

Above-Ground

There have been no historic structures analyses conducted in the Del Haven portion of the study area; however, given the history of the region with early settlers who fished and farmed both oysters and salt hay, there is moderate to high potential for historic structures potentially eligible for the NRHP may exist within this portion of the study area.

The Villas

Below-Ground

Phase I and II investigations between Pierces Point and Norbury's Landing include the community known as the Villas. No conclusive evidence for intact prehistoric archaeological deposits has been found in the tidal zone along the shoreline. However, a scatter of thermally altered rock has been given the designation of 28CM55.

A historic sluice gate system is considered eligible for the NRHP under Criterion C due to its function and design embodying the distinctive characteristics of a type, period, and method of sluice construction tied to the historic practice of reclaiming tidal marsh for agricultural purposes. *Above-Ground*

Four historic architectural resources have been identified near the shoreline that include three cottages at 30 High Beach Road and the Rutgers Cape Shore Laboratory Complex.

Research has discovered thirteen previously recorded historic structures further inland that are eligible for or listed on the NRHP within one mile of the Villas portion of the study area. The Judge Nathaniel Foster house and the Fishing Creek Schoolhouse are listed on the NRHP, and eleven structures determined to be eligible for listing on the NRHP.

Property Name	Property Location	NRHP Status
Eli Mickel House	3130 Bayshore Road	Eligible
	2841 Bayshore Road	Eligible
	2805 Bayshore Road	Eligible
	2801 Bayshore Road	Eligible
	2716 Bayshore Road	Eligible
	2701 Bayshore Road	Eligible
	2750 Bayshore Road	Eligible
	2501 Bayshore Road	Eligible
	2500 Bayshore Road	Eligible
	305 Oakdale Avenue	Eligible
Fishing Creek Schoolhouse	2102 Bayshore Road	Listed
	1800 Bayshore Road	Eligible
Judge Nathaniel Foster House	1649 Bayshore Road	Listed

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 Estuary is 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 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." Minority populations should be identified where either: (a) the minority population of the affected area exceeds 50% or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. 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.

Gandys Beach and Fortescue are located in Downe Township, Cumberland County and Villas is located in Lower Township, Cape May County (the two southernmost counties in New Jersey). The population of Cumberland County was 156,898 (2010) and grew 7.1% between 2000 and 2010. According to the 2010 Census data, Caucasians make up 62.7%; African Americans – 20.2%; Native Americans – 1.1%; Asians – 1.2%; Pacific Islanders – 0.3%; and Other Races (including Hispanic and Latino) – 14.5%. According to the American Community Survey (ACS) 5-Year Estimates for 2013-2017 published by the U.S. Census Bureau, minorities make up less than 7% of the total population of Downe Township. This is less than 50% and less than the percentage of minorities in Cumberland County and the State of New Jersey. Therefore, in accordance with CEQ Guidance the affected areas of the recommended plans for the Gandys Beach and Fortescue do not include a minority population for purposes of E.O. 12898. The population of Cape May County was 97,265 (2010). Caucasians make up 89%; African Americans – 5%; Native Americans - <1%; Pacific Islander – <1%; and Other Races (including Hispanic and Latino) - <3%. According to the American Community Survey (ACS) 5-Year Estimates for 2013-2017 published by the U.S. Census Bureau, minorities make up less than 6% of the total population of Lower Township. This is less than 50% and less than the percentage of minorities in Cape May County and the State of New Jersey. Therefore, in accordance with CEQ Guidance the affected area of the recommended plan for Villas does not include a minority population for purposes of E.O. 12898.

Poverty rates remain disproportionately higher for blacks and Hispanics and the official poverty level is highest in Cumberland County. Almost 19% of the individuals residing in Cumberland County are living below the poverty level. The median income for a household in Downe Township is \$34,667 and in Lower Township is \$54,624 (both of which are substantially lower than the median income for the state - \$71,919). According to the American Community Survey (ACS) 5-Year Estimates for 2013-2017 published by the U.S. Census Bureau, 12% of the 1585 individuals in Downe Township (which consists of 49 square miles of land) and 10.4% of the 22,866 individuals in Lower Township (which consists of 28 square miles of land) live below the poverty level. Low wage occupations employ proportionately far more workers in southern 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 CSRSM alternative plans, including the recommended plan. Impacts resulting from the O&M dredging activities (that will serve as the CSRSM dredged material source) are fully evaluated in several NEPA documents developed 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. It should be noted that the maintenance 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. Therefore, potential impacts to resources are conservatively presented in the following subsections inclusive of a construction period

that may occur during any month of the year. In addition to the No Action Plan, alternatives considered during the alternative analysis included the Levee/Dike Plan, the Beach Restoration and the Beach Restoration with Groin(s) Plan.

Given the presence of tidal marshes with sandy beach barriers at the southern reach CSRSM problem areas, the USACE focused the alternative impacts analysis on the Beach Restoration Plan, the Beach Restoration with Groin(s) Plan and the No Action Plan.

Analysis indicated that additional features, such as wetlands or living shorelines, would provide minimal additional CSRSM benefits compared to the added cost. For living shorelines, data from the NACCS indicates that they are generally applicable to relatively low current and wave energy environments in estuaries, rivers, and creeks with water depths less than 5 feet MLLW. Areas exposed to larger waves do not benefit significantly from a living shoreline application since the marsh vegetation and underlying soils would likely be eroded. NACCS also indicates that living shorelines are more effective at shorelines with existing vegetation as opposed to exposed beach areas. An essential component of a living shoreline is constructing a rock structure (breakwater/sill) offshore and parallel to the shoreline to serve as risk management from wave energy that would impact the wetland area and cause erosion of the substrate and damage or removal of the tidal plants. Typically, the rock structure is designed with a crest elevation at or slightly above MHW that is effective at reducing wave energy under normal conditions but allows waves under severe storm events to pass over the stone structure and impact the shore. Therefore, living shorelines are typically more effective at reducing long-term erosion than short-term storm driven erosion.

In the southern reach, the width of the bay (fetch) increases resulting in greater wind-generated wave energy at the shoreline. The greater wave conditions in the southern reach require a substantial rock structure associated with any living shoreline that would look and function similarly to a breakwater. Living shorelines in the southern reach are expected to have limited effectiveness at many of the sites since the most vulnerable houses are often located on or directly behind a sandy beach with significant wave exposure and potential for storm-driven erosion. As discussed above living shorelines have limited effectiveness at reducing short-term storm driven erosion since the waves pass over the rock structure and may require a substantial beach buffer behind the rock structure to prevent erosion damages. Due to these reasons coupled with a construction cost of \$1,415 per linear foot (as estimated in the NACCS) living shoreline measures were screened out of the southern reach.

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.

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, however, 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.

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, RSLC and flooding events by strengthening natural ecosystems and the fish and wildlife habitat they provide.

The No Action Plan does not provide CSRMs and will allow for continued erosional impacts and coastal storm risk to infrastructure. Continued erosion of the narrow sandy beaches along the bay coastline will leave adjacent salt marshes, farmland and residential communities (*e.g.* homes and roadways) vulnerable to frequent inundation, flooding and loss of vegetation. Adverse effects to land use include diminished aesthetic quality of bay beach communities and adjacent saltmarshes, recreational opportunities, and habitat availability as the remaining beach berms continue to erode under current and future storm conditions.

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 recommended plan entails beach restoration at Villas, but also includes construction of a new rubble mound terminal groin parallel to the 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 rapid end losses of the placed sand. The addition of a groin to a beach nourishment plan is typical in areas where relatively higher beach erosion rates and losses occur. The recommended plan to provide CSRMs 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 (*i.e.* the construction site would be inaccessible to beach users during the construction period for activities such as surf fishing, beachcombing, picnicking, *etc.*). 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 CSRMs 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 Bayshore: 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, but may alter the physiography of the beach. Groins deflect alongshore currents resulting in greater accumulation of transported sediments on the updrift side. Groins may provide additional CSRMs for structures located on the updrift side of the groin and navigation benefits when positioned adjacent to inlets. Specifically, the terminal groin at Gandys Beach may cause erosion on the downdrift side; however, it will be a rubble-mound structure designed to function as a cross-shore beach template (or brace), rather than as a block (or "dam") to longshore transport (Basco & Pope, 2004). The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004). The

terminal groin at Fortescue (adjacent to the inlet at Fortescue Creek) will serve to reduce sand accumulation within the inlet.

The recommended plan involves the restoration of the berm and dune system at Villas fronting the developed sections of the bayshore to provide CSR. The construction of terminal groins at two of the beaches (Gandys Beach and Fortescue) will provide added protection from erosion by deflecting alongshore currents resulting in greater accumulation of transported sediments on the updrift side, 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 (Delaware River Main Stem and Channel Deepening Project - 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 recommended plan). 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 range 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). 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 23, 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 Plan, 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 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. Beach restoration will reduce the sediment deficit in the Delaware Estuary, thereby improving the overall health of the estuary. The dredged material is predominantly sand and is not considered chemically contaminated. Beach restoration will not adversely impact sediment quality. As discussed in Section 3.5, grain size of the projected source material is anticipated to be similar to that which occurs on the proposed placement beaches and materials with large grain sizes (>90% sand) do not require chemical analysis for contamination.

Under the recommended plan, the use of sand dredged from lower Reach E (as mapped on Figure 29) for beach nourishment will provide a tangible economic benefit (*i.e.* CSR benefit) to the study area shoreline while restoring the sediments typical of a healthy sandy beach shoreline. The addition of a new rubble mound ground adjacent to existing timber 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. The terminal groin at Gandys Beach may cause erosion on the downdrift side; however, it will be a rubble-mound structure designed to function as a cross-shore beach template (or brace), rather than as a block (or “dam”) to longshore transport (Basco & Pope, 2004). The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004). The terminal groin at Fortescue (adjacent to the inlet at Fortescue Creek) will serve to reduce sand accumulation within the inlet.

Figure 29 - Reach E Sub-Reaches



5.1.4 Climate and Climate Change

The U.S. Climate Change Science Program (USCCSP, 2009) evaluated coastal sensitivity to RSLC 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.

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 RSLC increases (Rosen, 1978; Stevenson and Kearney, 1996). RSLC 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 erosion in the affected areas related to RSLC. While RSLC 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 RSLC. Both beach restoration and beach restoration with a terminal groin are expected to reduce the adverse impacts of RSLC on communities and beach habitat quality.

While there are many types of shorelines in estuaries, sandy 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 RSLC since they are able to migrate landward as the shoreline retreats and wetlands accrete sediment and build in elevation. However, the combination of RSLC 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.

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. RSLC 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 notable.

A study by Galbraith *et al.* (2002) illustrates the potential effect of RSLC on prime migratory shorebird habitat. The study used the SLAMM version 4 to investigate the effect of RSLC 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 RSLC 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 recommended plan to conduct beach nourishment operations best mimics the natural shoreline habitat while affording additional defense against RSLC. Although the proposed hardened structure (terminal groin) does not necessarily offer added defense against RSLC, 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 RSLC. 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 re-suspension 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 of the terminal 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 (Figure 30) 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 the MCD navigation project (USACE, 1992, 1997, 2009).

Figure 30 - Hopper Dredge



Hopper dredges are self-propelled ships equipped with propulsion machinery, hoppers for dredged material storage and dredge pumps (Figure 29). 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.

Beach placement activities and the construction/rehabilitation of terminal groins are not expected to impact groundwater and public water supplies. A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (PL 95-217), as amended, and a concurrence of USACE's 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 reduce 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 preferred plan entails planting American beach grass on the dune.

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. 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 terminal groin at Gandys Beach may cause erosion on the downdrift side; however, it will be a rubble-mound structure designed to function as a cross-shore beach template (or brace), rather than as a block (or “dam”) to longshore transport (Basco & Pope, 2004). The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004). 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. Continued shoreline erosion elevates water turbidity which reduces primary productivity. With the proposed plan, some infaunal organisms within the dredged material intertidal placement zone will be impacted by burial during the construction period although some species are capable of migrating up through the sand. The community will also re-establish through recruitment from neighboring unaffected areas. By pumping dredged material onto the beach above the MHWL and constructing a temporary sand berm seaward of the placement pipe outfall, water quality impacts to intertidal infauna can be minimized by reducing run-off and turbidity back into the bay. Phytoplankton and zooplankton within this reach may incur some turbidity-induced mortality during the construction period. Despite the resiliency of intertidal benthic fauna that are adapted to high energy turbulent environments within the swash zone, the initial effect of 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. The construction of a hardened structure, such as a groin would permanently reduce available shallow water soft bottom habitat in the structure footprint but add to intertidal habitat diversity by providing hard bottom substrate for benthic macroinvertebrates. There will be a temporary increase in turbidity during groin construction. 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. As noted above in Section 5.2, the temporary berm established above

the MHWL during construction serves to reduce elevated turbidity within the intertidal dredged material placement zone.

Recolonization depends on the availability of planktonic 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. 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; 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. Oysters are not present within the proposed construction areas. Notable species that may be present include:

Sandbuilder worms. Adult sandbuilder worms (*Sabellaria vulgaris*) are sessile tubeworms that have evolved to establish small aggregations under the dynamic conditions of the subtidal zone near the low tide line on sandy beaches in lower Delaware Bay. These beaches have continued to erode under severe and frequent storm conditions, rendering many areas unsuitable for the sandbuilder worms. Reef distribution patterns can vary widely depending on changing physical factors such as storm activity and shifting substrates. *Sabellaria* is an opportunistic species exhibiting rapid colonization in clumps and can be short-lived, subject to destruction by severe storm events. Recolonization is depending on larval supply in the water column and suitable substrate.

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. Beach restoration projects that reduce risk to developed areas provide habitat for horseshoe crab spawning. The NMFS recommends that placement operations avoid the 15 April through 30 September period (NMFS, 2018) while USFWS recommended an avoidance period 15 April through 31 August period (USFWS, 2015) for when horseshoe crabs begin migrating to the shallow water to spawn. USACE agreed to a seasonal restriction of 1 April through 31 August with USFWS (informal consultation for red knots) (USFWS, 2019). USACE will consult with the natural resources agencies once a maintenance dredging schedule is determined. Several steps can be taken to minimize impacts of beachfill placement on horseshoe crabs. By pumping the sand onto the beach above MHWL and constructing a temporary sand berm seaward of the placement pipe outfall, as noted in section 5.3.2, water quality impacts are minimized by reducing run-off and turbidity back into the bay. If dredging occurs during this timeframe, USACE has committed to floating the dredge pipe within the nearshore pumping zone to minimize adverse impacts to sandbar sharks. This method also serves to reduce potential impacts to horseshoe crabs coming ashore during their spawning season.

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 strandings 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).

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 CSRMs, 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 recommended plan 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. In early fall, the young sharks are larger and more mobile allowing them to avoid sand placement operations and are likely to move into deeper waters. The NMFS recommends that dredging be avoided during the 1 May to 15 September period to prevent potential impacts to newborn and juvenile sharks. USACE will continue to coordinate with NMFS as the project progresses to evaluate potential adverse impacts of beach nourishment to the sandbar shark and other nearshore species (e.g. horseshoe crabs) during sensitive periods of the year. USACE will continue to coordinate the bay channel maintenance dredging schedule with NJDEP and NMFS to determine how best to minimize or avoid potential adverse impacts to HAPC.

As mentioned previously, for the beach restoration alternatives, including the recommended plan, 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. 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. 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 during 1 May through 15 September.

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 terminal groin 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 restoration 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 minute x 10 minute 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:

Atlantic butterfish: No adverse effects 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.

Cleanose 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. A temporary disruption to benthic food prey organisms may occur in the shallows of the proposed placement areas. No direct physical adverse impact is anticipated for 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.

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. Adults are highly migratory and mostly congregate offshore. No adverse impacts are anticipated for juveniles or adults as these stages are unlikely to be in the shallow waters of the nearshore zone but if present, are expected to move out of the immediate impact area during the temporary construction period. Some adverse impact to neonate stages may occur if placement operations in the nearshore and intertidal zone occur during the spring and summer pupping season due to elevated water turbidity and burial of forage prey species.

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. 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. Some adverse impact to neonate stages may occur if placement operations in the nearshore and intertidal zone occur during the spring and summer pupping season due to elevated water turbidity and burial of forage prey species. The dredge pipe may be floated on pontoons to avoid disrupting movements of young sharks if dredging occurs during the spring and summer. Sand will be 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. The sand tiger is identified by NMFS as a Species of Concern. 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 polychaetes 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. A temporary disruption to benthic food prey organism may occur in the shallow water of the proposed placement areas.

In conclusion, the potential for adverse impacts to the EFH of the species identified with Fishery Management Plans, as well as the juvenile life history stages of highly migratory pelagics that may occur in the vicinity, is considered temporary and minimal. The egg and larval stages of winter flounder, which occur predominantly in inlets, are not anticipated to occur in the project area. 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. Sand tiger and dusky sharks have been listed as Species of Concern by NOAA. Species of Concern are those about which NOAA has concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the Endangered Species Act (ESA). NOAA's goal is to promote proactive conservation efforts for these species in order to preclude the need to list them under the ESA in the future. Additionally, the study area has also been designated as a Habitat Area of Particular Concern (HAPC) for sandbar shark. HAPCs are discrete subsets of EFH that provide important ecological functions and are vulnerable to degradation. Potential impacts are minimized if dredging can be conducted during the cooler, nonbreeding months of the year (*i.e.* fall and winter). As noted previously, 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. The USACE will continue to coordinate with NMFS with regard to determining the future dredging schedule in an effort to avoid impacting EFH/HAPC. To reduce the potential for impacts to juvenile shark species, the dredge pipe may be floated to avoid disruption of movements if placement operations occur between 1 May and 15 September. 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 a few months to a few 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. 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. 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). 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. The No Action Plan poses no benefits to diamondback terrapins as beach habitat would erode, reducing available suitable nesting habitat. Additionally, the No Action Plan does not restore a protective barrier beach berm and dune system that provides CSRMs to neighboring salt marshes, scrub shrub, and interior forest habitats during severe coastal storm events.

Under the proposed plan, species are expected to leave the immediate impact area temporarily during construction. The USFWS NJFO supports further investigation of providing CSRMs 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 recommended plan 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. The terminal groin proposed at Fortescue is positioned adjacent to an inlet, which provide a sediment source to the downdrift side of the groins due to tidal river flow to the bay.

Birds. 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. Robust healthy beaches provide CSRMs and reduce the potential for saltwater intrusion and inundation

of these critical coastal habitats. 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. 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. The USFWS (2016) has recommended avoiding sand placement operations for the 15 April through 31 August period for migratory shorebirds. 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. Nourished beaches using similar grain sizes and slopes have shown to be highly attractive to beach nesting birds in the Delaware Bay (pers. comm. USFWS, 2017).

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 ESA of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

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 recommended plan 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 and washover spits are the preferred nesting habitat for the piping plover. Beach nourishment activities can provide positive benefits to listed species by restoring preferred beach habitat for foraging, nesting and predator avoidance.

Beach restoration involving the construction of a hardened structure can reduce available coastal foraging habitat within the groin 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 palliatus*, 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 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 upper 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 recommended plan would provide improved nesting habitat for terrapins with an enlarged beach. Beach nourishment and the construction of terminal groins are not expected to result in adverse impact to diamondback terrapins if construction occurs outside of the nesting season. However, if construction occurs during nesting season, the presence of construction equipment and activities may displace nesting terrapins from nesting in the area. 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 and pose a critical concern for threatened and endangered species.

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.

Northern long-eared bat. 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 No Action Plan is not anticipated to impact the northern long-eared bat. The project site locations included in the recommended plan are beach habitat. The proposed plan will not adversely impact surrounding saltmarsh vegetation, mature trees and buildings. The recommended

plan project locations are not considered northern long-eared bat habitat; therefore, no impacts to the northern long-eared bat are anticipated (USFWS letter to USACE, 12 October 2017).

Red knot. 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. The Corps initiated informal consultation with USFWS for activities related to the beneficial use of dredged material within the red knot foraging areas. 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 cause continued adverse impacts on the red knot stopover habitat along the Delaware Bay as flooding and erosion of the beach will continue. During the Section ESA consultation process, USACE held several conference discussions and a site visit in collaboration with USFWS and TNC to address their concerns with respect to the proposed Gandys Beach groin plan's effects on red knots. USFWS expressed concern that the proposed terminal groin at Gandys Beach would further exacerbate the ongoing erosion of the TNC Gandys Beach Preserve (and associated red knot habitat in and adjacent to the Preserve) shoreline downdrift of the proposed groin. As noted in Section 4.2.1, TNC in collaboration with the USFWS implemented a living shoreline project in 2015-2016 northwest of Gandys Beach to provide erosion protection the eroding shoreline habitat for spawning horseshoe crabs and foraging migratory shorebirds, and in particular the Federally-listed red knot. Shell bag and oyster castle breakwaters were placed in the shallow inshore waters approximately 1,500-2,000 feet northwest of the community of Gandys Beach.

An LST assessment was prepared and provided to USFWS. The LST assessment included various groin permeability scenarios (see USACE letter to USFWS dated 11 April 2019 in Appendix E). USACE reduced the groin height seaward and increased permeability of the Gandys Beach groin design to allow some sand to pass over, through and around the proposed groin. The analysis showed that with periodic nourishment, the With-Project condition is likely to increase longshore transport downdrift of the

terminal groin to the Nature Preserve relative to what is currently occurring (*i.e.* the Without-Project condition). In addition to the design modifications to the proposed Gandys Beach terminal groin, a phased construction schedule and survey monitoring program were incorporated into the proposed plan in collaboration with USFWS due to their concerns for red knot seasonal usage of the habitat. Monitoring will track volumetric changes over time at the project site and includes the area northwest of the terminal groin at the TNC Preserve site. Consequently, USFWS concurred that the proposed project, with the aforementioned modifications, is not likely to adversely affect the red knot (see USFWS letter dated 19 April 2019). USACE will employ adaptive management strategies in assessing post-initial construction conditions downdrift of the Gandy's terminal groin, as reflected in the project cost which includes project monitoring costs for the project life cycle.

For any construction alternative, 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 (USFWS, 2015). Migratory shorebirds, including the red knot, feast on horseshoe crab eggs to fuel their northern migration to their Arctic breeding ground. Beach nourishment is not likely to result in adverse modification of critical red knot habitat if conducted outside of the migratory period.

The Corps will re-initiate consultation with the USFWS once the maintenance dredging schedule has been determined. Beach nourishment is likely to improve eroded beach habitat utilized by spawning horseshoe crabs and red knots, although foraging area will be reduced by construction of the groins at Gandys Beach and Fortescue within the groin footprints. The construction of a new terminal groin can impede the red knots visual field, if the birds are foraging near 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). Beach nourishment 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 and therefore the food source for red knots (USFWS, 2016).

Piping plover. 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. Therefore, neither the No Action Plan nor the proposed plan (*i.e.* beach restoration and groin construction) are expected to adversely impact the species. As beach habitat evolves, either due to beach nourishment activities or storm washovers, wider beach berms may potentially attract piping plovers. However, the USFWS does not currently cite the piping plover as a listed species expected to occur in the recommended plan project area.

Eastern Black Rail. As noted in Section, the USFWS has proposed the eastern black rail as a Federal candidate species for listing under the ESA. The bird is also currently state-listed in New Jersey as

endangered. The No Action Plan is expected to cause continued adverse impacts to beaches that provide storm protection to communities and neighboring saltmarshes. Although the proposed action will not occur within the marshes themselves, placement of sand on eroded Delaware Bay beaches is expected to provide a supplemental sand source, through natural longshore transport processes, to nearby eroded beaches fronting salt and freshwater marshes. Therefore, the proposed project is anticipated to provide an indirect positive impact to black rail habitat by providing an enhanced sand buffer protection from storms to adjacent marshes.

Bald eagles. 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 recommended plan are not anticipated to result in any long-term impact to bald eagles in the area. Elevated water turbidity within the immediate construction area may temporarily reduce fishing activities. Bald eagles have been observed using groins as resting areas.

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 kempfi*), 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 recommended plan 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 nest in Mexico primarily, although they consistently nest at Padre Island National Seashore in Texas, with rare nesting events in Florida, South Carolina, and North Carolina (USFWS); and loggerheads nest as far north as Virginia. Nesting in the mid-Atlantic is generally rare. Sea turtles are not expected to frequent the intertidal and near shore shallow zone of the proposed beach nourishment sites. A temporary elevation of turbidity during the construction period in the nearshore groin construction zone may adversely impact sea turtle foraging, migration or prey species. As presented in Section 4.4.2, water quality impacts are anticipated to be minor and temporary at the placement locations and the groin construction areas. No information is available on the effects of total suspended solids (TSS) on sea turtles, but studies on the effect 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 each beach placement operation may affect sea turtle behavior or turtle prey behavior but turtles are highly mobile and are likely to avoid areas of increased suspended solids.

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 construction 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 construction 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 or groin construction as the species is not expected to occur in the nearshore/intertidal zone of the recommended plan. The majority of impact studies conducted on the species assess potential dredging impacts, such as possible entrainment of cutterhead suction or hopper dredges or ship strikes by large vessels and are presented in the aforementioned MCD NEPA documents.

Direct physical impacts to Atlantic sturgeon by the dredge are less likely to occur in the wider bay region than upriver, given the various precautionary measures required to be in place during construction operations. Burial of benthic invertebrate species will occur at the beach placement sites within the intertidal zone and within the footprint of the proposed groin construction sites. Atlantic sturgeon are not expected to be in the nearshore and shallow intertidal zone of the selected placement and groin 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. 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, 2017) 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 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 and groin construction sites. The No Action Plan and the proposed project 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 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 B.O. (NMFS, 2017) for the MCD project that no Atlantic or shortnose sturgeon are likely to be injured or killed during hopper dredging operations in Reach E.

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 (*Megaptera novaeangliae*), harbor seal (*Phoca vitulina concolor*) and gray seal (*Halichoerus 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*).

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 B.O. 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 construction areas. Neither the No Action Plan nor the proposed project are expected to result in adverse impacts to marine mammals as they are not expected to occur in the nearshore and intertidal region of the bay.

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 B.O. for the MCD project and the DMUs (November 2017), NMFS focuses the impact concerns on dredging operations, not beach placement operations or groin construction. They concluded that the proposed dredging 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 endangered New York Bight, Chesapeake Bay, or South Atlantic 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 proposed action is likely to adversely affect, but not likely to adversely modify or destroy critical habitat designated for the New York Bight DPS of Atlantic sturgeon. The B.O. specifies reasonable and prudent measures (RPMs) and terms and conditions 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 was a modification to the original dredged material disposal plan, the USACE re-initiated Section 7 consultation with NMFS. The 17 November 2017 B.O. from NMFS concludes that consultation. The USACE will abide by NMFS' RPMs and terms and conditions as specified.

5.4 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 recommended plan, 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. Air quality impacts resulting from the dredging operation have been evaluated for the Delaware River Main Channel Deepening project (Moffat and Nichol, 2004) and are not included in this report. In addition, air emissions would result from bulldozers, trucks, and other heavy equipment used in the construction of the berm and dune during placement operations, which are assessed in the current report. 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 NO_x 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."

The selected plan was evaluated for air quality emissions (Section 176 of the Clean Air Act) over a three year period in order to incorporate recommended environmental windows for the protection of natural resources (e.g. shorebirds and fish). Project-related emissions associated with the federal action were estimated to evaluate the applicability of General Conformity regulations (40CFR§93 Subpart B). The requirements of this rule do not apply because the total direct and indirect emissions from this project are less than the 100 tons trigger levels for NO_x, PM_{2.5}, CO, and SO₂ and less than 50 tons for VOCs for each project year (40CFR§93.153(b)(1) & (2)) and for the project as a whole. The estimated total NO_x emissions for the project are 89.5 tons over the proposed schedule allows for yearly totals to be well below 100 tons. Emissions of VOC, PM_{2.5}, CO, and SO₂ are all well below the applicable trigger levels. The project is presumed to conform with the General Conformity requirements and is exempted from Subpart B under 40CFR§93.153(c)(1) (see Appendix E – Record of Non-Applicability – RONA).

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 recommended plan would similarly pose impacts on GHG in the study area by contributing construction equipment emissions. All of the remaining CSRSM alternatives respond to severe storm actions that erode beaches along the Delaware Bay shoreline. The degree to which the recommended plan 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 recommended plan entails dune grass planting which serves to reduce GHGs through carbon sequestering.

5.5 NOISE

No additional noise will result from the No Action Plan over existing and natural background noise levels. The recommended plan 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. Construction activities will be monitored to minimize noise impacts. The dredging contractor is responsible for complying with the provisions of the State of New Jersey and all local ordinances.

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 bird watching, 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; Ruggione *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 approximately 6-9 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. Noise levels

generated by groin construction (which will occur temporarily for approximately 7 months) are not anticipated to be damaging to fish and wildlife species; it is expected that they will avoid the direct area of construction temporarily until activities cease.

5.6 VISUAL AND AESTHETIC VALUE

Aesthetics play an important role in the perception of valued environments. Sandy beaches are considered desirable locales as long as they are clean with no obvious water pollution or litter. With the No Action Plan, beaches will continue to erode due to tidal and storm action. Exposed peat reduces the appearance and recreational value of the shoreline. Scarping of the beach slope by storm-induced waves and erosion can often render the beach inaccessible and reduces the available habitat and quality for beach nesting birds, foraging migratory shorebirds, and other wildlife.

Beach nourishment restores eroded beaches to a natural slope. Impacts to aesthetics will occur during construction operations for approximately 7 months (for initial construction) and approximately 7 months for subsequent periodic nourishments. However, beach nourishment is conducted in sections, rendering approximately 800-1,000 linear feet of beachfront inaccessible to beach users for a few days at a time, until that section is complete and construction proceeds to the next section of beach. Turbidity impacts to the water body are minimized by standard dredging protocols to construct a temporary sand berm parallel with the shoreline above the mhwL such that run-off from the pumped slurry settles before returning to the bay.

Construction of a terminal groin at Gandys Beach and Fortescue may take approximately 7 months. The presence of construction equipment and associated noise will impact the aesthetic value at these locations temporarily. Groins commonly occur in coastal areas and may or may not be considered unsightly. Groins offer additional recreational use for sitting or fishing and are often observed to have shorebirds resting on them, such as terns and gulls.

5.7 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

Beach placement activities (i.e. the recommended plan) 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.

5.8 CULTURAL RESOURCES

As a Federal agency, the USACE has certain responsibilities for the identification, protection and preservation of cultural resources that may be located within the Area of Potential Effect (APE) associated with the NJ DMU project. Present statutes and regulations governing the identification, protection and preservation of these resources include, but are not limited to, the National Environmental Policy Act of 1969 (NEPA); A historic property is defined in the NHPA as any prehistoric or historic district, site, building, structure or object included in or eligible for inclusion on the National Register of Historic Places (NRHP), including artifacts, records, and material remains related to such a property or resource.

No Action Plan

Under the No Action Plan, no direct adverse effects to historic properties are anticipated. However, the continued sea level rise and lack of additional protection from storm related wave action would likely result in the deterioration of historic properties leading to their loss of integrity and/or degradation.

Recommended Plan - Beach Restoration and Beach Restoration with Groin(s) Plans

Gandy's Beach

At Gandys Beach, the recommended plan calls for a berm only beachfill that will tie into a terminal groin that will be constructed at the northwest end of the beach. The groin will tie into the existing rubble revetment and will extend approximately 234 feet bayward. The source of the sand will be removed from lower Reach E of the Delaware Main Channel (Figure 28).

Fortescue

For Fortescue, the recommended plan calls for a berm only beachfill that will tie into a terminal groin that will be constructed at the northwestern end of the beach, 30 feet southeast of the existing timber groin. The groin will be constructed parallel to the existing timber groin and will extend 270 feet bayward. The source of the sand will be removed from lower Reach E of the Delaware Main Channel.

The Villas

At Villas, the recommended plan calls for a dune and berm beachfill that will tie into the existing shoreline at Francis Avenue and extends north to West Greenwood Avenue. The source of the sand will be removed from lower Reach E of the Delaware Main Channel.

The APE for the beach restoration and beach restoration with groin(s) plans (i.e. the recommended plan) represents the physical extent of the undertaking within which direct and/or indirect effects of the construction, operation and maintenance of the project, could be caused to the character or use of a historic property. Currently no staging areas have been identified but those areas would be considered part of the APE as well.

There is the potential for impacts to historic properties in all three areas within the RP. Such impacts can result from either direct impacts or indirect impacts to known and currently unknown resources that exists within the APE for the RP. Potential impacts to the reources include potential direct impacts to archaeological resources on or near the shoreline, submerged archaeological resources such as shiwrecks and inundated prehistoric archaeological sites, and viewshed impacts to historic structures. The District will work in coordination with the NJSHPO, the Tribes and other consulting parties to avoid, minimize, or mitigate any determined adverse effects.

It is recommended that: 1) a Phase I A/B cultural resources investigation be conducted within the APE to locate any potentially eligible archaeological resources and to expand on the archival research conducted for this report; 2) an Architectural Inventory be conducted within the APE to document and assess for the presence of potentially eligible historic structures and/or historic districts, to assess the eligibility of the existing groin at Fortescue, and to assess potential impacts to the historic viewshed; and, 3) to conduct remote-sensing marine surveys within the APE for the proposed groins to assess for the presence of submierged historic properties.

Due to study time and process constraints with accessing parcels and developing study criteria, the district determine that it would implement a Programmatic Agreement (PA) in accordance with Section 106 of the NRHP and its implementing regulations (36 CFR 800). This will allow the district to District to address potential adverse/signaificant effects to historic properties/resources within various Fedral regulations that govern cultural resources. A preliminary draft PA was prepared and submitted to the NJSHPO and the Tribes, along with other relevant information regarding the proposed project, in a letter dated March 16, 2016. The draft PA had since been revised to address comments received from the NJSHPO and to update the APE based on subsequent project modification. All correspondence can be found in Appendix E.

The final draft of the PA and supporting documentation was submitted to the ACHP on July 17, 2019 via the e106 electronic submission system. The ACHP declined to participate in a letter addressed to the USACE on July 29, 2019. Copies of the electronic submission to the ACHP via their e106 system and subsequent response from the ACHP can be found in Appendix E. A final draft of the PA, which includes the recommended investigations stated above as stipulations of the PA, will be sent to the NJSHPO, the Tribes and other consulting parties. Once final comments are received and the PA is completely negotiated it will be executed by the District Commander.

The PA will guide the actions the District will take through the Pre-Construction Engineering and Design and Construction phases of the project to ensure compliance with Federal regulations and ensure that

impacts to historic properties are avoided, minimized or mitigated and that the work is carried out in consultation with the NJSHPO, appropriate Federally recognized Tribes and other identified parties.

5.9 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 recommended plan 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. As noted in Section 4.10, for purposes of

E.O. 12898 no minority populations were identified in any of the areas affected by the recommended plans. While 12% of the individuals residing in Downe Township (where both Gandys Beach and Fortescue are located) live below the poverty line, it is unknown whether those individuals live near the affected areas. However, the recommended plans and the alternatives proposed in Downe Township are not anticipated to result in any significant or negative human health or safety impacts. The same is true for the 10.4% of individuals living below the poverty line residing in Lower Township with regard to the recommended plan and alternatives for Villas. Therefore, none of the alternatives will have a disproportionately high and adverse human health or environmental effect on low-income populations. The recommended plan 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.

5.10 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.

Habitat restoration along the lower Delaware Bay shoreline of New Jersey has been the focus of several wildlife oriented groups. Since 2013, habitat restoration work has been initiated along the western shoreline of Cape May County due to the loss of horseshoe crab spawning habitat and the critical foraging habitat that these same beaches offer to red knots and other shorebirds that consume horseshoe crab eggs to fuel their long flights to Arctic breeding grounds each spring. Beaches were supplemented with sand from area quarries and engineered to have a sloping berm with elevations favored by spawning horseshoe crabs. The work was expanded in 2015 into Cumberland County (Fortescue and Money Island) to provide additional locations where marshes along the water's edge received quantities of suitable sand to supplement horseshoe crab spawning habitat wiped out by Hurricane Sandy.

The Nature Conservancy (TNC), in coordination with USFWS under the Hurricane Sandy Resilience program, has been conducting Living Shoreline projects on TNC's property, lying approximately a half mile north of Gandys Beach. Hurricane Sandy ripped up the sand veneer and washed it inland among the marsh grasses leaving bare sod and mud in place of sand. Oyster castles and shellbags were installed along approximately 1 mile of eroded shoreline in 2016 within the intertidal and shallow subtidal waters to attenuate wave energy and capture sediments and provide structural habitat. Marsh restoration has long been considered within the Maurice River delta area to convert extensive mud flats back into viable marsh habitat.

In another coastal restoration project, the NJDEP conducted thin-layering placement of material dredged from the Fortescue Creek channel for placement on the Fortescue WMA, located north and east of the community of Fortescue. This pilot project was constructed over a 2-year period in 2015-2016. Approximately 6,500 cubic yards of fine-grained dredged material was pumped onto 6.4 acres of saltmarsh. Larger grained sand was pumped to restore 3.88 acres of beach fronting the northern section of the WMA about 1/3 to 1/2 mile north of the community of Fortescue. A supplemental beach placement was completed that winter to place 19,000 cy of sand from the channel to restore 2.5 acres of eroded dune in an effort to protect the adjacent marshes from inundation. Post-placement monitoring in 2016/2017 showed that the edges of the marsh where the dune was enhanced is continuing to erode. During optimization of the current plan to nourish Fortescue beach, the USACE study team will evaluate how the proposed terminal groin may effect wave activity to the north and how the project will impact erosion rates on the WMA shoreline. The NJDEP noted that they have no further plans to do environmental restoration work in the area. The NJDEP has indicated that the proposed terminal groin may be beneficial in reducing the need for maintenance dredging within Fortescue Creek if it reduces sediment transport back into the creek. USACE will evaluate how the proposed groin will affect nearfield wave action fronting the WMA.

All of the past, current and foreseeable future projects along the eastern shore of the Delaware Bay all are designed with the objective to restore eroded coastline. Whether it be for the restoration and protection of coastal habitats for wildlife or for coastal storm risk management to bayfront residential communities and their adjacent marshes, cumulatively these projects provide increased protection to the shoreline. USACE anticipates that periodic nourishment of the proposed beaches with maintenance material over the future 50-year project life will retain sand within the estuarine system. Through natural longshore distribution processes, the project will continue to contribute to the reduction of erosion within the study area.

Table 27 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).

Table 26 - 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.	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 recommended plan 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 recommended plan poses positive impacts through restoration of natural beach habitat and increased longshore sediment transport to the Nature Preserve northwest of Gandys Beach.

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.
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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 terminal groin at Gandys Beach may cause erosion on the downdrift side; however, it will be a rubble-mound structure designed to function as a cross-shore beach template (or brace), rather than as a block (or “dam”) to longshore transport (Basco & Pope, 2004). The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004). The terminal groin at Fortescue (adjacent to the inlet at Fortescue Creek) will serve to reduce sand accumulation within the inlet. Further, 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 CSRMs to communities.

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 of sand taken from the navigation channel in lower Reach E would be placed at the Buoy 10 open water disposal site. In 2017, Buoy 10 was estimated to be at or near capacity; however, the USACE requested and received from NJDEP a permit to expand the footprint and gain an approximate 10 years of additional capacity. A new CZM and WQC were received on 24 January 2018. 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 CSRMs 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 adverse effects.

Irreversible and Irrecoverable 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 CSRMs benefits to Bayfront communities from severe storm events but is not irreversible as storms will continue to occur, and in combination with RSLC, continue to erode the shoreline. There is the potential for adverse effects to historic properties from construction activities associated with groin construction to both shoreline archaeological sites, submerged archeological sites and shipwrecks. There is also the potential for adverse visual impacts to historic structures and/or historic districts associated with groin construction and berm placement. A Programmatic Agreement has been executed to complete these determinations.

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 natural resource agency recipients were informed of the purpose and scope of the feasibility study and were invited to provide input to the feasibility study, 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. Response to scoping letters provided species of concern; recommended seasonal periods of construction restriction; and recommended noise and emissions reduction construction methods. All comments received during the scoping phase of study were addressed in the report. The draft IFR/EA was released for public review on 18 October 2017. The draft IFR/EA was posted to the USACE Philadelphia District's external website and then an email notification was sent to a distribution list with approximately 300 subscribers representing agencies, nongovernmental organizations (NGOs), and other organizations. The email notifications were also sent to regional media as well. Letters requesting review and comment on the draft IFR/EA were submitted to the natural resource agencies identified in Section 6.2.1. Specific agencies that received notification letters include: New Jersey Department of Environmental Protection Historic Preservation Office; USEPA Region II; U.S. Fish and Wildlife Service, New Jersey Field Office; New Jersey Department of Environmental Protection, Office of Permit Coordination and Environmental Review; and National Marine Fisheries Service.

All comments received prior to and following the release of the draft report have been incorporated into the report within the applicable subsections. USACE responses to comment letters are presented in Appendix E: Pertinent Correspondence. The natural resource agency consultation reports are included in their entirety in Appendix H.

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), The Nature Conservancy (TNC) 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 recommended plan, and contains an integrated Environmental Assessment. It was subjected to public review and comment for a 30-day period. This public coordination and environmental impact assessment complies with the intent of NEPA. The recommended plan 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 recommended plan falls under the scope of the 17 November 2017 Biological Opinion – Deepening and Maintenance of the Delaware River Federal Navigation Channel (NMFS, 2017). Consultation was reinitiated by the USACE with NMFS on 16 August 2016 for the modification to beneficially use the dredged material from Lower Reach E to place on the bay front beaches identified in the recommended plan for this study. The 17 November 2017 B.O. from NMFS concludes that consultation (see Appendix H). The USACE will abide by NMFS' RPMs and terms and conditions as specified through re-initiation of consultation.

Coordination with the USFWS New Jersey Field Office (NJFO) was initiated on 24 November 2014. Section 7 consultation was re-initiated (2 October 2017) and was completed after the optimization process of the design had been completed and coordinated with the NJFO on 19 April 2019. The USACE modified the terminal groin design at Gandys Beach to reduce the groin height seaward and increase permeability to allow some sand to pass over, through and around the proposed groin via longshore transport. The initial construction plan was divided into 3 years such that it adheres to USFWS' recommended seasonal restriction from 1 April through 31 August for foraging red knots. USACE will

track LST downdrift of the groin post initial construction to employ adaptive management during periodic nourishment cycles and determine future nourishment quantities and placement locations. USACE will re-initiate ESA Section 7 consultation if new information arises that could cause effect to listed species and prior to nourishment cycles.

Section 7 consultation with USFWS will be re-initiated within 60 days prior to construction to coordinate with the natural resource agencies once the maintenance dredging schedule is known. 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 draft 2(b) report was completed by the USFWS and submitted to USACE 24 May 2019. USACE's seasonal restriction for red knots will also avoid construction operations during the horseshoe crab spawning season. In consultation with the NMFS, USACE will float the dredge pipe within the nearshore zone to minimize adverse impacts to sandbar sharks during their pupping season (1 May – 15 September). Water quality impacts at the construction beaches will be minimized by reducing run-off and turbidity by creating a small temporary sand berm and pumping above the MHWL. 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 recommended plan 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 recommended plan is also in compliance. In addition, the project is also in compliance with Executive Order 13175 (Consultation and Coordination with Indian Tribal Governments); Executive Order 13007 (Indian Sacred Sites); the Archaeological Resources Protection Act (ARPA); the Native American Graves Protection and Repatriation Act (NAGPRA). Consultation with all parties is ongoing.

6.2.2.5 Clean Water Act of 1972

A Section 401 water quality certification application was submitted to the NJDEP on 25 October 2017. On 22 December 2017, the NJDEP Division of Land Use Regulation (DLUR) determined that the project is conditionally consistent with New Jersey's applicable Rules guiding issuance for a Section 401 Water Quality Certificate provided that certain conditions imposed by NJDEP are met to NJDEP's satisfaction. 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 recommended plan will not significantly impact air quality. The requirements of this rule are not applicable to this recommended plan 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

NJDEP requires Federal agencies to follow the state's coastal management policies to obtain concurrence under the Act. The USACE coordinated with New Jersey's Coastal Zone Management Program and determined that the activity is consistent with the program. The draft feasibility report and integrated EA (including the Section 404(b)(1) Evaluation) and CZMA consistency evaluation were submitted to the state on 25 October 2017 and 26 October 2017, respectively. On 22 December 2017, the NJDEP DLUR determined that the project is conditionally consistent with New Jersey's CZM rules (NJAC 7:7-1.1 *et seq.*) provided that certain conditions imposed by NJDEP are met to NJDEP's satisfaction. The USACE will obtain NJDEP's final federal consistency determination prior to construction and adhere to the conditions as stipulated.

6.2.2.8 Farmland Protection Policy Act of 1981

No prime or unique farmland would be impacted by implementation of this recommended plan. 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 recommended plan. 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 recommended plan proposes to beneficially use sand material dredged from the Delaware River Main Channel to restore eroded bay front 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. USACE coordinated extensively with the USFWS and TNC to incorporate design features within the Gandys Beach groin to address their concerns regarding longshore sediment transport to the northwest of the project area. Therefore, this recommended plan 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 recommended plan 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 (MSFCMA) 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 in a letter dated 16 October 2017. NMFS recommended that construction be avoided during the 1 May to 15 September period for sandbar shark. USACE will consult with NMFS once a maintenance dredging schedule is determined. Pursuant to Section 305(b)(4)(A) of the MSFCMA, the Corps provided a response letter on 7 December 2017. The recommended plan has been 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 recommended plan beneficial use sites. The recommended plan is in compliance with CBRA and CBIA.

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 bay front beaches rather than disposal at Buoy 10 or an upland CDF. The recommended plan 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 could be minimally affected by dredging at the proposed sand source locations, contingent on the O&M dredging schedule. 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 recommended plan 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 (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. If the non-Federal Sponsor is required to acquire easements to implement the recommended plan, they will be required to comply with the requirements of the Act.

6.2.2.21 Executive Order 11990, Protection of Wetlands

No wetlands would be adversely affected by the recommended plan. The plan is in compliance with the goals of this Executive Order because it may reduce erosion damages due to excessive inundation and flood risk to adjacent wetlands.

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 floodplains 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 floodplains 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 floodplain, identify and evaluate practicable alternatives to the action or location of the action in the base floodplain.** 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 floodplain, 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 floodplain values. Where actions proposed to be located outside the base floodplain will affect the base floodplain, 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 floodplain, determine if a practicable non-floodplain 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 floodplain 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 floodplain and the project will not negatively impact the natural or beneficial floodplain values. Chapter 3 of this report summarizes the alternative identification, screening and selection process. The No Action Plan 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 floodplain, 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. As described in Section 4.10, for no minority populations were identified in the affected areas for purposes of E.O. 12898.

The recommended plan 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 high and adverse human health or environmental effects to minority or low income populations resulting from the implementation of the recommended plan.

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 recommended plan 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 27 - Project Delivery Team

Name	Discipline
Scott Sanderson	USACE – Project Manager/Planner
Barbara Conlin	USACE – Environmental Coordinator
Preston Oakley	USACE – Economics
Mark Gravens	USACE – ERDC
Robert Hampson	USACE – Hydrology & Hydraulics
Jake Helminiak	USACE – Hydrology & Hydraulics
Mary Cialone	USACE – ERDC
Alison Sleath	USACE – ERDC
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
Amanda Phily	USACE – Office of Counsel
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 CSR project along the New Jersey shoreline of the Delaware Bay. Upon approval by the 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).

In the Disaster Relief Appropriations Act of 2013, P.L. 113-2, Congress provided funding and authority for the Corps of Engineers to execute actions related to the consequences of Hurricane Sandy. The Federal share of initial construction of the recommended plan is eligible to be funded using construction funds provided in P.L. 113-2. The Corps will address whether P.L. 113-2 construction funds will be used to complete initial construction of the recommended plan at a later date.

If the Corps determines that P.L. 113-2 funds will be used for the Federal share of initial construction of the recommended plan, initial construction of the project may be completed following notification to the Committees on Appropriations of the House of Representatives and the Senate by the Assistant Secretary of the Army (Civil Works) that the recommended plan is technically feasible, economically justified, and environmentally acceptable. Congressional authorization and appropriations will be required in order to carry out periodic renourishment.

If the Corps, however, determines that P.L. 113-2 funds will not be used for the Federal share of initial construction of the recommended plan, Congressional authorization and appropriations will be required in order to carry out both initial construction and periodic renourishment.

Upon receipt of Federal construction funds, USACE and the non-Federal sponsor must 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 nourishment of the CSR project will be cost-shared 65% by the Federal government and 35% by the non-Federal sponsor, while the periodic renourishment will be cost-shared 50/50.

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 percent of initial project costs assigned to coastal and storm damage reduction, plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits, and 50 percent of periodic nourishment costs assigned to coastal and storm damage reduction, plus 100 percent 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 percent of design costs allocated to coastal and storm damage reduction in accordance with the terms of a design agreement 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 percent of initial project costs assigned to coastal and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;
 - Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;
 - Inform affected interests, at least yearly, of the extent of protection afforded by the flood risk management features; participate in and comply with applicable federal floodplain management and flood insurance programs; comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12); and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood risk management features;
 - Operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, 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 regulations and any specific directions prescribed by the Federal government;
- For so long as the project remains authorized, ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;
 - Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms;
 - At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal government;
 - Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;
 - Hold and save the United States free from all damages arising from the initial construction, periodic nourishment, operation, maintenance, repair, replacement, and rehabilitation of the project, except for damages due to the fault or negligence of the United States or its contractors;
 - Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;
 - Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the initial construction, periodic nourishment, operation and maintenance of the project;
 - 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 the initial construction, periodic nourishment, or operation and maintenance of the project;
 - Agree, as between the Federal government and the non-Federal sponsor, that non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and, to the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;

- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 101(e) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2211(e)), which provide that the Secretary of the Army shall not commence the construction any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;
- Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;
- Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army;” and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)); and
- 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 Public Access Plan

Engineering Regulation (ER) 1165-2-130, Federal Participation in Shore Protection Projects, requires that reasonable public access be provided in accordance with the recreational use objective of the particular area and public use is “construed to be effectively limited to the within one-quarter mile from available points of public access to any particular shore.” No two public access points can be further than ½ mile apart, and no visitor can be further than ¼ mile from an individual access point. ER 1165-2-130 also discusses parking requirements and states that parking on free or reasonable terms should be available within a reasonable walking distance of the beach. Public access and parking available and/or needed to comply with ER 1165-2-130 in each community of the recommended plan is described below:

Gandys Beach

Current public access at Gandys Beach is limited to a single point at the intersection of Gandys Avenue and Cove Road, as shown in Appendix G. Two additional public access points will be required, at the northern and southern ends of the project to satisfy ER 1165-2-130 requirements for provision of access

to points to be within one half mile of one another. The local sponsor has identified these two locations (see public access drawings) to fulfill the requirement. Vehicle access will be a necessary part of one or both of these new access points. Additionally sufficient public parking will be provided in accordance with ER 1165-2-130.

Fortescue

Current public access at Fortescue Beach consists of 4 locations dispersed along the shoreline, as shown in Appendix G. One additional public access point will be required, in the middle of the project to satisfy ER 1165-2-130 requirements for access to points to be within one half mile of one another. The local sponsor has identified a likely location (see public access drawings) to fulfill the requirements. An easement for vehicle access may need to be obtained to allow vehicle access of the new dune at the southern end. Additionally sufficient public parking will be provided in accordance with ER 1165-2-130.

Villas (South)

Current public access at Villas satisfies ER 1165-2-130 requirements for access to points to be within one half mile of one another. An easement for vehicle access may need to be obtained to allow vehicle access of the new dune at the southern end. Additionally sufficient public parking will be provided in accordance with ER 1165-2-130.

8.3 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	November 2019
Chief’s Report submitted to ASA (CW)	March 2020
ASA (CW) Final Feasibility Report & Integrated EA Approval	August 2020
ASA (CW) submits report to OMB	August 2020
Final Report to Congress	August 2020
Start Plans and Specifications (Design Phase)	January 2021
Execute PPA with non-Federal Sponsor	January 2021
Finalize Plans and Specifications for Contract	August 2021
Real Estate Certification for Contract	September 2021
Ready to Advertise Contract	October 2021
Award Construction Contract with Notice to Proceed	November 2022
Complete Project Construction	March 2024

8.4 Cost Summary

As referenced above in Section 3.5.1, the total project cost is approximately \$288,561,000. 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 28 – Cost Sharing for the Recommended Plan

Cost Share Description	Federal Cost Share %	Federal Cost	Non-Federal Cost Share %	Non-Federal Cost	
Initial Construction Cost	65%	\$80,777,320	35%	\$43,495,480	\$124,272,800
Real Estate Costs (LERRD)	0%	\$0	100%	\$6,530,000	\$6,530,000
Initial Construction					
Initial Construction Total Costs		\$80,777,320		\$43,495,480	
Periodic Nourishment					
Periodic Nourishment	50%	\$82,144,100	50%	\$82,144,100	\$164,288,200
Initial Construction + Periodic Nourishment					
Final Project Cost Share and Cost (50 Years)	56%	\$162,921,420	44%	\$125,639,580	\$288,561,000

8.5 Views of Non-Federal Sponsor

The NJDEP fully supports the recommended plan and its implementation requirements.

9 RECOMMENDATIONS

The recommended plan consists of beach restoration at 3 coastal communities in the southern reach of the study area. The 3 dredged material placement locations include: Villas (South), Gandys Beach and Fortescue.

Gandys Beach

At Gandys Beach, the recommended plan calls for a berm only beachfill with the parameters shown on Table 20. The full width of the design extends in front of all currently developed property bayward of Cove Road. 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 high with-project end losses without the use of a terminal groin. The design will tie into a terminal groin at the northwest end of Gandys Beach that will be constructed as part of the plan and the southeastern end will taper to the existing shoreline. Beachfill alternatives were evaluated and compared at Gandys Beach with and without a terminal groin. Analytical shoreline change modeling of beach restoration at Gandys Beach

shows that the beach template would be unstable without a terminal groin due to severe end losses of the fill. The rate at which the beachfill would erode would be so high that excessively frequent periodic nourishment would be required to maintain the project shoreline. Attempts to extend the periodic nourishment interval by increasing the fill volume would increase the project width and its perturbative effect on the shoreline alignment. This in turn would increase the beachfill loss rate so that the increased fill volume would do little to decrease the periodic nourishment frequency (Bodge 2003). Over a 50-year project life, the cumulative savings on periodic nourishments are expected to greatly exceed the initial cost of the terminal groin.

As discussed further in Section 5.3.5, USFWS and TNC expressed concern that the proposed terminal groin at Gandys Beach would further exacerbate the ongoing erosion of the TNC Gandys Beach Preserve (and associated red knot habitat in and adjacent to the Preserve) shoreline downdrift of the proposed groin. USACE held several conference discussions and a site visit in collaboration with USFWS and TNC to address their concerns with respect to the proposed Gandys Beach groin plan's effects on the Gandys Beach Preserve and associated red knot habitat. As a result of the continued coordination with USFWS and TNC, the terminal groin was optimized and refined to allow for transport over the groin at high tide at about mean sea level. Specifically, the groin will also include two layers of armor stone in order to increase the permeability of the structure to longshore sediment transport (LST) of sand. The permeability of the rubble-mound structure will allow hydrodynamic exchange across the groin, which is important to reducing rip currents and offshore losses (Basco & Pope, 2004).

USACE anticipates that periodic nourishment of the proposed beach over the project life will not only create and maintain sandy beach habitat in the Gandy Beach project area, but will also allow transport of sediment to the northwest into the TNC Preserve, which is sand-starved under existing conditions. It is expected that the nourishment of Gandys Beach will restore the two natural processes, upland beach erosion and LST, primarily responsible for providing sediment to bay beaches.

The groin will tie into the existing rubble revetment. From the tie-in, the groin will extend approximately 234 feet bayward and will consist of layers of armor stone, core stone and marine mattress.



Gandys Beach

Fortescue

For Fortescue, the recommended plan calls for a berm only beachfill with the parameters shown on Table 20. The full width of the design extends in front of all developed structures bayward of Delaware and Jersey Avenue. There is an existing timber groin currently separating the Fortescue beach area from Fortescue Creek. While the timber groin provides this separation, it is too short to retain the proposed beachfill at Fortescue. The proposed groin will be a rubble mound structure which is parallel to the existing groin and will extend 270 feet bayward (120 feet beyond than the bayward extent of the existing timber groin) to limit end losses of the planned beachfill. The proposed groin will tie into the existing shoreline and will be located approximately 30 feet east of the existing timber groin in order to allow for the timber groin to serve as a cofferdam during construction of the proposed rubble mound groin. The design beachfill will tie into the rubble mound groin at the northwest end of Fortescue (adjacent to the existing timber stem stone groin and Fortescue Creek) and the southeastern end will taper to the existing shoreline.



Fortescue

Villas (South)

At Villas (South), the recommended plan calls for a dune and berm beachfill with the parameters shown in Table 20. The design will tie into the existing shoreline at Francis Avenue and extend north to West Greenwood Avenue. The design will utilize tapers at each end to tie the beachfill into existing conditions.



Villas (South)

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 recommended plan with policies, desires, and capabilities of the State of New Jersey and other non-Federal interests. USACE has evaluated several alternative plans for the purpose of coastal storm risk management. A recommended plan 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 Table 29:

Table 29 - Summary of Costs & Benefits

FY2020	AAD Without Project	AAD With Project	AAD Reduced	Land Loss Reduced	Total AAB
Fortescue	\$4,864,669	\$1,883,795	\$2,980,873	\$34,456	\$3,015,329
Gandys Beach	\$2,713,966	\$165,248	\$2,548,718	\$0	\$2,548,718
Villas (South)	\$2,286,587	\$49,697	\$2,236,890	\$455,433	\$2,692,323
SUBTOTAL	\$9,865,222	\$2,098,741	\$7,766,481	\$489,889	\$8,256,370
AAC	-	-	-	-	\$5,912,633
AANB	-	-	-	-	\$2,343,737
AANB (Round)	-	-	-	-	\$2,344,000
BCR	-	-	-	-	1.4

Note: The cost and benefit values cover a 50-year period of analysis with a base year of 2022.
The Federal discount rate is 2.75%.

The recommended plan reflects information available at the time and current USACE policies governing formulation of coastal storm risk management projects. These recommendations may be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any such modifications and will be afforded the opportunity to comment further.

Date

David C. Park
Lieutenant Colonel, Corps of Engineers
District Commander

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