ENVIRONMENTAL AND CULTURAL APPENDIX

NEW JERSEY BACK BAYS COASTAL STORM RISK MANAGEMENT FEASIBILITY STUDY

PHILADELPHIA, PENNSYLVANIA

APPENDIX F

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NJBB
NEW JERSEY BACK BAYS STUDY

U.S. Army Corps of Engineers
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F-1) AFFECTED ENVIRONMENT

Land Use

Land use comprises the natural conditions and/or human-modified activities occurring at a particular location. Uses are identified first in general terms such as urban, wetland, agriculture, forest, water, and barren. From there, more specific classifications are derived within each land use category such as residential, commercial, industrial, recreational, forestland, cropland, etc. Further categorization can include density and intensity of land use. Federal and state laws, management plans, and zoning regulations determine the type and extent of land use allowable in specific areas and often intend to protect specially designed or environmentally sensitive areas. Zoning requirements are regulations developed by the local municipality to control potential future development. Comprehensive plans evaluate long-term demographic trends to identify how the region of analysis should be developed. Where zoning focuses on immediate trends in development, comprehensive plans are generally less regulatory in nature and often serve as guidance when current planning department is evaluating applications for development.

The entire study area falls within New Jersey's coastal zone, which is defined in N.J.A.C. 7:7, and provides rules for the NJDEP regarding the use and development of coastal resources that are reviewed by the Land Use Regulation Program in reviewing permit applications under the Coastal Area Facility Review Act (CAFRA), N.J.S.A. 13:19-1 et seq. (as amended 2016), Wetlands Act of 1970, N.J.S.A. 13:9A-1 et seq., Waterfront Development Law, N.J.S.A. 12:5-3, Water Quality Certification (401 of the Federal Clean Water Act), and Federal Consistency Determinations (307 of the Federal Coastal Zone Management Act).

The extent of the New Jersey coastal zone includes lands defined in 1. The Coastal Area Facility Review Act (CAFRA), N.J.S.A. 13:19-1 et seq.; 2. Coastal waters, which are any tidal waters of the State and all lands lying thereunder (Coastal waters of the State of New Jersey extend from the mean high water line out to the three geographical mile limit of the New Jersey territorial sea, and elsewhere to the interstate boundaries of the States of New York, and Delaware and the Commonwealth of Pennsylvania); 3. All lands outside of the coastal area as defined by CAFRA extending from the mean high water line of a tidal water body to the first paved public road, railroad or surveyable property line existing on September 26, 1980 generally parallel to the waterway, provided that the landward boundary of the upland area shall be no less than 100 feet and no more than 500 feet from the mean high water line; 4. All areas containing tidal wetlands; and 5. The Hackensack Meadowlands District as defined by N.J.S.A. 13:17-4.

The NJBB study area encompasses five coastal counties with a diverse array of land uses that are guided by comprehensive master plans for each county. With the exception of public lands, the beach communities along the coast including headland and barrier islands contain the most intense development in the upland areas consisting of residential (seasonal) homes, commercial – tourist oriented (amusement areas, marinas, and various smaller attractions and facilities), and some light industrial uses such as fishing related industry. In the coastal barrier complex areas, the mainland areas are generally separated by vast wetlands and open water bays. The mainland communities also include dense residential, commercial development, transportation, utilities services and some sporadic industrial development. Other land uses inland include woodland, farmland, and freshwater and tidal wetlands. Monmouth County is the northernmost county within the study area, which includes the beaches and coastal waters north of Manasquan Inlet, Shark River Inlet, and the Coastal Lakes Region of the study area. The Monmouth County Master Plan (Monmouth County Division of Planning, 2016) tracked land use changes between 1986 and

2012, and determined that the largest land use change was attributed to a growth in residential uses of 6.7% within that time period, which also saw a net decrease of 6.4% in agricultural land uses. Similar trends where urban lands (residential and commercial) saw net increases and agricultural lands saw net decreases were noted in Ocean County, Atlantic County and Cape May County. Ocean County experienced a 7.8% loss of farm land and a 7.7% gain in urban land from 2002 to 2007 (Ocean County Planning Board, 2011), and Atlantic County likewise lost 6.4% of agricultural land and 42.6% of barren land with a net gain of 14% of urban land from 2002 to 2012 (Heyer, Gruel & Associates, 2018). Recognizing the importance of farmlands and open space, all of the county comprehensive plans include goals to preserve farmlands and to acquire more open space for the communities.

Protected Lands in the Study Area

National Wildlife Refuges

The largest and most significant protected lands in the study area include E.B. Forsythe National Wildlife Refuge and Cape May National Wildlife Refuge. The E.B. Forsythe National Wildlife Refuge encompasses approximately 47,000 acres in two divisions (Brigantine Division and Barnegat Division) that are distributed in a patchwork along more than 50 miles of the coast in Atlantic, Burlington, and Ocean Counties. Approximately 82 percent of the refuge consists of wetlands, of which 78 percent is saltmarsh interspersed with shallow coves and bays. The wetlands include three large impoundments of freshwater and brackish marsh habitat totaling approximately 1,490 acres. The impoundments allow intensive water level management to enhance the habitat value for waterfowl, shorebirds, and wading birds. The remaining 18 percent of the refuge is upland, of which approximately 5,000 acres are forested, and 2,000 acres are a mix of grasslands, beaches and dunes. The refuge includes two undeveloped barrier island beaches, the Holgate Unit, which consists of the lower 3.5-mile end of Long Beach Island, and Little Beach Island. Little Beach Island is an important nesting area for the federally threatened piping plover with 23 nesting pairs using the area in 2013. Both of these coastal barrier areas, along with a pristine section of saltmarsh on the West side of Great Bay, have been designated a National Wilderness Area.

The Cape May National Wildlife Refuge encompasses approximately 11,800 acres within the Cape May Peninsula. It is divided into three main divisions: Great Cedar Swamp Division, Delaware Bay Division, and the Two-Mile Beach Unit. The Great Cedar Swamp Division includes approximately 6,000 acres of primarily moist woodlands and thickets located in the Peninsula’s interior. This Division receives limited tidal flow on the north end from Great Egg Harbor and on the south end from Dennis Creek. The Delaware Bay Division includes approximately 5,000 acres of mixed wooded uplands, tidal marsh, and beach habitat that extends for 5 miles along the Delaware Bay shoreline. The Two-Mile Beach Unit consists of approximately 800 acres bordering a 0.7-mile long section of ocean fronting beach just north of the Cape May Inlet.

The Two-Mile Beach Unit is important to shorebirds which stop here in large numbers during their spring and fall migrations. In addition to the abundant shorebirds, the Cape May Peninsula’s configuration and strategic location act to concentrate large numbers of songbirds, raptors, and woodcock as these birds funnel down to Cape May Point during the fall migration.

Parks and Wildlife Management Areas

Other protected areas found within the study area include: Corson's Inlet State Park, Cape May Point State Park, The Nature Conservancy's South Cape May Meadows Nature Preserve, Island Beach State Park, Barnegat State Park, Great Bay Boulevard State Wildlife Management Area, Manahawkin Wildlife Management Area, and numerous county and municipal parklands.

Natural Areas

There are several state natural areas designated under N.J.A.C. 7:5A within the NJBB Study Area. Natural Areas receive an exceptional degree of protection. Lands in the Natural Areas system may not be sold, leased or exchanged, and they may not be altered in any way without the approval of the NJDEP. When an area becomes part of the Natural Areas System, the NJDEP is required to develop and adopt a comprehensive management plan to ensure the continued protection of the ecosystems and species found within the area. The Natural Areas Council, a seven-member board appointed by the governor, advises the Commissioner on all matters relating to the System. The Natural Areas System Rules at N.J.A.C. 7:5A provide detailed procedures for classification and designation of natural areas, development of management plans, allowable uses and practices, procedures for conducting research and scientific activities, and revising boundaries (https://www.state.nj.us/dep/parksandforests/natural /natareas.html accessed on 1/2/2019). State Natural Areas within the NJBB Study Area are presented in Table 1.

Table 1: State Natural Areas within NJBB Study Area

Natural Area	Location	Management	Classification	Agency
Cape May Point Natural Area	Cape May Point State Park, Cape May Point Borough and Lower Township (Cape May County)	Preservation of freshwater marsh behind a coastal dune, habitat diversity for migratory birds, and rare species habitat.	Conservation Preserve	Division of Parks and Forestry – Cape May Point State Park
Cape May Wetlands Natural Area	Avalon Borough, Dennis and Middle Townships (Cape May County)	Preservation of tidal salt marsh ecosystem and rare species habitat	Ecological Reserve	NJDEP DFW – Cape May Coastal Wetlands Wildlife Management Area
Strathmere Natural Area	Corson's Inlet State Park, Upper Twp. (Cape May County)	Preservation of a dune habitat, plant community associations, and rare species habitat.	Conservation Preserve	Division of Parks and Forestry – Belleplain State Forest
North Brigantine Natural Area	City of Brigantine (Atlantic County)	Preservation of saltmarsh habitat, coastal dune, and rare species habitat.	Conservation Preserve	Division of Parks and Forestry – Bass River State Forest
Great Bay Natural Area	Little Egg Harbor Township (Ocean County)	Preservation of tidal salt marsh ecosystem and rare species habitat	Ecological Reserve	NJDEP DFW – Assunpink Wildlife Management Area
Manahawkin Natural Area	Manahawkin Wildlife Management Area, Stafford Twp. (Ocean County)	Preservation of mature bottomland hardwood forest, and rare species habitat.	Ecological Reserve	NJDEP DFW – Assunpink Wildlife Management Area
Island Beach Northern and Southern Natural Areas	Island Beach State Park (IBSP), Ocean and Berkeley Twp. (Ocean County)	Preservation of barrier island dune system, saltwater marsh, freshwater bogs, and rare species habitat.	Conservation preserve.	Division of Parks and Forestry – IBSP.

Natural Area	Location	Management	Classification	Agency
Swan Point Natural Area	Brick Twp. (Ocean County)	Preservation of tidal salt marsh ecosystem and Atlantic white cedar swamp.	Ecological Reserve	Division of Parks and Forestry – Island Beach State Park

National Reserves

New Jersey Pinelands

Portions of the NJBB study area fall within the Federal Pinelands National Reserve (PNR), which was created by the National Parks and Recreation Act of 1978. The PNR is approximately 1.1 million acres within 7 counties in New Jersey occupying 22% of New Jersey's land area. The reserve is a United States Biosphere Reserve, and is home to dozens of rare plant and animal species and the Kirkwood-Cohansey aquifer system, which contains an estimated 17 trillion gallons of water. Under this act, the Federal government formed a partnership with the State of New Jersey to form the Pinelands Commission (PC), as an independent agency, whose mission is to "preserve, protect and enhance the natural and cultural resources of the Pinelands National Reserve, and to encourage compatible economic and other human activities consistent with that purpose". The PC implements a Comprehensive Management Plan (CMP) that guides land use, development and natural resource protection programs in a 938,000-acre "Pinelands Area" of southern New Jersey. This results in two separate, but mostly overlapping boundaries between the Federal PNR and the state "Pinelands Area" (Figure 1). The Federal PNR, totaling 1.1 million acres, includes land east of the Garden State Parkway (including portions of the NJBB study area) and to the south bordering Delaware Bay, which is omitted from the state Pinelands Area (https://www.nj.gov/pinelands/reserve/; https://www.nps.gov/pine/index.htm; and https://www.nj.gov/pinelands/about/ accessed on 12/31/2018). In Cape May County, the PNR boundary (yellow line in Figure 1) is on the western side of the NJBB study area along the Garden State Parkway where the boundary turns further west at the Great Egg Harbor Bay along western Somers Point. Large portions of the NJBB study area are included within the PNR from north of Absecon Bay and the western side of Brigantine north through Little Egg Harbor Inlet, Little Egg Harbor, large portions of Barnegat Bay, Barnegat Inlet, and Island Beach State Park. The Pinelands Area (white line on Figure 1) that is governed by the Pinelands CMP and under the jurisdiction of the Pinelands Commission is outside of the NJBB study area.

Jacques Cousteau National Estuarine Research Reserve

The Jacques Cousteau National Estuarine Research Reserve (JC NERR) is part of the National Estuarine Research Reserve System (NERRS) developed to protect the biologically, ecologically, economically, and aesthetically important estuarine areas along the coasts. It is one of the 2 national estuarine reserves created to promote the responsible use and management of the nation's estuaries through a program combining scientific research, education, and stewardship. The JC NERR encompasses approximately 116,000 acres in southeastern New Jersey, including a great variety of terrestrial, wetland and aquatic habitats within the Mullica River-Great Bay ecosystem (retrieved from https://jcnerr.org/about.html on 1/25/2019).

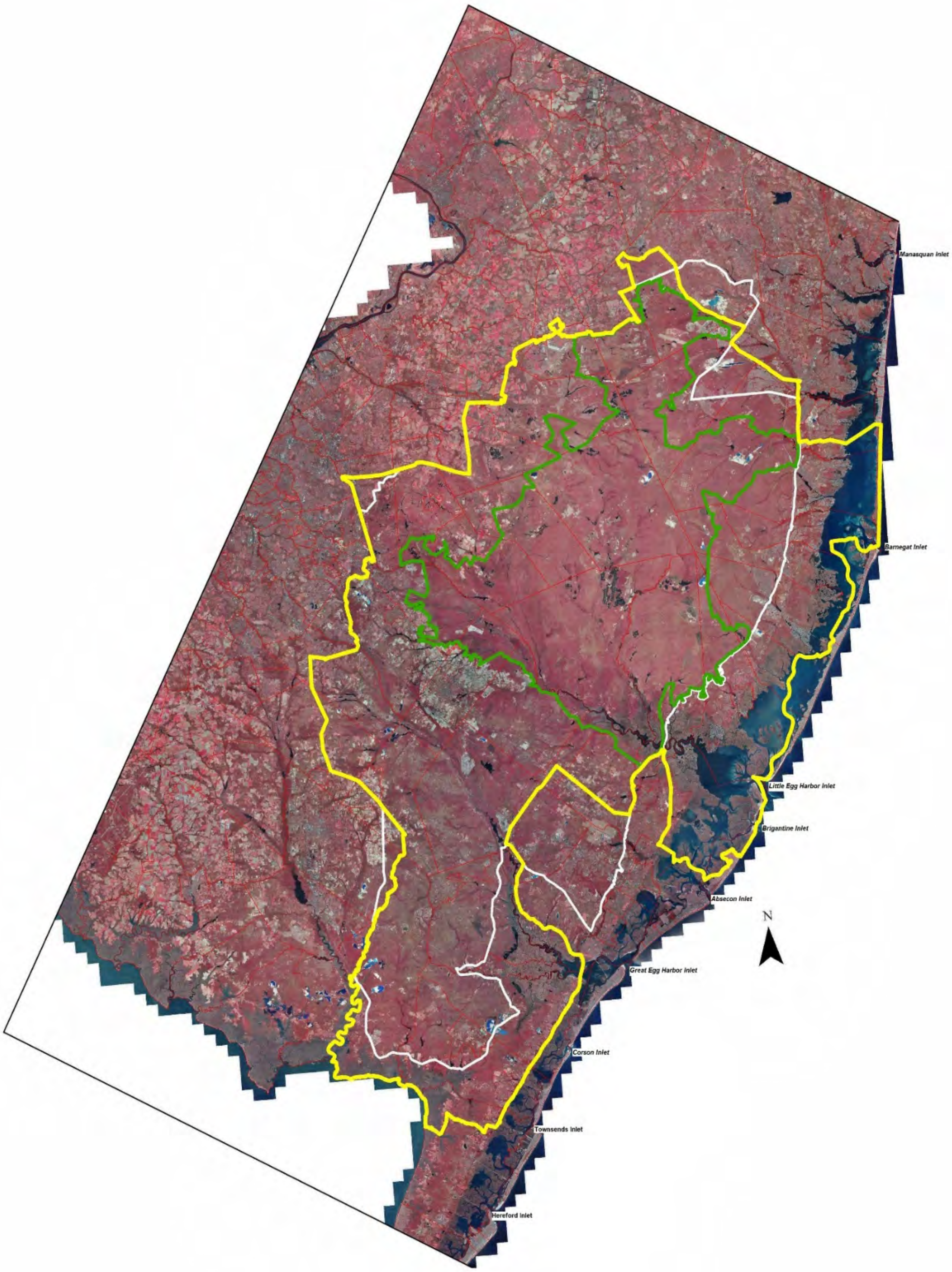

Figure 1: Pinelands National Reserve Boundary (Source: NJDEP)

Wild and Scenic Rivers

The National Wild and Scenic Rivers System was created by Congress in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection. The Great Egg Harbor River is located within the NJBB study area, and was designated as a Wild and Scenic River in October 27, 1992. In the NJBB study area, Wild and Scenic River status of the Great Egg Harbor River and tributaries are generally west of the Garden State Parkway. Key drainages that are part of the system include Patcong Creek and the Tuckahoe River at near the confluence west of the Garden State Parkway.

National Estuary Programs

The Barnegat Bay Program (BBP) is one of 28 national estuary programs administered by the Environmental Protection Agency program to protect and restore the water quality and ecological integrity of estuaries of national significance. The BBP is guided by the Comprehensive Conservation and Management Plan (CCMP) that focuses on four priority areas: water quality, water supply, living resources, and land use. For each priority, the plan will specify one or more goals, several objectives, and multiple actions to achieve those objectives.

Floodplains

<u>Executive Order 11988 – Floodplain Management</u>

Through Executive Order (EO) 11988, Federal agencies are required to evaluate all proposed actions within the 1% annual chance (100-year) floodplain. Actions include any Federal activity involving 1) acquiring, managing, and disposing of Federal land and facilities, 2) providing Federally undertaken, financed, or assisted construction and improvements, and 3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, and licensing activities. In addition, the 0.2% annual chance (500-year) floodplain should be evaluated for critical actions or facilities, such as storage of hazardous materials or construction of a hospital. The EO provides an eight-step process to evaluate activities in the floodplain that generally includes 1) determine if the proposed action is in the floodplain, 2) provide public review, 3) identify and evaluate practicable alternatives to locating in the 1% annual chance floodplain, 4) identify the impacts of the proposed action, 5) minimize threats to life and property and to natural and beneficial floodplain values and restore and preserve natural and beneficial floodplain values, 6) reevaluate alternatives, 7) issue findings and a public explanation, and 8) implement the action. Proposed actions may have limited impacts such that the eight-step process may vary or be reduced in application, which is the case for this project.

<u>USACE Engineering Regulation 1165-2-26 – Implementation of Executive Order 11988 on Floodplain Management</u>

This regulation sets forth general policy and guidance for USACE implementation of Executive Order 11988 as it pertains to the planning, design, and construction of Civil Works projects and activities under the Operation and Maintenance and Real Estate Programs.

Section 202 (c) of Water Resources Development Act of 1996

Section 202(c) provides that before the construction of any project for local flood damage reduction or hurricane or storm damage reduction that involves assistance from the Secretary of the Army, the non-Federal interest must agree to participate in and comply with applicable Federal floodplain management and flood insurance programs. It also requires non-Federal interests to prepare a Floodplain Management Plan designed to reduce the impacts of future flood events in the project area within one year of signing a Project Cooperation Agreement and to implement the Plan not later than one year after completion of construction of the project.

More specifically, Section 202 (c) requires that the non-Federal interest shall prepare a Plan designed to reduce the impacts of future flooding in the project area. It should be based on post-project floodplain conditions. The primary focus of the Plan should be to address potential measures, practices and policies which will reduce the impacts of future residual flooding, help preserve levels of protection provided by the USACE project and preserve and enhance natural floodplain values. In addition, the Plan should address the risk of future flood damages to structures within the post-project floodplain and internal drainage issues related to USACE levee/floodwall projects. Since actions within the floodplain upstream and downstream from the project area can affect the performance of a USACE project, the Plan developed by the non-Federal sponsor should not be limited to addressing measures solely within the immediate project boundaries.

Existing Conditions of Floodplains

CLIMATE

Southern New Jersey has a relatively mild climate, due to the influence of the Atlantic Ocean and the Gulf Stream, which results in longer summers and milder winters than areas further inland. The mean annual temperature ranges from about 45 to 53 degrees Fahrenheit (°F) depending on location. Average annual precipitation ranges from approximately 41 to 50 inches depending on location.

Storm-related floods are often a result of tropical cyclones moving up the Atlantic coast. Past history of flooding in the study area demonstrates that flooding can occur during any season of the year. Most serious tidal flooding problems are attributed to hurricanes, which occur during the late summer and early autumn. In addition to heavy precipitation, hurricanes produce high tides and strong waves, which can result in severe damage to coastal areas. Although extratropical cyclones, referred to as northeasters, can develop at almost any time of the year, they are more likely to occur during the winter and spring. Thunderstorms are a common occurrence during the summer months.

FLOOD EVENTS and CSRM EFFORTS

The highest recorded water level at Atlantic City was 6.4 feet NAVD88, recorded during the December 1992 Northeaster. (8.98 feet MLLW). The water level during Hurricane Sandy was 6.18 feet NAVD88 (8.76 feet MLLW).

The highest recorded water level at Ocean City was 9.95 feet (MLLW), recorded during the December 1992 Northeaster. The water level during Hurricane Sandy was 9.31 feet (MLLW).

The highest recorded water level at Barnegat Bay was 6.38 feet (MLLW), recorded during Hurricane Sandy. The water level during the December 1992 Northeaster was 6.10 feet (MLLW).

In the study area, there are approximately 183,000 structures with over $90 billion in damageable assets, critical infrastructure, and utilities. These structures are located in 84 separate municipalities across five counties. Of the total structures, approximately 95% are classified as residential structures. The other 5% are classified as non-high rise commercial, industrial or public facilities.

In terms of past flood damages, Hurricane Sandy in 2012 had the largest impact to the study area. Within the five New Jersey counties included in the study area, more than 260,000 people and 190,000 structures were exposed to the storm. The result was over 135,000 damaged structures and $4.5 Billion in total damages.

FEMA defined Flood Zones are predominantly high risk areas, designated by Zone AE, along the inland side of the barrier islands and the upland side of the bays. Base Flood Elevations associated with the AE Zones generally range from about 5 to 12 feet NAVD88. There are several high risk coastal areas that carry an additional hazard associated with storm waves, designated by Zone VE, which vary greatly in location and severity. Base Flood Elevations associated with the VE Zones generally range from 9 to 16 feet NAVD88 but go as high as 29 feet NAVD88.

More frequent flood events were analyzed for structure counts due to the high number of structures in the study area. There are approximately 31,000 structures below the elevation of the 5% Annual Chance of Exceedance (ACE) flood event as defined by the North Atlantic Coast Comprehensive Study (NACCS). For the 10% ACE and 20% ACE, the number of structures is about 17,000 and 8,000 respectively.

Land elevations vary greatly throughout the study area. Generally, developed areas in the southern portion of the project area are on lands below 20-feet NAVD88. In these areas, the inland side of the barrier islands is generally at or below about 10-feet NAVD88 and the upland side of the bay is generally at or below about 20-feet NAVD88. The same is generally true in the northern portion of the project area, but there are more developed lands in the 20 to 30-feet NAVD88 range.

As of September 2018, there were the following flood insurance policies in effect for each of the five counties in the study area: 28,526 active policies in Atlantic County; 3,713 active policies in Burlington County; 53,584 active policies in Cape May County; 19,214 active policies in Monmouth County; 50,464 active policies in Ocean County; 155,501 total active policies in the five counties. From 1978 through the end of September 2018, there were the following total payments on flood claims for each of the five counties in the study area: $484.8M in Atlantic County; $25.1M in Burlington County; $414.2M in Cape May County; $929.6M in Monmouth County; $2.6B in Ocean County; and $4.4B total claims paid in the five counties.

As of October 3, 2016, there were 6,402 properties identified as Repetitive Loss (RL) properties in the five county, 84 municipality study area. As defined by FEMA, a Repetitive Loss property is any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling ten-year period, since 1978. A Repetitive Loss property may or may not be currently insured by the NFIP. In addition, there were 358 recognized Severe Repetitive Loss structures. Severe Repetitive Loss is defined as a residential property that is covered under an NFIP flood insurance policy and:

(a) That has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or

(b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

Considering FEMA's Flood Insurance Rate Maps mainly depict tidal flooding, some Repetitive Loss areas may include damage associated only with rainfall flooding and/or combined tidal and rainfall flooding. Thus, some Repetitive/Severe Repetitive Loss properties may be located beyond or outside the designated FEMA 1% annual chance floodplain.

Of the 84 communities in the study area, 52 participate in FEMA's Community Rating System (CRS). By being proactive in flood mitigation activities such as public information, mapping and regulation, flood damage reduction, and flood preparedness, flood insurance policy holders in CRS communities are able to receive insurance premium discounts. FEMA encourages communities to participate and help prevent loss of life and reduce flood damage.

There are past construction activities in the five county study area undertaken by State or Federal entities that may be considered Coastal Storm Risk Management (CSRM) measures: Ocean Gate CSRM, Sedge Island Protection CSRM, Avalon-Stone Harbor Living Shoreline CSRM, Wildwood CSRM, Wildwood Crest CSRM, Middle CSRM, Galloway CSRM, Port Republic CSRM, Berkeley CSRM, and Manasquan CSRM. In some cases, these may have resulted in credit for CRS communities. In addition, there are numerous on-going studies that may lead to additional flood protection measures in the future.

Environmentally, flooding (either fluvial or tidal) can have beneficial effects on riparian and wetland ecosystems where nutrients and sediments are supplied by floodwaters to the floodplains and associated wetlands, which can enrich the fertility of the soils for human agricultural uses along with beneficial effects on fish and wildlife habitats. However, flooding can also be detrimental by increasing the amount of pollutants that enter the various water bodies, on a short and/or long term basis, which could be unsafe for people, animals, and plants. As flood levels increase, more surface area is impacted and pollutants are carried away, such as oil and gas from road pavement, sediment, pesticides, fertilizer, etc. Long duration events, such as nor'easters where tidal and rainfall flooding may occur, can aggravate the situation. In addition, many sanitary sewer pipelines can be taxed from floodwaters entering from manholes, underground seepage, or pump failure, where the floodwaters can be contaminated.

Geology and Soils

Geology

Geomorphology

The study area is situated along the New Jersey coast, which is located within the New Jersey section of the Coastal Plain Physiographic Province of Eastern North America. In New Jersey, the Coastal Plain Province extends from the southern terminus of the Piedmont Physiographic Province southeastward for approximately 155 miles to the edge of the Continental Shelf. The boundary between the rock units of the Piedmont and unconsolidated sediments of the Coastal Plain Physiographic Provinces is known as the Fall Line, which extends southwest across the state from Perth Amboy through Princeton Junction to Trenton. It is termed the Fall Line due to its linearity and the distinct elevation change that occurs across this border between the more rugged, generally higher rock terrain of the Piedmont and generally lower terrain of the soil materials comprising the Coastal Plain. The locations of the Physiographic Provinces in New Jersey and Fall Line are shown on Figure 2.

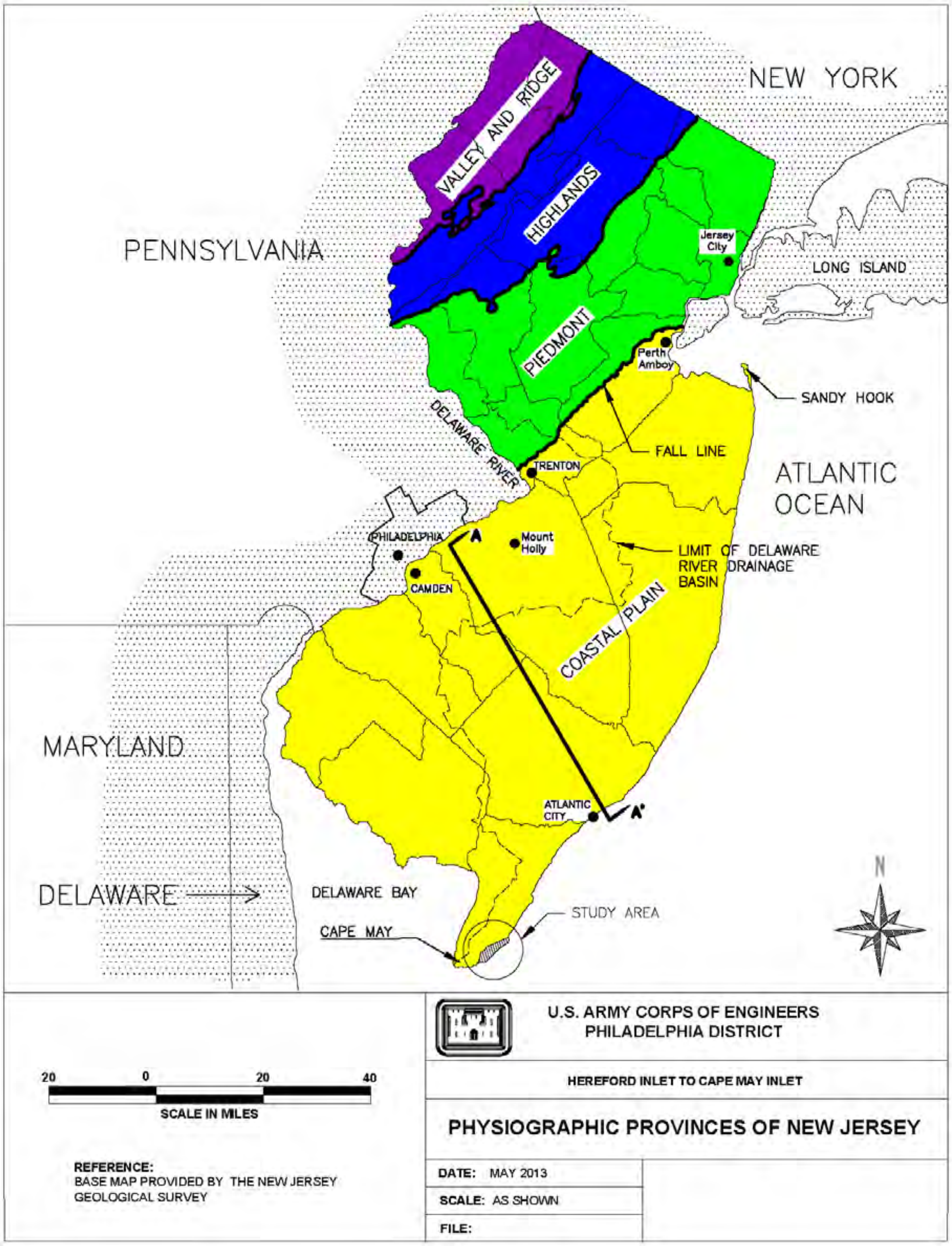

Figure 2: Physiographic Provinces of New Jersey

The Coastal Plain Province, lying southeast of the Fall Line, is part of the Atlantic Coastal Plain that extends along the entire eastern Atlantic Ocean coastline from Newfoundland to Florida. The Coastal Plain is the largest physiographic province in the state and covers approximately sixty percent of the surface area of New Jersey. This province encompasses an area of approximately 4,667 square miles, almost 3 million acres. More than half of the land area in the Coastal Plain is below an elevation of 50 feet above sea level (NGVD). The terrestrial portion of the Coastal Plain Province is bounded on the west and southwest by the Delaware River and Delaware Bay, on the north by the Fall Line and on the northeast by the Raritan Bay and Staten Island. The remaining portions of the Coastal Plain Province in New Jersey are bordered by the Atlantic Ocean. The Atlantic Coastal Plain has been further differentiated into the Inner and Outer Coastal Plain regions. The Inner Coastal Plain consists of lowlands and rolling hills underlain by Cretaceous deposits and is border to the north by the Piedmont Province. The Outer Coastal Plain is a region of low altitude where low-relief terraces are bounded by subtle erosional scarps, and consists of the unconsolidated Tertiary deposits of sand, silt and gravels. The eastern boundary of the Coastal Plain includes many barrier bars, bays, estuaries, marshes and meadowlands along the Atlantic coast extending from Sandy Hook in the north to Cape May Point at the southern tip of New Jersey.

Physiography

The New Jersey shoreline, which is included in the Coastal Lowlands can be divided into those sections where the sea meets the mainland, at the northern and extreme southern ends of the State, and where the sea meets the barrier islands, in the central to southern portion of the State. The Coastal Lowlands include as many as three scarp-bounded terraces, which are underlain by marine and estuarine deposits. The outer margin of the terraces are surrounded by the tidal marshes, bays and the barrier islands. The barrier islands extend from Bay Head, down the coast for approximately 90 miles, to just north of Cape May Inlet and are generally continuous, except for the interruption by 10 inlets.

Barrier Islands

The New Jersey barrier islands, which include the study area, belong to a land form susceptible to comparatively rapid changes. The barrier islands range in width from around 1000 feet to 5,000 feet. Landward of the barrier beaches and inlets along the barrier islands are tidal bays, which range from 1 to 4 miles in width. These bays have been filled by natural processes until much of their area has been covered with tidal marshes. The remaining water area landward of the barrier islands consists of smaller bays connected by water courses called thorofares. Four geologic processes are considered to be responsible for the detritus (or loose material) in the bay area: (1) stream sedimentation, which contributes a small amount of upland material; (2) waves washing over the barrier islands during storms; (3) direct wind action blowing beach and dune sand into the lagoon; and (4) the work of tidal currents, which normally bring in more sediments in suspension from the ocean on flood tide than they remove on ebb tide. The vegetation of the lagoons, both in marshland and bays, serves to trap and retain the sediments.

Drainage of the Coastal Plain

The land surface in the Coastal Plain of New Jersey is divided into drainage basins, based on the area that contributes runoff to streams and their tributaries in a particular region. A drainage divide marks the topographic boundary between adjacent drainage basins. A major drainage divide in the Coastal Plain separates streams flowing to the Delaware River on the west and to the Atlantic Ocean on the east and southeast.

The surficial drainage system of the New Jersey Coastal Plain was developed at a time when sea level was lower than at present. The subsequent rise in sea level has drowned the mouth of coastal streams where tidal action takes place. This tidal effect extends up the Delaware River to Trenton, New Jersey, a distance of 139 miles. The formation of the barrier islands removed all direct stream connection with the ocean between Barnegat Bay and Cape May Inlet. These streams now flow into the lagoons formed in the back of these barrier beaches and their waters reach the Atlantic Ocean by way of the thorofares and inlets, discussed above. The significance of these features to the drainage system in the study area is that the Coastal Plain streams, whose upper courses carry little sediment, lose that little sediment in their estuaries, and in the lagoons, and supply virtually no beach nourishment to the ocean front areas.

The material present within the coastal lagoons and tidal marshes consists primarily of alluvium, and salt-marsh deposits. The alluvium, which was deposited was derived from weathered upland soils of the Bridgeton and Cohansey Formations, consists of gray and brown sand, silt, pebble gravel, cobbles, minor peat and shells. The salt-marsh deposits, which are comprised of organic muck and peat, silt clay and sand. Black, brown and gray organic muck includes remains of salt-tolerant grasses. Silt and sand occur as deposits along tidal creek margins. These salt-marsh deposits were deposited largely as suspended sediment in turbid bays or rivers during high tides.

Regional Geology

The New Jersey Coastal Plain Physiographic Province consists of sedimentary formations overlying crystalline bedrock known as the "basement complex." From well drilling logs, it is known that the basement surface slopes at about 155 feet per mile to a depth of more than 5,000 to 6,000 feet near the coast. Geophysical investigations have corroborated well-log findings and have permitted determination of the profile seaward to the edge of the continental shelf. A short distance offshore, the basement surface drops abruptly but rises again gradually near the edge of the continental shelf. Overlying the basement are semi-consolidated sedimentary formations of Lower to Middle Cretaceous sediments. The beds vary greatly in thickness, increasing seaward to a maximum thickness of 2.5 miles then decreasing to 1.5 miles near the edge of the continental shelf. On top of the semi-consolidated beds lie unconsolidated sediments of Upper Cretaceous and Tertiary formations. These sediments range from relatively thin beds along the northwestern margin at the Fall Line, to around 4,500 feet beneath Atlantic City to over 40,000 feet in the area of the Baltimore Canyon Trough located around 50 miles offshore of Atlantic City.

Based on information provided by the New Jersey Geological Survey (NJGS) and United States Geological Survey (USGS), the wedge shaped mass of unconsolidated sediments that comprise the New Jersey Coastal Plain discussed above are composed of sand, gravel, silt and clay. The wedge thins to a featheredge along the Fall Line and attains a thickness of over 6,500 feet in the southern part of Cape May County, New Jersey. The system is comprised of relatively highly permeable sand and gravel layers separated by semi-permeable to impermeable silt and clay interlayers that form confining layers and restrict the vertical flow of groundwater. These sediments range in age from Cretaceous to Upper Tertiary (i.e. Miocene - 144 to 5 Ma) (Ma = mega annum = million years ago), and can be classified as continental, coastal or marine deposits. The Cretaceous and Tertiary age sediments generally strike on a northeast-southwest direction and dip gently to the southeast from ten to sixty feet per mile. The Coastal Plain is mantled by discontinuous deposits of Late Tertiary to Quaternary (geologically recent) sediments, which, where present are basically flat lying. The unconsolidated Coastal Plain deposits, are unconformably underlain by a Pre-Cretaceous crystalline basement bedrock complex, which consists primarily of Precambrian and early Paleozoic age (>540 Ma to 400 Ma) rocks. Locally, along the Fall Line in Mercer and Middlesex Counties, Triassic age (circa 225 Ma) rocks overlie the crystalline basement rocks and underlie the unconsolidated sediments.

Surficial Geology

As indicated above, the Coastal Plain of New Jersey consists of beds of gravel, sand, silt and clay, which dip gently towards the southeast. Fossil evidence indicates that these sediments range from the Cretaceous to Quaternary Period, with some more recent glacial period Quaternary sediments mantling the surface. The older and lower layers outcrop at the surface along the northwest margin of the Coastal Plain and pass beneath successively younger strata in the direction of their dip. Since the formations dip toward the southeast, this results in a series of successive generally parallel outcrops with a northeast-southwest strike, with successively younger layers outcropping at the surface towards the southeast and progressing southward along the shore.

The sea successfully advanced and retreated across the 155 mile width of the Coastal Plain during the Cretaceous through Quaternary Periods (144 Ma to present). Many sedimentary formations were deposited, exposed to erosion, submerged again and buried by younger sediments. The types of sorting, the stratification, and the fossil types in the deposits indicate that deposition took place offshore as well as in lagoons and estuaries, and on beaches and bars. Considerable changes in sea level continued to take place during Pleistocene time. Glacial periods brought a lowering in sea level as water was locked up in the large terrestrial ice masses. As the sea level fell to a beach line thousands of feet seaward of the present shoreline, Pleistocene sediments were deposited in valleys cut into older formations.

Between Bay Head and Cape May City, the coastal lagoons, tidal marshes and barrier beaches that fringe the coast have contributed to the sands of the present beaches. During Quaternary time, changes in sea level caused the streams alternately to spread deposits of sand and gravel along drainage outlets and later to remove, rework, and redeposit the material over considerable areas, concealing earlier marine formations. One of these, the Cape May Formation consisting largely of sand and gravel, was deposited during the last interglacial stage, when the sea level stood 33 to 46 feet higher than at present. The material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shoreline. In most places along the New Jersey coast, there is a capping of a few feet of Cape May Formation. This capping is of irregular thickness and distribution, but generally forms a terrace about 25 to 35 feet above sea level. The barrier beaches, being of relatively recent origin, are generally composed of the same material as that found on the offshore bottom.

Borrow Material for Berm Construction

Several offshore borrow areas are currently in use off the coast of New Jersey for beach nourishment and dune construction. Additional borrow areas have been studied but not permitted. Some borrow areas are located in inlets while others can be up to 7 miles off shore. Although most of these areas could be used for material for the project, only the near shore and inlet areas would be practical for use due to the distances and logistics involved.

There are numerous Confined Disposal Facilities (CDFs) along the back bay and New Jersey Intercoastal Waterway that have been used during past dredging events. These facilities are on a mix of federal, state, and local land. These CDFs contain sand, silt, and clay, however no complete inventory of them exists.

There are numerous quarries throughout the area that would be able to provide sand or other fill material by either truck, rail, or barge.

Soils

The soils within the study area are varied, ranging from deep fertile soils to droughty infertile soils with little humus or organic material present to organic tidal marshes, urban lands, and barrier island beach sands. In Monmouth County, the Natural Resources Conservation Service (NRCS) features 43 agronomic soil series and 114 types or subtypes. Soils associations encountered within the study area include the Klej-Galestown-Evesboro-Downer, Lakewood-Lakehurst-Evesboro-Atsion and Hooksan-Psamments-Udorthents along the coast. The NRCS recognizes 32 soil series, with 85 types or subtypes in Ocean County (USDA 1980). According to the Ocean County Soil Survey (1980), the dominant soil associations for the project area includes the Downer-Evesboro and Sulfaquents-Sulfihemists associations. The Downer-Evesboro association consists of well-drained and excessively drained, loamy and sandy soils on uplands that are nearly level and gently sloping. The Sulfaquents-Sulfihemists association consists of poorly drained, mineral and organic soils on tidal flats and marshes that are nearly level. Based on the project location within the Atlantic Coastal Plain province, fine to- medium sands from barrier formation processes or the underlying coastal plain are assumed to underlie the marsh deposits. Subsurface investigations performed in the area of the Barnegat Inlet South Jetty by USACE support this assumption. These subsurface investigations indicate that the area is underlain by fine-to-medium, dense-to-very dense sands with a layer of low density silts 4 to 6 feet thick at depths from 20 to 24 feet below ground surface. (CH2M Hill 1997).

The southeast corner of Burlington County is within the study area that includes outer coastal plain soils within the lower Mullica River watershed composed predominantly of the Downer-Sassafras-Woodstown association, which are mostly sandy loams and fine sandy loam subsoils and the Tidal Marsh association composed of organic silts subjected to daily flooding.

In Atlantic County, dominant soils within the study area are composed of the Appoquinimink-Transquaking-Mispillion (ATM)-Psamments-Hooksan-Urban Association, which contains nearly level, poorly drained tidal flats; nearly level excessively drained sandy fill land; and nearly level or gently sloping, excessively drained coastal beaches. The ATM soil series is located in areas near sea-level that are flooded twice daily by tidal waters and occupies about 16% of Atlantic County soil types. Psamments are located where several feet of sandy fill was placed on top of ATM soils to create developable land. Hooksan-Urban soils are located along the barrier beaches and includes areas that have been highly urbanized (Heyer, Gruel & Assoc., 2018).

In Cape May County, the barrier islands are composed of the heavily developed Coastal-Urban (CU) soil association and other fill lands (FL/FM) from tidal marshes converted to uplands. The tidal wetlands in the back bay marsh areas are Tidal Marsh (TM) association of various thicknesses of organic matter. Further inland and west, the dominant soil associations are the Downer-Sassafras-Fort Mott Association and Hammonton-Woodstown-Klej Association, which are high and intermediate landscape sandy loams and loamy sand soils found along the Garden State Parkway. A list of dominant soil associations within and near the study area are presented in Table 2.

Table 2: Dominant Soil Associations within New Jersey Back Bay Areas

Soil Association	County	Properties
Downer-Sassafras-Fort Mott	Cape May	Well-drained sandy loams or loamy sands in high landscape positions.
Downer-Hammonton-Sassafras	Atlantic	Nearly level or gently sloping, well drained to somewhat poorly drained soils that have a loamy subsoil in high or intermediate landscape positions.
Downer-Evesboro	Ocean	Nearly level and gently sloping, well drained and excessively drained, loamy and sandy soils on uplands on broad, high and intermediate landscape positions.
Manahawkin-Atsion-Berryland	Ocean	Nearly level, very poorly drained and poorly drained, organic and sandy soils on lowlands.
Hammonton-Woodstown-Klej	Cape May	Nearly level, moderately well-drained and somewhat poorly drained soils that have dominantly loamy subsoil and a sandy substratum in intermediate landscape positions.
Sassafras-Aura-Woodstown	Atlantic	Nearly level or gently sloping, well drained and moderately well drained soils that have a loamy subsoil in high to intermediate landscape positions.
Sassafras-Downer-Woodstown	Monmouth, Burlington	Nearly level to steep, deep, well drained and moderately well drained, loamy soils; on uplands.
Klej-Lakehurst-Evesboro	Atlantic	Nearly level to gently sloping, excessively drained to somewhat poorly drained soils that have a sandy sub-soil in high to intermediate landscape positions.
Pocomoke-Muck	Cape May	Nearly level, very poorly drained soils that have a loamy subsoil and a sandy substratum and soils that are organic throughout in low landscape positions.
Atsion-Muck-Pocomoke	Atlantic, Burlington,	Nearly level, poorly drained soils that have a sandy or loamy subsoil, and organic soils underlain mainly by sand that are organic throughout in low landscape positions.
Tidal Marsh	Cape May, Atlantic, Burlington	Nearly level, very poorly drained silty or mucky tidal flats that are subject to daily flooding.

Soil Association	County	Properties
Sulfaquents-Sulfihemists and Hooksan	Ocean, Monmouth	Nearly level, poorly drained, mineral and organic soils on tidal flats and sand dunes and beaches (Hooksan).
Coastal beach- Urban Land	Cape May, Atlantic	Nearly level to strongly sloping barrier beaches and areas developed for residential and commercial uses.
Urban land-Fripp	Ocean	Urban land on nearly level and gently sloping excessively drained sandy soils; beaches on the barrier islands

NJBB Watersheds

The New Jersey Back Bays are part of the New Jersey Atlantic Coast Water Region (Figure 3), which are heavily influenced by the freshwater inputs from a number of major river systems and smaller tributaries often originating as headwaters in the New Jersey Pinelands. These freshwater tributaries generally enter from the west where they meet tidally influenced polyhaline waters from the Atlantic Ocean that enter through the coastal inlets. The back bays are generally semi-enclosed estuaries bounded by the barrier islands and/or adjacent headlands. Five major watershed management areas (WMA) form the Atlantic Coast Water Region, however, the NJDEP now assesses water quality in individual subwatersheds as Assessment Units (AU's) at the USGS HUC 14 level. The northernmost area in the study area is Monmouth (WMA 12), which includes the Atlantic Ocean and inland bays along with two major river systems that are not in the NJBB study area: the Navesink River and Shrewsbury River. Within the NJBB study area, this area includes the Shark River and Manasquan River systems, which are connected to the Atlantic Ocean through the Shark River Inlet and Manasquan Inlet, respectively.

The Barnegat Bay Watershed Management Area (WMA 13) is very large and contains an estuarine drainage of 3,500 square kilometers (1,350 square miles), a surface area of 167 square kilometers (64 square miles), and a volume of 238 million cubic meters. This system includes Barnegat Bay and Little Egg Harbor Bay that form shallow lagoon estuaries that are fed by numerous streams including (from north to south): Metedeconk River, Kettle Creek, Toms River, Cedar Creek, Forked River, Oyster Creek, Manahawkin Creek, Mill Creek, and Tuckerton Creek. These rivers and streams provide freshwater influxes from the New Jersey Pinelands at a general rate of 10.2 cubic meters/second (360 cubic feet/second) with Toms River providing the greatest amount of that inflow followed by Cedar Creek (USFWS, 1997). WMA 13 is connected with the Atlantic Ocean through Barnegat Inlet to the north, Little Egg Harbor Inlet to the south, and also through the Bay Head-Manasquan Canal and Manasquan Inlet at the northern end of the bay complex.

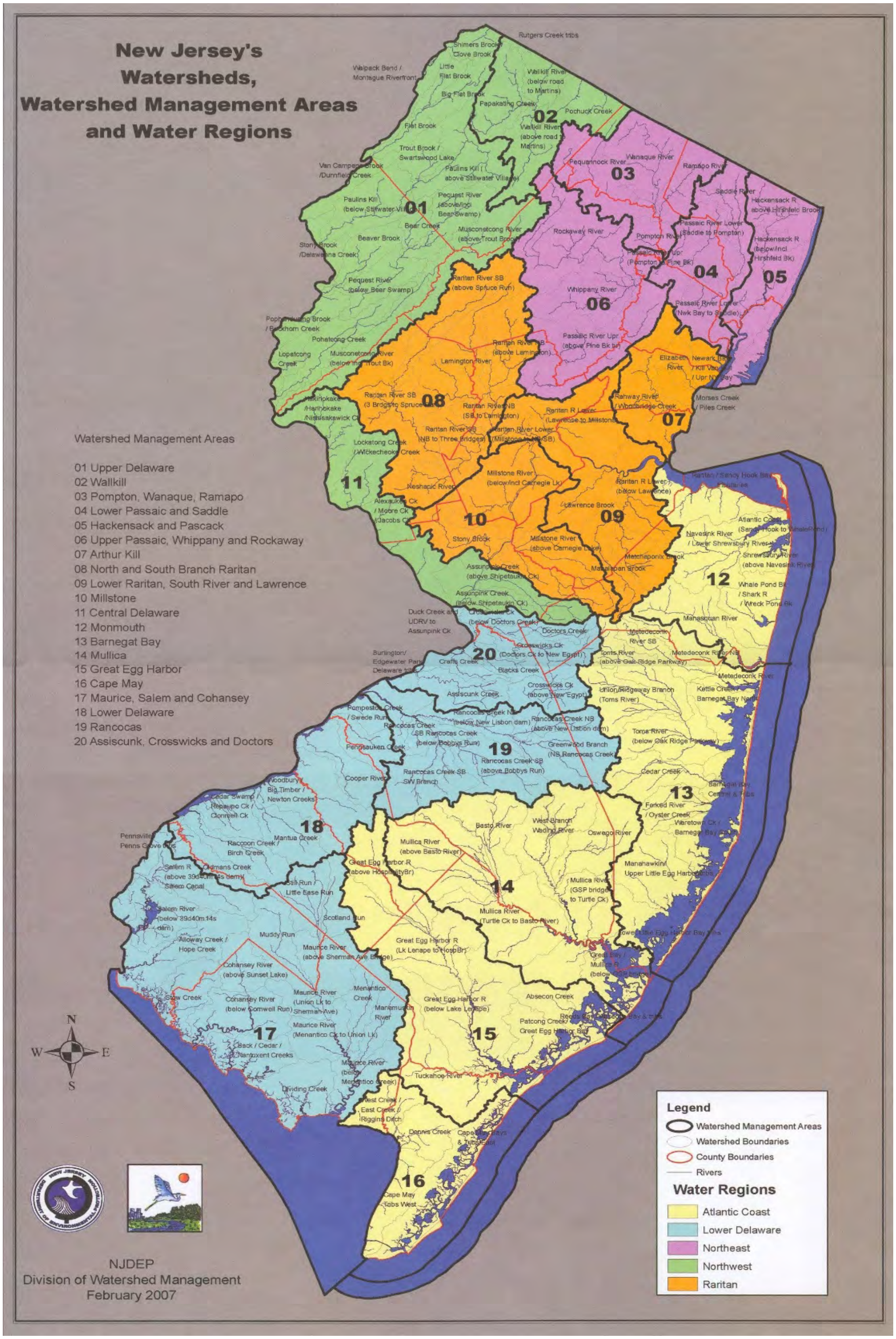

Figure 3: New Jersey's Watershed Management Areas (Source: NJDEP, 2007)

The Mullica River Basin (WMA 14) is a 1,471 square hectare (568 – square mile) area fed by a number of rivers and creeks originating from the heart of the New Jersey Pinelands including the Batsto River, Atsion (upper Mullica) River, Sleeper Branch, Nescocheague Creek, and Hammonton Creek. These major watersheds join at the head of tide near the town of Batsto to form the main stem of the Mullica River. The tidally influenced main stem from Batsto to the mouth at Great Bay is about 34 kilometers (21 miles) in length. A number of tributaries enter the main stem from the north, including Bull Creek, Wading River, and Bass River, with Landing Creek and Nacote Creek from the south. All of these tributaries are tidally influenced (USFWS, 1997). Great Bay is a polyhaline, well mixed estuary at the mouth of the Mullica River, and is fed tidally from the Atlantic Ocean through Little Egg Harbor Inlet to the east and Little Bay and Brigantine Inlet to the south.

The Great Egg Harbor River Basin (WMA 15) is composed of several embayments that extend behind Brigantine Island, Absecon Island, and Peck Beach. To the north, Reeds Bay and Absecon Bay receive freshwater inputs from mainly Absecon Creek. These bays are tidally connected to the Atlantic Ocean waters entering through Absecon Inlet and to a lesser extent from Little Bay and Brigantine Inlet to the north (WMA 14). Lakes Bay and Scull Bay occur south of the Atlantic City Expressway, and are west of Absecon Island. These bays are tidally influenced from the north and east via Beach Thorofare and Great Thorofare and from the south and east through Great Egg Harbor Inlet and Broad Thorofare. The dominant freshwater input into this area stems from two major river sources that originate in the New Jersey Pinelands to form an 875- square kilometer (338-square mile) area. These river sources are the Great Egg Harbor River and the Tuckahoe River. The Great Egg Harbor River is a 95-kilometer (59-mile) long river that is tidal for its lower 22.5 river kilometers (14 river miles) from the impoundment at May's Landing to its mouth where it joins the Middle and Tuckahoe Rivers at the head of Great Egg Harbor Bay. Smaller tributaries directly entering the estuary include the South River, Stephen Creek, Gibson Creek, and Middle River from the south, and Babcock Creek, Gravelly Run, English Creek, Lakes Creek, and Patcong Creek from the north. The Tuckahoe River is tidal for a distance of 22 river kilometers (13.5 river miles) upriver from the main stem of the Great Egg Harbor River (USFWS, 1997). These waters empty into the Great Egg Harbor Bay estuary that receive polyhaline tidal waters from the Atlantic Ocean through the wide Great Egg Harbor Inlet. Peck Bay is connected to the south end of Great Egg Harbor Bay, and occurs west of Ocean City/Peck Beach.

The Cape May Water Management Area (WMA 16) includes many smaller shallow bays and sounds inter-connected by an extensive system of tidal creeks and channels bounded by extensive salt marshes. There are four inlets in this area that connect the Atlantic Ocean to these bays. These inlets from north to south are: Corson Inlet, Townsends Inlet, Hereford Inlet and Cape May Inlet. The bays from north to south are Corson Sound, Ludlam Bay, Townsend Sound, Stites Sound, Great Sound, Jenkins Sound, Grassy Sound, Richardson Sound, Sunset Lake, Jarvis Sound, and Cape May Harbor. There is a higher percentage of salt marsh in this wetland complex than in the bays to the north. The Cape May lagoons have a small drainage area, with most of the surface water in Cape May draining to the north into Great Egg Harbor estuary or to the west into Delaware Bay, and only a few small tributaries emptying directly into the Cape May lagoons (USFWS, 1997).

Water Quality

Water quality is a primary determinant of habitat quality for fish and wildlife, and also affects recreational opportunities in regional water bodies and overall aesthetics of a water body. Parameters such as temperature, salinity, turbidity, dissolved oxygen (DO), nutrients, pH, and heavy metals are important influences on the survival of aquatic life. Water quality is generally indicated by measuring levels of the following: nutrients (nitrogen/phosphorus), pathogens, floatable wastes, and toxins. Rainfall is an important parameter for studying water quality; runoff leads to non-point source pollution and fresh water (rainfall, ground water seepage, runoff, and river discharge) can ultimately affect hydrodynamic circulation in the ocean. Ocean and bay recreational beaches are subject to opening and closing procedures of the State Sanitary Code and must be resampled when bacteria concentrations exceed the primary contact standard of 104 enterococci per 100 mL of sample. Consecutive samples that exceed the standard require the closing of the beach until a sample is obtained that is within the standard.

Elevated enterococci counts along the coast of New Jersey may result from failing septic tanks, wastewater treatment plant discharges, combined sewer overflows, stormwater drainage, runoff from developed areas, domestic animals, wildlife and sewage discharge from boats. Point source discharges from coastal wastewater treatment facilities can affect water quality at bathing beaches. Accordingly, the NJDEP routinely monitors the treatment of effluent at these facilities, to ensure that they operate in accordance with the requirements of their permits. For recreational beaches, the health agency also surveys the area visually and collects additional samples ("bracket samples") at either side of the station to determine the extent of the pollution and possible pollution sources. The results of the bracket samples determine the extent of restrictions imposed along the shore and the number of beaches closed.

Physical water quality parameters such as temperature, salinity and turbidity are influenced by natural processes, and can be used to establish baseline water quality conditions. Other parameters that are influenced directly by human activities can be used to indicate the extent of impairment of the aquatic ecosystem. DO, for example, is important to the survival of fish and other aquatic life and can be affected by human influenced nutrient loading. In addition, fecal coliform bacteria are an indicator of bacterial pollution often associated with sewage effluent that can affect habitat quality. Nitrates and other nutrients are indicators of the degree of eutrophication of the estuary, while heavy metals and other contaminants may directly affect habitat quality.

According to New Jersey regulations (N.J.A.C. 7:9B-1.12), the majority of surface waters in the study site reaches have a NJDEP classification of SE-1 (estuarine). Tidal water bodies classified as SE-1 are estuarine waters with the designated uses of:

- Shellfish harvesting in accordance with N.J.A.C. 7:12
- Maintenance, migration and propagation of natural and established biota;
- Primary and secondary contact recreation; and any other reasonable uses.

Off shore open water habitats have an SC classification with designated uses of:

- Shellfish harvesting in accordance with N.J.A.C. 7:12
- Maintenance, migration and propagation of natural and established biota;
- Primary and secondary contact recreation; and any other reasonable uses.

Water quality within the coastal waters of the New Jersey Atlantic Coast was comparable to that of similar coastal water bodies along the New York Bight and was indicative of similar coastal tidal river and estuary complexes along the Mid-Atlantic coast (USFWS, 1997). NJDEP (2017) summarizes that the coastal waters and estuaries of NJ were generally good for recreation and shellfish harvesting. However, there remain some areas where dissolved oxygen does not meet water quality criteria, which is a concern relative to aquatic life support particularly in Barnegat Bay. The quality of water in this coastal region is dependent largely on the influence of the major coastal freshwater rivers that flow into the bays that make up the study area reaches (e.g. the Mullica River empties in the Great Bay).Other factors that influence water quality over time include tides, time of year, ocean current fluctuations, nutrient enrichment, water depth, biotic communities, and other temporal and spatial variables.

The results of prior studies conducted on the bays and estuaries within the study area indicate that the water quality has historically been impacted by pollutants such as nutrients, pathogens, heavy metals (cadmium, lead, and zinc) and fecal coliform bacteria. (USACE, 1998; BBEP, 2001; Zimmer and Groppenbacher, 1999) As a result, habitat for fish and wildlife has been degraded in many areas relative to historical pre-developed conditions. In recent years, however, improvements in water quality have been seen in the region as a result implementation of the Clean Water Act, and state programs such as discharge permitting programs, coupled with improvements in wastewater treatment technology. The following is a discussion of selected water quality parameters within the study area that are important from the perspective of fish and wildlife habitat quality as well as human uses.

The U.S. EPA maintains a web-based information system that allows the user to access pollution information from a search based on a locality. A search was conducted on the “Hows My Waterway” maps for the NJBB study area (see Appendix F). With the exception of waters around Little Bay, Great Bay, Little Egg Harbor, and Southern Barnegat Bay, most of the waters were designated as polluted. These designations are based on State of NJ Water Quality Monitoring programs.

The NJBB study area is within the Atlantic Coast Region (ACR) for water quality monitoring, assessment, and management by the NJDEP. The Atlantic Coast Region is further divided into smaller assessment units (AU’s) that are based on the USGS Hydrologic Unit Code (HUC) 14 watershed level. Section 305(b) of the Clean Water Act requires states to report attainment of designated water uses, which include: Aquatic Life – General, Aquatic Life – Trout, Recreation, Water Supply, and Shellfish. A multitude of parameters are used to assess the water quality and designated uses, which include pathogens, nutrients, dissolved oxygen and toxics. The ACR consists of 293 AUs covering 2,962 square miles, 5,812 miles of nontidal and tidal rivers, 6,632 square acres of lakes/reservoirs, and 745 square miles of estuaries/bays and ocean waters. Use assessment results for the ACR’s 293 assessment units (AUs) showed that water quality is generally better in the ACR than water quality statewide. Both statewide and ACR assessment results showed that public water supply and recreation uses had the highest percentage of use support; moreover, the relative percentage of all AUs fully supporting applicable designated uses was generally higher in the ACR. Figure 4 shows the number of AUs that fully support applicable designated uses in each Water Region. The ACR has the highest number of fully supported designated uses (274 AU/use combinations) of the New Jersey’s Water Regions, followed by Lower Delaware (156), Northwest (146), Raritan (100), and Northeast (70) (NJDEP, 2017). Table 3 provides a breakdown of percentages of AUs that meet and do not meet designated uses within the ACR.

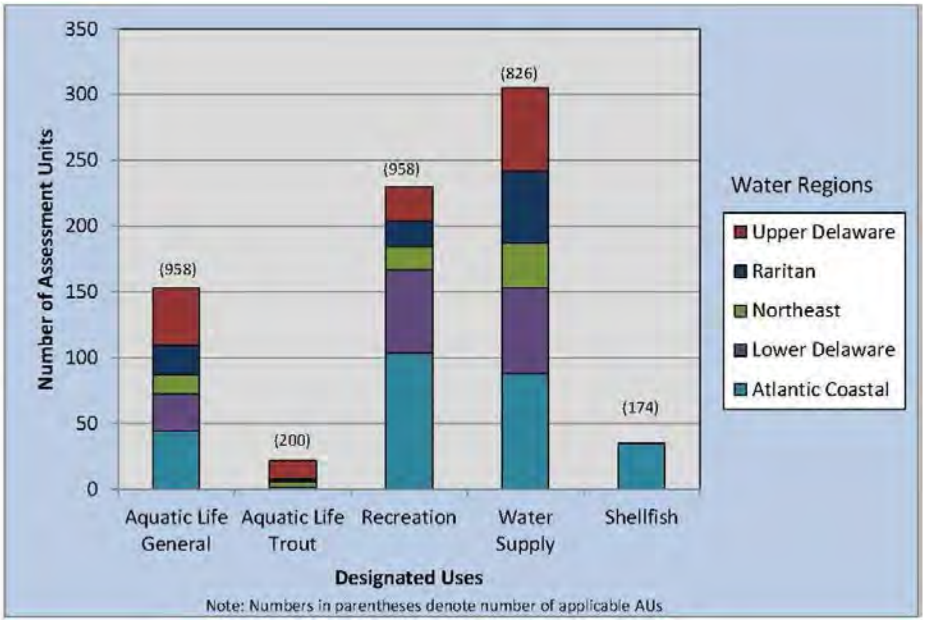

Figure 4: Number of AU's Fully Supporting Uses, Statewide (Source: NJDEP, 2017)

Table 3: Use Assessment Results for Atlantic Coastal Region (ACR), Number and Percentage of Assessment Units (AUs)

Designated Uses	**Aquatic Life-General**		**Aquatic Life-Trout**		**Recreation**	
Scope	**# AUs**	**% AUs**	**# AUs**	**% AUs**	**# AUs**	**% AUs**
Fully Supporting	45	15%	2	12%	104	35%
Not Supporting	184	63%	11	65%	76	26%
Insufficient Information	64	22%	4	24%	113	39%
Total AUs Applicable	293		17		293	
Notes:	The predominant parameter causing aquatic life use impairment is “cause unknown”, followed by pH, and dissolved oxygen.		Only applies to trout maintenance waters in the freshwater Manasquan River, Toms River and Metedeconk River watersheds.		Not supporting %’s due to pathogenic impairments in heavily urbanized areas such as in Monmouth and Ocean County and new tributaries added in upper Barnegat Bay area and beach closure data.	
Designated Uses	**Water Supply**		**Shellfish Harvest**		**Fish Consumption**	
Scope	**# AUs**	**% AUs**	**# AUs**	**% AUs**	**# AUs**	**% AUs**
Fully Supporting	88	41%	35	27%	0	0%
Not Supporting	59	28%	78	60%	84	29%
Insufficient Information	67	31%	17	13%	209	71%
Total AUs Applicable	214		130		293	
Notes:	Water supply only applies to freshwater AUs. Impairments are predominantly due to arsenic concentrations that exceed established human health criteria even though the arsenic is naturally occurring.		Only shellfish waters classified as “approved” are assessed as fully supporting the designated use even though shellfish may be harvested from shellfish waters that are seasonal and special restricted.		Mercury and PCB in fish tissue are major causes of use impairment although, PCB in fish tissue along the Atlantic Coast is no longer on the 303(d) List because the waters from which the fish contamination arose are unknown. Other causes of use impairment found in fish tissue or subject to fish advisories are DDT and its metabolites, chlordane, dioxin, dieldrin and benzo (a) pyrene.	

Section 303(d) of the Federal Clean Water Act requires TMDLs (Total Maximum Daily Loads) to be developed for the pollutant(s) of concern in water bodies that cannot meet surface water quality standards after the implementation of technology-based effluent limitations. Waters of the State are regularly assessed to determine if surface water quality standards are attained. Waters that do not meet the applicable standards are placed on the 303(d) List of Water Quality Limited Waters (303(d) List). The 2014 303(d) List identifies 40 different causes of impairment for a total of 1,958 assessment unit (AU)/pollutant combinations (some AUs are impaired by multiple causes) statewide. Of all causes of water quality impairment, five of the top ten are associated with the aquatic life use, including total phosphorus (TP). TMDLs have been established for 74% of the pathogens, 56% of the mercury, and 35% of the TP causing use impairment. Table 4 provides a list of impaired AUs within each Watershed Management Area (WMA) within the ACR, and demonstrates that the most impairments are for Aquatic Life-General.

Table 4: Number of Assessment Units (AUs) Listed within Each Watershed Management Area (WMA) within the Atlantic Coastal region as Impaired on the 2014 303(d) List

WMA	Aquatic Life General	Recreation	Water Supply	Shellfish Harvest	Fish Consumption
12 Monmouth	51	5	16	5	71
13 Barnegat	42	12	25	-	20
14 Mullica	50	-	18	-	34
15 Great Egg Harbor	39	-	14	1	4
16 Cape May	24	-	4	-	9
TOTAL AUs	206	17	77	6	138
Parameters:	Phosphorous, DO, Cause Unkn, TSS, pH, Turbidity, Copper, Nitrates	E. Coli, Enterococcus	Arsenic, Mercury, Lead	Total Coliform	PCB, Mercury, PAHs, DDT and Metabolites, Chlordane, Dieldrin, Dioxin,

Temperature and Salinity

The back bays generally exhibit the highest mean salinities and water temperatures within the project area. The higher salinities reflect the stronger influence of the ocean on dynamics of water within these bays and the absence of a major freshwater river. Similarly, warmer mean temperatures in this reach may also be accounted for by a stronger influence of oceanic (higher salinity) waters during the winter months when freshwater influences are likely to lower temperatures. Water temperature is driven primarily by seasonal shifts in weather and ambient air temperature. Summer water temperatures along New Jersey coastal waters averages between 20°C and 30°C throughout most of the coastal waters. During winter months the average water temperature ranges from 0°C and 10°C (Zimmer and Groppenbacher, 1999). While these temperature ranges describe a majority of the water bodies along the coast, variables such as water depth, productivity, mixing, and influx of freshwater can all affect water temperatures in habitats across the study area.

Salinity is another key water quality indicator as it can significantly affect aquatic community structure in estuarine waters and related habitats. Salinity of coastal surface waters is driven both by cyclical tidal shifts and also the non-cyclical pulses of freshwater flows from coastal rivers that empty into the bays and estuaries along the coast. Other factors influencing salinity in an estuary include evaporation, weather conditions affecting wind, distance from the mouth of the estuary, and river basin geomorphology (Kennish, 1992). On average, the salinity of much of the coastal waters ranges from 20-30 parts per thousand (ppt). However, similar to temperature, there is often a seasonal shift in salinity in New Jersey's coastal waters when rain and freshwater runoff brings salinities down during spring months (Zimmer and Groppenbacher, 1999).

Turbidity

Turbidity is a measure of the clarity of the water column, which is a function of suspended particles (Thurman, 1975) and is recorded as nephelometric turbidity units (NTUs). Turbid (cloudy) water can be caused by natural conditions (e.g., tidal flushing and resultant suspension of sediments), water from aquifer formations that is naturally elevated in total dissolved solids, or human activities, such as the release of suspended particles in urban runoff or wastewater discharges into the river. As a general trend, turbidity is somewhat lower in the winter months when biological productivity is lowest (Zimmer and Groppenbacher, 1999). Conversely high phytoplankton biomass and production during the warmer months of the year contribute to elevated turbidity readings. Other factors that may influence turbidity over the short term include storms, wind, and rain supplying energy that causes erosional processes that entrain suspended particles. Turbidity is also often elevated in areas near the mouth of estuaries, where tidal action and river flows result in great mixing.

Dissolved Oxygen

Dissolved oxygen is one of the most important water quality parameters, as most biota cannot survive without adequate DO levels. Dissolved oxygen concentrations in the water column are influenced by temperature, photosynthesis, respiration of aquatic life, aeration from physical processes, amount of organic matter, and pollutant inputs (USEPA, 1986). Generally DO is highest in the winter months and lowest in summer months (Zimmer and Groppenbacher, 1999), as its solubility increases when temperature decreases. DO can vary greatly over time within a specific area due to changes in presence of other nutrients that stimulate productivity. Furthermore, DO is highly dependent on salinity as the latter affects the solubility of oxygen in water.

Nutrients

The level of nutrients currently measured in coastal waters as a measure of non-point source pollution is among one of the higher priority management issues for the state and federal agencies (CBP, 2002). Two major nutrients (nitrogen and phosphorus) are monitored in water quality studies, although they may take many forms. Nitrogen is always present in aquatic systems although it exists in many forms simultaneously as ammonia (NH_4^+), nitrate (NO_3^-), nitrite (NO_2^-), and urea. It is the availability of the various nitrogen compounds that most influences the variety, abundance, and nutritional value of aquatic plants and eventually animals in an aquatic system (Goldman and Horne, 1983).

Many of New Jersey's coastal waters are experiencing high nutrient loadings that negatively impact water quality and biotic communities. For example, high nutrient inputs (especially nitrogen) can lead to a variety of adverse conditions (e.g., increased algal biomass and production, toxic or nuisance algal blooms, elevated turbidity, loss of submerged aquatic vegetation (SAV), exhausted DO levels, and a decline in biodiversity) that can severely impact the water quality of an estuary (BBEP, 2001). Kennish (2010) describes that the "nutrient enrichment of the Barnegat Bay-Little Egg Harbor Estuary is closely linked to a series of cascading environmental problems, notably increased growth of phytoplankton and benthic macroalgae (including both harmful and nuisance forms), loss of SAV, and declining shellfish resources. These problems have also led to deterioration of sediment and water quality, loss of biodiversity, and disruption of ecosystem health and function. Human uses of estuarine resources have also been impaired."

Plankton

Plankton are collectively a group of interacting minute organisms adrift in the water column. Plankton are commonly broken into two main categories (with some exceptions): phytoplankton (plant kingdom) and zooplankton (animal kingdom), and both form the base of the food web in aquatic ecosystems. Phytoplankton are the primary producers in the aquatic freshwater, estuarine, and marine ecosystems, and are assimilated by higher organisms in the food chain. Phytoplankton production is dependent on light penetration, available nutrients, temperature and wind stress. Phytoplankton production is generally highest in nearshore coastal waters. Seasonal shifts in species dominance of phytoplankton are frequent. Phytoplankton can be broken down into two major seasonal species associations. One is a spring-summer dinoflagellate dominated regime. October and November are periods of transition in the phytoplankton community. A second regime exists during the winter, which is predominantly diatoms. A two year baseline survey in Barnegat Bay and Little Egg Harbor reported that the most common phytoplankton species belonged to five major groups: diatoms (Bacillariophyceae), dinoflagellates (Dinophyceae), cryptophytes (Cryptophyceae), chlorophytes (Chlorophyceae), and chrysophytes (Chrysophyceae). Of these groups, diatoms made up approximately 50% of the total number of taxa, followed by dinoflagellates (Ren, 2015).

Zooplankton

Zooplankton provide an essential trophic link between primary producers and higher organisms. Zooplankton represent the animals (vertebrates and invertebrates) that are adrift in the water column, and are generally unable to move against major ocean currents. Many organisms may be zooplankton for their entire lifecycle (holoplankton), or at early stages in their respective life cycles (meroplankton) only to be able to swim against the currents (nektonic) in a later life stage, or become part of the benthic community. Zooplankton are generally either microscopic or barely visible to the naked eye. Zooplankton typically exhibit diurnal vertical migrations and seasonal variances in species abundance and distribution, which may be attributed to temperature, salinity and food availability. In marine environments, seasonal peaks in abundance of zooplankton distinctly correlate with seasonal phytoplankton peaks. These peaks usually occur in the spring and fall. Zooplankton species that are characteristic of coastal areas include: *Acartia tonsa, Centropages humatus, C. furatus, Temora longicornis, Tortanus discaudatus, Eucalanus pileatus,* *Mysidopsis bigelowi* (mysid shrimp), and *Crangon septemspinosa* (sand shrimp). Zooplankton species within the geographic area generally fall within two seasonal groups. The copepod, *Acartia clausi*, is a dominant species during winter-spring, and is replaced in spring by *A. tonsa*. Peak densities usually occur in late spring to early summer following the phytoplankton bloom.

Howson (2016) reports that the zooplankton community in Barnegat Bay is characterized by strong spatial, seasonal and interannual trends in abundance and diversity. Spatial variability is most apparent between the northern and southern sections of the bay, with a characteristic suite of taxa and water quality parameters associated with each area. The northern bay was characterized by higher nitrogen and chlorophyll a, high abundances of copepods, ctenophores, and barnacle larvae, and the lowest species diversity of zooplankton and ichthyoplankton in the bay; whereas species diversity of both zooplankton and ichthyoplankton were higher in the lower bay.

Harmful Algal Blooms (HABs) and Sea Nettles

Excessive phytoplankton blooms in the NJBB are attributed to eutrophication of the waters in the bays stemming from excessive nutrients and poor flushing. Excessive growth of some phytoplankton species can generate harmful algal blooms (HABs), an increasing phenomenon worldwide, which are characterized based on their pigments as brown, yellow, and red tides. HABs can cause numerous ecological and/or human health problems due to the toxins produced by certain species and/or their potential bioaccumulation in the food web, or may cause hypoxia in the water column due to their decay and degradation (Gastrich, 2000). Toxic forms that are particularly dangerous to numerous organisms include macroalgae, shellfish, finfish, and humans. Secondary impacts of algal blooms include shading of benthic habitats, altered grazing patterns, and changes in trophic dynamics that are detrimental to estuarine function. HAB-forming species that have been recorded in the Barnegat Bay-Little Egg Harbor estuary, include *Aureococcus anophagefferens, Dinophysis* spp., *Gymnodinium* (*Karlodinium*) spp., *Heterosigma* sp., *Pseudo-nitzschia* sp. and *Prorocentrum* spp. (BBP, 2016).

Brown-tide blooms caused by the minute algal species, *Aureococcus anophagefferens* (Pelagophyceae), were first reported in New Jersey coastal bays in 1988. These blooms have typically been observed in dry years. A brown tide algal bloom can discolor the water brown and may cause negative impacts on shellfish, such as the ecologically and commercially important hard clam and scallop, as well as on seagrasses. Adverse shellfish impacts include a reduction in the growth of juvenile and adult hard clams and mussels, reduced feeding rates of adult hard clams and other shellfish, recruitment failures, and increased mortality of bay scallops. The dense shading of benthic habitats caused by these blooms may also contribute to the loss of seagrass beds, which serve as important habitat for finfish and shellfish (BBP, 2016).

Each summer, the New Jersey DEP Bureau of Marine Water Monitoring monitors for concentrations of chlorophyll '*a*' (an indicator to determine the amount of algal biomass present) in New Jersey's coastal waters. Since chlorophyll is a plant pigment, high levels of chlorophyll in the water are typically associated with an algal bloom. To detect potential blooms, an airplane equipped with a remote sensor flies 6 days a week during clear, summer weather conditions over coastal NJ. These flights produce estimated chlorophyll '*a*' concentrations that are made available for viewing through an interactive map. Developing algal blooms are monitored through this tool and Marine Water Monitoring will strategically deploy field staff to locations of concern. Samples are collected and brought back to the bureau laboratory for analysis to determine if a HAB species is present. Additionally, the phytoplankton-monitoring program provides surveillance of shellfish growing areas for possible toxin-producing algal species. A station network of over 45 sites are monitored for chlorophyll '*a*' multiple times throughout the year. In addition, these samples are closely evaluated to determine if the concentration of any toxic algal species is present and at an unsafe level (retrieved from https://www.nj.gov/dep/bmw/phytoplankton.htm#/ on 12/20/2018). Through NJDEP and the Barnegat Bay Program, Barnegat Bay, Little Egg Harbor and Manahawkin Bay are regularly monitored to indicate if an algal bloom is occurring. Several years of monitoring demonstrates that overall chlorophyll '*a*' concentrations are highest in the Barnegat Bay segment (generally from Barnegat Inlet in the south to the Metedeconk River in the north), but the blooms were generally localized (BBP, 2016).

Sea nettles (*Chrysaora quinquecirrha*) are a stinging jellyfish that have become increasingly prevalent, and a nuisance, in Barnegat Bay and other coastal waterways in New Jersey. They can greatly affect recreational activities that involve human contact with the water where people can be stung by their tentacles. It is believed that sea nettle blooms are greatly influenced by a number of factors such as increases in the presence of manmade structures (pilings, floating docks, and bulkheads), which allow for a suitable substrate for the polyps to attach. Salinity can affect their populations where they prefer a narrow salinity range in lower salinity areas. A dry year or certain human activities that affect water use can affect their abundance and distribution in the bays. Other factors believed to contribute to increases in sea nettles are climate change (increases in temperature), eutrophication, and overfishing (https://www.barnegatbaypartnership.org/protect/threats-to-barnegat-bay/jellyfish/sea-nettles/ accessed on 1/4/2019).

Submerged Aquatic Vegetation and Macroalgae

A number of species of macroalgae can be found within the project area. The habitats include jetties, sand beaches, enclosed bays, and tidal creeks. The productivity is primarily seasonal with the densest population occurring in June through August. Distribution and abundance of algae is closely related to seasonal temperature, salinity variations and nutrient levels coming from tributary streams. The predominant benthic algae is Rhodophyta (red algae) while Chlorophyta (green algae) comprise the largest number of intertidal algae species. Phaeophyta (brown algae) such as rockweed (*Fucus* spp.) may be found attached or floating free around rock jetties and pilings or washed onto the shore to make up part of the wrack line. Other common algae species include sea lettuce (*Ulva lactuca*), spaghetti grass (*Codium fragile*) and *Gracilaria* sp., a red alga that grows unattached among seagrass beds (Good, et al., 1978). Eutrophication can influence the abundance of some macroalgae where excessive growth of sea lettuce, and the Rhodophytes: *Agardhiella subulata, Ceramium* spp., and *Gracilaria tikvahiae* can form extensive organic mats that can be detrimental to essential estuarine habitats such as seagrass beds (Kennish et. al 2010).

Submerged aquatic vegetation (SAV) and/or "seagrass" beds exist in localized areas of the New Jersey Back Bay estuarine system, and are an essential food for a number of waterfowl species, habitat for finfish, shellfish and a number of other invertebrates, and provide sediment stabilization. SAV are rooted vascular flowering plants that exist within the photic zone of shallow bays, ponds, and rivers. The Barnegat Bay – Little Egg Harbor Estuary have the most extensive beds and account for nearly 75% of the beds in New Jersey (Kennish et al. 2010). The most important species of SAV in New Jersey is eelgrass (*Zostera marina*), which is also the most common SAV that can form extensive beds important for fish, shellfish and other wildlife species. Other species of submerged vegetation found in the more brackish waters of the estuary that are also of ecological importance include widgeon grass (*Ruppia maritima*) and other more freshwater and slightly brackish species of pondweeds (*Zanichellia palustris* and *Potomogeton* spp.) and wild celery (*Vallisneria americana*) as reported in the Great Egg Harbor River, Tuckahoe River, Patcong Creek, and the Mullica River (USFWS, 1997). SAV beds provide an important direct food source via the grazing chain, indirect food source via the detritus chain, a substrate for epiphytes, and cover and protective habitat. Although eelgrass is not used in fresh form by many organisms, Bellrose (1976) lists Atlantic brant *(Branta bernicla)* and black duck (*Anas rubripes*) as waterfowl known to feed extensively on eelgrass. Other waterfowl such as American widgeon (*Anas americana*), gadwall (*A. strepera*), mallard (*A. platyrhynchos*), canvasback (*Aythya valisineria*), greater scaup (*A. marila*), black scoter (*Melanitta nigra*), and surf scoter (*Melanitta perspicillata*) are also known to feed on the plant. Large numbers of fish are also typically associated with eelgrass beds, although most do not feed directly on the plants (Good, et al., 1978). Additionally, eelgrass beds have been recognized as an important habitat for juvenile and adult blue crabs (*Callinectes sapidus*), and the leaves are used by the bay scallop (*Argopecten irradians)* as a setting substrate, and are also associated with hard clam (*Mercenaria mercenaria*) beds.

Eelgrass beds are sensitive to a number of stressors in estuaries, which include nutrient enrichment, docks, dredging, and boat scarring. Lathrop and Haag (2011) conducted an aerial comparison of eel grass beds in Barnegat Bay and Little Egg Harbor in 2003 and 2009, and found that the general extent of eelgrass beds did not significantly change although a nearly 60% decline of the dense eelgrass beds occurred. Some changes were noted in the difference in seasons sampled in Barnegat Bay and Little Egg Harbor. Fertig et al. 2013 attribute declines in eelgrass populations and biomass in this area to increased Nitrogen loading within the watershed. Effects of high Nitrogen loading are accelerated algal growth, epiphytic infestation, light attenuation, and shading of the estuarine floor, which can heavily stress these plants.

Wetlands and Tidal Flats

Wetland and aquatic habitat types dominate much of the study area. Aquatic habitats are principally associated with back water sound and bay areas such as Richardson Sound and Grassy Sound, Great Sound, Jenkins Sound, Townsend Sound, Corson's Sound, Great Egg Harbor, Peck Bay, Lakes Bay, Absecon Bay, Great Bay and Little Bay. In addition, nearshore and intertidal habitats are present within various channels and thoroughfares, while intertidal low marsh wetlands dominated by saltmarsh cordgrass (*Spartina alterniflora)* are present throughout much of the project area, and are the dominant vegetation feature. Common reed (*Phragmites australis*) marshes are also found throughout the area, but are present at higher elevations and around the edges of disturbed marsh areas.

Intertidal mudflats or sand flats often border saltmarsh habitats, pocket beaches along developed shorelines, or locations where either erosion or marsh dieback has removed vegetation or depositional shoals have formed in areas that were previously subtidal. These habitats are often rich in benthic food sources available to wading birds and shorebirds that forage at low tide.

Estuarine emergent wetlands occur extensively throughout the back bays, channels and inlets of the study area. The low marsh areas are typically dominated by saltmarsh cordgrass, the dominant saltmarsh plant species in the northeastern United States (Mitsch and Gosselink, 1993). This species grows in the intertidal zone between mean low water and mean high tide levels, so it is subject to daily tidal inundation. Wildlife species utilizing the low saltmarsh habitats include birds such as clapper rails (*Rallus longirostris*), common moorhen (*Gallinula chloropus*), waterfowl, and other species that feed on insects, crabs and other invertebrates that this community supports. The low marsh and tidal channel complex provides significant habitat for numerous fish species that depend on estuaries for nursery and spawning grounds, as well as smaller resident fish such as mummichog, killifish and silversides (Mitsch and Gosselink, 1993; Tiner, 1985). Tidal flats are generally soft bottom (mud or sand) areas that are covered with water at high tide and exposed at low tide. Mudflats and sandflats are common special aquatic sites in the New Jersey Back Bays, and are important areas for algal growth, as producers of fish and wildlife organisms, and as nursery areas for many species of fish, mollusks, and other organisms.

High saltmarsh habitats are generally found near the mean high tide level, and are generally dominated by saltmarsh hay (*Spartina patens*), seashore saltgrass (*Distichlis spicata*), and glasswort (*Salicornia spp.)*. High saltmarsh provides habitat for many of the same species found in the low tidal marsh areas. However, since high saltmarshes are inundated far less regularly than the low saltmarshes, waterfowl such as black ducks and mallards may breed within this habitat. White-footed mice (*Peromyscus leucopus*) and meadow voles (*Microtus pennsylvanicus*) may use this habitat, as well as raptors (hawks and owls) that feed on the rodents throughout the year.

The critical edge, or upland edge of the wetlands, is crucial for the survival of those coastal zone species that rely on this habitat for breeding, food, cover and travel corridors. It also acts as a buffer from nonpoint source pollution and activities affecting wildlife. Scrub/shrub habitats are common at the transition from high marsh to uplands. Common vegetation includes switchgrass (*Panicum virgatum*), groundsel tree (*Baccharis halimifolia*), bayberry (*Myrica spp*.), eastern red cedar (*Juniperus virginiana*), hightide bush (*Iva frutescens*), seaside rose (*Rosa rugosa*) and poison ivy (*Toxicodendron radicans*). Common reed competes with these species for dominance in these areas. Scrub/Shrub communities are an important component of the open water/tidal marsh/upland transition, providing habitat for numerous species of birds and mammals that utilize these areas.

The invasive common reed dominates much of the remaining high tidal marsh areas within the study area. Since this species may invade areas and exclude other species, it can reduce the diversity of habitats and species within an area (Roman et al. 1984). This has happened historically within the study area, especially in areas that have been subject to diking and ditching for mosquito control purposes. Because of this, tidal wetland restoration projects often focus on control of common reed. Due to the tenacious nature of this species, control efforts are not always successful without repeated herbicide application (Marks et al. 1993). Common reed marshes are common throughout the area and on a number of the sites but are generally present at higher elevations than other tidal marsh communities. Common reed communities also tend to gradually encroach and fill in or restrict tidal channel flows. As a result, this habitat often provides marginal fish habitat except in mosquito ditches and other channels that are sufficiently inundated to support fish. Common reed provides some habitat benefits for certain species of wildlife. When interspersed with other habitats, such as open water and mudflat areas, the value of common reed habitat may be greater, since this interspersion provides breeding, foraging, and resting habitat for several species. However, if left unmanaged, the species quickly spreads creating a monoculture and limiting habitat diversity and productivity. The root mat and thick biomass of common reed communities also presents an impenetrable barrier to nesting terrapins and competing native vegetation.

The study area includes six estuarine wetland complexes that have been identified as priority wetland sites pursuant to the Emergency Wetlands Resources Act of 1986 (EWRA) (100 Stat. 3582) because of national ecological significance. These wetland complexes (from north to south) are: the Barnegat Bay Complex (#6 Upper Barnegat Bay to Little Egg Inlet), Mullica River – Great Bay Estuary (#5), Brigantine Bay and Marsh Complex (#4), Great Egg Harbor Estuary (#3), New Jersey Pinelands (#2), and Cape May Peninsula (#1) (USFWS, 1997). The EWRA directs the Department of the Interior to identify specific wetland sites that should receive priority attention for acquisition by federal and state agencies using Land and Water Conservation Fund monies. Two of these wetlands, Brigantine - Barnegat and Great Egg Harbor - Jarvis Sound, include "focus areas" identified by the Atlantic Coast Venture of the North American Waterfowl Management Plan as critical waterfowl wintering, migratory, or breeding habitat, with an emphasis on American black duck habitat.

These estuarine wetland complexes are characterized by productive salt marshes, shallow bays, numerous tidal ditches, and salt ponds. These features contribute to making these wetlands some of the most important for wintering American black ducks, Atlantic brant, bufflehead (*Bucephala albeola*), and other waterfowl. The substrate of most bays and sounds are exposed at low tide and the invertebrates present are heavily utilized by shorebirds, wading birds, gulls, terns, and waterfowl. The predominant vegetation in these wetlands is salt marsh cordgrass, an important species for the production of food chain organisms for fish, shellfish, birds, and other wildlife.

The Reedy Creek (#6), Malibu Beach (#3) , Cape Island - Pond Creek, and Sewell Point wetlands have also been designated as priority wetland sites by the U.S. Fish and Wildlife Service. The Reedy Creek Wetlands are within the northernmost extent of Barnegat Bay in Ocean County and are part of the Edwin B. Forsythe National Wildlife Refuge (NWR). The Malibu Beach Complex in Egg Harbor Township, Atlantic County, consists of a 300-acre tract of coastal wetlands, tidal creeks and pools, and beach/dune system. This site has the potential to be managed as a prime shorebird nesting and feeding area. The federally listed (threatened) piping plover (*Charadrius melodus*), common tern (*Sterna hirundo*), and rufa red knot (*Calidris canutus rufa*) are among the beach nesting birds that have nested in the area. The Cape Island - Pond Creek priority wetland site is located in the southwestern tip of Cape May and contains ecologically valuable freshwater and estuarine marshes. Sewell Point contains important forested wetlands and is located in the southeastern portion of Cape May (USFWS, 1999).

Terrestrial Habitats

Upland terrestrial habitats within the NJBB study area include vegetated primary and secondary dunes along the coastal barrier islands, inlets and undeveloped back-bay areas. The primary dune is most susceptible to salt spray and wind, and is dominated by American beachgrass (*Amophila breviligulata*), sea rocket (*Cakile edentula*), seaside goldenrod (*Solidago sempervierens*), seaside spurge (*Euphorbia polygonifolia*), and seabeach pursulane (*Susuvium maritimum*). The back side of the primary dunes and the secondary dunes are more protected, which provide suitable conditions for beach heather communities (*Hudsonia tomentosa*) and scrub thickets composed of bayberry (*Myrica pennsylvanica*), wax myrtle (*M. cerifera*), beach plum (*Prunus maritima*) and poison ivy (*Toxicodendron radicans*). Maritime forests in the study area occur in several locations along the barrier islands that support black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), red cedar (*Juniperus virginiana*), serviceberry (*Amelanchier canadensis*) and American holly (*Ilex opaca*). These habitats are important for millions of neo-tropical migratory songbirds.

Open-sandy (unvegetated) upland areas on islands and spits in the NJBB study area provide important habitat for colonial nesting birds. Developed areas are common with numerous impervious and paved surfaces from buildings, roadways, parking lots, and sidewalks. Vegetation in these areas are limited to grassy strips, fields, lawns, and ornamental plantings, and waste areas that may harbor a number of non-native plant species.

Wildlife

The complex of shallow bays, estuaries, saltmarshes, channels, inlets, and barrier island habitats, within the study area, provides shelter, nesting habitat, and a rich food resource that support regionally significant wildlife populations, especially migratory and wintering waterfowl, nesting waterbirds, migratory shorebirds, raptors, reptiles and mammals. Wildlife species that utilize these habitats include federal and state listed threatened and endangered species. The following provides general information on the species within major wildlife groups that utilize the study area.

Birds

The shallow marsh habitat and islands in back bay area's provide habitat for a variety of wading birds including: cattle egret (*Bubulcus ibis*), great egret (*Casmerodius albus*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), tricolored heron (Egretta tricolor), yellow-crowned night-heron (*Nyctanassa violacea*), and black-crowned night-heron (*Nycticorax nycticorax*). Heron rookeries and gulleries have been sighted on marsh islands, although not as numerous as in regions immediately to the north and south of Townsends Inlet.

Many of the back bay islands, isolated or undeveloped marshes and beaches on the barrier islands and the mainland, provide nesting grounds for a wide variety of migratory shorebirds including: glossy ibis (*Plegadis falcinellus*), green-backed heron (*Butorides striatus),* little blue heron, snowy egret, great egret, black-crowned night heron, yellow-crowned night heron, great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), laughing gull (*Larus atricilla*), least tern (*Sterna antillarum*), black skimmer (*Rynchops niger*) and common tern (*Sterna hirundo*).

Migrating birds following both the ocean coastline and Delaware River Valley may converge in Cape May County and use the coastal wetlands and adjoining areas for nesting habitat. There are believed to be approximately 450 species of birds, which are endemic to, or naturalized in, the eastern United States. Based on habitat data and past records, 305 of those taxa are expected to occur in the project vicinity regularly (USACE, 2001).

Atlantic Flyway

Delaware Bay and the surrounding area ranks as the largest spring staging site for shorebirds in eastern North America. Staging sites, such as the study area, serve to link wintering areas with breeding grounds, and are critical to the survival of hundreds of thousands of migrating shorebirds (USACE 1999).

The most common species are the sanderling *(Calidris alba),* semipalmated sandpiper *(Calidris pusilla),* ruddy turnstone *(Arenaria interpres),* and red knot *(Calidris canutus)* (Niles~ Undated). Other common species include yellowlegs *(Totanus spp.),* dowitcher *(Limnodromus spp.),* dunlin *(Calidris alpina),* and least sandpiper *(Calidris minutilla).*

A variety of raptors use habitats along the New Jersey coastline for migrations and overwintering. Migratory raptors concentrate along the southern tip of New Jersey prior to crossing the Delaware Bay (USACE 1999).

The most numerous species encountered during these migrations are the sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*A. cooperii*), red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), broad-winged hawk (*Buteo platypterus*), American kestrel (*Falco sparverius*), and merlin (*Falco columbarius*). Owls, which undertake a similar migration, include the barn owl (*Tyto alba*), northern saw-whet owl (*Aegolills acadicus*), and long-eared owl (*Asio otus*) (U.S. Fish and Wildlife Service).

The Cape May peninsula is a critical stopover point along the Atlantic Flyway, as millions of migratory birds pass through the area during the spring and fall migrations. Almost any species that migrates along the east coast of North America can be found in Cape May County during migration. Other birds that would be expected to use dune/beach/sand flat habitat include the great egret, snowy egret, great black-backed gull, herring gull, ring- billed gull *(Larus delawarensis),* laughing gull, least tern, black skimmer, common tern, eastern willet *(Catoptrophorus semipalmatus),* black-bellied plover *(Squatarola squatarola),* and mallard duck (USACE 1999).

Waterbird Colonies

Numerous waterbird nesting colonies occur in New Jersey, particularly in the coastal region between Barnegat Bay and Cape May. They are notably absent from the Delaware Bay shoreline. The New Jersey colonies which are vulnerable to the effects of sea level rise, storm surge, and erosion are composed of up to eight species of long-legged wading birds (snowy egret, great egret, cattle egret, glossy ibis, black-crowned night heron, little blue heron, tricolored heron, and yellow-crowned night heron), four tern species (common, Forster's, least, and gullbilled), three gull species (laughing, herring, and great black-backed), and black skimmer. Great blue heron colonies also occur, but they are usually located in more inland forested areas. Most of the species in New Jersey utilize colony sites on low marshy islands in the coastal bays and on certain undeveloped barrier island beaches especially near inlets in areas where human related disturbance is low. Some colonies are located on islands and hummocks created by deposition of dredged material. For most species, suitable colony sites are scarce, and successful colony sites are typically used repeatedly for a number of years. One notable exception is the laughing gull which nests in large colonies on marsh islands and switches sites often. Most species will continue to use a successful colony site unless there is a change in the habitat conditions or a change in the larger regional population. Colonies may be abandoned for a variety of factors including increased predation pressure, human disturbance, and changes in the vegetation. In wading bird colonies the phytotoxic effects of the birds' excrement over time may alter the vegetation forcing them to find a new site. Climatic influences such as abnormally cold temperatures, storms, and floods may force the birds to re-nest which prolongs the nesting season and results in substantial yearly variation in reproductive success. If the rate of sea level rise increases and the coast is subjected to more stormy conditions, erosion and flooding will likely greatly limit the availability of suitable colony sites and cause a substantial reduction in reproductive success.

Migratory shorebirds are a federal trust resource responsibility of the U.S. Fish and Wildlife Service. Wetlands within the study area provide high quality habitats for a variety of migratory shorebirds. Shorebirds that use beach areas and associated estuarine wetlands in the vicinity of the proposed project area include State-listed (threatened) black rail (*Laterallus jamaicensis*), American oystercatcher (*Haematopus palliatus*), semipalmated plover, Wilson's plover (*C. wilsonia*), Federally listed (threatened) piping plover, lesser golden plover (*Pluvialis dominica*), black-bellied plover (*P. squatarola*), hudsonian godwit (*Limosa haemastica*), marbled godwit (*Limosa fedoa*), whimbrel (*Numenius phaeopus*), sanderling, semipalmated sandpiper, purple sandpiper, western sandpiper, least sandpiper, white-rumped sandpiper (*Canutus fuscicollis*), Baird's sandpiper *(C. bairdii*), pectoral sandpiper (*C. melanotos*), red knot, dunlin, greater yellowlegs (*Tringa melanoleuca*), eastern willet, curlew sandpiper (*C. ferruginea*), stilt sandpiper (*C. himantopus*), spotted sandpiper (*Actitis macularia*), ruddy turnstone, and short-billed dowitcher (*Limnodromus griseus*) (New Jersey Division of Fish, Game and Wildlife, 1994 as cited in USFWS 1999).

Migratory colonial nesting waterbirds are a federal trust resource responsibility of the U.S. Fish and Wildlife Service. Colonial nesting waterbirds known to occur within the study area include the great blue heron and little blue heron (both species of special concern), tricolored heron, snowy egret, State-listed (threatened) black-crowned night heron, State-listed (threatened) yellow-crowned night heron, cattle egret, great egret, glossy ibis, great black-backed gull, herring gull, laughing gull, glossy ibis, black-legged kittiwake (*Rissa tridactyla*), gull-billed tern (, Forster's tern (*Sterna forsteri*), common tern, State-listed (endangered) least tern, State-listed (endangered) black skimmer, common loon (*Gavia immer*), red-throated loon (*G. stellata*), great cormorant (*Phalacrocorax carbo*), and double-crested cormorant (*P. auritus*) (New Jersey Division of Fish, Game and Wildlife, 1994 as cited in USFWS 1999).

Waterfowl

Estuarine marshes, bays, and channels within the study area are important resting and feeding areas for migratory waterfowl on the Atlantic flyway. The bays and associated coves within the study area provided habitat for tundra swan (*Cygnus columbianus*), mute swan (*Cygnus olor*), Canada goose, Atlantic brant, American black duck, gadwall, American wigeon (*Anas americana)*, northern pintail (*Anas acuta*), blue-winged teal (*A. discors*), green-winged teal (*A. crecca*), northern shoveler (*A. clypeata*), redhead (*A. Americans*), lesser scaup (*Aythya affinis*), common goldeneye (*Bucephala clangula*), mallard, bufflehead, greater scaup, canvasback, long-tailed duck (*Clangula hyemalis*), wood duck (*Aix sponsa*), ruddy duck (*Oxyura jamaicensis*), red-breasted merganser (*Mergus serrator*), hooded merganser (*Lophodytes cucullatus*), common merganser (*M. merganser*), and canvasback (*Aythra valisneria*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS 1999).

Raptors

Raptors that occur in the study area include the State-listed (endangered) red-shouldered hawk, red-tailed hawk, State-listed (endangered) peregrine falcon, State-listed (threatened) osprey, State-listed (endangered) Cooper's hawk, State-listed (threatened) barred owl (*Strix varia*), and State-listed (endangered) short-eared owl (*Asio flammeus*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS 1999).

Ospreys nest on platforms in numerous locations throughout the study area and “feed primarily on fish within the back bays” (USFWS, 1999). The short-eared owl is a temporary resident of the high marsh areas of the study areas, feeding primarily on the small mammals and birds (USFWS, 1999). Northern harriers are also know to “nest and feed in the salt and brackish marshes” within the study area (USFWS 1997). The red-shouldered hawk and Cooper’s hawk migrate over the study area in spring and fall. Other raptors that could occur in the study area during migration include American kestrel, merlin, sharp-shinned hawk, broad-winged hawk, and the bald eagle (*Haliaeetus leucocephalus*).

Neo-Tropical Migratory and Resident Songbirds

The NJBB study area provides woodland and scrub-shrub habitats along the Cape May peninsula, barrier islands, and back-bay complexes important for millions of passerine songbirds that migrate south along the Atlantic coast in the fall, and for those that nest in the area during the spring and summer months. All types of natural habitat, marshes, field, successional habitat, and woods, are utilized by migrating land birds, although woodlands directly adjacent to the salt marshes seem to be particularly important for these birds. Coastal dune shrub lands and coastal dune woodlands on the barrier beach and the Delaware Bay shoreline of Cape May contained the highest mean bird surveys where the most abundant species were yellow-rumped warbler (*Dendroica coronate*), American redstart (*Setophaga ruticilla*), red-eyed vireo (*Vireo livaceus*), black and white warbler (*Mniotilta varia*), pine warbler (*Dendroica pinus*), and gray catbird (*Dumetella carolinensis*) (USFWS, 1997). Other birds that may inhabit the study area include the savannah sparrow (*Passerculus sandwichensis*), song sparrow (*Melospiza melodia*), mourning dove (*Zenaida macroura*), northern mockingbird (*Mimus polyglottos*), brown thrasher (*Toxostoma rufum*), common grackle (*Quiscalus quisquala*), sharp-tailed sparrow (*Ammodramus caudacutus*), seaside sparrow (*A. maritimus*), eastern kingbird (*Tyrannus tyrannus*), tree swallow (*Tachycineta bicolor)*, northern bobwhite (*Colinus virginianus*), robin (*Turdus migratorius*), Carolina wren (*Thryothorus ludovicianus*), American crow (*Corvus branchyrhynchos*), and fish crow (*C. ossifragus*).

Mammals

Mammals known to occur within upland habitats in the study area include raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*), meadow vole (*Microtus pennsylvanicus*), eastern cottontail (*Sylvilagus floridanus*), Virginia opossum (*Didelphis virginiana*), red bat (*Lasiurus borealis*), little brown bat (*Myotis lucifugus*) and white-tailed deer (*Odocoileus virginianus*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS, 1999).

Mammals that would likely inhabit freshwater and brackish wetlands, rivers, and saltmarshes along the back bays of the study area include common muskrat (*Ondatra zibethicus*), raccoon, Virginia opossum, white-tailed deer, and river otter (*Lutra canadensis)* (USFWS, 1999).

Small mammals that could also utilize the upper saltmarsh and marsh transition areas include the meadow vole, meadow jumping mouse (*Zapus hudsonius*), and white-footed mouse (Daiber, 1982).

Reptiles and Amphibians

In general, few amphibians are found in estuaries and saltmarshes due to a general intolerance to saline environments. However, amphibians may be present in adjacent freshwater wetlands and upland habitats. Two state listed endangered amphibians are known to occur in the project area.

The eastern tiger salamander is a member of the mole salamander family, and is seldom seen except during breeding season as it spends most of its life underground. This species congregates in vernal pools in late winter and early spring to mate and lay eggs, and returns underground shortly after, although it may be found under boards or rocks after wandering on rainy nights. It is unlikely that vernal pools suitable for the salamander's breeding requirements are located within the project area. Most likely, the eastern tiger salamander habitat is located in the western portion of the study area, near Cape May Courthouse.

The state listed endangered Cope's gray tree frog (*Hyla chrysoscelis*) is seldom seen on the ground or at the water's edge, except during breeding season. It typically forages in small trees and shrubs located near or within water.

Several species of turtles and snakes could occur in upland areas of the barrier island complex within the study area including the snapping turtle (*Chelydra serpentina*), eastern mud turtle (*Kinosternon subrubrum*), stinkpot (*Sternotherus odoratus*), northern watersnake (*Natrix sipedon*), northern black racer (*Coluber constrictor*), and eastern garter snake (*Thamnophis sirtalis*). The distribution of these species is limited by the availability of fresh water, as they are intolerant of higher salinity.

The northern diamondback terrapin (*Malaclemys terrapin terrapin*) is also known to inhabit marshes, tidal flats, and beaches within New Jersey estuaries. The northern diamondback terrapin has been subject to recent population declines as a result of entrapment in crab pots and a reduction in nesting habitat. Northern diamondback terrapins occur primarily in emergent wetlands and shallow water habitat and feed on crustaceans, mollusks and other invertebrates (Palmer and Cordes, 1988). During the winter, northern diamondback terrapins burrow into the mud of tidal creeks and ponds to hibernate either individually or in groups. Northern diamondback terrapins mate in the spring and lay their eggs in sandy substrates above the levels of high tides. Predation of eggs and hatchlings represent the major source of natural mortality in most terrapin populations. Eggs and juveniles are preyed upon by raccoons, crows, and gulls (Palmer and Cordes, 1988). However, northern diamondback terrapin entrapment in crab pots can result in significantly higher mortality rates than mortality due to natural causes (e.g., predation and disease) (Roosenberg, 1993). Additional mortalities result from vehicle strikes when northern diamondback terrapins attempt to cross roads in coastal areas bounded by marshlands.

Fisheries Resources

The presence of extensive estuarine wetlands, tidal creeks and inlets, mudflats and SAV beds within the New Jersey Back Bays allows the coastal waters of New Jersey to have a productive fishery. Many species utilize the estuaries behind the barrier islands for forage and nursery grounds. The finfish found along New Jersey coastal waters are principally seasonal migrants. Winter is a time of lower abundance and diversity as most species leave the area for warmer waters offshore and southward. During the spring, increasing numbers of fish are attracted to the New Jersey Coast, because of its proximity to several estuaries, which are utilized by these fish for spawning and nurseries (USACE 2002).

The great diversity of fish fauna found in the NJBB estuarine habitats includes both resident and transient species. Species habitat use is best understood in terms of life history, as many fish species occupy estuarine habitats only during certain life-stages. Several fish species are continuously present in coastal habitats, while others are present only during certain periods (e.g. during spring many fish species use specific habitats for spawning). Thus, the distribution and abundance of important indicator fish species vary both temporally and spatially (NOAA, 1994).

These estuarine environments are extremely important to a wide number of fish species because of the multitude of niche environments available to fish. Certain fish species utilize shallow water vegetated habitats for spawning while others migrate out to open water to distribute their eggs as planktonic forms. Similarly, some larval fish species migrate from open water as they develop and enter highly productive estuarine environments to grow and develop into juvenile stages. In this respect estuaries provide both ample amounts of both food and protection for larval and juvenile stages of fish (Able and Fahay, 1998).

High marsh and tidal mud flat areas have been shown to provide important year round habitat for many groups of fishes including killifishes (*Fundulidae*), needlefishes (*Belonidae*), and silversides (*Atherinidae*) (Talbot and Able, 1984). In addition, larval and juvenile stages of numerous fish species such as herring (*Clupidae*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), menhaden (*Brevoortia tyrannus*), and winter flounder (*Pseudopleuronectes americanus*) utilize high marsh and tidal mud flat environments during spring, summer, and fall seasons. The variable microhabitats found throughout these environments provide both protection and cover as well as food sources for early life stages of fish found throughout estuarine habitats and are important to the success of year classes of many of these species as nurseries, foraging areas and cover habitat.

Habitats with restricted tidal flows such as marsh potholes and closed ponds often have associated fish assemblages that consist of low diversity and high abundance. For example, killifish are highly tolerant of wide variations in salinity and temperature and are known to dominate these types of habitats. High marsh habitat dominated by common reed has been shown to negatively affect the success and survival of larval and juvenile fish (Able and Hagan, 2000). Common reed habitats offer few niche habitats and associated biomass available as food sources. Conversely, low marsh areas dominated by *Spartina alterniflora* have been shown to provide high quality habitat for many fish species (Able and Hagan, 2000). Other vegetation types present in submerged aquatic vegetation beds such as eel grass and water celery provide both spawning habitats as well as nursery and feeding habitat for juvenile fish.

Certain fish such as striped bass travel through numerous habitat types along with daily tidal fluctuations (Tupper and Able, 2000). They may utilize low and high marsh channels during flood tides to areas where food is available in higher abundance, and then move back into deeper water and channels with the ebb tide. Adult migratory fish species exhibit this behavior throughout estuarine habitats and utilize numerous types of intertidal habitat types.

Many species of estuarine-dependent fish (fish species that spend some stage of life history within an estuary) exist within the study area. Estuarine-dependent species that comprise the majority of the ecologically, recreationally, and commercially important fisheries include Atlantic menhaden, weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), northern kingfish (*Menticirrhus saxatilis*), silver perch (*Bairdiella chrysoura*), bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*) and winter flounder (Beccasio et al., 1980).

Species known to utilize estuaries along the Atlantic Coast of New Jersey include summer flounder (*Paralichtys dentatus*), black sea bass (*Centropristis striata*), striped bass, bluefish, winter flounder, tautog (*Tautoga onitiss*), weakfish, scup (*Stenotomus chrysops*), white perch, and Atlantic menhaden. In a study conducted at Peck Beach, 178 species of saltwater fishes were recorded. Of these, 156 were from the nearshore waters. Of the 124 species recorded in nearby Great Egg Harbor Inlet, 28 are found in large number in offshore waters. Eighty seven species were found in the nearshore-ocean, bay and inlets adjacent to Peck Beach. Of these, 46 were located in the near shore waters. Sixty-two species were identified in Great Egg Harbor Inlet (USACE, 1989; USACE 2001).

During a comprehensive baseline finfish survey of the Hereford Inlet estuary of Cape May County (an area characterized by shallow sounds and extensive saltmarshes), a total of 105 species were collected within the tidal marsh embayment (Allen et al., 1978). Species collected in more than 10 percent of samples included bay anchovy (*Anchoa mitchilli*), sheepshead minnow (*Cyprinodon variegatus*), mummichog (*Fundulus heteroclitus*), striped killifish (*Fundulus majalis*), Atlantic silverside (*Menidia menidia*), tidewater silverside (*Menidia beryllina*), northern pipefish (*Syngnathus fuscus*), black sea bass, bluefish, spot, white mullet (*Mugil curema*), smallmouth flounder (*Etropus microstomus*), summer flounder, windowpane (*Scophthalmus aquosus*), and winter flounder.

Man-made structures within the study area such as groins and jetties add more habitat diversity within the study area for finfish. Juvenile and larval finfish such as black sea bass, summer flounder, winter flounder, and striped bass utilize these areas for feeding, protection from predators, and nursery habitat. However, extensive development in the New Jersey Back Bay communities has resulted in degraded fish habitats where shallows including SAV beds, saltmarshes, and tidal flats have been significantly altered or lost due to dredging, bulk heading, revetments and other alterations along the NJBB shorelines.

The economic importance of New Jersey's marine fisheries are well documented. For 2012, it was estimated that the total economic impact of recreational fishing in New Jersey totaled over $1.1 billion (NMFS 2014). Fourteen recreational species of interest were identified by the New Jersey Department of Environmental Protection (NJDEP), including; scup, black sea bass, summer flounder, weakfish, bluefish, striped bass, red hake (*Urophycis chuss*), silver hake (*Merluccius bilinearis*), Atlantic mackerel (*Scomber scombrus*), Atlantic croaker, winter flounder, cunner (*Tautogolabrus adspersus*), Atlantic cod (*Gadus morhua*), and tautog.

Fifteen commercial species of fish generated over $1 million of revenue each in 2014 (NOAA 2015). In total, commercial landings in New Jersey were valued at $151,930,102 in 2014. Some of the highest grossing species include sea scallop (*Placopecten magellanicus*), Atlantic surf clam

(*Spisula solidissima*), blue crab, longfin squid (*Doryteuthis pealeii*), skates, menhaden, summer flounder, scup, and black sea bass.

Essential Fish Habitat

Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act, (PL 94-265 as amended through October 11, 1996 and 1998) as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity”. Regulations further clarify EFH by defining “waters” to include aquatic areas that are used by fish and may include aquatic areas that were historically used by fish where appropriate. A purpose of the act is to “promote the protection of essential fish habitat in the review of projects conducted under federal permits, licenses, or other authorities that affect, or have the potential to affect such habitat”. An EFH assessment is required for a federal action that could potentially adversely impact essential fish habitat.

Managed fish species are those species that are managed under a federal fishery management plan. Managed fish species for New Jersey are listed in the Guide to Essential Fish Habitat Designations in the Northeastern United States Volume IV prepared by the National Oceanographic and Atmospheric Administration (NOAA, 1999). This guide is often used to evaluate the fish species that might be adversely affected by proposed developments within a project area. The coastal estuarine habitats of the project area have been designated as habitat for a number of managed species and their specific life history stages of concern. Some specific species and life stages that are designated for EFH in the New Jersey Inland Bays include summer flounder (larvae through adult), scup (juvenile), black sea bass (juvenile and adult), bluefish (juvenile and adult), and juvenile butterfish (NOAA, 1999).

EFH assessments also examine the potential effects on prey species for the managed fish species potentially occurring within the area. Prey species are defined as being a forage source for one or more designated fish species. They are normally found at the bottom of the food web in a healthy environment. Prey species found in the project area estuaries include killifish, mummichogs, silversides and herrings.

Federally managed fish species that may be found within the project area are listed in Table 5. Several of these species including the highly migratory species primarily inhabit marine offshore habitats throughout their lives and are not of major concern since they are largely outside of the project area. The remaining fish species can be found within inshore habitats during at least part of their life cycle. Not all areas of the New Jersey Back Bays are EFH for the species in Table 5. An “X” only indicates EFH present within one or more areas within the NJBB study area.

Table 5: NJBB EFH Life Stages Identified in EFH Mapper

Managed Species	Eggs	Larvae	Juveniles	Adults
Mid-Atlantic Species				
Atlantic butterfish *(Peprilus tricanthus)*	X		X	X
Atlantic mackerel (*Scomber scrombrus*)	X			
Atlantic surfclam *(Spisula solidissima)*			X	X
Black sea bass *(Centropristus striata)*			X	X
Bluefish *(Pomatomus saltatrix)*			X	X
Short finned squid *(Illex ilecebrosus)*	X	X		

Managed Species	Eggs	Larvae	Juveniles	Adults
Long finned inshore squid *(Loligo pealei)*	X		X	X
Scup *(Stenotomus chrysops)*			X	X
Spiny dogfish *(Squalus acanthias)*			X	X
Summer flounder *(Paralicthys dentatus)**HAPC***		X	X	X
New England Species*				
Atlantic cod *(Gadus morhua)*	X	X		
Ocean pout *(Macrozoarces americanus)*	X			X
Pollock (*Pollachius virens*)		X		
White hake (Urophycis tenuis)	X			
Windowpane flounder *(Scopthalmus aquosus)*	X	X	X	X
Winter flounder (*Pleuronectes americanus*)** ****EFH for winter flounder does not occur south of Lat 39°22' N.**	X	X	X	X
Witch flounder (*Glyptocephalus cynoglossus*)	X			
Yellowtail flounder (*Limanda ferruginea*)	X	X	X	X
Silver hake/whiting (*Merluccius bilinearis*)	X	X	X	X
Red hake *(Urophycis chuss)*	X	X	X	X
Monkfish *(Lophius americanus)*	X	X		
Little skate (*Raja erinacea*)			X	X
Winter skate (*Raja ocellata*)			X	X
Clearnose skate (*Raja eglanteria*)			X	X
Atlantic sea herring (Clupea harengus)			X	X
Coastal Migratory Pelagic Species				
King mackerel *(Scomberomorus cavalla)*	X	X	X	X
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X
Cobia *(Rachycentron canadum)*	X	X	X	X
Highly Migratory Species				
Bluefin Tuna (*Thunnus thynnus*)			X	X
Skipjack Tuna (*Katsuwonus pelamis*)				X
Yellowfin Tuna (*Thunnus albacares*)			X	
Shark Species				
Managed Species	**Neonates**		**Juveniles**	**Adults**
Sand tiger shark *(Odontaspis taurus)*	X		X	X
Atlantic angel shark *(Squatina dumerili)*	X		X	X
Common thresher shark (*Alopias vulpinus*)	X		X	X
Dusky shark *(Charcharinus obscurus)*	X			
Sandbar shark *(Charcharinus plumbeus)*	X		X	X
Sandbar shark *(Charcharinus plumbeus)* ***HAPC***	**X**		**X**	**X**
Smoothhound shark (Mustelus mustelus)	X		X	X
Tiger shark *(Galeocerdo cuvieri)*			X	X
White shark *(Carcharodon carcharias)*	X		X	X
***Digital mapping and location queries were unavailable, maps in NEFMC (2017) were utilized for life stage mapping of New England Fishery Management Species that occur in NJBB Study Area Waters**				

Habitat Areas of Particular Concern

As a subset of EFH, Habitat Areas of Particular Concern (HAPCs) are EFH habitats that are rare, stressed by development, provide important ecological functions for federally managed species, or are especially vulnerable to anthropogenic (or human impact) degradation. HAPCs represent high priority areas for conservation, management, or research, are necessary for healthy ecosystems and sustainable fisheries, and are areas with greater focus, increased scrutiny, study, or mitigation planning (https://www.fisheries.noaa.gov/news/habitat-areas-particular-concern-within-essential-fish-habitat accessed on 1/2/2019). There are HAPC for sandbar shark in parts of the NJBB study area, including Ocean City, and Cape May. SAV beds are HAPCs for summer flounder within the NJBB areas.

Shellfish

Extensive shellfish beds, which fluctuate in quality and productivity, are found in the back bays and shallow marine waters of the study area. Atlantic surfclams, hard clams, blue mussels (*Mytilus edulis*) and blue crabs are common commercial and recreational shellfish within the coastal waters of the study area. Additionally, the soft clam (*Mya arenaria*), bay scallop (*Aequipecten irradians concentricus*) and Eastern oyster (*Crassostrea virginica*) are also found at certain locations within the study area. The blue crab and the hard clam are two of the most important invertebrates of recreational and commercial value along the New Jersey Coast, and are common in the back bays and inlets (USACE 1999).

Hard clams are typically found in the intertidal and subtidal zones of bays and lower estuaries. Shellfish distribution maps from 1963 (USFWS, 1963) demonstrate historic widespread occurrences of hard clams at various commercial and recreational densities throughout all of the study area. Subsequent commercial and recreational shellfish surveys have been performed by the Bureau of Shellfish in the mid 1980's and 2011-2012 centered in Little Egg Harbor, Barnegat Bay and the Manasquan River. The Barnegat Bay Partnership (BBP, 2016) reported from NJDEP Bureau of Shellfish surveys in 2011 and 2012 that there was an estimated standing stock of hard clams in Barnegat Bay and Little Egg Harbor of 224 million clams, which was down about 23% from surveys done in 1985/1986 (although there was a modest increase in Little Egg Harbor from a survey done in 2001). Based on the overall decline in hard clam stocks, the BBP has assessed that the indicator status for shellfish in Barnegat Bay as "degraded".

Shellfish Growing Waters

N.J.A.C. 7:12 provides rules for NJDEP to implement procedures to classify shellfish waters and their boundaries in order to protect the health, safety, and welfare from the risks associated with the consumption of shellfish. Classifications of shellfish waters were developed in accordance with the National Shellfish Sanitation Program (NSSP), a Federal/State cooperative program, guidelines. A number of factors determine the classification of shellfish waters that include ambient bacteriological water quality and point and non-point pollution sources. The classifications are: Approved, Conditionally Approved, Conditionally Restricted, Restricted, Prohibited, and Suspended. The NJBB study area includes a broad geographic area including Atlantic Ocean waters, large and small bays, and tidal creeks with surrounding variable land uses that have point and non-point discharges, and marinas that would result in variable shellfish growing water classifications. These classifications are summarized by reach/unit in Table 6.

Invertebrates

The coastal habitats along the New Jersey coast including the back bays are home to a wide variety of both benthic and free swimming and floating invertebrates. Invertebrate groups found in various coastal habitats include Cnidaria (hydra, corals, anemones, jellyfish), Platyhelminthes (flatworms), *Nemertinea* (ribbon worms), Nematoda (roundworms), Polychaetes (bristle worms), Oligochaetes, *Bryozoa*, Mollusca (chitons, bivalves, snails, squids, etc.), Crustaceans (crabs, shrimp, amphipods), insects (Dipterans), Echinodermata (sea urchins, sea cucumbers, sand dollars, starfish), Urochordata (tunicates), and zooplankton, which may represent a number of different phyla at various life stages.

Benthic macroinvertebrate communities are commonly used as indicators of overall quality of water and benthic habitats. Indices measuring such parameters as abundance and species composition are well developed and often used in describing quality of habitats and also the potential food sources for higher consumers. In particular, benthic invertebrates make up the primary food source for both juvenile and adult fish species in shallow water environments found in estuarine habitats. Benthic invertebrate communities vary spatially and temporally (NOAA, 1994) as a result of factors such as sediment type, water quality, depth, temperature, predation, competition, and season. Thus, benthic invertebrate communities differ between habitat types. For example, the community within fine grain sediment found in a deep water, low energy environment is likely to be dominated by a higher percentage of sessile organisms, while a shallow, high energy environment consisting of larger grain sediment may contain a higher percentage of mobile filter feeding invertebrates. The New Jersey Back Bays are rich in benthic taxa. A recent benthic survey of the Barnegat Bay and Little Egg Harbor estuaries by Taghon *et* al. (2016) demonstrated a fairly diverse benthic community where they collected a total of 276 taxa of which 220 were infaunal taxa. However, five of these taxa made up 50% of the total abundance, which include polychaetes: *Mediomastus ambiseta and Streblospio benedicti;* amphipods*: Ampelisca abdita and A. verrilli*; and Oligochaeta*.*

Shallow water intertidal areas consisting of habitats such as high salt marshes, low salt marshes, mudflats, and common reed dominated estuarine wetlands provide habitat for benthic invertebrate groups that are tolerant of a continuously changing environment such as *oligochaetes*, *polychaetes*, and nematodes. These habitats are frequently inhabited by the fiddler crab (*Uca spp*.), salt marsh snail (*Melampus bidentatus*), and ribbed mussels (*Geukensia demissus*). Other groups of benthic invertebrates that inhabit these habitats include ceratopogonids, nematodes, chironomids (mosquitos), tabanids (green head flies), mites, ostracods, isopods, and gastropods. High marsh habitats that are rarely affected by tidal influence generally contain lower abundances of aquatic invertebrates and a higher proportion of terrestrial taxa as a result. By comparison, habitats such as low saltmarsh and mosquito ditches are inundated most of the time and are home to a higher abundance of aquatic organisms. Similarly, the benthic macro invertebrate community may differ between vegetation types, such as within high marsh habitats dominated by common reed (*Phragmites*) vegetation versus low marsh habitat dominated by *Spartina alterniflora*. For example, low marshes dominated by *Spartina alterniflora* were shown to have greater abundance and species composition than high marshes dominated by *Phragmites* (Able, 2000; Angradi et. al., 2001).

Other benthic invertebrates common to estuarine and marine habitats within the New Jersey coast include mollusks such as bay scallop, hard clam, common blue mussel, and Eastern oyster; crustaceans such as common rock crab (*Cancer irroratus*), blue crab, snapping shrimp (*Crangon septemspinosa*), and grass shrimp (*Palaemontes spp*.); and an echinoderm: sea stars (*Asterias forbesi*).

Table 6: Shellfish Growing Water Classifications in NJBB Study Area

			Classifications					
Unit	**Reach**	**Growing Area (acres)**	**Approved**	**Condition-ally Approved**	**Restricted (no harvest for direct market)**	**Pro-hibited**	**Sus-pended**	**Notes**
Atlantic Ocean								
AON C	Monmouth Beach to Bayhead	46,664	68.5%			31.5%		A number of discharge pipes and outfalls of six wastewater treatment facilities are responsible for “prohibited” areas that also act as buffers for dilution.
AOCE	Bayhead to Beach Haven Terrace	78,443	91.5%			8.5%		A number of discharge outfalls of three wastewater treatment facilities are responsible for “prohibited” areas that also act as buffers for dilution.
AORE	Beach Haven Terrace to Absecon Inlet	38,549	100%					This area does not contain any actual or potential pollution sources.
AOS O	Absecon Inlet to Cape May Point	109,860	87.1%			12.9%		Four discharge outfalls for six wastewater treatment facilities are responsible for “prohibited” areas that also act as buffers for dilution.
Barnegat Bay								
BB1	Northern Barnegat Bay (from Seaside Hts. to Bay Head)	11,000	39.3%	9% (Nov-Apr)	39.1%	12.6%		Waters of N. Barnegat Bay, Metedeconk River, Beaver Dam Ck, Cedar Bridge Ck, & N. Branch Ck. Bordered by Brick Twp., Bay Head, Mantoloking, Lavallette, Point Pleasant, Seaside Hts, Berkeley Twp., and Toms River.
BB2	Central Barnegat Bay – Toms River, Cedar Creek.	14,000	67.5%	7.5% (Nov-Apr)	14.3%	10.6%		Waters of Central Barnegat Bay, Toms River, Cedar Ck and Tributaries. Bordered by Seaside Pk., Seaside Hts., Island Hts., S. Toms River, Beachwood, Pine Beach, Ocean Gate, Berkeley Twp., and Lacey Twp.
BB3	Barnegat Inlet Area	40,062	82.7%	11.4% (Nov-Apr)	3.7%	2.2%		Waters of Barnegat Bay, Westecunk Creek, Dinner Pt. Ck., Mill Ck., Big Flat Ck., Double Ck., Oyster Ck. & Forked River. Bordered by Eagleswood, Stafford, Barnegat Ocean Township, Forked River, Long Beach Twp., Barnegat Light, Harvey Cedars, Surf City and Ship Bottom.
BB4	Southern Barnegat Bay	13,552	94.1%	3.7% (Nov-Apr)	0.7%	1.5%		Waters of S. Barnegat Bay, Little & Big Sheepshead Ck, Jimmies Ck, Little Thoro, Big Thoro, Tuckerton Ck, Jeremy Ck, Thompson Ck, Jesses Ck, and Parker Run. Bordered by Long Beach Twp., Beach Haven, Little Egg Harbor, Tuckerton and Eagleswood Twp.
Northeast Waterbodies								
NE4	Shark River	800			66.7%		33.3%	All waters are restricted in Shark River with 266.7 acres of this area designated as “suspended” due to consistent data that indicate fecal coliform standards for Restricted are not met.
NE5	Manasquan River				55%	45%		Waters are prohibited upstream of the Rt. 70 Bridge across the Manasquan River and waters of Point Pleasant Canal, Lake Louise, The Glimmer Glass Bay, and Stockton Lake. Restricted waters are downstream of Rt. 70 through to the inlet.
Southeast Waterbodies								

			Classifications					
Unit	Reach	Growing Area (acres)	Approved	Condition-ally Approved	Restricted (no harvest for direct market)	Pro-hibited	Sus-pended	Notes
SE1	Mullica River - Great Bay	17,932	72.8%	3.6% (Nov-Apr) 0.1% (Jan-Apr)	21.3%	2.2%		Waters of Great Bay and Mullica River. Tributaries include Roundabout Ck, Ballanger Ck. Big and Little Sheepshead Ck., Jimmies Ck, Little Thorofare, Motts Ck and Oyster Ck. Borders Galloway Twp., Port Republic City, Egg harbor City, Mullica Twp., Bass River Twp. and Little Egg Harbor Twp.
SE2	Reeds Bay - Absecon	14,343	86.6%	3.5% (Nov-Apr) 2.6% (Jan-Apr)	6.7%	0.6%		Waters of Absecon Bay, Reeds Bay, Little Bay, Grassy Bay, Absecon Channel, Brigantine Channel, Beach Thorofare, Bonita Tideway and St. George Thorofare. Borders Atlantic City, Brigantine City, Galloway Twp.,
SE3	Lakes Bay	15,140	50.3%	14.2% (Nov-Apr) 3.2% (Jan-Apr)	24.6%	7.7%		Waters of Lakes Bay, Shelter Island Bay, Scull Bay, Great Egg Harbor Bay and Peck Bay including tributaries of Great Egg Harbor River, Patcong Ck and Tuckahoe River.
SE4	Corson Sound - Ludlam Bay	1,408	72.2%	17.0% (Nov-Apr)	2.7%	2.5%		Waters of Peck Bay, Crook Horn Ck, Corson Sound, Corson Inlet, Upland Thoro., Beach Ck, Edward Ck, Devils Thoro., Weakfish Ck, Middle Thoro., Strathmere Bay, Ben Hands Thoro., Mill Ck, Marshalls Ck, Main Channel, Flat Ck, Burroughs Hole, Main Thoro., Whale Ck, and Run Ck. South of Ocean City, north of Sea Isle City, Upper Twp. and Dennis Twp. to west.
SE5	Ludlum Bay - Townsends Inlet	3,574	79.8%	3.0% (Nov-Apr) 1.1% (Jan-Apr)	9.1%	9.9%		Waters of Ludlam Bay, Townsends Sound, Stites Sound, Townsends Inlet, Devauls Ck, Maple Swamp, Big Elder Ck, Little Elder Ck, Swimming Ck, Ludlam Thoro, Sunks Ck, Mill Ck, Scraggy Ck, Ware Thoro, Mill Thoro, Townsend Channel, Clem Thoro, Granny Creek, Mud Thoro, Jonadab Ck, Uncle Aarons Ck, Kitts Thoro, Bottle Ck, Middle Thoro, North Channel, South Channel, Leonard Thoro, Ingram Thoro, Gravens Thoro, Cornell Hbr, Pennsylvania Hbr, Princeton Hbr, S Ck, Deep Ck, Rachael Gut, Salt Ck, Cat Run, Deep Thoro, and Paddy Thoro. Uppr Twp., Sea Isle City/Avalon, and Dennis/Middle Twp.
SE6	Hereford Inlet and Jenkins – Richardson Sound	7,083	42.1%	44% (Nov-Apr) 0.02% (Jan-Apr)	2.2%	11.8%		Waters of Great Sound, Jenkins Sound, Grassy Sound, Richardson Sound, Hereford Inlet, Gull Island Thoro, Cresse Thoro, Scotch Bonnet Ck, Nicols Channel, Dung Thoro, Drum Thoro, Jenkins Channel, Great Channel, Grassy Sound Channel, Old Turtle Thoro, and Taugh Ck. Avalon, Stone Harbor, N.& W. Wildwoods, & WW.
SE7	Sunset Lake to Cape May Harbor	2,525		24.8% (Jan-Apr)	31.7%	43.5%		Waters of Taylor Sound, Sunset Lake, Jarvis Sound, the Cape May Canal, Cape May Hbr, Cape May Inlet, Richardson Channel, Grassy Sound Channel, Shaw Cutoff, Sedge Ck, Stites Ck, Stingaree Ck, Swain Channel, Taylor Ck, Terrapin Thoro, Jones Cr, Old Turtle Ck, Jarvis Sound Thoro, Reubens Thoro, Punyard Ck, Haulover Ck, York Ck, Meadow Ck, Shell Thoro, Upper Thoro, Bennett Ck, Mill Ck, Skunk Sound, Ford Ck, Middle Thoro, Duck Gut, Mud Hen Gut, Lower Thoro, Old Lower Thoro, Schellenger Ck, Spicer Ck, and Cape Island Ck. WW & WW Crest, Lwr. Twp. and Cape May.
Source: https://www.nj.gov/dep/bmw/nsspreports.html								

The horseshoe crab (*Limulus polyphemus*) is a common, yet important, invertebrate inhabiting the New Jersey Back Bays and nearby Atlantic Ocean waters. Although its numbers do not reach those found in the Delaware Bay, horseshoe crabs migrate from offshore waters to sandy beaches in the bays to lay their eggs near the water's edge. The eggs of the horseshoe crab provide a critical food source for migratory shorebirds during their annual spring migrations to their breeding grounds in the Arctic. Horseshoe crabs are also important for the pharmaceutical industry because their blood contains a substance call Limulus amebocyte lysate, which has clotting properties when bacteria are present, thereby very useful for testing for contamination of drugs and medical equipment. Additionally, horseshoe crabs have been valuable as bait for conch and eel fishermen. Populations of horseshoe crabs have experienced recent and serious declines, which also correlate with declines in shorebird population prompting resource agencies to implement immediate conservation measures to protect this species.

Other specialized habitats such as rock piles, jetties, bulkheads, pilings, and sunken debris have invertebrate communities dominated by sponges, hydroids, and barnacles. These invertebrates may act as food sources for both juvenile and adult fish species that also utilize vertical cover and niche habitat provided by the larger substrates that make up these habitats.

Special Status Species

Federally Listed Species

Seabeach amaranth (*Amaranthus pumilus*) is a Federally listed threatened plant. The seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beaches, and primarily occurs on over wash flats at the accreting ends of barrier beach islands and lower foredunes of non-eroding beaches. The species occasionally establishes small temporary populations in other areas, including bayside beaches, blowouts in foredunes, and sand and shell material placed as beachfill. Seabeach amaranth was found in New Jersey in 2000, after being absent from the state for over 80 years. In 2002, over 10,000 plants were present in the state, with the majority being found along the beaches in Monmouth County. Since that time, numbers in the state have been steadily declining with numbers dropping below 1,000 plants.

The Federally listed (threatened) and state listed (endangered) piping plover (*Charadrius melodus*) has historically nested along coastal beaches and inlets within the study area. Piping plover nests can be found above the high tide line on coastal beaches, on sand flats at the ends of sand spits and barrier islands, on gently sloping foredunes, in blowout areas behind primary dunes, and in washover areas cut into or between dunes. Plovers generally start to return to New Jersey in March with eggs being present on the beach as early as April. The nesting season generally concludes by mid-August once all chicks have fledged. Food for adult plover and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, or mollusks. Feeding areas include intertidal portions of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic material left behind by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

The federally threatened, rufa red knot (*Calidris canutus rufa*,) can be found in lower densities during the spring and fall migrations along Atlantic Coast beaches, and could occur within the project area. Red knots are also federally protected under the Migratory Bird Treaty Act and are listed as endangered by the State of New Jersey. Threats to the red knot include sea level rise; coastal development; shoreline stabilization; dredging; reduced food availability at stopover areas; disturbance by vehicles, people, dogs, aircraft, and boats; and climate change. Red knots typically occur in New Jersey during their annual spring and fall migration. Small numbers of red knots may occur year-round in New Jersey, whereas large numbers rely on New Jersey's coastal stopover habitats during the spring (mid-May through early June) and fall (late-July through November) migration periods (USFWS 2015). In wintering and migration habitats, red knots may forage on bivalves, gastropods, and crustaceans (USFWS 2013; Harrington 2001).

Portions of the project area have the potential to serve as fall migratory stopover habitat for the red knot. During the fall migration, the red knot typically spends time foraging and resting within and above the intertidal zone. In 2014, the US Army Corps of Engineers (Corps) contracted a red knot survey along the coast of New Jersey to aid in identifying areas frequented by red knots during the fall migration. A total of 31 one-mile transects were surveyed over 7 survey events from September to November of 2014. Only 20 red knots were observed during the surveys and those birds were only found in 3 of the transects. The survey report concluded that, overall, the results of the 2014 surveys indicated a low usage of the Corps Philadelphia beach nourishment Project Areas by red knots during the survey period (late September to late November). None of the transect surveys identified high concentrations of red knots using any part of the Project Areas as a focal point for foraging, roosting, or migration during the survey period.

On January 13, 2016, the U.S. Fish and Wildlife Service listed the northern long-eared bat (*Myotis septentrionalis*) as threatened under the Endangered Species Act (ESA). In an effort to conserve the northern long-eared bat, the U.S. Fish and Wildlife Service is using flexibilities under section 4(d) of the ESA to tailor protections to areas affected by white-nose syndrome during the bat's most sensitive life stages. The rule is designed to protect the bat while minimizing regulatory requirements for landowners, land managers, government agencies and others within the species' range. In areas of the country impacted by white-nose syndrome, incidental take is prohibited if it occurs within a hibernation site for the northern long-eared bat. It is also prohibited if it results from tree removal activities within a quarter-mile of a hibernaculum or from activities that cut down or destroy known occupied maternity roost trees, or any other trees within 150 feet of that maternity roost tree, during the pup-rearing season (June 1 through July 31). Occupied roost trees may be removed when necessary to address a direct threat to human life and property. In other cases, a permit for incidental take may be needed. Intentionally harming, harassing or killing the northern long-eared bat is prohibited throughout the species' range, except for removal of northern long-eared bats from human structures, and when necessary to protect human health and safety.

The National Marine Fisheries Service (NMFS) has jurisdiction over four (4) Federally-designated sea turtles: the endangered leatherback (*Dermochelys coriacea*), Kemp's Ridley (*Lepidochelys kempii*), and green (*Chelonia mydas*) sea turtles, and the threatened loggerhead (*Caretta caretta*) sea turtle. These sea turtles may be found in New Jersey's continental shelf waters, inshore bays and estuaries from late spring to mid-fall. Sea turtles feed primarily on mollusks, crustaceans, sponges and a variety of marine grasses and seaweeds. The endangered leatherback sea turtle may forage on jellyfish, as well. The northern diamondback terrapin (*Malaclemys terrapin terrapin*) is a Federal Category 2 candidate species that occupies shallow bay waters, and nests on the sandy portions of bay islands as well as the barrier islands themselves. The diamondback terrapin is considered a candidate species, as its nesting habitat is dwindling.

The New York Bight population of the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) was recently listed as endangered by the NMFS. Atlantic sturgeon are anadromous, spending a majority of their adult life phase in marine waters, migrating up rivers to spawn in freshwater then migrating to brackish water in juvenile growth phases. The Atlantic sturgeon are known to spawn within the Delaware River and migrate along the coast of New Jersey, although the extent of the use of marine habitat by Atlantic sturgeon is not fully known. This species could be present within the project impact area. Studies have indicated that depth distribution appears seasonal, with sturgeon inhabiting the deepest waters during the winter and the shallowest during summer and early fall.

Species of Concern listed by NMFS, and associated area of concern include the anadromous and highly migratory river herring (alewife and blueback herring) found in the Atlantic Ocean from Newfoundland to North Carolina, the pelagic and highly migratory Atlantic bluefin tuna found throughout the North Atlantic Ocean and adjacent seas, the Atlantic halibut found from Labrador to southern New England in the Northwest Atlantic Ocean, the dusky shark found in the Western Atlantic Ocean, the porbeagle shark found in the Northwest Atlantic Ocean, the anadromous rainbow smelt found in rivers and coastal areas of eastern North America from Labrador to New Jersey, and the sand tiger shark found in the Western Atlantic Ocean (http://www.nmfs.noaa.gov/pr/species/concern/).

State Listed Species

A variety of State-listed endangered and threatened species inhabit the beaches and marshes of the project area. Several birds-of-prey occur in the vicinity of the project area including the State-listed endangered Cooper's hawk, and the State-listed threatened northern goshawk *(Accipiter gentilis),* red-shouldered hawk, barred owl *(Strix varia),* and longeared owl *(Asia otus)* (USACE 1999).

Nesting populations of the State listed endangered northern harrier (*Circus cyaneus*) and black rail (*Laterallus jamaicensis*) nest in high emergent marshes. The State-listed endangered short-eared owl (*Asio flammeus*), and sedge wren (*Cistothorus latensis*) previously nested in Delaware bayshore marshes; however, their current breeding status in the project area is unknown. The State-listed threatened osprey (*Pandion haliaetus*) currently nests on trees, nesting platforms, and other structures within the project area. Nesting populations of the State-listed endangered sedge wren *(Cistothorus platens is)* occur in high emergent marshes.

The State-listed endangered least tern and black skimmer, and State-listed threatened yellow-crowned night heron utilize coastline habitats. Large colonies of State threatened least tern (*Sterna dougallii*), and black skimmer (*Rynchops niger*) use the Atlantic coast area along with any associated dunes (USACE 2002).

Coastal Lakes

The Coastal Lakes region of the study area is comprised of 16 freshwater/brackish water lakes. The lakes include: Lake Takanassee, Deal Lake, Sunset Lake, Wesley Lake, Fletcher Lake, Sylvan Lake, Silver Lake, Lake Como, Spring Lake, Wreck Pond, Stockton Lake, Glimmer Glass, Lake Louise, Little Silver Lake, Lake of the Lilies, and Twilight Lake. Most of the lakes have a connection to the ocean, but some are completely freshwater (Souza 2013). Eight of the lakes are non-tidal and eight are tidal whether on a tidal-cycle basis or just during storm conditions. Historically, most of the coastal lakes were estuaries (Souza 2013).

The Coastal Lakes region of the study is highly urbanized with very limited natural resources and many are considered eutrophic lakes (NJDEP 2013). The landscape defining the watersheds of the coastal lakes is primarily urban, and characterized by intensive residential and commercial development, which includes large contiguous swaths of impervious cover. Stormwater and runoff generated from these areas are a major contributor to lake pollution. As a result, the water quality of almost all the coastal lakes has declined dramatically resulting in a loss of aesthetic attributes and recreation opportunities (Tiedemann 2013). All were severely impacted by Hurricane Sandy in 2013 (Souza 2013). Impacts from the storm included: direct scouring, impaired water quality (contaminants), sediment deposition, and habitat alteration.

Specific information available for some of the individual lakes can be found below.

Wreck Pond

Ecological communities around the Wreck Pond area include sand beach, dunes, sandy shoals, tidal wetlands and open water. The tidal wetlands found within the study area provide valuable habitat for numerous aquatic and terrestrial species. Coastal marshes provide foraging and nesting habitat for waterfowl and wading birds, and spawning and nursery habitat to juvenile fish and shellfish. The beach, dune and sandy shoal communities provide habitat for shore nesting and foraging species, including migratory shore birds. The diverse mosaic of habitats in and around Wreck Pond makes it a significant coastal resource for many aquatic and terrestrial species including several state and federally listed threatened and endangered species. However, limited connectivity, poor water quality and sedimentation issues have led to habitat degradation in the pond's recent history (USACE 2016).

The Wreck Pond area has been known to be utilized by anadromous fish species, including alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and catadromous species such as the American eel (*Anguilla rostrata*). A fall fish survey conducted in 2014 by the American Littoral Society indicates that young of year alewife are present within the pond or its upstream reaches. In addition, the open water community is currently connected to the Atlantic Ocean via an outfall pipe. The aforementioned fish survey conducted in 2014 determined the presence of young of year alewife (*Alosa pseudoharengus*) within the pond and its upstream reaches, indicating that the outfall allows for some passage for migratory catadromous and anadromous fish species. In addition to alewife, the survey identified twenty-one other fish species, six crab species, two species of shrimp, one species of clam and one species of jellyfish that are all typically found in brackish and saline ecosystems within Wreck Pond (USACE 2016).

Wreck Pond is also included in the North Shore Coastal Ponds Complex Important Bird Area (IBA) designated by the National Audubon Society. IBA's are sites that support habitat necessary for breeding, overwintering or migration and the goal of the IBA Program is "to stop habitat loss by setting science-based priorities for habitat conservation and promoting positive action to safeguard vital bird habitats." Other coastal lakes that are also part of this IBA include: Stockton Lake, Wreck Pond, Spring Lake, Lake Como, Silver Lake, Fletcher Lake and Lake Takanassee. The National Audubon Society considers the North Shore Coastal Pond Complex as a breeding and foraging site for Least Terns and Piping Plovers and a wintering site for waterfowl species such as northern shoveler (*Anas clypeata*), American wigeon (*Anas Americana*), redhead (Aythya Americana), common goldeneye (*Bucephala clangula*), common merganser (*Mergus merganser*), brant goose (*Branta bernicla*) and American black duck (*Anas rubripes*) and gulls species including Bonaparte's (*Chroicocephalus philadelphia*), ring-billed (*Larus delawarensis*), herring (*Larus argentatus*), and great blackbacked (*Larus marinus*) (National Audubon Society 2016).

Lake Como, Spring Lake and Deal Lake

Lake Como and Spring Lake are relatively small water bodies (35.5 acres and 13.7 acres, respectively) in the same vicinity as Deal Lake and Franklin Lake along the coastline of Monmouth County. The watersheds of these lakes are highly urbanized and large relative to the size of the lakes (22.9 and 21.0 times the size of the lakes, respectively). The large urbanized watersheds of these lakes suppor the anecdotal evidence from local sampling programs that indicates these two water bodies are impaired due to eutrophication (NJDEP 2003).

Deal Lake is a large, dendritic water body (155 acres) in Monmouth County with a shape reminiscent of a four-legged octopus. Four tributaries join into two larger ones. The lake originated through flooding of the gradually sloping coastal lowlands, and is separated from the Atlantic Ocean by a flume structure that permits lake outflow but prevents tidal inflow. The watershed is 26 times the area of the lake. Average depth is measured at 5.3 feet, with a range of up to 9 feet in the main basin. Total volume is estimated at 1,020,000 m^3, with total annual inflow estimated at 10,000,000 m^3/yr. Hydraulic retention time of the lake is approximately 37 days. The 3,990-acre watershed incorporates portions of Asbury Park City, Interlaken Boro, Allenhurst Boro, Loch Arbour Village, Deal Boro, Ocean Township, and Neptune Township (NJDEP 2003).

As of 1986, at least 135 storm drains empty directly into Deal Lake. Samples taken in 1986 and tested for fecal coliform and nitrates revealed that 5 of these drains contained sewage. One source was traced back to a house built in the 1950's with its lateral sewer line mistakenly connected into the storm drain. Other possibilities include pet waste washed in during rain events as well as infiltration from sewer main overload. In addition, 39 of the 135 storm drains were flowing constantly in 1986. There are still a few small wetland areas scattered throughout the watershed, as well as some few remaining patches of forest; but the great majority of the land has been developed as either medium-to-high density residential with landscaping or commercial. Municipal and educational facilities are interspersed throughout the watershed. The educational complexes include multiple athletic fields. Two landfills exist within the watershed, as do one 9-hole and major portions of two 18-hole golf courses (NJDEP 2003).

There are some springs located at the headwaters of some tributaries, but they are not believed to be the major source of water. Runoff volume is considerable, mostly from the extensive labyrinth of storm sewers, with some overland flow directly to the lake. Lake use no longer includes swimming, but as with any coastal community the potential is there. Boating and fishing are the primary activities that take place currently in the lake (NJDEP, 2003).

Water Quality in Lakes

Benthic sampling involving the collection of sediment data, supporting in-situ water quality and benthic infauna samples from Wreck Pond and Deal Lake, approximately eight miles north of Wreck Pond, was conducted in 2014. Deal Lake was used as the reference waterbody for this study. All sampling stations within Wreck Pond were taken within the tidally influenced portion of the pond as were all of the Deal Lake sampling stations (USACE 2016).

Sediment samples taken in Wreck Pond primarily consisted of organic sand/silt while Deal Lake was comprised of an organic rich, reduced silty material. Based on water quality samples, Wreck Pond had a higher specific conductance and salinity, and is more affected by tidal inflow than Deal Lake; thus making it more of a saline ecosystem. Both water bodies had pH and dissolved oxygen levels considered supportive of a variety of fish and benthic species (USACE 2016).

The benthic community within Wreck Pond is dominated by a variety of marine worms (*polychaetes*) with the majority comprising of tube building deposit feeders (*Nereidae*, *Lumbrineridae* and *Spionidae*). The predominance of these species is conducive to the organic sandy/silt composition of the pond's sediments. Ostracods, a type of crustacean, were also fairly common, being collected in six of the eight samples. Very few clams (*Gemma gemma*) were collected. The propensity of polychaetes and ostracods in Wreck Pond indicates that Wreck Pond is brackish in nature which is supported by the in-situ water quality data (USACE 2016).

The benthic community within Deal Lake was dominated by pollutant tolerant organisms (that is organisms capable of existing under anoxic, environmentally stressed conditions). In addition, the invertebrate community was found to be far less diverse and in many samples, much lower total numbers than samples collected from Wreck Pond.

Furthermore, the Deal Lake benthic assemblage was represented by a greater number of pollution tolerant species and by a fewer number of mollusks and ostracods (USACE 2016).

Thus, the benthic community of Wreck Pond was determined to be more robust and representative of a less stressful environment than the benthic community of Deal Lake. The primary factors that appear responsible for these differences are the more reduced nature of the Deal Lake sediments, the sandier nature of the Wreck Pond sediments, and the greater rate of tidal exchange and overall volumetric flushing of Wreck Pond as compared to Deal Lake (USACE 2016).

Recreational Resources

Recreation and ecotourism services provided by the New Jersey Inland Bays, and adjacent marshes and beaches are a huge draw for tourism in the region. The New Jersey Back Bays support a number of sites with recreational bathing beaches along bayshores, inlets, and tidal rivers. Over 25 bathing beach locations in the back bays are monitored by local health departments for recreational beach water quality, which is reported to the NJDEP who issues beach advisories or closings if bacterial criteria are exceeded. Fishing is typically conducted along shoreline areas particularly where access to the water is available. Recreational fishing boats launch from private and public marinas and docks nearby to fish in deeper parts of the bays and creeks. Anglers in the back bays and tidal creeks typically target summer flounder (fluke), winter flounder, weakfish, bluefish, striped bass, kingfish, white perch and tautog. Other popular recreational activities in the back bays include clamming (hard clams), crabbing (blue crabs), hunting (waterfowl), sailing, boating, water skiing, jet skiing, paddling (canoes, kayaks, stand-up paddle boards), windsurfing, and birdwatching.

Visual Resources and Aesthetics

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. The New Jersey Back Bays contain extensive natural tidal marshlands and islands, tidal creeks and “guts”, and open-water embayments and lagoons on both the mainland (west side of the bays) and also along the western edges of some of the barrier islands. Likewise, the study area also contains heavily urbanized areas consisting of developed shorelines composed of homes, condominiums, businesses, marinas, boat ramps, some industrial activities, and power plants. Many of these developed shorelines include docks, wharves, and hardened shorelines with bulkheads, concrete revetments, and riprap.

Visual resources are the natural and man-made features that comprise the visual qualities of a given area, or “viewshed.” These features form the overall impression that an observer receives of an area or its landscape character. Topography, water, vegetation, man-made features, and the degree of panoramic view available are examples of visual characteristics of an area.

Visual resources can be subjective by nature, and therefore the level of a proposed project’s visual impacts can be challenging to quantify. Generally, projects that create a high level of contrast to the existing visual character of a project setting are more likely to generate adverse visual impacts due to visual incompatibility. Thus, it is important to assess a project’s effects relative to the existing conditions of the area.

Air Quality

The U.S. Environmental Protection Agency (EPA) adopts National Ambient Air Quality Standards (NAAQS) for the common air pollutants, and the states have the primary responsibility to attain and maintain those standards. Through the State Implementation Plan (SIP), The New Jersey Department of Environmental Protection – Division of Air Quality manages and monitors air quality in the state. The goal of the State Implementation Plan is to meet and enforce the primary and secondary national ambient air quality standards for pollutants. New Jersey air quality has improved significantly over the last 40 years, but exceeds the current standards for ozone (O_3) throughout the state. Fine particles (PM_{10} or $PM_{2.5}$) standards have been attained in NJ since 2012 using the 2006 24-hr fine particulate standard. Additionally, New Jersey has attained the sulfur dioxide (SO_2) (except for a portion of Warren County), lead (Pb), and nitrogen dioxide (NO_2) and carbon monoxide (CO) standards. The New Jersey Division of Air Quality also regulates the emissions of hazardous air pollutants (HAPs) designated by the U.S. EPA.

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 four highest daily maximum 8-hour average concentrations recorded each year for three years. For 2016, the design value is 0.070 ppm. The ozone attainment classification with respect to the 8-hour standard is shown in Figure 5. 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 entire state of New Jersey is in non-attainment and is classified as being either "Moderate" or "Marginal." Marginal classifications have been designated for counties in the Southern New Jersey – Pennsylvania-Delaware-Maryland Area, which include Ocean, Burlington, Atlantic, and Cape May Counties within the NJBB study area. Monmouth County is part of the Northern New Jersey-New York-Connecticut Area that have been reclassified from marginal to moderate non-attainment status in 2016 (NJDEP, 2017).

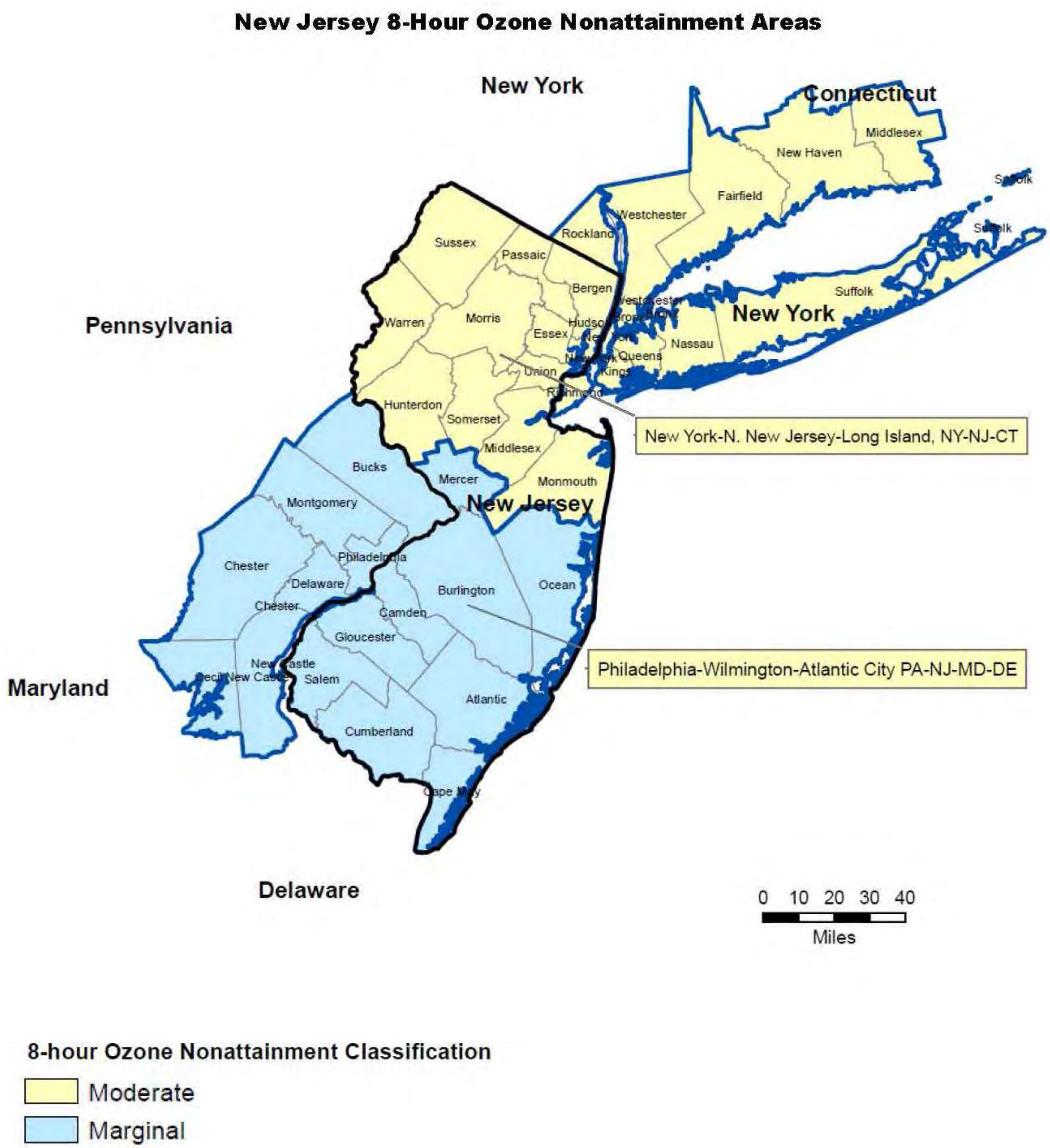

Figure 5: New Jersey Non-Attainment for Ozone (Source: NJDEP, 2017)

Greenhouse Gas Emissions

Greenhouse gases (GHGs) are gases that trap heat in the atmosphere. These emissions occur from natural processes and human activities. The accumulation of GHGs in the atmosphere can influence the earth's temperature. Predictions of long-term environmental impacts due to global climate change include sea level rise, changing weather patterns with increases in the severity of storms and droughts, changes to local and regional ecosystems including the potential loss of species, and a significant reduction in winter snow pack. Federal agencies are, on a national scale, addressing emissions of GHGs by reductions mandated in federal laws and EOs, most recently, EO 13423, *Strengthening Federal Environmental Energy, and Transportation Management*. The Council on Environmental Quality (CEQ) has issued final guidance to assist Federal agencies in their consideration of the effects of GHG emissions and climate change when evaluating proposed Federal actions in accordance with the National Environmental Policy Act (NEPA) and the CEQ Regulations Implementing the Procedural Provisions of NEPA (CEQ Regulations) (CEQ, 2016). This guidance recommends that when addressing climate change, agencies should consider: (1) The potential effects of a proposed action on climate change as indicated by assessing GHG emissions (e.g., to include, where applicable, carbon sequestration); and, (2) The effects of climate change on a proposed action and its environmental impacts. The CEQ guidance states: "it is now well established that rising global atmospheric GHG emission concentrations are significantly affecting the Earth's climate." In 1970, the mean level of atmospheric carbon dioxide (CO2) had been measured as increasing to 325 parts per million (ppm) from an average of 280 ppm pre-Industrial levels. Since 1970, the concentration of atmospheric carbon dioxide has increased to approximately 400 ppm (2015 globally averaged value). Since the publication of CEQ's first Annual Report, it has been determined that human activities have caused the carbon dioxide content of the atmosphere of our planet to increase to its highest level in at least 800,000 years (CEQ, 2016).

In the State of New Jersey, the New Jersey Global Warming Response Act of 2007 (GWRA), N.J.S.A 26:2C-37**,** establishes two GHG limits, one for 2020 and another for 2050. The GWRA requires two recommendations reports, one for each limit. The GWRA 2050 target requires New Jersey to reduce GHG emissions by 80 percent from 2006 levels by 2050. This limit is equivalent to 25.4 million metric tons (MMT) CO2 equivalent. The NJDEP has developed four scenarios to identify pathways to meet the GWRA target. In order to approach the 2050 GHG emission limit of 25.4 million metric tons, the following are a must: (a) energy efficiency measures for buildings, industry, and transportation; (b) electrification to avoid combustion wherever it is possible; (c) non-combustion electricity generating technology (e.g., renewables and nuclear); and (d) measures to increase and enhance natural sinks (NJDEP, 2016).

Climate and Climate Change

The NJBB area falls within the Coastal Zone, which is one of five climatic zones identified for the State of New Jersey. The New Jersey Atlantic Ocean coastal region experiences a moderate climate associated with the low elevations of the Coastal Plain and the presence of the large water bodies. Data obtained from the Office of the State Climatologist for 5 stations in the NJBB compiled from 1981-2010 are provided in Tables 7 and 8. The average annual temperature is approximately 54.6^{o}F. The monthly averages for the coldest months of January and February are about 33.8 and 35.8^{o}F, and the monthly averages for the warmest months of July and August range between 74.5^{o}F and 75.7^{o}F. Annual precipitation is approximately 42 inches that is evenly distributed throughout the year with monthly means ranging from 2.9 to 4.3 inches (NJ State Climatologist website retrieved on 2/24/2019 at http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html).

Table 7: New Jersey Back Bay Areas Monthly Temperature Range Normals (Deg F)

Mean Temperatures are in parentheses. Based on Data from 1981-2010													
STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
ATLANTIC CITY AP	24.5-41.5 (33.0)	26.4-44.3 (35.3)	32.7-51.8 (42.2)	41.8-61.7 (51.7)	51.0-71.3 (61.1)	61.2-80.6 (70.9)	66.9-85.5 (76.2)	65.2-83.7 (74.4)	57.4-77.0 (67.2)	45.6-66.6 (56.1)	37.2-56.3 (46.8)	28.4-46.0 (37.2)	44.9-63.9 (54.3)
ATLANTIC CITY MARINA	29.2-41.8 (35.5)	30.9-43.5 (37.2)	36.9-49.6 (43.3)	45.5-57.6 (51.6)	54.5-66.6 (60.6)	64.3-75.7 (70.0)	70.0-81.3 (75.6)	69.7-80.2 (75.0)	63.5-74.8 (69.1)	52.5-65.0 (58.7)	42.9-55.8 (49.4)	33.5-46.3 (39.9)	49.5-61.5 (55.5)
BRANT BEACH BECH HAVEN	26.2-41.1 (33.6)	28.2-42.7 (35.5)	34.1-49.1 (41.6)	42.8-57.5 (50.1)	52.7-67.7 (60.2)	62.3-76.9 (69.6)	69.0-83.4 (76.2)	68.2-82.4 (75.3)	61.8-76.1 (68.9)	50.5-65.9 (58.2)	41.0-55.6 (48.3)	31.5-45.4 (38.5)	47.4-62.0 (54.7)
CAPE MAY	27.9-42.3 (35.1)	29.2-44.3 (36.8)	35.2-51.4 (43.3)	43.8-60.8 (52.3)	52.7-70.4 (61.5)	62.5-79.4 (71.0)	67.7-84.5 (76.1)	66.8-83.4 (75.1)	60.7-77.8 (69.2)	49.9-67.1 (58.5)	41.1-56.8 (49.0)	31.9-46.8 (39.4)	47.5-63.8 (55.6)
TOMS RIVER	22.1-41.1 (31.6)	23.9-44.0 (34.0)	30.1-50.9 (40.5)	39.3-61 (50.2)	48.9-71.1 (60.0)	58.5-80.0 (69.2)	63.9-85.0 (74.5)	62.2-83.4 (72.8)	54.5-77.0 (65.7)	42.8-66.5 (54.6)	34.6-56.5 (45.5)	26.5-45.7 (36.1)	42.3-63.5 (52.9)
MEAN	(33.8)	(35.8)	(42.2)	(51.2)	(60.7)	(70.1)	(75.7)	(74.5)	(68.0)	(57.2)	(47.8)	(38.2)	(54.6)

Table 8: New Jersey Monthly Precipitation Normals (Inches)

Based on Data from 1981-2010													
STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
ATLANTIC CITY AP	3.2	2.9	4.2	3.6	3.4	3.1	3.7	4.1	3.2	3.4	3.3	3.7	41.8
ATLANTIC CITY MARINA	3.1	2.9	4.0	3.4	3.2	2.7	3.3	3.9	3.1	3.5	3.4	3.6	40.0
BRANT BEACH BECH HAVEN	3.3	2.9	4.0	3.3	2.8	3.1	3.9	3.7	2.8	3.7	2.9	3.4	39.5
CAPE MAY	3.3	2.8	4.3	3.5	3.5	3.4	3.7	3.6	3.3	3.7	3.3	3.5	41.9
TOMS RIVER	3.9	3.2	4.8	4.1	3.7	3.8	4.6	4.7	3.8	3.9	4.1	4.5	49.1
MEAN	3.4	2.9	4.3	3.6	3.3	3.2	3.9	4.0	3.2	3.6	3.4	3.7	42.4

Despite the historic moderate climate experienced within the Coastal Zone of New Jersey, the Earth's surface temperature has risen by 1.3 ^{o}F over the last century, which is attributed to the anthropogenic introduction of carbon dioxide and other greenhouse gases (NJDEP, 2013). In New Jersey, the New Jersey State Climatologist reports a statistically significant rise in average statewide temperature over the last 118 years. Also during this period, New Jersey has experienced a significant increase of the departure from normal indicating that average annual temperatures are consistently greater than the longer term average. This temperature trend coincides with an increase in precipitation due to more moisture in the atmosphere. However, despite a trend toward more precipitation, the Northeast is seeing longer periods without rainfall and longer growing seasons (NJDEP, 2013 and O'Neill, 2009).

As stated in NJDEP (2013): "Sea levels are rising at a rate of 3.5 millimeters per year (Cooper *et al.* 2005), and this rate is projected to increase into the 21st Century (Climate Institute 2010, UCS 2013). The global average of sea level rise is approximately 8 inches since the Industrial Revolution, but other areas of the world, particularly the East and Gulf Coasts are experiencing some of the highest rates of sea level rise (UCS 2013). Small increases in sea level dramatically affects the world's coastlines, physically, biogeochemically, and economically through impacts such as erosion, flooding, salinization, and habitat transformation for wildlife and plants (Climate Institute 2010, UCS 2013)."

Other impacts of climate change may include increased intensity of hurricanes; however, climate science projections for intensity and intense hurricane numbers suggest relatively large uncertainty at present (NOAA 2012). High magnitude storm events such as hurricanes and Nor'Easters could have extensive direct and indirect impacts to habitat, ranging from erosion from wave attack, salt water intrusion from inundation, as well as water quality impacts from developed areas experiencing inundation from floodwaters. Additionally, temporary and permanent impacts to habitat could occur across a broad temporal reference along the North Atlantic Coast. Some habitat areas could be exposed to different impacts based on the time of the year the storm occurs. Combined with sea level rise, extreme water levels may exacerbate coastal storm impacts to habitats over the long-term planning horizon (USACE 2014).

Climate change and Sea Level Rise are significant issues affecting coastal areas in New Jersey. Climate change has potential devastating ecological, economic and public health impacts in New Jersey (NJDEP, 2013 and IPCC, 2007). Executive Order 13653 on Preparing the United States for the Impacts of Climate Change was released 1 Nov 2013. EO 13653 contains very specific language, goals, and objectives to prepare the Nation for the impacts of climate change by undertaking actions to enhance climate preparedness and resilience. In response to this and other related Executive Orders, USACE has developed a comprehensive policy on climate change (USACE, 2015). It states in this document that: "It is the policy of USACE to integrate climate change preparedness and resilience planning and actions in all activities for the purpose of enhancing the resilience of our built and natural water-resource infrastructure and the effectiveness of our military support mission, and to reduce the potential vulnerabilities of that infrastructure and those missions to the effects of climate change and variability."

Noise

Noise is of environmental concern because it can cause annoyance and adverse health effects to humans and animal life. Noise can impact such activities as conversing, reading, recreation, listening to music, working, and sleeping. Wildlife behaviors can be disrupted by noises also, which can disrupt feeding and nesting activities. In heavily developed areas along the New Jersey coast, noises are common and can come in the form of restaurant and entertainment facilities, automobiles, boats, and recreational visitors. However, these communities impose local restrictive noise ordinances to minimize noise effects.

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by the human ear as well as most fauna. Noise is generally defined as loud, unpleasant, unexpected, or undesired sound that is typically associated with human activity and that interferes with or disrupts normal activities of humans and wildlife. The human environment is generally characterized by a certain consistent noise level that varies by area. This is called ambient, or background, noise. Although exposure to high noise levels has been demonstrated to cause hearing loss, the principal human response to environmental noise is annoyance. The response of individuals to similar noise events is diverse and influenced by the type of noise; perceived importance of the noise and its appropriateness in the setting; time of day and type of activity during which the noise occurs; and sensitivity of the individual. Wildlife near areas of human activity and associated noise react similarly. Boating noise can carry for long distances underwater, and disrupt the behavior of aquatic life for considerable distances from the source, depending on the size of and noise produced by marine engines (USACE, 2017).

The normal human ear can detect sounds that range in frequency from about 20 Hz to 20,000 Hz. However, all sounds in this wide range of frequencies are not heard equally well by the human ear, which is most sensitive to frequencies in the range of 1,000 Hz to 4,000 Hz. This frequency dependence can be taken into account by applying a correction to each frequency range to approximate the human ear's sensitivity within each range. This is called A-weighting and is commonly used in measurements of community environmental noise. The A-weighted sound pressure level (abbreviated as dBA) is the sound level with the “A-weighting” frequency correction. For aquatic life, the hearing range can be significantly different. All baleen whales (hearing range 7 Hz to 22 kHz), Odontocete species (hearing range 150 Hz to 180 kHz), Harbor porpoise (hearing range 200 Hz to 180 kHz16), Pinnipeds in water (hearing range 75 Hz to 75 kHz), and fish (hearing range 20 Hz to 1000 Hz) have a sensitivity to a wide range of sound. Reptiles tend to have a similar hearing range as fish, most bird species have a hearing range similar to humans, while many mammals can hear much higher frequencies than humans (USACE, 2017).

Changes in noise are typically measured and reported in units of decibels (dBA), a weighted measure of sound level. The A-weighted sound level (dBA) is a single number measure of sound intensity with weighted frequency characteristics that corresponds to human subjective response to noise (FHA, 2001). Noise ranging from about 10 dBA for the rustling of leaves to as much as 115 dBA (the upper limit for unprotected hearing exposure established by the Occupational Safety and Health Administration (OSHA, 2016)) is common in areas where there are sources of industrial operations, construction activities, and vehicular traffic (USACE, 2017). Common sounds encountered in outdoor settings are presented in Table 9.

Noise impacts result from perceptible changes in the overall noise environment that increase “annoyance” or affect human health. Human health effects such as hearing loss and noise-related awakenings can result from noise. “Annoyance” is a subjective impression of noise wherein people apply both physical and emotional variables. To increase “annoyance”, the cumulative noise energy must increase measurably (Navy, 2009, USACE, 2017).

Table 9: Common Sounds and Their Levels Outdoors

	Sound level (dBA)	**Equivalent**
Snowmobile	100	Subway train
Tractor	90	Garbage disposal
Noisy restaurant	85	Blender
Downtown (large city)	80	Ringing telephone
Freeway traffic	70	TV audio
Normal conversation	60	Sewing machine
Rainfall	50	Refrigerator
Quiet residential area	40	Library
Source: http://chchearing.org/noise/common-environmental-noise-levels		

F-2) ENVIRONMENTAL CONSIDERATIONS OF THE FOCUSSED ARRAY

General

This section discusses the generalized environmental consequences of the focused array of alternatives that have been screened in the plan formulation section. The focused array of alternatives are divided into three main regional sections: the north, central, and south. Exceptions to this are the Shark River Inlet and bay and the Coastal Lakes area, which were evaluated separately. The north region is generally from Manasquan Inlet south to Brigantine Egg Inlet, which includes the entire Barnegat Bay and Little Egg Harbor and tributaries. The central region spans from Brigantine Inlet to Corson Inlet, which includes all of the bays, sounds and thoroughfares in that region and the Great Egg Harbor River and Great Egg Harbor Inlet. The southern region spans from Corson Inlet south through Cape May Inlet and Cape May Canal, and includes all of the bays, sounds, and thoroughfares within that segment of the New Jersey coast.

At this point of the study, the focused array of alternatives include structural (floodwalls, levees, miter gates, inlet storm surge barriers, bay closures, and impermeable walls), non-structural (building raising), and combinations, thereof. Additional non-structural alternatives such as building acquisition and flood-proofing and the evaluation of natural and nature-based features (NNBF) such as wetlands, reefs, and living shorelines will be evaluated in the next phase. Table 10. presents the study regions, the current array of alternatives that have met preliminary economic, environmental, and social screening criteria, and their specific locations.

Table 10: Focused Array of Alternatives that Have Proceeded Past Initial Screening

REGION	ALT	NONSTRUCTURAL Building Raising for structures with first floor w/in 20-yr floodplain	PERIMETER Floodwalls, Levees and Miter Gates	STORM SURGE BARRIER Inlet Navigable Sector Gates, Auxiliary Lift Gates, Impermeable Barriers, Levees	BAY CLOSURE Navigable Sector Gates, Auxiliary Lift Gates, Miter Gates, Sluice Gates, Impermeable Barriers, Levees
SHARK RIVER	2A	Portions of Belmar, Bradley Beach, Neptune City & Shark River Hills			
NORTH **(Manasquan Inlet to Brigantine Inlet)**	3A	Point pleasant, all communities on LBI, western shore of Barnegat Bay, Mystic Island, and along lower Mullica River Basin			
	3D	All communities on LBI, western shore of Barnegat Bay, Mystic Island, and along lower Mullica River Basin	Manasquan Inlet/ Point Pleasant Area		
	3E(2)	All communities on southern LBI (Cedar Bonnet Island and south), western shore of Barnegat Bay at Beach Haven West and south, Mystic Island, and along lower Mullica River Basin		Manasquan Inlet and Barnegat Inlet	
	3E(3)	Cedar Bonnet Island, western shore of Barnegat Bay at Beach Haven West and south, Mystic Island, and along lower Mullica River Basin	Along western side of S. LBI from Ship Bottom to Holgate	Manasquan Inlet and Barnegat Inlet	
CENTRAL **(Brigantine Inlet to Corson Inlet)**	4A	Brigantine, Absecon, Pleasantville, West A.C., A.C., Ventnor, Margate, Longport, Northfield, Linwood, Estell Manor, Mays Landing, Somers Point, Marmora, Ocean City, Palermo			
	4D(1)	Brigantine, Absecon, Pleasantville, West A.C., Northfield, Linwood, Estell Manor, Mays Landing, Somers Point, Marmora, Palermo	Along Absecon Inlet and western side of A.C., Ventnor, Margate, Longport, & Ocean City		
	4D(2)	Absecon, Pleasantville, West A.C., Northfield, Linwood, Estell Manor,	Along Absecon Inlet and western side of		

REGION	ALT	NONSTRUCTURAL Building Raising for structures with first floor w/in 20-yr floodplain	PERIMETER Floodwalls, Levees and Miter Gates	STORM SURGE BARRIER Inlet Navigable Sector Gates, Auxiliary Lift Gates, Impermeable Barriers, Levees	BAY CLOSURE Navigable Sector Gates, Auxiliary Lift Gates, Miter Gates, Sluice Gates, Impermeable Barriers, Levees
		Mays Landing, Somers Point, Marmora, Palermo	Brigantine, A.C., Ventnor, Margate, Longport, & Ocean City		
	4E(2)	Absecon, Pleasantville, S. Ocean City, Marmora, & Palermo		Absecon Inlet & Great Egg Harbor Inlet	
	4E(3)	Absecon, Pleasantville, Marmora, & Palermo	Western side of S. Ocean City	Absecon Inlet & Great Egg Harbor Inlet	
	4E(4)	Absecon & Pleasantville		Absecon Inlet & Great Egg Harbor Inlet	Cross bay barrier in S. Ocean City from 52nd St.
	4G(6)	Brigantine, Absecon, Pleasantville, West A.C., Marmora, S. Ocean City, Palermo,		Great Egg Harbor Inlet	Cross bay barrier along S. Absecon Inlet and Absecon Blvd.
	4G(7)	Brigantine, Absecon, Pleasantville, West A.C., Marmora	Western side of S. Ocean City	Great Egg Harbor Inlet	Cross bay barrier along S. Absecon Inlet and Absecon Blvd
	4G(8)	Brigantine, Absecon, Pleasantville, West A.C.,		Great Egg Harbor Inlet	Cross bay barrier along S. Absecon Inlet and Absecon Blvd
	4G(10)	Absecon, Pleasantville, West A.C., Marmora, S. Ocean City, Palermo	Western side of Brigantine	Great Egg Harbor Inlet	Cross bay barrier along S. Absecon Inlet and Absecon Blvd
	4G(11)	Absecon, Pleasantville, West A.C., Marmora, Palermo	Western side of Brigantine and S. Ocean City	Great Egg Harbor Inlet	Cross bay barrier along S. Absecon Inlet and Absecon Blvd
	4G(12)	Brigantine, Absecon, Pleasantville, West A.C.,	Western side of Brigantine	Great Egg Harbor Inlet	Cross bay barrier along S. Absecon Inlet and Absecon Blvd. and cross bay barrier in S.

REGION	ALT	NONSTRUCTURAL Building Raising for structures with first floor w/in 20-yr floodplain	PERIMETER Floodwalls, Levees and Miter Gates	STORM SURGE BARRIER Inlet Navigable Sector Gates, Auxiliary Lift Gates, Impermeable Barriers, Levees	BAY CLOSURE Navigable Sector Gates, Auxiliary Lift Gates, Miter Gates, Sluice Gates, Impermeable Barriers, Levees
					Ocean City from 52nd St.
SOUTH **(Corson Inlet to Cape May Inlet)**	5A	All Atlantic Coast and bayside communities from Ludlam Island (Upper Twp.) south to Cape May and W. Cape May			
	5D(1)	All Atlantic Coast and bayside communities from Ludlam Island (Upper Twp.) south to Cape May and W. Cape May except for SIC, all WW, and Cape May	Western side of Sea Isle City, all Wildwoods, and southern shore along Cape May Harbor in Cape May		
	5D(2)	All bayside communities from Ludlam Island (Upper Twp.) south to Cape May and W. Cape May; Strathmere and N. Cape May Inlet along Atlantic Coast.	Western side of Sea Isle City, Seven Mile Island, all Wildwoods, and southern shore along Cape May Harbor in Cape May		

At this stage of the feasibility study and NEPA analysis, quantitative impact analyses are generally unavailable for a number of these alternatives due to the current preliminary low-level of design, and that detailed numerical modeling has not been applied at this point. Therefore, impact assessment is introduced in this section, and the general impacts and/or range of impacts (including direct, indirect, and cumulative impacts, where appropriate) are presented, as known, at this time. Additionally, a preliminary conceptual model intended to articulate the mechanisms of environmental impact of proposed flood risk management alternatives, inform the NEPA process and transparently link actions to specific pieces of environmental policy and legislation, and to identify any gaps in quantitative tools needed for future impact assessment is being developed. This conceptual model is at an early stage, but will be further developed with research from relevant peer-reviewed literature, engagement with resource agency staff technical experts, and iterative development with USACE staff, which will help guide the impact analyses and development of numerical modeling leading up to the tentatively selected plan (TSP) and Draft Integrated Environmental Impact Statement.

Some generalized assumptions for the array of alternatives are that no action (future without project) will continue existing trends unless significant changes are implemented such as regulatory changes, development, land use, etc. with awareness of current knowledge of climate change and sea level rise as a major driving force.

For structural measures in the array, the perimeter plans are expected to have significant direct impacts particularly on wetlands and shallow aquatic habitats within the footprint of floodwalls and levees over long linear distances. Additionally, perimeters are expected to have significant impacts on visual resources. The inlet storm surge barriers (SSBs) and bay closures (BCs) would have significant direct impacts on aquatic habitats, but comparatively less than the perimeter plans. However, there may be more potential indirect impacts of inlet barriers and bay closures on hydrodynamics, water quality, and shifts in flora and fauna abundance, distributions and migrations. These potential effects have a high level of uncertainty particularly with the unknown frequency and duration of gate closures coupled with changes in tidal flooding events related to sea level rise. This would require further modeling efforts to inform the impact assessment of SSBs and BCs.

Non-structural (NS) measures are a component for all of the focused array of alternatives either as a standalone alternative or in various combinations with other structural components. NS measures such as building raising may have some temporary adverse direct and indirect effects related to earth disturbance, but are not significant. However, impacts on cultural resources (particularly if building modifications are on historic structures or in a historic district) and community are potentially significant.

Natural and Nature-Based Features (NNBFs) would need to have a direct coastal storm risk management (CSRM) function for flooding and/or function as a scour protection feature of a traditional structural CSRM feature while providing some degree of ecological uplift. NNBFs are expected to have temporary and minor impacts on aquatic resources and water quality during their construction, but would have a long-term beneficial effect on aquatic and some terrestrial habitats and the flora and fauna that inhabit these habitats.

Land Use

Future Without Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk along the New Jersey Back Bays study area. Land use change has been significant in New Jersey from 1986 to 2012 where approximately 350,000 acres of forest and farmland have been converted to urban lands. However, many of the study area communities, especially along the barrier islands, are already heavily developed, and the remaining land areas are protected lands (parks, wildlife management areas), wetlands, and beaches. Therefore, the trend of conversion to urban land may not fully apply to the NJBB study area.

It is assumed that no action would leave the communities within the study area more vulnerable to coastal storm risks from storm surge and inundation. Coastal storm risks coupled with sea level rise have the potential to devastate communities, tourist areas, associated transportation, commercial, industrial, health –related and educational activities, which could potentially have significant effects on land use. Low-lying areas would be increasingly susceptible to flooding, making these locations inaccessible at times to residents and visitors. It is expected that some localized measures (structural or non-structural) would be implemented by residents, businesses, local municipalities or at the state level to mitigate flooding. However, areas left unprotected over time may be uninhabitable following a major storm event or recurrent flooding. These areas could revert to open water, intertidal mudflat or tidal marsh.

All Structural

Perimeter – Floodwalls, Levees and Miter Gates & Storm Surge Barriers/Bay Closures

The structural alternatives identified in the focused array, in the long-term, are expected to maintain current land uses by providing greater stability to areas susceptible to coastal flooding. However, the construction of these structures would require the acquisition of real estate easements from a large number of residences, commercial, and municipal properties. The perimeter protection plans would affect the most properties, followed by the BCs, and the least amount of property would be affected by the SSBs. However, these acquisitions would not significantly affect overall land use of the affected areas.

Table 11 presents the focused array of alternatives and the structural features that may interact with protected land uses or have comprehensive management plans that affect land use as discussed in the affected environment section.

Table 11: Protected Lands or Areas with Comprehensive Management Plans that Regulate or Guide Land Use Within or Adjacent to the NJBB Focused Array of Alternatives

ALT	Feature	NJ Coastal Zone	NJ Pine-lands Boundary	National Reserves/Wild and Scenic Rivers and Wilderness Areas	National Wildlife Refuges	CBRA Sites (Existing)	CBRA Sites (Draft Revised)	National Estuary Program	State Parks/State Wildlife Mgt. Areas/Natural Areas
2A	Nonstructural	X							
3A	Nonstructural	X	X	1. Pinelands National Reserve 2. Jacques Cousteau NERR	E.B. Forsythe NWR	NJ-04B NJ-04BP (OPA) NJ-06 NJ-07P (OPA)	NJ-04B NJ-06 NJ-07P (OPA)	Barnegat Bay Program	Allaire S.P. Manahawkin W.M.A. Wharton S.F. Bass River S.F
3D	Perimeter	X						Barnegat Bay Program	
3D	Nonstructural	X	X	1. Pinelands National Reserve 2. Jacques Cousteau NERR	E.B. Forsythe NWR	NJ-04B NJ-04BP (OPA) NJ-06 NJ-07P (OPA)		Barnegat Bay Program	Allaire S.P. Manahawkin W.M.A. Wharton S.F. Bass River S.F.
3E(2)	SSB	X		1. Pinelands National Reserve (Barnegat Inlet)		NJ-05P (OPA)	NJ-05P (OPA)	Barnegat Bay Program	Island Beach S.P. Barnegat Lt. S.P.
3E(2)	Nonstructural	X	X	1. Pinelands National Reserve 2. Jacques Cousteau NERR	E.B. Forsythe NWR	NJ-06 NJ-07P (OPA)	NJ-06 NJ-07P (OPA)	Barnegat Bay Program	Manahawkin W.M.A. Wharton S.F. Bass River S.F
3E(3)	Perimeter	X		1. Pinelands National Reserve 2. Wilderness Area (Holgate Unit)	E.B. Forsythe NWR	NJ-07P (OPA)	NJ-07P (OPA)	Barnegat Bay Program	
3E(3)	SSB	X		1. Pinelands National Reserve (Barnegat Inlet)	E.B. Forsythe NWR	NJ-05P (OPA)	NJ-05P (OPA)	Barnegat Bay Program	Island Beach S.P. Barnegat Lt. S.P.
3E(3)	Nonstructural	X	X	1. Pinelands National Reserve 2. Jacques Cousteau NERR	E.B. Forsythe NWR	NJ-07P (OPA)	NJ-07P (OPA)	Barnegat Bay Program	Manahawkin W.M.A. Wharton S.F. Bass River S.F
4A	Nonstructural	X	X	1. Pinelands National Reserve 2. Great Egg Harbor National Wild and Scenic River	1. E.B. Forsythe NWR 2. Cape May NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-19P (OPA) NJ-07P (OPA) NJ-08P (OPA)		Belleplain S.F. N. Brigantine S. Nat. Area Absecon W.M.A. Tuckahoe W.M.A. Corson's Inlet S.P.
4D(1)	Perimeter	X				NJ-08P (OPA)	NJ-19P (OPA) NJ-08P (OPA)		Corson's Inlet S.P.
4D(1)	Nonstructural	X	X	1. Pinelands National Reserve 2. Great Egg Harbor National Wild and Scenic River	1. E.B. Forsythe NWR 2. Cape May NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-19P (OPA) NJ-07P (OPA) NJ-08P (OPA)		Belleplain S.F. N. Brigantine S. Nat. Area Absecon W.M.A. Tuckahoe W.M.A.
4D(2)	Perimeter	X				NJ-08P (OPA)	NJ-19P (OPA) NJ-08P (OPA)		N. Brigantine St. Nat. Area Corson's Inlet S.P.
4D(2)	Nonstructural	X	X	1. Pinelands National Reserve 2. Great Egg Harbor National Wild and Scenic River	1. E.B. Forsythe NWR 2. Cape May NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-19P (OPA) NJ-07P (OPA) NJ-08P (OPA)		Belleplain S.F. Absecon W.M.A. Tuckahoe W.M.A.
4E(2)	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
4E(2)	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-07P (OPA) NJ-08P (OPA)		Absecon W.M.A. Corson's Inlet S.P.
4E(3)	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
4E(3)	Perimeter	X				NJ-08P (OPA)	NJ-08P (OPA)		Corson's Inlet S.P.
4E(3)	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA)	NJ-07P (OPA) NJ-08P (OPA)		Absecon W.M.A
4E(4)	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
4E(4)	BC	X				NJ-08P (OPA)	NJ-08P (OPA)		Corson's Inlet S.P.
4E(4)	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA)	NJ-07P (OPA)		Absecon W.M.A
4G(6)	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		

ALT	Feature	NJ Coastal Zone	NJ Pine-lands Boundary	National Reserves/Wild and Scenic Rivers and Wilderness Areas	National Wildlife Refuges	CBRA Sites (Existing)	CBRA Sites (Draft Revised)	National Estuary Program	State Parks/State Wildlife Mgt. Areas/Natural Areas
	BC	X							
	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-07P (OPA) NJ-08P (OPA)		N. Brigantine S. Nat. Area Absecon W.M.A. Corson's Inlet S.P.
	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
	BC	X							
4G(7)	Perimeter	X				NJ-08P (OPA)	NJ-08P (OPA)		Corson's Inlet S.P.
	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA)	NJ-07P (OPA)		N. Brigantine S. Nat. Area Absecon W.M.A.
	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
4G(8)	BC	X				NJ-08P (OPA)	NJ-08 NJ-08P (OPA)		Corson's Inlet S.P.
	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA)	NJ-07P (OPA)		N. Brigantine S. Nat. Area Absecon W.M.A.
	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
	BC	X							
4G(10)	Perimeter	X							Absecon W.M.A N. Brigantine S. Nat. Area
	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-07P (OPA) NJ-08P (OPA)		Absecon W.M.A. Corson's Inlet S.P.
	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
	BC	X							
4G(11)	Perimeter	X				NJ-08P (OPA)	NJ-08P (OPA)		Absecon W.M.A Corson's Inlet S.P.
	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-07P (OPA) NJ-08P (OPA)		N. Brigantine S. Nat. Area Absecon W.M.A. Corson's Inlet S.P.
	SSB	X		Great Egg Harbor National Wild and Scenic River*			NJ-19P (OPA)		
	BC	X				NJ-08P (OPA)	NJ-08 NJ-08P (OPA)		Corson's Inlet S.P.
4G(12)	Perimeter	X							N. Brigantine S. Nat. Area Absecon W.M.A
	Nonstructural	X		Pinelands National Reserve	E.B. Forsythe NWR	NJ-07P (OPA)			Absecon W.M.A
5A	Nonstructural	X		Pinelands National Reserve		NJ-09 NJ-09P (OPA) NJ-10P (OPA) NJ-11P (OPA)	NJ-08 NJ-09 NJ-09P (OPA) NJ-10P (OPA) NJ-11P (OPA) NJ-20P (OPA)		Strathmere Natural Area Cape May Wetlands WMA Stone Harbor Point Cape Island WMA Cape May Point S.P. Higbee Beach WMA
	Perimeter	X			Cape May NWR	NJ-09	NJ-09		
5D(1)	Nonstructural	X		Pinelands National Reserve	Cape May NWR	NJ-09P (OPA) NJ-11P (OPA)	NJ-08 NJ-09P (OPA) NJ-11P (OPA)		Strathmere Natural Area Cape May Wetlands WMA Stone Harbor Point Cape Island WMA

ALT	Feature	NJ Coastal Zone	NJ Pine-lands Boundary	National Reserves/Wild and Scenic Rivers and Wilderness Areas	National Wildlife Refuges	CBRA Sites (Existing)	CBRA Sites (Draft Revised)	National Estuary Program	State Parks/State Wildlife Mgt. Areas/Natural Areas
5D(2)									Higbee Beach WMA
5D(2)	Perimeter	X			Cape May NWR	NJ-09	NJ-09		Cape May Wetlands WMA
5D(2)	Nonstructural	X		Pinelands National Reserve	Cape May NWR	NJ-09 NJ-09P (OPA) NJ-11P (OPA)	NJ-08 NJ-09P (OPA) NJ-11P (OPA)		Strathmere Natural Area Stone Harbor Point Cape Island WMA Higbee Beach WMA

Northern Region | Central Region | Southern Region

*Feature is not located in area, but could have potential indirect impact on area.

Nonstructural Measures

For this alternative, Building Retrofit, which includes building elevation (raising existing structures) emerged within the focused array of alternative as a nonstructural means for CSRM in the NJBB. However, other retrofit measures that will be considered include dry floodproofing, wet floodproofing, ringwalls and redbuilding, which are discussed in greater detail in Section 9.2.2. Building retrofits such as elevation would help protect only individual structures from storm surge. This could disrupt land uses temporarily during construction, as these measures are being constructed. However, the land use disruption would likely be limited to those specific structures being protected, and this alternative should not cause many permanent impacts to land use.

Other measures, such as buyout programs and relocations, fall under the category of “managed coastal retreat”, as described in Section 9.2.2 or are also considered as “floodplain acquisitions”. This type of program, if implemented on a widespread basis, could have significant impacts on land use. A buyout program would utilize public funds to purchase the title of privately held land, and existing structures are then demolished. The land is left in an undeveloped state for public use in perpetuity. This could change the land use from an urban use to a publicly accessible open space for recreation or conservation. Depending on the scale of implementation, this could occur structure by structure, by street or block, or an entire neighborhood.

Natural and Nature-Based Features (NNBFs)

NNBF’s in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs are not expected to have significant effects on existing land uses as these measures are primarily water-based, and would likely be compatible and consistent with existing water uses. At this time, no specific NNBFs and locations have been identified. However, the identification of NNBFs and their locations will be evaluated for their compatibility with existing land uses.

Floodplains

Future Without Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk along the New Jersey Back Bays study area. Therefore, it is expected that existing structures within the study area, those that are not protected by a certified and accredited flood protection system or have been elevated with appropriate freeboard, will continue to be at risk to flooding or could become more at risk due to sea level rise and climate change. Without local or non-Federal interventions, it is expected that nuisance flooding in low-lying areas will continue, where the potential impacts from tidal and/or rainfall flooding will likely increase and worsen over time with climate change and sea level rise. These areas would also become more susceptible to catastrophic flooding from storm surges.

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

The structural plans in the focused array are typically large scale projects that would protect a large number of structures, which is a beneficial and significant impact. The high cost of constructing, operating, and maintaining these structures usually reflects the size and complexity of the system, including the storm surge barriers, bay closures, miter gates, road closures, number of pumps needed for interior drainage, real estate needs for berms, floodwalls, levees and closures, easements, and right-of-ways, engineering and design, etc. After a community experiences several flood events, the damages prevented can easily justify the costs for such a project. If properly inspected, maintained, and operated, the flood protection system can last and function as designed during its project life.

However, flood protection systems can fail, be overtopped, and/or flood due to interior drainage, which would be an adverse and significant impact to those on the protected side. In these possible flood scenarios, rather than having minor damage, there could be significant damage within the protected area. Although a temporary impact, recovery could take several years for an individual and the community, especially if citizens do not have flood insurance. In addition to having flood insurance and floodplain regulations in place for new development and substantially damaged or improved structures within the protected area, other things to consider which could influence the severity of the impacts, include outreach and education to citizens on the need for evacuation of the protected area and removing or elevating valued items in advance of a storm event; locating critical structures outside the protected area in case of flooding; and preventing unwise development within the protected area that may aggravate interior flooding due to rainfall (USACE, 2017).

Nonstructural Measures

For this alternative, Building Retrofit, which includes building elevation, (raising existing structures) emerged within the focused array of alternative as a nonstructural means for CSRM in the NJBB. However, other retrofit measures that will be considered include dry floodproofing, wet floodproofing, ringwalls and redbuilding, which are discussed in greater detail in Section 9.2.2.

Building retrofit measures will help reduce flood insurance premiums and keep neighborhoods and communities sustainable and resilient after a flood, which is a beneficial and significant impact to those living and working in a floodplain and to the local municipality. FEMA recognizes elevation, acquisition, and relocation in reducing the cost or eliminating the need for flood insurance for residential and commercial structures. For commercial structures only, flood proofing is recognized by FEMA, where a flood proofed building has been designed and constructed to be watertight. Depending on the nonstructural method used and level of protection, a residential or commercial structure could possibly stay flood-free during its design life. An advantage of nonstructural measures when compared to structural measures is the ability of nonstructural measures to be sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement. If an existing structure does not meet FEMA's regulations, if substantially damaged in any way, or the structure has been substantially improved, as may apply with a nonstructural measure, then the structure will need to be brought into compliance with FEMA's and the municipality's floodplain regulations (USACE, 2017).

Natural and Nature-Based Features (NNBFs)

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

Natural and nature based features provide beneficial impacts in many ways, such as reducing flood impacts, valuable habitat, recreational areas, urban landscape diversity, etc. These types of features can be long lasting or temporary as necessary. While the measures will not significantly reduce flood risks during major storms, they may make a difference for small and localized flood events, and can aid in dissipating wave energies and scour on flood structures.

Geology and Soils

Future Without Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk along the New Jersey Back Bays study area. No significant impacts are expected on the underlying geology or geologic processes. Continued sea level rise would likely increase flooding and wave attack are likely to increase soil erosion particularly on tidal marshes and mudflats in vulnerable locations. Sea level rise may also exceed normal sediment accretion rates in the saltmarshes resulting in increased inundation and subsidence.

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

Because of the depth of overlying soils and sediments within the affected areas, construction of the structural measures, which include pile driving, is not expected to affect bedrock competency, aquifers, or cause long-term changes in seismic activity that would be damaging for structures. Short-term effects would involve vibrations from heavy construction equipment including pile or vibratory hammers, which could affect structures that include nearby residential homes, attached decks and commercial buildings and shops. Therefore, appropriate seismic monitoring is implemented in locations susceptible to vibration utilizing seismographs at locations on or at the base of the representative structures to obtain the highest peak particle velocities. Representative structures would be defined as one of each foundation type (pile foundation, masonry, concrete, and slab on grade).

Construction activities would also impact soils through compaction, disturbance, and mixing of discrete soil strata in all areas involved in construction including staging areas that involve clearing, grading, excavations, backfilling, and the movement of construction equipment. These impacts can be minimized by implementing Best Management Plans (BMPs) for sediment and soil erosion control to minimize earth disturbance impacts.

The structural measures within the focused array of alternatives involve structures affecting primarily the shoreline areas of the bays, inlets, open water, beaches, and tidal marsh. No disturbance of soils in areas classified as prime farmland would occur; therefore, no adverse significant impact on the agricultural use of soil is expected.

Importation of earthen materials including rock, sand, backfill materials, and topsoil, would be obtained from existing approved commercial quarries, sandpits, and other approved sources.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/revegetation. All of these activities would involve earth disturbances similar to some of the effects discussed for construction of the structural measures. Soil disturbances can be readily managed by implementing appropriate BMPs.

Natural and Nature-Based Features (NNBFs)

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. For instance, some NNBFs like wetland restoration or reef construction may require the aquatic placement of fill materials that would disturb existing substrates (soil or sediments), and likewise generate localized, but temporary, turbidity in the water column. These effects are expected to be temporary after construction is completed and the areas become stabilized with vegetation and/or other biogenic processes. NNBFs are not expected to result in any adverse impacts on underlying geology (bedrock, aquifers), but are likely to result in minor changes in topography and bathymetry depending on the measure being implemented.

Water Quality

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, water quality will remain undisturbed in its current conditions, and is not expected to have direct, indirect, or cumulative effects when considering existing trends and future conditions such as climate change and sea level rise. It is reasonable to conclude that current water quality trends will continue without any significant interventions such as changes in land use or improvements through implementation of new water quality improvement programs such as TMDLs administered by Federal, State, and local agencies. BBP (2016), in their state of the bay report, have summarized status and trends for the Barnegat Bay system, and concluded that there is a negative trend association for nutrient loading, which was scored with a status as "below average" due to measurable increases in nutrient loading from the period of 1989-2011. The status of algal blooms in the Barnegat Bay estuary were scored as "degraded" (mainly in the northern portion of the bay), but no discernable trend was apparent. Dissolved oxygen, temperature, freshwater macroinvertebrates, and shellfish bed closures have not exhibited any trend changes, although their statuses ranged from "above average" to "good". These trends may be similar for the other inland bays with some local variations. However, climate change and sea level rise introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns, and chemical changes such as ocean acidification could impose synergistic effects on the NJBB water quality.

Structural Measures

Perimeter – Floodwalls, Levees, and Miter Gates

Direct Impacts

The direct impacts of the implementation of floodwalls, levees, and miter gates on water quality would result in temporary increases in turbidity and total suspended solids in the vicinity during construction. Minor and temporary increases in turbidity are expected during construction from activities such as the installation and removal of temporary cofferdams, temporary excavations, fill and rock placement, and vibrations during the driving of sheet piles. Other activities such as earth disturbances resulting from construction access activities, staging/storage areas and upland excavations and soil stockpiles have the potential to generate turbidity as a non-point source. In accordance with Section 402 of the Clean Water Act, a sediment/erosion control plan will be submitted to the county conservation districts for their review and approval. Several measures such as rock entrances, silt fencing, physical runoff control as well as other best management practices will be in the plan. Compliance with the approved sediment/erosion control plan/earth disturbance permit will result in minimal sedimentation/turbidity. Areas disturbed during construction would be subsequently stabilized upon completion of construction activities and turbidity is expected to return to normal levels.

Indirect Impacts

The generation of turbidity during construction will have temporary impacts on fish respiration, filter feeders, sight feeders, and may inhibit photosynthesis of nearby SAV beds. These impacts would be more severe on sessile organisms because they will not be able to avoid the turbidity generated during construction. However, this effect is expected to be minor and of short duration until construction activities cease. Miter gates will be installed and operated across smaller channels that require navigable access. These gates would remain open during normal conditions and would be closed during significant storm events. Some localized, but minor changes in hydrodynamics around the gates are expected, however, no significant changes in water quality are expected while the gates are open. Miter gate closures during storms may temporarily affect water quality in a localized area by inhibiting circulation and mixing.

With any of the perimeter plans, pump stations will be required to collect interior drainage from significant precipitation events. These pump stations, for the most part, would receive urban run-off from impermeable surfaces from buildings, streets, and parking lots that may contain typical urban non-point source pollutants such as sediments, bacteria, nutrients, and oil and grease. The pumps would not necessarily increase these stormwater discharges; however, they may focus these discharges more at fewer points based on the pump station location and outfall discharge points rather than the current stormwater drainage systems. Current stormwater discharges may either have discharges directly into the bays at the street ends or through combined sewers. Stormwater systems vary by community, and would require further investigation to determine the appropriate locations and design for the interior drainage pumps and outfalls.

Cumulative Impacts

The cumulative impacts of floodwalls and levees on water quality are not expected to be significant because the generation of turbidity during construction would be of short duration and limited to within work the segments. However, the cumulative effects of turbidity may be increased if there are other similar activities ongoing and nearby that generate turbidity such as dredging, earth disturbance, non-point storm water discharges, etc.

Inlet Storm Surge Barriers/Bay Closures

Direct Impacts

The direct impacts of the implementation of inlet storm surge barriers and bay closures on water quality would result in temporary increases in turbidity and total suspended solids in the vicinity during construction. Minor and temporary increases in turbidity are expected during construction from activities such as the installation and removal of temporary cofferdams, temporary excavations, fill and rock placement, concrete work, and vibrations during the driving of sheet piles. Other activities such as earth disturbances resulting from construction access activities, staging/storage areas and upland excavations and soil stockpiles have the potential to generate turbidity as a non-point source. In accordance with Section 402 of the Clean Water Act, a sediment/erosion control plan will be submitted to the county conservation districts for their review and approval. Several measures such as rock entrances, silt fencing, physical runoff control as well as other best management practices will be in the plan. Compliance with an approved sediment/erosion control plan/earth disturbance permit will result in minimal sedimentation/turbidity. Areas disturbed during construction would be subsequently stabilized upon completion of construction activities and turbidity is expected to return to normal levels.

Indirect Impacts

The indirect impacts of the implementation and operation and maintenance of inlet storm surge barriers and bay closures on water quality are complex. The generation of turbidity during construction will have temporary impacts on fish respiration, filter feeders, sight feeders, and may inhibit photosynthesis of nearby SAV beds. These impacts would be more severe on sessile organisms because they will not be able to avoid the turbidity generated during construction. However, this effect is expected to be localized and of short duration until construction activities cease.

Hydrodynamic modeling among many of the New Jersey coastal inlets and bays is limited, therefore, the impacts of inlet storm surge barriers and bay closures are not well known. However, it is known that estuaries with poor flushing and long residence times are more likely to retain nutrients longer in the system, which could lead to higher primary production rates, thus becoming more susceptible to eutrophication. Whereas, well-flushed estuaries demonstrate greater resilience to nutrient loading attributed to reduced residence time and greater exchange with less impacted coastal waters (Lancelot and Billen, 1984 as cited in Defne and Ganju, 2015). Barnegat Bay and Little Egg Harbor (BB-LEH) estuaries are the most studied concerning hydrodynamic modeling and residence times where Guo and Lordi (2000) estimated an average residence time at Barnegat Inlet based on velocity and salinity as occurring between 24 and 74 days (depending on season). Defne and Ganju (2015) performed systemic modeling using a combination of hydrodynamic and particle tracking modeling of the BB- LEH estuaries to determine a mean residence time of 13 days, but special variability was between 0 and 30 days depending on the initial particle location. This modeling also demonstrated that there is a pronounced northward subtidal flow from Little Egg Inlet in the south towards Point Pleasant Canal in the north attributed to frictional effects in the inlets. This effect resulted in better flushing of the southern half of the estuary and more particle retention (poor flushing) in the northern estuary.

The operation of barriers and closures has the potential for significant impacts on water quality in the estuarine systems based on their potential for altering flow and circulation patterns. These impacts are inherently based on the design of the barrier/closure such as the number of openings and widths of these openings, which could significantly alter the flow patterns through the inlets and bays by constricting flows and affecting current velocities. A number of design components make up these barriers/closures, which include navigable sector gates, auxiliary flow lift gates, impermeable barriers, levees and seawalls. For the inlet barriers, the navigable sector gates and auxiliary flow lift gates are the predominant in-water structures. The impermeable barrier structure is a hardened structure that is also an in-water structure that ties the gates into features on the adjacent land such as a levee, seawall or existing dune. The bay closures have the same components as the inlet barriers, but the bay closures also have other features such as road closures and miter gates and sluice gates, which are for smaller channels and tidal guts. The navigable sector gate is open under normal conditions to allow for navigation traffic and tidal exchange. The auxiliary lift gates are vertical gates that are "up" during normal conditions to allow for tidal exchange. These gates would be designed to remain open during normal conditions. However, even with the gates in opened positions, there would be a net reduction in channel cross-sectional area that would act as a constriction to flood and ebb tidal flow through the inlets. Thus, localized increases in velocity surrounding these gates are expected and a slight reduction in tidal prism (tidal range) may occur in other parts of the bays. These flow pattern changes may result in changes in circulation and increased residence times, which could have more profound effects in backwater areas that are already poorly flushed. Restrictions in tidal flows and increases in residence times could affect salinity levels, nutrients, chlorophyll *a* and dissolved oxygen concentrations. These effects could be exacerbated at times when the gates are closed during a significant storm event when increased freshwater inputs, nutrients, bacteria and other pollutants discharged from tributaries and point and non-point sources are held in the bays for a longer period. The frequencies and durations of gate closures may vary where closures at a minimum would be over two tide cycles (approximately 24 hours) to approximately 48 hours several times a year. These closures are unpredictable, and would depend on the number and severity of the storms in the affected area.

To better understand the effects of the various inlet barriers and bay closures under consideration, the next phase of the study will include initial hydrodynamic and water quality modeling that would be applied to better assess the effects that these measures would have on these bay systems.

Cumulative Impacts

The cumulative impacts during the construction of the inlet storm surge barriers and bay closures on water quality are not expected to be significant because the generation of turbidity during construction would be of short duration and limited to within work segments. However, the cumulative effects of turbidity may be increased if there are other similar activities ongoing and nearby that generate turbidity such as dredging, earth disturbance, non-point storm water discharges, etc.

The cumulative impacts of the operation of storm surge barriers and bay closures on water quality are not well known. Since these structures have the potential to affect bay-wide system water quality, there is a potential for cumulative effects on water quality when coupled with existing water quality trends and the effects of climate change/sea level rise. To better understand the effects of the various inlet barriers and bay closures under consideration, the next phase of the study will include initial hydrodynamic and water quality modeling that would be applied to better assess the effects that these measures would have on these bay systems.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that would produce turbidity. However, soil disturbances can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays.

Natural and Nature-Based Features (NNBFs)

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. For instance, some NNBFs like wetland restoration or reef construction may require the aquatic placement of fill materials that would disturb existing substrates (soil or sediments), and likewise generate localized, but temporary, turbidity in the water column. These effects are expected to be temporary after construction is completed and the areas become stabilized with vegetation and/or other biogenic processes. NNBFs are expected to have long-term beneficial impacts on water quality by providing services such as more stable substrates (less turbidity), nutrient uptake, and/or provide habitat that is better suited for filter feeders that can capture phytoplankton and suspended particles.

Plankton

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative changes in the planktonic community are expected as described in the Affected Environment section. However, there is a potential for increased phytoplankton blooms (including Harmful Algal

Blooms) associated with increases in nutrient loadings and estuarine eutrophication. BBP (2016) report that algal blooms, which include macroalgae and phytoplankton, are considered to be in a "degraded" state within northern Barnegat Bay, but there are no discernable trends with algal blooms. This is attributed to the localized nature of algal blooms and the "spottiness" of chlorophyll *a* concentrations in the monitoring programs. Any significant interventions such as changes in land use or improvements through implementation of new water quality improvement programs such as TMDLs administered by Federal, State, and local agencies may have an effect on algal blooms. However, climate change and sea level rise introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality where the bays' plankton may experience shifts in distribution and abundance.

Structural Measures

Perimeter – Floodwalls, Levees, and Miter Gates

Direct Impacts

The direct impacts of the implementation of floodwalls and levees on both zooplankton and phytoplankton would result in temporary increases in turbidity and total suspended solids in the vicinity during construction. Increased turbidity is likely to inhibit photosynthesis and primary production provided by phytoplankton and thus may have some minor effects on the food chain.

Indirect Impacts

Indirect impacts could be the resuspension of sediments containing nutrients and a decrease of transitional upland areas (by increasing hardened shoreline) that act as filters for non-point source run-off. An indirect effect of increased run-off and nutrients would contribute to eutrophication and phytoplankton blooms. Additionally, sea nettles (*Chrysaora quinquecirrha*) are a stinging jellyfish that have become increasingly prevalent, and a nuisance, in Barnegat Bay and other coastal waterways in New Jersey. They can be planktonic for a brief period, but occur as sessile polyps or as free-swimming medusae. Sea nettles can greatly affect recreational activities that involve human contact with the water where people can be stung by their tentacles. It is believed that sea nettle blooms are greatly influenced by a number of factors such as increases in the presence of manmade structures (pilings, floating docks, and bulkheads), which allow for a suitable substrate for the polyps to attach (https://www.barnegatbaypartnership.org/protect/threats-to-barnegat-bay/jellyfish/sea-nettles/ accessed on 1/4/2019) . Therefore, the installation of floodwalls and miter gates would provide hardened substrate that could potentially be used by stinging nettle polyps to attach. In areas with existing hardened shorelines such as bulkheads, the construction of floodwalls will not have a significant effect. However, any increases in hardened substrate where there are no current man-made features, could potentially result in a net-increase of the surface area for polyps to attach, although the degree of this potential effect is not well understood

Cumulative Impacts

The cumulative impacts of floodwalls and levees on plankton are not expected to be significant because the generation of turbidity during construction would be of short duration and limited to within work segments. However, the cumulative effects of turbidity, which may affect plankton, may be increased if there are other similar activities ongoing and nearby that generate turbidity such as dredging, earth disturbance, non-point storm water discharges, etc. The widespread construction of floodwalls and levees may have some indirect cumulative effects as discussed previously such as losses of transitional upland areas that could filter nutrients and additional hardened substrates suitable for sea nettle polyp attachment. These effects coupled with climate change and sea level rise are less understood.

Storm Surge Barriers/Bay Closures

Direct Impacts

The direct impacts of the implementation of storm surge barriers and bay closures on both zooplankton and phytoplankton would result in temporary increases in turbidity and total suspended solids in the vicinity during construction. Increased turbidity is likely to inhibit photosynthesis and primary production provided by phytoplankton and thus may have some minor effects on the food chain.

Indirect Impacts

The operation of storm surge barriers and bay closures could potentially have significant effects on plankton abundance and distribution in the affected bays by altering water quality, velocities, salinity levels and nutrient levels. The potential changes associated with constrictions of flow while the gates are open during normal conditions may be negligible to significant. Hydrodynamic and water quality modeling will help inform what these changes may produce on water quality and effects on the planktonic community. However, during the operation of the gates when they are closed during storm events, these changes may be more profound, albeit temporary, but could have a potential to affect the survival rate of plankton. A salinity reduction due to structural gate closures (>5 days) post-hatch zooplankton larvae could experience a 100% mortality rate. A majority of larvae will not survive past day three (Richmond & Woodin, 1996). Varying growth rates during a salinity drop is dependent on the duration of the salinity reduction and the age of the embryos and larvae when exposed to the reduced salinity environment. Phytoplankton is vulnerable to large salinity changes, with the exception of picoplankton, which is able to survive in salinities from 5ppt and up. In the upper reaches of the waterbodies protected by surge barriers, closures during storm events can decrease salinity to less than 5ppt. Drastic changes can be expected to cause some mortality of phytoplankton (Lancelot and Muylaert, 2011), as well as zooplankton (Lance, 1963). Any closures are not planned to be for long periods of time so these salinity differences due to closures are minor to moderate and are temporary, but they will cause local mortality of plankton. However, these impacts are temporary and negligible due to the size of the area impacted relative to the Bay and its tributaries, as well as the ability of plankton communities to rapidly recover from local impacts. As pump stations are activated during storm events, plankton will also be entrained in the pumping mechanism. This will cause plankton mortality in the local area and waters immediately around the pump station. This impact is minor and temporary, as significant amounts of the plankton will survive this operation and the local population will be able to quickly recover (USACE, 2017).

Predictive alterations in hydrodynamics through changes in bay circulation and flushing would require hydrodynamic modeling to determine changes in residence time with gates open and closed. Significant changes in residence time could affect nutrient levels, salinity and temperature, which could potentially promote phytoplankton blooms including the more problematic harmful algal blooms (HABs). HABs can adversely affect aquatic life including fish, shellfish and SAV beds along with some human health implications. To better understand the effects of the various inlet barriers and bay closures under consideration, the next phase of the study will include initial hydrodynamic and water quality modeling that would be applied to better assess the effects that these measures would have on these bay systems.

Cumulative Impacts

The combination of storm surge barriers and/or bay closures with existing water quality trends concerning algal blooms and climate change/sea level rise have the potential to result in cumulative disruptions in the planktonic community by affecting the balance and seasonal abundances of the native planktonic species. Potential adverse cumulative effects could result in phytoplankton/zooplankton mortalities and/or the promotion of increased bay-wide systemic algal blooms including HABs. However, the cumulative impacts of the operation of storm surge barriers and bay closures on water quality are not well known. Since these structures have the potential to affect bay-wide system water quality, there is a potential for cumulative effects on water quality and plankton when coupled with existing water quality trends and the effects of climate change/sea level rise. Hydrodynamic and water quality modeling of these structures will help inform the degree, if any, of cumulative effects on plankton in the affected NJBB.

Climate change and sea level rise introduce greater uncertainty when combined with the effects of storm surge barriers where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality where the bay's plankton may experience shifts in distribution and abundance.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that would produce turbidity, introduce nutrients, and increase eutrophication that could help facilitate the formation of an algal bloom. However, soil disturbances can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays. Thus, reducing nutrients and their potential for promoting algal blooms.

Natural and Nature-Based Features (NNBFs)

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. NNBFs are expected to have long-term beneficial impacts on water quality, and thus on helping to minimize harmful phytoplankton blooms by providing services such as more stable substrates (less turbidity), nutrient uptake, and/or provide habitat that is better suited for filter feeders that can capture phytoplankton and suspended particles.

Submerged Aquatic Vegetation (SAV) and Macroalgea

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative changes in the SAV and marcroalgae coverages or density are expected as described in the Affected Environment section. BBP (2016) report that the current condition of seagrasses in Barnegat Bay are “degraded” with no discernable trends. Any significant interventions such as changes in land use or improvements through implementation of new water quality improvement programs such as TMDLs administered by Federal, State, and local agencies may have an indirect effect on seagrasses/SAVs/macroalgae through either degradation or improvements in nutrient loads in the NJBB. However, climate change and sea level rise introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality, algal blooms, and SAV/macroalgae distribution and abundance. Additionally, sea level rise could potentially impact seagrass beds by increasing water depths resulting in reductions in light penetration, photosynthesis, and productivity (Strange, 2008; USACE, 2014).

Structural Measures

Perimeter - Floodwalls, Levees and Miter Gates

Direct Impacts

The direct impacts of construction of floodwalls and miter gate structures within shallow bay waters would be the direct mortality of SAVs and permanent loss of SAV habitat within the footprint alignment of the structure. These mortalities would result through either removal from excavations, burial from fill placement or excessive turbidity, which may inhibit photosynthesis. Additionally, temporary losses of SAVs may be experienced through the placement of de-watering structures and either temporary fills or excavation for temporary access points to the work segment. Preliminary estimates of affected SAV beds are based on existing mapping, the current (preliminary) alignments and an assumed width of the disturbance offset from the structure. No SAV surveys have been conducted along any of the preliminary perimeter plan alignments. Additionally, mapping of SAV beds are only available for Barnegat Bay (spatial data adopted from http://crssa.rutgers.edu/projects/coastal/sav/ and Lathrop and Haag, 2010). Therefore, the only alternative in the focused array with a perimeter plan where SAV bed mapping is available is 3E(3), which includes a perimeter along the southern end of Long Beach Island (from Ship Bottom to Holgate). Based on the current alignment and level of design, it was estimated that up to 11 acres of predominantly sparse (10-40%) cover density SAVs would be impacted. A loss of 11 acres of SAVs would be considered significant based on the value of this type of habitat and the acreage involved, and would, therefore, require compensatory mitigation if avoidance and minimization of the impact cannot reduce this impact. However, it should be noted that this estimate is very preliminary. A more precise estimate of temporary and permanent disturbance will be available upon completion of SAV surveys in all locations/waterways with perimeter structures and with a higher level of design and construction plan of the structures involved.

Indirect Impacts

Indirect impacts are not significant due to the duration of impact, but they may contribute to additional stressors on an already biologically stressed community. Indirect impacts could be the resuspension of sediments containing nutrients and a decrease of transitional upland areas (by increasing hardened shoreline) that act as filters for non-point source run-off. An indirect effect of increased run-off and nutrients would contribute to increased turbidity, eutrophication and phytoplankton/filamentous algae and macroalgae blooms. Increased phytoplankton blooms contribute to significant declines in SAV beds and their density by interfering with photosynthesis that include shading of the water column and/or promoting the epiphytic growth on the leaves (wasting disease), and the smothering of beds with decaying algae. Reductions in SAV beds have further indirect impacts on the ecological services provided by SAVs including benthic invertebrate communities, shellfish beds, fish nurseries, sediment stabilization and wave attenuation. The level of these effects are difficult to quantify, but the temporary impacts can be managed by implementing best management practices during construction to minimize sedimentation and turbidity.

Cumulative Impacts

Despite recent efforts at restoration of SAVs in Barnegat Bay, the direct loss of SAV beds from the implementation of the perimeter plan will contribute to continued degradation and losses of this valuable habitat. A loss of 11 acres of SAVs would be considered significant based on the value of this type of habitat and the acreage involved, and would, therefore, require compensatory mitigation if avoidance and minimization of the impact cannot reduce this impact.

Climate change and sea level rise introduce greater uncertainty when combined with the effects of perimeters within the vicinity of SAV beds where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality where the bay's SAV may experience shifts in distribution and abundance.

Storm Surge Barriers/Bay Closures

Direct Impacts

No SAV surveys have been conducted along any of the preliminary storm surge barrier (SSB) and bay closure (BC) alignments. Additionally, mapping of SAV beds are only available for Barnegat Bay (spatial data adopted from http://crssa.rutgers.edu/projects/coastal/sav/ and Lathrop and Haag, 2010). Therefore, the only alternatives with a storm surge barrier plan in the general vicinity where SAV bed mapping is available are 3E(2) and 3E(3), which includes a storm surge barrier across Barnegat Inlet. According to the mapping, there are no SAV beds within a mile of the Barnegat Inlet SSB alignment, therefore, no direct impacts to SAVs are expected. This is also likely in other inlet SSBs in the array of alternatives including Manasquan Inlet, Absecon Inlet, and Great Egg Harbor Inlet due to the high energies and depths, which would be unsuitable for SAVs. Two bay closures (BCs) are at Absecon Blvd. (Atlantic City) and one at Southern Ocean City. No mapping is available for these locales. A more precise estimate of temporary and permanent disturbance will be available upon completion of SAV surveys in all locations/waterways with SSB and BC structures and with a higher level of design and construction plan of the structures involved.

Indirect Impacts

The implementation of storm surge barriers (SSBs) and bay closures (BCs) could potentially have significant effects on SAV abundance and distribution in the affected bays by altering velocities, sediment scour and deposition, water quality, salinity levels and nutrient levels. These changes may be most significant in the Barnegat Bay – Little Egg Harbor Estuary, which have the most extensive beds, and account for nearly 75% of the beds in New Jersey (Kennish et al. 2010). The potential changes associated with constrictions of flow while the gates are open during normal conditions may be negligible to significant depending on the gate design and associated cross-sectional areas. Localized changes in velocity are expected; however SAV beds are not expected within the immediate vicinity of the SSBs within the inlet areas. There are no bay closures identified in the focused array of alternatives in the Barnegat Bay and Little Egg Harbor estuaries. No SAV information is currently available for bay closure locations in Absecon Blvd. (Atlantic City) and 52nd St. (Ocean City).

Except for maintenance activities, gate closures would occur at times of storms with increased precipitation, which have the potential to alter salinity (reduce), sedimentation patterns, and circulation. The duration of these closures is uncertain, but could generally range from 24 to 48 hours. Although eelgrass can be found in a wide range of salinity (0-30 ppt), eelgrass populations from different areas may have developed genetic adaptations to local salinity regimes and salinity/nutrient interactions (Kukola, undated draft white paper), which could potentially make them susceptible to stress due to increased fluctuations in salinity. These fluctuations in salinity would result from the gates preventing polyhaline marine waters from entering the estuary during a time of heavy freshwater precipitation and freshwater discharge from the rivers and streams entering the estuary.

The effects of gate closures may alter sedimentation patterns that could affect eelgrasses. Kukola (undated) reports that coarse-grained sediment substrates with less than 4% organic matter are ideal for eelgrass and that dark anaerobic silty sediments are not suitable. It is not known if significant deposition of fine grained sediments would occur following a gate closure. However, any changes in sediment deposition patterns could affect eelgrass distribution in the bay.

Gate closures could potentially affect circulation and bay water residence time, which could exacerbate existing eutrophication problems resulting in eelgrass becoming more stressed and more susceptible to wasting disease from these changes.

Predictive alterations in hydrodynamics through changes in bay circulation and flushing would require hydrodynamic modeling to determine changes in residence time with gates open and closed. Significant changes in residence time could affect nutrient levels, salinity and temperature, which could potentially promote phytoplankton and certain macroalgae blooms including the more problematic harmful algal blooms (HABs). HABs can adversely affect aquatic life including fish, shellfish and SAV beds along with some human health implications. The degree of measured changes to residence times based on storm surge barrier and bay closure gate openings and closure scenarios through the use of hydrodynamic and water quality modeling will inform the level of concern for the potential of promoting phytoplankton blooms including HABs. To better understand the effects of the various inlet barriers and bay closures under consideration, the next phase of the study will include initial hydrodynamic and water quality modeling that would be applied to better assess the effects that these measures would have on these bay systems.

Cumulative Impacts

Climate change and sea level rise, which are expected to affect future bay temperatures, precipitation events, water quality, and shifts in photic zones due to changes in water depths along with current negative trends on nutrient enrichment are all significant stressors on eelgrass beds, particularly in the Barnegat Bay – Little Egg Harbor estuary. The introduction of storm surge barriers, which have the potential to affect hydrodynamics and water quality could impose additional indirect stressors on SAVs (eelgrass in particular); therefore contributing to cumulative adverse impacts on this resource. Hydrodynamic and water quality modeling will help inform the degree of this effect.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that would produce turbidity, introduce nutrients, and increase eutrophication that could help facilitate the formation of algal blooms. Both turbidity and algal blooms are detrimental to SAVs. However, soil disturbances can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays. Thus, reducing nutrients and their potential for promoting algal blooms, which are detrimental to SAVs.

Natural and Nature-Based Features (NNBFs)

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. Avoidance of important SAV habitats would be part of the criteria for choosing NNBF locations. Therefore, no adverse effects on SAVs are expected. However, as discussed, SAVs can be utilized as an NNBF measure in the form of restoration. The implementation of SAV NNBFs would provide all of the ecological services as described in the affected environment section including more stable substrates (less turbidity), and nutrient uptake, as well as provide habitat that is better suited for filter feeders that can capture phytoplankton and suspended particles, and critical fish and shellfish habitat life requisites.

Wetlands and Tidal Flats

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. The No Action scenario is expected to continue existing conditions for wetland systems as described in the Affected Environment and continuation of existing trends unless there are significant interventions. BBP (2016) reports that tidal wetland areas in Barnegat Bay and their overall condition are in a degraded state due to losses from development and erosion from boat wakes, and degradation from other stressors such as sudden marsh die-backs and subsidence that result in more than 94% of tidal wetlands in Northern Barnegat Bay and 77% of tidal wetlands in Southern Barnegat Bay to be classified as moderate to severely stressed. Therefore, the current trend for wetland losses is negative and the trend for wetland conditions is unknown due to a limited sample period. Most of the other bay systems of the NJBB have similar issues, and it can be inferred that there are similar statuses and trends.

Predicted climate change impacts such as increased sea level rise, have the potential to cause changes in the nature and character of the wetlands in the NJBB study area. In general, wetlands both inside and outside of the NJBB study area are at increased risk of degradation and loss from sea level rise. Wetlands may erode further, or be at increased risk of becoming too inundated to support vegetation while not keeping up with sediment accretion rates. Eventually, sea level rise may cause estuarine and freshwater wetlands to retreat inland (USACE, 2017). However, wetland retreat may not be possible in a lot of locations due to exiting heavy development and structures that would halt this process.

As reported in USACE (2014), New Jersey's coastal wetlands and tidal mudflats are highly susceptible to the effects of sea level rise. Tidal mudflats would experience increased inundation and/or their tidal regimes changed from intertidal to subtidal. Coastal wetlands can adapt and keep pace with sea level rise through vertical accretion and inland migration, but must remain at the same elevation relative to the tidal range and have a stable source of sediment. Cooper et al. (2005) reported that coastal wetlands in New Jersey will generally be unable to accrete at a pace greater or equal to relative sea level rise (3.53 mm/year) and are extremely susceptible to permanent inundation. According to Lathrop and Love (2007), New Jersey's salt marshes appear to have been able to keep pace with historical rates of sea level rise, but if sea level rises faster than marsh accretion, tidal marshes could eventually be drowned and replaced by open water. Strange (2008) reported that New Jersey's tidal salt marshes are keeping pace with current local rates of sea level rise of 4 mm/yr, but will become marginal with a 2 mm/yr acceleration, and will be lost with a 7 mm/yr acceleration except where they are near local sources of sediments (e.g., rivers such as the Mullica and Great Harbor rivers in Atlantic County). Coastal wetlands are forced to migrate inland due to a combination of sea level rise and vertical accretion forcing the saline marshes on the coastline to drown or erode and the upslope transitional brackish wetlands to convert to saline marshes. A significant portion of New Jersey's coastal wetlands are adjacent to human development or seawalls that block natural wetland migration paths and increase the likelihood of wetland loss from inundation (Cooper et al. 2005).

Two National Wildlife Refuges (Edwin B. Forsythe and Cape May) that are located within the NJBB system have been modeled for their coastal wetland habitat responses to sea level rise (SLR) using the Sea Level Affecting Marshes Model (SLAMM) (Warren Pinnacle Consulting, 2011 and 2012). This modeling simulates responses to multiple sea level rise scenarios by year and water surface elevation change, but may be generally inferred for the entire NJBB study area. SLAMM scenarios generally exhibit profound shifts in habitat with SLR where some losses and gains are offset between open water, tidal mudflats and regularly flooded marshes. However, habitats at the upper fringes such as irregularly flooded marshes (high marshes composed of salt meadow hay and scrub shrub habitats) and freshwater wetlands (palustrine forested and palustrine emergent wetlands) would experience complete losses due to the increased inundations. Table 12 presents some key results of the modeling for both of these areas.

Table 12: Wetland Change Simulations at Two National Wildlife Refuges Within the NJBB System Utilizing the Sea Level Affecting Marshes Model (SLAMM)

SLR SCENARIO at Year 2100	**General Effect on Wetland Habitats within Edwin B. Forsythe NWR (Barnegat Bay and Little Egg Harbor) and Cape May NWR**
>=0.69 meters	Near complete loss of Irregularly flooded marsh habitat
	Irregularly flooded marshes converted to regularly flooded marshes
<1.5 meters	Regularly flooded marshes converted to open water or tidal flat
>1.5 meters	Gains of tidal flats are less pronounced as inundation of the newly-formed tidal flats is predicted.
2 meters	50%-55% of freshwater swamp loss and conversion to transitional salt marsh/regularly flooded marsh due to inundation
	Undeveloped and developed dry land inundated, but not as significantly impacted as wetlands
	Open water increased from current 23% coverage to 70% coverage

Source: USACE (2014) and Warren Pinnacle Consulting (2011 and 2012)

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates

Direct Impacts

The direct impacts of the construction of floodwalls, levees and miter gate structures within coastal wetlands and shallow bay waters would be the loss of these habitats within the footprint alignment of the structures. These losses would result from either their removal from excavations or burial from fill placement. Additionally, temporary losses may be experienced through the placement of de-watering structures and either temporary fills or excavations for temporary access points to the work segment. Preliminary estimates of the affected wetland and shallow water habitats are based on existing mapping (NJDEP wetland mapping and National Wetlands Inventory - NWI), the current (preliminary) alignments and an assumed width of the disturbance offset from the structure. The footprints of the perimeter plans pass through subtidal, intertidal, and supratidal regimes, which include 14 different aquatic and wetland habitat types. The habitats most affected by the perimeter plans are the subtidal soft bottom areas with hardened (bulkhead, concrete wall) shorelines, intertidal mudflats and sandy beaches, low and high tidal saltmarshes, scrub-shrub habitats, and *Phragmites*-dominated marshes. A high number of these habitats are encountered as small pockets along heavily developed bay shorelines of the barrier islands. However, since the perimeter plan segments tend to be several miles long, the impacts are cumulative and significant. Table 13 provides preliminary estimates of direct permanent wetland impacts resulting from the construction of the focused array of alternatives (see Appendix A for maps and component features), which also include storm surge barriers and bay closures. Table 13 does not account for future losses of these habitats due to sea level rise. It should be noted that, to date, no jurisdictional wetland delineations have been conducted along any of the preliminary perimeter plan, storm surge barrier and bay closure alignments at this point. Therefore, these impact estimates may be modified and refined based on a higher level of design detail that include surveyed wetland jurisdictional lines, and mitigation measures that first employ avoidance and minimization. However, it is assumed that for unavoidable wetland and aquatic habitats, compensatory mitigation will be required based on habitat modeling. Ecosystem modeling being considered for wetlands and aquatic habitat

Table 13: Preliminary Estimated Direct Impacts (Losses in Acres) on Wetland and Other Aquatic Habitats from the Focused Array of Alternatives

HABITAT:	SUB-TIDAL OPEN WATER	SUBTIDAL OPEN WATER W/ HARDENED SHORELINE (bulkhead)	SAV BEDS	INTER-TIDAL MUDFLAT	INTERTIDAL SANDY BEACH	INTERTIDAL ROCKY SL	SALINE LOW MARSH	SALINE HIGH MARSH	SCRUB SHRUB DECID-UOUS	SCRUB SHRUB CONIF-EROUS	FORESTED	HERB-ACEOUS	PHRAG-MITES DOM-INATED	MANAGED WETLAND (LAWN)	DIST-URBED WETLAND
NWI CODES:	E1UBL, E1UBLx	E1UBL, E1UBLx, E1UBL6	E1AB3L E1ABLx	E2USM, E2USP, E2USN	E2USS, E2USM, E2USP, E2US2P E2USN	E2RS2, M2USN	E2EM1N, E2EM1Nd E2EM1P	E2EM1N, E2EM1P	E2SS1P, PSS1/4B	PEM1R, E2EM1P	PFO1/SSR1	E2EM1N	E2EM1N, E2EM5P, E2EM1P	PEM1R	PEM1R, E2EMP
ALTER-NATIVE															
2A N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3A N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3D † N	0.77	8.0	-	0.92	1.2	0.1	1.0	1.7	-	2.0	-	-	0.9	-	-
3E(2) * N	7.5	-	-	-	0.1	0.4	-	-	0.9	-	-	0.2	-	-	-
3E(3) †* N	8.8	67.6	11.2	9.1	15.1	1.4	10.0	11.2	5.1	0.6	-	0.2	2.3	-	-
4A N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4D(1) † N	4.3	91.8	-	18.4	8.3	3.6	54.6	8.5	6.9	3.4	-	0.3	19.5	4.5	5.6
4D(2) † N	4.6	106.8	-	29.1	9.4	3.6	69.3	13.6	7.1	3.4	-	0.7	19.5	4.5	5.6
4E(2) * N	24.4	-	-	-	4.5	3.0	-	-	-	-	-	-	-	-	-
4E(3) †* N	24.4	1.1	-	0.3	4.5	3.0	30.4	2.9	1.8	1.8	-	-	6.1	4.5	-
4E(4) *≈ N	25.9	-	-	-	4.5	3.0	20.7	1.2	-	0.7	-	-	19.5	4.5	-
4G(6) *≈ N	20.9	17.9	-	3.2	3.7	2.2	39.2	12.8	1.5	-	-	0.6	2.6	-	1.0
4G(7) †*≈ N	20.9	19.0	-	3.5	3.7	2.2	69.6	15.8	3.3	1.8	-	0.6	8.7	4.5	1.0
4G(8) *≈ N	22.4	17.9	-	3.2	3.7	2.2	59.9	14.1	1.5	0.7	-	0.6	2.7	-	1.0
4G(10) †*≈ N	21.2	32.9	-	13.9	4.9	2.2	53.9	18.0	1.6	-	-	1.1	2.6	-	1.0
4G(11) †*≈ N	21.2	34.0	-	14.2	4.9	2.2	84.3	20.9	3.4	1.8	-	1.1	8.7	4.5	1.0
4G(12) †*≈ N	22.8	32.9	-	13.9	4.9	2.2	74.6	19.2	1.6	0.7	-	1.1	2.7	-	1.0
5A N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5D(1) † N	0.5	38.8	-	22.5	9.5	2.9	46.7	24.9	13.4	2.1	4.6	1.8	9.0	0.5	1.7
5D(2) † N	0.6	107.7	-	32.8	11.3	3.0	68.3	34.4	14.4	6.1	4.6	1.8	11.2	0.5	1.7

KEY: † Alternative includes one or more perimeter (floodwalls/levees) protection segments. N Alternative includes non-structural (building raising) measures at one or more location(s).

* Alternative includes one or more inlet storm surge barrier(s).

≈ Alternative includes one or more bay closure barrier(s).

Northern Region	Central Region	Southern Region

Note: Estimates (in acres) are very preliminary based on a low-level of design, and have not undergone avoidance and minimization analyses, which may result in later changes in estimates.

impacts and mitigation include the USACE EcoPcX-approved New England Marsh Model (McKinney et al., 2009) and the Benthic Index of Biotic Integrity (B-IBI).

Indirect Impacts

The indirect impacts of perimeter structures on aquatic habitats and wetlands are expected to be minimal to moderate and are related to temporary impacts such as sedimentation during construction and long-term impacts where hardened structures could halt landward migration of marshes, particularly with sea level rise. However, this effect is not significant since the majority of the shorelines along the back bays already are hardened with bulkheads, concrete revetments and riprap.

Significant losses of these habitats will indirectly affect a number of aquatic biota such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors and neo-tropical migrants that utilize these habitats for various life requisite stages such as spawning/nesting, nursery/rearing, feeding, reproduction, etc.

Cumulative Impacts

Direct cumulative impacts from the implementation of perimeter plans on wetland and other aquatic habitats are potentially significant based on the linear nature of these structures over long distances. These linear features encounter a number of wetland aquatic habitats that are predominantly subtidal soft bottom, intertidal mudflats, intertidal sandy beaches, low salt marshes, high salt marshes, scrub-shrub wetlands, and *Phragmites*-dominated wetlands. Losses of these habitats particularly on the upper intertidal range (ie. high salt marshes, scrub-shrub wetlands) may be more significant when coupled with sea level rise, as these types of habitats will not be able to migrate landward where existing heavy development and hardened structures already exist. Cumulative losses of wetland and other aquatic habitats will indirectly affect a number of aquatic biota such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors and neo-tropical migrants where they may be forced to crowd into diminishing suitable habitats affected by sea level rise.

Storm Surge Barriers/Bay Closures

Direct Impacts

The direct impacts that the implementation of storm surge barriers (SSB) in inlets would have on aquatic and wetland habitats would be significant, but due to the smaller footprint of these structures, they would have comparatively less direct impacts than the bay closures and perimeter structures. Because SSBs are located within existing stabilized inlets, the footprint of these structures would mostly affect subtidal soft bottom, intertidal sandy beach, and intertidal rocky shorelines (inlet jetties) resulting in losses of these habitats. These losses would result from either their removal from excavations or burial from fill placement. Additionally, temporary losses may be experienced through the placement of de-watering structures and either temporary fills or excavations for temporary access points to the work segment.

Bay closures (BCs) would potentially have greater direct impacts on wetland habitats than SSBs mainly due to their locations, which span (generally east-west) across a number of habitats including subtidal soft bottom, intertidal mudflats, and intertidal low and high saltmarshes across the bays. The BCs that are in the focused array of alternatives are both located in the Central Region, and they would occur at Absecon Blvd. (Atlantic City) and Southern Ocean City (along an abandoned railroad embankment off of 52nd St.). None of the BCs in the focused array of alternatives are stand-alone and are in various combinations with SSBs and perimeter plans.

It should be noted that, to date, no jurisdictional wetland delineations have been conducted along any of the preliminary perimeter plan, storm surge barrier and bay closure alignments at this point. Therefore, these impact estimates may be modified and refined based on a higher level of design detail that include surveyed wetland jurisdictional lines, and mitigation measures that first employ avoidance and minimization. However, it is assumed that for unavoidable wetland and aquatic habitats, compensatory mitigation will be required based on habitat modeling. Ecosystem modeling being considered for wetlands and aquatic habitat impacts and mitigation include the USACE EcoPcX approved New England Marsh Model (McKinney et al., 2009) and the Benthic Index of Biotic Integrity (B-IBI).

Indirect Impacts

The short-term indirect impacts of SSB and BC structures on aquatic habitats and wetlands are expected to be minimal to moderate, and are related to temporary impacts such as sedimentation during construction. However, SSBs and BCs may pose long-term significant indirect effects on wetlands and other aquatic habitats. Depending on the design of an SSB or BC, the available openings to pass tidal flows when open during normal conditions may be somewhat more constricted than existing inlets and other waterways. A constriction could conceivably change the tidal prism by limiting incoming (flood) tides that could result in a lowered high tide elevation and the outgoing (ebb) tides could result in higher low tides, thereby affecting wetland and aquatic habitats at each end of the tidal range on a bay-wide scale. These changes, even if subtle, could significantly impact a whole wetland habitat such as high salt marsh/transitional wetlands at the upper end of the tidal range or at the intertidal mudflat-open water subtidal transitional areas at the lower end of the tidal range over an entire bay-wide system. Flow constrictions could also result in increased velocities causing scour in the vicinity of the gates and decreased tidal velocities in areas further away thereby increasing sediment deposition in other areas. Additional indirect impacts on these habitats relate to potential changes in salinity from gate closures and influxes of freshwater from precipitation, which could result in floral and faunal community shifts within these habitats. Climate change and sea level rise also could compound these changes as evidenced in the predictive SLAMM modeling where significant shifts in wetland types were observed over variable time intervals and SLR scenarios. Therefore, interactions of these types of structures with the existing tidal conditions and sea level rise are complex. The degree of impact on the various wetland systems, if any, requires hydrodynamic modeling to predict these changes. The hydrodynamic modeling would consider existing tidal conditions, tidal conditions with future sea level rise, and various design configurations of the gates (w/ SLR) when opened and closed. Additionally, losses of wetland and other aquatic habitats will indirectly affect a number of aquatic biota such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors and neo-tropical migrants.

Cumulative Impacts

Indirect cumulative impacts from the implementation of SSBs and BCs on wetland and other aquatic habitats are potentially significant based on the potential system-wide effects on hydrodynamics including tidal range and salinity. Small induced changes over a widespread area such as an entire bay system have the potential to result in significant impacts including losses of high marshes/transitional wetlands on the upper end and losses of mudflats on the lower end of the tidal range. These effects coupled with sea level rise and potential habitat shifts as evidenced by SLAMM model runs are uncertain, and will require hydrodynamic modeling to inform the degree of this effect. Additionally, cumulative losses of wetland and other aquatic habitats will indirectly affect a number of aquatic biota such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors and neo-tropical migrants.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities would not result in any direct wetland and aquatic habitat impacts. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that would produce turbidity, introduce nutrients, and increase eutrophication that could degrade wetlands and aquatic habitats from stormwater. However, soil disturbances can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality and wetland habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities or as freshwater wetlands in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays, and potentially provide additional wetland habitat.

Natural and Nature-Based Features (NNBFs)

NNBF’s in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it’s method of construction. For instance, some NNBFs like wetland restoration or reef construction may require the aquatic placement of fill materials that would disturb existing substrates of subtidal soft bottoms or intertidal mud or sand flats, and likewise generate localized, but temporary, turbidity in the water column. These effects are expected to be temporary after construction is completed and the areas become stabilized with vegetation and/or other biogenic processes. The installation of NNBFs would also result in conversions of habitat. For instance, a subtidal soft-bottomed subtidal habitat may be changed to an intertidal saltmarsh, mudflat, beach, or reef. However, the installation of NNBFs would have beneficial impacts, by providing overall ecological uplifts of wetland and aquatic habitats in the NJBB study area.

Terrestrial Habitats

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative changes to terrestrial habitats are expected as described in the Affected Environment section. It is assumed that continued beach nourishment along the Atlantic Coast beaches would maintain terrestrial habitats such as the upper beach, dunes and lands behind these features along the developed barrier islands. Existing land use trends may continue with conversions of some upland habitats to urban lands within areas zoned for development. Sea level rise may convert some lower lying upland areas into transitional wetlands.

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates

Direct Impacts

In general, the perimeter plans include floodwalls and levees that would be constructed on the western side of the barrier islands along residential bay fronts and would tie into existing dunes at the northern and southern ends of the barrier islands. An exception to this would be for Manasquan Beach (north of Manasquan Inlet), where a levee/dune structure would be constructed along the upper beach for over 1 mile of Atlantic Coast beach (alternative 3D). The majority of the terrestrial habitats affected by the various perimeter plan configurations are urbanized residential areas, where there are predominantly bulkhead structures that line the back bays and lagoons. The impacts of floodwall construction on terrestrial habitats in these areas would be temporary and minimal since they do not provide high habitat value for terrestrial fauna, and disturbance to ground and vegetation would be temporary until construction activities cease and the areas are stabilized and vegetation is restored.

Table 14 provides estimates of terrestrial vegetated dune and upper beach habitats affected by the various focused array of alternatives. Upper beach habitats are along the Atlantic Ocean coast beaches, and are above mean high water. These areas receive frequent salt spray, and possess sparse vegetation. In the case of Manasquan Beach, there is little or no existing vegetated dune along the upper beach. Alternative 3(D) includes a levee type of structure for a distance of about 6,000 linear feet from Manasquan Inlet and north. Although design details are limited at this time, this levee would likely include an impermeable core with an outer dune-like sandy layer that would be stabilized with American beachgrass and other suitable vegetation. Other alternatives with perimeter plans that affect vegetated dunes include levee/floodwall structures on the northern and/or southern ends of barrier islands where they tie into existing dunes. These areas would be stabilized and restored with coastal dune vegetation once construction is completed, and impacts on terrestrial habitat would, therefore, be temporary and minor. Pump stations for interior drainage will be required for perimeter plans, and would likely be located in a terrestrial location behind the perimeter structures. At this time, it is not known where the location of pump stations would be constructed. However, urbanized locations for these features would have the least impacts on terrestrial habitats.

Table 14: Estimate of Vegetated Dune/Upper Beach Habitats Affected by Alternatives with Structural Measures

Alternative	Vegetated Dune/Upper Beach Impacted (Acres)**	Notes:
2A [N]	-	All non-structural
3A [N]	-	All non-structural
3D [†N]	20.9	Levee structure for PP along approx.. 6,000 l.f. of upper beach area along Atlantic Ocean north of Manasquan Inlet.
3E(2) [*N]	22.6	Levee structure for SSB along approx.. 6,000 l.f. of upper beach area along Atlantic Ocean north of Manasquan Inlet and SSB tie-ins into existing dunes N. and S. of Barnegat Inlet.
3E(3) [†*N]	22.6	Levee structure for SSB along approx.. 6,000 l.f. of upper beach area along Atlantic Ocean north of Manasquan Inlet and SSB tie-ins into existing dunes N. and S. of Barnegat Inlet.
4A [N]	-	All non-structural
4D(1) [†N]	8	PP in vegetated dunes in N. Ocean City (Great Egg Harbor Inlet)
4D(2) [†N]	10.6	PP in vegetated dunes in S. Brigantine and N. Ocean City (Great Egg Harbor Inlet)
4E(2) [*N]	1.1	SSB seawall tie-ins to dunes at Absecon Inlet and Great Egg Harbor Inlet.
4E(3) [†*N]	2.3	SSB seawall tie-ins to dunes at Absecon Inlet and Great Egg Harbor Inlet and PP levee at S. O.C.
4E(4) [*≈N]	1.6	SSB seawall tie-ins to dunes at Absecon Inlet and Great Egg Harbor Inlet and BC levee at S. O.C.
4G(6) [*≈N]	1.4	SSB seawall tie-ins to dunes at Great Egg Harbor Inlet
4G(7) [†*≈N]	2.5	SSB seawall tie-ins to dunes at Great Egg Harbor Inlet and PP levee at S. O.C.
4G(8) [*≈N]	1.9	SSB seawall tie-ins to dunes at Great Egg Harbor Inlet and BC levee at S. O.C.
4G(10) [†*≈N]	4.0	PP in vegetated dunes in S. Brigantine and SSB seawall tie-ins to dunes at Great Egg Harbor Inlet
4G(11) [†*≈N]	5.1	PP in vegetated dunes in S. Brigantine and SSB seawall tie-ins to dunes at Great Egg Harbor Inlet and PP levee at S. O.C.
4G(12) [†*≈N]	4.5	PP in vegetated dunes in S. Brigantine and SSB seawall tie-ins to dunes at Great Egg Harbor Inlet and BC levee at S. O.C.
5A [N]	-	All non-structural
5D(1) [†N]	3.7	PP levee on vegetated dunes in S. Sea Isle City.
5D(2) [†N]	9.3	PP levee on vegetated dunes in S. Sea Isle City and S. Stone Harbor.

KEY: † Alternative includes one or more perimeter (floodwalls/levees) protection (PP) segments.
N Alternative includes non-structural (building raising) measures at one or more location(s).
* Alternative includes one or more inlet storm surge barrier(s).
≈ Alternative includes one or more bay closure barrier(s).

** Acreages only estimate areas affected by construction, and do not represent permanent losses of habitat since some of the alignments include levees that would be planted with coastal vegetation that would function as a vegetated dune habitat.

Alternative			Vegetated Dune/Upper Beach Impacted (Acres)**	Notes:
Northern Region	Central Region	Southern Region	Note: Estimates (in acres) are very preliminary based on a low-level of design, and have not undergone avoidance and minimization analyses, which may result in later changes in estimates.	

Indirect Impacts

Indirect impacts are not significant. Construction activities will temporarily remove vegetation and displace terrestrial wildlife during construction. These habitats will be available to nesting species such as neo-tropical migrant birds and diamondback terrapins (dunes) once construction is completed, and these areas are restored with dune vegetation.

Cumulative Impacts

Cumulative impacts on terrestrial habitats are not expected to be significant because the perimeter plans will not result in cumulative losses of terrestrial habitats since the levee structures would be designed to mimic existing dunes.

Storm Surge Barriers/Bay Closures

Direct Impacts

In general, the storm surge barriers (SSBs) would be constructed at the selected inlets, and would tie into existing dunes at the northern and southern ends of the barrier islands. An exception to this would be for Manasquan Beach (north of Manasquan Inlet), where a levee/dune structure would be constructed along the upper beach for over 1 mile of Atlantic Coast beach (alternatives 3E(2) and 3E(3)). All SSBs require seawall tie-ins to existing dunes at all of the inlets identified in the focused array. The impacts of seawall construction on terrestrial habitats in these areas are variable based on the local habitat conditions. For example, a seawall that ties into an existing natural dune on the north side of Barnegat Inlet represents a permanent loss and disturbance to a sensitive habitat whereas a seawall on the south side of Absecon Inlet would align with existing paved surfaces.

Upper beach habitats are along the Atlantic Ocean coast beaches, and are above mean high water. These areas receive frequent salt spray, and possess sparse vegetation. In the case of Manasquan Beach, there is little or no existing vegetated dune along the upper beach. Alternatives 3E(2) and 3E(3) include a levee type of structure for a distance of about 6,000 linear feet from Manasquan Inlet and north. Although design details are limited at this time, this levee would likely include an impermeable core with an outer dune-like sandy layer that would be stabilized with American beachgrass and other suitable vegetation.

Other perimeter plans that affect vegetated dunes would be the construction of the levee structures for BCs through existing vegetated dune habitats particularly on the southern end of Ocean City where the BC ties into existing dunes. These areas would be stabilized and restored with coastal dune vegetation once construction is completed, and impacts on terrestrial habitat would, therefore, be temporary and minor. Other terrestrial habitats affected by BCs involve levee structures along urbanized roadways and abandoned railroad embankments (S. Ocean City). Pump/generator stations for SSBs will be required, and would likely be sited in a terrestrial location adjacent to the barriers. At this level of design, it is not known where these features would be constructed.

Indirect Impacts

Indirect impacts are not significant. Construction activities will temporarily remove vegetation and displace terrestrial wildlife during construction. These habitats will be available to nesting species such as neo-tropical migrant birds and diamondback terrapins (dunes) once construction is completed, and these areas are restored with dune vegetation. The permanent seawalls required to tie SSBs into existing dunes will result in a permanent loss of habitat for these species. However, the actual footprint of these structures is small.

Cumulative Impacts

Cumulative impacts on terrestrial habitats are not expected to be significant because the SSBs and BCs will not result in cumulative losses of terrestrial habitats such as vegetated dunes since the levee structures associated with SSBs and BCs would be designed to mimic existing dunes. The footprint impacts of seawalls at dune tie-in locations on vegetated dune habitats would be minimal.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. Existing structures would most likely be in upland urbanized settings where construction activities would result in direct terrestrial habitat impacts. However, these effects would be temporary, and would be most likely in urban areas that do not possess high terrestrial habitat values.

Nonstructural measures such as buyout and relocation could result in direct improvements to terrestrial habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation.

Natural and Nature-Based Features

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. At this time, it is not known the degree and extent of impacts an NNBF measure would have on terrestrial habitats. NNBFs, for the most part, involve implementing aquatic habitats. It is assumed that access through terrestrial areas and the need for staging may be required that could result in temporary land disturbance. Avoidance of sensitive terrestrial habitats would be managed to the maximum extent practicable. Depending on the NNBF measure proposed, terrestrial habitat could be incorporated into it, if appropriate. An example would be the creation of a supratidal open sandy area for colonial nesting birds on a predominantly saltmarsh island.

Wildlife

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, some direct, indirect and cumulative changes to wildlife are expected as described in the Affected Environment section. Projections for sea level rise (SLR) have the potential to adversely affect wildlife species based on losses of irregularly flooded marshes, freshwater wetlands, and some upland habitats. In locations where marshes and transitional areas have room to migrate, conversions of irregularly flooded marshes to regularly flooded marshes and regularly flooded marshes to intertidal mudflats may not necessarily adversely affect the species that depend on these habitats since these conversions (more or less) offset each other. However, irregularly flooded marshes, regularly flooded marshes, and intertidal mudflats and beaches that abut hardened shoreline structures in the back bays may be lost and converted to subtidal open water due to the inability of these habitats to retreat against a hardened shoreline. Conversion of intertidal mudflats and sandy shorelines to open water may have impacts on a number of bird species. Strange (2008) reported that inundation of tidal flats, marsh pannes, and pools as a result of rising seas would eliminate critical foraging opportunities for hundreds of species of shorebirds, passerines, raptors, and waterfowl, as the tidal flats of New Jersey's back-barrier bays, including the flats of Great Bay Boulevard Wildlife Management Area, North Brigantine Natural Area, and the Brigantine Unit of the Forsythe Refuge would be inundated more. In addition, as tidal flat area declines, increased crowding in remaining areas could lead to exclusion and mortality of many foraging birds (USACE, 2014). Strange (2008) further reports that SLR would affect (and possibly eliminate) the more vulnerable low lying islands within the back bays that are habitat for several species of conservation concern including the northern diamondback terrapin, and nesting common terns, Forster's terns, black skimmers, and American oystercatchers (USACE, 2014). Several scenarios presented by Strange (2008) and USACE (2014) demonstrate potential impacts on SLR and loss of marsh habitats on birds include:

- Deeper tidal creeks and marsh pools will become inaccessible to short-legged shorebirds such as plovers and long-legged waterbirds such as yellow-crowned night heron, which forages almost exclusively on marsh crabs (fiddler crab and others), will lose important food resources.
- High marsh nesting birds such as northern harrier, black rail, which are state-listed as endangered, clapper rail, and willet may be most at risk.
- Complete conversion of marsh to open water will affect the hundreds of thousands of shorebirds that stop in these areas to feed during their migrations.
- Waterfowl also forage and overwinter in area marshes and will likely be impacted by lost habitat as a result of sea level rise- midwinter aerial waterfowl counts in Barnegat Bay alone average 50,000 birds.
- Local populations of marsh-nesting bird species will also be at risk where marshes drown and this will have a particularly negative impact on rare species such as seaside and sharp-tailed sparrows, which may have difficulty finding other suitable nesting sites.
- Species that nest in other habitat but rely on marshes for foraging, such as herons and egrets, will also be affected as marshes drown.

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates

Direct Impacts

Disturbance during construction including habitat losses and noise will temporarily displace most of the wildlife as described in the Affected Environment section. Most of the wildlife are expected to return to the vicinity of the work areas once construction activities cease and the areas are stabilized. However, permanent displacement of wildlife through permanent loss of habitat will result in significant adverse impacts on wildlife. Wildlife species such as shorebirds and wading birds that feed in intertidal mudflats, sandy beaches and saltmarshes would lose this habitat. Additionally, affected areas would require an evaluation of their potential for impacting nesting migratory birds, and the implementation of appropriate measures to be in compliance with the Migratory Birds Treaty Act. Vertical barriers such as floodwalls may cut-off access between aquatic and terrestrial habitats, which could affect diamondback terrapins migrating from the bays and saltmarshes to nest in sand dunes (Although, this effect may be minimal since the majority of floodwall areas are located at existing bulkheads/hardened shorelines, and the terrestrial land behind them is urbanized.). In some locations, a floodwall may act as a barrier that prevents diamondback terrapins from crossing roads thereby, preventing mortalities resulting from vehicle strikes.

Indirect Impacts

The indirect impacts that habitat loss would have on wildlife may result in displacement of birds into more crowded areas that have fewer food resources available. This situation would be particularly critical for resting and feeding shorebirds in their stopovers during migratory flights.

Cumulative Impacts

Cumulative impacts from the implementation of perimeter plans on wetland and other aquatic habitats necessary for a number of wildlife species, particularly birds, are potentially significant based on the linear nature of these structures over long distances. These linear features encounter a number of wetland aquatic habitats that are predominantly subtidal soft bottom, intertidal mudflats, intertidal sandy beaches, low salt marshes, high salt marshes, scrub-shrub wetlands, and *Phragmites*-dominated wetlands. Losses of these habitats particularly on the upper intertidal range (ie. high salt marshes, scrub-shrub wetlands) may be more significant when coupled with sea level rise, as these types of habitats will not be able to migrate landward where existing heavy development and hardened structures already exist. Cumulative losses of wetland and other aquatic habitats will indirectly affect a number of aquatic biota such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors and neo-tropical migrants.

Storm Surge Barriers/Bay Closures

Direct Impacts

The construction of storm surge barriers (SSBs) and bay closures (BCs) will temporarily displace wildlife within the active areas as described in the Affected Environment section. However, most of the displaced wildlife are expected to return to the vicinity of the work areas once construction activities cease and the areas are stabilized. Permanent direct losses of wildlife habitats at inlet SSBs are minimal as the majority of the impacts are in marine subtidal habitats. Some terrestrial upper beach/vegetated dune habitat would be lost to seawalls that tie into existing dunes on both sides of the inlets affected. The BCs, based on their cross-bay orientation), would result in greater intertidal aquatic and wetland habitat losses that could affect a number of shorebirds and wading birds. Additionally, affected areas would require an evaluation of their potential for impacting nesting migratory birds, and the implementation of appropriate measures to be in compliance with the Migratory Bird Treaty Act.

Indirect Impacts

The indirect effects of SSBs and BCs with respect to changes in hydrodynamics and water quality on wildlife are unknown. However, it is assumed that any adverse effects caused by SSBs and BCs on organisms lower in the food chain such as phytoplankton, zooplankton, benthic invertebrates and fish would result in indirect trophic impacts on wildlife that depend on these food resources. Additionally, velocity changes in the vicinity of an opened SSB gate could potentially impede migration of sea turtles and marine mammals through coastal inlets. Increased human activity associated with gate operations and maintenance activities may also result in intermittent or long-term adverse effects to wildlife within the vicinity of the activities.

Cumulative Impacts

The cumulative impacts of SSBs and BCs on wildlife are generally unknown, and could result indirectly from potential cumulative impacts on organisms lower in the food chain over entire bay-wide systems.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. Existing structures would most likely be in upland urbanized settings where construction activities would result in direct terrestrial wildlife habitat impacts and noise and disturbance may result in wildlife temporarily relocating. However, these effects would be temporary, and would be most likely in urban areas that do not possess high terrestrial habitat values.

Similarly, nonstructural measures such as buyout and relocation could result in temporary impacts to wildlife species that inhabit urbanized settings. However, direct improvements to terrestrial habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation would offer more opportunities for birds, mammals, and reptiles to inhabit these areas.

Individual properties would require an evaluation of their potential for impacting nesting migratory birds, and the implementation of appropriate measures to be in compliance with the Migratory Birds Treaty Act.

Natural and Nature-Based Features

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. At this time, it is not known the degree and extent of impacts an NNBF measure would have on terrestrial habitats. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction would are expected to have short-term adverse impacts on wildlife species, particularly for migratory shorebirds, water birds and waterfowl. However, NNBFs have the potential for having substantial beneficial impacts on these wildlife species by providing suitable foraging, resting, and breeding habitats such as saltmarshes, SAV beds, and living shorelines. This benefit would depend on the scale of implementation and the quality of habitat to meet the life requisites of target species.

Fisheries Resources

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. The No Action scenario is expected to continue existing conditions for fisheries (finfish and shellfish) and Essential Fish Habitat as described in the Affected Environment and continuation of existing trends unless there are significant interventions. BBP (2016) reports that estuarine fish communities in the northern portion of Barnegat Bay (north of Cedar Creek) are fairly diverse (a total of 69 species of fish) with the most common species encountered in a variety of estuarine habitats and salinity ranges that include Atlantic silversides, bunker/menhaden, bay anchovy, juveniles of black drum (*Pogonias cromis*), silver perch, winter flounder and bluefish. Based on the application of diversity indices, BBP (2016) provides an "above average" indicator status for fish with no discernable trends. Shellfish resources (primarily the hard clam) as reported by BBP (2016) are in a degraded state and no discernable trend in abundance in Barnegat Bay and Little Egg Harbor due to limited sample intervals. It is assumed that other NJBB systems have similar statuses with some local variations for fish and shellfish resources. Climate change and sea level rise (SLR) introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns along with chemical changes that could impose synergistic effects on the NJBB water quality (salinity, nutrients, DO) and algal blooms, which could adversely impact fish and shellfish habitat. Changes in salinity and flow patterns could disrupt migratory fish patterns and recruitment of shellfish. Some fish such as Atlantic silverside, mummichog, and bay anchovy may actually benefit from SLR as marshes along protected shorelines that experience an increase in tidal flooding and a deepening and widening of tidal creeks become more abundant. However, continued SLR may adversely affect these species in marshes along hardened shorelines that convert to open water by decreasing protection from predators, nursery habitat and foraging areas (Strange, 2008; USACE, 2014).

Structural Measures

The structural measures considered in the focused array of alternatives have a potential for significant direct, indirect and cumulative adverse impacts on fisheries and Essential Fish Habitat (EFH). Since the focused array of alternatives are very preliminary, a full evaluation of the effects on fisheries and EFH is not available at this time. As the study progresses and more information is obtained leading to the identification of a TSP, an EFH evaluation commensurate with the level of design will be conducted in accordance with the Magnuson-Stevens Fisheries Conservation Act.

Perimeter – Floodwalls, Levees and Miter Gates

Direct Impacts

The construction of perimeters including floodwalls, levees, and miter gates will have temporary and permanent adverse significant impacts on fisheries and Essential Fish Habitat (EFH). The temporary effects on fisheries would be based on disturbances during construction such as noise, water quality (turbidity, DO), and physical displacement. Noise impacts such as pile-driving could result in direct lethal and/ or sub-lethal effects to some finfish during construction. The generation of turbidity can adversely affect fish respiration, sight feeding, and could smother eggs/larvae. The generation of turbidity can also affect dissolved oxygen levels that can result in either mortalities or heavily stressed fish. However, with the exception of some smaller species and larval stages, most mobile fish would be able to move out of the active construction areas. The construction of floodwalls along intertidal and subtidal areas would also require temporary de-watering structures, which would temporarily displace access to these aquatic habitats for feeding or spawning activities.

Temporary effects on shellfish such as hard clams in construction areas would be adverse related to their sessile nature and for blue crabs that may become trapped in a construction segment. The generation of turbidity and low DO could result in lethal or sub-lethal effects on shellfish.

Permanent impacts to fish and fisheries are significant, and are associated with permanent habitat losses within the footprints of the perimeter structures. The highest direct losses of fisheries habitat (and EFH), are within shallow subtidal soft bottom habitats along an existing hardened shoreline, which is usually a bulkhead structure. The habitat loss is based on the width of a proposed floodwall in these areas that would be wider than the existing structure. Estimates of this impact range from 1.1 acres to nearly 108 acres of subtidal soft bottom. Alternatives with the highest impact on the bottom also have the longest perimeter plans along the bayfronts, these include 3E(3) (68 acres), 4D(1) (92 acres), 4D(2) (107 acres), and 5D(2) (108 acres). Some other habitats directly affected by perimeters are intertidal mudflats that range from 0.3 acres to 33 acres and lower salt marshes that range from 1.0 acres to 84 acres (includes perimeter and bay closure). Additionally, alternative 3E(3) was estimated to impact approximately 11.2 acres of seagrass (SAV) beds within the Barnegat Bay/Little Egg Harbor Estuaries. These habitats are all EFH for a number of managed species including summer flounder, winter flounder (north of Absecon Inlet), and bluefish. Additionally, SAV beds are a “Habitat Area of Particular Concern” (HAPC) for summer flounder.

Estimates of shellfish habitat impacts are based on historical mapping obtained from NJDEP (Source: https://www.nj.gov/dep/landuse/shellfish.html) that include coast-wide mapping from 1963, and mapping in the Barnegat-Little Egg estuary from the mid-1980’s, and 2011-2012. These estimates include affected habitats such as soft-bottom subtidal habitats, intertidal sand and mudflats, and SAV beds. The focused array did not encounter soft clam, oyster seed production, scallop production, and leased beds. However, mapped hardclam beds were encountered resulting in potential significant impacts. Table 15 provides estimates of these impacts for the focused array of alternatives, which includes perimeter and/or storm surge barriers and bay closures.

Table 15: NJBB Focused Array of Alternatives Preliminary Estimates of Impacts (Acres) on Shellfish Beds Based on Historic Shellfish Resource Maps

Year of Mapping:	1963			1980's (Northern Region Only)			2011-2012 (Northern Region Only)			
Alternative	**Hard clam High Com. Value**	**Hard clam Mod. Com. Value**	**Hard clam Rec. Value**	**Hardclam High Density**	**Hardclam Mod. Density**	**Hardclam Occ.**	**Hardclam High Density**	**Hardclam Mod. Density**	**Hardclam Low Density**	**Hardclam Occ.**
2A [N]	0	0	0	0	0	0	0	0	0	0
3A [N]	0	0	0	0	0	0	0	0	0	0
3D [†N]	0	0	7	2	0	7	-	-	-	-
3E(2) [*N]	0	0	0	0	0	0	0	0	0	0
3E(3) [†*N]	0	44	45	-	-	-	0	2	0	30
4A [N]	0	0	0	0	0	0	0	0	0	0
4D(1) [†N]	70	0	0			-	-	-	-	-
4D(2) [†N]	96	0	0	-	-	-	-	-	-	-
4E(2) [*N]	0	0	0	-	-	-	-	-	-	-
4E(3) [†*N]	1	0	0	-	-	-	-	-	-	-
4E(4) [*≈N]	0	2	0	-	-	-	-	-	-	-
4G(6) [*≈N]	2	7	0	-	-	-	-	-	-	-
4G(7) [†*≈N]	4	7	0	-	-	-	-	-	-	-
4G(8) [*≈N]	2	8	0	-	-	-	-	-	-	-
4G(10) [†*≈N]	29	7	0	-	-	-	-	-	-	-
4G(11) [†*≈N]	30	7	0	-	-	-	-	-	-	-
4G(12) [†*≈N]	29	8	0	-	-	-	-	-	-	-
5A [N]	0	0	0	0	0	0	0	0	0	0
5D(1) [†N]	68	0	0	-	-	-	-	-	-	-
5D(2) [†N]	140	0	0	-	-	-	-	-	-	-

KEY: † Alternative includes one or more perimeter (floodwalls/levees) protection segments.
N Alternative includes non-structural (building raising) measures at one or more location(s).
* Alternative includes one or more inlet storm surge barrier(s).
≈ Alternative includes one or more bay closure barrier(s).
"0" Indicates that the alternative either avoids impacting that resource category or resource category is not present
"–"Indicates that no surveys or data are available.

(blue)	Northern Region	(yellow)	Central Region	(green)	Southern Region

Note: Estimates (in acres) are very preliminary based on a low-level of design, and have not undergone avoidance and minimization analyses, which may result in later changes in estimates.

The alternatives with the longest perimeter plans and/or bay closures had the highest impact acreages of historic shellfish (hardclam) habitat. In the north, alternative 3E(3) had the highest impacts of a combined 89 acres for hardclam - moderate commercial value and recreational value from the 1963 mapping and a total of 32 acres from the 2011-2012 mapping. This impact is attributed to the perimeter plan for southern Long Beach Island. Based on the 1963 mapping for hardclam high commercial values, the central region with the highest impacts from the perimeter plans in 4D(1) (70 acres) and 4D(2) (96 acres), and the southern region had high impacts from both plans that had perimeter plans 5D(1) (68 acres) and 5D(2) (140 acres).

Indirect Impacts

Indirect impacts of perimeters on fisheries are not significant and are related to temporary impacts on noise, water quality such as turbidity and sedimentation during construction. The displacement and/or mortality of smaller forage fish could have some indirect trophic effects within the food chain for commercial and recreational species including species with EFH within the affected areas.

Cumulative Impacts

The direct cumulative losses of aquatic habitats for finfish, shellfish, and EFH over long distances of perimeters are significant based on the current estimated impacts. These losses coupled with the effects of climate change and sea level rise are likely to contribute to stressors on finfish and shellfish habitats, population abundances, and distributions.

Storm Surge Barriers/Bay Closures

Direct Impacts

The direct impacts of the construction of storm surge barriers (SSBs) and Bay Closures (BCs) on fisheries including finfish, shellfish and EFH are similar to perimeters. The temporary effects on fisheries would be based on disturbances during construction such as noise, water quality (turbidity, DO), and physical displacement. Noise impacts such as pile-driving could result in direct lethal and/ or sub-lethal effects to some finfish during construction. The generation of turbidity can adversely affect fish respiration, sight feeding, and could smother eggs/larvae. The generation of turbidity can also affect dissolved oxygen levels that can result in either mortalities or heavily stressed fish. However, with the exception of some smaller species and larval stages, most mobile fish would be able to move out of the active construction areas. The construction of floodwalls for BCs along intertidal and subtidal areas would also require temporary de-watering structures, which would temporarily displace access to these aquatic habitats for feeding or spawning activities.

Gate closures and pump operations of SSBs and BCs are likely to entrain smaller and slow moving fish or larvae resulting in their mortalities. Impediment of movement and/or migration of fishes trapped behind closed tide gates and/or surge barrier is also possible (USACE, 2017). These effects could impact migrations of anadromous fish species such as river herrings: alewife and blueback herring and striped bass that transit through inlet areas to spawn in freshwater upstream and the catadromous fish: American eel that transit through inlets to spawn in the Sargasso Sea. The frequency of these events are currently unknown, but it is reasonable to assume that the frequencies of closures would increase with sea level rise.

Based on preliminary estimates, SSBs are likely to have less direct fish and shellfish habitat losses than perimeter plans due to the smaller footprints affected. SSBs would primarily affect subtidal soft bottom habitats within the coastal inlets. BCs, because of their lengths and locations, resulting in higher impacts on fish habitats compared to SSBs. Alternative 3E(2) utilizes SSBs at Manasquan Inlet and Barnegat Inlet and only directly impact about 7.5 acres of subtidal soft bottom. However, alternatives with both SSBs and BCs such as 4E(4) demonstrate higher impacts to fish habitat, and those combinations with SSBs, BCs and perimeters have comparatively much higher impacts to fish habitats.

Historic shellfish bed mapping did not demonstrate SSB impacts on hardclam beds. However, the plans with BCs did impact historic (1963) hardclam areas, but to a much lesser extent than the perimeter plans.

Indirect Impacts

The indirect impacts of SSBs and BCs on finfish, shellfish and EFH are potentially significant. SSBs and BCs are likely to have constricted flows (40-60%) in the inlets/waterways, which are expected to produce changes in velocity and residency within the back bays affecting sedimentation patterns, water quality, and salinity. These changes could potentially result in significant effects on the abundance and distribution of fisheries. For instance, adult hard clams cannot tolerate lowered salinities where they do not grow at ≤ 12 ppt salinity, and are intolerant of protracted salinities < 15 ppt, and interactions between temperature and salinity on hard clam larval development are stressed at lower salinities (Bricelj *et al*. 2012). However, changes in hydrodynamics, water quality, and salinity are unknown at this time, and require modeling to predict these changes with the gates open, closed during storm events, and sea level rise effects.

Under normal conditions, the gates of SSBs and BCs would remain open and fish and other aquatic organisms should be able to transit through these structures. However, the effects of increases in velocities through the gate openings on fish migration patterns is unknown.

Gate closures may have more of an effect on fisheries, although temporary. Extreme storm and high tide events would trigger the closure of SSBs and BCs, causing shifts in water quality and flow rates. During these closures, tidal fluxes in water would cease for a period of time, potentially reducing water quality and dissolved oxygen (DO), while increasing the number of harmful nutrients in the water. The changes in water quality, DO, and nutrients could have compound and/or cumulative interactions, causing increased stress levels to fish populations, which may lead to increased susceptibility to disease or even a mortality event (Tietze 2016; Bachman and Rand 2008). Additionally, periodic maintenance of the structures proposed for would be necessary over time; the maintenance would likely result in localized disturbances caused by increased underwater noise and turbidity. The operation and maintenance of SSBs and BCs could potentially result in temporary to permanent significant adverse impacts to fish and fisheries resources (USACE, 2017).

Cumulative Impacts

The direct cumulative losses of aquatic habitats for finfish, shellfish, and EFH over long distances of SSBs, BCs and perimeters are significant based on the current estimated impacts. Operation of SSBs and BCs could potentially affect bay-wide fisheries by affecting hydrodynamics and water quality. These effects coupled with the effects of climate change and sea level rise are likely to contribute to stressors on finfish and shellfish habitats, population abundances, and distributions.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities would not result in any direct wetland and aquatic habitat impacts. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that could potentially produce turbidity, introduce nutrients, and increase eutrophication that could degrade wetlands and aquatic habitats from stormwater. However, soil disturbances can be readily managed by implementing appropriate BMPs. Therefore, direct and indirect impacts to fisheries resources and EFH are expected to be minimal.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality and wetland habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities or as freshwater wetlands in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays, and potentially provide additional wetland habitat. Depending on the scale of implementation, this alternative may have an indirect minor to moderate beneficial impact on fisheries resources and EFH through water quality improvements.

Natural and Nature-Based Features

NNBF’s in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it’s method of construction. At this time, it is not known the degree and extent of impacts an NNBF measure would have on fisheries and essential fish habitats. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on fish, EFH, and shellfish species, as these activities may significantly disturb the aquatic habitat and generate turbidity during construction. Most finfish would be expected to be able to move out of the active areas. However, shellfish and other less mobile organisms would be impacted within the footprint of the disturbance and through the effects of turbidity. The long-term effects of NNBFs on fish and shellfish are either beneficial for some or detrimental to others depending on the NNBF measure and the existing habitat. For instance, an existing intertidal mudflat may have suitable hard clam habitat that is converted to a low saltmarsh by raising the substrate elevation, thus eliminating the hard clam habitat, while saltmarshes are important nursery areas for fish species such as spot and flounder. However, the restoration of an SAV bed NNBF may have substantial benefits for both fish and shellfish. These effects would have to be weighed based on the location of existing sensitive habitats and the ecological services and uplift that an NNBF measure provides.

Invertebrates

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. The No Action scenario is expected to continue existing conditions for invertebrates as described in the Affected Environment and continuation of existing trends unless there are significant interventions. Climate change and sea level rise (SLR) introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns along with chemical changes that could impose synergistic effects on the NJBB water quality (salinity, nutrients, DO) and algal blooms, which could adversely impact benthic invertebrate communities, and could cause shifts in benthic community structure (diversity, abundance, etc.). SLR is not expected to have significant effects on benthic invertebrates inhabiting subtidal habitat as this habitat would likely increase. Permanent losses of intertidal mudflats, sandy beaches, regularly flooded and irregularly flooded marshes due to SLR are more likely to affect the invertebrates that inhabit these areas through their entire lifecycle as well as those that depend on these habitats for a portion of their life cycle such as spawning horseshoe crabs.

All Structural

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

Direct Impacts

The direct impacts of the focused array of alternatives that involve structural measures such as perimeters (floodwalls, levees, miter gates), storm surge barriers (SSBs), and bay closures (BCs) will result in direct mortalities of benthic fauna and permanent loss of their habitat located within the footprint of the construction. These losses are associated with construction activities that involve excavation/dredging and fill placement over benthic habitats, which result in complete removal or burial of these organisms. Subtidal (including SAV beds) and intertidal soft bottom habitats are likely to include polychaetes (worms), bivalves (clams), gastropods (snails), amphipods, and various decapods (crabs). Important commercial and recreational species affected include hard clams and blue crabs. Species composition may vary based on sediment substrate types, depth, water quality, and predation. Rocky intertidal habitats may include more encrusting organisms such as barnacles, blue mussels, and bryozoans as well as crabs, polychaetes and amphipods. Tidal marsh habitats are likely to have polychaetes, snails, ribbed mussels, fiddler crabs and various insect larvae. Hardened structures with subtidal and intertidal portions are likely to become colonized by encrusting organisms; however, the degree of recruitment on these structures will depend on the suitability of the substrate. Smooth vertical walls may not be very attractive to benthic organisms, but rough and rocky substrates may have more value.

Indirect Impacts

The loss of benthic fauna would indirectly affect fisheries by eliminating an important food source within the footprint of these structures. Loss of benthic food sources in subtidal SAV beds, intertidal mudflats, sandy beaches and tidal marshes would also affect shorebirds and other various wading birds and waterfowl. The effects of the implementation and operation of SSBs and BCs could result in changes to hydrodynamics and water quality, thereby potentially affecting benthic community composition due to changes in substrate and salinity.

Cumulative Impacts

The direct cumulative losses of benthic habitats over long distances of SSBs, BCs and perimeters are significant based on the current estimated impacts. Operation of SSBs and BCs could potentially affect bay-wide benthic communities by affecting hydrodynamics and water quality. These effects coupled with the effects of climate change and sea level rise are likely to contribute to stressors on benthic habitats, population abundances, and distributions.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities would not result in any direct wetland and aquatic habitat impacts. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that could potentially produce turbidity, introduce nutrients, and increase eutrophication that could degrade wetlands and aquatic habitats from stormwater. However, soil disturbances can be readily managed by implementing appropriate BMPs. Therefore, direct and indirect impacts to benthic invertebrate resources are expected to be minimal.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality and wetland habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities or as freshwater wetlands in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays, and potentially provide additional wetland habitat. Depending on the scale of implementation, this alternative may have an indirect minor to moderate beneficial impact on benthic invertebrate resources through water quality improvements.

Natural and Nature-Based Features

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. At this time, it is not known the degree and extent of impacts an NNBF measure would have on the benthic habitats. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on benthic species (infauna and less mobile epifauna), as these activities may significantly disturb the aquatic habitat and generate turbidity during construction. Most benthic organisms are sessile in nature, and would not be able to move out of an area being disturbed, where they could either be removed through excavation/dredging or buried. The long-term effects of NNBFs on benthos may have variable results where habitat conversions may suit one species or community over another. For instance, an existing subtidal soft bottom that contain burrowing deposit feeders could be converted to either a hard reef or a living shoreline composed of shell material, which may be more favorable for encrusting organisms. These effects would have to be weighed based on the location of existing sensitive habitats and the ecological services and uplift that an NNBF measure provides.

Special Status Species

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative changes to Federal and State listed threatened and endangered species are expected as described in the Affected Environment section. It is expected that current trends of populations and distribution of these species would continue unless significant new interventions or impacts are implemented. However, climate change and sea level rise (SLR) may exacerbate conditions for some of these species. SLR may contribute to loss of intertidal foraging habitats critical for rufa red knots. For piping plovers, SLR may introduce direct impacts on beach habitats in areas where beach erosion is persistent, yet beach migration and overwash are curtailed by human development limiting available nesting and foraging habitat. Continued implementation of beach nourishment projects may lessen this effect when implemented in accordance with reasonable and prudent measures to protect this species. According to Cooper et. al (2005) seabeach amaranth is highly susceptible to the effects of SLR, and likely to be irreversibly damaged (USACE, 2014). NMFS (2014) considered the effects of climate change on Atlantic sturgeon, and concluded that projections of rising sea temperatures of 3-4^{o} C by 2100 could, “over the long term, affect Atlantic sturgeon by affecting the location of the salt wedge in rivers, distribution of prey, water temperature and water quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which Atlantic sturgeon will be able to successfully adapt to any such changes.” NMFS (2014) further concludes that for sea turtles, “the temperature changes are unlikely to be enough of a change to contribute to shifts in the range or distribution of sea turtles even though, theoretically, it is expect that as waters in the action area warm, more sea turtles could be present or sea turtles could be present for longer periods of time.” Additionally, it is uncertain that long-term habitat changes to SAV beds would have any indirect effects on species like green sea turtles that venture into the shallow areas to feed on marine algae and eelgrass.

All Structural

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

Direct and Indirect Impacts

A large number of special status species occur within the NJBB study area that could potentially be affected by construction activities (temporary) and/or habitat losses from the implementation of structural measures that include perimeter plans, storm surge barriers (SSBs) and bay closures (BCs). Table 16 provides a brief summary of the structural measures identified in the focused array and their impacts on the special status species. For Federally listed species, coordination is ongoing with the U.S. Fish and Wildlife Service and National Marine Fisheries Service to determine if the alternatives in the focused array require informal or formal consultation pursuant to Section 7 of the Endangered Species Act. Both the piping plover and red knot have the potential to nest (red knot nesting in NJ is rare), forage, rest, and/or migrate through the affected areas. Construction has the potential to slightly impact flight and foraging behaviors. Noise generated during construction and maintenance could produce disturbance effects, flushing both piping plovers and red knots from foraging and/or resting areas. In addition, localized sediment disturbances caused by aquatic construction operations have the potential to indirectly affect the foraging success of the piping plover and red knot by disturbing benthic invertebrates and fish. This could potentially impact prey species availability to piping plovers and red knots. Closure of the storm surge barriers and tide gates can result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species

Table 16: Potential Impacts of Structural Features in the Focused Array of Alternatives on Special Status Species in the NJBB Study Area.

Species	Status	Habitat in NJBB	Perimeter Impacts	SSB Impacts	BC Impacts
American Bittern (*Botaurus lentiginosos*) BR	SE	Freshwater and brackish marshes for breeding season. Salt marshes rest of year.	Direct habitat impacts are likely on non-breeding saltmarsh losses. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts are likely on non-breeding saltmarsh losses. Indirect impacts through disruptions in food chain.
Bald Eagle (*Haliaeetus leucocephalus*) BR/NB	SE/ ST	Forest edges, open water	Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Indirect impacts through disruptions in food chain.
Northern Harrier (*Circus cyaneus*) BR	SE	Tidal marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.
Red knot* (*Calidris canutus rufa*) NB	**FT***, SE	Sandy beaches, spits, marsh islands, tidal flats	Direct habitat impacts are likely on non-breeding saltmarsh and tidal flats losses. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts are likely on non-breeding saltmarsh and tidal flats losses. Indirect impacts through disruptions in food chain.
Short-Eared Owl (*Asio flammeus*) BR	SE	Coastal marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.
Black-Crowned Night-Heron (*Nycticorax nycticorax*) BR	ST	Maritime forests, scrub-shrub, mixed *Phragmites* marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.
Yellow-Crowned Night-Heron (Nyctanassa violacea)	ST	Maritime forests, scrub-shrub on barrier and bay islands	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.
Osprey (*Pandion haliaetus*) BR	ST	Coastal rivers, marshes, bays & inlets. Nest on dead trees, platforms, poles	Potential disturbance to nests/nesting platforms throughout bay areas. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/nesting platforms throughout bay areas. Indirect impacts through disruptions in food chain.
Piping plover* (*Charadrius melodus*)	**FT*** SE	Ocean beaches, inlets, washover areas, tidal flats	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.
Black Rail (*Laterallus jamaicensis*) BR/NB	SE/ST	High marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.
Black Skimmer (*Rynchops niger*)	SE	Sandy beaches, inlets, sandbars, offshore islands	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.
Least Tern (*Sternula antillarum*)	SE	Sandy beaches, bay islands	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.
Roseate Tern (*Sterna dougallii*)	**FE**/SE	Beaches w/ vegetated dunes	No breeding population currently in NJ. Potential disturbance to foraging areas. Indirect impacts through disruptions in food chain.	No breeding population currently in NJ. Potential disturbance to foraging areas. Indirect impacts through disruptions in food chain.	No breeding population currently in NJ. Potential disturbance to foraging areas. Indirect impacts through disruptions in food chain.
Sedge Wren (*Cistothorus platensis*)	SE	High marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.
American oystercatcher (*Haematopus palliates*)	SOC	Breed in coastal beaches, inlet spits, and backbay marshes.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.
Common Tern (*Sterna hirundo*)	SOC	Nest on islands, barrier beaches, coastal promontories, dredged material islands, and some other artificial structures.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.
Atlantic Loggerhead* (*Caretta caretta*)	**FT***/SE	Marine/Estuarine Pelagic	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on SSB gates when closed. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on BC gates when closed. Indirect impacts through disruptions in food chain.
Kemp's Ridley* (*Lepidochelys kempii*)	**FE***/SE	Marine/Estuarine Pelagic	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on SSB gates when closed. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on BC gates when closed. Indirect impacts through disruptions in food chain.
Atlantic Green Sea Turtle* (*Chelonia mydas*)	**FT***/ST	Marine/Estuarine Pelagic	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on SSB gates when closed. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on BC gates when closed. Indirect impacts through disruptions in food chain.
North Atlantic Right Whale (*Eubalaena glacialis*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Blue Whale (*Balaenoptera musculus*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Fin Whale (*Balaenoptera physalus*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Humpback Whale (*Megaptera novaeangliae*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Sei Whale (*Balaenoptera borealis*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Sperm Whale (*Physeter microcephalus*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Northern Long-Eared Bat (*Myotis septentrionalis*)	FT	Summertime roosts beneath the bark of live and dead trees.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Atlantic Sturgeon* (*Acipenser oxyrinchus oxyrinchus*)	**FE***/SE	Marine/estuarine Demersal/pelagic	Construction/noise vibrations could impact migrations/feeding habits of adults and subadults. Indirect impacts through disruptions in food chain.	Construction/noise vibrations could impact migrations/feeding habits of adults and subadults. Hydrodynamic/velocity changes could affect migrations through inlets. Indirect impacts through disruptions in food chain.	Construction/noise vibrations could impact migrations/feeding habits of adults and subadults. Hydrodynamic/velocity changes could affect migrations through BC gates. Indirect impacts through disruptions in food chain.
Northeastern Beach Tiger Beetle (*Cincindela d. dorsalis*)	SE	Atlantic coast sandy beaches	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.
Bronze Copper (butterfly) (*Lycaena hyllus*)	SE	Brackish marshes	Potential disturbance to habitat: brackish marshes.	No direct or indirect impacts anticipated.	Potential disturbance to habitat: brackish marshes.
Seabeach amaranth* (*Amaranthus pumilus*)	**FT***/SE	Upper sandy beaches, accreting ends of inlets	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.

FT= Federally Threatened
FE= Federally Endangered
ST=State Threatened
SE= State Endangered
SOC=Species of Concern
BR= Breeding Population Only
NB= Non-Breeding Population Only

Note: There are over 800 species of Special Status Plants in NJ. Due to the large study area, site specific species data searches will be conducted for the TSP

*Informal or formal Section 7 Endangered Species Act consultation anticipated availability. These closures could have some effects on adult and sub-adult Atlantic sturgeon, but the extent of these effects are unknown. For a number of the special status species, construction impacts can be avoided by implementing timing restrictions and buffer areas. Habitat losses would be addressed through compensatory mitigation. Indirect impacts on several special status species would result from disruptions in the food chain by losses of habitat.

Cumulative Impacts

The direct cumulative losses of aquatic and some terrestrial habitats over long distances of SSBs, BCs and perimeters are potentially significant based on the current estimated impacts, and therefore, have the potential to adversely affect a number of special status species that inhabit these areas. In addition, the operation of SSBs and BCs could potentially affect bay-wide ecosystems by affecting hydrodynamics and water quality. These effects coupled with the effects of climate change and sea level rise are likely to contribute to stressors on special status species. At this time, no formal or informal consultation has taken place with USFWS and NMFS. However, consideration of the cumulative impacts on these species would be a part of the consultation process upon initiation of consultation and the development of a TSP.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities are not expected to result in any direct takes or loss of critical habitats for special status species. However, for Federal status species, a “no effect” determination cannot be made until site specific details on locations and methods are available.

Natural and Nature-Based Features

NNBF’s in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it’s method of construction. At this time, it is not known the degree and extent of impacts an NNBF measure would have on special status species. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on both aquatic and terrestrial habitats, as these activities may significantly disturb these habitats and generate turbidity during construction. NNBFs such as saltmarsh restoration have the potential to have long-term direct or indirect benefits for a number of Federal and state special status species that require an NNBF habitat for one of its life requisite needs. These effects would have to be weighed based on the location of existing sensitive habitats and the ecological services and uplift that an NNBF measure provides.

Coastal Lakes

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative changes to the Coastal Lakes are expected as described in the Affected Environment section. No significant changes in land use are expected around these lakes as they are currently in very heavily developed areas. However, climate change and sea level rise (SLR) could have effects on these lakes, though, as the freshwater lakes would be subject to shifts to warmer temperatures, increased precipitation events and associated stormwater input to lakes, drought events, and potential breaches and salinity intrusion from SLR. These factors could have profound adverse effects on the freshwater aquatic ecosystems as described in the Affected Environment Section.

All Structural

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

Direct and Indirect Impacts

Several Coastal Lakes occur within the lower Manasquan River estuary, which are tidally connected to the Manasquan River and Manasquan Inlet. These lakes include Stockton Lake, Glimmer Glass, and Lake Louise. The Manasquan perimeter plan (Alternative 3D) would provide miter gates at the bridges on Brielle Road and Green Road. These gates would remain open during normal conditions, and would maintain tidal exchange with Glimmer Glass and Stockton Lake. However, closure of the miter gates during extreme storm events could result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability.

SSBs are features located in Manasquan Inlet and Barnegat Inlet (alternatives 3E(2) and 3E(3)). The Manasquan Inlet SSB would indirectly affect Stockton Lake, Glimmer Glass, and Lake Louise, and the Barnegat Inlet SSB would have indirect effects on Twilight Lake (Bay Head), which is in the upper Barnegat Bay. Similar to the perimeter plan miter gates, the SSB closures during extreme storm events could result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability.

Nonstructural Measures

Nonstructural measures were identified in the focused array of alternatives in several coastal lake areas that are within the Shark River and Northern Region. The Shark River area includes nonstructural measures around the freshwater and slightly brackish lakes that do not have direct tidal influence: Sylvan Lake, Silver Lake, and Lake Como, which are all considered to be impaired due to pathogen contamination, algal blooms, aquatic weed overgrowth and eutrophication that was primarily related to inputs of stormwater and runoff from their surrounding watersheds (Tiedeman et al. 2009). In the Northern Region, tidally influenced lakes occur in the Manasquan Estuary, which include Stockton Lake, Glimmer Glass, and Lake Louise. Whereas, Twilight Lake receives tidal influence from the northern Barnegat Bay. Other lakes included in this region that do not have direct tidal connections are: Little Silver Lake and Lake of the Lilies, which are both in Point Pleasant Beach.

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that could potentially produce turbidity in the coastal lakes causing further degradation of these impaired waterbodies. However, soil disturbances can be readily managed by implementing appropriate BMPs to minimize turbidity generated from stormwater runoff into these waterbodies.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the coastal lakes.

Natural and Nature-Based Features

At this time, there are no NNBFs being considered in the Coastal Lakes.

Cultural Resources

Future Without-Project (No Action)

Cultural Resources can be defined as any Native American archaeological site, historic archaeological site, historic district, building, structure, object or Traditional Cultural Properties (TCPs) eligible for or listed on the National Register of Historic Places (NRHP).

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative effects on cultural resources are expected as described in the Affected Environment section. However, USACE (2014) reports that as sea level continues to rise and inland marshes and barrier islands erode or subside, cultural resources existing on them or behind them could be exposed to the elements or inundated, putting them at a greater risk of damage or destruction. Cultural resources could also be adversely impacted over time by an increased risk of storm damage. Cultural resources would continue to be affected in coastal areas where there is no protection against storm events.

All Structural

Perimeter – Floodwalls, Levees and Miter Gates

In general, the perimeter plans include floodwalls and levees that would be constructed on the western side of the barrier islands along residential bayfronts and would tie into existing dunes at the northern and southern ends of the barrier islands. An exception to this would be for Manasquan Beach (north of Manasquan Inlet), where a levee/dune structure would be constructed along the upper beach for over 1 mile of Atlantic Coast beach (alternative 3D). The majority of the areas affected by the various perimeter plan configurations are urbanized residential areas, where there are predominantly bulkhead structures that line the back bays and lagoons. There may be both direct and indirect impacts to both above-ground and below-ground cultural resources, mainly with direct impacts to archaeological resources and with visual impacts to historic structures and/or historic districts.

Storm Surge Barriers/Bay Closures

In general, the storm surge barriers (SSBs) would be constructed at the selected inlets, and would tie into existing dunes at the northern and southern ends of the barrier islands. An exception to this would be for Manasquan Beach (north of Manasquan Inlet), where a levee/dune structure would be constructed along the upper beach for over 1 mile of Atlantic Coast beach (alternatives 3E(2) and 3E(3)). All SSBs require seawall tie-ins to existing dunes at all of the inlets identified in the focused array. The main potential impacts due to the construction of the SSBs would be to submerged cultural resources, such as shipwrecks, and to archaeological sites and/or historic structures in or near the tie-ins.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. Existing historic structures and historic districts would be adversely affected by these types of measures, as it would alter the characteristics that qualify the resources for inclusion in the NRHP in a manner that would diminish the integrity of the resources location, design, setting, feeling or association. It would be difficult to try to find comparable measures to mitigate for these types of adverse effects, as it would be difficult to engender support from the Advisory Council on Historic Preservation, the State Historic Preservation Office, and other state and local consulting parties.

Natural and Nature-Based Features

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it's method of construction. At this time, it is not known the degree and extent of impacts an NNBF measure would have on cultural resources, both terrestrial and submerged.

It is assumed that construction activities, access, and the need for staging may be required that could result in land disturbance, which would require archaeological investigations as well as avoidance and monitoring measures. These investigation would need to be conducted prior to any construction activities, and the results coordinated with the SHPO, the Tribes, and other consulting parties. Additional investigations and mitigative data recovery may be required if avoidance and minimization to archaeological sites cannot be obtained by design.

Recreation

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative effects on recreation are expected as described in the Affected Environment section. Water-based recreation activities are not expected to change significantly even with climate change and sea level (SLR) rise scenarios. However, SLR may increase vulnerability of land-based recreational facilities such as athletic fields to flooding. Sea level rise would subject the communities in the study area to increased vulnerabilities to coastal storms, and thus, any damages experienced by the communities from coastal storms would result in temporary and possibly long-term degraded tourism opportunities. Lesser known would be the potential for indirect losses of ecotourism opportunities resulting from diminishing wetland habitats due to SLR.

All Structural

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

"Leisure and Recreation" is a category in the "Other Social Effects" system of accounts in USACE plan formulation. Leisure and Recreation are defined as having access to healthy and safe outdoor recreation. For the perimeter protection plans, the implementation of floodwalls and levees could have potential significant adverse effects on recreation by limiting easy access to the bays and other waterways for water- oriented activities as described in the Affected Environment Section. In many locales within the focused array of alternatives, the floodwalls would form a barrier that would be approximately 5 to 10 feet higher than the ground surface elevation, which would make it difficult for persons to access docks, boats or the bay shoreline. This potential effect would require further evaluation to determine the extent of this impact, and to identify acceptable means to avoid or minimize this impact. In some locales, levees are also a perimeter feature that could also limit access to recreational activities.

Storm surge barriers in the inlet and bay closures would maintain navigable access under normal conditions through opened sector gates or miter gates (in smaller waterways). However, navigation in these locations would be restricted to only locations where there are navigable sector gates. Miter gates are also a component of the perimeter plans. The gates of these structures during extreme flood events would be closed, thereby, cutting off all recreational access during this closure. However, this effect would not have significant impacts on recreation because recreational activities are not likely during a storm event. Additionally, gate openings (when open) may permanently constrict flows, which could result in flow velocity changes through the gates. Therefore, further evaluation of potential effects on velocity changes would be required to determine if there are any indirect effects such as changes to navigation channel velocities and effects on recreational water uses.

Potential adverse indirect impacts of SSBs and BCs (open or closed) on water quality could result in water quality degradation or worsen existing impairments thereby reducing water-oriented recreational opportunities. Further evaluation of the potential effects of SSBs and BCs on water quality will inform the degree and extent, if any, of impacts on recreation.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to noise, vehicles, and temporary road closures. All of these disruptions could temporarily affect recreation depending on the type of construction activity, season, and the type of recreation activities within the vicinity. However, recreation activities would be expected to resume once the construction/demolition ceases. Programs such as buyouts could result in more recreational opportunities as these areas would likely become public lands intended for recreation and conservation.

Natural and Nature-Based Features

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs during their implementation phases, may result in reduced recreational access and opportunities. However, long-term recreational opportunities may be increased in some NNBFs that offer greater fishing, clamming, birdwatching, and hunting opportunities. Therefore, NNBFs are expected to have beneficial impacts on recreation.

Visual Resources and Aestheitics

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative effects on visual resources and aesthetics are expected as described in the Affected Environment section, and therefore, would be maintained in the study area. Sea level rise would subject the communities in the study area to increased vulnerabilities to coastal storms, and thus, any damages experienced by the communities from coastal storms would result in temporary and possibly long-term degraded aesthetics.

All Structural

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

Perimeter protection plan structures such as floodwalls, levees, miter gates, and pump stations, have the potential to produce significant adverse impacts on aesthetics, particularly for visual resources, which may affect several key human needs dimensions under the "Other Social Effects" category in the system of accounts. Floodwalls with heights ranging from approximately 5 to 10 feet along the back bay communities would obstruct first-floor and patio views of the bays, marshes and other waterways. Therefore, many residents, restaurants, hotels, and other businesses that include attractive bay views may lose this amenity. Levees with vegetation would be more aesthetically pleasing than floodwalls, but would still obstruct bay and marsh views. Also, views would be obstructed along roadways and walking paths. It is anticipated that these effects would be of great interest to adjacent landowners and the communities in general. As such, further evaluation of these potential impacts would be required to determine their social acceptability.

Pump stations, depending on their locations, are expected to have localized minor effects on the aesthetics and visual resources.

Similar to the perimeter protection plans, SSBs and BCs are likely to have significant visual impacts, and given their sizes, would be visible from far distances. However, the obstruction of views would be expected to be more localized than the perimeter plans because, in general, SSBs and BCs would be in locations with less intensive development.

Non-Structural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures. Earth disturbances would be a temporary impact on aesthetics, and would improve after the disturbed areas are stabilized with vegetation. Building retrofits such as elevation may have minor permanent adverse impacts on visual resources in some locations where views could potentially be blocked for some people by raised structures; alternatively, some structures may have improved views due to being elevated. Buyouts would likely result in permanent beneficial impacts by improving aesthetics with more natural scenery through increased green spaces and the removal of visual obstructions caused by buildings.

Natural and Nature-Based Features

NNBF’s in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and it’s method of construction. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on aesthetics by earth and sediment disturbances, noise, and odors. Most of the NNBFs would be constructed in aquatic ecosystems, and would therefore, be low-profile. Therefore, they are not expected to have adverse effects on viewsheds. Additionally, NNBFs in most cases, may improve aesthetics by providing natural features that are consistent with the surrounding landscapes and bay features.

Air Quality

Future Without Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk, and it is expected that current air quality trends will continue. The primary pollutant of concern in the study area is ground level ozone. It is expected that no action will continue the trends in ground level ozone, which are influenced by many factors including emissions of NOx and VOCs (ozone precursors), weather conditions and emission reductions brought about by control measures. Short term fluctuations are most likely due to weather conditions. The long term trend shows ozone concentrations decreasing significantly due to State and Federal requirements to reduce emissions of NOx and VOCs (http://www.nj.gov/dep/dsr/trends/ accessed on 1/30/2019). With no action, no significant direct, indirect and cumulative effects on air quality in the region are expected as described in the Affected Environment section, and therefore, current trends would be maintained in the study area.

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

The structural alternatives will temporarily produce emissions associated with diesel-fueled equipment relating to either water-based or landside construction activities. Construction schedules and durations for any of the focused array of alternatives are unknown at this time. Although it is likely that construction would be in phases over several years. The localized emission increases from the diesel-fueled equipment from construction will last only during the project's construction period (and primarily only locally to where work is actually taking place at any point in time), and then end when the project is over. Therefore, any potential construction impacts will be temporary in nature. However, longer term effects are possible with the operation and maintenance of pump stations for the perimeter protection plans and pump and gate mechanisms for SSBs and BCs. These pumps and gate mechanisms would likely be operated by diesel-powered electrical generators that would produce emissions. Because the study area is in marginal and moderate non-attainment status for ground level ozone, a detailed emissions estimate will be completed upon selection of the TSP.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce emissions associated with diesel-fueled equipment relating to landside construction activities. Construction schedules and durations for any of the focused array of alternatives are unknown at this time. Although it is likely that construction/demolition would be in phases over several years. The localized emission increases from the diesel-fueled equipment from construction will last only during the project's construction period (and primarily only locally to where work is actually taking place at any point in time). Therefore, any potential construction impacts on air quality will be temporary in nature. Implementation of buyouts or relocations may have localized permanent beneficial impacts on air quality by removing emissions sources in residential and commercial areas. However, the effect of the relocation of residents and business on air quality to other locations is unknown.

Natural and Nature-Based Features (NNBFs)

NNBF's in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to: living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

Similar to the structural and nonstructural alternatives, the NNBFs will temporarily produce emissions associated with diesel-fueled equipment relating to water and landside construction activities. Construction schedules and durations for any NNBFs are unknown at this time. Although it is likely that construction would be in phases over several years. The localized emission increases from the diesel-fueled equipment from construction will last only during the project's construction period (and primarily only locally to where work is actually taking place at any point in time). Therefore, any potential construction impacts on air quality will be temporary in nature.

Greenhouse Gas (GHG) Emissions

Future Without Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk, and it is expected that current air quality trends will continue. New Jersey's estimated GHG emissions have increased slightly in recent years, although 2015 levels remain below the 2020 Global Warming Response Act (GWRA) limit (which is equivalent to the 1990 level). To achieve the 2050 GWRA limit (of 80% below the 2006 value), NJ would need to reduce estimated GHG emissions by 78%, or about 2.2% per year on average, between 2014 and 2050. New Jersey expects to meet this goal in the future through several initiatives including the implementation of the State's Energy Master Plan (EMP) (http://www.nj.gov/dep/dsr/trends/ accessed on 1/30/2019). As such, no action is not expected to have any significant direct, indirect and cumulative effects on GHGs in the region as described in the Affected Environment section.

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

The structural alternatives will temporarily produce GHG emissions (carbon dioxide, methane, nitrous oxide, et. al) associated with diesel-fueled equipment relating to either water-based or landside construction activities. Construction schedules and durations for any of the focused array of alternatives are unknown at this time. Although it is likely that construction would be in phases over several years. The localized emission increases from the diesel-fueled equipment from construction will last only during the project's construction period (and primarily only locally to where work is actually taking place at any point in time), and then end when the project is over. Therefore, any potential construction impacts will be temporary in nature. However, longer term effects are possible with the operation and maintenance of pump stations for the perimeter protection plans and pump and gate mechanisms for SSBs and BCs. These pumps and gate mechanisms would likely be operated by diesel-powered electrical generators that would produce GHG emissions. The CEQ 2014 GHG guidance focuses the consideration of GHGs on 1) the potential effects of the proposed action on climate change as indicated by its GHG emissions, and 2) the implications of climate change for the environmental effects of the proposed action. At this time, the quantity of GHG emissions is not known. However, a detailed emissions estimate and analysis will be completed upon selection of the TSP in accordance with current CEQ guidance.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce GHG emissions associated with diesel-fueled equipment relating to landside construction activities. Construction schedules and durations for any of the focused array of alternatives are unknown at this time, although it is likely that construction/demolition would be in phases over several years. The GHG emission increases from the diesel-fueled equipment from construction will last only during the project's construction period (and primarily only locally to where work is actually taking place at any point in time). Therefore, any potential construction impacts on GHGs will be temporary in nature. Implementation of buyouts or relocations may have localized permanent beneficial impacts on GHGs by removing emissions sources in residential and commercial areas, and by replacing these structures with vegetation such as trees that can consume carbon dioxide. However, the effect of the relocation of residents and business on GHGs to other locations is unknown.

Natural and Nature-Based Features

Similar to the structural and nonstructural alternatives, the NNBFs will temporarily produce GHG emissions associated with diesel-fueled equipment relating to water and landside construction activities. Construction schedules and durations for any NNBFs are unknown at this time, although it is likely that construction would be in phases over several years. The localized GHG emission increases from the diesel-fueled equipment from construction will last only during the project's construction period (and primarily only locally to where work is actually taking place at any point in time). Therefore, any potential construction impacts on GHGs will be temporary in nature.

Climate and Climate Change

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. This assumes that current CSRM projects along the Atlantic Coast are maintained. No action is not expected to contribute to the causes of climate change, which are primarily in the form of increased Greenhouse Gas Emissions.

New Jersey is experiencing climate change with a long-term upward trend for temperature of 2.2ºF per century. The statewide average temperature in 2012 was the highest since 1895. Additionally, nine of the ten warmest calendar years on record have occurred since 1990 with five of the warmest years occurring since 1998. (BBP, 2016; Broccoli et al. 2013). It is estimated by the Union of Concerned Scientists that the seasonal average temperatures across most of New Jersey will rise 7ºF to 12º F above historic levels in winter and 6º F to 14º F in summer by the end of the century, which could lead to a dramatic increase in the number of days over 100º F. Increases in temperatures in temperate zones like New Jersey can lead to earlier springs, which can have severe impacts on native flora and fauna, which rely on temperature changes as a cue for important life history events (BBP, 2016).

Climate change may lead to increased ocean temperatures, ocean acidification, sea level rise, changes in currents, and upwelling and weather patterns, and has the potential to cause changes in the nature and character of the estuarine ecosystem (USACE, 2017). Climate change is expected to result in more intense and frequent extreme precipitation events by the end of the century, which would cause flooding, streambank erosion, and increases in the rate and amount of nutrients and sediments entering the estuary (BBP, 2016; IPCC, 2013). Cumulative losses of saltmarsh habitat due to sea level rise and other factors may reduce the ability to capture and hold carbon. Saltmarshes are considered to be carbon sinks. When these habitats are damaged or lost, carbon (i.e. CO_2) is emitted back into the atmosphere where it can contribute to climate change (https://oceanservice.noaa.gov/facts/bluecarbon.html accessed on 2/27/2019).

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

As discussed previously, construction and operation and maintenance of the structural alternatives would result in emissions of GHGs. The extent of these emissions are unknown at this time. However, a detailed emissions estimate and analysis will be completed upon selection of the TSP in accordance with current CEQ guidance on GHGs and Climate Change.

The implementation of the structural measures would have beneficial permanent impacts on the affected communities and the region by making them more resilient to future storms and sea level rise.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buy/out relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce GHG emissions associated with diesel-fueled equipment relating to landside construction activities, but are expected to have a negligible effect on climate change and sea level rise. Implementation of buyouts or relocations may have localized permanent beneficial impacts on GHGs by removing emissions sources in residential and commercial areas, and by replacing these structures with vegetation such as trees that can consume carbon dioxide. However, the effect of the relocation of residents and business on GHGs to other locations is unknown. Therefore, the effect on climate change is either negligible or unknown.

The implementation of nonstructural measures would have beneficial permanent impacts on the affected communities and the region by making them more resilient to future storms and sea level rise.

Natural and Nature-Based Features

Similar to the structural and nonstructural alternatives, NNBFs will temporarily produce GHG emissions associated with diesel-fueled equipment relating to water-based and landside construction activities, but are expected to have a negligible effect on climate change and sea level rise. Implementation of NNBFs, such as saltmarsh restoration may have complex associations with GHGs. Under normal conditions, saltmarshes can act as sinks for carbon dioxide where they may store more carbon than a forest, thus giving the CO2 the term, “blue carbon”. However, GHG fluxes of carbon dioxide, methane and nitrous oxide may vary based on the degree of cultural eutrophication from high nutrient loads (inputs of N and P), and other factors such as temperature and salinity that affect soil microbe activity. This could result in greater fluxes of the more potent GHG gases: methane and nitrous oxide where marshes could be converted as a GHG sink to a GHG source (Chmura et al. 2016). Since cultural eutrophication is well documented in the NJBB estuary systems, the degree of this effect is unknown when applied to the implementation of saltmarsh NNBFs. Therefore, the effect on climate change is either negligible or unknown.

Noise

Future Without-Project (No Action)

The No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. With no action, no significant direct, indirect and cumulative effects on noise are expected as described in the Affected Environment section. Assuming no significant changes in land use or the introduction of new activities that emit noise, it is expected that noise levels in the communities and wetland bay habitats would remain the same as current conditions. Climate change and sea level rise is not expected to be a significant factor in future noise impacts.

Structural Measures

Perimeter – Floodwalls, Levees and Miter Gates &Storm Surge Barriers/Bay Closures

Humans and fish and wildlife are likely to be adversely impacted by noise generated from the construction activities of the structural measures. During construction of these various features, there will be associated noise from the operation of equipment to construct the floodwalls, levees and associated miter gates, SSBs, BCs and pump stations. These activities will produce noise emissions in excess of ambient noise conditions in the general vicinity. The use of heavy construction equipment including graders, dozers, front end loaders, backhoes, cranes, air compressors, and pile hammers will produce the majority of noise during construction, where much of the work will be done in close proximity to residential and commercial areas.

Noise can impact humans and animals in a number of ways. Depending on the magnitude and duration, loud noises can result in hearing loss. On construction sites, hearing loss is typically not associated with residents, but is more addressed with the worksite under OSHA regulations. Other effects that noise can have on humans include speech interference, activity interference (sleeping, watching TV, reading, schools, church, etc.) and general annoyance. Water-borne sound and vibration waves caused by construction activities such as blasting and pile-driving can physically harm aquatic mammals and fish. Knowledge of physical effects of noise on land-based animals is limited.

HUD (1985) provides a range of sounds in decibels (dB) that are comparable to common sounds. On the very faint end of the spectrum, an average whisper measures about 20 dB. Average office sounds and auto traffic near a freeway describe moderate noises in the 42-62 dB range. A loud car horn at 10 feet away is considered very loud at 100 dB, and the noise produced near a jet engine at 140 dB is at the extreme end of the spectrum, which is described as deafening. The U.S. EPA (1972) has adopted the "A" weighting system which adjusts noises frequencies to approximate the sensitivity of a human ear (FAA, 2008). Using this system, construction equipment likely to be used may include common earth moving equipment (72-96 dBA at 50 feet), concrete mixers/pumps (75-88 dBA at 50 ft.), and impact pile drivers (peaks at 95-105 dBA at 50ft.)(Canter, 1993 and U.S. EPA, 1972). Table 17 provides maximum noise ranges of construction equipment over variable distance. Both the FAA and Department of Housing and Urban Development (HUD) define the DNL (average day/night sound level) 65 dB as the threshold of noise incompatibility with residential land uses. Also, the DNL 65 dB provides the basis that FAA uses to determine sound insulating eligibility. Impact pile drivers would likely generate the loudest noises while driving piles. At 50 ft. from the source of pile driving, this would produce noise levels approximately 40 dB higher than the DNL 65 dB level estimated by the FAA (106 dB). Vibratory pile hammers would be less at 95 dBA at 50 feet. Table 18 provides an example of lot-line construction noise criteria limits that were set-up for a project.

Table 17: Maximum Noise Ranges at Various Distances Over Open Air for Some Common Construction Equipment.

Equipment	Max. Noise Level at 50 feet. dBA*	Max. Noise Level at 100 ft. dBA**	Max. Noise Level at 200 ft. dBA**	Max. Noise Level at 500 ft. dBA**	Max. Noise Level at 1000 ft. dBA**	Max. Noise Level at 2000 ft. dBA**	Max. Noise Level at 1 mile (5,280 ft.) dBA**
Backhoes	93	87	81	73	67	61	52.5
Tractors	95	89	83	75	69	63	54.5
Cranes, movable	87	81	75	67	61	55	46.5
Generators	82	76	70	62	56	50	41.5
Jackhammers and Rock drills	98	92	86	78	72	66	57.5
Impact pile drivers, peaks	106	100	94	86	80	74	65.5
Vibrator	81	75	69	61	55	49	40.5
Vibratory Pile driver w/ noise emission controls	95†	89	83	75	69	63	54.5

*from U.S. EPA (1972)

** caluculated using inverse square equation: $\text{Sound level}_1 - \text{Sound level}_2 = 20 \log_{10} r_1/r_2$

†U.S. Department of Transportation (FHWA, 2006)

Table 18: Example of Lot-Line Construction Noise Criteria Limits A-weighted in dB, RMS slow (FHWA, 2006)

Noise Receptor Locations and Land-Uses	Daytime (7 AM to 6 PM)		Evening (6 PM to 10 PM)		Nighttime (10 PM - 7 AM)	
	L_{10}	L_{max}	L_{10}	L_{max}	L_{10}	L_{max}
Noise-Sensitive Locations: (Residences, Institutions, Hotels, etc.)	75 or Baseline + 5 (whichever is louder)	85- 90 (impact)	Baseline + 5	85	Baseline + 5 > (if Baseline <70) >Baseline + 3 (if Baseline 70)	80
Commercial Areas: (Businesses, Offices, Stores, etc.)	80 or Baseline + 5	None	None	None	None	None
Industrial Areas: (Factories, Plants, etc.)	85 or Baseline + 5	None	None	None	None	None
Notes: L_{10} noise compliance readings are averaged over 20 minute intervals. L_{max} noise compliance readings can occur instantaneously. Baseline noise conditions must be measured and established prior to construction work, commencing in accordance with the noise specification, which requires baseline noise readings over three 24-hour periods at each receptor lot-line location.						

Based on information provided in Tables 17 and 18, it is likely that maximum noise emissions during construction will exceed the L_{10} of 75 dB or the DNL of 65 dB in any residential or noise-sensitive land uses unless measures are implemented to reduce these levels for the receptors. Construction will be limited to daytime (7 AM to 6 PM) hours during the workweek (Monday – Friday). However, many of these locales are immediately adjacent to residential and rental homes, and this impact would be greatest during peak tourist season.

Effects of noise on fish are complex, and less understood. Studies have indicated that fish are sensitive to sounds where they can detect and respond to sound utilizing cues to hunt for prey, avoid predators, and for social interaction (LFR, 2004). It is documented that intense pressure waves generated from blasting or pile driving can harm or kill most fish in close proximity to the source. High intensity sounds can also permanently damage fish hearing (Nightingale and Simenstad, 2001). Depending upon the duration, location, distance to the fish, and type of sound (i.e., explosions vs. vessel sounds), man-made noise in the marine environment has the potential to impact fish. Studies have found that there are a wide range of potential impacts in response to sounds by fish, ranging from death to behavioral responses. According to ERC, 2012, little research has been done on the effects of sound from dredging on aquatic life, and therefore, little data is available. Behavioral reactions to construction noises (particularly pile driving) are to be expected, however, with possible negative consequences. Behavioral changes could consist of a mild “awareness” of the sound, a startle response (but otherwise no change in behavior) (Wardle et al., 2001), small temporary movements for the duration of the sound, or larger movements that might displace fish from their normal locations for short or long periods of time. Depending upon the level of behavioral change, there may be no significant impact on individual fish or fish populations or there may be a substantial change (e.g. movement from a feeding or breeding site) which could negatively impact the survival of a population (Popper and Hastings, 2009). The noise associated with construction activities will be fairly continuous or at times sporadic throughout the course of the construction activities. Given the uncertainty, short-term negative consequences to fish are anticipated, but they are not expected to have a significant long-term impacts on fishery resources in the study are. It is expected that fish will generally avoid the active areas during construction, but will return once work is complete.

Likewise, construction generated noise can potentially impact wildlife species by impacting breeding, foraging, and resting activities. Buffer zones around sensitive nesting areas would likely minimize this impact. Recent monitoring for piping plovers demonstrate that buffers of 100 meters are appropriate for construction activities from a nest location. A 100-meter buffer zone was established previously in the Longport Bridge Replacement Biological Opinion (USFWS, 2001), where a no jeopardy opinion was rendered provided that a number of protective measures and construction limitations including a 100-meter buffer from pile driving or demolition activities from active nests was implemented. Also, informal consultation for the Route 36 Bridge Replacement over the Shrewsbury River required a noise threshold of +6.0 dBA over ambient sounds on adjacent beaches (Amy S. Greene Environmental Consultants, Inc., 2009). The results of this monitoring concluded that the highest recorded noise level from all construction activities was at +6.1 dBA (from a vibratory pile hammer). However, no behavioral responses by piping plovers to the vibratory pile hammer or other activities were observed. Based on these monitoring studies, it appears that a 100 meter buffer area may be sufficient to minimize and/or prevent impacts to nesting piping plovers from the noise associated with waterborne activities.

Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce noise emissions associated with diesel-fueled equipment relating to landside construction/demolition activities. The effects of the noises generated would be similar to the effects described in the structural impacts section as these activities would be conducted in urbanized settings composed of residents and commercial activities. However, no long-term adverse noise impacts are expected once construction activities cease. The buyout/relocation alternative may actually improve noise conditions in the surrounding community by the localized removal of noise sources typical of urbanized settings.

Natural and Nature-Based Features

Similar to the structural and nonstructural alternatives, NNBFs will temporarily produce noise emissions associated with diesel-fueled equipment relating to water-based and landside construction activities. The effects of the noises generated would be similar to the effects described in the structural and non-structural impacts section as these activities would be conducted in either urbanized settings composed of residents and commercial activities or in remote bay locations. However, no long-term adverse noise impacts are expected once construction activities cease.

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APPENDIX F MAP FIGURES

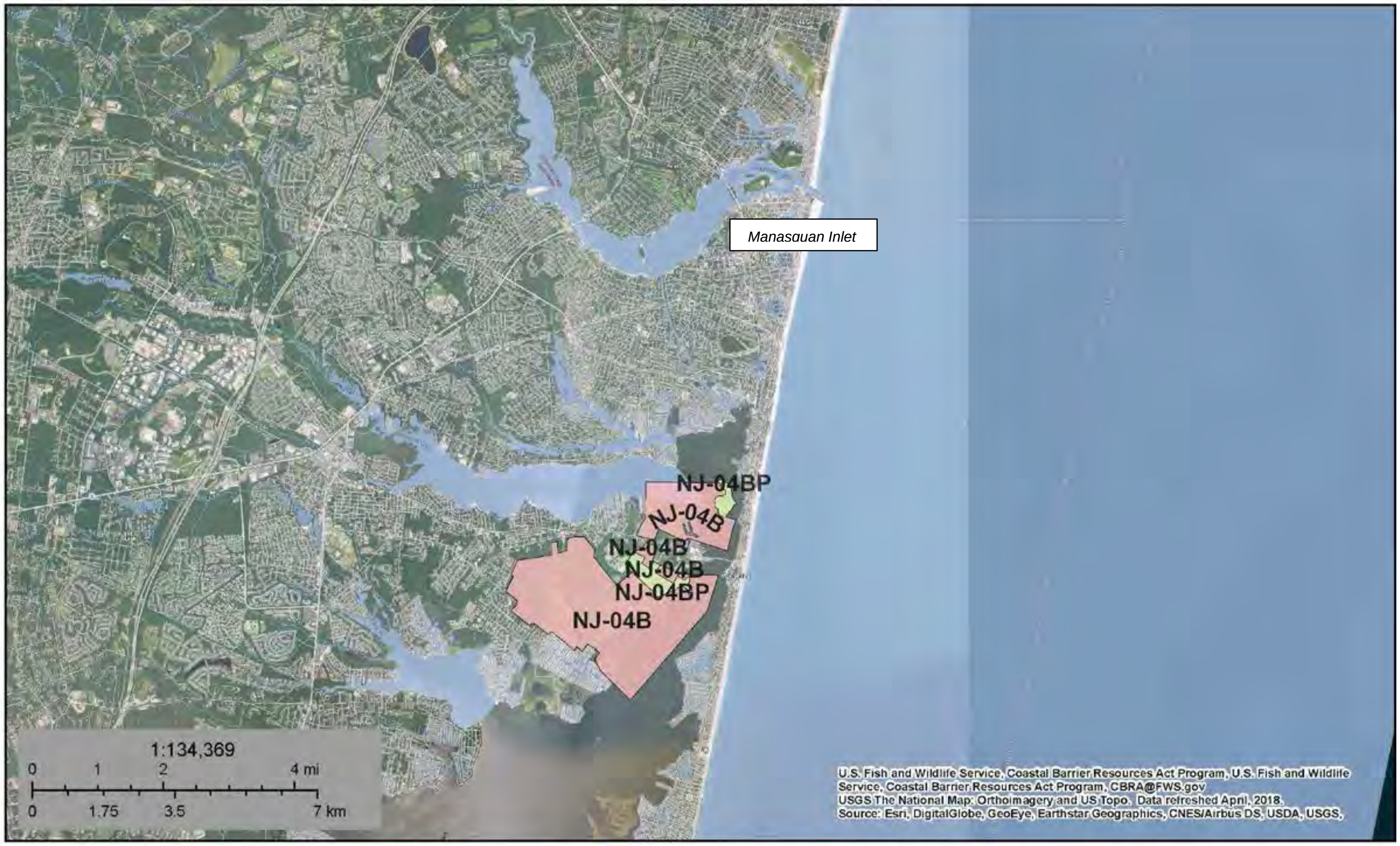
COASTAL BARRIER RESOURCES ACT (CBRA) AREAS

WITHIN THE NJBB STUDY AREA

U.S. Fish and Wildlife Service

Coastal Barrier Resources System

1 Mantoloking



February 9, 2019

This map is for general reference only. The Coastal Barrier Resources System (CBRS) boundaries depicted on this map are representations of the controlling CBRS boundaries, which are shown on the official maps, accessible at https://www.fws.gov/cbra/maps/index.html. All CBRS related data should be used in accordance with the layer metadata found on the CBRS Mapper website.

The CBRS Buffer Zone represents the area immediately adjacent to the CBRS boundary where users are advised to contact the Service for an official determination (http://www.fws.gov/cbra/Determinations.html) as to whether the property or project site is located "in" or "out" of the CBRS.

CBRS Units normally extend seaward out to the 20- or 30-foot bathymetric contour (depending on the location of the unit). The true seaward extent of the units is not shown in the CBRS mapper.

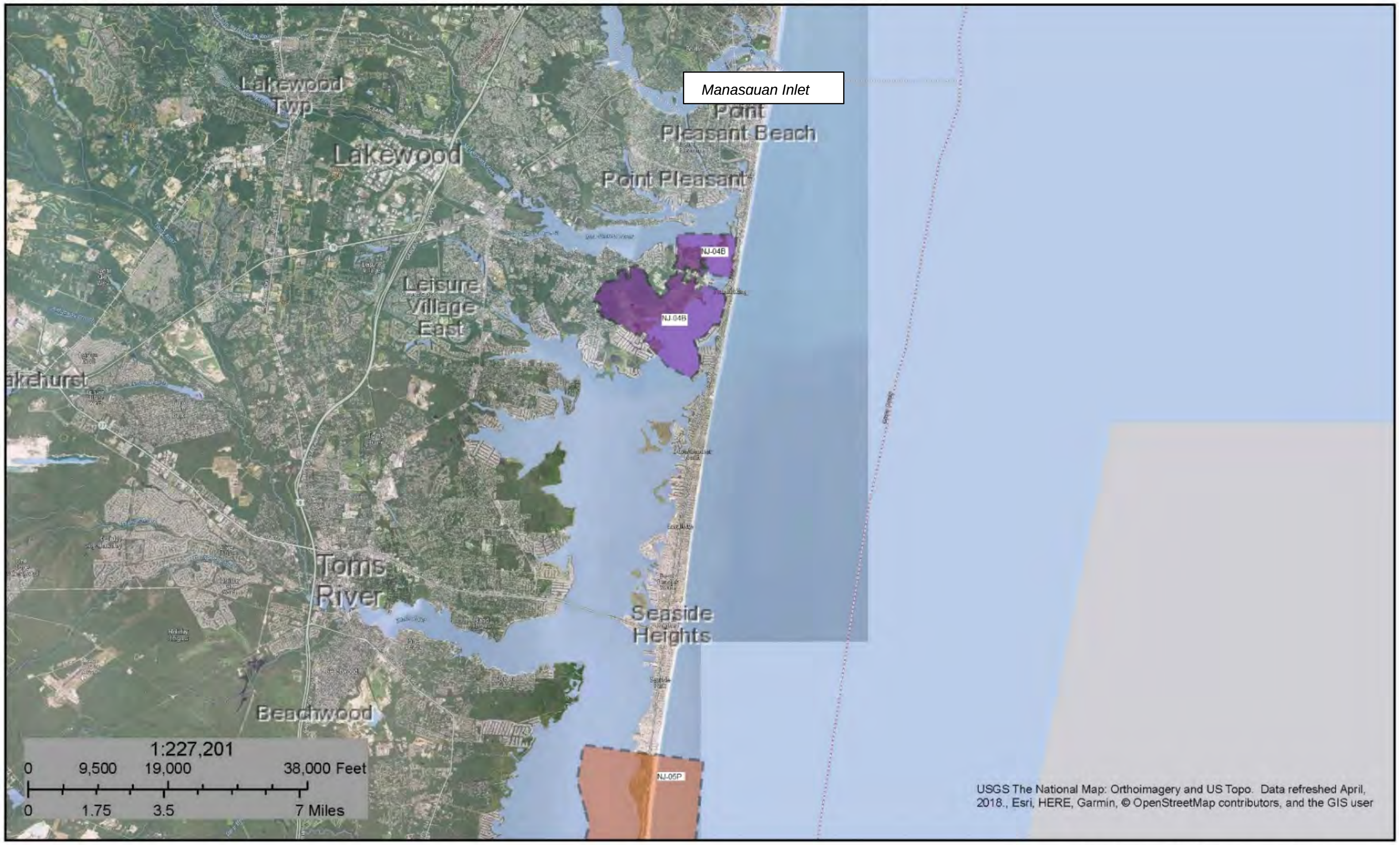
This page was produced by the CBRS Mapper

Figure 6: Existing CBRA Areas - Mantoloking

U.S. Fish and Wildlife Service

Coastal Barrier Resources System Projects Mapper

Draft Revised CBRS



February 9, 2019

Other Existing Units

- Unit Outside Project Area

Revised Units

- System Unit
- Otherwise Protected Area

This map is for reference only. The draft revised CBRS boundaries depicted on this map have not been adopted through legislation enacted by Congress. Areas and structures depicted on this map may or may not currently be within the CBRS. To view the current CBRS boundaries for this area, please use the CBRS Mapper: https://www.fws.gov/cbra/Maps/Mapper.html.

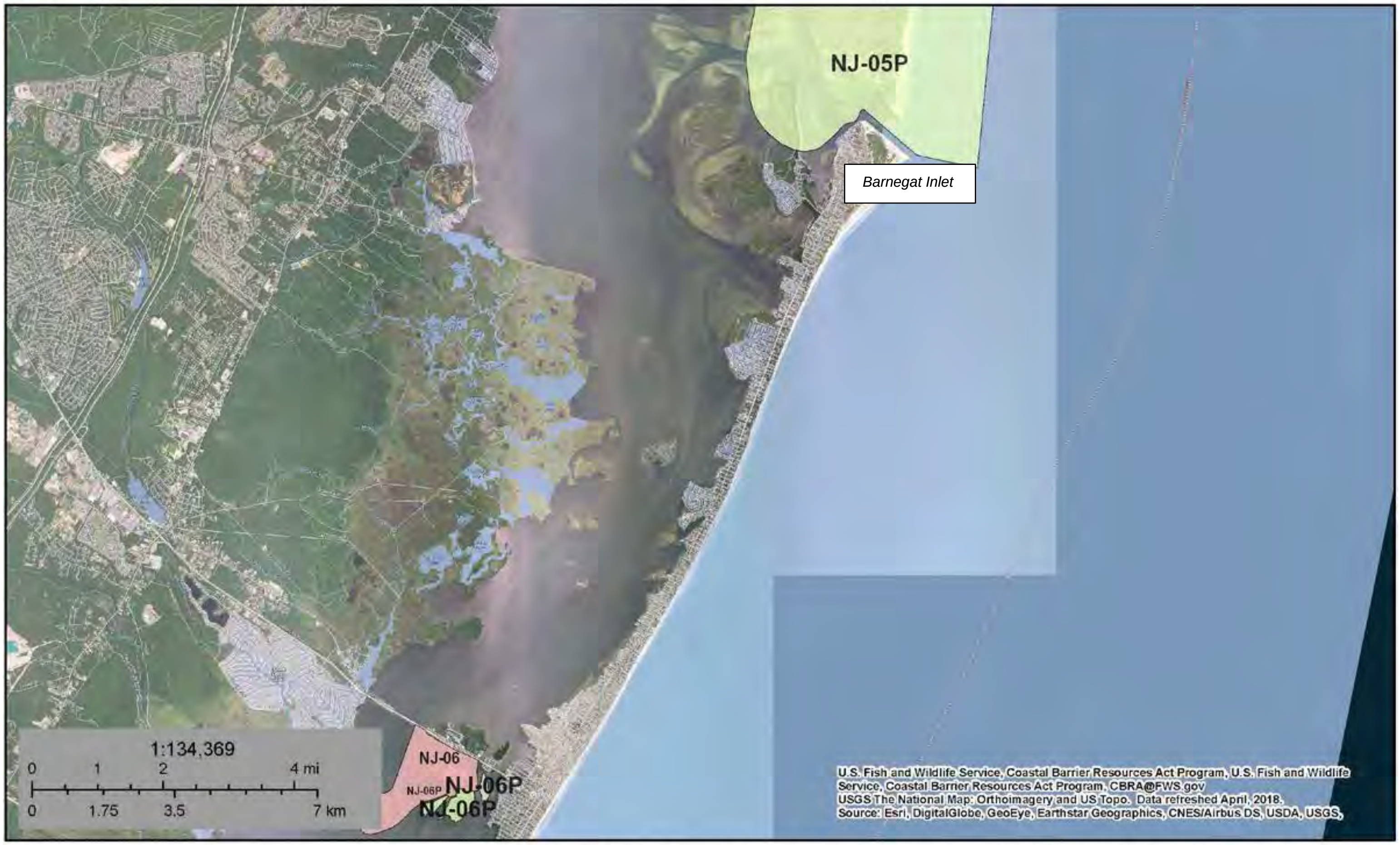
Coastal Barrier Resources System (CBRS)
This page was produced by the CBRS Projects Mapper

Figure 7: Draft Revised CBRA Areas - Mantoloking

U.S. Fish and Wildlife Service

Coastal Barrier Resources System

Cedar Bonnet and Barnegat



February 9, 2019

This map is for general reference only. The Coastal Barrier Resources System (CBRS) boundaries depicted on this map are representations of the controlling CBRS boundaries, which are shown on the official maps, accessible at https://www.fws.gov/cbra/maps/index.html. All CBRS related data should be used in accordance with the layer metadata found on the CBRS Mapper website.

The CBRS Buffer Zone represents the area immediately adjacent to the CBRS boundary where users are advised to contact the Service for an official determination (http://www.fws.gov/cbra/Determinations.html) as to whether the property or project site is located "in" or "out" of the CBRS.

CBRS Units normally extend seaward out to the 20- or 30-foot bathymetric contour (depending on the location of the unit). The true seaward extent of the units is not shown in the CBRS mapper.

This page was produced by the CBRS Mapper

Figure 8: Existing CBRA Area - Barnegat Inlet and Cedar Bonnet Island

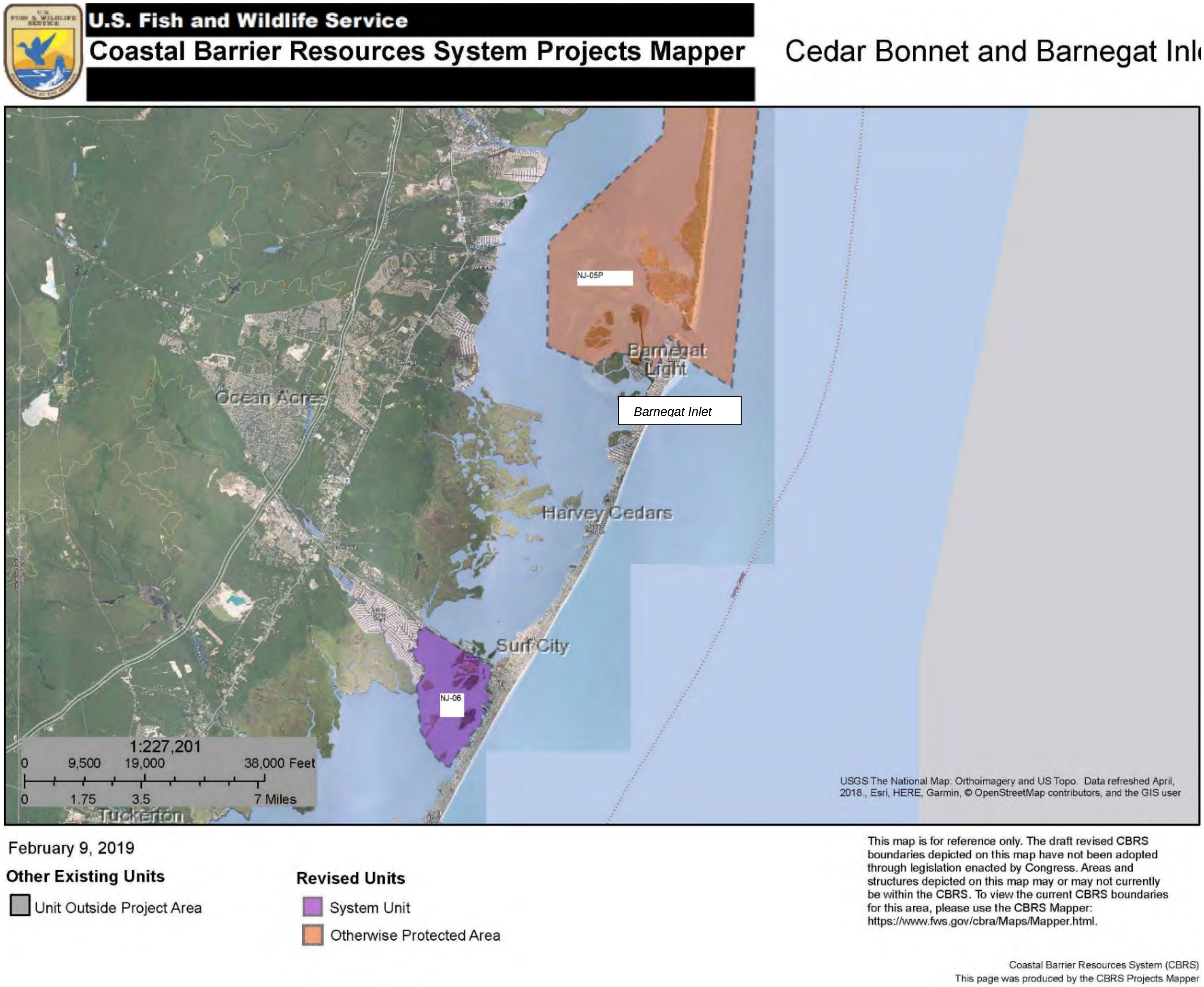
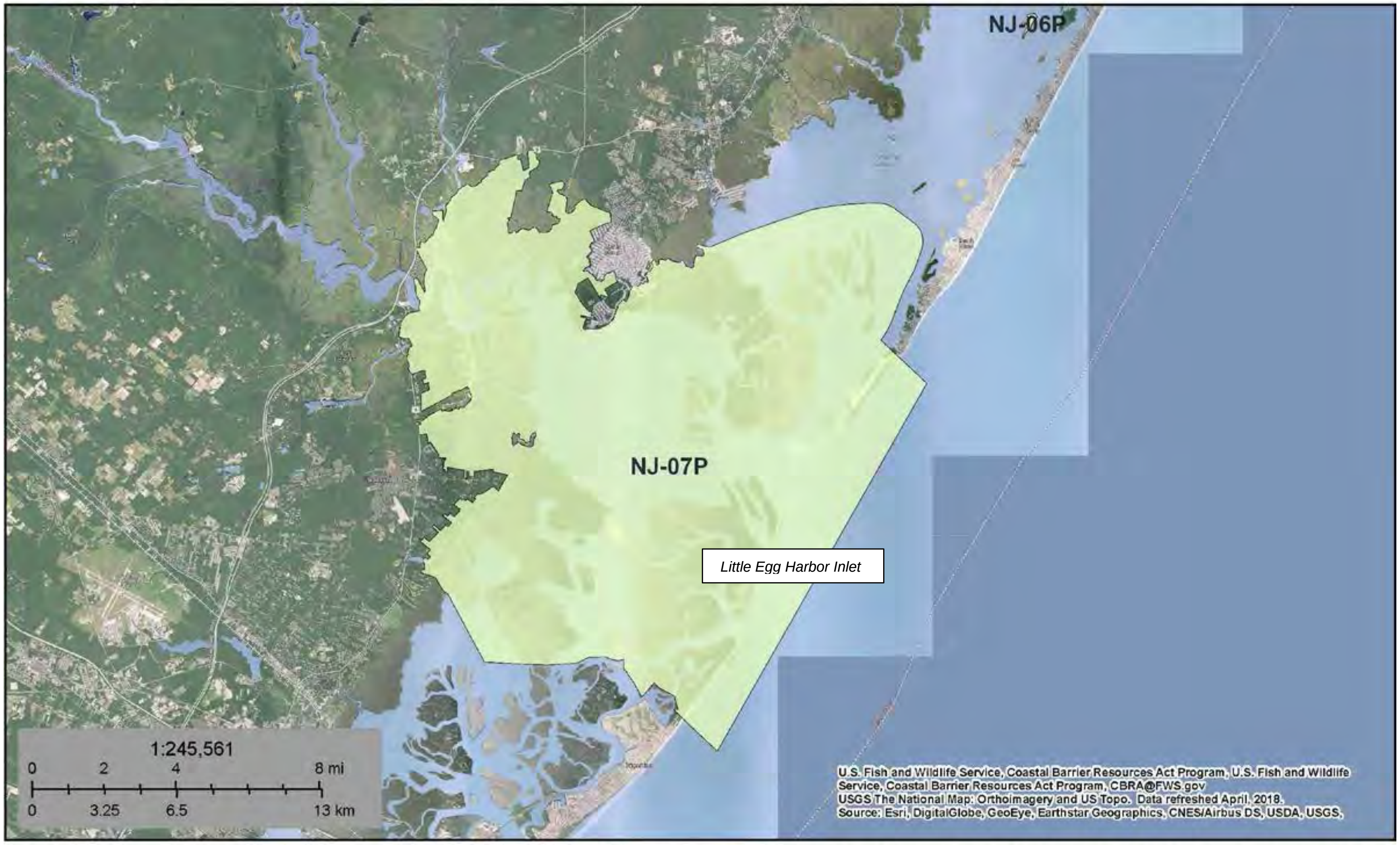


Figure 9: Draft Revised CBRA Areas - Barnegat Inlet and Cedar Bonnet Island

U.S. Fish and Wildlife Service
Coastal Barrier Resources System

EB Forsythe Area



February 9, 2019

This map is for general reference only. The Coastal Barrier Resources System (CBRS) boundaries depicted on this map are representations of the controlling CBRS boundaries, which are shown on the official maps, accessible at https://www.fws.gov/cbra/maps/index.html. All CBRS related data should be used in accordance with the layer metadata found on the CBRS Mapper website.

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CBRS Units normally extend seaward out to the 20- or 30-foot bathymetric contour (depending on the location of the unit). The true seaward extent of the units is not shown in the CBRS mapper.

This page was produced by the CBRS Mapper

Figure 10: Existing CBRA Areas - Edwin B. Forsythe National Wildlife Refuge

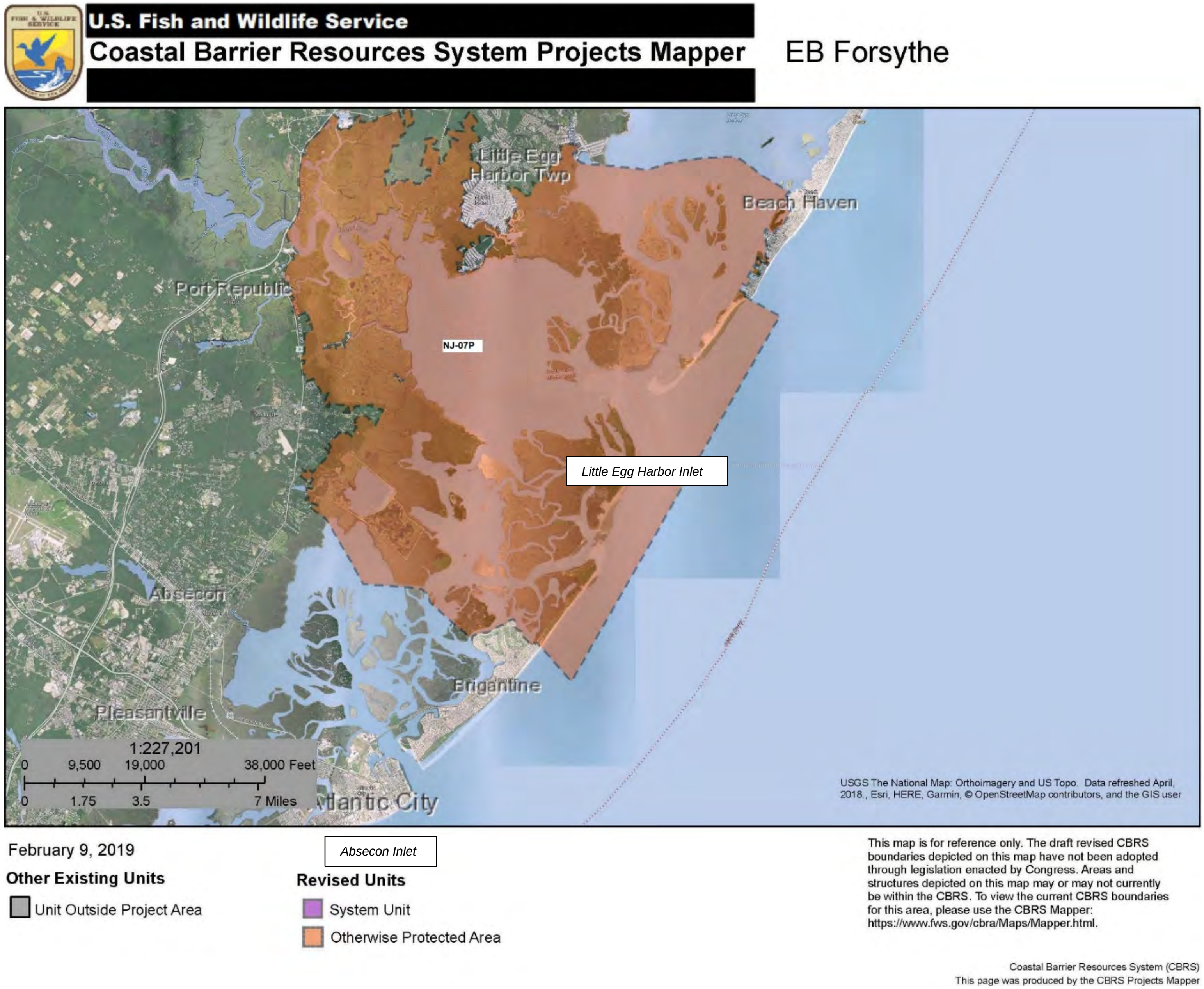


Figure 11: Draft Revised CBRA Areas - Edwin B. Forsythe National Wildlife Refuge

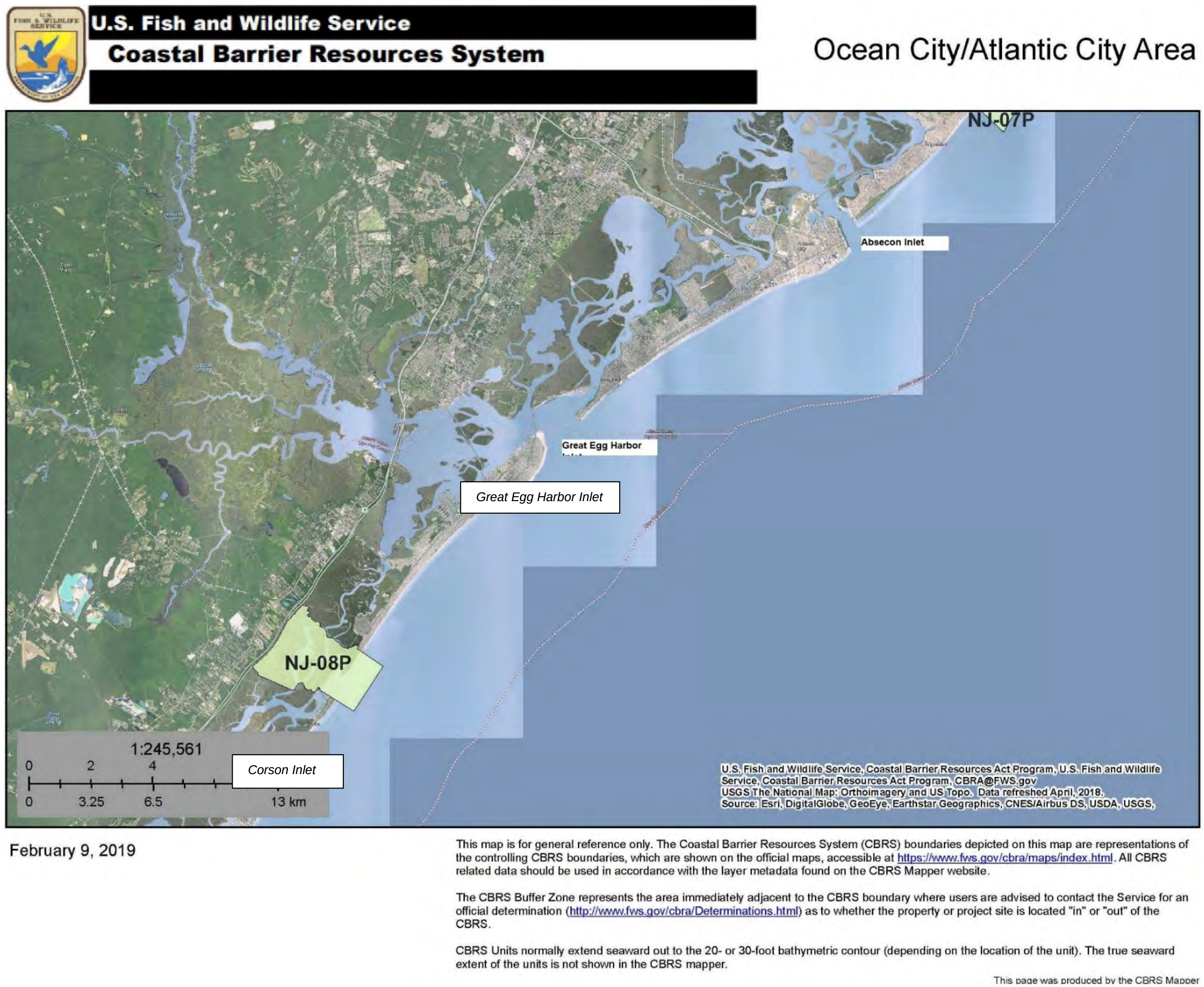


Figure 12: Existing CBRA Areas - Ocean City/Atlantic City

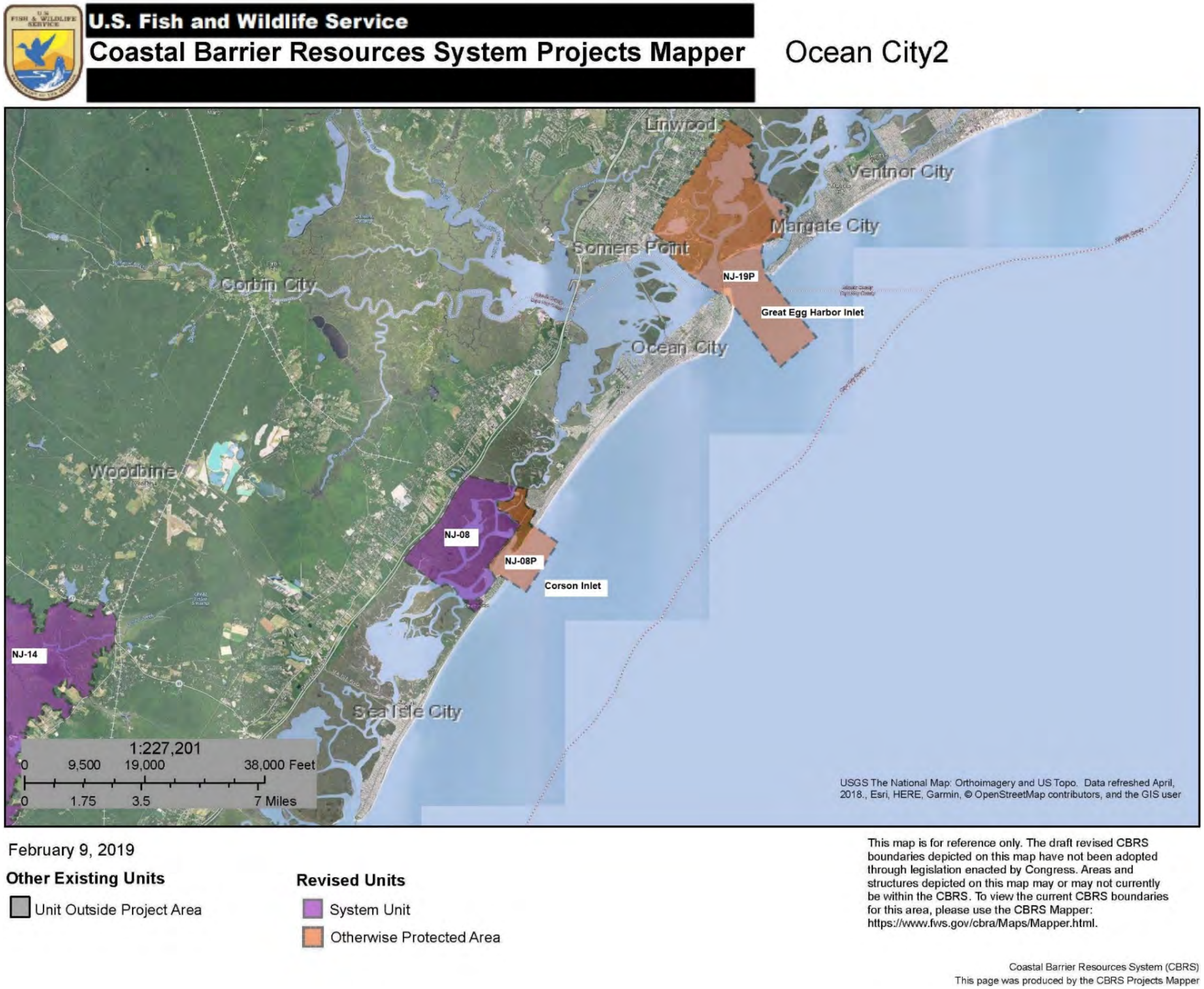


Figure 13: Draft Revised CBRA Areas - Ocean City/Atlantic City

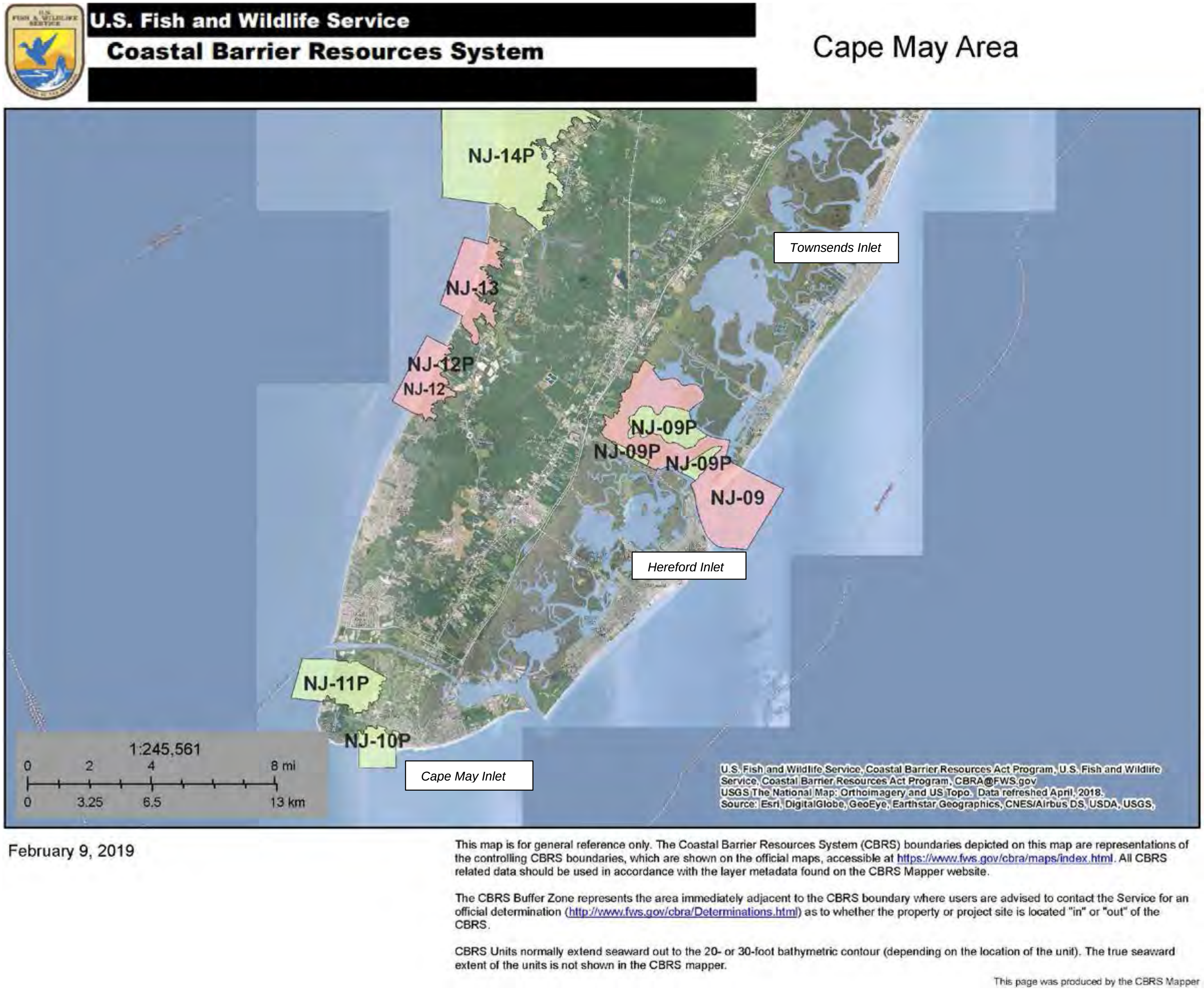


Figure 14: Existing CBRA Areas - Wildwood/Cape May

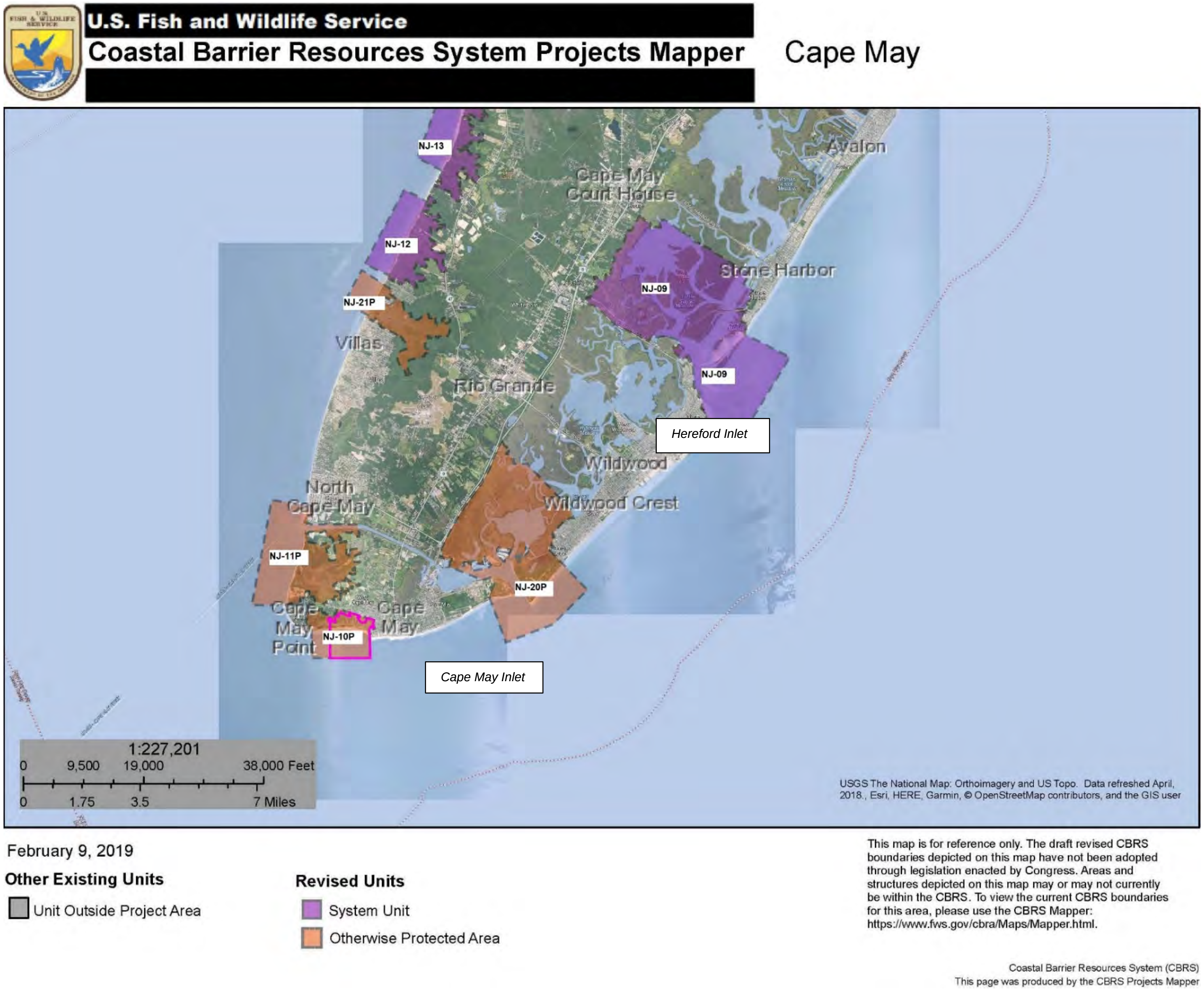


Figure 15: Draft Revised CBRA Areas - Wildwood/Cape May.

NJBB SHELLFISH MAPS

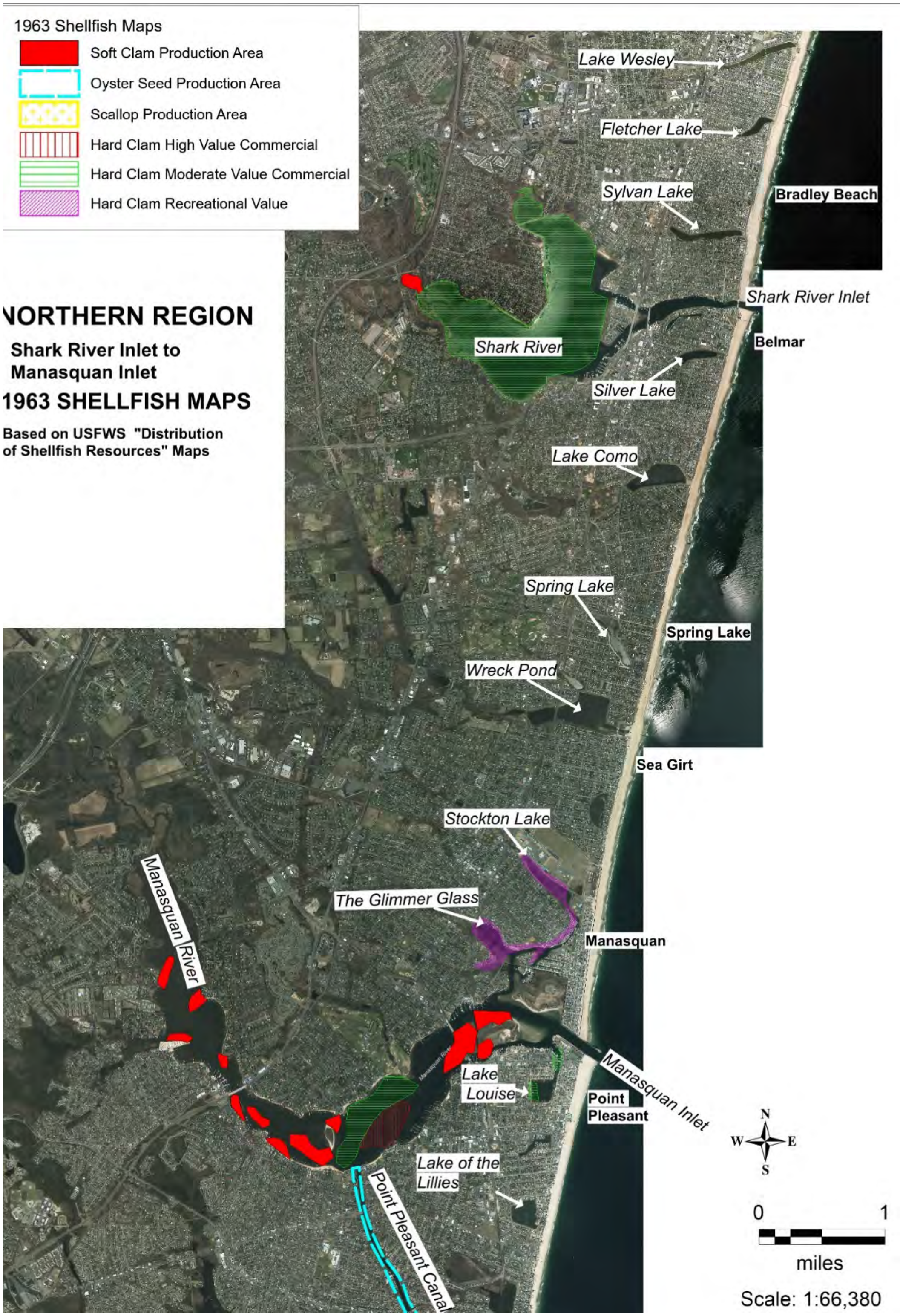


Figure 16: Northern Region - Shark River Inlet to Manasquan Inlet - 1963 Shellfish Map

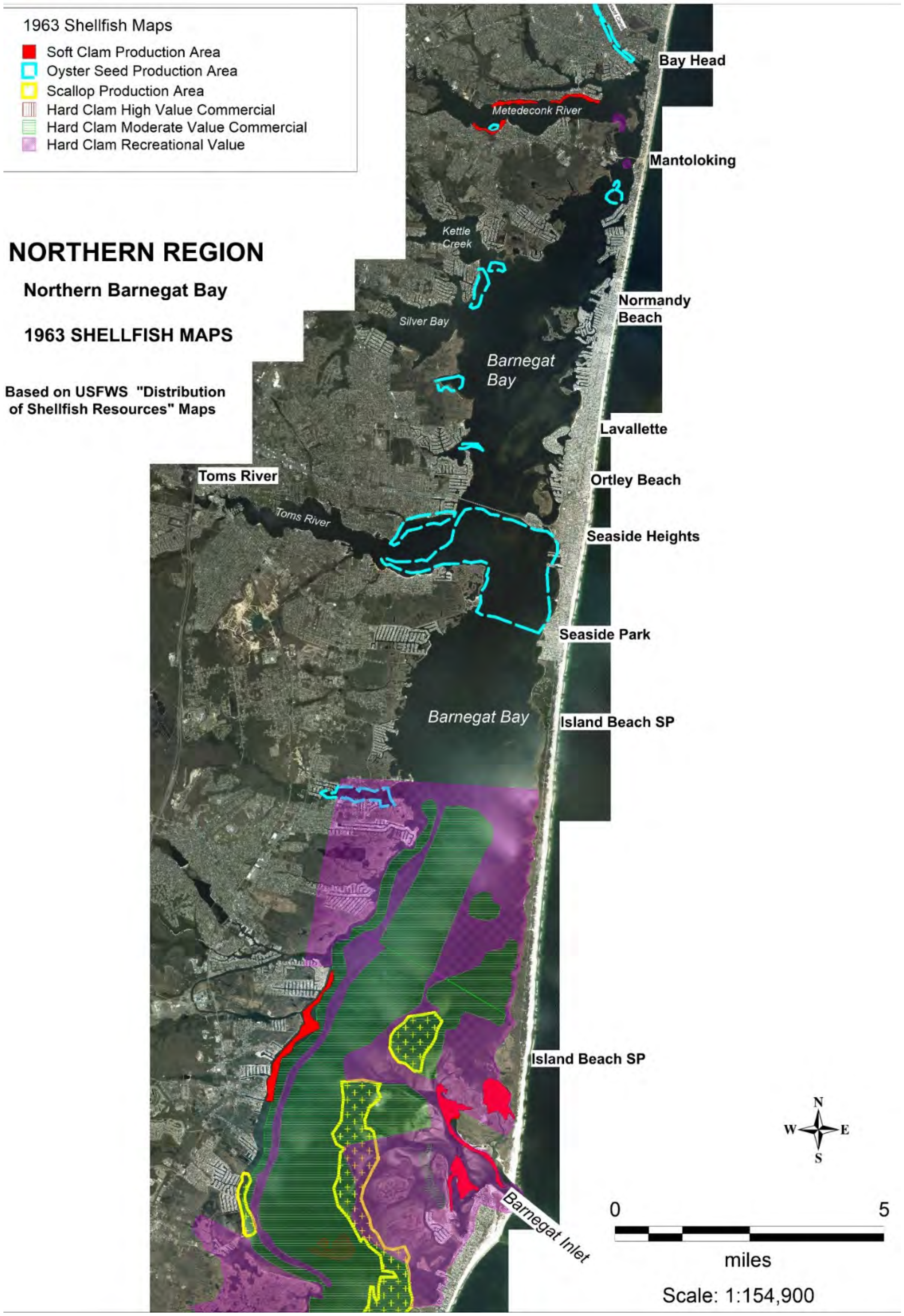


Figure 17: Northern Region - Northern Barnegat Bay - 1963 Shellfish Map

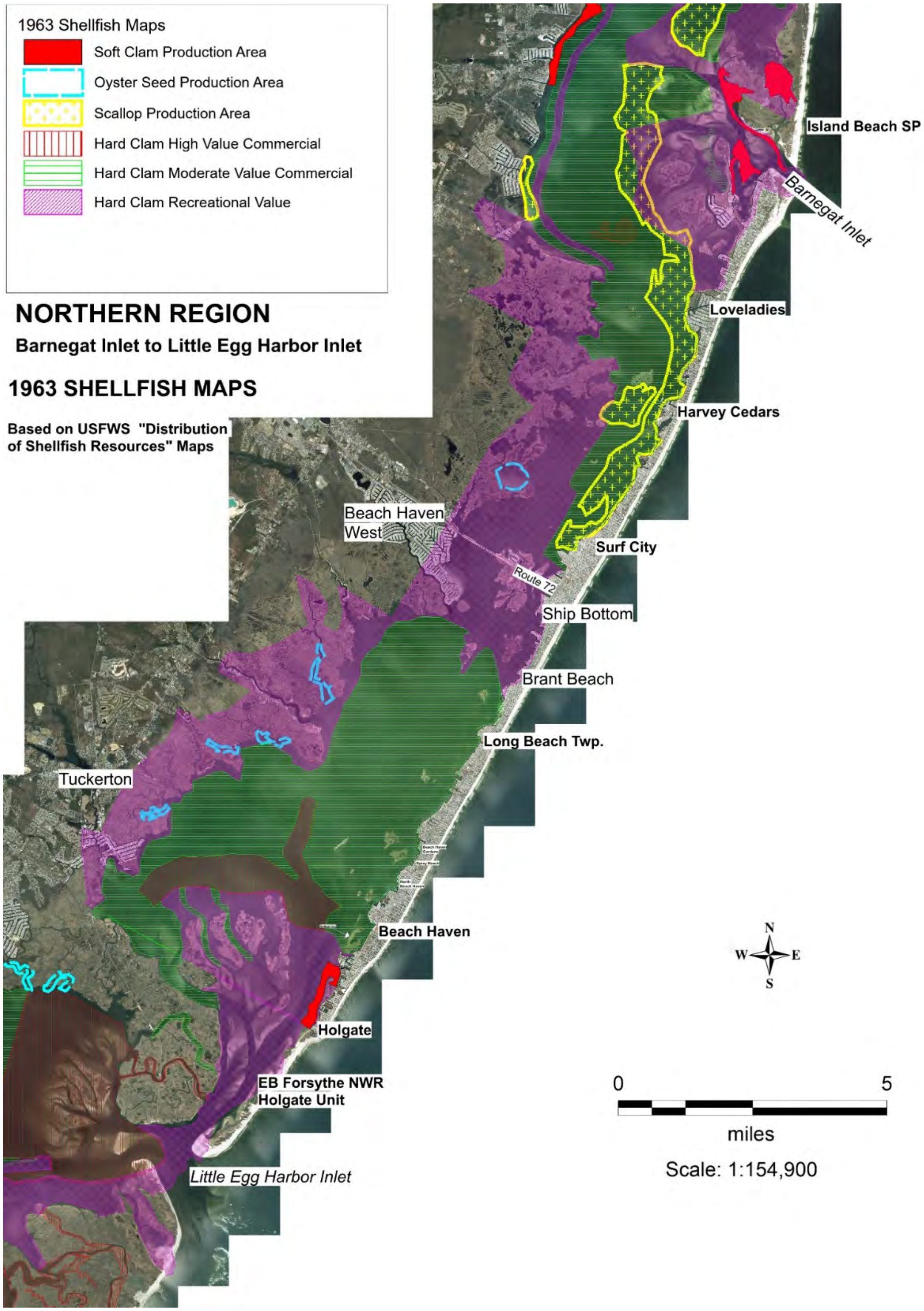


Figure 18: Northern Region - Barnegat Inlet to Little Egg Harbor Inlet - 1963 Shellfish Map

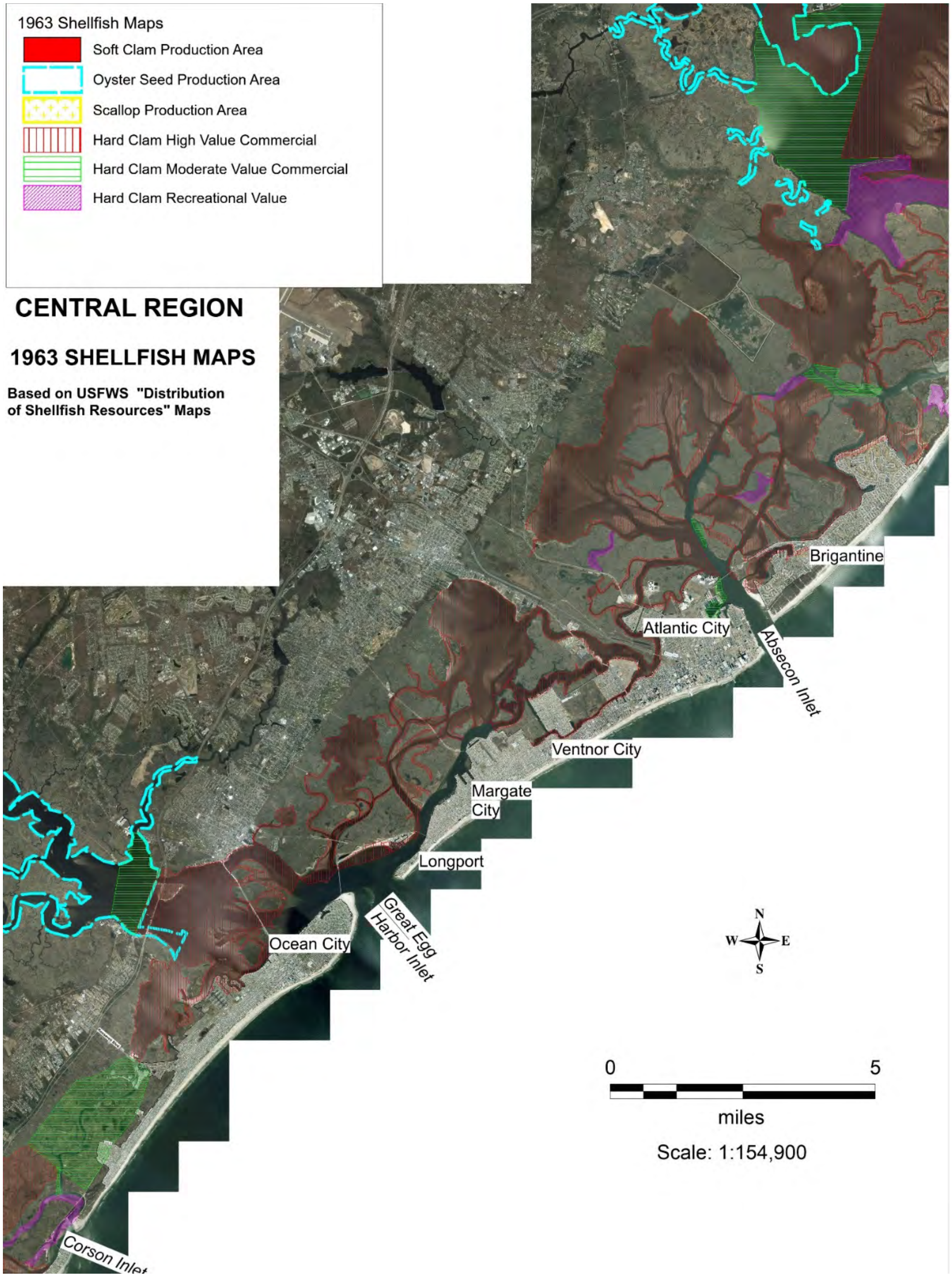


Figure 19: Central Region - Absecon Inlet to Corson Inlet - 1963 Shellfish Map

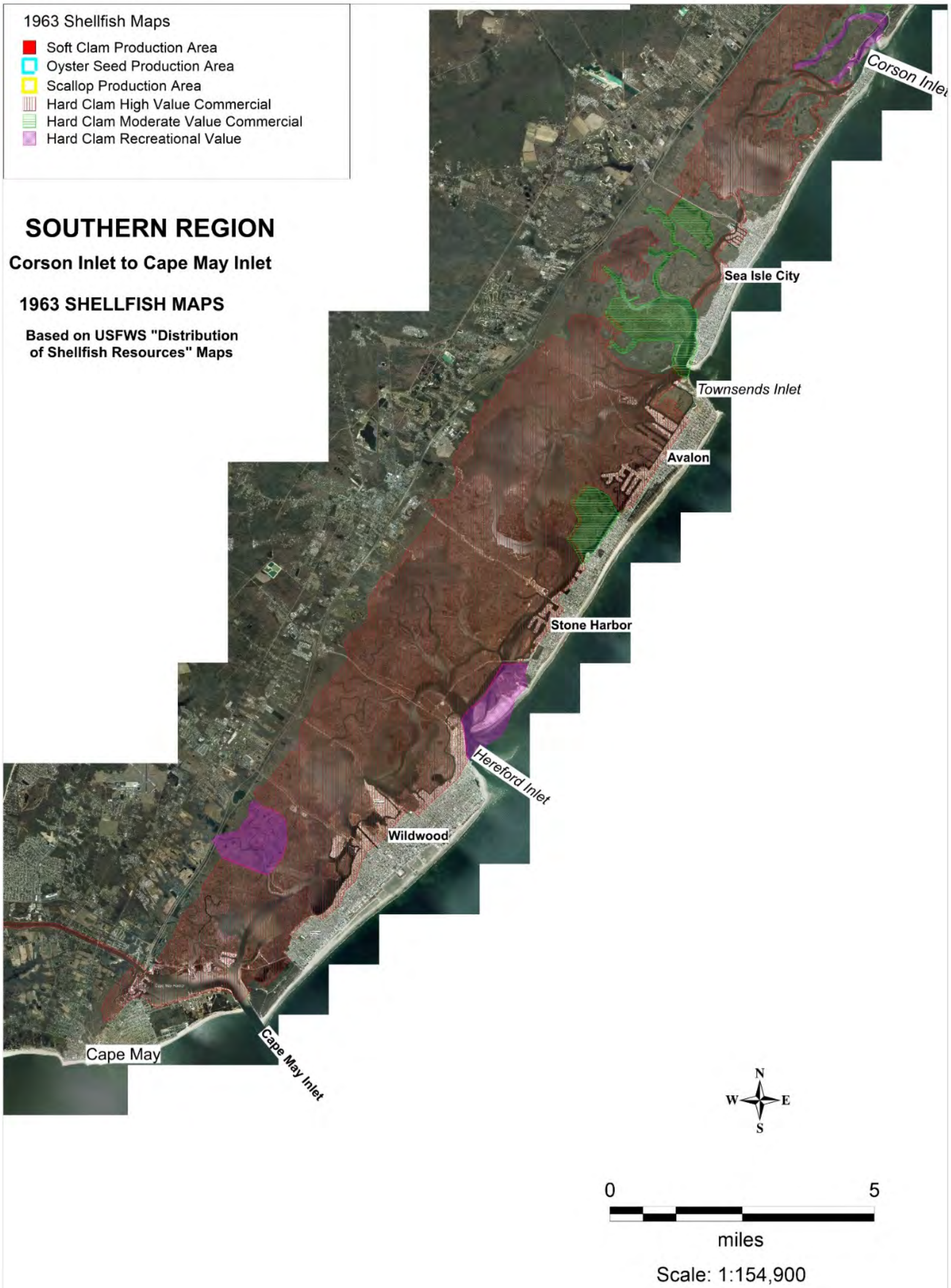


Figure 20: Southern Region - Corson Inlet to Cape May Inlet - 1963 Shellfish Map

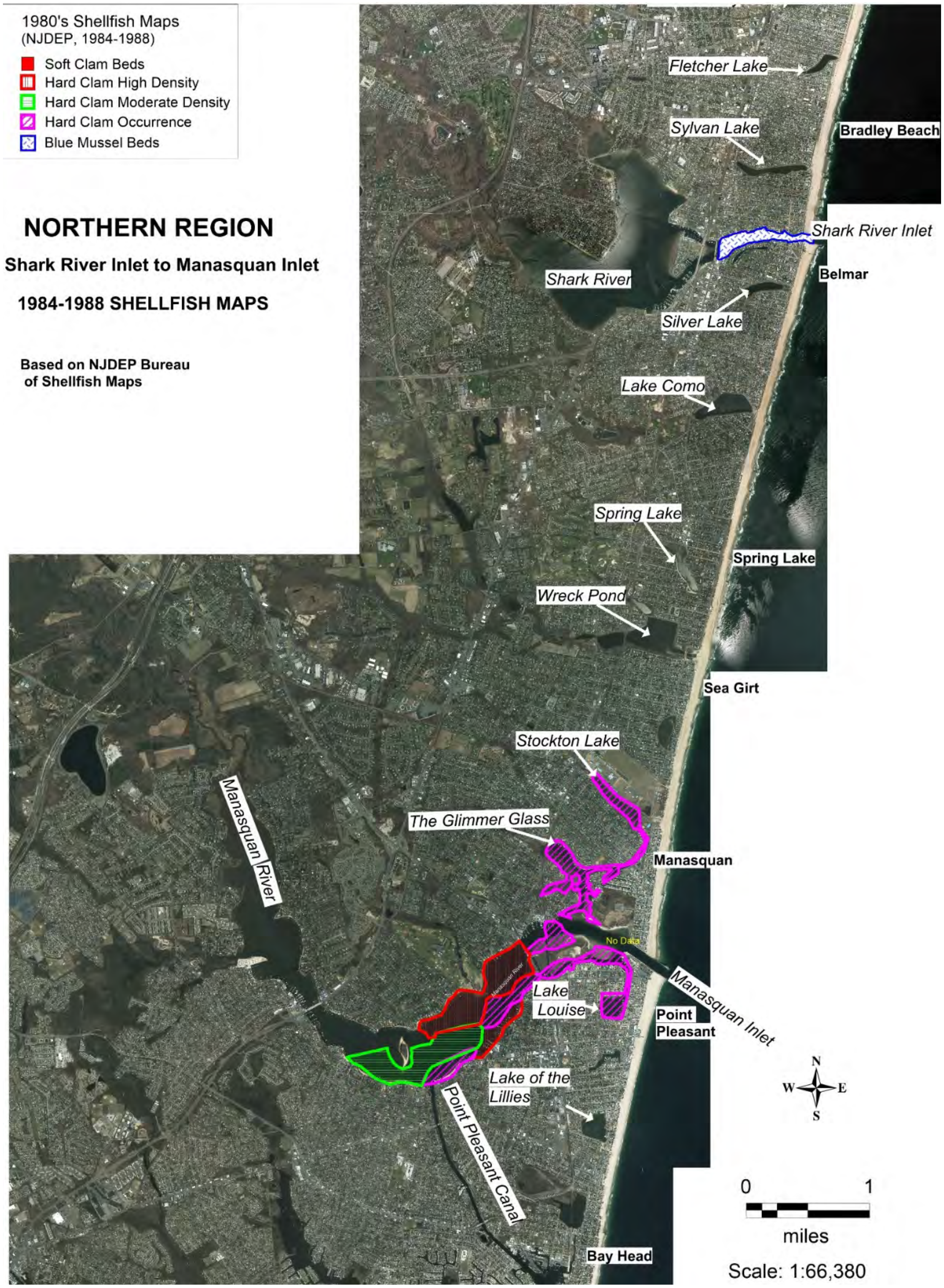


Figure 21: Northern Region - Shark River Inlet to Manasquan Inlet - 1984-1988 Shellfish Map

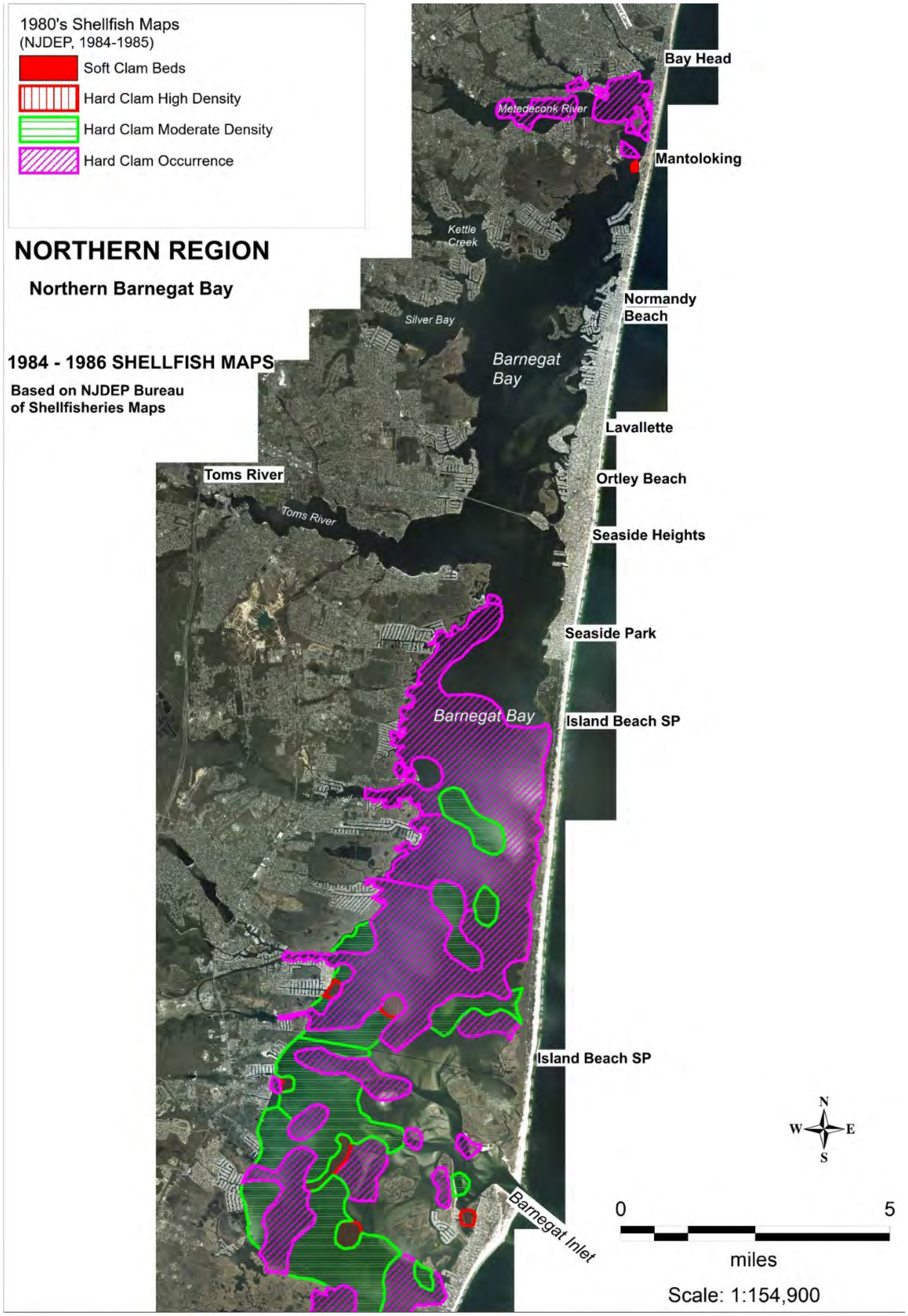


Figure 22: Northern Region – Northern Barnegat Bay – 1984-1988 Shellfish Map

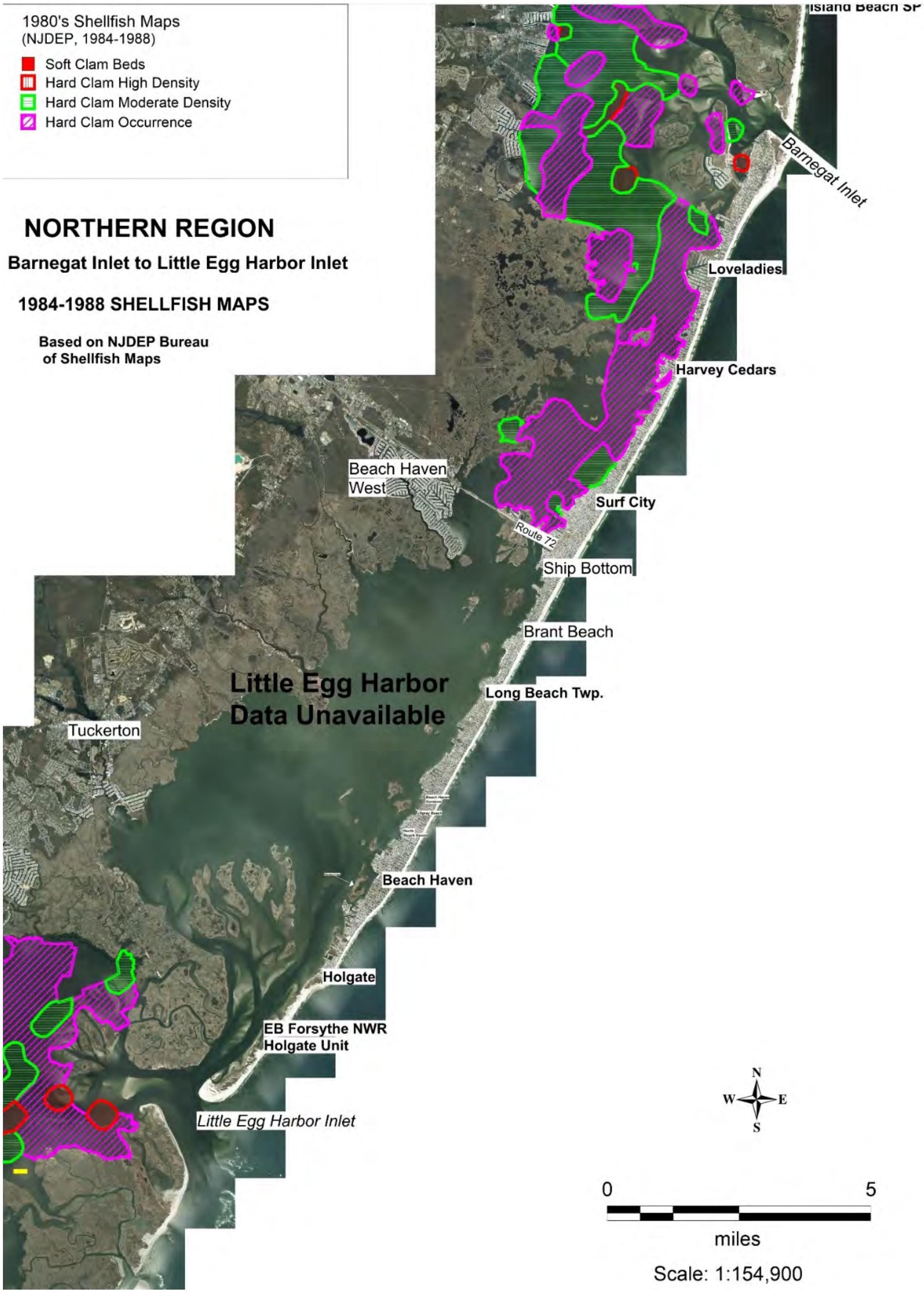


Figure 23: Northern Region - Barnegat Inlet to Little Egg Harbor Inlet – 1984-1988 Shellfish Map

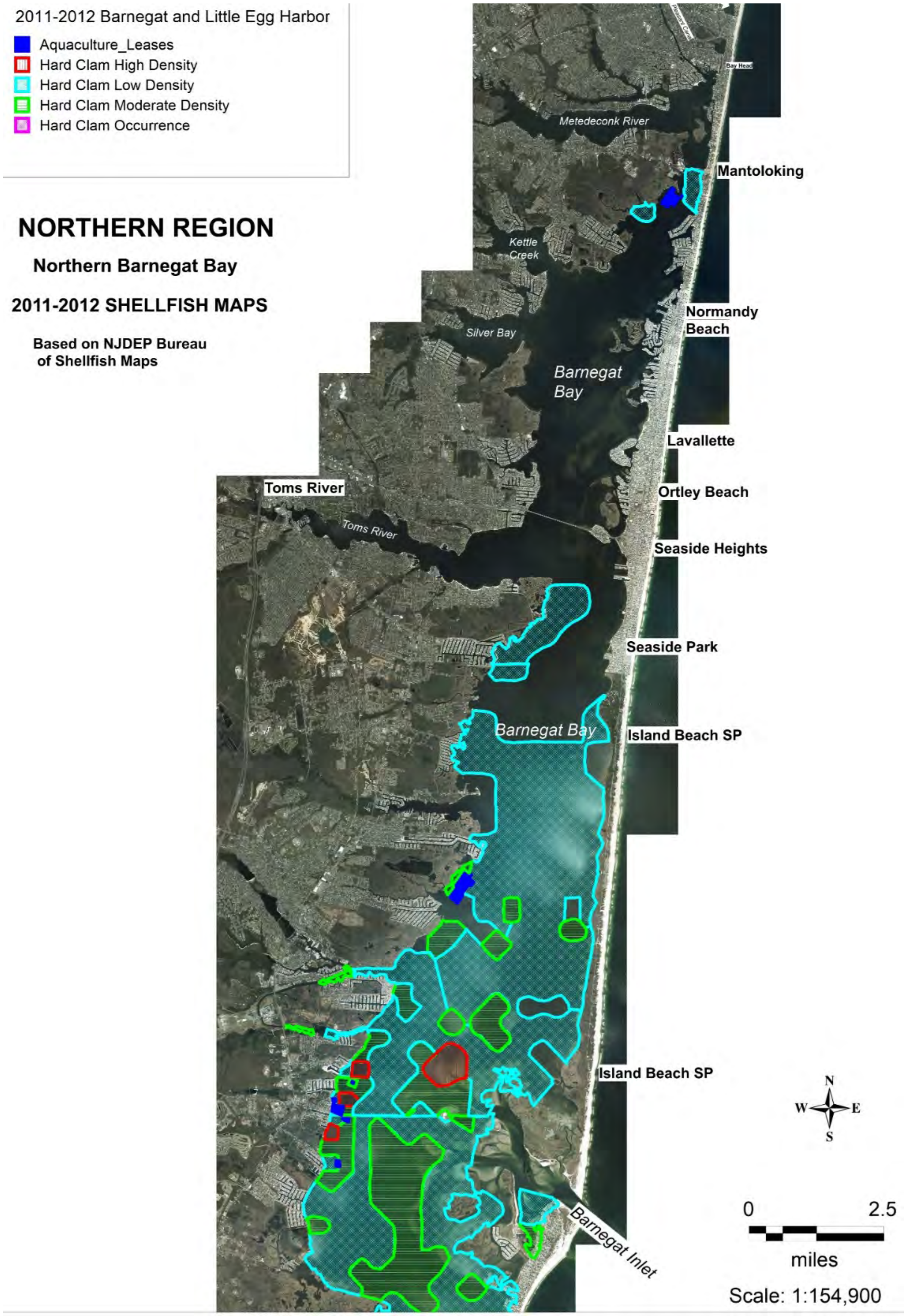


Figure 24: Northern Region - Northern Barnegat Bay - 2011-2012 Shellfish Map

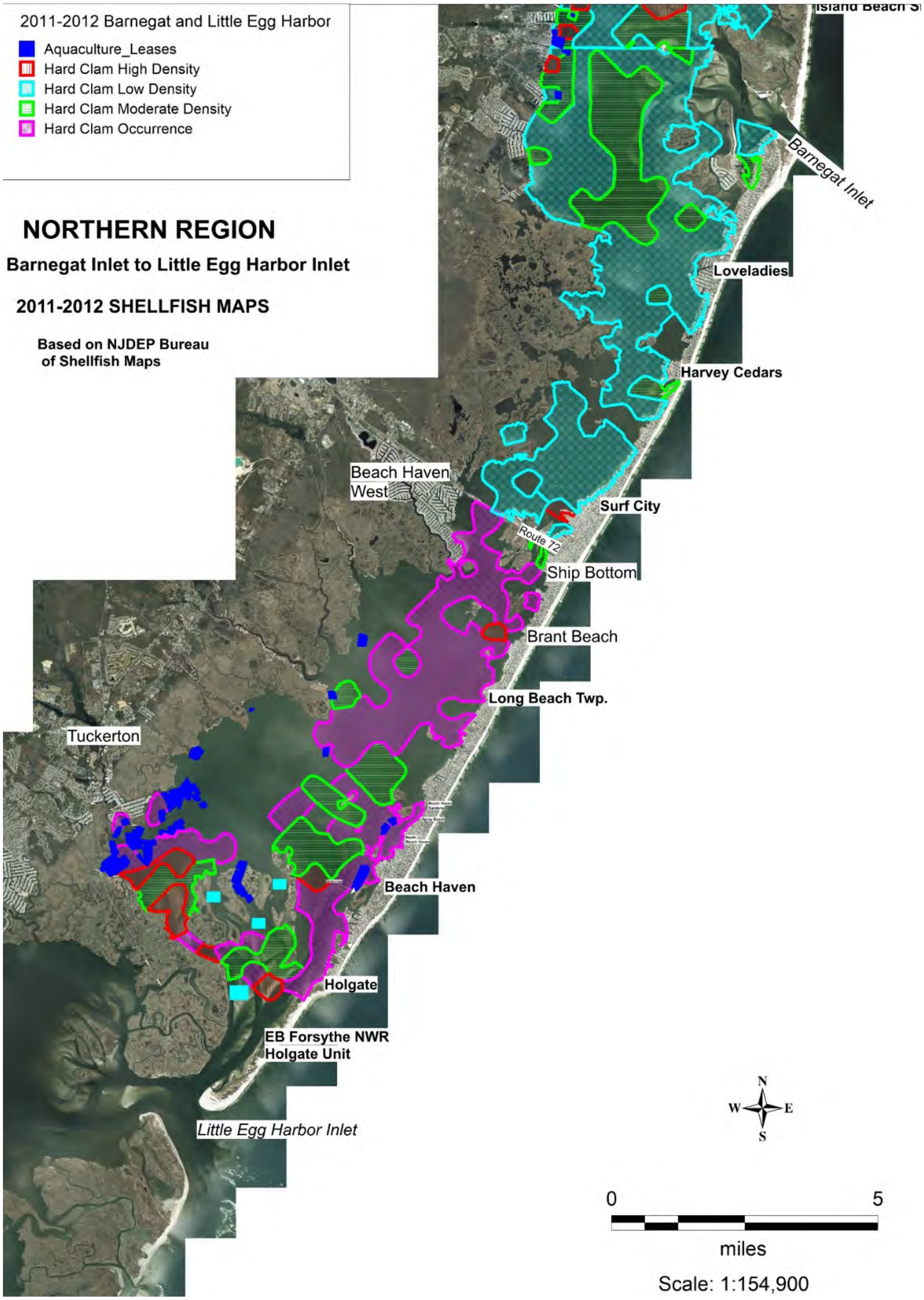


Figure 25: Northern Region - Barnegat Inlet to Little Egg Harbor Inlet - 2011-2012 Shellfish Map

HABITAT IMPACTS OF STRUCTURAL COMPONENTS OF THE FOCUSED ARRAY OF ALTERNATIVES

NORTH REGION

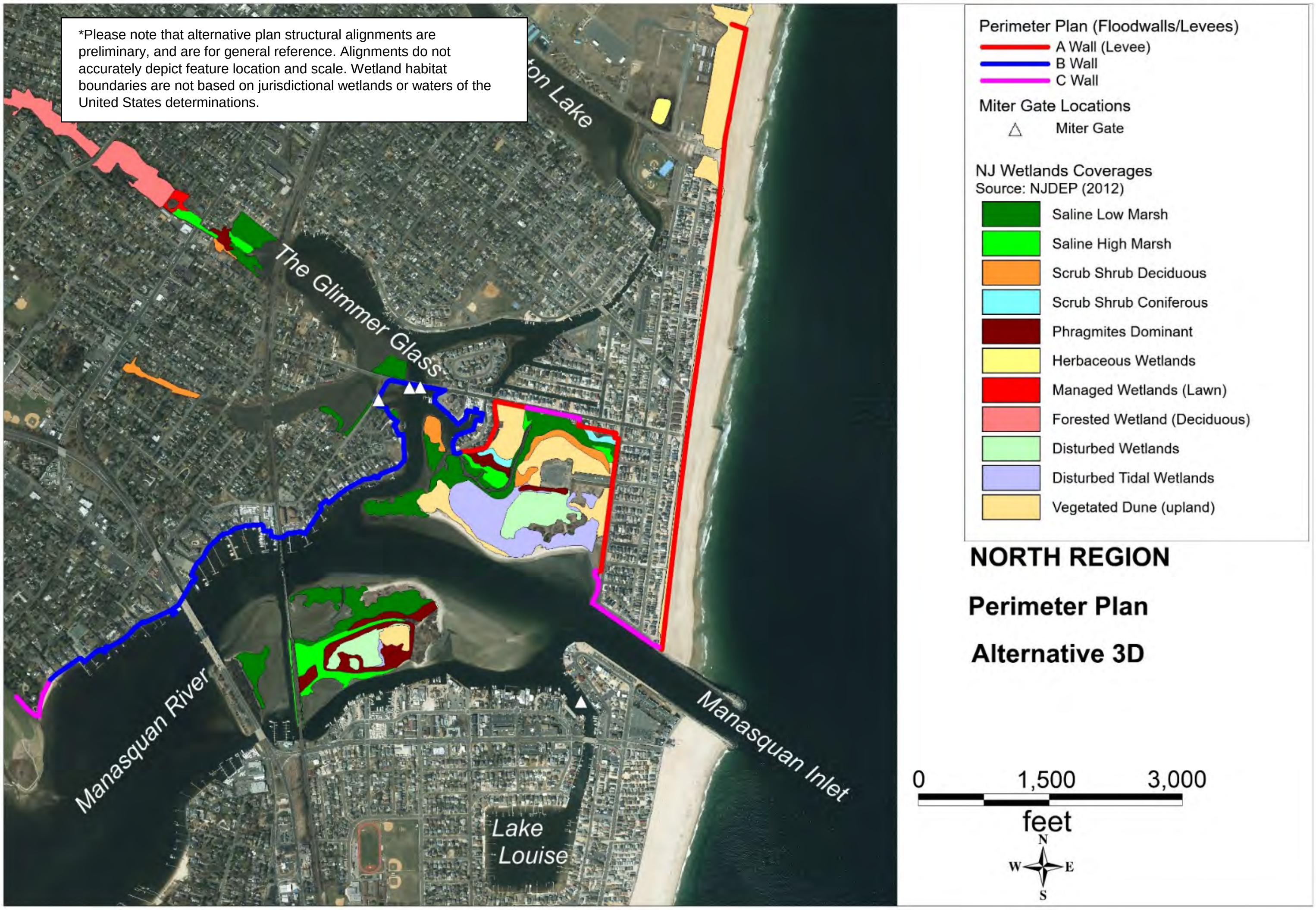


Figure 26: Perimeter Plan Overlay with Wetland Habitats along Manasquan Perimeter Plan Alignment in Alternative 3D

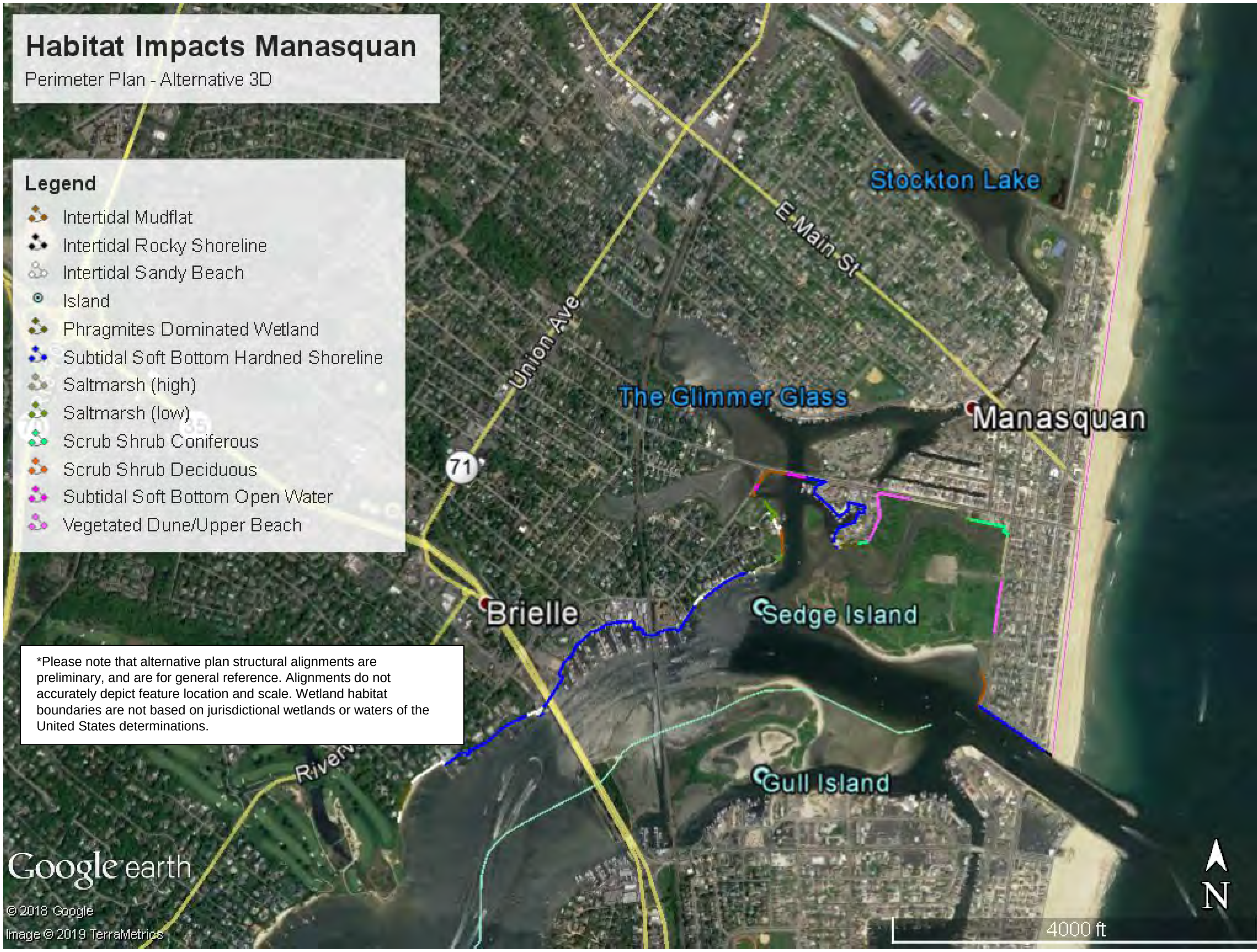


Figure 27: Habitat Impacts along Manasquan Perimeter Plan Alignment in Alternative 3D

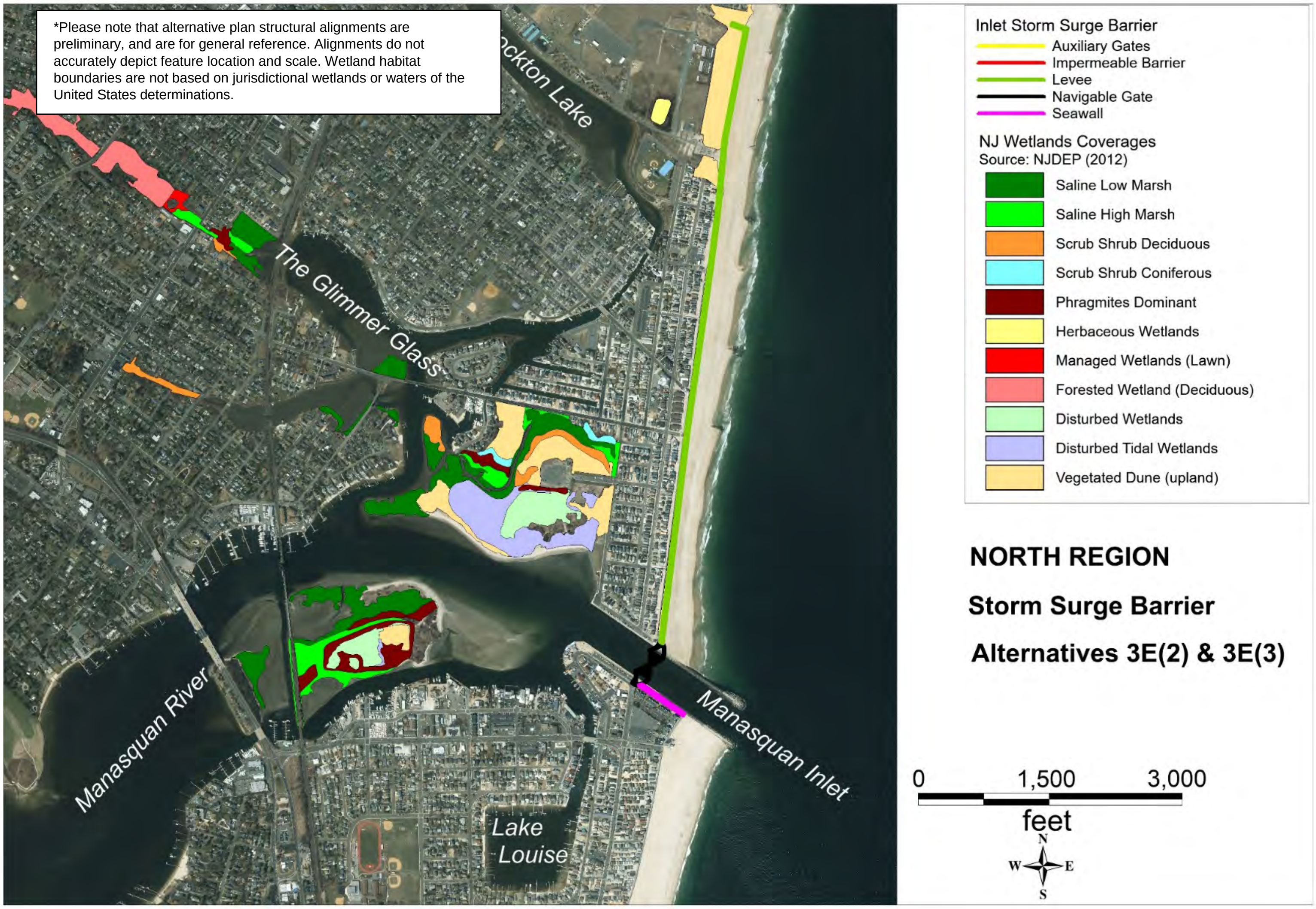


Figure 28: Storm Surge Barrier Overlay with Wetland Habitats along Manasquan in Alternative 3E(2) and 3E(3)

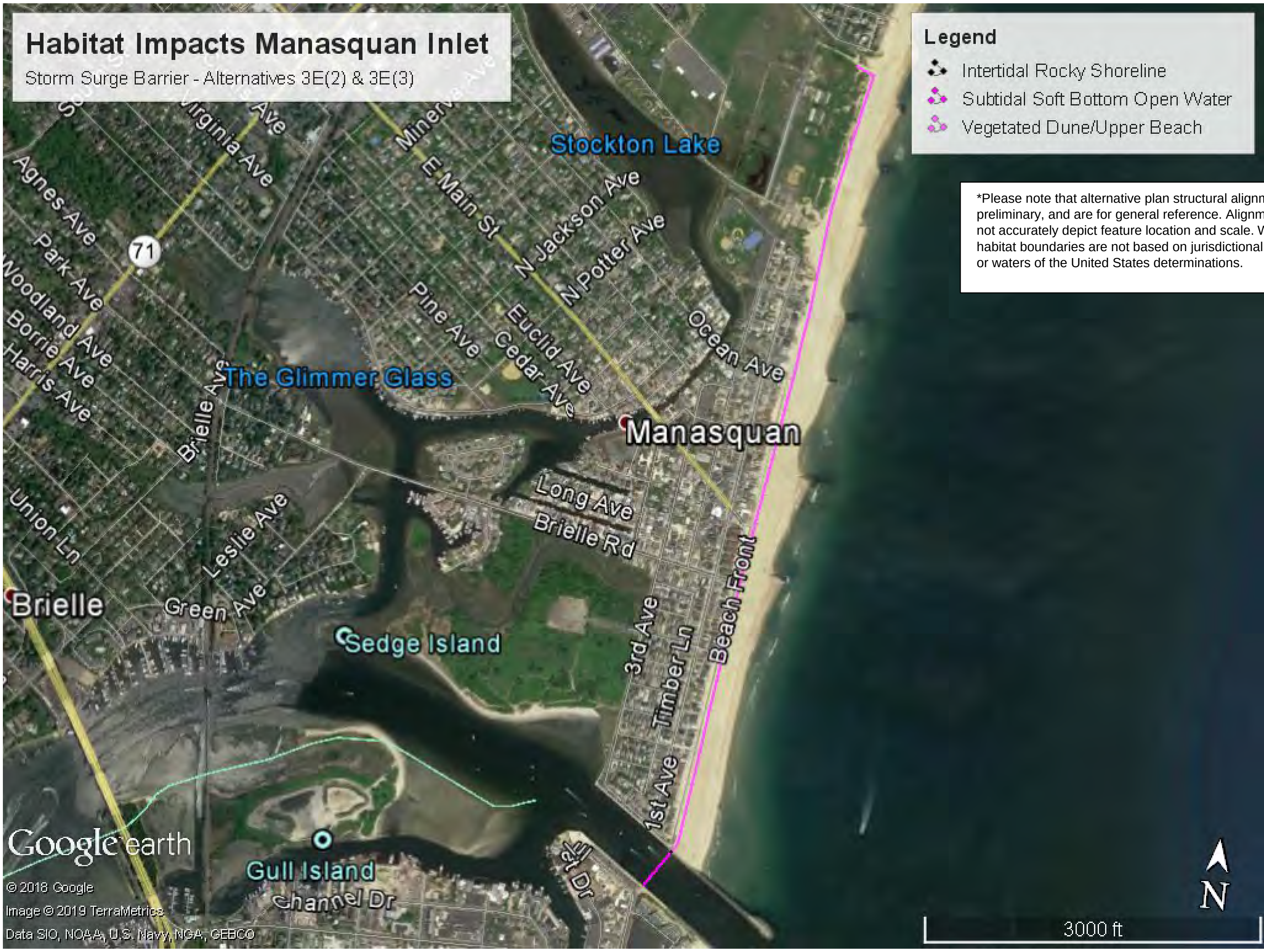


Figure 29: Habitat Impacts along Manasquan Inlet Storm Surge Barrier Plan Alignment in Alternatives 3E(2) and 3E(3)

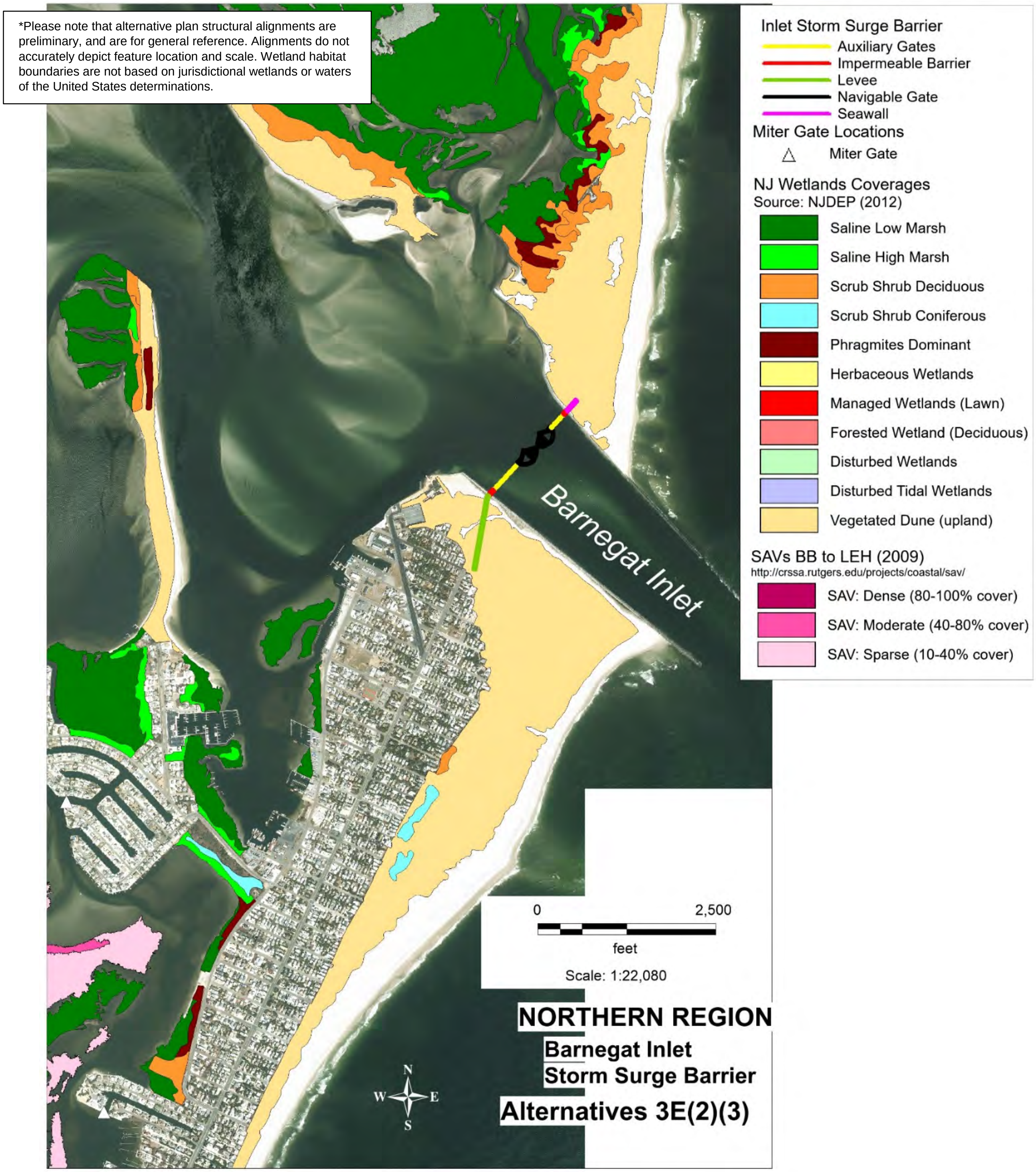


Figure 30: Storm Surge Barrier Overlay with Wetland Habitats along Manasquan in Alternative

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

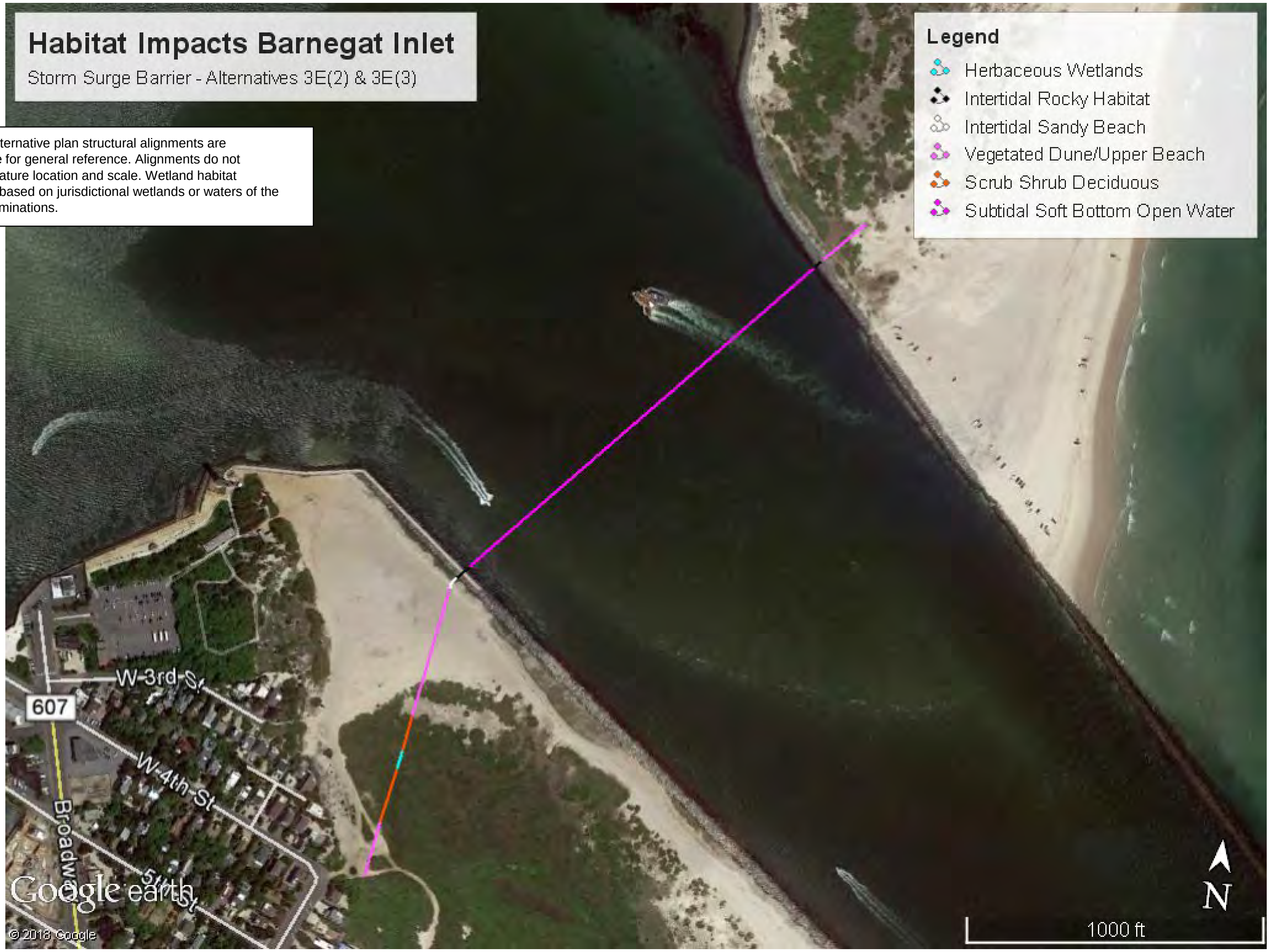


Figure 31: Habitat Impacts along Barnegat Inlet Storm Surge Barrier Plan Alignment in Alternatives 3E(2) and 3E(3)

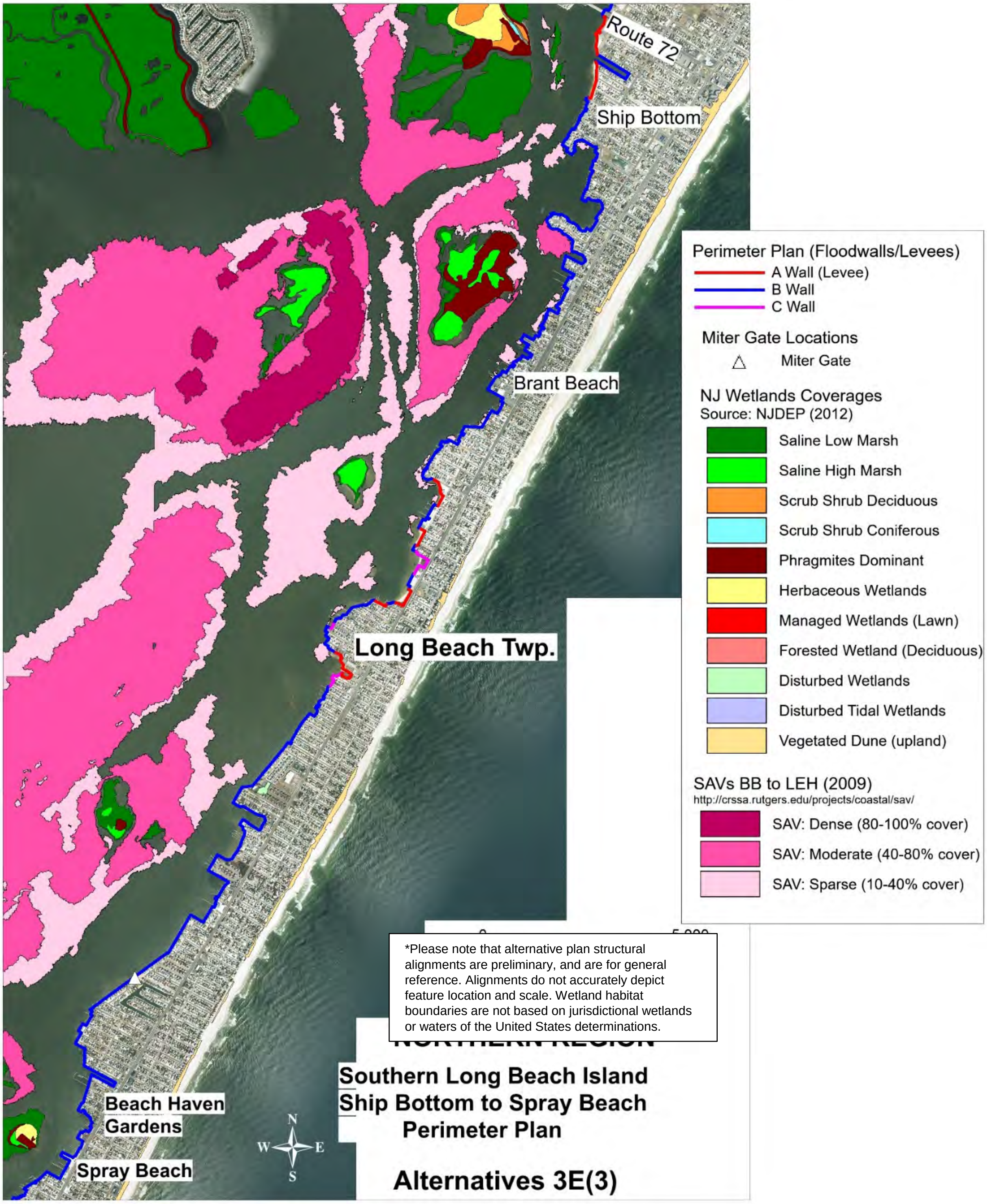


Figure 32: Perimeter Plan Overlay with Wetland Habitats along Southern Long Beach Island (north) Alignment in Alternative 3E(3)

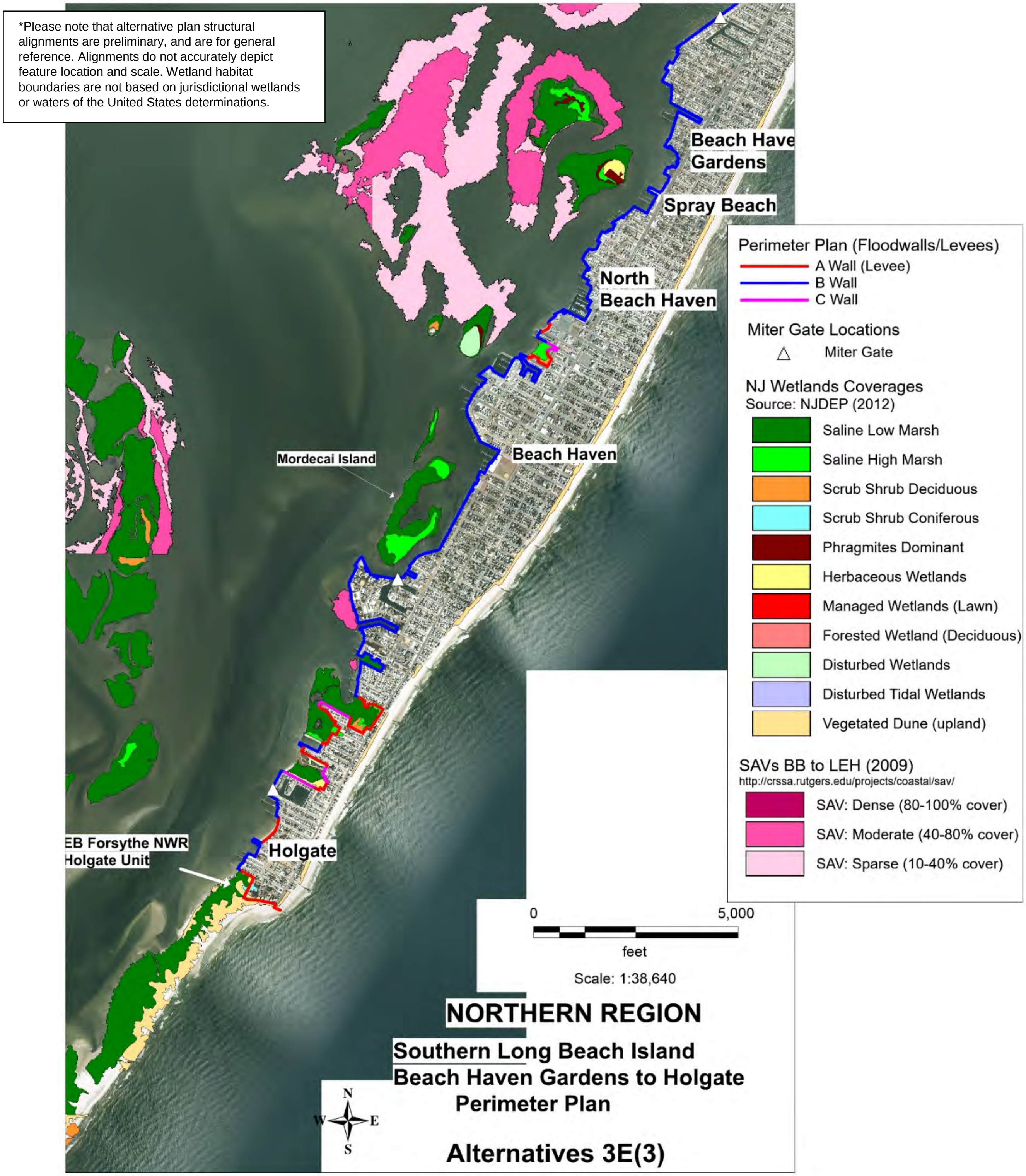


Figure 33: Perimeter Plan Overlay with Wetland Habitats along Southern Long Beach Island (south) Alignment in Alternative 3E(3)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

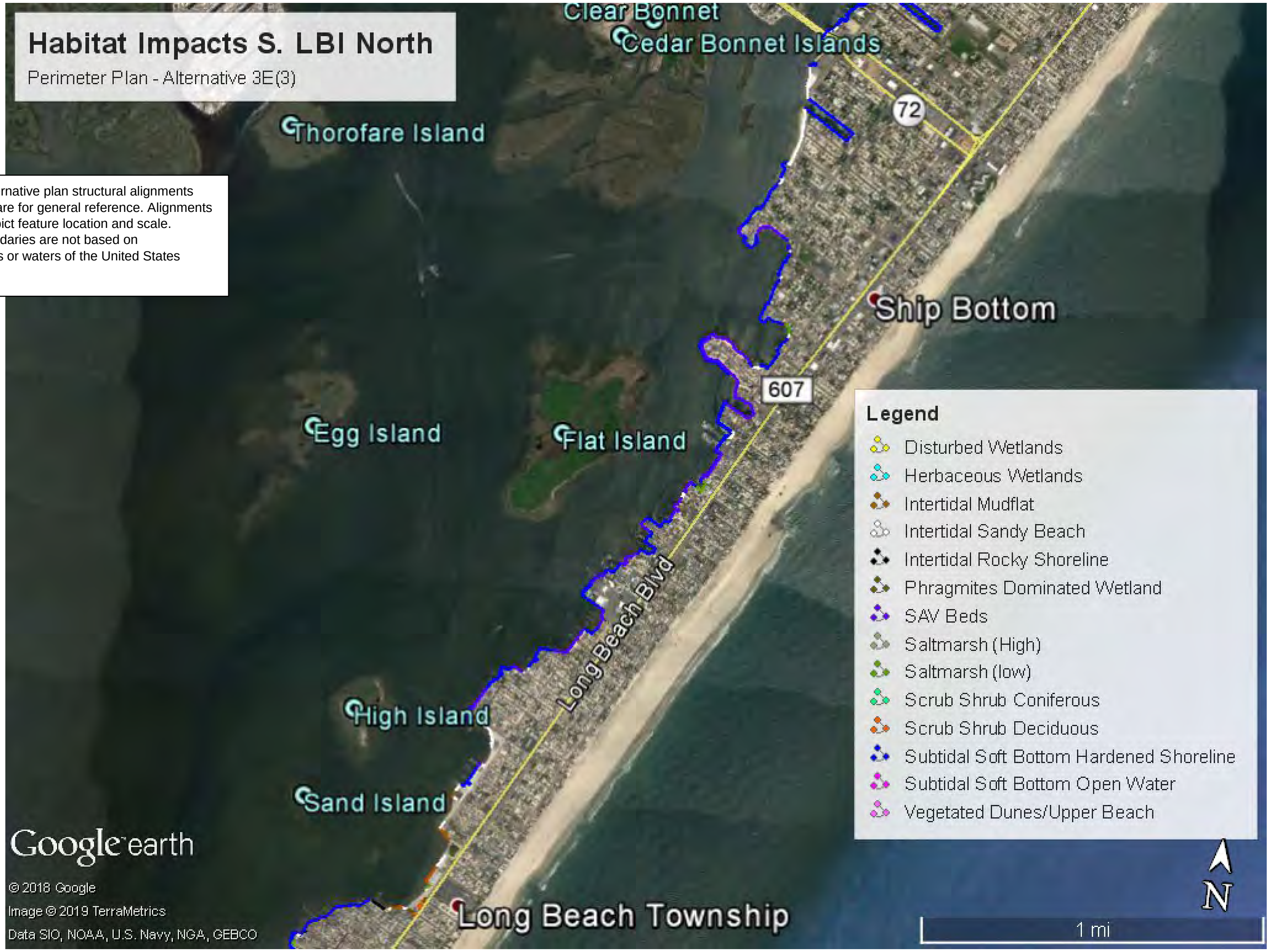


Figure 34: Habitat Impacts along Southern Long Beach Island (north) Perimeter Plan Alignment in Alternative 3E(3)

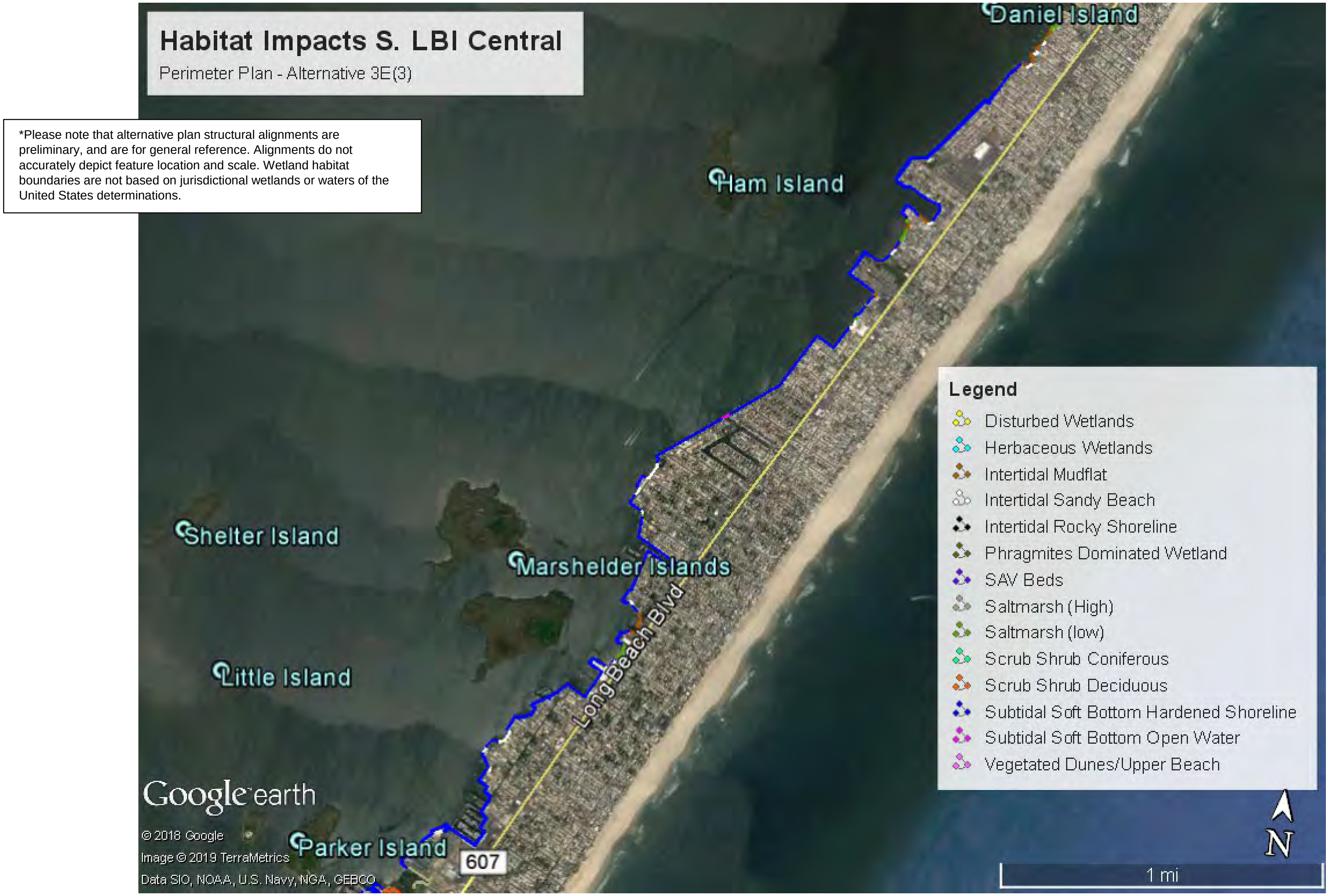


Figure 35: Habitat Impacts along Southern Long Beach Island (central) Perimeter Plan Alignment in Alternative 3E(3)

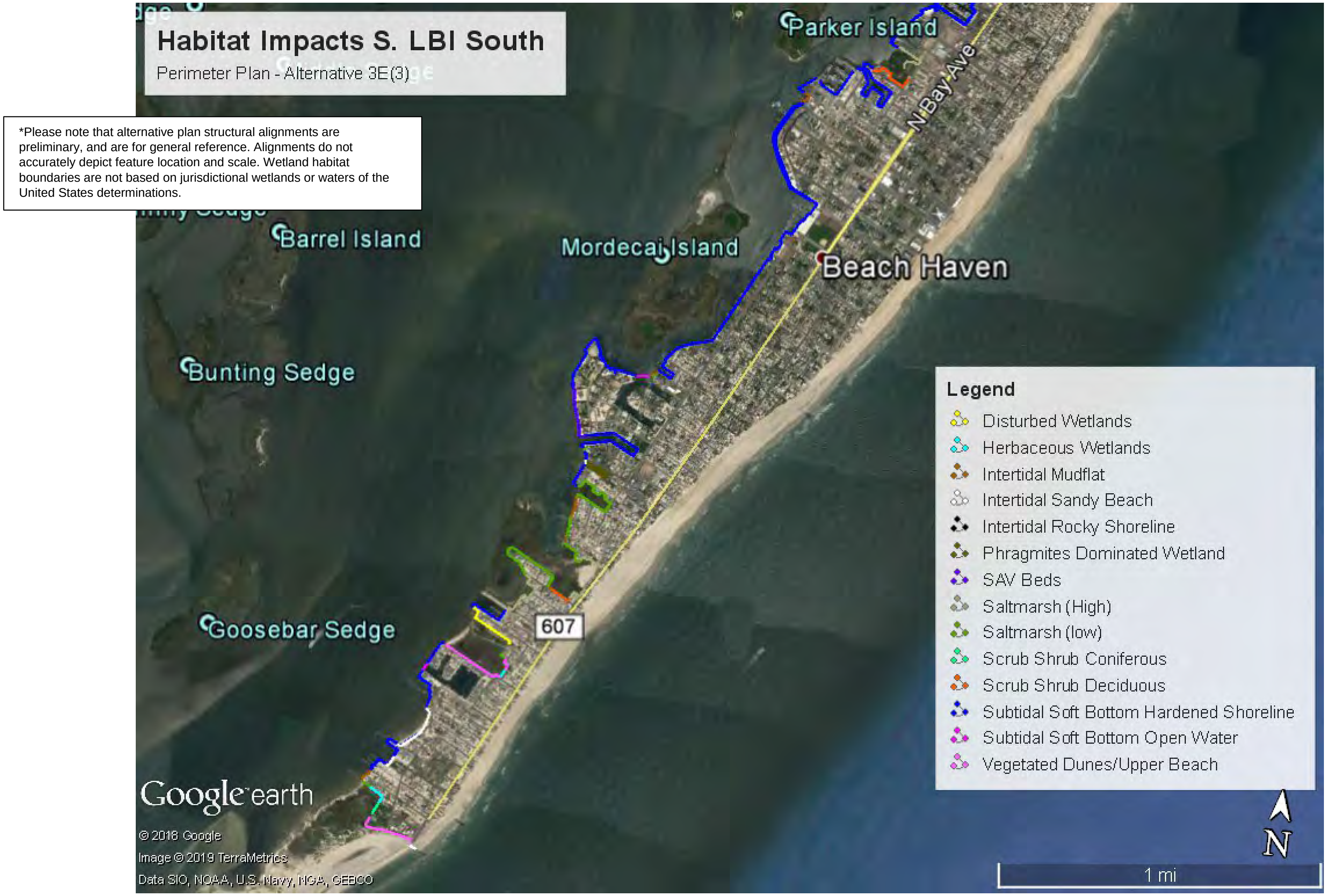


Figure 36: Habitat Impacts along Southern Long Beach Island (south) Perimeter Plan Alignment in Alternative 3E(3)

HABITAT IMPACTS OF STRUCTURAL COMPONENTS OF THE FOCUSED ARRAY OF ALTERNATIVES

CENTRAL REGION

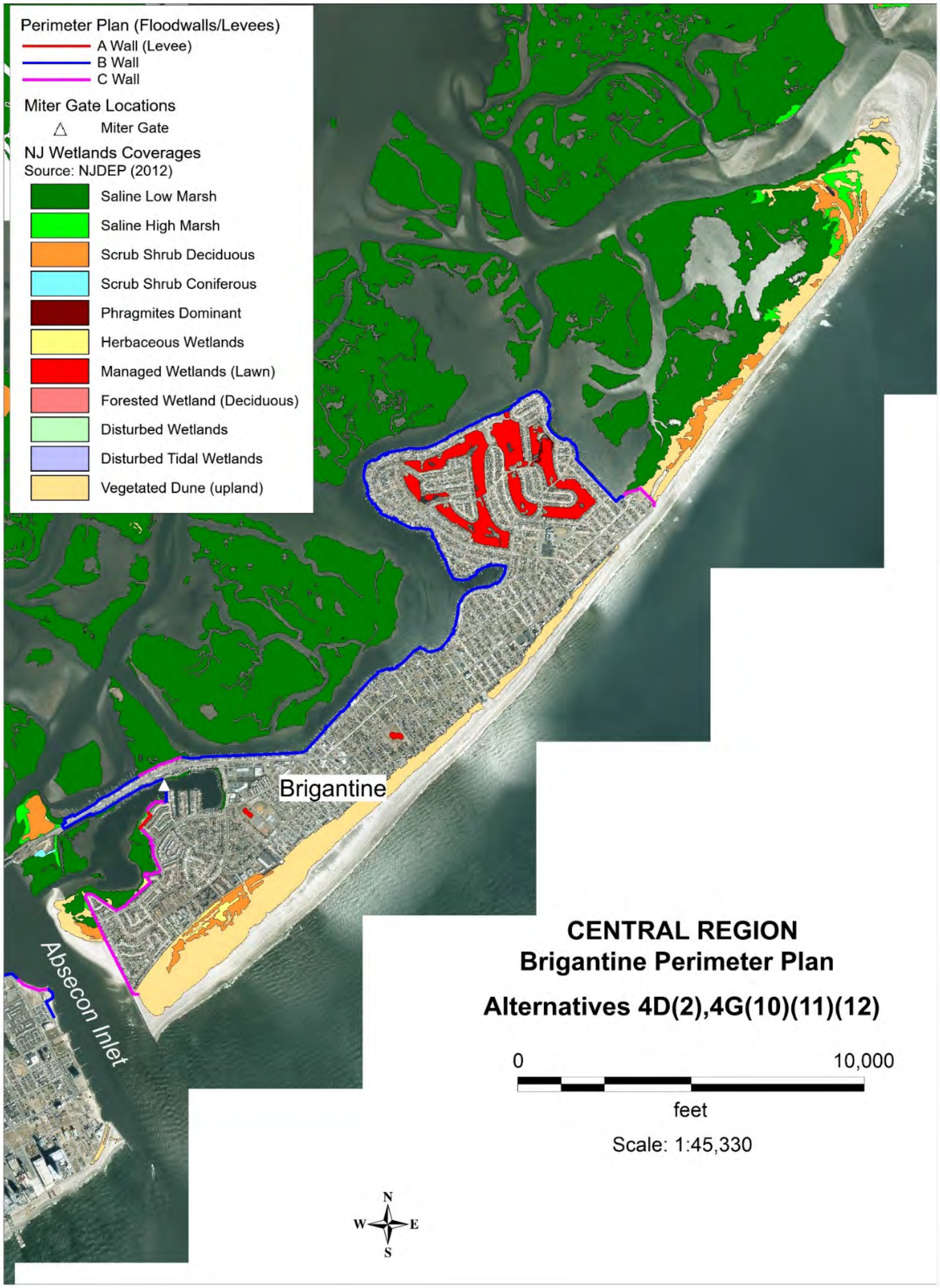


Figure 37: Perimeter Plan Overlay with Wetland Habitats along Brigantine Alignment in Alternatives 4D(2), 4G(10), 4G(11), and 4G(12)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

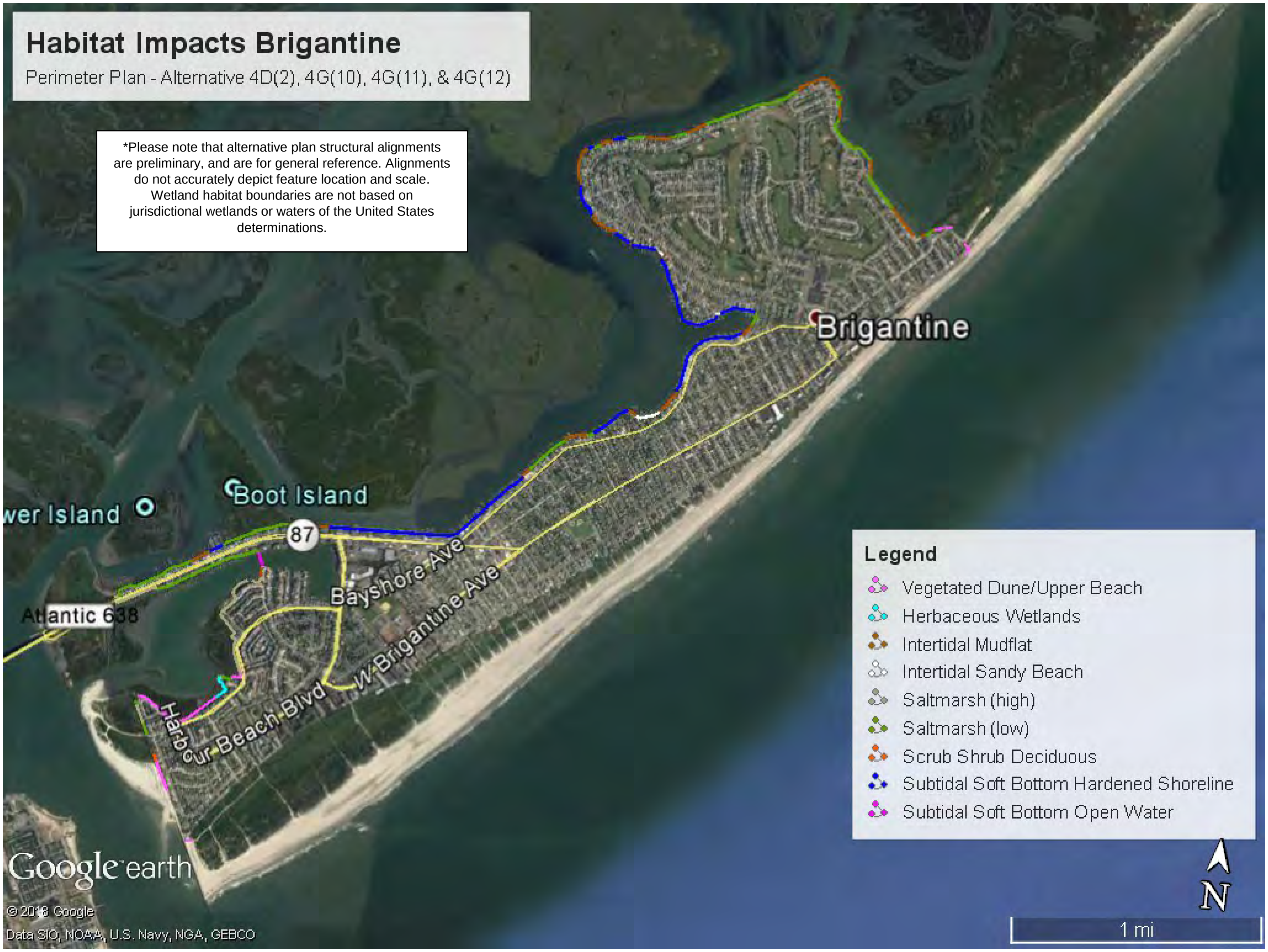


Figure 38: Habitat Impacts along Brigantine Perimeter Plan Alignment in Alternatives 4D(2), 4G(10), 4G(11), and 4G(12)

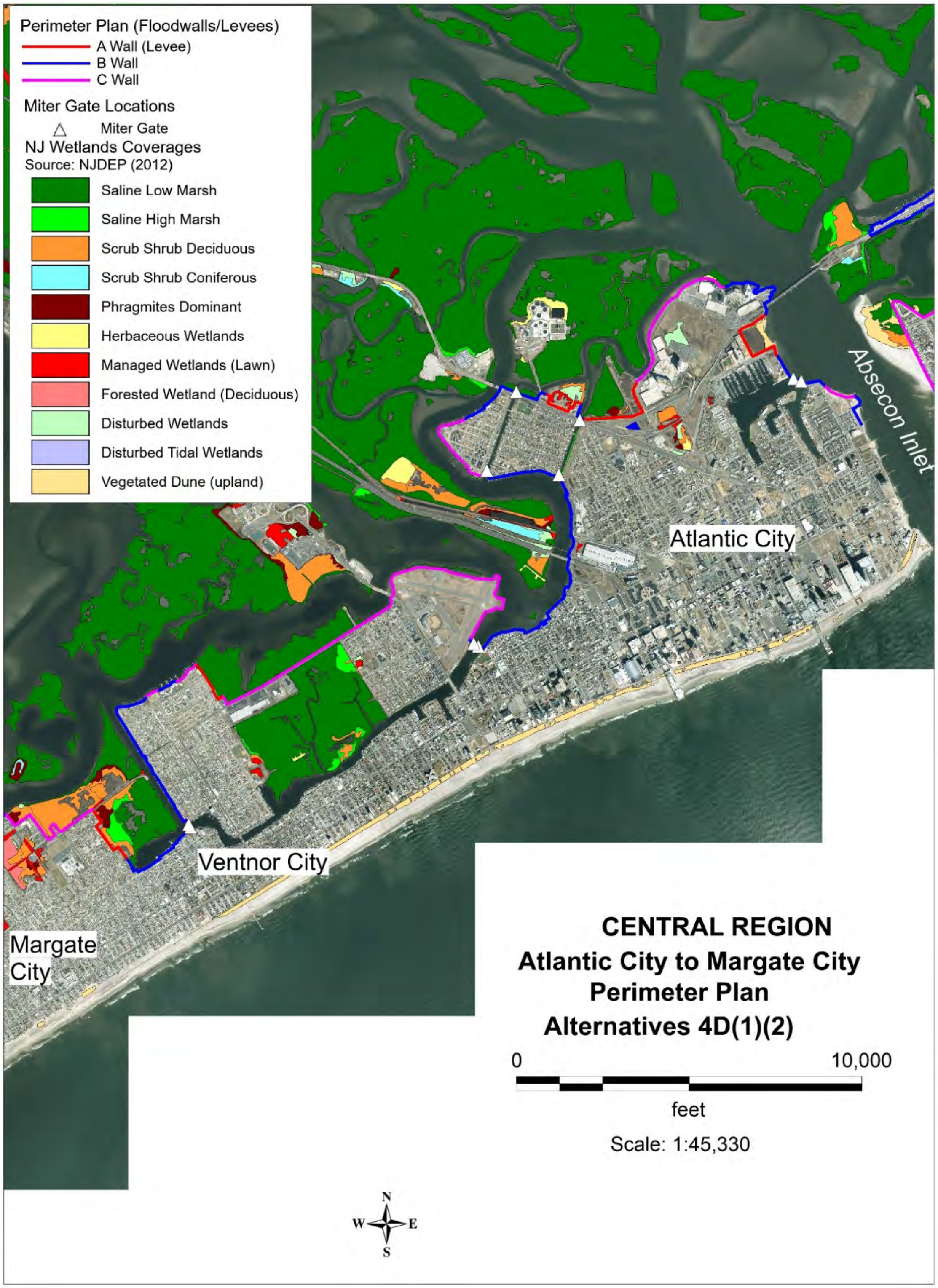


Figure 39: Perimeter Plan Overlay with Wetland Habitats along Atlantic City to Margate City Alignment in Alternatives 4D(1) & (2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

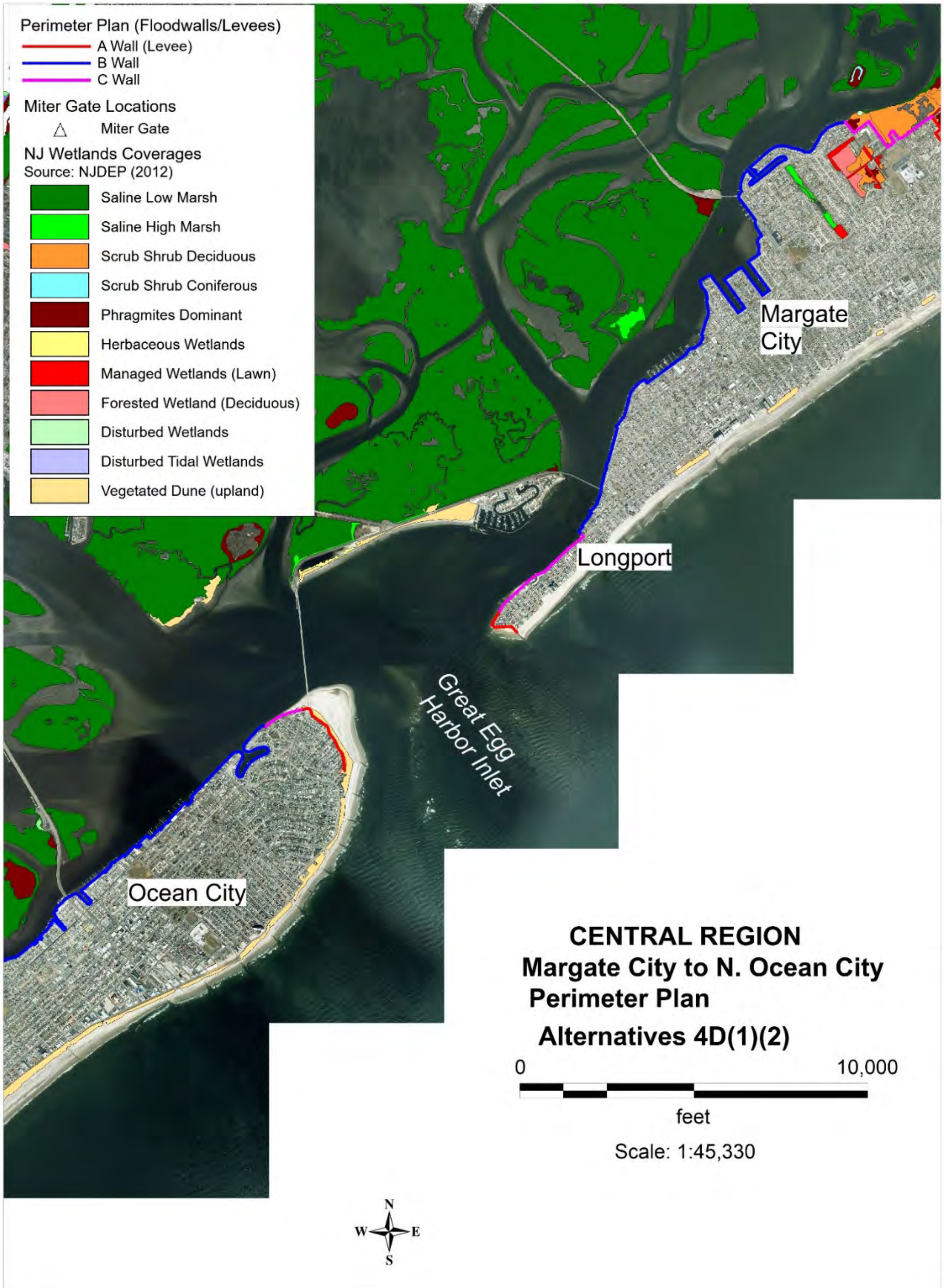


Figure 40: Perimeter Plan Overlay with Wetland Habitats along Margate City to N. Ocean City Alignment in Alternatives 4D(1) & (2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

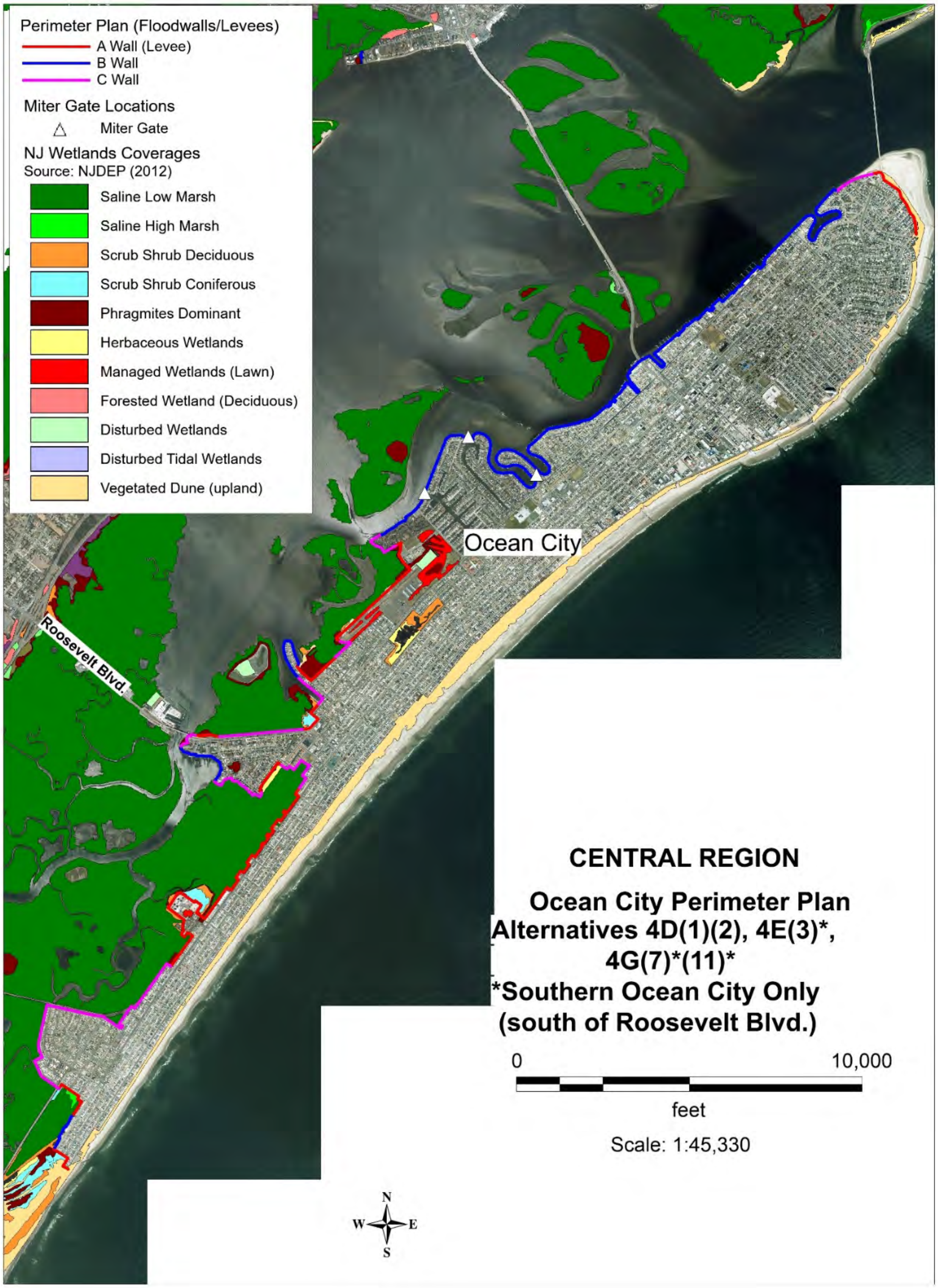
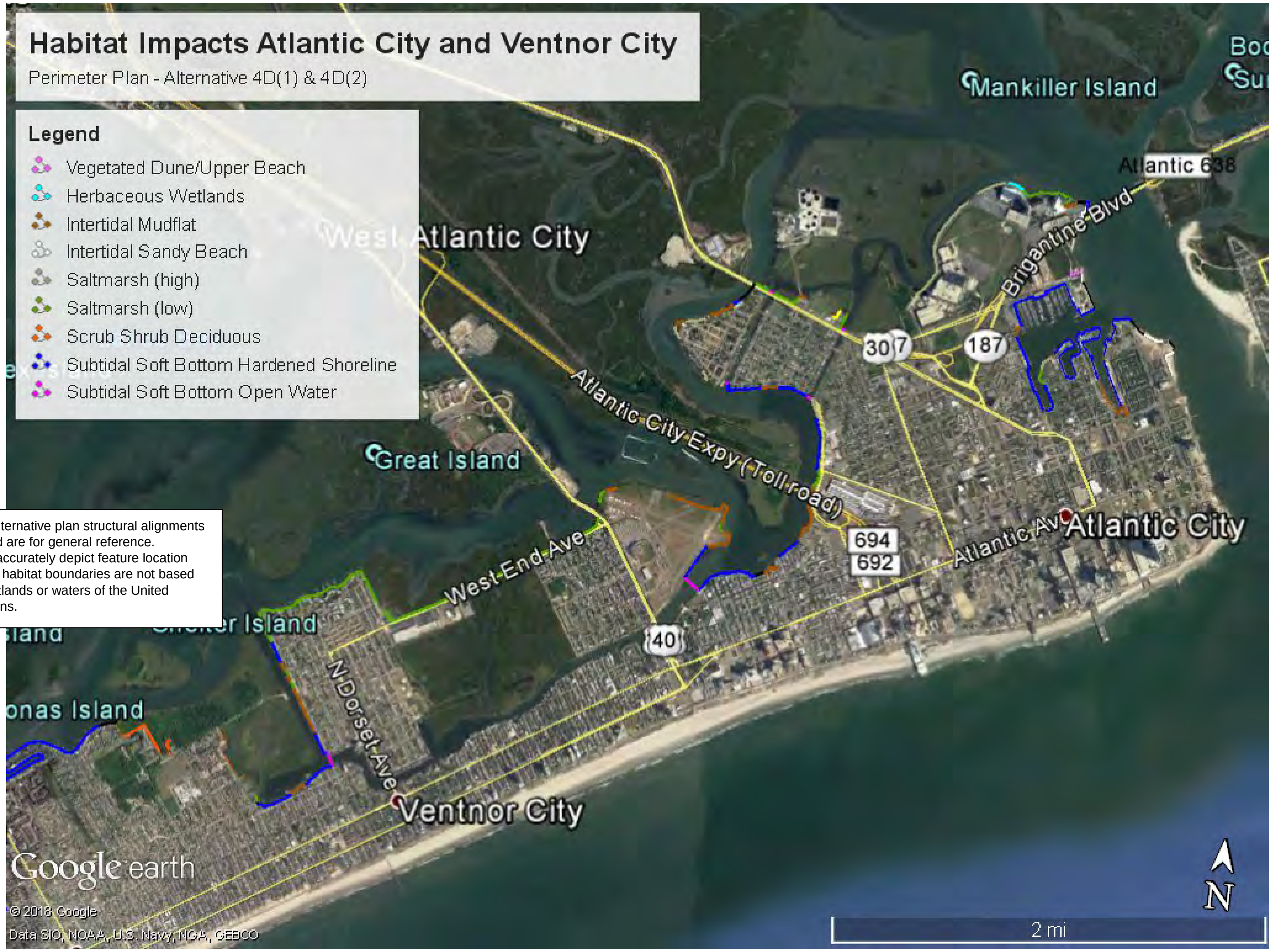


Figure 41: Perimeter Plan Overlay with Wetland Habitats along Ocean City Alignment in Alternatives

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.



*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

Figure 42: Habitat Impacts along Brigantine Perimeter Plan Alignment in Alternatives 4D(1) and 4D(2)

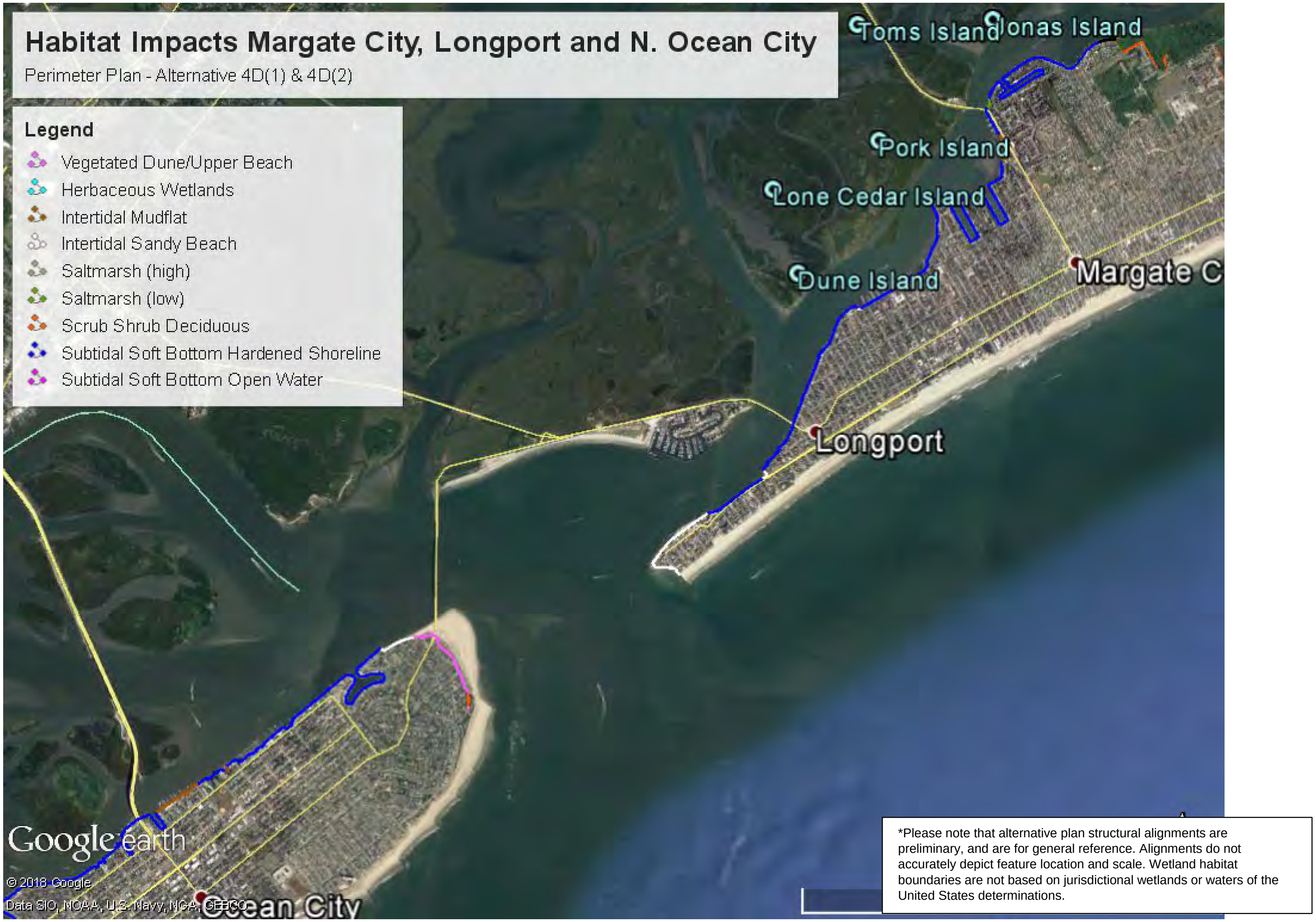


Figure 43: Habitat Impacts along Margate City, Longport, and N. Ocean City Perimeter Plan Alignment in Alternatives 4D(1) and 4D(2)

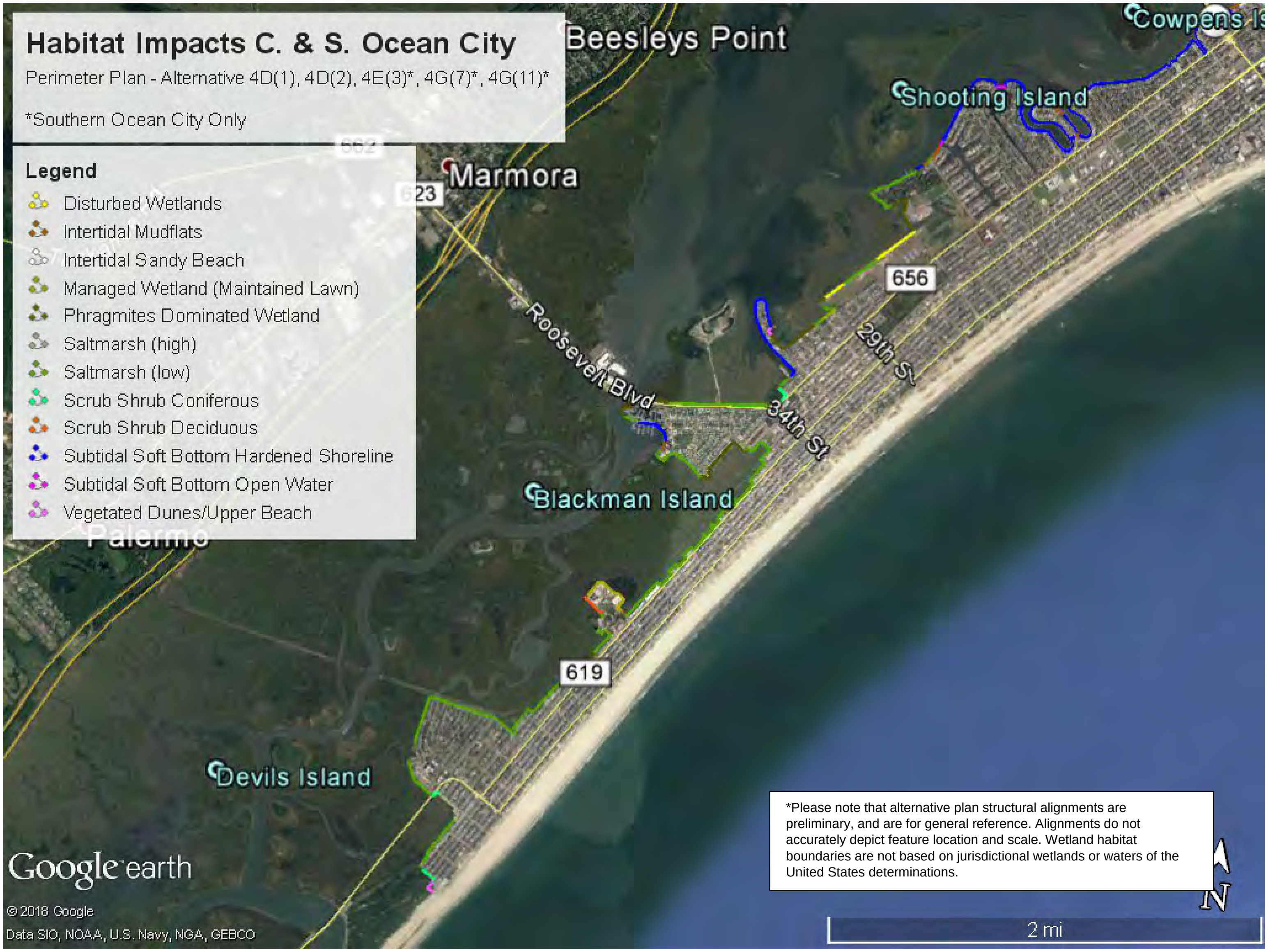


Figure 44: Habitat Impacts along Central and Southern Ocean City Perimeter Plan Alignment in Alternatives 4D(1) and 4D(2). Alternatives 4E(3), 4G(7) and 4G(11) have perimeter plan only south of 34th Street

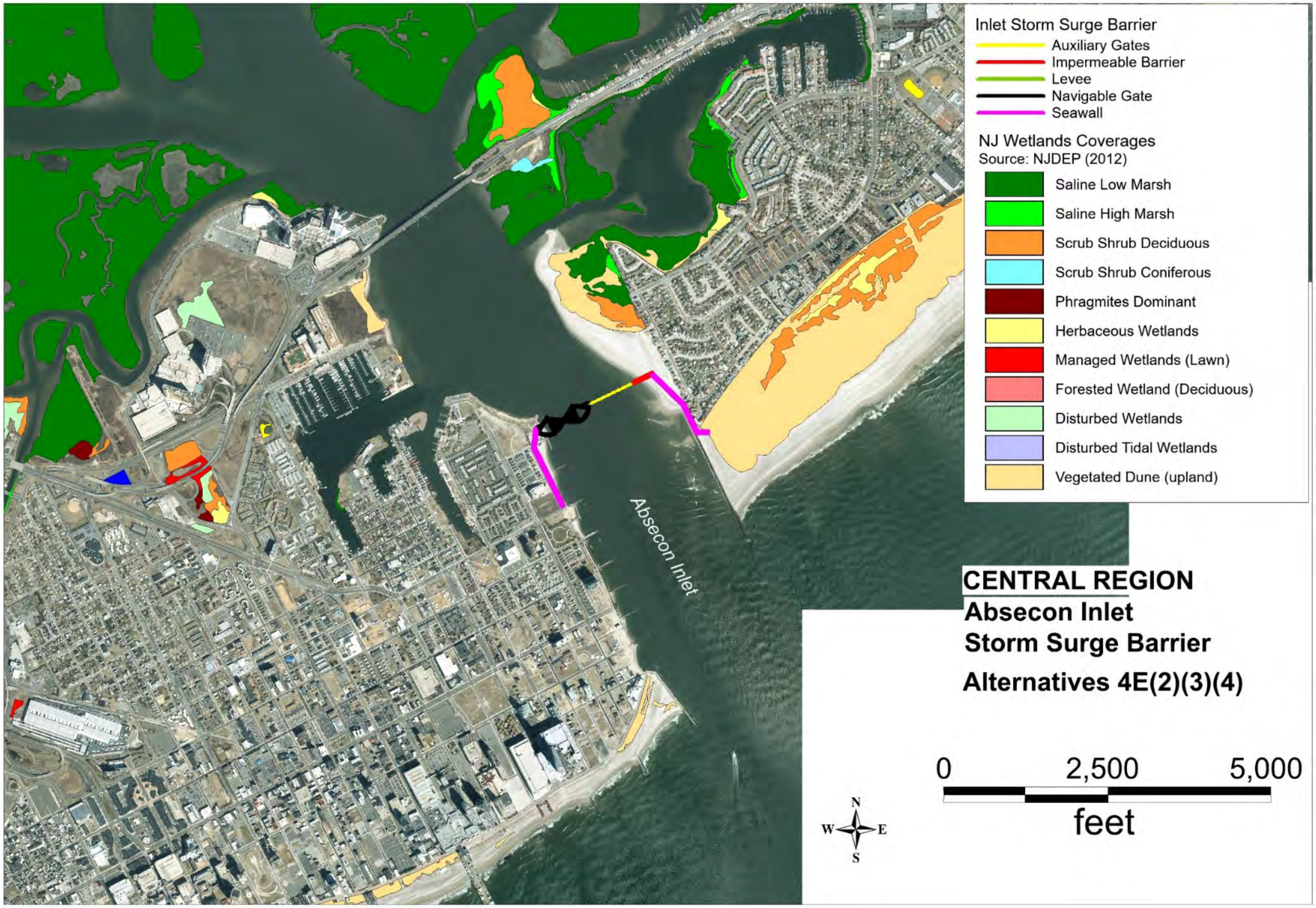


Figure 45: Storm Surge Barrier Overlay with Wetland Habitats in Absecon Inlet in Alternatives 4E(2)(3) & (4)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

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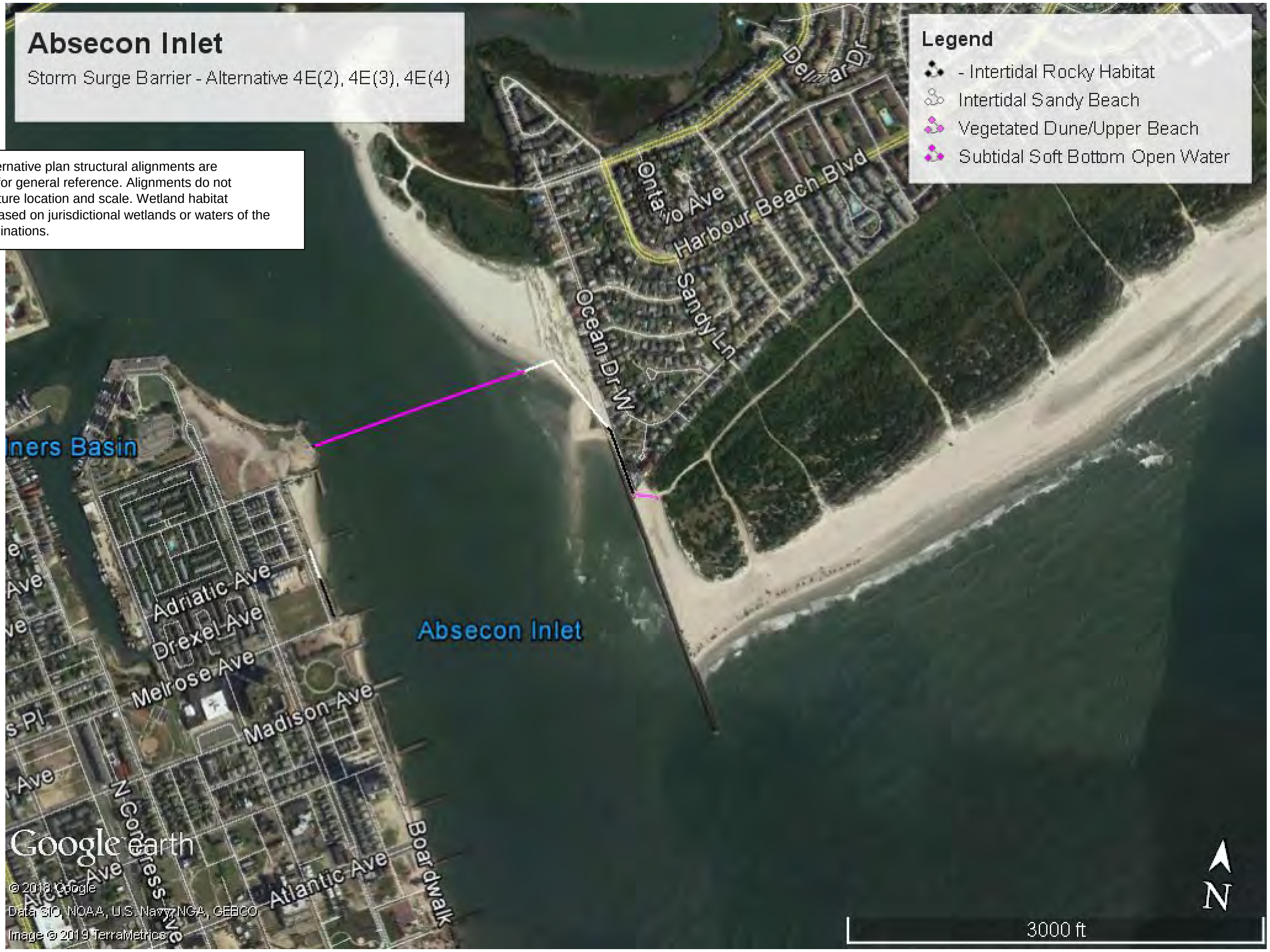

Figure 46: Habitat Impacts along Absecon Inlet Storm Surge Barrier Plan Alignment in Alternatives 4E(2), 4E(3) and 4E(4)

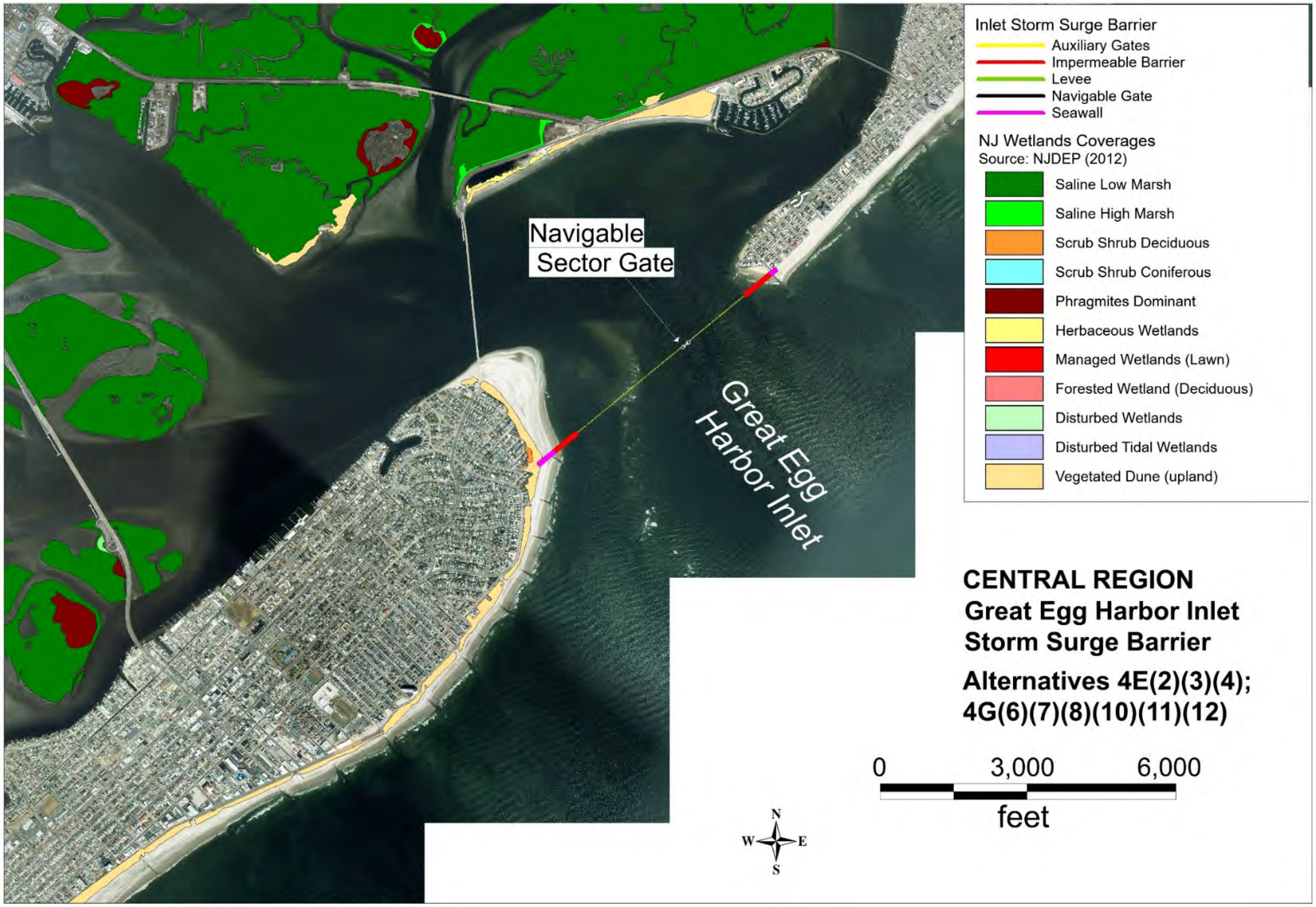

Figure 47: Storm Surge Barrier Overlay with Wetland Habitats in Great Egg Harbor Inlet in Alternatives 4E(2)(3)(4), 4G(6)(7)(8)(10)(11) & (12)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

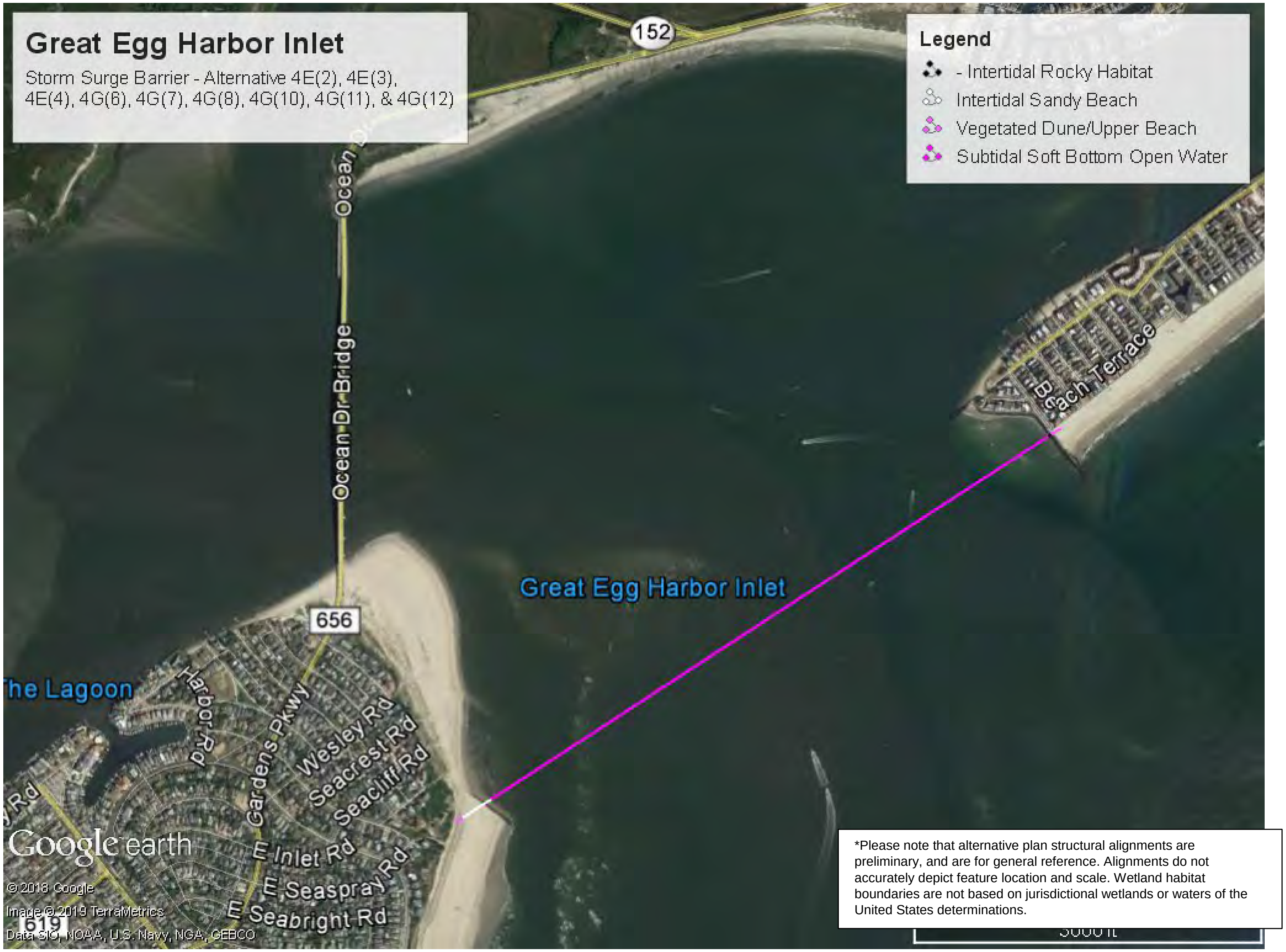

Figure 48: Habitat Impacts along Great Egg Harbor Inlet Storm Surge Barrier Plan Alignment in Alternatives 4E(2), 4E(3), 4E(4), 4G(6), 4G(7), 4G(8), 4G(10), 4G(11), and 4G(12)

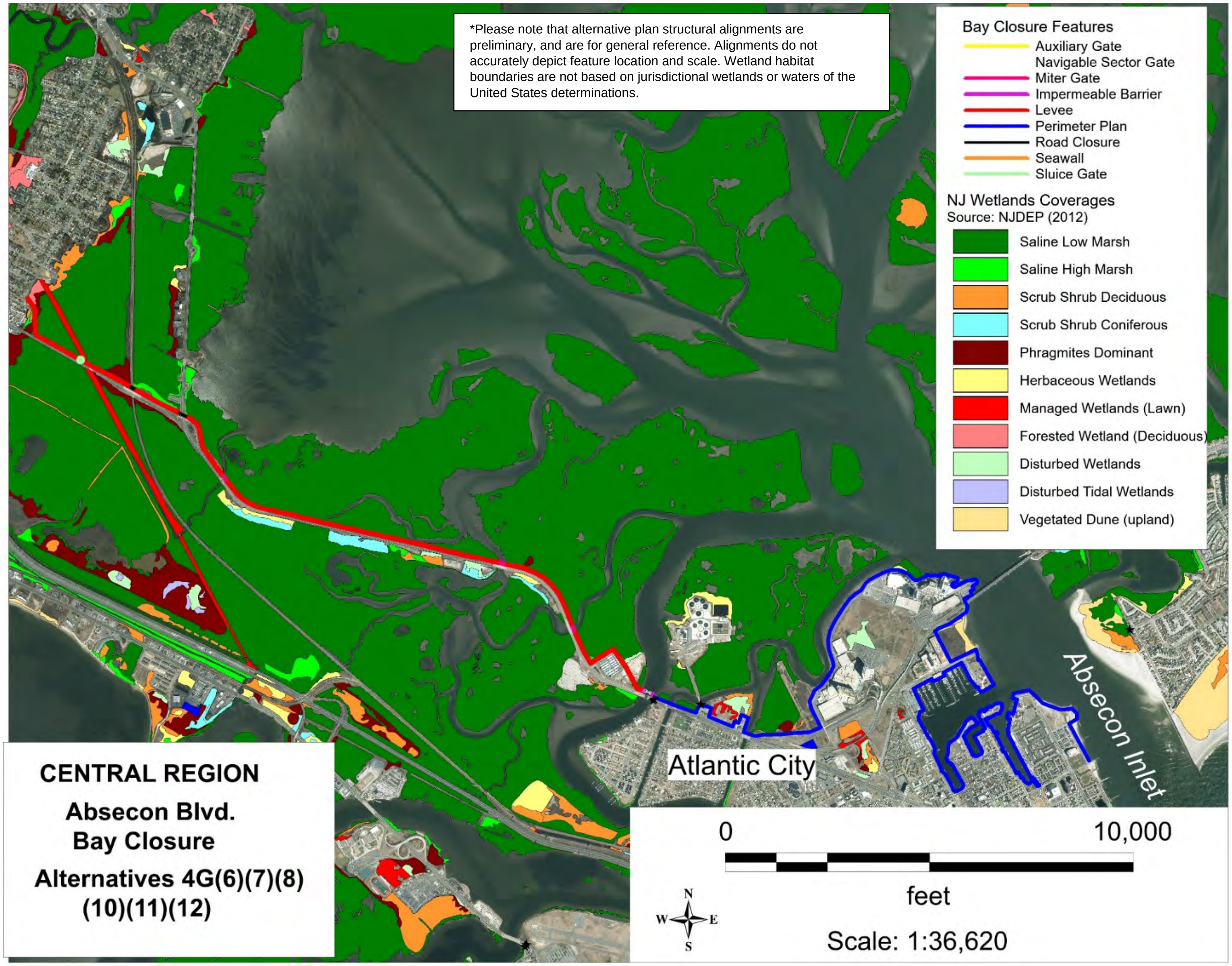

Figure 49: Bay Closure Overlay with Wetland Habitats Absecon Blvd. in Alternatives 4G(6)(7)(8)(10)(11) & (12)

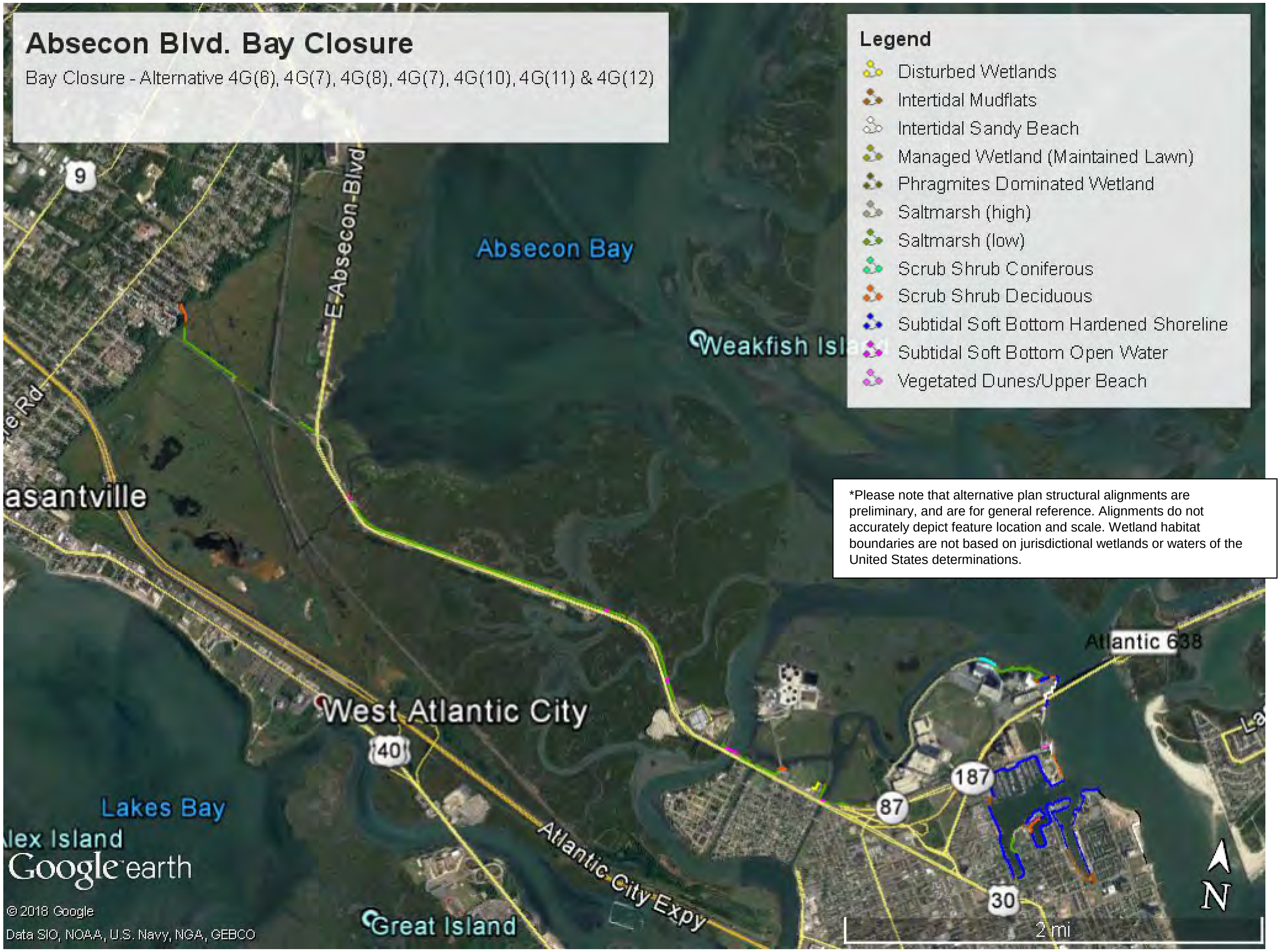

Figure 50: Habitat Impacts along Absecon Blvd. Bay Closure Plan Alignment in Alternatives 4G(6), 4G(7), 4G(8), 4G(10), 4G(11), and 4G(12)

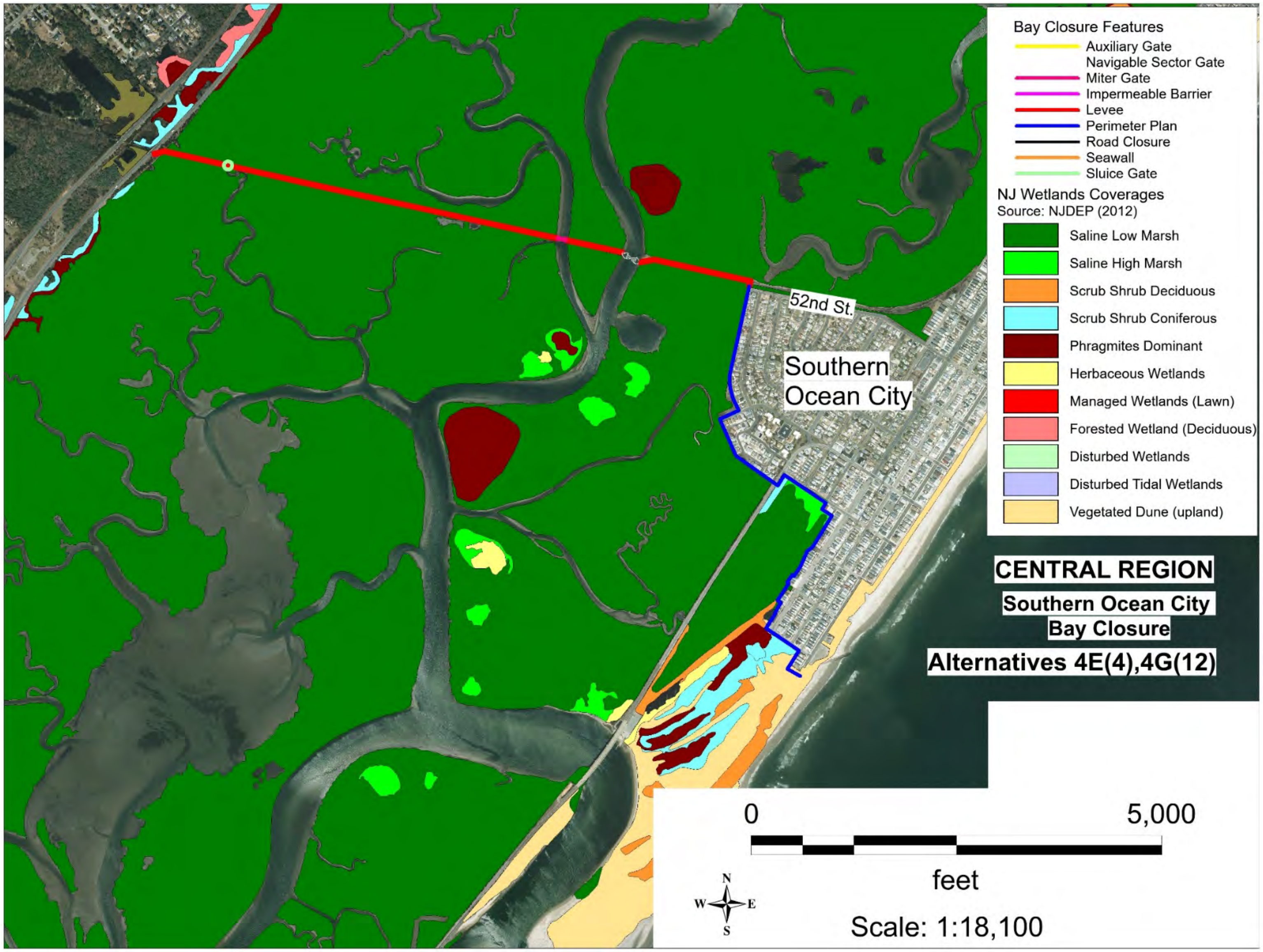

Figure 51: Bay Closure Overlay with Wetland Habitats along Southern Ocean City (52nd St.) in Alternatives 4E(4) & 4G(12)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

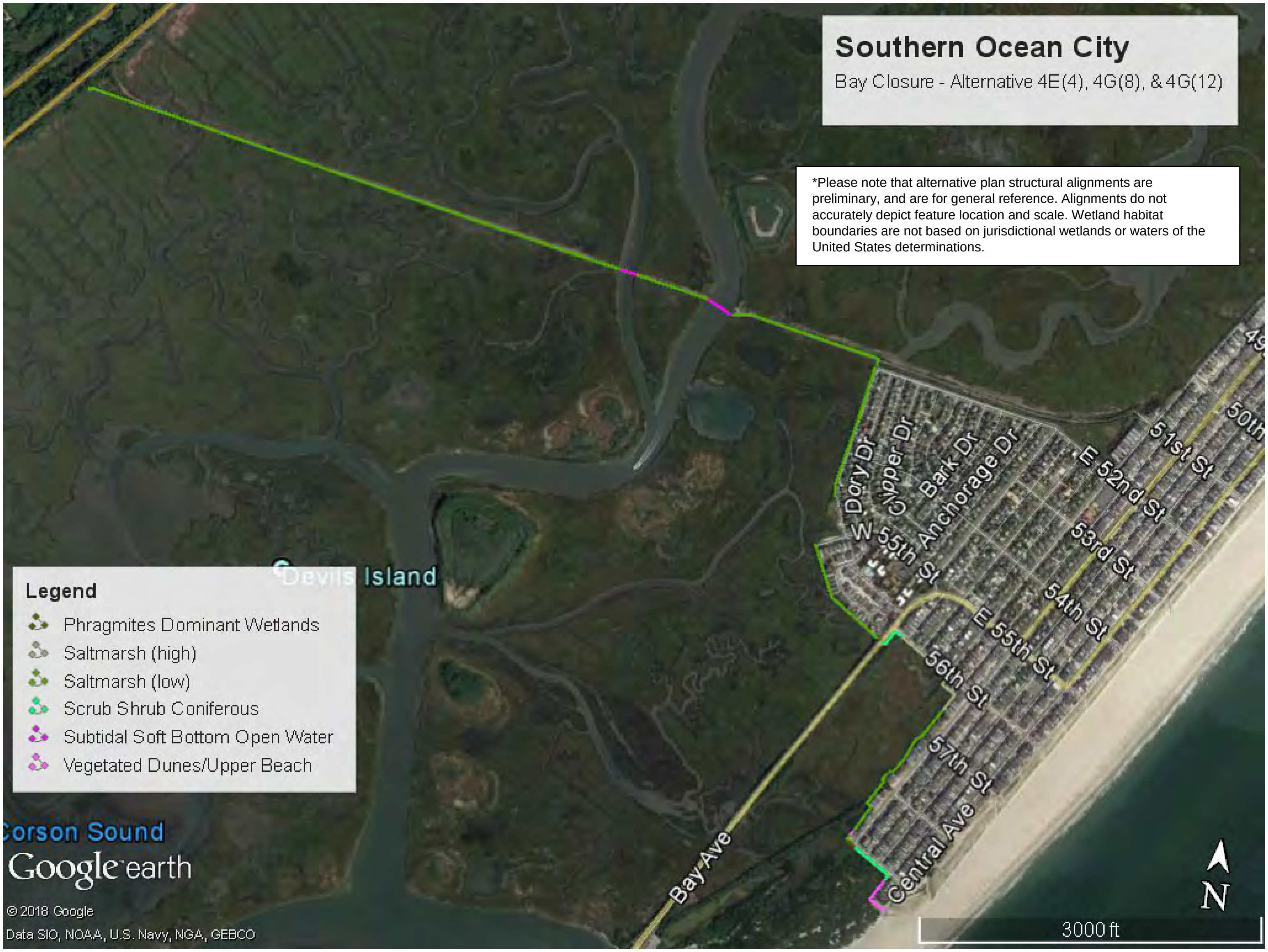

Figure 52: Habitat Impacts along Southern Ocean City (52nd St.) in Alternatives 4E(4) & 4G(12)

HABITAT IMPACTS OF STRUCTURAL COMPONENTS OF THE FOCUSED ARRAY OF ALTERNATIVES

SOUTHERN REGION

Figure 53: Perimeter Plan Overlay with Wetland Habitats along Sea Isle City Alignment in Alternatives 5D(1) & (2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

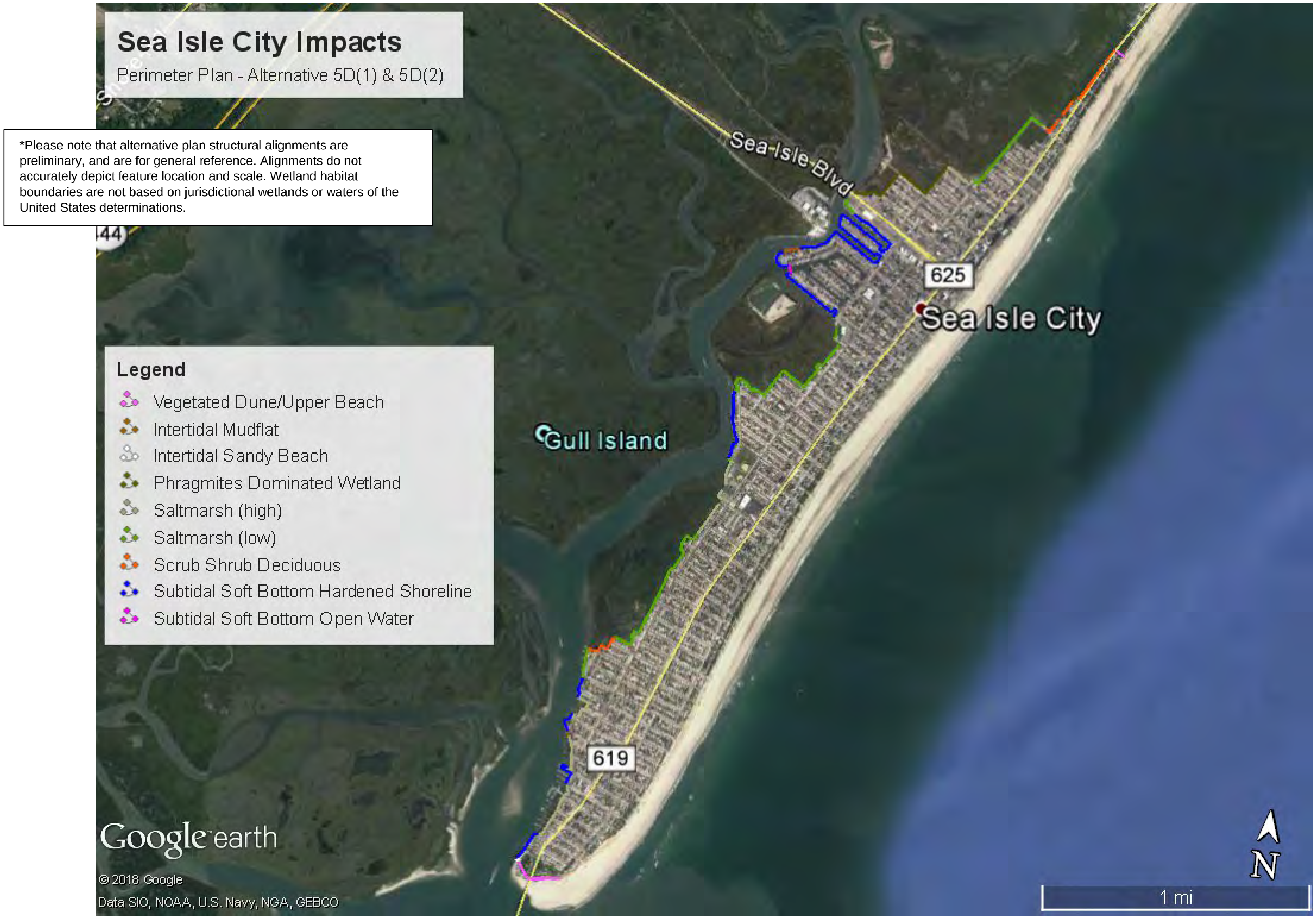

Figure 54: Habitat Impacts along Sea Isle City Perimeter Plan Alignment in Alternatives 5D(1) and 5D(2)

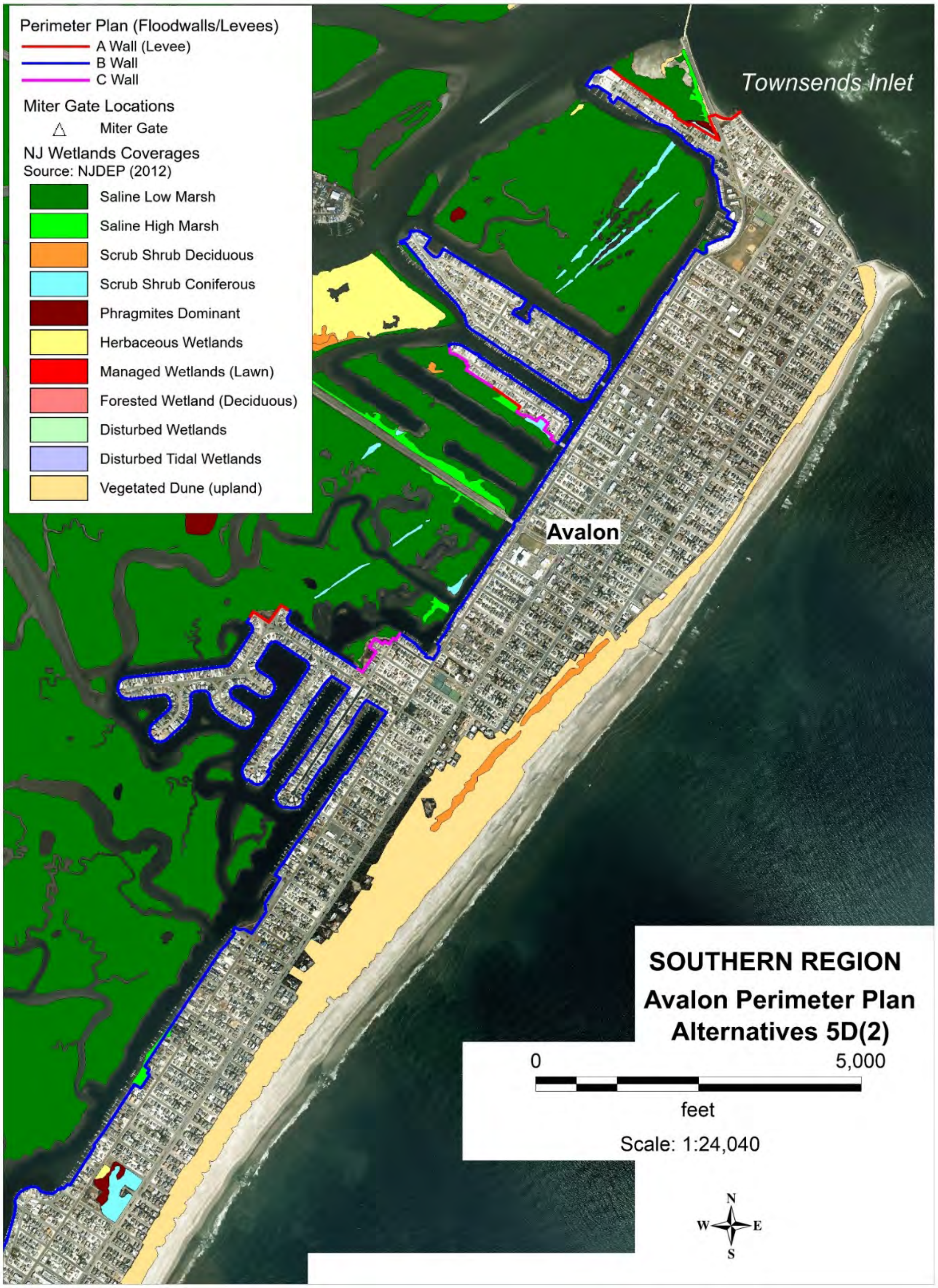

Figure 55: Perimeter Plan Overlay with Wetland Habitats along Avalon Alignment in Alternatives 5D(2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

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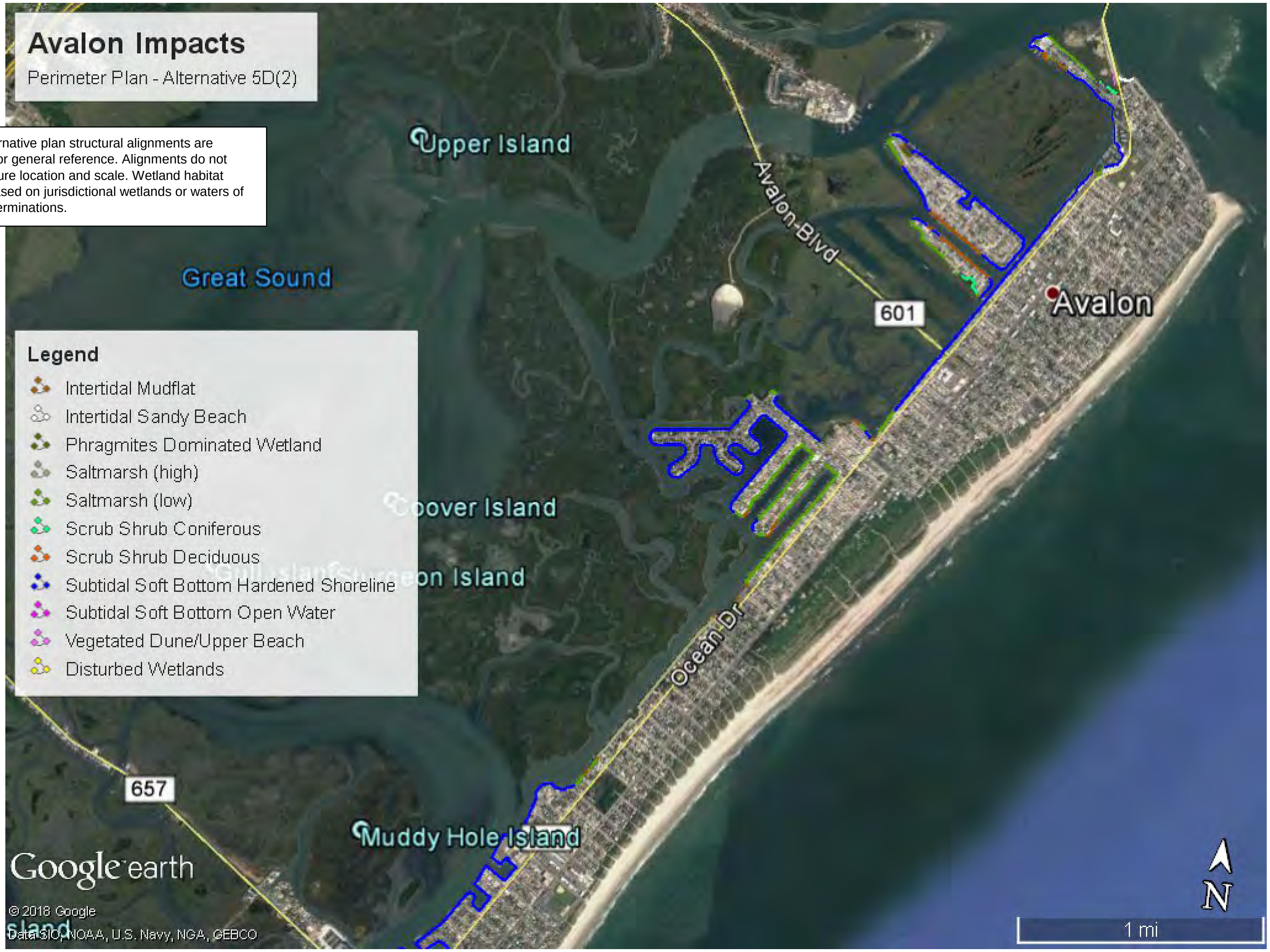


Figure 56: Habitat Impacts along Avalon Perimeter Plan Alignment in Alternatives 5D(2)

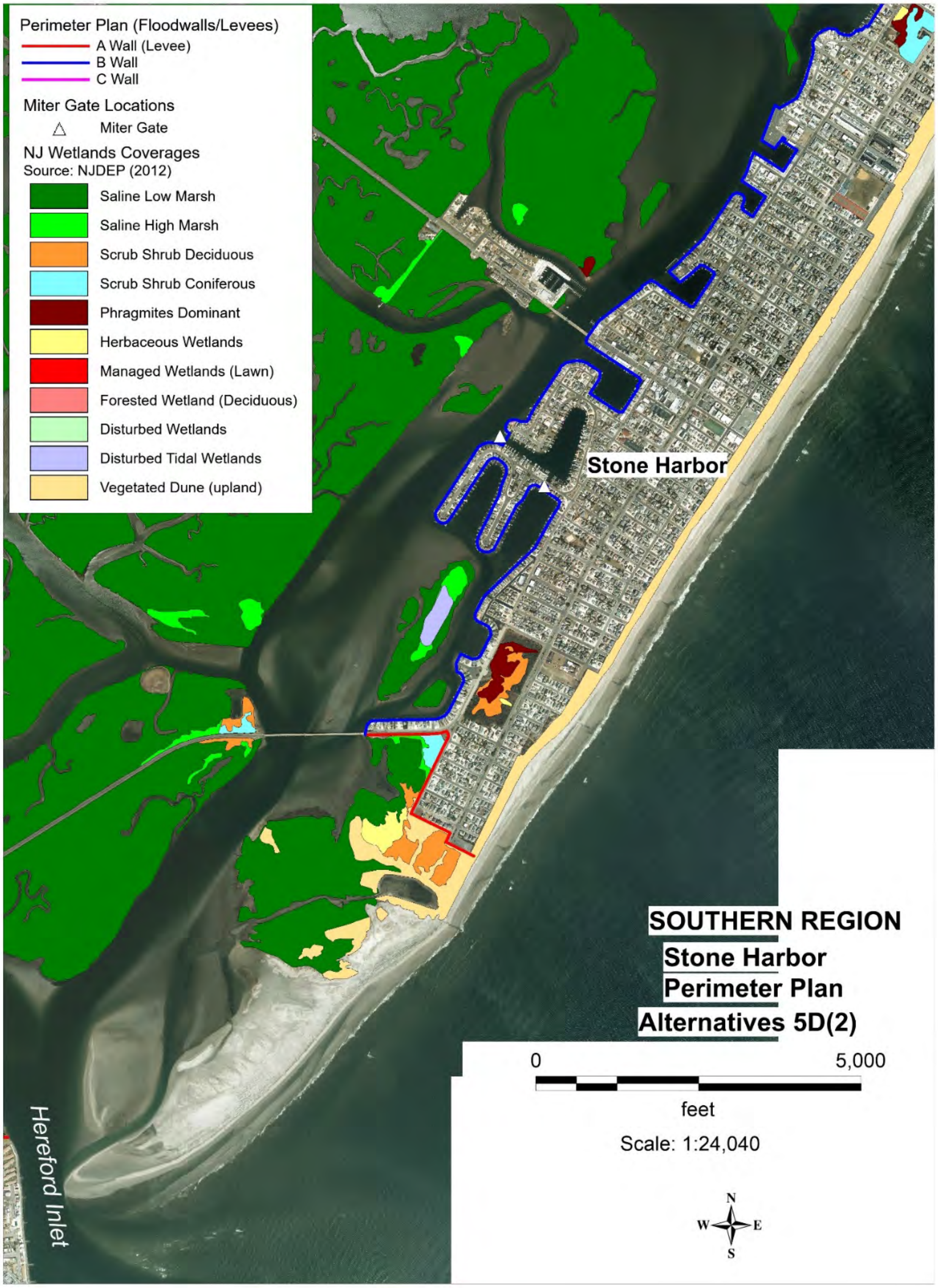


Figure 57: Perimeter Plan Overlay with Wetland Habitats along Stone Harbor Alignment in Alternatives 5D(2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

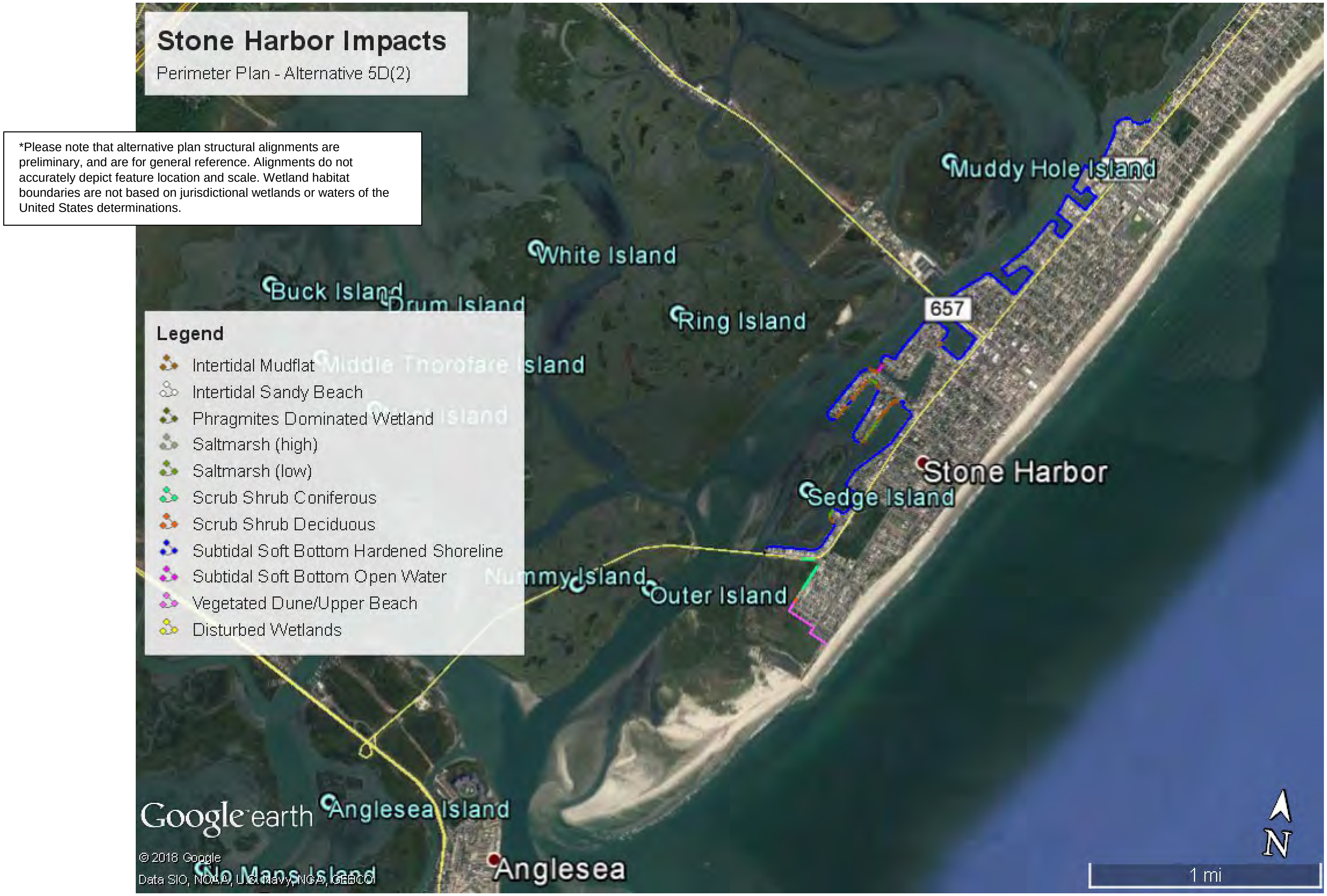


Figure 58: Habitat Impacts along Stone Harbor Perimeter Plan Alignment in Alternatives 5D(2)

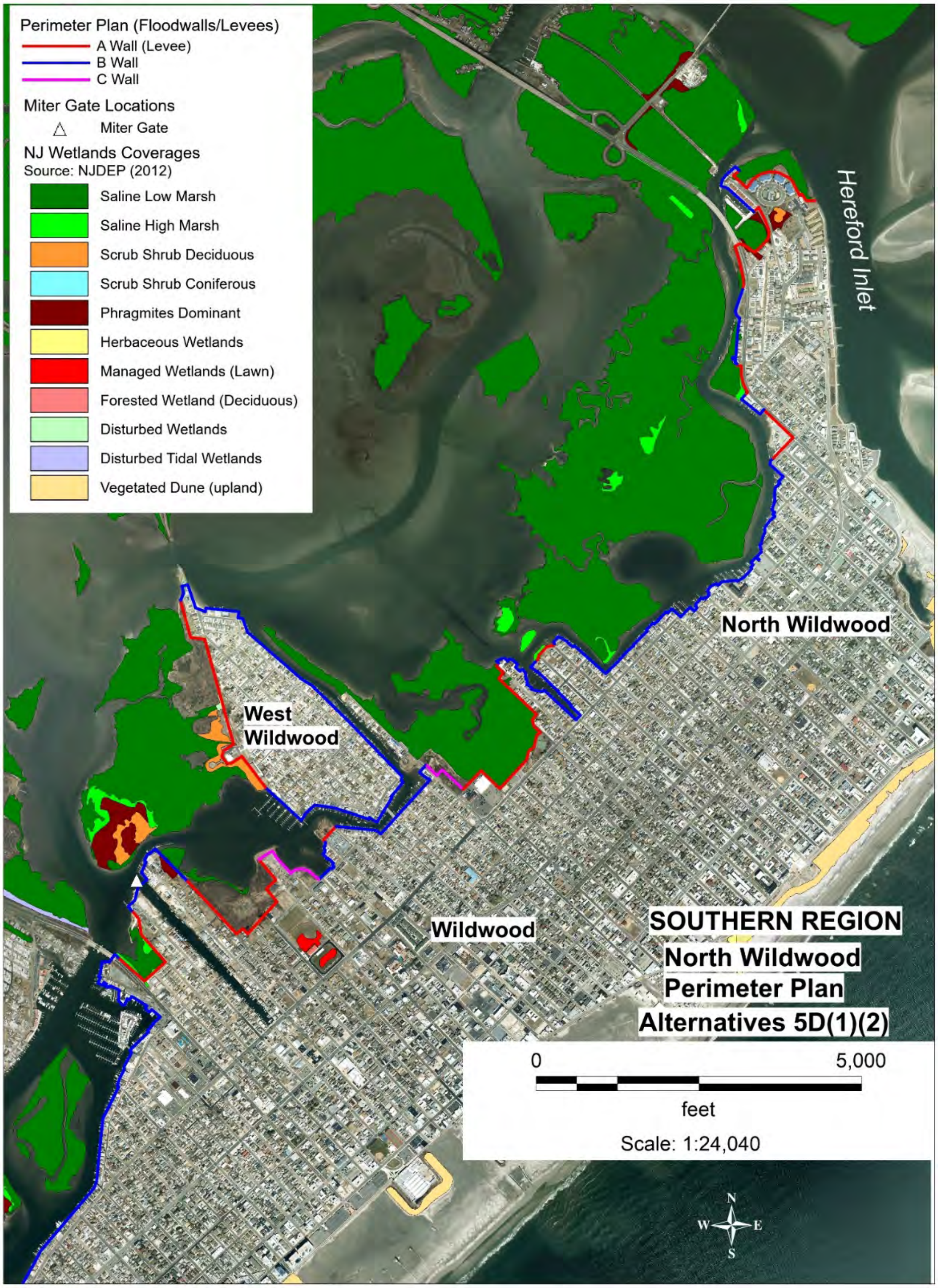
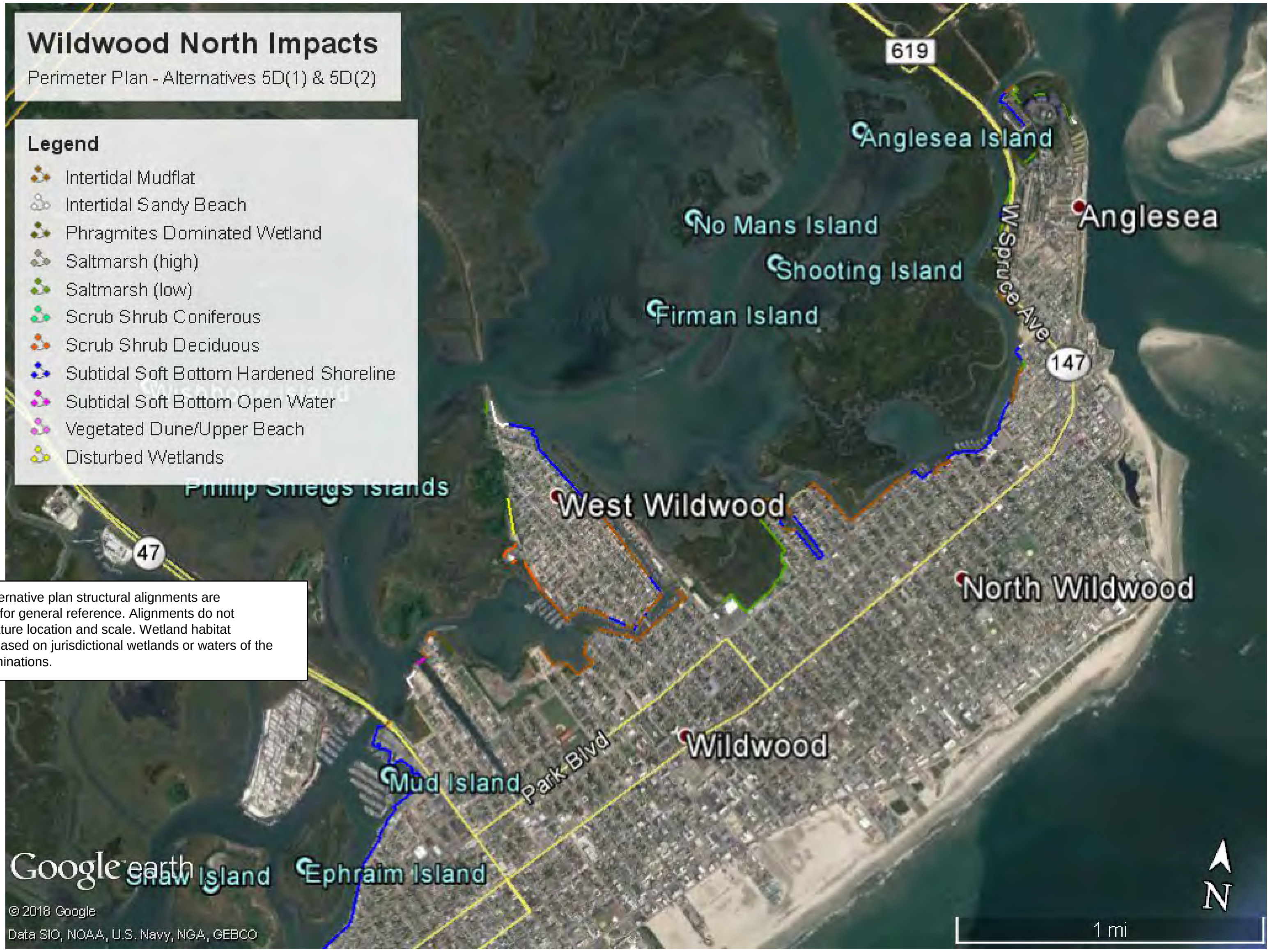


Figure 59: Perimeter Plan Overlay with Wetland Habitats along Wildwood (north) Alignment in Alternatives 5D(1)(2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

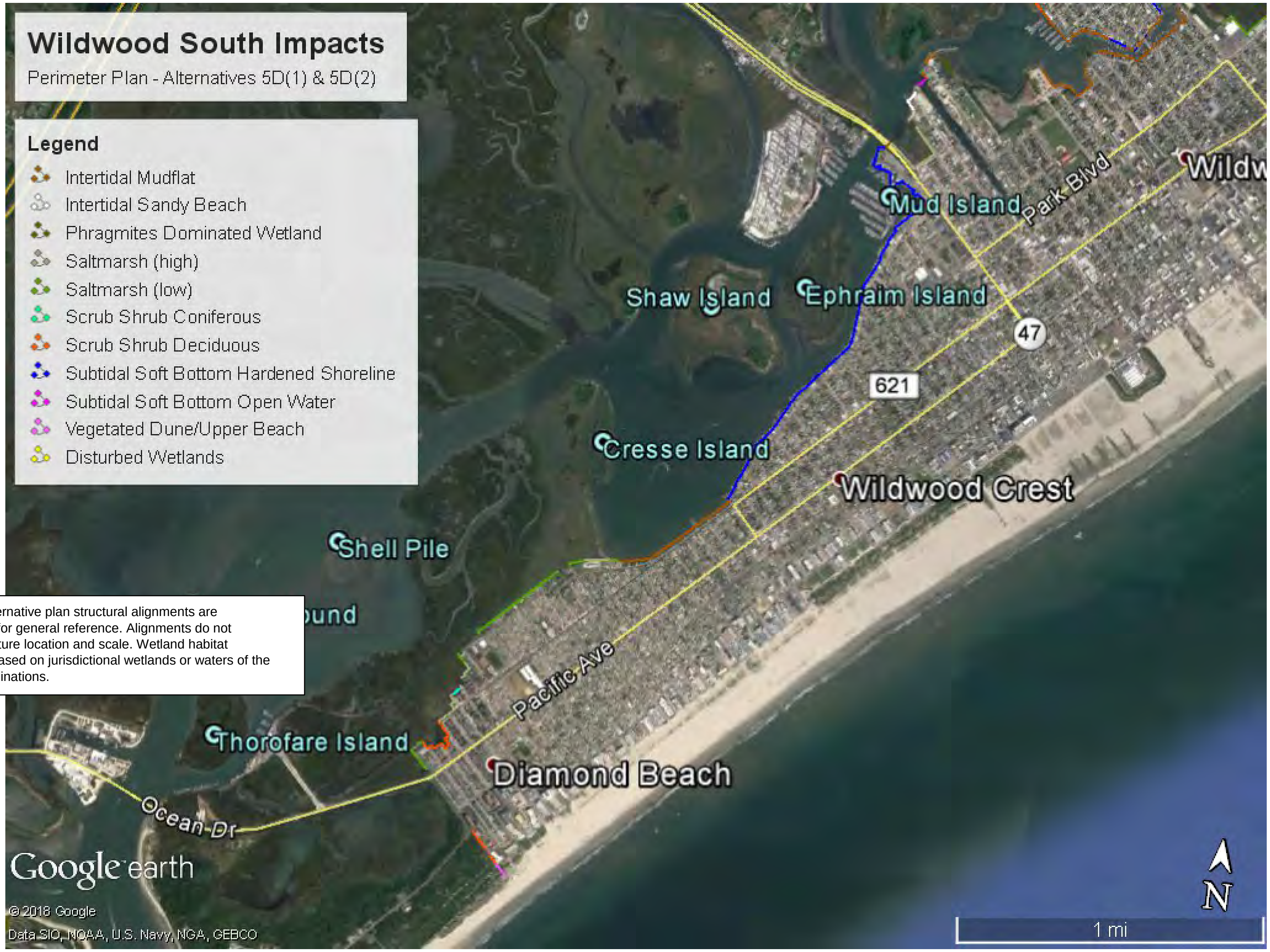
Figure 60: Perimeter Plan Overlay with Wetland Habitats along Wildwood (south) Alignment in Alternatives 5D(1)(2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.



*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

Figure 61: Habitat Impacts along N. Wildwood Perimeter Plan Alignment in Alternatives 5D(1) and 5D(2)



*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

Figure 62: Habitat Impacts along S. Wildwood Perimeter Plan Alignment in Alternatives 5D(1) and 5D(2)

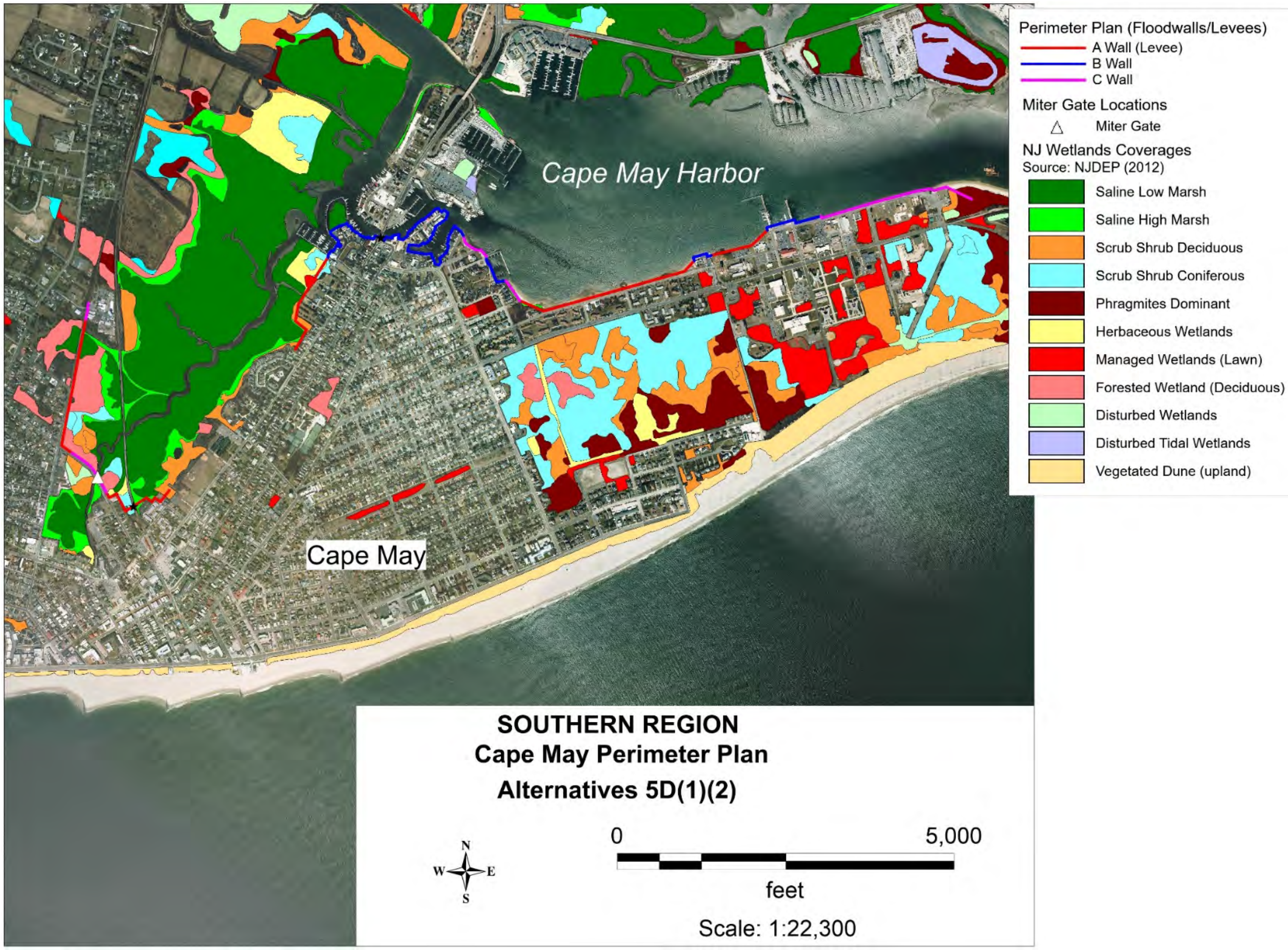


Figure 63: Perimeter Plan Overlay with Wetland Habitats Along Cape May Alignment in Alternatives 5D(1) & (2)

*Please note that alternative plan structural alignments are preliminary, and are for general reference. Alignments do not accurately depict feature location and scale. Wetland habitat boundaries are not based on jurisdictional wetlands or waters of the United States determinations.

Figure 64: Habitat Impacts along Cape May Perimeter Plan Alignment in Alternatives 5D(1) and 5D(2)