VILLAGE OF BALD HEAD ISLAND
SHORELINE PROTECTION PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

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Village of Bald Head Island Shoreline Protection Project
Environmental Impact Statement
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SECTION 1.0 – PROJECT PURPOSE

1.1 PURPOSE AND NEED STATEMENT

The purpose of the Village of Bald Head Island Shoreline Protection Project is to address on-going and chronic erosion at the western end of South Beach and to thereby protect public infrastructure, roads, homes, businesses and rental properties, golf course, beaches, recreational assets, and protective dunes.

The west end of South Beach experiences on-going and chronic erosion resulting in considerable sand loss and shoreline recession. Severe erosion has been chronicled along this section of shoreline since the 1970s (Dennison 1998). In 1992, an approximate 10,000-linear foot (lf) segment of the western end of South Beach received approximately 350,000 cubic yards (cy) of sand as part of an authorized Section 933 Project by the US Army Corps of Engineers (USACE). Within 18 months of the placement of this material, the entire beach fill (plus additional natural material) had reportedly eroded away (Dennison 1998). Under more recent detailed physical monitoring, Olsen Associates, Inc. (2011) reported that the Island's gross volumetric loss (excluding East Beach) over the November 2000 to May 2011 timeframe was approximately 4.363 Mcy (corresponding to an average annualized loss of 415,000 cy). The highest rates of sand loss have occurred principally at the extreme west end of South Beach in the vicinity of the Cape Fear River entrance. Similarly, physical monitoring data collected by the USACE identify the presence of an approximate 2,050- to 3,400-lf section of the western end of South Beach prone to accentuated rates of littoral

transport resulting in chronic erosion and shoreline recession (USACE 2010 and USACE 2011).

Over the course of the USACE's physical monitoring period (August 2000 to September 2009), the shoreline of concern on the western end of South Beach has retreated by as much as 315 ft (USACE 2011). Over this same time period, there was nearly 6 Mcy of sand placement on South Beach through federal disposal events and Village-sponsored nourishment and disposal projects. The threat to existing homes and infrastructure as a result of the erosion and shoreline recession has prompted the Village to seek other alternatives for long-term protection of its and its citizens' resources.

1.2 PROJECT GOAL AND OBJECTIVES

The overall goal of the project is to reduce beach and dune erosion and thereby protect Island residences, public infrastructure, roads, and beaches/dunes including their associated functions (e.g. recreation) and values (e.g. storm protection).

Given the threat of loss of homes, roads, businesses, infrastructure, and protective dunes along the western end of South Beach and the resultant need for long-term solutions to this problem, the following project objectives have been formulated:

(1) To reduce sand losses from beach disposal or construction (either federal disposal actions or Village-sponsored beach nourishment projects) along the inlet margin; and

(2) To effectively control shoreline alignment along the westernmost segment of South Beach in such a manner to reduce alongshore transport rates and shoreline recession.

1.3 PROJECT LOCATION

Bald Head Island is a 3-mile long south-facing barrier island located immediately eastward of the mouth of the Cape Fear River at 33.85°N, 77.9889°W (NAD27). The island forms the southern terminus of the Smith Island complex at Cape Fear Point from which Frying Pan Shoals extend over twenty miles southeastward into the Atlantic Ocean.

Bald Head Island's east and south shorelines (East Beach and South Beach, respectively) front the Atlantic Ocean. The western shoreline (a.k.a. West Beach) is located immediately adjacent to the Cape Fear River entrance. The north side of the island is bounded by the Bald Head Creek estuary. The remainder of Smith Island is composed of interior tidal creeks (including Cape Creek and Deep Creek), associated tidal marsh, Middle Island, and Bluff Island. The mouth of the Cape Fear River (over one mile in width) separates Bald Head Island from the eastern end of Oak Island (or Caswell Beach). The enclosed nautical chart (Figure 1.1) depicts the location of these islands relative to the Cape Fear River entrance channel and its associated shoal formations.

1.4 INLET AND SHORELINE MANAGEMENT TO DATE

The State of North Carolina began navigation improvements to the Cape Fear River entrance in 1822 and continued until such time when the Federal government assumed responsibility for maintaining safe navigation in 1829. Modification to the Cape Fear River entrance channel has continued since that time, and channel depths have gradually increased to accommodate the increasingly larger vessels calling at the Port of Wilmington (USACE 2000). Since the implementation of the Wilmington Harbor Deepening Project in 2000, the Cape Fear River entrance channels have been regularly maintained at an authorized depth of -44 ft Mean Lower Low Water (MLLW) (+2 ft overdepth).

The Village of Bald Head Island has relied on a variety of shoreline management actions in response to chronic erosion of the western end of South Beach, the Point, and West Beach over the last 18 years. Various responses to erosion have included the use of periodic nourishment; retreat (e.g. relocation and eventual demolition of the Bald Head Island Inn and private homes); beach scraping; sand bag revetments; and the installation and maintenance of a sixteen sand-tube groinfield. Shoreline management has been influenced by federal dredge and disposal actions particularly since 2000 with the implementation of the Wilmington Harbor Sand Management Plan (SMP), which has included the disposal of beach-quality dredged material from the Wilmington Harbor Channel along Bald Head Island and Caswell Beach at federal expense.).

The following is a summary of inlet modifications to date, associated federal disposal, and Village-sponsored nourishment on the southern and western shorelines of Bald Head Island.

1.4.1 Wilmington Harbor Entrance Channel and the Sand Management Plan

Substantial navigation improvements of the Cape Fear River entrance began in 1871 with the construction of a 12-foot deep and 100-ft wide channel along the general alignment of the Bald Head Shoal Channel. Prior to this action, the river entrance was characterized by the presence of two equally-sized channels, the Western Bar Channel and the Baldhead Shoal Channel. Deepening of the single channel entrance (Baldhead Shoal Channel) continued throughout the late 1800's and 1900's. In 1911, the bar channel was deepened to 26 feet and widened to 400 ft (USACE 1989). Subsequent channel improvements through 1968 are listed below in Table 1.1.

Table 1.1. Cape Fear River Entrance Channel Improvements (1925 through 1972).[1]

Year Constructed	Depth (ft below MLW)	Width (ft)
1925-26	30	400
1949	32	400
1956	35	400
1968	40	500

In 2000, the USACE implemented the "Wilmington Harbor 96 Act Project" (also known as the Wilmington Harbor Deepening Project) which included the deepening of the ocean entrance channels to -44 feet (MLLW) and the extension and realignment of the Baldhead Shoal Channel. Note that this more recent channel modification is discussed in more detail below.

Prior to the National Environmental Policy Act of 1969 and the Federal Water Pollution Control Act of 1972, dredged material was often considered a waste material. As such, its treatment often consisted of unconfined disposal into waters and wetlands adjacent to navigation channels. In the latter part of the last century, material from the Wilmington Harbor entrance channels was deposited within confined disposal islands or transported to the Ocean Dredged Material Disposal Site (ODMDS) approximately 4 miles offshore from Bald Head Island (USACE 2000).

Since ocean disposal of dredged material can remove sand from the active littoral system, it is no longer considered a preferable practice if other cost-efficient, engineeringly sound, and environmentally acceptable options are available. Per the tenets of the Sand Management Plan (SMP) (implemented by way of the construction of the Wilmington Harbor Deepening Project in 2000), beach quality sand derived from navigation channel maintenance is now disposed of primarily on the shorelines of Bald Head Island and Oak Island. Such action was determined to represent the least costly, engineeringly feasible and environmentally

[1] Adapted from USACE Reconnaissance Report (Section 111, PL 90-483) (January 1989).

acceptable action and is in keeping with North Carolina coastal zone management policy to ensure, when practical, that beach quality sand is not removed from the active littoral system. Note that dredged material not suitable for beach or littoral zone placement (due to silt/clay content in excess of 10%, excessive shell, or other incompatibility with beach material) continues to be transported to the new ODMDS approximately 7 miles offshore (USACE 2000). Furthermore, when navigation maintenance is required for small volumes (for example less than 100,000 cy), dredged material (regardless of content) may be transported to the ODMDS for disposal (USACE 2000).

The Wilmington Harbor Entrance Channel, which extends seaward of Bald Head Island, is not stabilized by jetties and until channel modifications initiated in 2000, had been maintained at a single location and orientation by dredging since the late 1800's. In recent time, prior to the modifications of the Harbor Deepening Project in 2000, maintenance of the entrance channel typically required the removal of between 500,000 and 1,000,000 cy of material each year. Beginning in 2000, the federal navigation channel was deepened by four feet and widened at several locations. Since initial construction in 2000, four (4) maintenance dredging operations have been conducted within the channel (with the fourth maintenance operation completed in April 2013). It should be noted that the seven-mile long ocean entrance segment of the channel was likewise reoriented in 2000 from its historical southwesterly alignment to a more south-southwest orientation through Bald Head Shoals. The new alignment follows the old channel (Baldhead Shoal Channel) from the inlet (Sta 0+00) seaward approximately 4,500 lf to a new 15-degree turn (at Sta 45+00); then proceeds about 4,300 lf to a second turn of 14 degrees (at Sta 88+43); and then proceeds seaward through the former ODMDS to the 46-ft depth contour located approximately 7.0 miles outside the inlet. Note that the realignment also included a single 200-ft channel widener along the first 4,500 lf seaward from the inlet and two 200-ft wideners along the next 4,300 lf of channel (refer to Figure 1.2). The new alignment was recommended based upon several advantages including an approximate $40-million cost savings (by avoiding rock removal) and avoiding ecologically valuable hardbottom in the path of the 3.5-mile channel extension.

Wilmington Harbor Sand Management Plan

The Wilmington Harbor Sand Management Plan (SMP) was formulated as a disposal plan in the planning and environmental assessment process for the 2000 deepening project for Wilmington Harbor. The SMP identifies the methods by which USACE will dispose of material from its operations associated with the Wilmington Harbor Project. While recognizing the primary purpose of the project as navigation, one objective of the SMP was the retention of beach quality sand within the littoral system (USACE 2000).

As a result, over a typical six-year channel maintenance cycle, the initial SMP anticipated that approximately 1.0 Mcy of sand would have to be dredged from the channel, and would then be placed on the beaches of Bald Head Island in years two and four (after completion of initial construction of the channel) and on Oak Island/Caswell Beach during year six. The cycle would then repeat. Since completion of the deepening project in 2002, the Corps dredged the channel with beach disposal in 2004/2005, 2007, 2009 and 2013.

As an adjunct to the SMP, and as specifically addressed by the Wilmington Harbor Navigation Project Environmental Assessment, the USACE initiated a physical monitoring program to assess the effectiveness of the 6-year sand distribution scheme. Reports are prepared on an annual basis and the associated data are intended to ultimately evaluate and modify the SMP, as determined necessary (after coordination with interested parties).

1.4.2 Summary of Beach Disposal and Nourishment Events

The limits and magnitude, as well as the source of major beach fill/disposal placement operations along South Beach, have varied over the last two decades. Major beach fill/disposal placements occurring principally on South Beach since 1991 are depicted in Table 1.2.

Table 1.2. Beach Fill/Disposal Placement Events on South Beach, Bald Head Island (since 1991).

Year	Volume	Location	Sponsor	Funding (Percent Contribution) by Federal or State
1991	0.35 Mcy	Sta 24+00 to Sta 138+60	VBHI	0%
1996	0.70± Mcy	Sta 24+00 to Sta 142+00	VBHI	0%
1997	0.45 Mcy	Sta 24+00 to Sta 128+00	VBHI	0%
2001	1.849 Mcy	Sta 41+60 to 205+50	Federal	100%
2004/2005	1.217 Mcy	Sta 46+00 to 130+00	Federal	100%
2006	0.0478 Mcy	38+00 – 64+00	VBHI	0%
2007	.9785 Mcy	Sta 44+00 to Sta 91+00 and Sta 110+00 to 170+00	Federal	67% Federal 27% State (6% VBHI)
2009/2010	1.85 Mcy	Sta 56+56 – 218+00	VBHI	0%
2012	0.102 Mcy	38+00 – 74+00	VBHI	100%
2013	1.525 Mcy	Sta 8+00 to Sta 28+00 and Sta 44+00 to 150+00	Federal	100%

Nourishment projects sponsored by the Village of Bald Head Island were funded entirely by the Village with the exception of the 2012 post-Irene nourishment which was reimbursed 100% by the Federal Emergency Management Agency (FEMA). The 2001 disposal resulted from sand excavated during the construction of the last channel widening and deepening project (to -44 ft MLW). Subsequently, the sand berms constructed by the Corps of Engineers have been in accordance with the Wilmington Harbor SMP. In past disposal

actions, the USACE has placed maintenance material as far westward as Sta 45+00 on South Beach. Since that time, monitoring has indicated that, when properly maintained, the sand tube groinfield reduces (but does not eliminate) sand losses from each sand placement project back to the navigation channel. In addition, the existence of the groinfield has reduced or prevented damage to public infrastructure and Bald Head Wynd in the vicinity of Sta 63+00 to Sta 70+00 where the roadway and associated subgrade utilities are closest to the ocean. A more detailed description of the configuration and functioning of the sand tube groinfield is provided below (Section 1.4.3).

A small scale non-federal West Beach nourishment project was constructed by the Village in 2006 with beach-suitable sand sourced from the mouth of Bald Head Creek. In response to erosion of the western end of South Beach, the Village designed and implemented a larger beach restoration project that resulted in the placement of 1.85 Mcy of beach sand during the 2009/2010 dredge and nourishment window. The sand source site for this project was the distal, subtidal portions of Jay Bird Shoals.

Sand losses subsequent to the 1.85 Mcy project in 2010 prompted the Village to identify and permit the use of an approximate 21-acre sand source site at the mouth of Bald Head Creek. The purpose of the project was to provide supplemental sand to an eroded segment of western South Beach. In March 2012, the Village completed the dredge and placement of 140,000 cy at a cost of $1.25M. Most recently, during the Winter and early Spring of 2013, the maintenance dredging of the Federal channel has resulted in the disposal of approximately 1.525 Mcy along South Beach between Sta 44+00 and 150+00 and along a portion of West Beach.

1.4.3 Sand Tube Groinfield

Presently, the 5,300 ft. westernmost segment of South Beach of Bald Head Island is quasi-stabilized by a sixteen (16) structure sand tube groinfield originally constructed in 1995 and subsequently replaced in its entirety in both 2005 and 2010. With the last two

reconstruction programs, minor design changes to groin location, groin length, and (most importantly) geotextile materials comprising the individual tube structures have occurred in accordance with the original design precepts. During the offshore passage of Hurricane Irene in the late summer of 2011, the ends of five (5) sand tubes were damaged. The affected groins were numbered as 16 (as relocated), 1, 2, 3, and 4. These groins were removed and replaced in their entirety as part of the FEMA project performed in conjunction with the USACE Operations and Maintenance (O & M) that was completed in 2013.

The sand tube groinfield was authorized by CAMA Major Permit No. 9-95 (USACE Action ID No. SAW-1994-04687). Note that the CAMA Major Permit was issued by way of a variance in 1995 and is compliant with North Carolina G.S. 113A-115.1(c).

The current location, individual lengths and spacing of the sixteen (16) sand tube groins are depicted by Figure 1.3. The structures currently exist along South Beach between survey baseline Station 47+50 (on the west) and Station 100+00 (on the east). The groin tubes vary in length from 250 ft. to 350 ft. Each geotube is tapered and varies in height from 5.7 ft. to about 4 ft., at its seaward tip. For purposes of installation, the beach is excavated to elevation +2 ft. NGVD. Each tube is then filled within the excavated beach (*i.e.* in a trench) which is subsequently backfilled. During each beach fill operation, the groins are essentially buried (*i.e.* overfilled) by design and therefore remain inactive until the fill berm equilibrates to the point that the tubes are exposed to wave energy. Their effectiveness in reducing littoral transport and maintaining a protective beach berm within each groin cell (located between any two groins) varies over time depending on their level of interaction with waves. Long-term data (Olsen 2003, Olsen 2004, Olsen 2005, Olsen 2006, Olsen 2007) have indicated that the sand tube groinfield, when properly maintained, has performed as intended by reducing sediment losses above the MHWL. This measured performance of the groinfield likewise reduces the rate of shoaling of material from BHI into the adjacent segment of the navigation project channel (bordering the Point).

While the groinfield has had a positive influence on retaining material within the area of the groinfield, it can also have a negative impact on the beach. Failure or degradation of the groinfield can create a "domino-like" progressive failure and result in rapid beach erosion. An example of this is documented in the USACE's Monitoring Report 7 (USACE 2010), detailing the process on Bald Head Island in the 2008/2009 timeframe.

1.4.4 Sand Bag Revetment

In July 2011, the North Carolina Division of Coastal Management (NCDCM) granted a minor modification of existing Permit No. 9-95 thereby authorizing the construction of a 350 linear-foot sandbag revetment beginning at sand tube groin No. 16 and extending in a general northwesterly alignment. Note that the minor modification was granted by CRC variance in July 2011 with the resulting modification issued in August 2011. The purpose of the temporary structure was to address chronic inlet-related beach and dune erosion and recession occurring westward of the last sand tube groin. Subsequently, in 2012 a second minor modification was issued to the Village which allowed for the placement of up to 1,200 cy of sand to be placed on top of the sand bag revetment. The source of the sand was the 2009-2010 Village beach fill project berm located to the east of the revetment. The selection of borrow areas was based upon existing dry beach width. All of the area subject to temporary borrowing was subsequently filled as a result of a large scale (1.8 Mcy) federal navigation maintenance project with beach disposal undertaken in the spring of 2013.

1.5 SUMMARY OF EIS PROCESS

According to the Council of Environmental Quality (CEQ), a federal agency must prepare an EIS if it is proposing a major federal action (including federal approval of a non-federal action) significantly affecting the quality of the human environment (CEQ 2007). The Draft Environmental Impact Statement (DEIS) objectively evaluates all reasonable alternatives which substantially meet the stated purpose and need. In addition to the purpose and need and identification of reasonable alternatives, the DEIS contains the environmental effects of the alternatives and a description of the environment that would be affected by the various alternatives. The environmental analysis should also account for the practicability and feasibility of implementing each potential alternative. The Final EIS (FEIS) considers all comments received during the NEPA Process, including those from government agencies and the general public.

1.6 PERMITS, LICENSES AND ENTITLEMENTS

The following section provides a description of Federal and State laws applicable to the environmental review process for the Village of Bald Head Island Shoreline Protection Project.

1.6.1 National Environmental Policy Act of 1969

The National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321-4347), set forth requirements for agencies of the federal government in Title I and established the Council on Environmental Quality (CEQ) in Title II. NEPA requires federal agencies to consider the effects of all actions on the environment, consider alternatives that reduce impacts, and prepare detailed statements for public and federal agency review where significant impacts may occur. Agencies are required to solicit and respond to comments from the public, affected interests, and relevant government agencies on the impacts of

proposed actions before and after environmental documentation is developed. Documentation consists of an Environmental Assessment (EA) or an EIS.

1.6.2 Rivers and Harbors Act of 1899

The Rivers and Harbors Act of 1899 focuses on maintaining navigation and protecting waters of the United States from pollution. Various sections of the Act establish permit requirements to prevent unauthorized obstruction or alteration of any navigable water of the United States. Section 10 of the Rivers and Harbors Act covers construction, excavation, or deposition of materials in, over, or under such waters, or any work which would affect the course, location, condition, or capacity of those waters. Activities requiring Section 10 permits include structures (e.g., piers, wharfs, breakwaters, bulkheads, jetties, weirs, transmission lines, etc.) and work such as dredging or disposal of dredged material, or excavation, filling, or other modifications to the navigable waters of the United States. Section 10 permits are regulated through the USACE (USACE 2013).

1.6.3 Migratory Bird Treaty Act of 1918

The Migratory Bird Treaty Act is the primary legislation protecting native birds in the United States. This legislation makes it unlawful to pursue, hunt, take, capture, kill, offer for sale, purchase or offer for shipment any bird, or the parts, eggs, or nest protected under several migratory bird treaties, except as permitted under federal regulation (USFWS 2013).

1.6.4 Fish and Wildlife Coordination Act of 1958 (16 U.S.C. 661 et seq.)

The Act of March 10, 1934 authorizes the Secretaries of Agriculture and Commerce to provide assistance to and cooperate with Federal and State agencies to protect, rear, stock, and increase the supply of game and fur-bearing animals, as well as to study the effects of domestic sewage, trade wastes, and other polluting substances on wildlife. The 1958 amendments added provisions to the Act of March 10, 1934 to recognize the vital contribution of wildlife resources to the nation and to require equal consideration and

coordination of wildlife conservation with other water resources development programs and authorized the Secretary of Interior to provide public fishing areas and accept donations of lands and funds. The amendments also titled the law as the Fish and Wildlife Coordination Act and expanded the instances in which diversions or modifications to water bodies would require consultation with the Fish and Wildlife Service. These amendments permitted lands valuable to the Migratory Bird Management Program to be made available to the State agency exercising control over wildlife resources (USFWS 2013).

1.6.5 National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.)

The National Historic Preservation Act (NHPA) of 1966 expresses a general policy of supporting and encouraging the preservation of prehistoric and historic resources and underwater archeology. NHPA created the role of the State Historic Preservation Office (SHPO) to administer state historic preservation programs and consult with federal agencies on their proposed actions (NCSHPO 2013). This Act also established the National Register of Historic Places.

1.6.6 Clean Water Act of 1972

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of dredged and fill material into the Waters of the United States (including wetlands) and regulating quality standards for surface waters. The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained (USEPA 2013). This Act is jointly administered by the Environmental Protection Agency (EPA) and the USACE.

Section 404 of the Clean Water Act established a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill

material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities). The USACE is the federal agency responsible for issuing 404 permits (USEPA 2013).

Section 401 of the federal Clean Water Act provides states with the authority to ensure that federal agencies will not issue permits or licenses that violate the established water quality standards through a process known as water quality certification. In North Carolina, the Division of Water Resources (DWR) is the state agency responsible for issuing 401 water quality certifications (WQC). A 401 WQC is required for any federally permitted or licensed activity that may result in a discharge to waters of the U.S. Issuance of a 401 certification certifies that a given project will not degrade Waters of the State or violate State water quality standards (NCDWQ 2013).

1.6.7 Coastal Zone Management Act of 1972

The U.S. Congress recognized the importance of meeting the challenge of continued growth in the coastal zone by passing the Coastal Zone Management Act (CZMA) in 1972. The Act encourages states to keep the coasts healthy by establishing programs to manage, protect and promote our country's fragile coastal resources. The NC Division of Coastal Management (DCM) carries out the CZMA in the twenty designated coastal counties, using rules and policies of the NC CRC. DCM receives oversight and partial funding from the Office of Ocean and Coastal Resource Management, part of the National Oceanic and Atmospheric Administration (NCDCM 2013).

1.6.8 Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)

Through federal action and by encouraging the establishment of state programs, the 1973 Endangered Species Act provided for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend. Section 7 of the Endangered Species Act requires federal agencies to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify

their critical habitat. A Biological Assessment of the proposed action has been prepared in consultation with the USFWS and NOAA in accordance with 50 CFR §402.12. Previous Section 7 consultations exist for the Wilmington Harbor Project (1996), modifications to the Harbor Project (2000) and the Village-sponsored Bald Head Island Beach Restoration Project that resulted in the placement of approximately 1.8 Mcy (cumulatively) on South Beach and West Beach.

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

The Coastal Barrier Resources Act (CBRA) of 1982 established a defined set of coastal barrier units located along the Atlantic, Gulf of Mexico, Great Lakes, Puerto Rico, and U.S. Virgin Island coasts known as the John H. Chafee Coastal Barrier Resources System (CBRS). Most new federal expenditures and financial assistance are prohibited within the CBRS. Congress enacted CBRA to minimize the loss of human life, wasteful federal expenditures and the damage to natural resources associated with coastal barriers. There are no restrictions on development utilizing non-federal funds; however, federal flood insurance through the National Flood Insurance Program is not available for new or substantially improved structures within the CBRS (USFWS 2013).

The Coastal Barrier Improvement Act (CBIA) of 1990 expanded the CBRS and added a new category of coastal barriers called "otherwise protected areas" (OPAs). OPAs are generally comprised of lands held by a qualified organization primarily for wildlife refuge, sanctuary, recreational or natural resource conservation purposes. Portions of the northern Bald Head Island complex are designated as OPA (Cape Fear Unit NC-07P). The only federal spending prohibition within the limits of the OPA is the prohibition on federal flood insurance (USFWS 2013).

1.6.10 Magnuson-Stevens Fishery Conservation and Management Act of 1996

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) is the primary law governing marine fisheries management in United States federal waters. The Act was first enacted in 1976 and amended in 1996. The 1996 amendments focused on rebuilding overfished fisheries, protecting essential fish habitat and reducing bycatch. The Magnuson-Stevens Reauthorization Act of 2006 established new requirements to end and prevent overfishing through the use of annual catch limit and accountability measures. The Act also specified additional requirements for the role of scientific advice in this process, specifically through the Councils' Scientific and Statistical Committees.

The MSA, implemented through the National Oceanic and Atmospheric Administration and (NOAA) Fisheries, created eight regional fishery management councils to manage fisheries and promote conservation and established procedures designed to identify, conserve, and enhance Essential Fish Habitat (EFH) for those species regulated under a federal fisheries management plan (NOAA 2013). The EFH Guidelines outline the process for federal agencies, NOAA Fisheries and the South Atlantic Fishery Management Council (SAFMC) to satisfy the EFH consultation requirement of the MSA. As part of the EFH consultation process, the guidelines require federal agencies to prepare a written EFH Assessment describing the effects of a proposed action on EFH. The EFH Assessment included in this EIS was prepared in accordance with the EFH guidelines set forth in the MSA.

1.6.11 North Carolina Environmental Policy Act (as amended)

The purpose of the North Carolina Environmental Policy Act (NCEPA) is to protect natural resources and to keep the public informed of actions that may affect their natural resource interests. NCEPA also provides a method for state agencies to consider the environmental aspects and consequences of a proposed development. The NC Department of Administration adopts rules to implement NCEPA, ensures compliance with the Act and maintains a State Environmental Review Clearinghouse of information. Note that per North Carolina Session Law 2011-384, an EIS prepared pursuant to NEPA is considered to satisfy

the NCEPA requirement. As such, the NC DCM serves as a commenting agency to the USACE under NEPA. This EIS has been developed in accordance with the requirements of the State Clearinghouse review process under NCEPA. Upon preparation and submittal of the Final EIS, additional filing under the NCEPA will not be required. Clearinghouse distribution under the federal NEPA process will satisfy the requirements of NCEPA.

1.6.12 North Carolina Coastal Area Management Act of 1974

The North Carolina General Assembly passed the Coastal Area Management Act (CAMA) in an effort to preserve the physical, aesthetic, cultural and recreational values of the North Carolina coast. CAMA established the Coastal Resources Commission (CRC), required local land use planning in the twenty coastal counties and provided for a program for regulating development. As a part of this program, the CRC designated "Areas of Environmental Concern" within the twenty coastal counties and set rules for managing development within these areas. The four designated AECs in the State of North Carolina include; the estuarine and ocean system, the ocean hazard system, public water supplies and natural and cultural resource areas (NCDCM 2013). A CAMA permit is required for development within any AEC. This law and its programmatic requirements are administered by the NC DCM.

1.6.13 North Carolina Dredge and Fill Law

In accordance with the North Carolina Dredge and Fill Law, a permit must be obtained prior to excavation or filling in any estuarine waters, tidelands, marshlands, or State-owned lakes. This law is administered by the NC DCM. Permits will be granted for dredge or fill projects that are not expected to prevent use of the water by the public; take away from the value or enjoyment of the land of adjoining property owners; adversely impact water supplies, or public health, safety, and welfare; or adversely affect wildlife or fisheries.

1.6.14 North Carolina Surface and Water Quality Standards

Water quality standards are state regulations or rules that protect lakes, rivers, streams and other surface water bodies from pollution. The rules are identified in Title 15A of the North

Carolina Administrative Code (NCAC). Water quality standards are used to determine if the designated uses of a water body are being protected.

The lower section of the Cape Fear River, from Federal Point to the Atlantic Ocean, is designated as Class "SA" and are suitable for marketable shellfishing and all uses identified under the "SC" and "SB" classes (15 NC AC 2B .0311). The waters of the Atlantic Ocean in the vicinity of the mouth of the Cape Fear River are designated "SB". "SB" waters are suitable for primary recreational uses as well as all uses identified for "SC" waters (e.g. fishing, fish and wildlife propagation, and secondary recreation) (15 NC AC 2B .0311).

1.6.15 Ownership of Lands

According to NC Administrative Code 15A NCAC 07H .0207, public trust areas include all waters of the "Atlantic Ocean and the lands thereunder from the mean high water (MHW) mark to the seaward limit of state jurisdiction" (approx. 3 miles offshore). The position of the MHW boundary is continually altered by physical processes influencing the deposition and/or loss of material in the nearshore zone. The proposed action will include the placement of beach-compatible sand in the littoral zone updrift of the structure. This will include both the existing dry beach and the intertidal and subtidal areas below the current MHW line. This area has been nourished several times over the last 20 years (see Table 1.2). With regard to the ocean shoreline, North Carolina General Statute §§ 146-6(f) provides that "the title to land in or immediately along the Atlantic Ocean raised above the mean high water mark by publicly financed projects which involve hydraulic dredging or other deposition of spoil materials or sand vest in the state." The placement of structure below the MHW in public trust bottom ordinarily requires an easement from the North Carolina State Property Office. However, no easement is required for the project as the Village is a political subdivision of the State of North Carolina and exempt from this requirement (N.C.G.S. § 146-12(n)(3)).

1.6.16 North Carolina Senate Bill 110 and Senate Bill 151

In June 2011, the General Assembly of North Carolina ratified Senate Bill 110 (*An Act To Authorize The Permitting And Construction Of Up To Four Terminal Groins at Inlets Under Certain Conditions*). The Act authorized the Coastal Resources Commission (CRC) to permit the construction of a terminal groin under a terminal groin pilot project provided the applicant demonstrated that specific criteria as outlined in the bill were met.

In July 2013, the General Assembly ratified Senate Bill 151 (An Act to Amend Marine Fisheries Laws; Amend the Laws Governing the Construction of Terminal Groins; and Clarify that Cities May Enforce Ordinances within the State's Public Trust Areas. Under the new legislation and in addition to requirements of Part 4 of Article 7 of Chapter 113A of the General Statutes, an applicant seeking authorization to construct a terminal groin must submit all of the following: (i) information to demonstrate that structures or infrastructure are threatened by erosion; (ii) an Environmental Impact Statement that satisfies the requirements of G.S. 113A-4 (note that an EIS prepared pursuant to NEPA, 42 U.S.C. § 4321, et seq., shall satisfy this requirement); (iii) a list of property owners and local governments that may be affected by the construction of the groin and proof of notification to these owners and local governments of the application for construction of the terminal groin and its accompanying beach fill project; (iv) a plan for the construction and maintenance of the groin and its accompanying beach fill prepared by a professional engineer licensed to practice in North Carolina; (v) a plan for the management of the inlet and the estuarine and ocean shorelines immediately adjacent to and under the influence of the inlet; (vi) proof of financial assurance sufficient to implement long-term maintenance and monitoring, implementation of mitigation measures, and modification or removal of the groin. The legislation includes various requirements that must be met prior to issuance of a CAMA Major Permit for a terminal groin. In addition, the legislation states that the CRC may issue no more than four permits for such structures. Refer to Appendix A for a copy of the entire SB 151 legislation.

The applicant and its coastal engineer, Olsen Associates, Inc., have provided information in response to these requirements (refer to Appendix B, Inlet management Plan).

SECTION 2.0 – SCOPING AND PUBLIC INTEREST REVIEW

2.1 SUMMARY OF SCOPING

The scoping phase of the environmental analysis process was initiated subsequent to the publication of the Notice of Intent (NOI) to Prepare and Environmental Impact Statement in the *Federal Register* on March 14, 2012 (a copy of the NOI is provided in Appendix C). The NOI provided a brief purpose and need statement and identified the Applicant's proposed action to satisfy the identified need. A Public Notice (PN) was subsequently issued March 14, 2012 by the U.S. Army Corps of Engineers (USACE), Wilmington District (Action ID No. SAW-2012-00040). The PN provided a brief description of the proposed action and information that would allow for the public to submit comment on the proposed action. The PN also identified the date and meeting location for the Public Scoping Meeting. The Public Scoping Meeting was subsequently held in Southport on March 22, 2012.

At the Public Scoping Meeting, the USACE provided a description of the environmental review process and the project engineer provided an overview of the existing conditions and proposed action for the Village's Shoreline Protection Project. In an effort to include the input of the public, interested stakeholders, and federal and state agencies, the USACE solicited comments regarding topics to be addressed in this EIS from those individuals in attendance at the meeting via the use of smaller break-out sessions. Meeting notes for the Public Scoping Meeting are provided in Appendix C.

2.1.1 Project Review Team

Scoping also included the development of a Project Review Team (PRT) to solicit input on issues to be addressed in the EIS, the range of alternatives to be considered, and the environmental analyses necessary to allow agencies to reach their respective permit decisions. The PRT consists of members representing various entities, including but not limited to: federal and state regulatory agencies; federal and state resource agencies; non-profit environmental organizations; and the Village of Bald Head Island. The complete list of members of the PRT is provided in Table 2.1.

Two PRT meetings were held prior to the development of the Draft EIS (DEIS). These meetings were held on April 24, 2012 and September 12, 2012, respectively. Notes from each of these meetings are provided in Appendix C.

Note that the USACE scheduled and held an interagency meeting via the North Carolina Department of Environment and Natural Resources (DENR) "One-Stop" meeting format in an effort to obtain input and comments from any federal and state agency personnel that did not have the opportunity to attend the Public Scoping Meeting. This meeting was held on March 28, 2012. The notes for this meeting are included in Appendix C.

2.2 ISSUES IDENTIFIED DURING SCOPING

As part of the Public Scoping and Public Notice process, the USACE received several comment letters regarding the proposed action and the environmental review process. Comment letters received during the scoping process are provided in Appendix C. Appendix C also includes a table summarizing the comments received through scoping and identifies the specific section in the EIS where the comment is addressed. The comments are organized by general category. Note that the summary table is not intended to be an exhaustive description but rather a synopsis of the nature of the comments received during

scoping. Refer to comment letters in Appendix C for specific comments received during scoping. While all comments have been considered in the creation of this EIS, not every issue on this list was evaluated in detail.

Table 2.1. Project Review Team Members.

NAME	REPRESENTING
Beter, Dale	USACE – Wilmington District – Regulatory Chief
Timpy, Dave	USACE – Wilmington District – Project Manager
McCorcle, Justin	USACE – Wilmington District – Legal Counsel
Piatkowski, Doug	USACE – Wilmington District (Environmental Section)
Horton, Todd	USACE – Wilmington District (Navigation)
Dennis, Bill	USACE – Wilmington District (Coastal Engineering)
Ellis, John	US Fish and Wildlife Service
Sechler, Ron	National Marine Fisheries Service – Habitat Conservation Division
Huggett, Doug	NC Division of Coastal Management
Wilson, Debbie	NC Division of Coastal Management
Coats, Heather	NC Division of Coastal Management
Dunn, Maria	NC Wildlife Resource Commission
Godfrey, Matthew	NC Wildlife Resource Commission
Allen, David	NC Wildlife Resource Commission
Rohde, Fritz	National Marine Fisheries Service
Baker, Jessie	NC Division of Marine Fisheries – Wilmington
Coburn, Chad	NC Division of Water Quality
Giles, Mike	NC Coastal Federation
Rogers, Spencer	University of North Carolina at Wilmington, NC Sea Grant
Dorsey, Suzanne	Bald Head Island Conservancy
McCall, Chris	Village of Bald Head Island (VBHI) Shoreline Protection Manager
Peck, Calvin	VBHI – Village Manager
Sayre, Andy	VBHI – Mayor
Baldwin, Charles	Attorney for VBHI (Brooks, Pierce, McLendon, Humphrey & Leonard, LLP)
Olsen, Erik	Olsen & Associates, Inc., consultant to the applicant
Howard, Steve	Olsen & Associates, Inc., consultant to the applicant
Preziosi, Christian	Land Management Group, Inc. , 3rd party USACE Contractor
Stasavich, Laura	Land Management Group, Inc., 3rd party USACE Contractor

2.3 PUBLIC NOTICE OF RELEASE OF DEIS

Subsequent to completion of the scoping process, the USACE completed its preparation of the DEIS. The Department of Army (DA) Notice of Availability (NOA) of the DEIS was filed on January 10, 2014. The Wilmington District USACE also issued its local Public Notice releasing the DEIS and the permit application received by the Applicant for the proposed project on January 10, 2014. Digital files of the DEIS document (including all supporting figures and appendices) were made available on the USACE Wilmington District's Regulatory homepage. In order to more fully integrate Section 404 permit requirements with the National Environmental Policy Act of 1969, and to give careful consideration to required public interest review and 404(b)(1) compliance determination, the USACE solicited public comment on the merits of the proposed project. The DEIS was also submitted to the North Carolina State Environmental Review Clearinghouse for distribution and publication of notice in the North Carolina Environmental Bulletin. Both the federal and state release of the DEIS allowed for a 45-day comment period. The USACE subsequently issued a public notice on February 13, 2014 that extended the commenting period on the DEIS to March 17, 2014. A Public Hearing to solicit oral and written comments was held on March 4, 2014. The transcript of the Public Hearing is available on the USACE Wilmington District's website (http://www.saw.usace.army.mil/Missions/RegulatoryPermitProgram/MajorProjects).

Comments on the DEIS were provided by various stakeholders including federal and state agencies, local governments, a non-governmental organization, and concerned citizens. These comments were provided to the Applicant for review, consideration, and response. A copy of all comments received on the DEIS and subsequent agency and/or Applicant response, as appropriate, is provided in Appendix D. The USACE has reviewed all comments and has updated the EIS based upon the comments received. A summary spreadsheet of the comments received and considered is included in Appendix D. While all comments have been considered in the creation of the Final EIS (FEIS), not every issue on the list was evaluated in detail.

2.4 AGENCY CONSULTATIONS

Concurrent with the release of the DEIS, the USACE initiated Endangered Species Act (ESA) Section 7 consultation with the USFWS and NMFS via transmittal of the project Biological Assessment (BA) characterizing the potential adverse effects of the proposed action on federally-listed species. The Section 7 consultations are designed to assist federal agencies in fulfilling their duty to ensure federal actions do not jeopardize the continued existence of a listed species or destroy or adversely modify critical habitat. Formal consultation with the USFWS was completed on June 19 (2014) with the transmittal of the USFWS' biological and conference opinions and final effect determinations. As of the publication of this FEIS, the USACE is awaiting the final effect determinations and conservation recommendations for federally-listed species under the jurisdiction of NMFS.

The USACE has also coordinated with NMFS for Essential Fish Habitat (EFH) consultation under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). The USACE has since received final comments and conservation recommendations in accordance with the MSA.

As required under Section 106 of the National Historic Preservation Act, the USACE is coordinating with the North Carolina State Historic Preservation Office (SHPO) for an effects determination of the proposed action on significant cultural or archaeological resources. SHPO has provided written concurrence regarding cultural and archaeological assessments performed on behalf of the Applicant for the proposed project area. Based upon correspondence from SHPO, no further investigations are warranted.

SECTION 3.0 – PROJECT ALTERNATIVES

3.1 SCREENING OF ALTERNATIVES

Based upon the stated project purpose and need, the USACE, in consultation with the Project Review Team (PRT), developed a range of alternatives to be considered in the EIS. The range of alternatives includes considerations of various means by which to respond to the project need and associated objectives. The preliminary list of alternatives was screened via the scoping process and PRT input. An initial alternative identified during scoping, but not advanced further in the EIS analysis included consideration of construction of a terminal groin without beach nourishment. As this alternative is not compliant with the provisions of SB 151 and is not preferred from an engineering standpoint, it has been eliminated from further consideration. The remaining alternatives evaluated within this document are identified in Table 3.1 below.

Table 3.1. List of Project Alternatives

Alternative #1	**No-Action (includes component of Status-Quo)**
Alternative #2	**Retreat**
Alternative #3	**Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place**
Alternative #4	**Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal**
Alternative #5	**Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining)**
Alternative #6	**Terminal Groin with Beach Nourishment/Disposal (Removal of Sand Tube Groinfield)**

3.2 DESCRIPTION OF ALTERNATIVES

3.2.1 No Action/Status Quo Alternative (Alternative #1)

Under the No-Action Alternative, the Village would not implement any comprehensive action (or actions) to offset the on-going erosion of the western end of South Beach. The No-Action Alternative takes into consideration the existing or status quo condition. As such, disposal events occurring under the existing Wilmington Harbor Sand Management Plan (SMP) may occur. The current SMP calls for the sand from Bald Head Shoal Reaches 1 and 2 and Smith Island Reach to be placed on Bald Head Island in two out of every three channel dredging cycles. These cycles are scheduled to occur every other year if conditions, funding, and navigation priorities permit. Under the No-Action Alternative, short-term stabilization measures such as the placement of emergency sand-bags for protection of structures imminently threatened by erosion (in compliance with current state regulations) and the maintenance of the existing sand-tube groinfield would occur (as they have over the last decade or more). Furthermore, the no-action or status quo alternative would include use of beach scraping during the winter months to help rebuild and stabilize foredunes in critically-eroded areas. In similar regard, the Village would continue its program of sand fencing to promote dune formation and stabilization.

3.2.2 Retreat (Alternative #2)

Under the Retreat Alternative, the Village would identify high-risk areas for the development and implementation of a Managed Shoreline Retreat Plan that would ultimately provide for the unimpeded recession of the shoreline. The Plan would provide for the systematic removal of the sand tube groinfield and the demolition or relocation of residences, roads, and infrastructure, if land and funds are available, in advance of the shoreline recession. Thresholds would be identified to trigger the demolition or relocation of specific structures. As part of the retreat strategy, undeveloped lots of the interior sections of Bald Head Island would be identified and acquired for the explicit use of relocating homes. Unimproved lots potentially available for acquisition and structure relocation have been identified (refer to

Figure 3.1). These lots were identified based upon several factors, including: distance from nine-year predicted shoreline position under the Retreat Alternative; condition of lot (i.e. unimproved); and relocation logistics (e.g. avoiding areas in maritime forest that would require additional clearing along narrow right-of-ways for structure transport).

Based upon Delft 3D modeling results (described in Section 5.0), relocation efforts would need to be initiated rather quickly, as roads and several residences would be susceptible to loss within the first three years. Much of the demolition and relocation would need to be completed by Year 9 of the implementation of this alternative (refer to Section 5.2 for predicted shoreline positions). It can be expected that retreat measures would need to be implemented over the 30-year period under consideration. Where necessary and feasible, new right-of-way corridors would be acquired for the relocation of roads and utilities. It is expected that all or portions of secondary right of ways in the permit area (including Sandpiper Trail, Water Thrush Court, and Cape Fear Trail) would need to be abandoned, while the primary route along South Beach (South Bald Head Wynd) would need to be relocated. Detailed information regarding the number of lots (both improved and unimproved) and the specific right of ways and infrastructure that would be subject to relocation or demolition is provided in Section 5.0.

As part of the overall strategy, temporary stabilization methods may be employed to prolong the life of homes, buildings, roads, and infrastructure to provide adequate time for relocation or demolition. For instance, placement of temporary sand bags in accordance with state regulations may be utilized seaward of imminently threatened structures. Use of sand bags would be for a defined period to provide for adequate planning and implementation of retreat measures. In a similar manner, it is expected that the existing sand tube groinfield would be left in place until such time as sufficient retreat measures (e.g. demolition or relocation of infrastructure and homes) have been employed to minimize the risk of potential environmental and safety hazards associated with rapid shoreline recession.

Upon completion of the necessary retreat measures, the sand tube groinfield would be removed at a cost to the Village.

While not relied upon to prolong the life of any structure, it is assumed that under the Retreat Alternative sand disposal would continue to occur per the federal SMP and contingent upon federal funding. However, it is likely that removal of the sand tube groinfield would influence the location and extent of future federal sand disposal on South Beach.

3.2.3 Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place (Alternative #3)

Under Alternative #3, it is assumed that beach disposal would continue per the terms of the existing SMP. The Village would continue to design and implement independently-sponsored beach nourishment and beach disposal projects on an as-needed basis. While FEMA funds may be available to the Village to address sand losses subsequent to a declared disaster, FEMA support is not available for scheduled renourishment events. Note that the levels of federal and/or state contribution for prior disposal and nourishment events on Bald Head Island are identified in Table 1.2 (Section 1.0). As described further in Section 5.0, costs associated for Village-sponsored nourishment under this alternative are considered to be borne wholly by the Village.

In light of calculated volumetric losses provided by the Applicant (see Section 5.0), it is anticipated that the volume and frequency of Village-sponsored nourishment/disposal events required to reduce the risk of further shoreline erosion is on the order of magnitude of 1.5 Mcy of sand beginning at Year 3 post federal SMP disposal and continuing every nine years for the life of the project (30 years). The sand tube groinfield would be maintained so as to continue its beneficial effect on sand losses which are most evident for two years after a large scale sand placement event.

Potential sand sources that may be considered under this alternative are described below. Note that the locations of each of the potential sand source sites are depicted in Figure 3.2.

3.2.3.1 Wilmington Harbor Entrance Channel

Prior federal channel maintenance and disposal events conducted under the Wilmington Harbor SMP have demonstrated that the innermost segment of the Ocean Entrance Channel is a suitable source of beach-compatible material. Navigation channel surveys for three channel reaches (Smith Island Range, Baldhead Shoal Reach 1, and Baldhead Shoal Reach 2) continue to be conducted on bi-monthly intervals. Condition surveys performed in 2012, preceding the Spring 2013 maintenance dredging contract, indicate the occurrence of continued shoaling in the western side of the Smith Island Channel and the eastern side of Baldhead Shoal Reach 1 and 2. The most recent pre-dredging hydrographic surveys for these channel reaches are provided for reference in Appendix E. Areas of pronounced decreases in channel depth resulting from shoaling represent suitable high quality sources for beach nourishment material.

Per the Wilmington Harbor Dredged Material Management Plan (USACE 1996) and the SMP (USACE 2000), beach quality sand can be found within the interior reaches north of the Smith Island Channel. According to sediment composition data, dredged material from Horseshoe Shoal and Reaves Point contained 98% sand and 99% sand, respectively (USACE 1996). The SMP contains a section dedicated to the management of sediments dredged from the Inner Harbor channels (Snows Marsh and Horseshoe Shoals channels). Based upon investigations conducted in support of the development of the SMP, it was estimated that 0.6 Mcy of beach quality material would be removed from these channels as part of the proposed Wilmington Harbor Deepening Project. Prior to 2000, maintenance dredging operations for these reaches utilized the ODMDS. Subsequent to the development and implementation of the SMP, placement of dredged material from these reaches may occur on adjacent beaches including Carolina Beach, Kure Beach, the Fort Fisher area, Bald Head Island, or Caswell Beach (when such options are deemed the least costly and

environmentally acceptable alternatives that are consistent with the engineering requirements of the project) (USACE 2000).

3.2.3.2 Jay Bird Shoals

Jay Bird Shoals is a linear, ebb tidal feature of the Cape Fear River and is situated immediately west of the confluence of the current Wilmington Harbor entrance channel and the former, abandoned channel. Suitable sediment (i.e. beach compatible by North Carolina sediment standard criteria) has been previously identified throughout much of the shoal feature to an average depth of -22 ft National Geodetic Vertical Datum (NGVD). In 2009, the Village of Bald Head Island received federal and state authorizations (Department of Army (DA) Permit No. 2007-02699 and CAMA Major Permit No. 67-09, respectively) to dredge up to 2 Mcy of material from Jay Bird Shoals. The permitted borrow site was approximately 158 acres and was located at the seaward end of the shoal. Prior to authorization of the final borrow site footprint, boundaries were refined to avoid and minimize disturbance to potential cultural and environmental resources. For instance, a 200-ft buffer was maintained around two groupings of magnetic anomalies exhibiting signatures consistent with potential shipwreck material. In addition, the final authorized borrow limits avoided shallow subtidal and intertidal habitat (Land Management Group, 2009).

Approximately 1.85 Mcy of material (measured volume from borrow site) was excavated and pumped to South Beach and West Beach during the Village-sponsored 2009/2010 Beach Restoration Project at a Village cost of approximately $17M. As indicated in Section 1.0, this project was funded entirely by the Village with no federal or state contribution. Note that the contract pay volume measured on the beach via as-built survey was 1.55 Mcy. Based upon geotechnical evaluations completed in 2007, the Jay Bird Shoals borrow area that was investigated contained over 3 Mcy of beach quality material (Olsen 2007). However, as indicated above the final volume permitted for the 2009/2010 project was 2 Mcy for a one-time nourishment event. Nonetheless, geotechnical, cultural, and environmental resource

investigations were completed for the larger shoal formation as part of the Environmental Assessment (EA) prepared by the Village at that time.

3.2.3.3 Bald Head Creek Shoals

The depositional shoal feature located at the mouth of Bald Head Creek (BHC) represents a smaller volume sand source in the immediate vicinity of the Island. The creek mouth is located approximately 1600 lf north of the entrance to Bald Head Marina. BHC, itself, is a relatively small saltwater creek system (approximately 3.5 km from headwaters to mouth) subject to semidiurnal tidal flows. It is bordered to the south by Bald Head Island and to the north by Middle Island.

In November 2010, the Village received federal and state authorization (DA Permit No. 198000291 and CAMA Major Permit No. 139-10, respectively) to dredge 100,000 cy of material from an approximate 21-acre borrow site at the mouth of BHC for the purpose of providing supplemental sand to a severely eroded segment of western South Beach. The permit was subsequently modified to allow for up to 140,000 cy of material to be excavated. The Village completed the dredge and nourishment work in March 2012 at a Village cost of approximately $1.25M. The total amount dredged at that time was 137,990 cy. Physical and biological monitoring of the borrow site was conducted for 3 years post-construction. Biological monitoring has indicated rapid recovery of characteristic benthic infauna within the borrow site. Based upon Year 1 and Year 2 post-construction monitoring, species diversity and richness were both significantly greater at the borrow site than at the reference sites (LMG 2013 and 2014). Physical monitoring surveys of the excavated area has shown only limited shoaling (or recovery) resulting from sediment transport from Bald Head Creek, the Row Boat Row shorefront, and the adjustment of side slopes. As a result, the Applicant's engineer has recommended the expansion of the prospective borrow site to the north.

The entire Bald Head Creek shoal borrow site delineated by the Applicant's engineer is 65.1 acres (refer to Appendix F). Of this, the 21.3-acre borrow site excavated in 2012 and its adjacent side slopes will remain undisturbed over the near term and will be allowed to physically recover over time. Agency consent would be sought for purposes of its future reuse as a sand source for use by the Village. In the near term, an undredged 37.6-acre area is identified as a prospective source site. Geotechnical analysis and a Phase I archaeological survey has been completed for the proposed borrow area expansion (refer to Appendix F and G, respectively). Based upon the geotechnical analysis, all the material within the 37.6-acre site meets the State of North Carolina's standards for borrow site compatibility relative to the recipient beaches (i.e. the west end of South Beach and West Beach). More detailed information regarding the existing conditions of the Bald Head Creek borrow site are provided in Section 4.0 of the FEIS and respective appendices (Appendix F and Appendix G).

3.2.3.4 Frying Pan Shoals

Frying Pan Shoals is a submerged extension of a cuspate foreland (i.e. accretional feature formed by processes of longshore drift and prevailing wind and wave conditions). The shoals extend nearly 20 miles offshore from the eastern end of Bald Head Island. Early reconnaissance level sand resource evaluations conducted for the Cape Fear Region (Meisburger 1977) identified that "modern sediment accretion on the inner shelf appears to be largely restricted to the shoal fields off Cape Lookout and Cape Fear, and to inlet shoals along the coast." It included exploratory density type seismic lines, as well as a limited number of cores and surficial grab samples. Based upon sediment core data collected as part of this study, the most appropriate beach quality sand identified within the Cape Fear shoal field was some sixteen (16) nautical miles offshore of Bald Head Island. It should be noted that sediment sampling for the study was relatively limited given the expansive area of Frying Pan Shoals. Other suitable borrow areas have been tentatively identified closer to shore.

More recent evaluations conducted by the USACE as part of the General Reevaluation Report (GRR) for the Brunswick County Beaches Coastal Storm Damage Reduction Project indicate the presence of substantial volumes of "beach-compatible" material. A Notice of Intent (NOI) to prepare an EIS for the project was published in the Federal Register on February 24, 2012. The USACE has identified Frying Pan Shoals as a potential sand source for this 50-year project. Updated geotechnical information from recent USACE site investigations is provided in Section 4.0 of this document.

3.2.4 Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

Under this alternative, beach disposal would continue per the terms of the existing SMP, and the Village would implement supplementary beach nourishment and/or beach disposal projects on intervals sufficient to accomplish the stated Purpose and Need. In addition, the Village would terminate maintenance of the sixteen (16) sand-filled tube groinfield or seek means by which it would be removed. Note that information regarding the existing sand-tube groinfield (including dates of installation and replacement) is provided in Section 1.0 of the EIS.

Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Although solid in appearance when full, the geotubes have no integral strength due to the limited strength of the geotextile fabric of which they are comprised. As a result they cannot be lifted, and the sand must be emptied in place. The tubes can be physically removed relatively easily, as demonstrated in previous sand tube groin reconstruction projects, where tube removal occurred before replacement. Sand tube removal can occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal. Similarly, excavation of the structures – essentially in the "dry" after a fill project – ensures both complete and relatively cost-effective removal.

The residual shoreline after groin removal would be subject to littoral transport rates unaffected by stabilizing structures. In doing so, the frequency and extent of Village-sponsored sand placement events will likely be greater than that of Alternative #3, as substantiated by the applicant's Delft 3D modeling results discussed in Section 5.0.

The potential sand sources required for this Alternative are the same as those identified under Alternative #3.

3.2.5 Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining) (Alternative #5)

3.2.5.1 Description of Alternative #5 (Applicant's Proposed Action)

Alternative #5 includes the construction of a 1,900 lf terminal groin to be constructed in two phases. Phase I consists of a 1,300 lf structure to be constructed immediately subsequent to the next federal beach disposal operation on Bald Head Island. Any extension beyond the 1,300 lf structure would be based principally on the results of physical monitoring for a period of two (2) or more years following initial construction. The various elements of the proposed construction phasing are described further below. Note that design drawings of the proposed terminal groin are provided in Appendix H. The structure would serve as a "template" for fill material placed eastward thereof. In other words, the structure would help to form the three-dimensional limits (length, width, and height) of the sand placement or updrift fillet. Note that federal beach disposal activities on South Beach generally proceed from west to east. The typical westernmost limit of direct federal beach disposal in proximity to the channel (by design specification) is South Beach baseline station 44+00 (refer to Sheet 7 of Appendix H for station location relative to the proposed structure).

The primary function of a permanent terminal structure is to limit the rapid loss of fill material. Over the long-term, such an approach is anticipated to reduce erosion at the westernmost segment of South Beach (an identified hot spot for erosion). The placement of

beach quality sand with concurrent installation of a groin structure is anticipated to reduce the volume of material otherwise lost via longshore drift and tidal currents. The extent to which this may occur is discussed in greater detail in Section 5.0.

According to the applicant's engineer, an advantage of a singular, relatively long terminal structure should be its ability to reorient the South Beach shoreline (through updrift impoundment, or sand retention) closest to the Cape Fear River navigation channel so as to reduce the rate of transport of beach sand from the island. This is a design goal that has been modeled (results of which are discussed in Section 5.0 of this document). The applicant's engineer states that a single terminal groin is intended to do what the existing sand tube groinfield cannot satisfactorily accomplish due to its limited scope, configuration and composition, that is to control sand losses in a more effective manner. As indicated above, the terminal structure is to serve as a "template" for comprehensive sand fill projects placed eastward thereof. The design goal is to reduce inlet-directed sand loss (both short-term and long-term) and to allow for a more stable condition (particularly post sand placement).

As required by current North Carolina General Statute, the construction of a terminal groin would necessarily involve the placement and maintenance of a concurrent beach fillet (NC Session Law 2013-384, G.S. 113A-115.1(f)(3)). The proposed 1,300-lf Phase I structure would utilize the sand placement from the federal beach disposal project that would occur immediately prior to groin construction. Sand from the federal placement is anticipated to be rapidly impounded by the Phase I groin structure as it is constructed. Should this not occur to a satisfactory level, the Applicant would place sand hydraulically from an alternate borrow source. The Applicant's preferred borrow source would be the remaining, undredged portions of the Jay Bird Shoals borrow site (previously authorized in 2009). Groin construction would be initiated immediately following the federal beach disposal project. Should the federal project be delayed (for funding or any other reason), the initiation of the Phase I groin construction would be similarly delayed. For the full 1,900-ft structure, a

concurrent beach fillet would be achieved via disposal from the identified Jay Bird Shoals borrow site. Sand source sites identified for fillet creation or maintenance as well as future Village-sponsored nourishment are: (1) Jay Bird Shoals; (2) reaches of the Wilmington Harbor Channel demonstrated to contain beach-compatible material (i.e. Baldhead Shoal Reach 1, Baldhead Shoal Reach 2, and Smith Island Range); (3) Bald Head Creek Shoals; and (4) Frying Pan Shoals. The extents of the proposed borrow sites for Jay Bird Shoals, reaches of the Wilmington Harbor Channel, and Bald Head Creek Shoals are depicted in Appendix H (Sheets 15-19).

The expanded borrow site at Bald Head Creek Shoals is the applicant's proposed site to be utilized to comply with the terms and conditions of SB 151 which requires a plan to mitigate for any potential adverse downdrift effects of the terminal groin and to provide for a plan to address groin fillet maintenance. The entire delineated borrow site (including the area dredged in 2012) is 65.1 acres. Of this, the 21.3-acre borrow site excavated in 2012 and its adjacent side slopes will remain undisturbed over the near term and will be allowed to physically recover over time. Agency consent would be sought for purposes of its future reuse as a sand source for fillet maintenance or nourishment on West Beach (downdrift of the proposed groin). In the near term, an undredged 37.6-acre area is identified as a prospective source site for terminal groin mitigation or fillet maintenance. As indicated above, geotechnical analysis and a Phase I archaeological survey has been completed for the proposed borrow area expansion (refer to Appendix F and G, respectively). More detailed information regarding the existing conditions of the Bald Head Creek borrow site are provided in Section 4.0 of the FEIS and respective appendices (Appendix F and Appendix G).

Under this alternative, the existing sand tube groinfield would essentially remain in place. It is predicted that some of the sand tubes will be located in the upland portion of the sand fillet created by the terminal groin and therefore essentially become non-functional. The anticipated maximum extent of that phenomenon is the westernmost six (6) groins. Eastward thereof, the remaining sand tube groins may provide benefit during some portion

of the life cycle of each sand placement operation (presently assumed to vary from two to three years). Periodic maintenance and modification to the groinfield would be anticipated (as it has over its existence to date). Example maintenance activities would include the replacement of damaged sand tubes or repair to the field via sand placement around tubes susceptible to flanking. Example of modification activities would include the relocation of one or more sand tubes. Groinfield modification may also include the removal of one or more sand tubes while leaving a majority of the field intact and functional. Sand tubes demonstrated to be non-functional via long-term burial, and as verified through a minimum of three years of monitoring, may be removed. Alternative 6 (below) considers the scenario of the removal of the entire sand tube groinfield in conjunction with, or subsequent to, the installation of a terminal structure.

A number of design and construction measures have been identified to avoid and minimize potential adverse effects of Alternative #5 on natural resources. Many of these measures are outlined as part of the project description below and in Section 6.0 (Avoidance, Minimization and Mitigative Measures).

Construction Phasing: In order to expedite beneficial post-groin shoreline equilibration conditions (both updrift and downdrift of the structure, and including formation of the sand fillet), the applicant proposes that the terminal groin would be constructed in two phases. Phase I would involve the construction of an approximate 1,300-lf structure (approximately 2/3 of the structure's overall design length) to occur immediately subsequent to the federal disposal of sand on South Beach. Based upon coordination with the USACE Wilmington District Navigation Branch, the Village will not perform any groin construction activities on South Beach until the USACE dredging contractor has completed the federal channel maintenance disposal project and has demobilized all equipment and pipeline from that location. As a result, actual groin construction is expected to begin April 2015 and continue for four to six months (pending weather conditions and the specific method of construction employed by the contractor). The start of groin construction immediately following federal

disposal will theoretically allow for sand to be transported westward toward the structure and will help minimize its lee side effects.

If implemented in concert with the federal disposal, the Phase I structure may not require additional sand from a supplemental source site (i.e. Jay Bird Shoals or, as appropriate, a sufficient quantity of borrow material within the federal channel). A Phase I structure is expected to reduce both the initial volume of sand required, as well as to potentially delay the timing of updrift fillet enhancement (if necessary) by approximately six months to one year. Should the updrift fillet require additional sand, dredging and disposal for such would occur during the winter months (and outside the sea turtle nesting moratorium). The location and extent of the Phase I structure relative to the applicant's expected beach condition subsequent to federal disposal is depicted in Sheet 9 of Appendix H.

It is likely that a Phase I groin construction operation can benefit from the creation of sand work pads on the structure's updrift side with the source of sand being the federal disposal berm. The purpose of the work pads is to minimize, or ideally eliminate, the need for a construction trestle. Any work pad sand placement likewise beneficially contributes to the expedited formation of an updrift fillet. Construction activities during the summer months would include material staging on the northern and western riverfront shoreline (north of the Point); transport of rock between the material storage area and groin location by 4WD trucks; excavation of sand for placement of rock in post-disposal berm; individual placement of armor stone (with optional, potential use of construction trestle); and excavation of sand in post-disposal berm for use in forming construction pads. Specific work zones and construction activities are graphically depicted in Figure 3.3. Construction practices designed to minimize potential adverse effects to environmental resources are described in Section 6.0.

The approximate proposed maximum physical extent of an updrift fillet for both the Phase I and Phase II structure, constructed through sand placement from an appropriate borrow

site, is depicted by Sheet 7 (Appendix H). Phase II would extend the seaward end of the structure to complete the structure's overall design length (1,900 lf). Refer to Sheet 8 of the design drawings (Appendix H) for the proposed phases. The timing of the Phase II groin construction would be based upon an estimated two or more years of performance monitoring. The implementation of Phase II would be coordinated with resource agencies subsequent to the submittal of physical monitoring data. Physical monitoring is described in more detail in Section 6.0.

3.2.5.2 Terminal Groin Design Goals and Precepts

A number of design parameters influence the effectiveness of a terminal structure. Under this alternative, varying options related to structure length and permeability have been evaluated to determine the level of performance relative to the project objectives (see Appendix I.

Specific design goals and precepts are identified below.

Terminal Groin Design Goals:

The following is a list of the design goals developed to evaluate predicted performance:

(1) Reduce sediment transport rates from the westernmost segment of South Beach to the Cape Fear River;
(2) Minimize the potential for adverse impacts to a downdrift shoreline (e.g. West Beach) which is presently both highly dynamic and erosional;
(3) Establish an updrift (easterly) impoundment fillet with the goal of protecting currently threatened residential structures and public infrastructure (water, sewer, roads, etc.);
(4) Protect an important upland evacuation route which parallels South Beach;
(5) Protect and stabilize beachfront along the western end of South Beach ;
(6) Provide potential benefits to an adjacent navigation project via reduced shoaling;
(7) Preclude impacts to other coastal barrier islands;

(8) Require little to no structural maintenance;

(9) Minimize or reduce future maintenance requirements for portions of an existing sand tube groinfield located along South Beach;

(10) Provide an improved beach condition conducive to the facilitation of future federally-constructed beach disposal projects; and

(11) Extend the effective life and benefit level associated with future beach improvement projects (updrift of the structure).

Terminal Groin Design Precepts: In order to achieve the design goals as outlined above, the following design precepts have been considered and evaluated:

(1) Porosity – the structure should be sufficiently permeable (or "leaky") as to limit its effectiveness in the long-term impoundment of sand.

(2) Template (length and width) – the direct, as well as synergistic effects of the groin structure should provide an equilibrated profile or template for the stabilization of the updrift South Beach shoreline sufficient to last between federal beach disposal events, *i.e*., nominally two to three years. The beach profile is expected to progressively reduce in size between sand placement events.

(3) Elevation – portions of the groin should be sufficiently low such that wave overtopping and resultant sediment transport can occur past the structure during periods of energetic wave conditions.

(4) Settlement – the structure should have a foundation designed to be highly resistant to long-term settlement so as to substantially reduce future maintenance requirements.

(5) Adjustment – the structure should be capable of post-construction "tuning" if deemed necessary to refine performance characteristics.

(6) Constructability – the structure should be adequately robust so as to resist damage during low probability storm events, but at the same time sufficiently straight forward in design to assure cost-effective constructability in a highly energetic and dynamic environment.

The precepts above have been used by the applicant's engineer to develop a structural design that meets the applicant's goals regarding optimal performance. The proposed groin is designed as a low-crested, semi-permeable (i.e. "leaky") structure so as to not totally disrupt sand transport to either the "Point" or West Beach. In order to foster structure permeability, the cross-section and crest of a terminal groin would be constructed with a large (and atypical) void ratio. This is accomplished through the use of large and relatively uniformed-diameter quarried granite stone. No core stone is specified, and the use of any mix of stones is discouraged. As a result, the uppermost one meter (or more) of the rock terminal structure will be subject to some level of sediment transport through the section during occasions of wave wash. For illustrative purposes, oblique aerial photography of a permeable groin of similar design to that of the proposed structure on Bald Head Island is provided in Appendix J. The photographs depict a chronology of shoreline conditions on South Amelia Island (at Amelia Island State Park in Nassau County, Florida) from construction (August 2004) to two years post construction (March 2006).

An important design characteristic of a permeable terminal groin structure is the continued opportunity for spit formation on its downdrift (channel facing) side. The applicant's engineer believes that the latter feature would be conducive for continued northward sand transport along the Point toward West Beach. It should be noted however that since the Point shoreline and West Beach shorefront are both highly erosive and dynamic, the forces which control those processes would be expected to result in a shoreline and spit configuration which may be different from those of the past. That is to say, the terminal structure is *not* expected to necessarily resolve ongoing erosion issues on its downdrift side. As noted previously, a design goal is to neither exacerbate existing erosion trends nor result in a condition which cannot be remediated in a manner similar to the pre-project condition – which in this instance is direct sand placement along the affected West Beach shorefront on an as-needed basis. Detailed engineering analyses of post-project conditions within and adjacent to the project area are provided in the Applicant's engineering report entitled "*Shoreline Stabilization Analysis (July 2013)*" (Olsen 2013). Inclusive in this report is the

prediction of any potential increase in erosion on West Beach due to the maximum length of the proposed groin. According to the Applicant's engineer, the total predicted difference is estimated to be -5200 cy/yr over nine years. The analyses in this report are the professional engineering opinions of the Applicant's engineer, and have not been independently reviewed or verifed. Mitigative measures for potential down-drift effects (including thresholds for mitigative action) are further described in the Inlet Management Plan prepared by the Applicant (Appendix B).

The design process itself considers various structural characteristics that ultimately define performance relative to the design goals. Evaluations of design characteristics such as permeability and length are described in Appendix I and within the Engineering Report (Olsen 2013).

3.2.5.3 Terminal Groin Design Details

Design drawings are provided in Appendix H. The terminal groin can be defined by three principal sections: (1) the upland tieback; (2) the groin stem; and (3) the structure head. The latter segment is generally more robust structurally since it experiences the highest levels of incident wave energy (particularly during storms). The stem comprises the majority of the structure and is typically the segment of greatest sediment transmissivity above a certain elevation. The tieback is defined herein as the "root" of the structure higher in elevation and therefore not necessarily subject to sand loss due to daily or monthly tide and wave conditions. It therefore defines the template for the minimum level of updrift beach impoundment and resultant beneficial shoreline alignment (due to its relative non-permeability and higher crest elevation).

Note that Sheet 3 of the design drawings (Appendix H) depicts a "no-construction" area associated with a 150-ft buffer located around the remains of a wooden sailing vessel considered to be from the late 19th or early 20th century. The shipwreck was located and documented by Tidewater Atlantic Research, Inc. (T.A.R) under contract to the Village of

Bald Head Island. The investigation carried out by T.A.R. was part of the design due-diligence associated with the siting of the proposed terminal structure seaward of the westernmost segment of South Beach shoreline. Following consultation with NC Department of Cultural Resources (NCDCR) personnel at Fort Fisher it has been determined that the shipwreck is potentially significant and eligible for nomination to the National Register of Historic Places (NRHP). NCDCR recommended a 150-ft buffer to protect the wreck. In order to accommodate a 150-ft buffer, the original conceptual design for the terminal structure was modified as to both its footprint and its orientation. In addition, the identified wreck is located updrift of the proposed structure. It is the intent of the design engineer for accreting sediment to afford some protection for the surviving hull remains. Per the findings of the T.A.R. archaeological study, burial of the remains as a result of the accretion updrift of the structure would be considered a positive impact. The final report of findings of the archaeological survey and shipwreck assessment prepared by T.A.R. is enclosed (refer to Appendix K).

Sheet 4 (Appendix H) depicts the spatial footprint or "plan" of the proposed groin structure relative to a May 2012 survey and aerial photography. Hence, the shoreline shown relative to the groin is in an eroded condition. All survey information is relative to NGVD 29. As shown, the present-day elevation of the seabed near the terminus of the groin is -10 ft NGVD. The approximate 1900-lf structure has a curvilinear orientation toward the east in order to account for the proximity of the depths associated with the navigational project channel to the west and the existence of a shore-attached shoal formation extending southward from the existing shoreline in the vicinity of the terminal structure's root. The current groin structure and fillet location is intended to avoid the shoal feature (i.e. the shoal will remain outside or westward of the groin). Although the overall structure length is 1,900 ft, its terminus is only 700 ft offshore (or southward) of the 2012 MLW location. Subsequent to filling of the structure through sand placement, the post-fill location of the MLW will initially be at, or in the proximity of, the structure head. The latter condition would likely represent the maximum level of sand impoundment by the structure.

Sheet 5 (Appendix H) depicts the design characteristics of the three (3) typical structural sections associated with the proposed rock structure. The general locations of the cross sections are noted on Sheet 4. Similarly, the general profile of the terminal groin is presented on Sheet 6. As shown, the *specified elevation* of the crest (top of stones) for the section of the groin conducive to westward sand transport is +4.5 ft NGVD. Due to the resultant formation of large voids (between large similarly sized armor stone), the "effective" crest elevation will typically be about one-third to one-half an armor stone diameter below the specified elevation. In the present case, the specified crest elevation is +4.5 ft NGVD and the requisite cap stones average 3 to 5 ft in diameter.

The terminal structure under this alternative is not intended to eliminate the need for nourishment events on West Beach. West Beach (downdrift of the proposed terminal structure) is not presently in a stable condition and will remain prone to sand losses, which may be exacerbated by the presence of the groin structure.

Predicted shorelines and physical conditions resulting from the terminal groin (and its associated design characteristics) are discussed further in Section 5.0 of this EIS.

3.2.5.4 Terminal Groin Construction Methods

Rock-filled marine mattresses would be utilized as a foundation for the seawardmost section of the rock groin structure so that long-term settlement would be minimized and that the project's design intent and unique performance characteristics would be maintained over time. In the more landward section of the rock groin, a composite geogrid/geotextile fabric would in all probability be used as an underlayment (where settlement is less of an issue).

The terminal groin would be constructed of relatively large granite armor rock of varying size (weight and dimensions). Rock would be transported to Bald Head Island by barge from an upland location. Typically rock is transported from the quarry to the waterside transfer site

by rail and/or truck. Placement of the foundation mattresses and rock is generally by crane from a barge, from the upland and/or from a temporary trestle or pier constructed in close proximity to the groin structure. Such a pier is typically pile-supported and necessitates the driving or jetting of steel pile which are later retracted and removed from the site once the rock structure is completed. Note that for construction of Phase 1, use of a temporary trestle may be minimized or avoided entirely. Instead, equipment may be operated from sand work pads on the updrift side of the structure (with the applicant's preferred source of the sand being the federal disposal). Upland portions of the structure tieback necessitate excavation and backfilling of beach sand in order to place the groin foundation and rock at their prescribed elevations (normally below existing grade). Since the construction of the structure is best performed subsequent to sand placement (via either federal disposal of Village-sponsored nourishment), groin construction itself is planned to begin April 2015 and would extend into environmental moratorium periods (including periods of sea turtle nesting). Hydraulic dredging and filling for fillet enhancement (if necessary) would be expected to occur the following winter (outside of the environmental moratoriums). The effects of these proposed actions are further described in Section 5.0.

3.2.5.5 Post-Construction Mitigative Actions

Mitigative actions for any potential adverse effects of the proposed action are outlined in Section 6.0 with more detailed descriptions of the proposed post-construction monitoring, thresholds for implementation of mitigative measures, and mitigative measures that may be implemented included within the Applicant's Inlet Management Plan (Appendix B). A brief description of some of these measures is described below.

Priority for any required mitigation on West Beach would be alongshore sand placement sufficient to protect endangered residential structures and the total loss of protective dune formations. The timing of a mitigative sand placement, however, may be adversely affected by factors such as design document formulation, dredge availability, and public project bid requirements. As a result, the following interim actions may likewise need to be considered:

(1) sand bag revetment construction along the section of shorefront where threatened structures exist; (2) temporary borrowing of sand mechanically from the updrift impoundment fillet of the terminal groin and placement along the affected shorefront; or (3) both actions. Note that any proposal to borrow small volumes of sand from the terminal groin fillet would be predicated upon the existence of an emergency condition only (where sand was required seaward of a building endangered by erosion and where such a condition could not be remedied in sufficient time through hydraulic sand placement). It is estimated that any updrift fillet eastward of the terminal groin would readily hold 250,000 to 500,000 cy of sand. According to the Applicant's engineer, the borrowing of small emergency volumes (e.g. 5,000 to 10,000 cy) would have no measureable effect on the spatial extent of the updrift fillet or the performance of the terminal structure.

As discussed above, the proposed terminal groin is to be constructed as a "leaky" structure with some level of reduced sediment transport continuing to occur either through and/or over the structure crest. As a rubble mound structure, sand permeability can be physically increased through the removal of stones. Any reduction in effective structural elevation will increase sediment transport across the groin. Increased transport would be conducive to spit or dry beach growth on the downdrift side of the structure which, in effect, would be expected to increase sediment transport to West Beach. Such "tuning" of a permeable structure is often desirable with respect to achieving the desired performance goals even if mitigation is not required. Normally, tuning would not occur without the benefit of significant post-construction monitoring, since the transmissivity of such a structure varies over time – dependent upon the condition (*i.e.* size and elevation) of the updrift sand fillet, seasonal wave climatology, storm effects and other site specific factors. In an extreme circumstance, and absent more reasonable, cost-effective alternatives, effective "removal" or major dismantling of the structure may be required.

The effective height of the structure can also be adjusted by the addition of rock to the structure crest should physical monitoring demonstrate that it is not achieving the updrift

design goals, or as needed in the future if it is deemed necessary to address the effects of sea-level rise. Any such proposal for modification would need to be reviewed and authorized by the appropriate state and federal regulatory agencies upon review of sufficient monitoring data and in consultation with resource agencies.

3.2.6 Terminal Groin with Beach Nourishment/Disposal and Removal of Sand Tube Groinfield (Alternative #6)

Alternative #6 would involve the construction of a single, low-profile terminal groin as described in Alternative #5 above. However, upon completion of the installation of the terminal groin, the Village would begin the systematic removal of the existing sand-tube groinfield on South Beach. Sand placement via Village-sponsored nourishment projects and federal beach disposal would continue on periodic intervals. As with Alternative #5, the proposed structure would utilize the sand placement from the federal beach disposal project occurring immediately prior to the groin construction. Sand from the federal placement would be rapidly impounded by the groin structure as it is constructed. . Should this not occur to a satisfactory level, the Applicant would place sand hydraulically from an alternate borrow source. The Applicant's preferred borrow source would be the remaining, undredged portions of the Jay Bird Shoals borrow site (previously authorized in 2009). Groin construction would occur immediately following the completion of the federal beach disposal project. Should the federal project be delayed (for funding or any other reason), the initiation of the groin construction would be similarly delayed. For the full 1,900-ft structure, a concurrent beach fillet would be achieved via disposal from the identified Jay Bird Shoals borrow site. Sand source sites identified for fillet creation or maintenance as well as future Village-sponsored nourishment are the same as those identified for Alternative #5.

Note that to accurately characterize potential costs and environmental consequences of this alternative, it is anticipated that nourishment would occur on a greater frequency than that

of Alternative #5. The Delft 3D modeling results associated with future physical performance are further discussed in the applicant's Engineering Report (Olsen Associates 2013). The engineering report provides detailed analyses on post-project conditions of the project area including potential adverse effects to the down-drift shoreline (i.e. West Beach). Potential adverse effects are described in Section 5.0 of the EIS.

Mitigative actions for Alternative #6 would be similar to those described for Alternative #5. These actions are further described in Section 6.0 and within the Applicant's Inlet Management Plan (Appendix B).

SECTION 4.0 - AFFECTED ENVIRONMENT

4.1 GENERAL ENVIRONMENTAL SETTING

Please refer to Figures 4.1 – 4.3 for specific study area boundaries.

4.1.1 Geology and Morphology of Study Area

The coastal system in the southern geologic province of North Carolina, from Cape Lookout south to South Carolina, is underlain by geologic units ranging in age from the Upper Cretaceous through the Pliocene with only a thin, variable layer of sediments of Quaternary age. The system is largely composed of rocks associated with the Carolina Platform, which underlies the region between Cape Fear and Myrtle Beach, South Carolina (Cleary et al. 2001). Bald Head Island represents the largest segment of the Cape Fear Foreland. The origin of the Cape Fear Foreland is related to a variety of mechanisms including ocean current eddies and erosion of remnant Pleistocene river deltas (Cleary 2008).

The Cape Fear River rises in the Blue Ridge of central North Carolina, the upper reach being the Haw River. The river has eroded the Late Proterozoic to Permian granitic, gneissic and volcanic rocks of the Blue Ridge and Piedmont provinces, delivering this detritus to the coast in a relatively fast moving current compared to nearby rivers draining only Coastal Plain sediments. The Cape Fear River valley lies astride a broad and temporally persistent feature, the Cape Fear arch, and five river terraces are present with successively older terraces farther from the river. An ancestral Cape Fear River began draining the region at least 2.75 million years ago (Mya) during the late Pliocene age and since that time has been migrating to the southwest. This pattern of erosion is evidenced by the pattern of the river's

tributaries which are numerous and large on the northeast side of the river while tributaries on the southwest margin are comparably limited in development (Soller 1998).

Hydrologic modifications to the Cape Fear River mouth began in 1822 with initial navigation improvements conducted by the State of North Carolina. Improvements by the State continued until the Federal government assumed responsibility for maintaining safe navigation in 1829 (Cleary 2008). The first major navigation improvement was initiated in 1871 with the construction of a 12-ft deep and 100-ft wide channel along the general alignment of the Bald Head Shoal. Prior to the dredging of this bar channel, the river entrance was characterized by the presence of two equally-sized channels, the Western Bar Channel and the Bald Head Shoal Channel. In 1871, construction began on the New Inlet Dam (between Federal Point and Zekes Island) which was intended to close New Inlet, thus eliminating shoaling issues within the main river channel (USACE 1989). Modification to the Cape Fear River entrance channel has continued since that time, and channel depths have gradually increased to accommodate the increasingly larger vessels calling at the Port of Wilmington (USACE 2000). Refer to the USACE Wilmington Harbor – Bald Head Island Reconnaissance Report (Section 111) (USACE 1989) for a more detailed description of navigation channel improvements from the late 1800's through 1987. Since the implementation of the Wilmington Harbor Deepening Project in 2000, the Cape Fear River entrance channels have been regularly maintained at an authorized depth of -44 ft MLLW (+2 ft overdepth) and widened by as much as 900 ft (USACE 2008).

Federal navigation improvements have yielded an increased depth, width, and realignment of the channel. Geological investigations of the shoal configurations in the vicinity of Bald Head Island indicate that the reorientation and subsequent stabilization of the shipping channel in the 1880's led to significant changes in the morphology and volume of the ebb-tidal deltas. Large-scale dredging led to the segmentation of the ebb tide delta and an eventual re-organization of the shoal complex into two distinct east and west features. It is estimated that since that time, western Jay Bird Shoal has gained approximately 11.0 million

cubic yards of material while the eastern Bald Head Island shoal segment has lost 28.8 million cubic yards of material (Cleary 2008).

Historical shoreline trends on Bald Head Island are described in the Section 111 Report referenced above (USACE 1989) and by Cleary (2008). Readers are referred to both of these reports for detailed information on shoreline patterns pre- and post-development of Bald Head Island. The following is a brief summary of some of the major trends cited in the referenced reports.

Stabilization of the newly aligned Bald Head Shoal Channel (beginning in the 1880s) allowed the remnant shoal of the 1851 channel to migrate and eventually weld to the west end of South Beach (USACE 1989). By 1923, this phenomenon had resulted in the progradation of western South Beach by more than 2,625 ft. In association with this, the eastern ebb-tide delta fronting South Beach (which was no longer being nourished by eastward moving longshore current) continued to reconfigure as bypassing ceased (Cleary 2008). According to the Section 111 Report, the west end of South Beach remained fairly stable from 1942 to 1975 (USACE 1989). Cleary (2008) states that since 1962, the western segment of South Beach has been eroding and attributes the shoreline recession to "a lack of sand by-passing and the continued reconfiguration of the often-poorly defined marginal flood channel juxtaposed along the southwestern portion of South Beach."

Development of Bald Head Island began in 1972 with the construction of the golf course and the Bald Head Island Inn. The Inn was located near the west end of South Beach. When first constructed, the Inn was located behind a substantial frontal dune. Severe erosion along this area of shoreline prompted the relocation of the structure 300 ft landward (USACE 1989). Continued erosion prompted the use of sand bags and a Longard tube to help stabilize the immediate shoreline area of interest (Moul, personal communication). However, erosion continued to the extent that ultimately required the demolition of the Inn. More recently (1989 to 1996) the shorelines along the western approximate third of South

Beach have continued to erode with the remaining portions of South Beach exhibiting greater stability. These general shoreline responses have continued until present, being influenced periodically by federal disposal and Village-sponsored nourishment events (USACE 2004). Detailed physical monitoring data of the shorelines of Bald Head have been collected and reported on by both the USACE and Olsen Associates since 2001.

Note that geo-rectified, historic aerial imagery of the shorelines of Bald Head Island (1938 to 1989) are provided for reference (Appendix L). In addition, Figures 4.4 - 4.6, adapted from the USACE Wilmington Harbor Physical Monitoring Report – Year 1 (USACE 2008), are provided for reference.

4.1.2 Sand Source and Quality

Pursuant to the tenets of SB 151, a proposed terminal groin must include the placement of a sand fillet updrift of the structure. As indicated earlier, the source of the sand fillet for the Village's proposed action may be any one of the following: (1) reaches of the Wilmington Harbor Entrance Channel; (2) Jay Bird Shoals; (3) Bald Head Creek Shoal; or (4) Frying Pan Shoals.

In 2007 the North Carolina Coastal Resources Commission (CRC) adopted new State Sediment Criteria language which established grain size standards for beach fill projects (15A NCAC 07H .0312). For the purpose of these standards, four grain size categories are defined by the State as the following:

Gravel – sediment grain sizes greater than 4.76mm and less than 76mm
Granular – sediment grain sizes 2mm and greater and less than 4.76mm
Sand - sediment grain sizes .0625mm and greater and less than 2mm, and
Fines – sediment grain sizes less than .0625mm (i.e. passing a no. 230 sieve).

It is important to note that while some level of sediment characterization is required for Wilmington Harbor, borrow sediment excavated from regularly maintained navigation channels is largely exempt from the state sediment criteria language. This high-quality sand is a key source of beach fill materials for many coastal communities (Limber and Warren 2006). Borrow site characterization of navigation channels requires at least five cores with a minimum spacing of 5,000 lf and no geophysical imaging is necessary. Sediment from navigation channels is assumed to originate from the adjacent beach and is therefore considered to be beach-quality. As such, characterization of the recipient beach is not required. Sediment completely confined to the permitted dredge depth of a regularly maintained navigation channel is considered beach-compatible if the average percentage by weight of fine-grained (<0.0625 mm) sediment is less than 10%.

The following is a summary of the sand quality within each of the potential sand source sites.

4.1.2.1 Wilmington Harbor Entrance Channel

Subsequent to the 2001 modification to the alignment of the Wilmington Harbor Entrance Channel and the development of the Sand Management Plan (SMP), the Corps of Engineers has performed on-going physical monitoring of the entrance channel reaches (both survey and geotechnical analyses). Prior federal channel maintenance and disposal events conducted under the Wilmington Harbor SMP have demonstrated that the Entrance Channel is a suitable source of beach-compatible material. Navigation channel surveys for three channel reaches (Smith Island Channel, Baldhead Shoal Reach 1, and Baldhead Shoal Reach 2) continue to be conducted at regular intervals. These surveys indicate the occurrence of continued shoaling in Smith Island Channel and Baldhead Shoal Reach 1 and 2 (USACE 2011). Areas of pronounced decreases in channel depth resulting from shoaling represent suitable sources for beach nourishment material. Note also that per the Wilmington Harbor Dredged Material Management Plan (USACE 1996) and the SMP (USACE 2000), beach quality sand can be found within the interior reaches north of the Smith Island Channel. This material has

recently (i.e. since the inception of the SMP) been disposed of on other beaches in New Hanover County (including Kure Beach and Fort Fisher).

4.1.2.2 Jay Bird Shoals

Detailed geotechnical analyses of the sediments within the Jay Bird Shoals depositional feature was performed as part of the Village-sponsored Bald Head Island Beach Restoration Project (implemented in 2009). The findings of these analyses were reported in the Sand Search Investigation Summary (Olsen 2007) and incorporated into the project Environmental Assessment (LMG and Olsen 2009). The general findings of this investigation are that sediments within the shoal feature are characterized as SP sands under the Unified Soil Classification System and defined as poorly graded sands-gravelly sands with little to no fine sand components. SP sands were found to occur to an average depth of -25 ft at which point a thin clay layer was identified to exist. Overall, the sediments were determined to be compatible with the existing beach substrate on South Beach and West Beach as confirmed via post-nourishment grain size analyses and inspections by the project engineer. In addition, staff of NC Wildlife Resources Commission (WRC) performed visual inspections of color, sediment content, and compaction of the nourished shoreline and found the sand suitable with respect to sea turtle nesting habitat.

4.1.2.3 Bald Head Creek Shoals

In December 2008, fifteen Vibracores were acquired by the firm of Athena Technologies, Inc. (ATI) throughout portions of the ebb tidal shoal feature located at the entrance to Bald Head Creek. The purpose of the effort was to document sediment conditions in the proposed excavation area for the project being considered at that time as well as to characterize the sediments of the ebb tidal platform in general. The sediments encountered were predominantly medium grained, moderately well sorted sands. It was common for sand lithologies to show layered variations in grain size from medium sands to finer sands. The coarser lenses were typically cleaner and occasionally reflected a higher percentage shell content. Carbonate content on average was generally about 10%. Shell material was

typically finer grained with few instances of large intact shells encountered. Fines content was also typically very low (i.e., about 1% ±) with a slight trend of increase with depth.

In January 2014, ATI was contracted by Olsen Associates, Inc. to collect additional geotechnical Vibracore samples of the expanded prospective borrow site north of the 2012 dredge area. Seven (7) additional cores were acquired to a depth of 10 ft below the existing seabed. Based upon ATI's investigation, the average percentage of fine-grained material (i.e. silt and clay) passing a #200 sieve (based upon the composite samples) was 1.4% with a maximum reported value of 2%. The average grain size was 0.37 mm. The average carbonate percentage for the composite samples was 10.7% with a maximum reported value of 21.3%. All of the core analyses reported relatively clean fine sand (SP) above elevation -8 ft (NGVD 29). The Applicant's engineer has concluded that the expanded borrow site at Bald Head Creek Shoals meets the State of North Carolina's standards for borrow site compatibility relative to the proposed recipient beaches (i.e. the west end of South Beach and West Beach). Refer to the complete geotechnical report prepared by Olsen (Appendix F) for more detailed information regarding methodology, results, and findings of the geotechnical investigation).

4.1.2.4 Frying Pan Shoals

The USACE has identified Frying Pan Shoals as a potential source site for the Brunswick County Beaches Coastal Storm Damage Reduction Project. Geotechnical evaluations of sediments within Frying Pan Shoals were conducted by the USACE as part of the General Reevaluation Report (GRR) for this 50-year project. The findings of these analyses were reported in the Brunswick County Beaches Renourishment Study (Catlin 2010). Review of the Vibracore borings indicate that the Frying Pan Shoal borrow area identified in the GRR has an average silt content of 3.2% and an average percentage by weight shell content of 1.5%, within the NCDCM Sediment Criteria. Grain size testing results of the sediment samples ranged from 1.47 (phi) to 2.83 (phi) with a weighted mean average of 2.53 (phi).

Based on compatibility analysis criteria for percent silt content, percent shell content, mean grain size and standard deviation from sediment sampling within Frying Pan Shoals, the material from the borrow area identified in the GRR is largely compatible with the native beach material (Catlin 2010).

4.2 THREATENED AND ENDANGERED SPECIES

Federal and state protected species known to occur within the project area are listed in Table 4.1. Federally-listed threatened and endangered species are protected under the Endangered Species Act of 1973 and/or the Marine Mammal Protection Act of 1972. State-listed animal species are protected under North Carolina General Statutes 113-331 through 113-337 (commonly known as the NC Endangered Species Act). State-listed endangered, threatened and rare plants are protected by the North Carolina Plant Protection and Conservation Act of 1979 (General Statutes, Article 19B, 106: 202.12-22), as amended.

The North Carolina Natural Heritage Program (NHP) has identified four Significant Natural Heritage Areas (SNHA) that occur wholly or partially within the jurisdiction of the Village of Bald Head Island. These include Bald Head Island, Bluff Island and East Beach, the Lower Cape Fear Aquatic Habitat, and Middle Island. A SHNA is a site (terrestrial or aquatic) of special biodiversity significance. An area's significance may be due to the presence of rare species, exemplary or unique natural communities, important animal assemblages, or other important ecological features. The project area is located within the mapped Bald Head Island SHNA. The southeastern extent of the Lower Cape Fear River Aquatic Habitat includes the estuarine waters near the mouth of Bald Head Creek (north of the Bald Head Island Marina) and includes the prospective borrow area of the Bald Head Creek Shoal sand source site. This area is also in close proximity to the western extent of the Middle Island SNHA. In addition to the listed SNHAs, there are records for a high quality Dune Grass (Southern

Subtype) natural community and conservation lands in the project vicinity. Conservation lands on Bald Head Island include the Bald Head Island Natural Area (which comprises the estuarine waters adjacent to Middle Island), Bald Head Woods Coastal Reserve (comprising the maritime forest adjacent to Federal Road), the Silt Tracts (on East Beach), and the Smith Island Land Trust Tract (adjacent to Federal Road).

Descriptions of both federally-listed species and state-listed rare species more likely to occur in the vicinity of the project area are provided below. A complete list of federal- and state-listed species is provided in Table 4.1.

Table 4.1. List of Federally and State Protected Species Known to Occur in the Vicinity of the Study Area (information provided by NCNHP, USFWS, NMFS and BHIC).

Common Name	Scientific Name	Status	
		Federal	State
Mammals			
Eastern woodrat*	*Neotoma floridana floridana*		T
Finback whale	*Balaenoptera physalus*	E	
Humpback whale	*Megaptera novaeangliae*	E	
Right whale	*Eubaleana glacialis*	E	
Sei whale	*Baleanoptera borealis*	E	
Sperm whale	*Physeter catodon*	E	
West Indian manatee	*Trichechus manatus*	E	E
Birds			
American oystercatcher	*Haematopus palliatus*		SC
Brown pelican	*Pelecanus occidentalis*		SR
Common ground-dove*	*Columbina passerina*		SR
Common tern	*Sterna hirundo*		SC
Eastern painted bunting	*Passerina ciris ciris*	FSC	SC
Least tern	*Sternula antillarum*		SC
Peregrine falcon	*Falco peregrinus*		E
Piping plover	*Charadrius melodus*	T	T
Red knot	*Calidris canutus rufa*	P (T)	
Tri-colored heron	*Egretta tricolor*		SC
Wilson's plover	*Charadrius wilsonia*		SC

Reptiles			
American alligator	*Alligator mississippiensis*	T(S/A)	T
Coachwhip	*Masticophis flagellum*		SR
Diamondback terrapin	*Malaclemys terrapin*	FSC	SC
Green sea turtle	*Chelonia mydas*	T	T
Hawksbill sea turtle	*Eretmochelys imbricata*	E	E
Kemp's ridley sea turtle	*Lepidochelys kempi*	E	E
Leatherback sea turtle	*Dermochelys coriacea*	E	E
Loggerhead sea turtle	*Caretta caretta*	T	T
Fish			
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	E	SC
Shortnose sturgeon	*Acipenser brevirostrum*	E	E
Insects			
Giant swallowtail	*Papilio cresphontes*		SR
Plants			
Beach morning glory	*Ipomoea imperati*		T
Blue witchgrass*	*Dichanthelium caerulescens*		E
Cabbage palm	*Sabal palmetto*		T
Coralbean	*Erythrina herbacea*		E
Cuban schliessmund*	*Syrrhopodon incompletus*		SR-P
Dune bluecurls	*Trichostema sp. 1*	FSC	SR-L
Four-angled flatsedge	*Cyperus tetragonus*		SC-V
Large-seed pellitory*	*Parietaria praetermissa*		SC-V
Liverwort	*Cheilolejeunea rigidula*		SR-P
Liverwort	*Plagiochila dubia*		SR-P
Moundlily yucca	*Yucca gloriosa*		SR-P
Nerved witch grass*	*Dichanthelium aciculare ssp. neuranthum*		SC-V
Saltmarsh dropseed*	*Sporobolus virginicus*		T
Seabeach amaranth	*Amaranthus pumilus*	T	T
Seabeach knotweed*	*Polygonum glaucum*		E
Shortleaf basket grass	*Oplismenus hirtellus ssp. setarius*		SR-P
Silverling*	*Baccharis glomeruliflora*		SC-H
Southern seaside spurge*	*Euphorbia bombensis*		SR-T
Spreading sandwort*	*Arenia lanuginosa var. lanuginosa*		SR-P
Sunrise lichen	*Teloschistes flavicans*		SR-P
Tough bumelia	*Sideroxylon tenax*	FSC	T

KEY TO TABLE 4.1:

Status	Definition
E	Endangered - A taxon in danger of extinction throughout all or a significant portion of its range.
T	Threatened - A taxon likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
T(S/A)	Threatened due to similarity of appearance - A taxon that is threatened due to similarity of appearance with another listed species and is listed for its protection. Taxa listed as T(S/A) are not biologically endangered or threatened and are not subject to Section 7 consultation.
FSC	Federal Species of Concern - A species under consideration for listing, for which there is insufficient information to support listing at this time.
P	Proposed for listing.
SC	Special Concern - Any species of wild animal native or once-native to North Carolina which is determined by the Wildlife Resources Commission to require monitoring but which may be taken under regulations adopted under the provisions of this Article.
SC-H	Special Concern- Historical- Any species or higher taxon of plant that occurred in North Carolina at one time, but for which all known populations are currently considered to be either historical or extirpated.
SC-V	Special Concern- Vulnerable - Any species or higher taxon of plant which is likely to become a threatened species within the foreseeable future.
SR	Significantly Rare - Any species which has not been listed by the N.C. Wildlife Resources Commission as an Endangered, Threatened, or Special Concern species, but which exists in the state (or recently occurred in the state) in small numbers and has been determined by the N.C. Natural Heritage Program to need monitoring.
SR-L	Significantly Rare- Limited - The range of the species is limited to North Carolina and adjacent states (endemic or near endemic). These are species that may have 20-50 populations in North Carolina, but fewer than 100 populations rangewide.
SR-P	Peripheral - The species is at the **periphery** of its range in North Carolina. These species are generally more common somewhere else in their ranges, occurring in North Carolina peripherally to their main ranges, mostly in habitats which are unusual in North Carolina.
SR-T	Throughout - The species is rare **throughout** its range (fewer than 100 populations total).
*	Historical: has not been seen in area for twenty years or more.

4.2.1 Mammals

The federally-protected right whale, finback whale, humpback whale, sei whale, and sperm whale all occur infrequently in the ocean off the coast of North Carolina. Of these, only the right whale and the humpback whale pass close enough nearshore to encounter the study area. Humpback whales are often found in protected waters over shallow banks and shelf waters for breeding and feeding. They migrate toward the poles in summer and toward the tropics in winter and visit the North Carolina coast during seasonal migrations, especially between December and April (Conant 1993). While it usually winters in the waters between

Georgia and Florida, the right whale can on occasion be found in the waters off North Carolina.

Sighting data provided by the Right Whale Program of the New England Aquarium found that most of the sightings in the vicinity of Wilmington from 1974 to 2002 occurred between October and April, with peak sightings in February and March (Knowlton et al. 2002). According to data from the University of North Carolina at Wilmington's Marine Mammal Stranding Program, right and humpback whales are documented in the region with some frequency. In December of 2008, a right whale and her calf were spotted off the coast of Wrightsville Beach. The same mother whale was seen with another calf four years earlier. Also in December of 2008, a very young right whale washed up on the Outer Banks with numerous health ailments. These sightings indicate that right whales are giving birth off the coast of North Carolina. Additionally, a humpback whale stranding was documented in Oak Island in February of 2009. In 2012, humpback whales have been confirmed in the waters near Topsail Beach and right whales have been observed swimming past Wrightsville Beach.

Another listed mammal previously documented on Bald Head Island is the eastern woodrat (*Neotoma floridana floridana*) of the coastal plain population. It is known to utilize various moist, vegetated habitats such as floodplain and swamp forests, wet scrub thickets, and maritime forest. The coastal plain woodrat ranges from Pender County in southeastern North Carolina and southward throughout much of the coastal plain of the southeast (SC DNR, 2005). In North Carolina, the eastern woodrat is listed as threatened due to habitat loss. It has been observed in Bald Head Island's maritime forest habitat, but no sightings have occurred since 1966 (Weakley, 2014).

The West Indian manatee (*Trichechus manatus*), also known as the Florida manatee, is an occasional summer resident off the North Carolina coast. The species can be found in shallow (5 feet to usually less than 20 feet), slow-moving rivers, estuaries, saltwater bays,

canals, and coastal areas (USFWS 1991). Recent sightings include an individual being spotted in Carolina Beach in June of 2008. The West Indian manatee is herbivorous and eats aquatic plants such as hydrilla, eelgrass, and water lettuce (USFWS 2001). During winter months, the United States' manatee population confines itself to the coastal waters of the southern half of peninsular Florida and to springs and warm water outfalls as far north as southeast Georgia. They are sighted frequently in southeastern North Carolina with most records occurring in July, August, and September, as they migrate up and down the coast (Clark 1993). However, scattered records of this species in the region span all seasons. Based on these data, the manatee is considered a year-round resident with a maximum population in the summer months.

4.2.2 Birds

4.2.2.1 Federally-Listed Birds

Piping Plover

The Atlantic Coast piping plover population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast from North Carolina south, along the Gulf Coast, and in the Caribbean (USFWS 1996b). Since being listed as threatened in 1986, the population has increased from approximately 800 pairs to 1676 pairs in 2003, although most of this increase may be attributable to an increase in surveying intensity. Of the 1676 pairs, 24 were observed in North Carolina (USFWS 2004). Piping plovers nest above the high tide line on coastal beaches, sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes (USFWS 1996b). Feeding areas include intertidal portions of ocean beaches, washover areas, mud flats, sand flats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes. Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the species' decline.

Staff of the NC Wildlife Resources Commission (WRC) perform annual surveys for piping plovers along the beaches of North Carolina during the breeding season and have not observed any nesting in the vicinity of the project area. However, non-breeding piping plovers have been observed using this area, most commonly the intertidal surf zone along South Beach (Cameron, Schweitzer, NC WRC, personal communication). Bird monitoring data available through WRC is provided in Appendix M. Staff of the Bald Head Island Conservancy surveyed the beaches of Bald Head Island on several occasions in July of 2012 and did not observe any piping plovers (Hancock, personal communication). Additional monitoring associated with the Wilmington Harbor Deepening Project was conducted by CZR, Inc. in 2001 and 2002. Three transects within Bald Head Island were surveyed. Year-round monitoring was conducted in two of the three transects. The other transect was monitored only during the non-breeding season. Piping plovers were noted on several occasions, especially along the southeastern tip of the island (CZR 2003). However, no breeding activity was observed. The US Fish and Wildlife Service (USFWS) has not designated any part of Bald Head Island as critical habitat for the piping plover.

Red Knot

The rufa red knot (*Calidris canutus rufa*) is a medium-sized shorebird about 9 to 11 inches in length. Its breeding plumage is a muted red color that covers the breast and extends up its neck and eyes. The red knot makes one of the longest distance annual migrations, traveling up to 19,000 miles between its breeding grounds in the Canadian Arctic and several wintering regions, including the Southeast United States, the Northeast Gulf of Mexico, northern Brazil, and Tierra del Fuego at the southern tip of South America (Niles *et al.* 2008). Large and small groups of red knots, sometimes numbering in the thousands, may occur in suitable habitats all along the Atlantic and Gulf coasts from Argentina to Canada during migration (Niles *et al.* 2008). Red knots are most commonly observed along the mid-Atlantic coast during the middle of May (B. Watts, pers. comm.).

Habitats used by red knots in spring/fall migrations and wintering areas are generally coastal marine and estuarine (partially enclosed tidal area where fresh and salt water mixes) habitats with large areas of exposed intertidal sediments. In North America, red knots are commonly found along sandy, gravel, or cobble beaches, tidal mudflats, salt marshes, shallow coastal impoundments and lagoons, and peat banks (Cohen *et al.* 2010; Cohen *et al.* 2009; Niles *et al.* 2008; Truitt *et al.* 2001). The primary prey of the rufa red knot in non-breeding habitats include blue mussel (*Mytilus edulis*) spat (juveniles); *Donax* and *Darina* clams; snails (*Littorina* spp.), and other mollusks, with polycheate worms, insect larvae, and crustaceans also eaten in some locations.

Red knots utilize the beaches of BHI as a stop-over area during their spring migrations. NC WRC staff observed approximately 30 red knots in June of 2006 along Bald Head Island's east beach (S. Cameron, pers. comm.). Additionally, four birds were observed in May of 2011 and 25 birds were observed in May of 2012 along the entirety of Bald Head Island beaches (S. Schweitzer & B. Watts, pers. comm.). Along the Atlantic coast, small numbers of wintering red knots have been documented to extend as far north as Virginia (USFWS 2014).

In 2013, the USFWS proposed to list the rufa red knot as a threatened species under the Endangered Species Act of 1973, as amended (78 FR 60023). The USFWS has determined that the rufa red knot is threatened due to the loss of both breeding and nonbreeding habitat; potential for disruption of natural predator cycles on the breeding grounds; reduced prey availability throughout the nonbreeding range; and increasing frequency of asynchronies in the timing of the birds' annual migrations relative to favorable foraging and weather conditions (USFWS 2014).

4.2.2.2 State-Listed Birds

Several state-listed birds have been documented to occur in the vicinity of the project area. These include species such as the Wilson's plover, least tern, common tern, and American oystercatcher which are all known to utilize intertidal flats for foraging and roosting grounds.

In addition, American oystercatchers, least terns, and Wilson's plovers have been documented nesting on the upper dry beach along the shorelines of Bald Head. These species tend to nest just above the high tide line on bare sand and shell with little or no vegetation. A significant colony of least tern nests on the southeastern end of South Beach has been documented on the NC NHP records database.

Other state listed species that may occur in other habitats of the island include the peregrine falcon (*Falco peregrinus*), common ground-dove (*Columbina passerina*), and the eastern painted bunting (*Passerina ciris ciris*). According to the NC NHP database, the peregrine falcon (state-listed as endangered) has been documented to occur in the vicinity of South Beach, Bald Head Island (NHP 2014). It is known to utilize coastal ponds and mudflats during fall migrations. The common ground-dove (state-listed as significantly rare) can be found in dunes or the margins of maritime thickets. It has not been observed within the project area in many years and may be extirpated from the region. The eastern painted bunting (state-listed as a species of concern) is a summer resident and more commonly occurs within the shrub thickets and edges of the maritime forest.

4.2.3 Reptiles

4.2.3.1 Hawksbill Sea Turtle, Kemp's Ridley Sea Turtle, and Leatherback Sea Turtle

In North Carolina, the Kemp's ridley sea turtle is known to occur in estuarine and oceanic waters, whereas the hawksbill and leatherback are found primarily in oceanic waters (Schwartz 1977, Epperly et al. 1995). These species are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). Both the leatherback and the hawksbill sea turtles are only occasionally observed migrating through North Carolina waters. The Kemp's ridley sea turtle is commonly observed migrating within North Carolina inshore waters during the spring and fall. The principal food sources for these sea turtle species are crustaceans, mollusks, other invertebrates, fish, and plant material (Schwartz 1977).

The hawksbill sea turtle and Kemp's ridley sea turtle are not known to nest along the Brunswick County beaches. The hawksbill is found throughout the world's tropical waters. It is also found along the Atlantic coastline from Massachusetts southward to Brazil. This turtle has been known to nest in Florida, but is not common along the North Carolina coast (NMFS 1993). The Kemp's ridley sea turtle has been documented to nest only three times in North Carolina. The entire population generally nests on approximately fifteen miles of beach in Mexico between the months of April and June (USFWS 1991). The leatherback sea turtle primarily nests on beaches in the tropics, but is occasionally observed nesting in areas north of Florida (Rabon et al. 2003). In 2010, one leatherback sea turtle laid a nest on East Beach on Bald Head Island. Prior to that, the closest known leatherback nesting sites to the project area were in Georgetown County, SC and Carteret County, NC.

4.2.3.2 Loggerhead Sea Turtle

In North Carolina, the loggerhead and green sea turtles are known to occur in estuarine and oceanic waters (Schwartz 1977, Epperly et al. 1995). These species are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). Both species are known to frequently use coastal waters as travel corridors and have been observed migrating along the North Carolina coast (Epperly et al. 1995). Only the loggerhead is considered to be a regular nester in North Carolina, while the green nests occasionally in the state.

The loggerhead turtle utilizes Bald Head Island for its seasonal (May-November) nesting events. Nests are typically laid between the high tide line and the dune front (Routa 1968, Witherington 1986, Hailman and Elowson 1992). Loggerheads generally prefer high energy, relatively narrow, steeply sloped, coarse-grained beaches. In the southeastern United States mating occurs in late March to early June and females lay eggs between late April and early September. Females lay three to five nests, and sometimes more, during a single nesting season. The eggs incubate approximately two months before hatching sometime between late June and mid-November.

Off the Carolina coast, these turtles commonly occur at the edge of the continental shelf when they forage around coral reefs, artificial reefs, and boat wrecks. They feed on benthic invertebrates including mollusks, crustaceans, and sponges (Morrimen 1982). They have also been found to eat fish, clams, oysters, sponges, jellyfish, shrimp, and crabs when near shore. Research has shown that the turtle populations have greatly declined in the last 20 years due to a loss of nesting habitat along the beachfront and by incidental drowning in shrimp trawl nets. It appears that the combination of poorly placed nests coupled with unrestrained human use of the beach by auto and foot traffic has impacted this species greatly. Eroding steep beach escarpments, lights, sand fences, and other physical barriers (debris) often cause the mature females to select poor nesting sites at the dune toes which causes higher nestling mortality rates. Loggerhead turtles are known to regularly nest at Bald Head Island. Staff of the Bald Head Island Conservancy (BHIC) patrol the beach front daily during the nesting season to document and monitor sea turtle nests. Between 1980 and 2011, an average of 97.4 nests per year was recorded on Bald Head Island, with the majority of the nests occurring along South Beach and East Beach (BHIC sea turtle data). Between 2007 and 2011, an average of 19 nests per year were noted within the project area.

The U.S. Fish and Wildlife Service recently proposed the designation of 739.3 miles of shoreline in the states of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi as critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle. This area accounts for approximately 84 percent of the documented nesting (numbers of nests) within these six states. This designation would include the project area. However, at the time of the publication of this FEIS, the proposal is currently in the rulemaking process and thus not in effect (Federal Register 2013).

4.2.3.3 Green Sea Turtle

With an estimated population of no more than 600,000 adults worldwide, the green sea turtle exists in both tropical and temperate seas and oceans (USFWS 1992). The North

American distribution ranges from Massachusetts to Mexico, and from British Columbia to Baja California. Green sea turtles generally favor protected waters inside reefs, bays, estuaries, and inlets. Primary habitats appear to be lagoons and shoals supporting an abundance of marine grass and algae. These turtles are predominantly herbivorous, feeding upon marine algae and shallow beds of marine grasses. However, additional food sources may include mollusks, sponges, crustaceans, and jellyfish.

The major reasons for the decline in green sea turtle numbers include over-exploitation of eggs and meat for food, commercial fishing and dredging operations, and nesting habitat destruction associated with outer beach development (USFWS 1992). Green sea turtle nesting habitat consists of open beaches with a sloping platform and minimal human disturbance. Eastern United States nesting is primarily limited to Florida's east coast (300 to 1000 nests reported annually). However, occasional nesting has been documented as far north as North Carolina. In 2006, one green sea turtle nest successfully hatched from the south-facing beach of the project area (Dewire, personal communication.). In 2011, three nests successfully hatched from the south-facing beach of the project area. Since green sea turtles appear to have strong nesting site fidelity and often lay eggs on the same beach on which they hatched (USFWS 1992, Carr et al. 1978), surviving female green sea turtles will likely return to Bald Head Island for future nesting habitat.

4.2.4 Fish

4.2.4.1 Atlantic Sturgeon

The Atlantic sturgeon is an anadromous fish species whose range extends from Maine to Florida (NMFS 2011). The Atlantic sturgeon is a benthic feeder and typically forages on invertebrates such as crustaceans, worms, and mollusks. Adults spawn in freshwater in the spring and early summer and then migrate into estuarine and marine waters where they spend most of their lives. They spawn in moderately flowing water (46-76 cm/s) in deep parts of large rivers. Juveniles usually reside in estuarine waters for months to years.

Subadults and adults live in coastal waters and estuaries when not spawning, generally in shallow (10-50 m depth) nearshore areas dominated by gravel and sand substrates.

In 2012, four distinct population segments (DPS) of Atlantic sturgeon were listed as endangered under the Endangered Species Act: the Chesapeake Bay, New York Bight, Carolina, and South Atlantic populations. The Gulf of Maine population is listed as threatened. The project area is located within the Carolina DPS habitat range, which includes all Atlantic sturgeon that spawn in the watersheds from the Roanoke River, Virginia, southward along the southern Virginia, North Carolina, and South Carolina coastal areas to the Cooper River. The marine range of Atlantic sturgeon from the Carolina DPS extends from the Bay of Fundy, Canada to the Saint Johns River, Florida. While Atlantic sturgeon exhibit a high degree of spawning fidelity to their natal rivers, multiple riverine, estuarine, and marine habitats may serve various life (*e.g.,* nursery, foraging, and migration) functions. Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002, Secor 2002). Prior reductions from the commercial fishery and ongoing threats such as dams have drastically reduced the numbers of Atlantic sturgeon within the Carolina DPS to less than 3 percent of what it was historically (ASSRT 2007). Because of the lack of suitable freshwater spawning areas in the project area, any Atlantic sturgeons present would most likely be non-spawning adults.

Since 2011, the North Carolina Division of Marine Fisheries (NCDMF) has maintained an acoustic monitoring array of receivers stationed throughout the lower Cape Fear River basin to track the movements of acoustically tagged anadromous fish. Two station locations (located at Bald Head Island and Caswell Beach, respectively) with overlapping ranges essentially serve as a "gate" at the mouth of the river to record the immigration and emigration of tagged fish (NCDMF 2014). The NCDMF summary of sturgeon tracking data collected from the two river mouth stations is provided in Appendix N.

4.2.4.2 Shortnose Sturgeon

The shortnose sturgeon ranges along the Atlantic seaboard from southern Canada to northeastern Florida (NMFS 1998). It feeds on invertebrates and stems and leaves of macrophytes. From historical accounts, it appears that this species was once fairly abundant throughout North Carolina waters; however, many of these early records are unreliable due to confusion between this species and the Atlantic sturgeon. Because of the lack of suitable freshwater spawning areas in the project area and the requirement of low salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults. Refer to the NCDMF summary of telemetry tracking data for more detailed information on migration trends of sturgeon through the Cape Fear River mouth (Appendix N).

4.2.5 Insects

The giant swallowtail is a state-listed butterfly that is primarily found in maritime forests or thickets. Its host plants include prickly-ash and hoptree. Approximately 50 to 60 individuals were observed in the summer of 2003 within maritime forest habitat located on BHI.

4.2.6 Plants

4.2.6.1 Federally-Listed Plants

Seabeach amaranth is an annual herb that occurs on beaches, lower foredunes, and overwash flats (Fussell 1996). Weakley (1986) found that in North Carolina the plant is most common on overwash flats on accreting ends of barrier islands. This species occupies elevations ranging from 0.2 to 1.5 m above mean high tide (Weakley and Bucher 1992). Historically, seabeach amaranth was found from Massachusetts to South Carolina. But according to recent surveys (USACE 1992-1995), its distribution is now restricted to North and South Carolina with several populations on Long Island, New York. The decline of this species is caused mainly by development of its habitat, such as inlet areas and barrier islands, and increased ORV and human traffic which tramples individuals (Fussell 1996).

Seed dispersal of seabeach amaranth is achieved in a number of ways, including water and wind dispersal (USFWS 1996). Flowering begins as soon as plants have reached sufficient size, sometimes as early as June, but more typically commencing in July and continuing until the death of the plant in late fall. Seed production begins in July or August and peaks in September during most years, but continues until the death of the plant.

Since 1992, the US Army Corps of Engineers has performed annual surveys of amaranth from three reaches on Bald Head Island. Less than five amaranth plants have been observed annually on Bald Head Island since 2006.

4.2.6.2 State-Listed Plants

A variety of state-listed plant species have been observed within or near the project area. Seaside spurge, beach morning-glory, seabeach knotweed, dune bluecurls, and moundlily yucca may be found in the area and prefer dunes and/or dry beach habitat. The NC Natural Heritage Program has identified a dune grass natural community along the southeastern portion of South Beach. A population of dune bluecurls and beach morning-glory (in addition to seabeach amaranth) has been observed within this community.

Maritime forests support an assortment of rare plants including spreading sandwort, liverwort, four-angled flatsedge, nerved witch grass, Terrell grass, coralbean, shortleaf basket grass, large-seed pellitory, cabbage palm, tough bumelia, Cuban schliessmund, and dune bluecurls.

4.3 PERMIT AREA HABITATS

4.3.1 Estuarine

4.3.1.1 Salt Marsh

Salt and brackish marshes occur in the intertidal zone, along the margin of coastal and estuarine waters. The acreage of salt marsh habitat in North Carolina is estimated to be 212,800 acres. Roughly 9,000 acres of this total have been mapped in the Cape Fear River basin (SAFMC 1998). Salt marshes are utilized for food and cover for juvenile and adult finfish and shellfish and have a significant role in coastal ecosystem processing by stabilizing unconsolidated sediment, filtering runoff from the upland watershed and controlling water volumes, especially during meteorological events. Tidal marsh habitat in the Bald Head Island vicinity is primarily located along the interior tidal creeks of Bald Head Island and the neighboring Smith Island Complex. Most of the tidal marsh habitat associated with the interior creeks is beyond the limits of the biological resource study areas (refer to Figure 4.7). Smaller areas of tidal marsh near the mouth of the Bald Head Creek are within the identified area of study and potential consequences to such are evaluated in the following environmental analyses.

Plant distribution within salt marsh habitat is linked to physical environmental factors, including, but not limited to, tidal inundation duration, frequency and amplitude as well as salinity. The salt marshes of North Carolina, including Bald Head Island, typically display a monoculture of smooth cord grass (*Spartina alterniflora*) in the low marsh zone where tidal amplitude is high and tidal inundation is frequent. As elevation increases, a more diverse floral community emerges mainly due to a decrease in both tidal amplitude and inundation period. Common vegetation in this transitional, high marsh area includes salt meadow hay (*Spartina patens*), salt reed grass (*Spartina cynosuroides*), black needlerush (*Juncus romerianus*), sea oxeye (*Borrichia frutescens*), salt grass (*Distichlis spicata*), glasswort (*Salicornia* spp.), sea lavender (*Limonium* spp.), *Scirpus* spp., and saw grass (*Cladium jamaicense*) (Weigert and Freeman 1990, SAFMC 1998). Terrell grass and silverling, state-

listed plants, have been observed in or near brackish marshes in the Smith Island complex. Silvering has not been observed in the region in many years.

Estuarine intertidal marshes provide habitat for fish and shellfish, including two South Atlantic Fishery Management Council species of concern (red drum and shrimp). Chemical and biological processing within salt marshes additionally supports the coastal migratory pelagics fishery and the snapper – grouper fishery (SAFMC 1998). Salt marshes also provide important roosting and foraging habitat for migrating and wintering waterbirds and shorebirds. Wading birds, such as herons and egrets, feed on fishes, shrimps and fiddler crabs. The diamond back terrapin, a state-listed species of concern, also utilizes the marsh foraging and refuge habitat.

4.3.1.2 Unvegetated Subtidal and Intertidal Bottom

Estuarine unconsolidated bottom, or soft bottom, is characterized by a number of physiochemical factors including sediment grain size and distribution, water depth, hydrography as well as water quality (dissolved oxygen and salinity). Collectively, these factors will affect the condition of the bottom habitat as well as the organisms that utilize it. Bottom habitat in North Carolina estuaries is generally categorized as subtidal bottom in rivers, creeks and sounds, intertidal flats and shell bottom. The approximate extent of soft bottom habitat in the study area is depicted in Figures 4.8 - 4.9.

Surficial sediments of subtidal bottom substrate (consisting of unvegetated and unconsolidated sands) act as a storage bank for nutrients, sediment and chemicals, cycling between the sediments and the water column (Deaton et al. 2010). Benthic microalgae on subtidal bottom are composed primarily of benthic diatoms and blue green algae, with benthic dinoflagellates and filamentous green algae also present (Peterson and Peterson 1979). Together, the benthic microalgal and invertebrate populations within subtidal bottom may serve as an important food source for many juvenile fish. Juvenile and adult fish species that forage on the abundance of microalgae, detritus, and small invertebrates in

turn attract larger, economically valuable, predatory fish such as Florida pompano (*Trachinotus carolinus*), red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*Paralichthys dentalus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), and striped bass (*Morone saxatilis*).

Intertidal flats include the area of unvegetated bottom which lies between the high and low tide mark within estuarine and marine systems. Similar to subtidal soft bottom habitat, intertidal flats are considered unvegetated since macroscopic plants such as grasses and shrubs are not present; however, the benthic microalgal community within intertidal flats can be very abundant. The sediment texture of this habitat generally reflects the physical environment of the system. Coarser sediments (sands, shell fragments) are dominant in high energy systems while fine sediments (silts, clays) are more indicative of lower energy environments. Tidal current velocities are highest within the inlet complex, diminishing with increased distance from the inlet. As a result, inlet sediments can be highly mobile leading to the creation of new sand flats as well as erosion of existing flats.

The dynamic nature of the inlet system and the relative instability of sediment can create an inhospitable environment for the benthic community. Intertidal flats and shoals located upstream of the inlet complex and within semi-protected areas of the estuary are more stable and support a larger, more diverse benthic community. In conjuction with the Bald Head Island Beach Restoration Project (SAW-2007-2699), the Village of Bald Head Island intitiated a biological monitoring program to characterize the benthic macrofuanal communities inhabiting nearshore soft bottom communitites including Jay Bird Shoals and Bald Head Shoals. Benthic samples yielded three dominant taxa including approximately 37 crustacean, 22 polychaete and 12 mollusk taxa. In general, the mean taxa were relatively low at each of the three sites (borrow site and reference sites) due to the factors described above as well as due to temporal variability associated with recruitment and predation patterns.

Monitoring for the Bald Head Island Beach Restoraiton Project indicated that mean total abundances did not differ between years at any of the sites (Jay Bird Shoals, Bald Head Shoals, and Middle Ground) sampled. In 2012 (Year 3 post-dredging), mean total abundance at Jay Bird Shoals was greater than at two of the three reference sites (Middle Ground and Jay Bird Reference), but the differences were not significant. Similar to the reference sites, diversity and species richness at Jay Bird Shoals did not significantly differ between 2009 (pre-construction) and 2012 (post-construction Year 3). Jay Bird Shoals was dominated in both years by amphipods and other taxa which are adapted for life in environments prone to natural disturbance. These taxa presumably recolonized quickly after project construction and were joined by other taxa that may have capitalized on the reduced competition for space associated with recently disturbed habitats. The rapid recolonization of Jay Bird Shoals observed in 2010 (Year 1 post-construction) appeared to have resulted in a relatively stable benthic community assemblage which persisted through 2011 and 2012. The dominant taxa inhabiting these shoals appear to be highly resilient and many actually thrive in environments that are prone to disturbance (LMG 2011, 2012, 2013).

Intertidal shoals provide important foraging and roosting habitat for a variety of shorebirds and waterbirds. Federally-protected species such as the piping plover and state-listed species such as the Wilson's plover, least tern, common tern, and American oystercatcher are all known to utilize intertidal flats for foraging and roosting grounds.

In North Carolina, shell bottom is defined as estuarine intertidal or subtidal bottom composed of surface shell concentrations of living or dead oysters, hard clams and other shellfish (Deaton et al. 2010). Shell bottom, commonly referenced as oyster beds, oyster rocks, oyster reefs, oyster bars or shell hash, can be intertidal or subtidal, natural or man-made. Oysters are the principal builders of natural shell bottom in North Carolina’s estuaries and generally co-exist with adjacent habitats including, salt marsh and mudflat habitat. Shell hash refers to an accumulation of unconsolidated broken shell fragments (oyster, hard clam, bay scallop and/or other shellfish) on soft bottom substrate.

Shell bottom is recognized as an important link in the transfer of productivity between surface waters and bottom habitat and oyster reefs have long been recognized for their importance in overall water quality through water filtration and sediment stabilization. In addition, shell bottom provides critical fisheries habitat not only for oysters, but also for recreationally and commercially important finfish, other mollusks, and crustaceans.

While salinities in the Cape Fear River estuary are suitable for larval settlement and recruitment, living shellfish resources (eastern oysters, hard clams and bay scallops) have not been identified in the immediate project area. A 2010 shellfish survey in the mouth of Bald Head Creek and adjacent intertidal shoals found individual relic oyster shells and clam shells and several small clumps of relic oyster shells which were isolated to an area around a remnant dock structure at the mouth of the creek.

4.3.2 Coastal Beach and Dune Habitats

There are three primary beach segments along Bald Head Island, the beachfront community from the point at Cape Fear facing east toward the Atlantic Ocean (East Beach), the south facing beach (South Beach) and the portion of the island bordering the Cape Fear River (West Beach). As indicated earlier in Section 4.1, there have been significant, long-term morphological changes to the shorelines and beach environs of Bald Head. Some of these changes have been characterized by prior studies (USACE 1989, Cleary 2008, USACE 2004). While beaches and dunes have not been surveyed in detail until recent times (i.e. 1999 to the present), qualitative changes may be assessed via nautical charts and historic aerial photography. Please refer to Figures 4.1-4.3 for a graphical depiction of approximate shoreline positions over the last 150 years (USACE 2004) and to Appendix L for geo-rectified, historical aerial imagery.

4.3.2.1 Wet Beach

Coastal beachfront environments are typically characterized by high wave energy and relatively low primary productivity (Steele 1968). The foreshore and nearshore zones of Bald Head Island consist of exposed bars and spits with sandy subtidal and intertidal substrates. As documented for similar barrier island complexes, percent organic matter of beachfront sediments is low relative to the sediments of protected, back-barrier sandflats. In addition, relative species diversity and abundance tends to be less than backwater habitats (Hackney et al. 1996). Overall, the wet beach habitat of Bald Head Island (particularly South Beach and West Beach) is a highly dynamic zone exposed to extreme physical forces that result in high rates of erosion and shoreline recession. In addition, these particular shorelines are affected by episodic sand disposal and nourishment events.

Benthic species along the ocean beachfront are adapted to coarser-grained substrates and high-energy environments. Collectively, the benthic assemblage represents an important food source for many shore birds and important recreational fish species such as flounders, pompanos, mullets and kingfish. While meiofaunal assemblages are rather diverse, the larger macrofaunal community in the swash zone is generally characterized by low density and abundance due to dynamic and active wave conditions (Posey et al. 1996).

In conjunction with the Bald Head Island Beach Restoration Project (SAW-2007-2699), the Village intitiated a biological monitoring program to determine the abundance of coquina clams and mole crabs along various beach segments including the intertidal surf zone of South Beach and West Beach. Results from the study indicate inter-year variability among all three invertebrate taxa likely attributed to seasonal fluctuations in species abundance with low abundances during the winter season (LMG 2010, 2011, 2012).

Many species of birds forage within this habitat type. Shorebirds and waterbirds such as sandpipers, willets, sanderlings, dunlins, terns, and gulls utilize the surf zone to prey on fauna that either wash out of the sand due to wave action, or come close enough to the

shore to be captured. Furthermore, 25 red knot (*Calidris canutus rufa*) individuals were observed along the beaches of Bald Head during an annual survey conducted in May of 2012 (Schweitzer, personal communication). Rare species such as Wilson's plovers, American oystercatchers, least terns, common terns, and piping plovers have been observed foraging within the surf zone of Bald Head.

Subsequent to an acceleration of erosion along the western extremity of South Beach, the Village sponsored a 360,000 cy beach fill along 10,000 ft of shorefront in 1992. The material was eroded in its entirety in 18 months. As a direct result, the Village's engineer determined that any subsequent fill at that location would necessitate a groinfield suitable for improving the longevity of the nourishment material. The ensuing project constructed in 1996 provided for the installation of sixteen "soft groins" employing sand filled geotextile tubes. Although a "hard" structure ban was in existence at that time within N.C., the State provided a variance to the Village allowing the installation of 16 sand filled geotextile tubes. Construction of the groins was performed concurrent with a 650,000 cy beach fill. No additional large-scale fill projects occurred on Bald Head Island until 1.89 Mcy of sand was disposed in 2001 along South Beach as a direct result of the construction of the Wilmington Harbor Deepening Project, with entrance channel realignment seaward of Bald Head Island.

All sixteen groins were replaced in 2005, immediately subsequent to the federal fill placement. The entire sixteen tube groinfield was again replaced in 2010 as part of a Village-sponsored fill project. In the spring of 2013, the westernmost five (5) sand tube groins (damaged by Hurricane Irene in 2011) were replaced concurrent with a 1.8 Mcy federal beach disposal project. Both the Village and the Wilmington District have concurred that the groinfield to date has served to reduce the effective loss rate of sand placed on South Beach.

4.3.2.2 Dry Beach

Upper-beach habitats are situated just above the mean high tide limit, but are flooded by high spring tides and storm surges. Substrates consist of unconsolidated sand and shell

sediments that are constantly shifted by winds and floods thereby supporting less vegetation than the adjacent dune community. Vegetation is generally limited to the upper dry beach and, on Bald Head Island, commonly includes beach spurge (*Euphorbia polygonifolia*), sea rocket (*Cakile edentula*) and pennywort (*Hydrocotyle bonariensis*).

The dry beach of South Beach and West Beach is subject to continual morphological changes due to erosion. While sediment losses along western South Beach and West Beach occur irrespective of nourishment or federal disposal, the lack of nourishment actions for any extended period of time results in shoreline recession and deflation to an extent that dry beach can be effectively lost or severely degraded in some areas. Physical surveys of these segments of shoreline have documented the eroded condition exemplified by nearly vertical profiles from upland dune to the mean high water line (MHW). In addition, beach profiles often demonstrate the presence of a scarp of varying slope and height more pronounced along the chronically eroded segment of western South Beach than along beachfront areas to the east. The presence of the sixteen-tube groinfield has a net benefit in the retention of sand and stabilization of South Beach. However, it should be noted that when sand tubes become exposed or flanked, erosion and its associated effects (including escarpments and loss of dry beach) become more pronounced.

The sandy beaches are generally characterized by low productivity, both primary and secondary, likely attributed to the environmental instability of the exposed beach (Dexter 1992). As such, protected beaches buffered from physical extremes display greater species diversity than beaches associated with dynamic shorelines. Macroinvertebrates identified in the study area include relatively low densities of ghost crabs, mole crabs, and coquina clams (LMG 2010, 2011, 2012).

In addition to offering recreational benefits to residents of Bald Head Island and the general public, the dry beach is utilized by nesting and foraging shorebirds and waterbirds and provides a nesting ground for sea turtles. American oystercatchers, least terns, willets, and

Wilson's plovers have been documented nesting at Bald Head. These species tend to nest just above the high tide line on bare sand and shell with little or no vegetation. Their nests are shallow unprotected depressions that can be as small as a teacup.

As stated above, the loggerhead and green sea turtles utilize Bald Head Island for their seasonal (May-November) nesting events. Nests are typically laid between the high tide line and the dune front (Routa 1968, Witherington 1986, Hailman and Elowson 1992). Loggerheads generally prefer high energy, relatively narrow, steeply sloped, coarse-grained beaches. Green sea turtle nesting habitat consists of open beaches with a sloping platform and minimal human disturbance.

Some mammals are also known to utilize beaches as feeding grounds. Among these are raccoons, feral cats and foxes, which are known to patrol the wrack line at the high water mark and scavenge eggs from sea turtle nests (Dewire, personal communication).

The federally-protected plant, seabeach amaranth, occurs on beaches, lower foredunes, and overwash flats. Less than five amaranth plants have been documented annually on Bald Head Island since 2006.

4.3.2.3 Dune

Dune habitat typically presents a rigorous environment of physical extremes with varying hydrologic regime, precipitation, wind, and salt spray influencing vegetation species growth and composition (Wagner 1964). Further, dune structure is significantly influenced by the physical effects of storms and extreme high tides. Therefore, morphology and ecological function can vary along any particular segment of shoreline. Coastal dunes and dune systems are closely tied to geologic processing and are products of sand source, transport and deposition. Upper beach areas that are relatively stable may begin to trap wind-borne sands (Rogers and Nash 2003). In these accretional zones between upper beach and dune, smaller features or “dunelets” that tend to be sparsely covered with vegetation capture

wind-driven sand. Over time, these features increase in size and elevation and larger dunelets may attach to the foredunes. The lee slopes of foredunes tend to be more stable due to decreased exposure to wind and salt spray (Wagner 1964). Interdune flats and swales occupy more expansive areas behind the foredunes. Godfrey (1977) describes the barrier island dune complex of southeastern North Carolina as relatively low, irregular and discontinuous with overwash areas between dune structures.

Various definitions have been used to characterize dunes pending context and use. In the regulatory context, the North Carolina Division of Coastal Management (DCM) defines two principal types of dunes: (1) frontal dune; and (2) primary dune. Frontal dune is defined as the first mounds of sand that have enough vegetation, height, and continuity to offer protection. Primary dune is defined as the first mound of sand that is six feet taller than mean flood level (15A NCAC 07H .0305). Rogers and Nash (2003) present a singular and broader definition. According to these authors, dunes are defined as any area landward of the active beach where dune grasses are the dominant plants. Regardless of the specific definition ascribed, it is well recognized that dunes are dynamic features of the shoreline that provide important storm protection functions. As a result, the Village adopted a dune protection ordinance to ensure the safety of the frontal dune line which runs along oceanfront portions of the Village's corporate limits. According to this ordinance, it is unlawful to disturb or infringe on any frontal dune areas except as marked public access points. The ordinance prohibits the construction of a dune crossing or oceanfront access without the issuance of a building permit and CAMA permit.

Dune communities occur in a highly dynamic and stressful environment. Long-term trends on shoreline accretion and recession on Bald Head Island have been summarized by others (USACE 1989; USACE 2004; Cleary 2008). Periods of progradation (e.g. 1888 to 1962) create conditions suitable for natural dune-building processes including vegetation establishment and the subsequent interception of wind-borne sands (as described above). Similarly, dunes may be susceptible to destabilization and collapse during periods of increased erosion.

Refer to historic aerial photography provided in Appendix L depicting shoreline conditions on Bald Head Island from 1938 to 2010.

In addition to erosion, dune vegetation is susceptible to other physical forces (e.g. wind) that influence vegetation establishment and growth. Blowing sand may bury the vegetation and wind erosion may expose plant roots. Coastal dune vegetation experiences near constant exposure to salt spray and must be able to withstand soils with excessive drainage, low nutrients, extreme temperature fluctuations and oceanic overwash. Vegetative coverage within the dune community ranges from sparse on foredunes and dynamic areas to fairly dense on more stable dunes (Schafale and Weakley 1990). Common dune vegetation identified on Bald Head Island includes American beach grass (*Ammophila breviligulata*), panic grass (*Panicum amarum*), sea oats (*Uniola paniculata*), broom straw (*Andropogon virginicus*) and salt meadow hay (*Spartina patens*). Rare plant species that may occur within upper beach and/or dune habitat at Bald Head Island include seaside spurge, beach morning-glory, seabeach knotweed, dune bluecurls, and moundlily yucca. Furthermore, the NC Natural Heritage Program has identified a dune grass natural community along the eastern portion of South Beach.

The dune-ridge system acts as a barrier to storm tides and waves thereby protecting low-lying backshore habitat as well as infrastructure. Dunes also provide habitat for a number of animals. Shorebirds, colonial waterbirds and other waterbirds utilize the dune community for breeding, foraging, nesting, roosting and overwintering during seasonal migrations. Among the nesting species are the willet, American oystercatcher, and Wilson's plover, which prefer nest sites in dune areas with sparse grass or herbaceous cover. Several gull species also nest in dunes, but prefer areas with somewhat more dense coverage. The common ground dove (state protected) has also been noted in dunes or the margins of maritime woods near the project area, but has not been observed in over twenty years and may be extirpated from the region.

Several mammals including mice, rabbits, foxes, raccoons, and feral cats also use dunes for feeding. Reptiles are also common inhabitants of dunes. Several species of anoles are quite common. Many different types of snakes also live and feed in dune systems. Eastern hognose snakes, yellow rat snakes, and eastern coachwhip snakes all utilize grassy dunes or more woody areas of backdunes as habitat.

4.3.2.4 Interdunal Wetlands

Wetlands in the project study area are confined primarily to herbaceous and shrub-dominated interdune depressions and swales of the maritime dune system. Figure 4.7 depicts the approximate location and extent of interdune wetlands mapped in the study area. The wetland depressions exhibit varying hydroperiods (seasonal saturation to intermittent inundation) depending upon elevation. Hydrologic inputs are from precipitation and episodic storm overwash. Soils are generally characterized by the presence of a thin muck (i.e. high organic) surface underlain by gleyed sand. The vegetative community is influenced by the specific hydrologic regime of each depression and its exposure to salt spray. Dominant herbaceous species include salt-meadow cordgrass (*Spartina patens*), sawgrass (*Cladium mariscus*), black-needle rush (*Juncus roemerianus*), bushy bluestem (*Andropogon glomeratus*), marsh fimbry (*Fimbristylis castanea*), and slender goldentop (*Euthamia caroliniana*). In areas of disturbed soils, common reed (*Phragmites australis*) is also prevalent. Characteristic shrub species include wax myrtle (*Morella cerifera*), red cedar (*Juniperus virginiana*), seacoast marsh elder (*Iva imbricata*) and groundsel tree (*Baccharis halimifolia*).

Intertidal and supratidal coastal wetlands exist northwest of the project area. These wetlands are associated with the tidal waters of Bald Head Creek and are dominated by S. alterniflora (in the lower marsh) and *S. patens*, coastal salt grass (*Distichlis spicata*), and marsh elder (*Iva frutescens*) in the high marsh.

4.3.2.5 Maritime Shrub/ Maritime Forest

Maritime shrub and maritime forest communities occur within sheltered areas of barrier island systems but are still somewhat subject to the extremes of the maritime environment. The more exposed areas of forest tend to grade to maritime shrub or dune grass community. Salt spray has long been recognized as an important on-going stress, sculpting the canopy and excluding most species (Schafale and Weakley 1990). Heavy winds and salt water intrusion resulting from episodic meteorological events such as hurricanes can damage significant portions of the forest, but typically do not destroy the entire forest canopy. Maritime forests play an important role in the barrier island ecosystem by providing habitat for wildlife, stabilizing soil thereby reducing island erosion, and store precipitation in the surface water table (Bellis 1995).

Vegetation of the maritime forest of Bald Head Island generally consists of live oak (*Quercus virginiana*), laurel oak (*Quercus laurifolia*), willow oak (*Quercus phellos*), and loblolly pine (*Pinus taeda*) in the canopy. These species, in addition to red cedar (*Juniperus virginiana*), yaupon (*Ilex vomitoria*), flowering dogwood (*Cornus florida*), and Carolina laurelcherry (*Prunus caroliniana*) tend to also occupy the sub-strata. Dwarf palmetto (*Sabal minor*) and various vines (including *Vitis rotundifolia*, *Toxicodendron radicans*, and *Smilax* spp.) tend also to be prevalent within these communities. Areas lacking a mature canopy tend to be dominated by shrubs (e.g. wax myrtle, yaupon), dwarf palmetto, vines, and stunted live oak. The southern and eastern exposure on Bald Head Island and associated high frequency disturbance has been cited to result in the higher occurrence of shrubs and less dense canopy in many of these areas (Lopazanski et al. 1988). Maritime forests on the island have been found to support an assortment of rare plants including: spreading sandwort, liverwort, four-angled flatsedge, nerved witch grass, Terrell grass, coralbean, shortleaf basket grass, large-seed pellitory, cabbage palm, tough bumelia, and Cuban schliessmund. Several populations of dune bluecurls have also been documented in dunes and sandy openings in maritime scrub habitat.

Common fauna of maritime forests include wading birds such as herons, egrets, brown pelicans, as well as a variety of ducks and songbirds. Birds of prey such as red-tailed hawks and ospreys also utilize hammocks for feeding, roosting and nesting. Other bird species include the Carolina wren, blackburnian warbler, golden-winged warbler, and the eastern painted bunting. Small mammals such as mice, rats, raccoons and the red fox are prevalent throughout the forest and shrub thickets. The eastern woodrat is a rare mammal that inhabits moist forests. However, it has not been observed on the island since 1966. A variety of species of herpetofauna including the glass lizard, black racer, and five-lined skink can also be found within this habitat type. The giant swallowtail, a state-listed butterfly, is primarily found in maritime forests or thickets. Its host plants include prickly-ash and hoptree. Approximately 50 to 60 individuals were observed in the summer of 2003 within maritime forest habitat at BHI.

Maritime forest is considered one of the most endangered community types in North Carolina. The principle source for loss or impairment is barrier island development and subsequent habitat fragmentation (Schafale and Weakly 1990). Approximately 191 acres of relatively undisturbed maritime forest habitat is protected via the Bald Head Woods Coastal Reserve located in the central portion of Bald Head on both the north and south sides of Federal Road.

4.3.3 Marine Habitats

4.3.3.1 Soft Bottom Communities

The *2010 NC Coastal Habitat Protection Plan* defines soft bottom as areas of primarily unvegetated, unconsolidated sediment (i.e. loose sediments typically categorized into four grain size classes: fines, sand, granular, and gravel) beneath the water column including both deeper subtidal bottom as well as shallow bottom areas (Deaton et al. 2010). Soft bottom habitat is an important component of primary nursery areas, anadromous fish spawning areas and anadromous fish nursery areas. Habitat varies according to geomorphology,

sediment type, water depth, hydrography and/or salinity regime. Note that intertidal bottom and its associated functions are described in Section 4.3.1 (Estuarine Resources). Marine soft bottom habitat in the vicinity of the project area occurs in areas seaward of MLW of the shoreline of Bald Head Island and includes bottom areas of the offshore prospective borrow sites (including Jay Bird Shoals, Frying Pan Shoals and the Baldhead Shoal Channel of the Wilmington Harbor Navigation Project).

Similar to estuarine soft bottoms, marine soft bottoms provide important foraging areas for fish. Benthic microalgae play a fundamental role in the ecological function of soft bottom habitat and are recognized as an important source of primary production in these systems and support large numbers of benthic invertebrates. Benthic invertebrate populations in sand bottom communities along the North Carolina coast have been documented to have a high species diversity. The *2010 NC Coastal Habitat Protection Plan* summarizes scientific research which found offshore sand bottoms contain over 600 species of benthic invertebrates. A study conducted by UNCW researchers off Kure Beach found polycheates dominated the soft bottom but bivalves, crabs and amphipods were also present in high numbers (Posey and Alphin 2002). Ebb tide deltas at the mouth of the inlet are also expected to contain polycheates, amphipods, clams, crustaceans and echinoderms (Deaton 2010). These benthic infaunal and epifaunal taxa provide an important link between primary production and consumers and are considered the primary food base to North Carolina's bottom feeding fish species.

Marine soft bottoms in the project area, including ebb tide portions of the inlet, the shoreface and shoals provide foraging areas for several marine fish species. Species that may utilize thes soft bottom foraging areas include Florida pompano (*Trachinotus carolinus*), red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*Paralichthys dentalus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*) and striped bass (*Morone saxatilis*). Several of these species are known to congregate along cape shoals and ebb tide deltas. All coastal inlets in North

Carolina are designated as Habitats Areas of Particular Concern (HAPC) for blue crabs, estuarine-dependent snapper-grouper species, paneaid shrimp, and red drum by the South Atlantic Fisheries Management Council (SAFMC) (Deaton 2010). The sandy shoals of Cape Fear are also designated HPAC from the shore to the end of the shoal for all coastal migratory pelagics such as king mackerel, Spanish mackerel, dolphin and cobia.

Marine soft bottoms in the area may also provide spawning areas for shark species. Specifically, nearshore waters with soft bottoms may support spawning areas for Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), bonnethead shark (*Sphyrna tiburo*), blacknose shark (*Carcharhinus acronotus*), spinner shark (*C. brevipinna*) and dusky shark (*C. obscurus*) (Deaton 2010).

Soft bottoms, particularly in the estuarine system, provide refuge for small juvenile fish and invertebrates. Unvegetated intertidal flats adjacent to intertidal marsh, which provides cover, are utilized by juvenile fish. Estuarine soft bottoms with shallow depths also limit the ability of larger predatory fish to access the area, thereby benefiting juvenile fish and invertebrates (Deaton 2010). The ability to burrow into soft bottoms is often utilized by cryptic fish such as gobies, flatfish, skates, rays and various invertebrates. Soft bottoms located in marine environments may be utilized by species with burrowing or camouflaging adaptations, such as rays and flounders. Sandy marine soft bottoms, particularly those in deeper waters, are not thought to provide protective refuge for small fish without such adaptations since the lack of structure makes them susceptible to predation.

Soft bottoms provide important migration corridors for fish utilizing varying environments for juvenile and adult stages of the life cycle and for spawning. Soft bottoms provide a corridor between freshwater, estuarine, and marine environments and are often utilized by juvenile fish moving from freshwater and marine areas into estuarine nursery areas (Deaton 2010). Subadults leaving nursery areas may subsequently utilize soft bottom corridors to move into the ocean. Larger fish may utilize sandy soft bottoms for these migrations;

however, juveniles prefer estuarine muddy bottoms adjacent to wetlands where structure and suspended sediments provide cover from predation (Deaton 2010). Sturgeon (Atlantic and shortnose) have been documented to utilize soft bottom corridors to reach freshwater spawning areas. While shortnose sturgeon would not be expected to be present in the project area, adult Atlantic sturgeon are known to move through the mouth of the Cape Fear River to reach freshwater spawning areas in upper reaches of the river.

As part of Carolina Power and Light's NPDES Permit NC0007064, CP&L (now Duke Energy), embarked on a multi–decade, comprehensive biological monitoring program to describe the offshore concentrations and changes in density over time of commercially important taxa in the nearshore and estuarine environments of the Cape Fear River Estuary. Beginning in 1971 and continuing through 1992, fish and invertebrate taxa were sampled, identified and monitored for changes in abundance, seasonality, or recruitment to the estuary via impingement resulting from the normal operations and modification of the Brunswick Electric Steam Plant's (BESP) water intakes. More than 40 taxa (CP&L, 1979) of fish and invertebrates were identified with 9 commercially significant species (Atlantic menhaden, bay anchovy, spot, croaker, southern flounder, brown shrimp, pink shrimp, white shrimp, and blue crab) documented to be relatively abundant throughout the Cape Fear River Estuary (CP&L,1992). Silversides (*Atherinidae* family), hogchokers (*Trinectes maculatus*), and blackcheek tonguefish (*Symphurus plagiusa*) were also reported to be relatively abundant (as a percent total catch).

Markovsky (2004) reported the abundance of ichthyoplankton sampled during 2002 and 2003 from plume, ocean, and estuarine stations in the vicinity of the Cape Fear River mouth. Based upon this sampling effort, Atlantic croaker, gobies (*Gobiosoma* spp.), anchovies (*Anchoa* spp.), and feather blenny (*Hypsoblennius hentzi*) were reported to be the most abundant ichthyoplankton collected at the estuary and plume stations. Larval abundance of southern kingfish (*Menticirrhus americanus*) and hogchoker were also relatively high during 2003 sampling.

Several other studies have investigated estuarine and nearshore larval and juvenile fish distribution and abundance near inlets along the South Carolina and North Carolina coast. An annotated bibliography (with emphasis on inlets in close proximity to the Cape Fear region) has been assembled and is included for reference (Appendix O).

4.3.3.2 Hardbottom Communities

Hard bottom habitat in the South Atlantic Bight generally consists of exposed rock or consolidated sediments in near-shore or off-shore marine waters. Exposed hard bottom provides the substrate surface area for colonization by invertebrates and algae. In turn, these areas serve as an important food source to a variety of invertebrate and fish species. Community structure varies widely with depth, location and season.

These habitats are characterized by a rich diversity of invertebrates (e.g. sponges, corals, anemones, tunicates, and mollusks) and reef fish such as gag grouper (*Micteroperca microplepis*), red grouper (*Epinephelus morio*), red snapper (*Lutjanus campechanus),* vermillion snapper (*Rhomboplites aurorubens*), black sea bass (*Centropristis striata*), greater amberjack (*Seriola dumerili*) and white grunt (*Haemulon plumieri*) and are thus commonly referred to as "live bottoms" or "live rock".

Ocean-bottom surveys conducted by the USACE in the vicinity of the new channel alignment for the Wilmington Harbor Navigation Project did not indicate the presence of hard bottoms within or near its path (USACE 2000). Hard bottoms have, however, been identified near the seaward limit of the former federal navigation channel (approximately five miles offshore). The presence of this hard bottom during the design of the last Harbor deepening project ultimately prompted the re-orientation of the channel alignment to avoid dredging impacts to this type of biological community. Natural hardbottom outcrops have been identified in federal waters of Onslow Bay and Long Bay (Deaton et al. 2010). Refer to Figure 4.10 depicting the locations of mapped hard bottom in the vicinity of Bald Head Island.

4.4 WATER COLUMN

Water column habitat is defined as "the water covering a submerged surface and its physical, chemical, and biological characteristics" (Deaton et al. 2010). This habitat is considered the primary component which binds the entire coastal aquatic ecosystem connecting a complex web of influences from both land and sea [15A NCAC 07H .0206(b)]. The water column provides a basic ecological role in the assimilation of energy and nutrients at the base of the food chain through primary productivity, largely by phytoplankton, and benthic-pelagic coupling. Open water provides nursery habitat for planktivorous larvae and a number of juvenile pelagic species and provides a corridor for numerous anadromous and catadromous species (Deaton et al. 2010). Primary Nursery Areas (PNA) as designated by the Marine Fisheries Commission are depicted in Figures 4.11 and 4.12.

Estuarine waters have moving boundaries and are maintained by tide and wind driven mixing coupled with freshwater supplied from the upland watershed. The estuarine water column is the medium of transport for nutrients and migrating organisms between river systems and the open ocean. While nearby wetlands contain some assimilative capacity abating nutrient enrichment, fresh water inflow and tidal flushing are primarily important for circulation and removal of nutrients and wastes from the estuary. Coarse-grained sediment, saline water and migratory organisms, including larvae, are introduced from the ocean while finer-grained sediments, fresh water, nutrients and organic matter are supplied by rivers and tidal creeks. The Cape Fear River is the only major river in North Carolina that flows directly into the Atlantic Ocean making its estuary unique compared to others in the state. The estuarine surface area totals 100km^2 (Ensign et al. 2004), and the river mouth is approximately one mile in width. The average flow rate of the Cape Fear River at its mouth is 9,700 cubic feet per second (USACE 2000) and the flushing rate is approximately 14 days which makes it the most rapid turnover of all major estuaries in North Carolina.

The marine water column includes waters overlying the continental shelf and associated high-energy coastlines where salinities exceed 30 ppt. (Deaton et al. 2010, Cowardin et al. 1979). Lunar tidal cycles are the major mixing mechanism in the marine water column with tidal amplitudes averaging 4.3 ft. near Cape Fear. Winds are also an important component to water movement and mixing in the marine water column. Winds move large water masses inshore, in turn, aiding larval transport of ichthyofauna spawned in the offshore waters of the continental shelf in their migration to the beachfronts, inlets and estuaries vital for the next phase of development.

Several commercially and recreationally important fish species in North Carolina are estuarine-dependent species that spawn offshore and utilize estuarine nursery areas for the juvenile life stage. Estuarine-dependent species which spawn offshore of North Carolina include Atlantic menhaden (*Brevoortia tyrannus*), spot (*Leistomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), flounders (*Paralichthys albigutta*, *P. dentatus*, and *P. lethostigma*), and shrimp (Forward 1999). The supply and harvest of these commercially important species has been strongly correlated to the success of larval recruitment through relatively small inlets into the estuary (Blanton 1999).

Computer modeling of physical conditions off the North Carolina coast have generally concluded that movement of larvae across the continental shelf to mid and inner portions of the continental shelf is primarily wind-driven (Luettich et al. 1999, Blanton 1999). However, once larvae reach nearshore waters at the mouth of the inlet, the exact mechanisms for transport through the inlets was not well documented prior to studies conducted in the late 1990s. In an effort to better understand the mechanisms for larval transport through a tidal inlet and those factors that most affect successful recruitment, a multidisciplinary study was conducted around Beaufort Inlet, NC. The South Atlantic Bight Recruitment Experiment (SABRE) was funded through a NOAA Coastal Ocean Program Grant and included a series of field-based and physical modeling studies conducted in March 1999.

The studies generally found that transport into the inlet was most strongly influenced by astronomic tidal factors, and once larvae were located in nearshore waters at the inlet, wind direction had minimal influence (Luettich et al. 1999). A key finding of the SABRE was that larval transport through the inlet was not symmetrical, with an order of magnitude difference in the number of larvae entering on the eastern side of the inlet than on the western side of the inlet (Forward et al. 1999). Similarly, higher larval abundances were found in eastern channels of the estuary (Shackleford Channel) based on circulations patterns from the eastern side of the inlet into the estuarine channel.

Evidence for behavioral adaptations by the larvae was found, and suggested behavioral adaptations enhanced retention once in the estuary but were less apparent during transport across the inlet. Larvae were found to rise to higher portions of the water column during flood tides and moved to lower portions of the water column on ebb tides (Forward et al. 1999). Increased larval abundance was also found at night, suggesting diel patterns of larvae may enhance recruitment on spring tides which occur at night.

Physical studies of the SABRE found net subtidal flow into the estuary on the flood tide was higher on the eastern side of the channel, and net subtidal flow out of the estuary was highest on the western side of the channel (Churchill et al. 1999). Modeling of tidal circulations suggested a residual eddy existed on the western side of the inlet near the western ebb tide delta. Low larval abundance on the western side of the inlet may have been due to trapping of larvae in the eddy (Luettich 1999). Larvae that approach the inlet from the western side may not make it into the inlet due to this physical feature of the inlet. Therefore, the asymmetrical transport across Beaufort Inlet may be specifically related to the geometry and nearshore features of this inlet (Luettich 1999). Larval transport through other North Carolina tidal inlets may be similarly dependent on the geometry and physical tidal circulations of each inlet.

4.5 WATER QUALITY

The Cape Fear watershed is the most heavily industrialized basin in North Carolina, with numerous industries utilizing the Cape Fear in the upper watershed and eleven major industrial dischargers in the tidal basin itself. The watershed (about 9,149 square miles) has 244 permitted wastewater discharges with a permitted flow of approximately 425 million gallons per day, and (as of 2000) over 1.83 million people residing in the basin (NCDENR 2005). Approximately 24% of the land use in the watershed is devoted to agriculture and livestock production (NCDENR 2005), with livestock production dominated by swine and poultry operations. Thus, the watershed receives considerable point and non-point source loading of pollutants. A map of the Lower Cape Fear River Basin (Cataloging Unit 03030005) is included for reference (Figure 4.13). In addition, the 14-digit watershed map of Bald Head Island is depicted in Figure 4.14).

The Cape Fear River estuary is unique in comparison to other North Carolina estuaries due to the magnitude of tidal exchange and relatively high light attenuation which inhibits algal bloom formation (Mallin et al. 1999). Physiochemical parameters are affected by freshwater river flow, tides and wind forces. The salinity of waters in the proposed project area are generally near 35 ppt, but may be lower during ebb tide conditions and associated freshwater outflow. Water quality parameters including temperature, salinity, dissolved oxygen, total suspended solids, nutrients (primarily nitrogen and phosphorus) and chlorophyll *a* have the potential to affect fisheries resources as fish and invertebrates occur where water characteristics suit their physical requirements.

All surface waters in North Carolina are assigned a primary classification by the NC Division of Water Resources (DWR). According to DWR's classification of waterbodies, the lower section of the Cape Fear River, from Federal Point to the Atlantic Ocean, is designated as Class "SA" (the "S" denotes that these are tidal waters and the "A" denotes the Class A category). Class "SA" waters are suitable for marketable shellfishing and all uses identified

under the "SC" and "SB" classes (15 NC AC 2B .0311). All SA waters are also High Quality Waters[1] (HQW) by supplemental classification. The waters of the Atlantic Ocean in the vicinity of the mouth of the Cape Fear River are designated "SB". Class "SB" waters are tidal salt waters protected for all SC uses in addition to primary recreation. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. Class "SC" waters are all tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact; fish and noncommercial shellfish consumption; aquatic life propagation and survival; and wildlife (NC DENR 2014).

The NC Division of Water Resources' Modeling and Assessment Branch provides use ratings in compliance with Section 303(b) of the Clean Water Act. Waters considered to be impaired due to loss of designated uses are listed in the *2012 North Carolina 303(d) List-Category 5* dated February 24, 2012 and approved by the EPA on August 10, 2012. The draft 2014 303(b) listings were available but were not EPA-approved at the time this document was prepared. Waters listed in 2012 as Category 5 impaired within the project area and the immediately vicinity are described below.

Bald Head Creek from the source to the Cape Fear River (assessment unit NC18-88-8-4) is listed as impaired due to the loss of use as a shellfish harvesting area. Shellfish harvesting is not permanently open, and may be opened only if conditionally approved by the NC Shellfish Sanitation Office. The 2010 Waterbody Report for Bald Head Creek lists pathogens as the cause of the impairment, presumably from sources such as individual wastewater treatment systems on residential lots along Bald Head Creek. Fishing Creek which drains into Bald Head Creek from the north is also listed as impaired from its source to Bald Head Creek (assessment unit NC18-88-8-4-1). The cause for impairment is also due to the loss of use as

[1] Supplemental classification intended to protect waters which are rated excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Marine Fisheries Commission.

a shellfish harvesting area. There are no total maximum daily loads (TMDL) developed for either Bald Head Creek or Fishing Creek.

The Atlantic Ocean along Bald Head Island's South and West Beaches, and extending north to Kure Beach, is classified as mercury impaired with a loss of harvest of aquatic life (fishing) due high mercury concentrations in fish tissue. This assessment unit (NC99-(3)A) covers 14.5 miles and is specifically defined as "extending from the mouth of the Cape Fear River around Cape Fear to Dolphin Court in Kure Beach". There are no TMDLs for this listing.

Several 303(b) listed waterbodies are located in the adjacent Caswell Beach and Southport area. Portions of the Cape Fear River in the vicinity of Southport are listed. The Southport Restricted area, assessment unit NC18-88-3.5 is defined as "beginning at a point on the west bank of the Cape Fear River 1,000 yards upstream of Price Creek, thence in an easterly direction to the eastern border of the Cape Fear River". The Southport Restricted Area is listed for loss of aquatic life propagation and survival due to standards violations for arsenic, copper, and nickel. No TMDLs have been developed for this waterbody. Two assessment units exist for waters of the Cape Fear River which are impaired due to loss of shellfish harvesting uses. Those units are described as a prohibited area near Southport and a prohibited area east of the AIWW near Fort Fisher (assessment units NC18-(87.5)b1 and NC18-(87.5)d respectively).

Waters within the Elizabeth River-marsh complex behind Caswell Beach contain three assessment units which are impaired by the loss of shellfish harvesting areas. Assessment unit NC18-(87.5)c is located along the soundside of Caswell Beach extending from the eastern edge of Caswell Basin to the eastern edge of Molasses Creek (0.5 square miles). Molasses Creek from its source to the Elizabeth River (assessment unit NC18-88-9-2-5) and Coward Creek from its source to Molasses Creek (assessment unit NC18-88-9-2-5-1) are also listed due to prohibited shellfish harvesting. A section of the Elizabeth River "from the mouth of Molasses Creek and running northeast to a point of marsh at the junction of the

Elizabeth River and Dutchman Creek" is listed due to a loss of open shellfish waters with a status of conditionally approved waters (assessment unit NC18-88-9-2-(2)). No TMDLs are developed for any of these assessment units.

The AIWW located from the Dutchman Creek outlet to the mouth of Cottage Creek, in western Southport, is listed as impaired due to loss of shellfish harvesting uses and low dissolved oxygen (assessment units NC18-88-9a and NC18-88-9b).

Waters located west of the CP&L canal were not considered to be in the immediate vicinity of the project, and are not described in this document. However, it is noted that Piney Point Creek and Denis Creek, located within the tidal creek-marsh complex behind Oak Island, and the Dutchman Creek outlet adjacent to the CP&L canal are all impaired due to loss of shellfish harvesting use. Portions of the Elizabeth River west of the CP&L canal are similarly impaired.

4.6 AIR QUALITY

The Wilmington Regional Office of the NCDENR has jurisdiction over the air quality in this location. It has been determined that the ambient air quality for the area including Bald Head Island is in compliance with the National Ambient Air Quality Standards.

4.7 PUBLIC SAFETY

The Public Safety staff monitor for both natural and manmade disasters and events. The Village of Bald Head Island utilizes an all-call phone dialing system to notify residents, visitors and island workers of emergency situations such as pending hurricanes, evacuation notices, problems with utilities, etc. South Bald Head Wynd has been identified as a primary

evacuation route for residents and guests of Bald Head Island. The Public Safety staff also has contingency plans in place in the event evacuation is not a viable option.

The United States Coast Guard (USCG) Boating Statistics of 2011 ranked North Carolina as 11 out of 56 for the total registered vessels within United States governed territories (USCG 2011). There was an average of 396,706 recreational boats (motor boats and sailboats greater than 14 ft in length) registered in North Carolina in 2011 and 2010. In 2011 there were 9,366 registered vessels in Brunswick County (NCWRC 2011). There has been an average of 150 boating incidences each year in the state over the past five years. In 2011 there were 7 reported boating accidents (0 fatal) in Brunswick County.

4.8 AESTHETIC RESOURCES

The coastline of Bald Head Island possesses visually pleasing attributes including the natural resources of the Atlantic Ocean and the Cape Fear River estuary. There is a natural aesthetic to Bald Head Island which provides uninterrupted natural vistas of maritime forest, salt marsh and barrier island ocean habitat. The Island also has a rich maritime history which is visually apparent and offers scenic opportunities to residents and guests alike.

4.9 RECREATIONAL RESOURCES

Bald Head Island is open to the general public for a variety of recreational uses. Regular public ferry service to Bald Head Island is operated by Bald Head Island Transportation, Inc. For most of the year, ferries leave the mainland on the hour and from the Island on the half-hour, beginning at 7 a.m. Typically, the winter schedule is abbreviated due to the reduced number of visitors to the Island. Round-trip ferry tickets are available for purchase by the public at the Bald Head Island Mainland Ferry Terminal. In the summer, round-trip tickets

cost $24.75 for adults, $13.75 for children ages 3-12. There is no charge for children ages two and younger. Tram service may be provided based on ticket type and availability.

Bicycles and golf carts are available for rent in close vicinity to the ferry landing. There are approximately 27 public beach accesses, including approximately nine in the project study area. Most beach access points also provide parking for golf carts. While there is a relatively small population of permanent, year-round residents (approximately 220), there are on average 5,000 visitors to the Island during a typical summer weekend day. Water-related activities along Bald Head Island include, boating, diving, sailing, windsurfing, surfing, kite surfing, stand-up paddle boarding and canoeing. The Bald Head Island Conservancy offers organized hikes, nature walks and kayak tours to permanent residents, guests and the general public. An eighteen-hole golf course is also available at the Bald Head Island Club. The golf course is open to member guests and is available with rental properties that have memberships.

This area of coastal North Carolina offers an array of recreational fishing opportunities from the sandy beach, large sport-fishing boats and smaller jon boats and skiffs. Surf fishing is popular on Bald Head Island, and commercial entities also offer surf fishing activities on the Island. According to the North Carolina Division of Marine Fisheries recreational fishing statistics, 15,891 Coastal Recreational Fishing Licenses (CRFL) were issued in New Hanover County, NC in 2011. An additional 10,296 CRFLs were issued in Brunswick County, NC in the same year, a testament to the popularity of recreational fishing in coastal counties. The National Oceanic and Atmospheric Administration (NOAA) – National Marine Fisheries Service (NMFS) recreational fishery database indicates that drums (Family Sciaenidae), porgies (Family Sparidae) and bluefish (Family Pomatomidae) were the most commonly caught fish recreationally along the coast of North Carolina over the past three years (NOAA - NMFS 2012).

4.10 NAVIGATION

The Cape Fear River ocean bar channel has been maintained by the federal government for over 100 years. Over this time period, the width and depth of the navigational channel has been increased numerous times to accommodate larger vessels. By 1945, the federal channel had been deepened to 32 feet. In 1964, the USACE initiated deepening of the main harbor channel to 38 feet to accommodate 34-foot-draft (26,000 deadweight ton) vessels to call at any tide. This project was completed in 1970. Since the 1970s, vessel sizes have continued to increase. By the 1990s, approximately 50% of the ocean-going ships exceeded the 26,000 deadweight ton (DWT) design vessel. As such, these vessels could enter or leave Wilmington Harbor only at high tide or only when light-loaded (USACE 1996). The resultant increased shipping costs prompted the more recent Wilmington Harbor Deepening Project in 2001. The channel modifications included realignment of the ocean bar channel (30-degree southern shift); deepening of the ocean bar channel and entrance channel to 44 feet; and deepening of the 24.3-mile river reach (from Battery Island Channel to the Cape Fear Memorial Bridge) to 42 feet (USACE 2008).

The Cape Fear River is utilized on a daily basis for both recreational and commercial navigation. In 2010, 442 cargo ships and 6 barges came through the mouth of the river to access the Port of Wilmington (NC State Ports Authority 2012).

4.11 HISTORIC PROPERTIES AND CULTURAL RESOURCES

The Cape Fear River is recognized as one the most significant and historically important waterways of the Carolinas. The attached cultural resources report (Appendix K) provides a brief history of the Cape Fear River from the earliest Spanish explorers in 1526 through the present. The Lower Cape Fear in particular has served as a commercially important

navigational artery for over three hundred years serving both the ports of Brunswick and Wilmington. Numerous shipwrecks are known and identified within this section of the river.

Tidewater Atlantic Research, Inc. (TAR) conducted a magnetometer and sidescan sonar survey of the proposed construction area in May and August 2012. Analysis of the remote-sensing data generated during the Bald Head Island terrestrial and marine surveys identified a total of 104 magnetic anomalies. The cluster of four anomalies was associated with a shipwreck adjacent to the shoreline along South Beach. All other magnetic targets appear to have been generated by modern debris such as fish and crab traps, pipes, small diameter rods, cable, wire rope, chain, small boat anchors, etc. Following consultation with NCDCR personnel at Fort Fisher, NC, the vessel was investigated by TAR archaeological divers. The identified wreck remains appear to be a vessel approximately 160 to 190 ft in length, likely a sailing vessel. Per guidance received from the Division of Cultural Resources State Historic Preservation Office (SHPO), as the wreck has the potential for eligibility for Nomination to the National Register of Historic Places, a 150 ft buffer would be established to protect the wreck. Results of the 2012 archeological study and guidance received from SHPO can be found in Appendix K.

In addition to the archaeological investigations of the proposed terminal groin site, TAR has completed surveys of both the Jay Bird Shoals and the Bald Head Creek Shoals sand source sites. The investigation of the Jay Bird Shoals site was completed as part of the Bald Head Island Beach Nourishment Project authorized in 2009 and constructed in 2010. The findings of this investigation were presented within the project EA (LMG 2008). Magnetometer and side-scan sonar surveys (conducted by TAR) indicated two groups of magnetic anomalies exhibiting characteristics consistent with potential shipwreck material and/or significant cultural resources.

More recently, TAR completed an investigation of the Bald Head Creek Shoals site (including the 37.6-acre proposed expansion to the north). Based upon the historical and remote

sensing survey data collected as part of this effort, no NRHP eligible submerged cultural resources were identified in the 2014 survey area. The shallow area north of the mouth of Bald Head Creek is reported to have been the location of a number of channel range markers. TAR recommended that in the event dredging exposes the remains of one or more range beacons the NC Underwater Archaeology Branch (UAB) at Fort Fisher should be informed so that an assessment of the structures' historical significance can be assessed and remains documented. With that exception, no additional investigations were recommended by TAR. SHPO recently issued a letter (dated July 3, 2014) concurring with the findings of TAR's report. Refer to Appendix G for SHPO's letter and for the complete report prepared by TAR.

4.12 SOCIO-ECONOMIC CONSIDERATIONS

Population growth among permanent residents on Bald Head Island has occurred since the Village's incorporation in 1985. Between 1990 and 2000, the population increased by 121.8%. Bald Head Island is a popular travel destination and the Village relies on seasonal visitors as a source of revenue. During summer months the population on the island increases significantly. In 2010 roughly 996 housing units of a total of 1,111 housing units were considered to be seasonal in nature. Businesses focus on providing the necessary services to support seasonal demands as well as servicing the year round clientele. The Island offers two bed and breakfasts, restaurants, a market and retail stores.

Bald Head Island, Limited, LLC is the Island's largest employer and one of the largest in Brunswick County, employing 270 employees. It is also the Village's largest source of tax revenue with real estate holdings valued in excess of $97,000,000.00. The Bald Head Island Club is the second largest employer on the Island and one of the largest single tax payers on the Island, paying approximately $140,000 per year in property taxes, in addition to sales taxes on approximately $5 million in Club revenues and $500,000 in ferry ticket purchases.

The Club also pays approximately $20,000 in sales taxes on out-of-state purchases. The current economic impact of the Club is not known, but clearly extends to surrounding municipalities and states.

In addition to a championship golf course, the Club houses a pool, fitness facility, tennis courts and two restaurants. Because the Club serves as the foundation for recreation and social activity island wide, the gross domestic product (GDP) of the Island is strongly associated with the Club, its associated activities, and the resultant effect on home purchases and rentals on the Island. On average, twenty-thousand rounds of golf are played each year on the Club's championship eighteen-hole golf course. A majority of these rounds (63%) are played by non-members that rent Island residences. It is estimated that 500 homes are rented each year (equivalent to $5,700 weekly in rental income) as a direct result of the amenities offered by the Club. Over 81,000 full meals were served at the club in 2011, totaling roughly $3 million in food and beverage sales. All of the Club's seafood and produce are locally sourced. The Club is also the second largest employer on the Island, employing 151 people during the summer and 75 people during the off-season. None of the Club's employees are Island residents. The Club's largest expense is payroll (accounting for an average of 57% of accounts payable) in most years (Norton, personal communication).

Bald Head Island serves the public, including residents of North Carolina and many other States and Countries, with its beachfront being among its principal draws. It is not atypical to find 5,000 or more visitors on a summer weekend day. As such, the Village has constructed and maintained numerous beach accesses to support the daily public demands.

4.13 LAND USE

Development of Bald Head Island began in 1972 with the construction of an inn and 18-hole golf course. The successor and current developer, Bald Head Island Limited, designed the

planned unit development (PUD) of the Island which encompasses 2,000 acres. With increasing build-out and anticipated increase of both permanent and part-time residents, along the with inherent advantages of municipal form of government for achieving the planned community goals, the Village of Bald Head Island was incorporated as a municipality in 1985.

The island is accessible to the public by means of a passenger ferry which operates between Southport, NC and Bald Head Island Marina. The Village exists primarily as a second home community and is a well known tourist and seasonal destination. Commercial activity includes real estate, rentals and support services, construction, vehicle repair and numerous retail establishments. Construction activity involves the marina, country club, Shoals Club, multifamily common areas, Bald Head Island Conservancy, office space, and town-owned facilities.

The Village developed its own CAMA Land Use Plan certified by the CRC on May 22, 2008 and has adopted its own policies regarding planning and resource management. Bald Head Island policies have been incorporated into the Brunswick County Land Use Plan. These policies promote natural resource protection and management and guide responsible development. Additionally, state and federal laws manage development in Ocean Hazard Areas of Environmental Concern and Estuarine Shoreline Areas of Environmental Concern (AECs). The proposed project is located within the Ocean Hazard AEC.

According to the Village's LUP, approximately 59% of the Village's total platted tax parcels remain undeveloped. Of the 1,291 vacant parcels, 1078 (87%) are zoned for single family residential. According to the environmental composite analysis performed as part of the development of the LUP, nearly all of these lots are located within the Class II designation. This is land that has hazards and limitations for development that can be addressed by restrictions on land uses, special site planning, or the provision of public services such as water and sewer. Land in this class will generally support only the less intensive uses such as

low density residential (VBHI 2006). Maps of current and future land use classifications are provided for reference (see Figure 4.15 and Figure 4.16). Likewise, FEMA floodzones are identified in Figure 4.17.

4.14 HYDRODYNAMICS

4.14.1 Tides and Tidal Flow

The astronomical tides in the vicinity of Bald Head Island are semi-diurnal and have average mean and spring ranges of approximately 4.3 ft and 5.0 ft, respectively. Tidal datums for Bald Head Island are listed in Table 4.2.

Table 4.2. Tidal Datums for Bald Head Island, North Carolina

Datum	Elevation (Relative to NGVD 1929*)
Mean Higher High Water (MHHW)	+2.82 FT
Mean High Water (MHW)	+2.51 FT
Mean Tide Level (MTL)	+0.35 FT
NGVD 1929	0.00 FT
Mean Low Water (MLW)	-1.81 FT
Mean Lower Low Water (MLLW)	-1.98 FT

* Approximations based upon extrapolation from Southport, NC.

Figure 4.18 plots the predicted astronomical tides for the 2014 calendar year near Bald Head Island. The water levels ranges suggest minor seasonal fluctuations in tide range whereby astronomical tides are minimally higher during fall (October through December). The lowest tides of the year are predicted to occur January through March.

As part of the monitoring program of the Wilmington Harbor Navigation Project, the USACE has conducted annual measurements of the tidal flows through the Cape Fear Inlet. Measurements are taken along predefined transects by boat mounted Acoustic Doppler Current Profiler (ADCP). The most recent set of ADCP measurements was completed on

April 24-25, 2009 and include separate descriptions of upper and lower water column velocities (USACE, 2011a). Flow patterns measured in August 2009 are described in the 2010 USACE monitoring report as follows:

> *During flood flow, the currents are concentrated within the main channel between Bald Head Island and Jay Bird Shoals. Flow is also concentrated through the flood margin channel near Oak Island. A similar flow pattern is seen just off the Bald Head spit entering the main channel; however, there is not an associated flood margin channel visible. …One interesting feature is also evident with the flood flow pattern which reveals eddies off the main flow. These are evident in the lee of the point at the juncture between South Beach and West Beach [on Bald Head Island] and also near Oak Island.*
>
> *The peak ebb flow patterns have two velocity peaks along the inlet transect, one near the marginal channel along Oak Island and the other within the main channel. These flows funneled into the main channel during ebb impinging on the bank along Bald Head's West Beach. … Previous surveys indicated that [ebb] flow was constrained within the main channel [at the seaward end of the survey transect]. The new survey transect shows that while significant velocities are still recorded within the main channel further offshore, they also begin to flow over the eastern ebb tidal delta. In addition, an eddy is noticed along the eastern side of the main channel just landward of the seaward extent of the current profile track.*

Olsen Associates, Inc. developed a calibrated hydrodynamic model of the inlet using the numerical model Delft3D (Olsen, 2012). As part of hydrodynamic model verification, tidal currents throughout the inlet were simulated for the time period monitored by the Corps, April 2009. Figure 4.19 plots the predicted peak ebb and flood tidal currents. The numerical model results indicate the aforementioned measured concentration of flood tidal currents

within the main navigation channel and Jay Bird Shoals and within a marginal flood channel off the eastern end of Oak Island. Also, the model reproduces a similar confluence of flood flow around the tip of Bald Head Island, which is less pronounced given the lack of a significantly developed marginal channel off the west-point spit. The monitoring data (described above) indicate eddies along the west point of Bald Head Island and near Oak Island, which the model also reproduces during various phases of the tide.

According to the project engineer (Olsen Associates, Inc.), the model is in general agreement with ebb flow patterns identified by USACE (2010). Both identify strong ebb flows concentrated in both the main navigation channel and within Oak Island's marginal flood channel. The model results suggest that ebb flows tend to spread over the ebb shoal platform with increasing distance from shore. While this phenomenon was not identified in previous physical monitoring efforts, the most recent current study at the inlet did identify this pattern. Finally, while not shown in the still images of model results shown herein, the model does predict formation of a small eddy along the eastern side of the navigation channel, seaward of Bald Head Island.

Maximum flood tide, near surface currents measured by the Corps through the inlet in 2009 were about 1.39 m/s, while near bottom peak flood velocities were about 1.2 m/s. In comparison, the model results suggest peak depth averaged flood velocities of about 1.3 to 1.4 m/s. Peak surface ebb currents measured by the Corps were about 1.61 m/s, while near bottom peak ebb velocities were about 1.48 m/s. The model predicted peak, depth averaged ebb current speeds of about a 1.4 m/s. The Corps defines near surface and near bottom as being the lower and upper halves of the water column. Measured and predicted peak currents are summarized in Table 4.3.

Table 4.3: Maximum Magnitude of Mean Flows at Inlet Transect (USACE 2010).

		October-00	April-02	March-03	January-04	March-05	March-06	February-07	March-08	April-09	Delft3D Depth Averaged (April '09)
Near Bottom	ebb	1.06	1.17	1.18	1.57	1.35	1.1	1.75	1.62	1.48	
	flood	1	1.12	1.47	0.98	1.18	1.16	1.36	1.42	1.2	
Near Surface	ebb	1.35	1.97	1.65	1.18	1.7	1.38	1.65	1.62	1.61	1.4
	flood	1.1	1.26	1.27	1.14	1.34	1.37	1.4	1.42	1.39	1.3-1.4

Figure 4.20 plots the residual tidal flows resulting from a one-month long, tide-only simulation using the calibrated Delft3D hydrodynamic model. Residual flows is the "net" flow that remains after subtracting all of the flood flow vectors from the ebb flow vectors for one lunar month. This results in potential movement of sediment from each island. According to the applicant's engineer, material tidally removed from Oak Island appears to be directed towards Jay Bird Shoals and the navigation channel, suggesting to him that the material deposited into the shoals may remain in the local littoral system and/or be transported back onto Oak Island. The applicant's engineer states that the proximity of the navigation channel to Bald Head Island suggests that material moved off the island and ebb shoal enters the channel and may be subsequently transported offshore, out of the littoral system. However, the potential movement of sand within the tidal circulation pattern is interrupted by the deep navigation channel into which the sediment accumulates, as described in a subsequent result, described later.

According to the applicant's engineer, the large gyre indicated in the residual flow plot off Bald Head suggests potential for sediment transport back towards the island. It is unlikely, however, that sediment deposited into the channel bottom (-42 ft, MLLW) could be transported back up to the ebb platform. Rather it is likely dredged during maintenance and disposal activities. Sediment transport leaving the Point's south facing shoreline is indicated by the reoccurring submerged shoal feature depicted in the photo chronology presented in Figure 4.21.

A net tidal flow circulation is suggested across the flood shoals by the applicant's modeling. Net counter-clockwise flow is indicated across the channel, whereby water moved northward along the Bald Head Island side of the channel (presumably on the flood tide) is suggested to be circulated southward along the Oak Island side of the channel (presumably on the ebb tide), in the net, and ultimately toward the Smith Island Range segment of the navigation channel, between the two islands.

4.14.2 Tidal Prism

The tidal prism of an inlet describes the volume of water exchanged from the ocean to the interior estuary throughout a tidal period. The tidal prism is a function of inlet and estuary geometries, tide range, river discharge, and frictional components of the inlet. The USACE has annually monitored the Cape Fear River Entrance as part of a physical monitoring program of the Wilmington Harbor Federal Navigation Project. Data collection has typically included computation of the inlet's tidal prism (USACE 2011a). Table 4.4 lists the tidal prism measured by USACE since October 2000. Values presented have been normalized across an inlet cross sectional area measured in January 2003 (raw monitoring data are not available). Comparison of the ebb and flood prism computations suggests that the Cape Fear River Entrance is ebb-dominated with average ebb and flood flows equal to about 1.79×10^8 and 1.21×10^8 m^3, respectively.

Jay Bird Shoals Middle Ground

Table 4.4: Measured (Normalized) Tidal Prism Values 2000-2009 (adapted from USACE 2011a).

Date	Ebb Prism (m^3)	Flood Prism (m^3)	Total Prism (m^3)
Oct-00	1.90E+08	1.30E+08	3.20E+08
Apr-02	1.50E+08	1.10E+08	2.60E+08
Mar-03	1.70E+08	1.20E+08	2.90E+08
Jan-04	1.50E+08	9.00E+07	2.40E+08
Mar-05	2.30E+08	1.10E+08	3.40E+08
Feb-07	2.10E+08	1.50E+08	3.60E+08
Mar-08	1.50E+08	1.50E+08	3.00E+08
Apr-09	1.80E+08	1.10E+08	2.90E+08

4.14.3 River Discharge

Figure 4.22 plots the measured daily river discharge for the years 1969 to 2010, as reported by the USGS National Water Information System. The data suggest that, on historical average, the Cape Fear River discharge is approximately 268 m3/s (cms). Flows attributable to astronomical tides and waves are more significant in terms of the physical processes controlling inlet dynamics than those derived from river discharge.

4.14.4 Waves

Waves are the dominant forcing mechanism for most coastal processes. Factors affecting waves in the vicinity of the proposed project include transformation over ebb tide shoals as well as other shallow bottom habitats, filtering of wave energy by Frying Pan Shoals, wave generation by local winds, and wave/current interactions. Near Bald Head Island, dominant wave directions are south to southeast. Nearshore waters of Bald Head Island are sheltered to the east southeast by Frying Pan Shoals and, as such, wave movement from an easterly direction is virtually absent (Thompson et al. 1999). The offshore and nearshore wave climates are quantified by both measured data collected at several wave buoys, as well as numerically hindcasting offshore wave conditions completed by USACE.

4.14.4.1 Measured Wave Data

In addition to the offshore wave buoy maintained by NOAA and NOS (41013, see Figure 4.23), the USACE, maintains an array of offshore and nearshore ADCP wave gauges. The gauges of interest to the study: 11-mile ADCP (offshore), Bald Head ADCP (nearshore), and Oak Island ADCP (nearshore). The location of these gauges is shown in Figure 4.23 along with the location of the far offshore NOAA wave buoy number 41013.

Directional wave data from the Corps' ADCP gauges span the period September 2000 to the present. Directional wave and wind data are available from NOAA buoy 41013 from late 2003 to the present.

Figures 4.24 through 4.27 present wave roses and histograms describing the available wave data for each of the stations shown in Figure 4.23. Frying Pan Shoals is a large shoal feature extending towards the southeast from the southern tip of Bald Head Island. NOAA buoy 41013 is the only measurement station located outside of the influence of the shoals and within meaningful proximity to the area of interest. Comparison of the wave roses illustrates the sheltering capacity of Frying Pan Shoals to efficiently filter out wave energy from the northeast, east, and southeast. Outside of the shoals, at wave buoy 41013, the dominant wave direction is from the east southeast. Immediately inside the shoals, in relatively unprotected water, the 11-mile ADCP data suggest a dominant wave direction of south southeast. At the protected, nearshore ADCP gauges, the dominant wave direction is from the south with very little wave energy arriving from east of south.

4.14.4.2 WIS Data

The USACE maintains a database of coastal wave characteristics for the Atlantic Ocean. These wave characteristics are derived by numerically simulating past wave and wind conditions, a process called hindcasting. The most recent hindcast for the Atlantic Ocean basin result describes conditions for the twenty year period 1980 to 1999. The WIS dataset includes hourly time series output at selected coastal stations within the numerical model domain. The locations of WIS stations (both epochs) and the wave measurement arrays are plotted in Figure 4.28.

Figure 4.29 plots several wave roses in the vicinity of the study area. Also plotted, for comparison, are wave roses computed using measured ADCP and wave buoy data. Scaling and bin definitions are consistent for each rose plot in the figure. The mean wave direction at the peak frequency is presented. An analysis of the ability of most recent WIS data to accurately incorporate the effects of Frying Pan Shoals was conducted by Olsen (2012) which suggested that the numerical resolution of the WIS model (5 degrees or 5 nautical miles) is likely insufficient to fully resolve the bathymetry of the shoals. Given their availability, the

study recommended the use of measured wave data or an alternative WIS Station located outside of the influence of Frying Pan Shoals (i.e., WIS Station 63510, not shown herein).

4.14.5 Analysis of Sediment Transport Pathways

4.14.5.1 Bald Head Island

A 1989 sediment transport study completed by Olsen Associates, Inc. described the sediment transport patterns along Bald Head Island. This analysis considered both wave and tidally driven currents. Figure 4.30 describes the potential sediment transport regime around Bald Head as described in the earliest Olsen report. This analysis utilized a relatively coarsely-resolved wave transformation model along with an empirical estimate of sediment transport potential derived from the wave transport results (i.e. CERC formula) and qualitative interpretation of tidal flows. The following describes the conceptual sediment transport patterns derived in the Olsen study.

The most notable sediment transport feature described by Olsen (1989) is a nodal point located between Starfish Trail and Sandspur Trail where the direction of sediment transport diverges. West of this divergence point, alongshore transport rapidly increases in magnitude westward, towards the inlet and navigation channel. Sand along this reach is expected to be removed from the beaches and nearshore seabed and either (a) stored within the west-point spit at the end of the island; (b) transported to the beaches along the west side of Bald Head; (c) and/or trimmed from the west-point spit by tidal currents and transported to the channel or nearshore shoals.

East of the nodal point, alongshore transport is directed towards the east, gradually increasing in magnitude. The 1989 study concluded that sediment was removed from the east end of the island and either deposited onto a spit formation or transported offshore onto Frying Pan Shoals. Sediment transport along East Beach was predicted to be southerly directed in the net.

4.14.5.2 Channel Shoaling

Figure 4.31 plots areas where the navigation channel shoals with beach compatible sand, indicated by shaded areas within the channel. Since March 2005 the USACE has undertaken bi-monthly surveys of the navigation channel immediately adjacent to the western end of Bald Head Island. Select monitoring surveys were digitized by the applicant's engineer and overlaid upon one another in order to visualize areas of chronic shoaling pressure within the channel and deduce the sediment transport pathways. Selected surveys were digitized from construction plans issued by the USACE prior to dredging of the navigation channel.

Figure 4.32 plots the approximate locations of the -44 ft, MLLW contour for the April 2003 (pre-2004 project), August 2008 (pre-2008/09 project) and September/November 2010 USACE condition surveys of the channel. For reference, the federal channel is currently maintained at a depth of -44+2 ft, MLLW. With the exception of the most recent survey (2010), the data were digitized from construction plans issued by USACE.

In the opinion of the applicant's engineer, the channel survey data suggest that there are specific, repeatable shoaling trends within these three reaches of the navigation channel. Bald Head Shoal Channel Reaches 1 and 2 chronically shoal from the east while the northern Smith Island Channel cut tends to recurrently shoal from the west. Alternatively stated, shoal material deposited into Bald Head Shoal Channel cuts 1 and 2 appears to be derived from Bald Head Island and the nearshore ebb shoal platform. Material deposited in the Smith Island cut appears to be principally from Jay Bird Shoals complex, Middle Ground Shoals complex, and/or Oak Island.

4.14.5.3 Transport Along Oak Island

Figure 4.33, plots a wave height rose for data collected at the Oak Island ADCP gauge, located in about 23 feet (7 m) of water off Oak Island. The western limit of U.S. Army Corps monitoring of the federal placement project is indicated for reference. This limit is

approximately 1,000 feet west of the limits of federal fill. Figure 4.33 differs from that shown in Figure 4.26 only with respect to the increased density of directional sorting bins and the depiction of a common shoreline angle along the Oak Island project shoreline, which is indicated by the bold, red line oriented about 15 degrees north of west along with a shore-perpendicular dashed red line. The percent occurrence data shown in the plot, as well as, computation of the wave power (energy flux), H^2T, suggests a tendency towards a net westerly bias as waves approach the shore. Approximately 11 percent more wave power originates from the 105 to 195 degree directional bin (westerly directed) than from the 196 to 285 degree bin (easterly directed)[2].

It is important to note there is marked variability in the shoreline along the project reach, which impairs the ability to make localized conclusions in the relative directionality of wave energy. While the approximate generalized shoreline angle away from the immediate effects of the inlet is closer to 15 degrees, the project shoreline appears to range in angle from around 13 to 15 degrees (+/-), with shallower angles predominate along the western reaches of the project. Usage of these angles alters the estimated directional distribution of energy flux. For example, at a shoreline angle of 14 degrees, there is approximately 5.1 percent more westerly-directed energy flux. As the shoreline approaches 13 degrees there is only about 0.4 percent more westerly-directed energy flux suggesting little net transport. Taken in total, these observations are supportive of a littoral climate which consists largely of bimodal transport with a relatively weak net westerly component. Given the proximity to the inlet, however, one would anticipate the existence of a point of divergence in net littoral transport (i.e., net easterly-directed) at some point along eastern Oak Island associated with tidal currents and the influence of inlet shoals – despite the higher incident shoreline angles nearest the inlet (~17 degrees). The measured wave data at the Oak Island ADCP, however, do not resolve the effects of local inlet shoals and currents on the wave climate and are better suited to a discussion of general patterns in transport potential.

[2] The azimuth ranges represent shore-normal directional bins corresponding with a 15 degree shoreline angle.

Approximately 31,000 feet of the Oak Island/Caswell Beach shoreline is surveyed semi-annually by USACE as a part of the overall monitoring program for the Wilmington Harbor Navigation Project and associated beach disposal program. In comparison to the DCM shoreline data, USACE physical monitoring data also indicates that since July 2001, Oak Island has been stable to accretional -- excepting for an erosional "hot spot" located on Fort Caswell Beach not indicated in the DCM data. This "hot spot" occurs at two USACE monitoring profiles located at the east end of the island that have experienced consistent recession since the navigation channel was realigned and deepened in 2000 (USACE, 2011a).

The 2011 USACE monitoring report documents continuing erosion between COE survey stations 35 and 40. Figure 4.34 is adapted directly from the most recent USACE monitoring report and presents the historical (pre-2000) and recent (post-2000) shoreline response at stations 35 and 40, within the erosional "hot spot" (USACE, 2011a p. B-4). The data suggest that prior to August 2000, profiles 35 and 40 experienced persistent seaward shoreline growth at an average annual rate of about 29.9 ft/yr and 17.2 ft/yr, respectively. Since August 2000, the shorelines at stations 35 and 40 have experienced landward retreat at an average annual rate of about -8.8 ft/yr and -4.5 ft/yr, respectively.

4.14.5.4 Olsen Associates 2012 Study

Olsen Associates, Inc. utilized the process-based numerical model Delft3D in order to more accurately predict sediment transport and seabed morphology in the vicinity of the Inlet as a function of average annual wave conditions. Input wave conditions were derived from measured wave buoy data collected in deep water between November 2003 and December 2009 (NOAA Buoy 41013), located beyond the effects of Cape Fear Shoals. Schematization involved sorting the measured wave data into distinct bins based on wave height, direction, period, and contribution to morphological change, and accounting for gaps in the data, as described by Lesser (2009). For each resulting bin, a weighted mean wave condition and an annual probability of occurrence were computed. The numerical model was calibrated and verified using measured rates of beach profile change along Bald Head and Oak Islands,

historically documented rates of shoaling within the navigation channel, and qualitative comparisons of measured morphological changes in the nearshore shoal systems. Figure 4.35 presents the model output in terms of the predicted net sediment transport pathways in the vicinity of the Inlet. The areas identified as chronically shoaling with beach compatible sediment are overlaid onto the plot.

In the opinion of the applicant's engineer, the numerical model analysis confirmed the accuracy of the aforementioned 1989 conceptual predictions of overall trends in average annual net sediment transport along Bald Head Island and allowed for a detailed analysis of inlet dynamics. For example, he states that the model correctly predicts the magnitude and extent of the severe erosional gradient along western Bald Head along with a reversal in net transport direction east of the existing tube groin field.

Olsen states that in addition to correctly describing alongshore sediment magnitudes and directions, the model proved capable of reasonably predicting the magnitude and spatial distribution of shoals within the navigation channel. Volumetric changes predicted by the model were computed within the limits of the Smith Island Cut, Bald Head Shoal 1, and Bald Head Shoal 2. The results suggest that these three channel cuts shoaled with a combined 963,500 cy during a two-year model simulation. Approximately 32 percent of this volume (about 311,900 cy) is deposited within the Smith Island Cut while the remaining 68 percent (about 651,600 cy) shoals both Bald Head Shoal Reaches. According to Olsen, these model predictions demonstrate good consistency with measured values and distributions of channel shoaling published by the USACE for the time period of model calibration and since the last harbor dredging project.

A 2011 reevaluation report of the Sand Management Plan for the Wilmington Harbor Navigation Project completed by the USACE, identified a total shoaling volume of about 1,176,000 cy over a typical two-year dredge cycle. This shoaling volume was based on the analysis of the first three maintenance dredging cycles following the 2001 channel

deepening. The USACE analysis further shows that deposition within the Smith Island Cut comprises about 33 percent of this total volume with the remaining and 67 percent shoaling within both Bald Head Shoal cuts (USACE 2011b). The model's predicted two-year shoaling volume (963,500 cy) is within about 18%, slightly less, than the measured volumes. The model's predicted distribution of shoaling between the Smith Island Cut and Bald Head Shoal Reaches (32% and 68%, respectively) is nearly identical to the measured distribution (33% and 67%).

Perhaps of greater importance, the results of the USACE 2011 reevaluation report further supports the aforementioned sediment transport patterns which link the shoaling in the specific channel locations to the individual beaches. Specifically, sediment depositing within the Baldhead Shoal Channel Reaches 1 & 2, nearest to Bald Head Island comes from that island. Likewise, the shoaling within the Smith Island Range comes from Middle Ground Shoals and the Oak Island/Caswell Beaches. The report finds that in essence, these two littoral systems can be thought of as largely independent with little sand sharing between the islands.

The gross sediment transport potential predicted for individual wave cases was additionally investigated by Olsen Associates via the real-time tracking of motion patterns of specific 'tracer' sediments inserted into the numerical model. The tracer code represents a special purpose addition to the Delft3D modeling suite[3] and describes computed sediment transport as opposed to traditional particle tracking models which describe only particle motion due to water movement and dispersion. The tracer model does not yield estimates of transport magnitude or the final destination of sediments, however. Rather, the tracer code predicts maximum movement rates (potential transport pathways) associated with previously

[3] Elias, E. (2011). "Predicting Sediment Transport Patterns at the Mouth of the Columbia River". Proceedings Coastal Sediments 2011 Conference. May 2-6, 2011. Miami, Florida. Pp.588-601

calibrated hydrodynamics. This process revealed complex transport patterns which are not otherwise definable in the net, as well as stark differences in transport between Bald Head and Oak Islands beyond the aforementioned magnitudes in transport leaving the respective islands.

Under south southwest incident offshore waves, sediment off Oak Island is transported towards the lee of the Island on flood tides. The subsequent ebb tide forces material which is not trapped in the navigation channel out of the inlet and back into the littoral system of Oak Island – both onto Middle Grounds, Jay Bird Shoals, and the active beach profile off Oak Island. Similar patterns exist under west-southwest storm waves. In contrast, material which enters the navigation channel from Bald Head Island under easterly-directly waves adds volume to the Point and/or shoals the navigation channel to be mobilized seaward by the next ebb tide. Either way material is lost from the littoral system along South Beach. The most commonly occurring east southeast incident waves tend to produce a similar, highly erosive trend on Bald Head Island, excepting that some material entering the navigation channel is transported into the Smith Island Channel cut on a flood tide, although the results suggest the subsequent ebb tide is capable of mobilizing these sediments further seaward. Unlike the south southwest condition, east southeast waves mobilize little-to-no sediment in the nearshore profile of Oak Island. Additional details and results from the tracer analysis are included in the Engineering Report prepared by Olsen Associates (2013).

4.14.6 Sea-Level Rise

Sea level, also known as eustatic sea level, is a measure of the average height of the ocean surface. Sea-level rise is an increase in eustatic sea level that is sustained over a long period of time. There are two types of sea level change over the long-term, relative sea level (RSL) and global mean sea level (GMSL). RSL, local sea level, fluctuates as the local land and sea floor move up and down as a result of tectonic plate collisions, glaciation, sediment compaction in large deltas or any other process that increases or decreases the weight of the Earth's crust. GMSL is a measure of the increase in water volume in the ocean expressed as

a change in the height of the oceans. Several factors influence sea-level change at the local to regional level including global sea-level change, local vertical land movement, changes in tidal range, changes in coastal currents and/or water temperature and gravitational effects (NCCRC 2010b).

According to the NC Coastal Resource Commission Science Panel on Coastal Hazard's, historical tide gauge data and geologic evidence obtained over the last several centuries provide evidence that sea level is steadily rising in the state of North Carolina. Additionally, data collected from scientific studies within the state suggest that RSL change varies as a function of latitude along the North Carolina coast. RSL change is higher in the northern part of the state with lower documented rates in the south and varies from 2.04 mm/yr to 4.27 mm/yr (NCCRC 2010b).

NOAA maintains a detailed record of sea level trends at stations around the United States. The nearest such station to the study area is at Southport, immediately inside Cape Fear Inlet (Station 8659084). Figure 4.36 was taken directly from the NOAA data archives and plots the linear trend of sea level rise at the Southport station. The measured data at Southport cover the period between 1933 and 2006 and suggest that the local water level rises approximately 2.08 mm/year, or about 0.21 meters (0.69 feet) per 100 years, on average.

4.15 INFRASTRUCTURE

Bald Head Island is a well-recognized destination for both daily visitors (from the local region) and longer-term vacationers (visiting from the region, other states, and foreign countries). There are two bed and breakfasts and hundreds of rental homes, timeshares and fractional ownership dwellings. There are only approximately 220 full time residents, but there are approximately 5,000 or more visitors on a summer weekend day. The resident and

visiting population is serviced by a network of roads (used by golf carts as well as emergency, delivery, maintenance, and construction motor vehicles) and utilities (including sub-grade water, sewer, power and communication lines). In addition, potable water is delivered via pipeline under the Cape Fear River and supplemented through the use of sixteen groundwater wells located in different areas of the Island. The Village has also constructed and maintained numerous beach accesses along West Beach, South Beach, and East Beach.

Bald Head Island was initially developed in the early 1970's when Carolina Cape Fear Corp. began developing the Island. The Island consists of approximately 2,000 single-family residential lots. The Island is accessible by boat with daily ferry service providing access from Southport, NC.[4] Transportation is primarily limited to golf cart, bicycle and pedestrian traffic; however, vehicular service is allowable to facilitate construction, delivery, and maintenance activities and for emergency purposes. Bald Head Island Marina is accessed from the Cape Fear River and offers 153 wet boat slips accommodating vessels up to 100 ft in length, gas and diesel fuel pumps and a marina pump-out. The Island also supports two clubhouses with associated amenities, restaurants, a market and additional shopping opportunities.

Existing infrastructure within the project study area includes a number of roadways and sub-grade utilities including sewer, water distribution, fire suppression, power, communications, and stormwater ponds (Figure 4.37). In addition, there are privately held infrastructure components associated with the facilities at the Bald Head Island (BHI) Club. While wastewater is primarily collected via sewer and treated by a package treatment system, there are few individual septic tanks for single-family residences that are still in existence. In particular, there are privately-owned and operated septic tanks and attendant lines for four homes on Cape Fear Trail (located within the permit study area and in close proximity to the

[4] Note that Bald Head Island is also accessible by foot or bicycle via public beaches from Fort Fisher to the north.

Point). Additional privately-owned infrastructure associated with major habitable structures within the study area include, furnishings, pools, outbuildings, over-walks, pavilions, etc.

4.16 URBAN QUALITY

The location of the project study area is within the Cape Fear River estuary. There are no urban quality issues associated with the Village of Bald Head Island Shoreline Protection Project.

4.17 SOLID WASTE

The Village of Bald Head Island wastewater treatment facility operates in accordance with the provisions of Article 21 of Chapter 143, General Statutes of North Carolina as amended and other applicable Laws, Rules, and Regulations under permit numbers WQ0000193 and NC0085553. The collection system consists of approximately 180,000 feet of sewer mains with size ranging from 1.5" to 10" in diameter, and 38 lift stations, which collect and convey waste to the wastewater treatment facility for processing (Permit No. WQCS00276).

The wastewater treatment facility was originally constructed in 1996. An expansion to the wastewater treatment facility was brought online in June 2003 and increased the treatment capability to 400,000 gallons per day. The treatment facility is an Aqua-Aerobic System with sequencing batch reactors with tertiary treatment and UV disinfection.

The Village of Bald Head Island Public Works Department provides routine collection of yard debris and can take receipt of recycable materials at its facility for transport off island to the Brunswick County facility. Additional trash receptacles are located throughout the island for

public use. The Village has a contract through Brunswick County for Waste Industries to provide household waste collection services.

4.18 DRINKING WATER

Groundwater of the area is generally supplied from the semi-confined aquifer and the deeper Castle Hayne limestone aquifer. Potable water is supplied to Bald Head Island through a combination of sources. The Village of Bald Head Island constructed a ten inch (10") water main from Caswell Beach to Bald Head Island (the subaqueous portion having an eight inch (8") diameter). This line is operated by the Village of Bald Head Island. Brunswick County water consists of ground water from the Castle Hayne Aquifer and surface water drawn from the Cape Fear River above Lock and Dam # 1. Peak water usage averages 340,000 gallons per day in July and August. The minimum water usage occurs in February, which averages 68,000 gallons per day.

Potable water is also supplied to Bald Head Island through a series of 16 state approved groundwater supply wells scattered across the inland portion of the island (Figure 4.37). The water supply wells are situated at an average depth of sixty (60) feet below the ground surface in the semi-confined aquifer. Individual groundwater wells produce approximately 40 GPM. Water from the production wells is piped to the Village water treatment facility located at 256 Edward Teach Extension and filtered by three (3) reverse osmosis units.

4.19 NON-RELEVANT RESOURCES

4.19.1 Hazardous, Toxic and Radioactive Waste

In light of the substrate composition and the physical processes of the mouth of the Cape Fear River, it is unlikely that bottom sediments have accumulated any toxic or hazardous

substances as regulated by CERCLA (1980) or RCRA (1976). Contaminants tend to bind more readily to the surfaces of fine-grained sediments uncharacteristic of the substrate of the project area. In addition, there have been no known sources of contamination (i.e. spillage, treatment, or storage of toxic substances) within or near the project area. Therefore, it is unlikely that a composite bottom sample would yield contaminant levels exceeding EPA standards.

According to the EPA's Envirofacts website (www.epa.gov/enviro/index/html), there are several Federal Indexed system EPA sites listed as occurring in Southport and Oak Island. There were no sites listed on Bald Head Island. All of the sites listed in Southport and Oak Island were for RCRA generators and handlers. The EPA Region IV website was also reviewed to determine if there are any EPA Superfund sites located in the project area. There are no EPA Superfund sites listed to southeastern Brunswick County.

The U.S. Coast Guards' National Response Center website (www.nrc.uscg.mil/index.htm) was reviewed for the past five-year interval for incidents located in Southport, Bald Head Island, and Oak Island. There were a total of 15 incidents listed in the National Response Center website that occurred between 2009 through 2014. Of these 15 incidents, 14 of the incidents involved very minor petroleum spills on land adjacent to the water or on the water that has since been cleaned up according to the coast guard website.

The North Carolina Department of Environment and Natural Resources (NC DENR) Inactive Hazardous Sites Branch website was also reviewed. There are currently three NC DENR IHSB sites listed in Southport and one located in Oak Island. All four of these sites were reviewed on-line through the NC DENR "https://edm.nc.gov/DENR-Portal/". All four sites were either (1) relatively minor incidents and/or (2) located far enough away from the proposed sand source sites to pose no contaminant threat to the sand to be excavated.

4.19.2 Noise

Ambient noise levels within and adjacent to the project area are relatively low. No industrial properties are located near the project site. Some commercial properties are located adjacent to the Bald Head Island Marina. Short-term elevations in noise levels may be attributed to ferry and boat traffic near the marina basin and residential construction activity. In general, the predominant low-impact land use of the island equates to low ambient noise levels.

SECTION 5.0 - ENVIRONMENTAL CONSEQUENCES

5.1 ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

As indicated in Section 3.0 of the EIS, a range of alternatives was developed in consultation with the Project Review Team (PRT). The range of alternatives includes considerations of various options that meet the purpose and need for this project. One alternative has been eliminated from the alternatives analysis: construction of a terminal groin without beach nourishment. The reason that this alternative has been eliminated from further consideration is that it is not compliant with current state statute as ratified in Senate Bill 151 which requires the placement of a concurrent beach fillet.

5.2 DESCRIPTION OF PREDICTED PHYSICAL EFFECTS

5.2.1 Shoreline Conditions

5.2.1.1 Methodology

The prediction of potential post-construction shoreline locations associated with each of the six (6) alternatives under consideration is primarily based upon numerical modeling of each alternative over a nine (9) year period. Within that time frame, the Wilmington Harbor Sand Management Plan (SMP) is assumed to occur on an average 3-year interval for Bald Head Island disposal except for identified "gaps" in the cycle when the SMP calls for placement on Oak Island. Though the current SMP anticipates disposal on adjacent beaches on two-year

intervals, federal funding and other considerations may impact the timing and occurrence of maintenance and disposal events. To that end, the model assumes that actual disposal would occur in a manner similar to the past decade with placement occurring on an average three-year interval. The use of a 3-year interval vs. a 2-year interval would not reflect any large-scale differences in the comparative nature of the modeling results, particularly over a nine-year analysis. In addition, the same annualized sand disposal volumes would be used, irrespective of the disposal interval, further dampening any difference in model results.

For more detail regarding the engineering that supports the Applicant's proposal, Applicant has provided public access to the engineering report entitled *Shoreline Stabilization Analysis* (Olsen 2013) on its Village website. The report was prepared by the Applicant's engineer for detailed modeling methodology, assumptions, forcing conditions, and analyses for each of the alternatives modeled. According to the Applicant's engineer, the principal goal of the modeling was to be able to compare the impacts or benefits of each alternative considered and not to make predictions of performance over a 30-year time period. A 30-year analysis would necessarily compromise the level of accuracy desired for the morphological model.

Note that the Delft3D modeling does not account for sea-level rise. Relative sea-level rise (RSL) varies as a function of latitude on the NC coast with higher rates of rise documented in the northern part of the state and lower rates in south (NCCRC 2010). While different studies predict varied rates of sea-level rise in the future, use of a predicted accelerated rate in the Delft3D model would not appreciably affect model results. This is due primarily to the length of analysis considered in the model runs (i.e. up to nine years). Over a nine-year period, the range of potential sea level rise and corresponding influence on numerical morphological modeling is negligible. NOAA maintains a detailed record of sea level trends at stations around the United States. The nearest such station to the study area is at Southport, immediately inside Cape Fear Inlet (Station 8659084). The measured data at Southport cover the period between 1933 and 2006 and suggest that the local water level

rises approximately 2.08 mm/year, or about 0.21 meters (0.69 feet) per 100 years, on average. If the future rise of local water level accelerates, then the effects would be observed across alternatives and the relative differences between alternatives would be expected to be the same.

While consideration of sea-level rise is not required under SB 151, the specification of a rubble-mound type structure (as evaluated under Alternative #5 and Alternative #6), allows for cost-effective structure modifications in the future if it is deemed necessary to address the effects of sea-level rise. The structure's effective height can be adjusted by the addition of rock to the structure crest.

In each model run, beach fill is assumed to be placed on Bald Head Island at time zero. Therefore, the analysis of each alternative assumes the same "improved" condition (i.e. 1.2 Mcy of sand fill placed along a portion of South Beach) at time zero. In the same way, period of analysis for each alternative ends at Year 9 prior to the next scheduled sand disposal event. The description of each of the six alternatives is provided in Section 3.2 of this document.

For each of the six alternatives considered, the initial modeled bathymetry comprising the nearshore zone and navigation channel were set to reflect conditions in spring 2011. The nearshore bathymetry and upland were described by physical monitoring survey data measured in May 2011. Input conditions within the navigation channel used in the Delft3D model are based upon U.S. Army Corps of Engineers (USACE) condition surveys performed in February 2011. Combined, these surveys describe a generally eroded South Beach, an unimproved West Beach, and a shoaled navigation channel, particularly in the Bald Head Shoal I and II reaches.

A distribution of dredged material which reflects the current ratio of the division of sand pursuant to the SMP was taken into consideration in the model. However, in keeping with recent experience, the applicant's engineer chose to model dredging and sand fill projects on an average three year interval within the 9-year model simulation. *For all alternatives, a fill placement is specified to occur at model startup, at time zero.* A second dredge/fill event with disposal onto Bald Head Island occurs at year 3 in the model for all alternatives. For alternatives that consider a Village-sponsored nourishment event (during the period when sand from the federal navigation project is placed on Oak Island), a third fill is placed onto Bald Head Island at Year 6 (reflecting a Village-sponsored project). Alternatives without Village action place no "additional" material after Year 3 during the 9-year simulation. In either case, federal dredging events continue on a 3-year schedule throughout the period of simulation. As noted previously, the Year 9 prediction for each alternative therefore simulates a pre-disposal condition.

All fill placement events specify a volume of 1.2 Mcy. The limits of fill for Alternatives 1 through 4 remain constant with placement occurring between Stations 46+00 and 168+00 on South Beach (refer to Appendix P for station location map). The western limit of fill was established at the westernmost sand tube groin no. 16. The eastern limit of fill is based on prior federal disposal projects completed in 2001, 2005, and 2007. The limits of fill for Alternatives 5 and 6 specify placement between the terminal groin and Station 152+00 (+/-). The eastern limit of fill for these two alternatives was moved westward relative to non-terminal groin alternatives in order to accommodate the additional fill required to construct a fillet eastward of the terminal groin, as required by SB 151. Note that for alternatives considering a terminal groin structure, the applicant proposes that construction of the groin would be concurrent with, and following, a federal beach disposal with the limits of federal disposal occurring no further west than the proposed groin location (see Appendix H).

5.2.1.2 Findings

The predicted approximate location of the mean lower low water (MLLW) shoreline at the end of each 9-year simulation for each of the alternatives is plotted in Figure 5.1. Note that for reference, the six alternatives are outlined in Table 5.1 below. As depicted in Figure 5.1, substantial seabed erosion and shoreline recession is predicted for Alternative 1 (No-Action), Alternative 2 (Retreat), and Alternative 4 (beach fill without sand tube groins). For each of these alternatives, erosion is predicted to extend well into the seaward limit of existing development on Bald Head Island. Alternative 3 (existing sand tube groins, SMP disposal, and Village beach fill), Alternative 5 (terminal groin, federal beach disposal, and existing sand tube groins), and Alternative 6 (terminal groin, federal beach disposal, without the existing sand tube groins) do not exhibit as pronounced a change in shoreline position as those identified above. For purposes of assisting in the interpretation the predicted MLLW line locations presented by Figure 5.1, Figures 5.2 – 5.7 portray cumulative erosion/sedimentation patterns for each of the six alternatives over the 9-year period of analysis. In each figure, red/yellow shading represents seabed or beach deflation (erosion) while blue shading reflects sedimentation (accretion). The bold black dashed line in each figure represents the approximate digitized seaward limit of development (homes, roads, etc.).

Table 5.1. List of Project Alternatives

Alternative #1	**No-Action (includes component of Status-Quo)**
Alternative #2	**Retreat**
Alternative #3	**Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place**
Alternative #4	**Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal**
Alternative #5	**Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining)**
Alternative #6	**Terminal Groin with Beach Nourishment/Disposal (Removal of Sand Tube Groinfield)**

It should be noted that for Alternative 3 the cumulative erosion patterns predicted in the model indicates erosional stress along discrete areas of shoreline west and north of the westernmost sand-filled tube groin (refer to Figure 5.4). This result is consistent with actual recent events on western Bald Head, whereby additional emergency shore protection measures were required in 2011 westward of the sand tube groin field (several years after two SMP disposals and a Village-sponsored nourishment project). Additionally, the predicted erosion immediately adjacent to the westernmost sand-filled tube groin indicates structural failure of at least one tube groin and the existing sandbag revetment that lie westward thereof (which was not included in the model). If left unmitigated, sand tube failure would transfer to adjacent sand tubes resulting in increased erosion and land/property loss. As a result of the potential for this risk, the westernmost five (5) sand tube groins were replaced in the spring of 2013.

The MLLW analysis for Alternatives 5 and 6 (reference Figure 5.1) similarly demonstrates protection of existing upland development near the Point. The applicant's investigation of the complete model results for Alternative 6 indicates to its engineer that while erosion did not directly impact upland infrastructure nearest the Point, it does occur near areas which have previously been historically highly vulnerable to storm induced upland erosion (specifically along Bald Head Wynd on South Beach across from the Bald Head Island Club) (Olsen 2013).

The terminal groin is designed to allow for the ability to control sediment loss rates, thereby reducing end losses experienced with reoccurring sand placement projects. The structure's permeability is predicted to reduce downdrift impacts associated with the terminal groin by allowing some degree of controlled sand transport through and over the rock structure. As discussed in Section 3.0, the proposed structure for Alternative #5 and Alternative #6 would be constructed in two phases. The first phase would consist of a 1,300 lf groin that would require a smaller sand volume for the updrift fillet and result in a more rapid activation of downdrift transport to West Beach.

The MHHW shoreline position for each alternative is predicted by calculating composite intertidal beach widths derived from historical beach profiles. The resulting MHHW shoreline estimates for the six alternatives under consideration are shown in Figure 5.8. The applicant's engineer has calibrated and verified the Delft3D model and indicates that it provides excellent predictive ability relative to measured and observed physical processes within the study area. The results of the modeling described herein, however, are *not* intended to be a precise prediction of future shoreline or bathymetric conditions given computational limitations and uncertainties surrounding the future local meteorology, oceanographic conditions, sediment characteristics, non-project related anthropogenic works, etc.

The estimated MHHW shorelines resulting from Alternative 5 and Alternative 6 (both terminal groin alternatives) depict a relatively stable Point feature albeit at a more northerly location along with the continued erosion of the West Beach shoreline due to its current directional migration (as documented through USACE and Village surveys). The estimated post-project MHHW contours for both alternatives coincide with the existing bluff escarpment indicated in the aerial photography. The estimation is conservative as the initial shoreline condition modeled along West Beach reflects eroded conditions without beach improvements (i.e., sand placement) which have been historically necessary along this reach and are expected to continue into the future. The most recent West Beach Sand Placement fill occurred in February of 2013 as a result of federal channel disposal by the Wilmington District, USACE at the request of VBHI.

5.2.2 Beach Conditions

The calibrated Delft3D model was used to describe the physical performance of sand placement operations for the six alternatives. The model predicts the relative volumetric

changes three years following construction of each project alternative. Refer to Section 3.0 for a detailed description of the alternatives under consideration.

For alternatives without a terminal groin, the initial bathymetry used as model input included a 1.2 Mcy beach fill extending eastward from the Point to just east of Station 162+00. Project berm widths were roughly similar to those constructed in 2009/10; however, because the 2009 project volume was larger than that which was simulated, the eastern extent of the fill was truncated in order to simulate placement of 1.2 Mcy. The latter volume is more consistent with that placed in 2005 and what is conservatively expected to result on average from routine maintenance dredging (on an average 3-year basis).

For alternatives with a terminal groin, the initial bathymetry used as model input also included a similarly sized 1.2 Mcy beach fill. Because the terminal groin (i.e., fillet) was "pre-filled" with a portion of this material, it was necessary to adjust the spatial limits of the fill for the post-groin construction simulation. The initial sand placement extended from the terminal groin eastward to about Station 126+00. This station is still well east of the predicted nodal point in sediment transport and coincides with the eastern limit of sand fill that was placed for the 2004/05 beach disposal project.

The sand-filled tube groins along South Beach were included in the hydrodynamic model in their existing (2013) locations and simulated as thin dams, which are numerically considered infinitely high and impermeable to flow and sediment transport. The tube groins are not permitted to fail due to erosion in the model. The terminal groin was described in the model using porous plates, which are also infinitely high but are permeable. That is, they allow through-flow and sediment transport. The permeability of porous plates is numerically controlled by a friction term which was set to roughly represent a level of permeability between about 10 and 30 percent.

For each alternative, two comparative computations were made with respect to the predicted changes within the project area: (1) gross volume change within the limits of the placed beach nourishment and (2) net volume change within an area representing the limits of the placed beach nourishment and the nearshore equilibration area. The latter area describes sand that remains in the littoral system (i.e., nearshore bar, etc.), but has been transported offshore during equilibration of the construction beach. Volume changes in the immediate vicinity of the navigation channel were not included because these sediments are effectively removed from the Bald Head Island littoral system once they are transported beyond the Point. An example of these computation areas is shown graphically in Figure 5.9 for the sand-filled tube groin scenario. Similar computation limits were applied to all the alternatives. In the figure, the red shading denotes areas of predicted erosion while blue shading denotes areas of predicted net accretion throughout the model run.

The model predicts that the presence of the semi-permeable terminal groin has the potential to retain approximately 33 to 39 percent more sand over three years within the littoral system relative to a tube-groin only alternative (see Table 5.2). This comparison suggests net benefit for the construction of a terminal groin in combination with the existing tube groin field. In terms of minimizing gross and net volume loss along South Beach, the terminal groin with tube groins (Alternative 5) performs the best while the fill only condition (Alternative 4) experiences the largest volume losses after three years. In all instances, the addition of the sand-filled tube groins tends to reduce volume losses relative to a comparable no sand tube groin scenario.

Relative terminal groin performance was also viewed in the context of the total fill placement volume for all alternatives. The results shown in Table 5.3 indicate the following:

- Within the fill placement area, volumetric losses exceed the initial placement volume by about 11 percent under the sand tube groin with fill only (Alternatives 1 and 3)

scenario. Consideration of expected equilibration indicates that approximately 35 percent of the placed fill remains within the nearshore littoral system.

- Omission of all structures on Bald Head (Alternatives 2 and 4) suggests that losses within the fill area exceed the placement volume by about 62 percent. The nearshore littoral system is predicted to experience a net deficit of about 17 percent after three years.
- With the terminal groin and tube groins (Alternative 5), more than ¼ of the placed fill volume remains within the placement limits after three years. Consideration of expected equilibration indicates that approximately 61 percent of the placed fill remains within the nearshore littoral system.
- With the terminal groin only (Alternative 6), approximately 8 percent of the placed fill remains within the fill limits after three years. Consideration of expected equilibration indicates that approximately 44 percent of the placed fill remains within the nearshore littoral system.

Table 5.2: Predicted Volumetric Changes in the Project Area after Three Years.

	Gross Loss Within Fill Limits, "Area 1" (cy)	Net Change Including Nearshore, "Area 2" (cy)
Alts 1 and 3 – Tube Groins w/Fill	-1,332,800	-776,000
Alts 2 and 4 – Fill Only	-1,944,500	-1,398,900
Alt 5 – Terminal Groin, Fill, & Tube Groins	-883,000	-467,000
Alt 6 – Terminal Groin and Fill Only	-1,110,000	-667,500

Note. See narrative above for the description of "Area 1" and "Area 2".

Table 5.3: Predicted Percentage of Initial Fill Volume Remaining after Three Years.

	Within Fill Limits, "Area 1" (%)	Within Nearshore, "Area 2" (%)
Alts 1 and 3 – Tube Groins w/Fill	-11.1	35.3
Alts 2 and 4 – Fill Only	-62.0	-16.6
Alt 5 – Terminal Groin, Fill, & Tube Groins	26.4	61.1
Alt 6 – Terminal Groin and Fill Only	7.5	43.5

Similar volumetric analysis was carried out along the westernmost one mile of Bald Head Island (the shoreline west of about Station 102+00). This reach presently experiences the highest volume losses on Bald Head Island. Approximately 760,300 cy of initial fill were placed along this reach under the tube groin only scenario. Under the terminal groin plus tube groin scenario, about 990,230 cy of initial fill were placed along this reach. (The latter volume is higher due to the requirement to initially pre-fill the terminal groin fillet.) The model results are presented in Table 5.4 for the shoreline reaches west of Station 102+00. The results indicate the following:

- Less than 10 percent of the initial nourishment volume remains within the placement limits for the tube-groin only condition (Alternatives 1 and 3).
- The beach fill only conditions (Alternatives 2 and 4) experience severe sediment deficits west of Station 102+00 which well exceed the sand volume historically placed along this reach.
- For the terminal groin with tubes condition (Alternative 5), about 41 percent of the initial fill placement remains within the fill limits after three years over the same reach. The relative difference between Alternatives 3 and 4 is not as dramatic when including equilibrated material mobilized into the nearshore zone. Nevertheless, addition of the terminal groin with tube groins alternative is predicted to result in an approximate 19 percent increase in initial fill material remaining within the littoral zone relative to the tube-groin only alternative; that is, 65% remaining with the terminal groin versus only 46 percent remaining with the tube-groin only alternative.
- The terminal groin with beach fill only condition (Alternative 6) performs approximately 10 percent better than the sand tube groin with fill only alternatives (Alternatives 1 and 3) with respect to the percent volume remaining within the limits of fill, west of Sta. 102+00. Within the overall nearshore littoral area, the performance of this alternative is effectively the same as that of the tube groin only condition, with about 46 percent of the fill remaining.

Table 5.4: Predicted Percentage of Fill Remaining West of Station 102+00 after Three Years.

	Within Fill Limits, "Area 1" (%)	Within Nearshore, "Area 2" (%)
Alts 1 and 3 – Tube Groins w/Fill	9.6	46.0
Alts 2 and 4 – Fill Only	-69.3	-33.0
Alt 5 – Terminal Groin, Fill, & Tube Groins	41.1	64.6
Alt 6 – Terminal Groin and Fill Only	19.5	45.7

The results discussed above are predictions based on average annual wave, wind and, tide conditions. Storm impacts are not explicitly included in these estimations and actual volumetric performance is expected to vary[1]. Although the model has been calibrated and verified with respect to its ability to predict sediment transport along Bald Head Island, the results discussed in this document are not intended to serve as a definitive prediction of future project performance – particularly given the uncertainty associated with predicting future oceanographic conditions. Rather, these model simulations are intended for use in *relative* comparisons between the predicted performances of differing project alternatives under the same environmental conditions.

Within this context, extrapolation of these outcomes to longer term project performance may be instructional for planning purposes. The model results indicate that even with the best performing terminal groin and tube groin alternative, periodic sand placement at South Beach would likely be required. Under Alternatives 3 through 6 (those accounting for Village-sponsored nourishment), it is anticipated that nourishment would occur 3 years post-construction and then on roughly nine-year intervals thereafter. However, non-groin alternatives would be expected to require larger volumes of nourishment and would be susceptible to greater sand losses over time. As a result, there would be increased incidence of critically-eroded conditions which would in turn increase the likelihood of emergency-

[1] Note that the engineer has completed an analysis of the effects of a hypothetical tropical storm event (conditions on a level comparable to Hurricane Bertha in 1996) for simulated conditions with and without a groin. The findings of this analysis are provided in Appendix V.

level responses (i.e. sand-bags, beach scraping, or smaller-scale nourishment) by property owners or the Village.

Figure 5.10 compares hypothetical long-term cumulative volume changes within the fill areas for the modeled alternatives. Year zero in the figure is assumed to represent post-construction conditions and identical fill volumes are added every three years. For each alternative, this analysis assumes a constant project volume, beach response, and typical average annual wave conditions. Under Alternatives 3 and 4, the analysis suggests that erosion creates a sand deficit which theoretically grows over time without additional (supplemental) sand placement volumes. Such a condition would likely grow exponentially more severe at hot spots as beach morphology would become progressively more conducive to continued erosion requiring greater renourishment volumes. Such is the present case along western Bald Head (i.e., rollback of the shoreline along western Bald Head).

Under Alternative 5 and Alternative 6, a fraction of material placed by the previous nourishment may remain within the fill placement area.

5.2.3 Duneline Conditions

Along the westernmost segment of South Beach, as well as the Point and the West Beach shorelines, the primary dune crest varies in elevation from approximately +10 ft NGVD to +20 ft NGVD. In most places the duneline averages +15 ft (NGVD). Figure 5.11 plots the maximum apparent dune elevation between survey baseline STA 0+00 (the northeasternmost extent of West Beach) and STA 106+00 (just westward of the terminus of the sand tube groinfield). Portions of the existing duneline are natural, whereas others are manmade. For example, dune features eastward of STA 47+00 extending to STA 97+00 (more or less) have been substantially enhanced or replaced since 2000 concurrent with, or following sand placement projects. As of this date, on average this duneline continues to increase in height annually due to continued beach disposal as well as comprehensive

revegetation and sand fencing programs implemented by the Village. The landward limit of most existing primary dune formations lay in close proximity to (*i.e.* immediately seaward of) residential structures or infrastructure (i.e. Bald Head Wynd).

The present duneline provides an added element of storm protection to upland properties, but is highly vulnerable to loss due to large scale morphological changes which are predicted to occur for several of the stabilization alternatives under consideration, and due to the development of the areas behind the dunes which limit the duneline's ability to naturally retreat. For example, the predicted MHWL location at Year-9 (see Figure 5.1) would suggest that Alternative 2 and Alternative 4 would result in the loss of oceanfront dune resources between STAs 34+00 and STA 79+00 (more or less) as well as STA 30+00 through STA 106+00, respectively. The principal cause for these predicted dune losses is the removal of the existing fill berm presently supported by the sand tube groinfield (in the absence of a terminal structure) and the ensuing destabilization of the end of the island which would be expected to eventually occur.

Similarly, the modeling predictions indicate that Alternative 1 results in large scale dune loss between STA 73+00 and STA 28+00, (more or less) in accordance with the 9-year prediction depicted by Figure 5.1. Alternative 3 does not result in large scale primary dune losses over a 9-year period; however, beyond 9 years, the existing trend of shoreline adjustment immediately westward of groin no. 16 is expected to continue into the future. Since Alternative 3 best reflects the series of cumulative actions taken over the last 10 years, it has been well monitored. As a result, the 9-year erosional response reflected by the numerical modeling is very much in keeping with what has been documented by survey for Alternative 3. This includes the migration of the Point northward over the last decade.

Alternative 5 and Alternative 6 (which address the installation of a terminal groin pursuant to SB 151) do not have a predicted downdrift impact on the primary duneline to the north.

This is due to the design requirement for some level of sand transmissivity over, or through, the groin. It is predicted however that Alternative 6, which stipulates the removal of the sand tube groinfield, will have an impact on the existing South Beach dunes located eastward of STA 61+00 (more or less). Dune (and beach) recession would be expected to occur along a section of Bald Head Wynd where the upland was severely damaged and overtopped in 2002 prior to the reconstruction of the sand tube groinfield. Due to the orientation of the shoreline at that location, it is an area of high erosional stress due to wave energy concentration, particularly during storms. Removal of the sand tube groins at this location may release sand retained between tubes which presently support a protective beach berm thereby potentially making some portions of the duneline subject to sand loss at/or near the end of each 3-year sand placement operation. As discussed previously, the direct updrift benefits associated with the proposed terminal structure do not extend throughout the length of the sand tube groinfield in its entirety.

5.2.4 Sand Volume Requirements and Borrow Sites

As described in Section 3.0, Alternative #1 (No Action/Status Quo) and Alternative #2 (Retreat) preclude the use of any large scale Village-sponsored nourishment and the associated need for a sand source site. Each of the remaining four alternatives would have varying sand volume requirements depending upon the predicted (and monitored) condition of the beachfront relative to the stated project purpose and goals. Based upon the predicted beach performance under Alternatives #3 through #6 (as described in Section 5.2.2 above), the project engineer has identified the volume requirement, frequency of nourishment, and prospective sand source site for each of these alternatives over a 30-year planning horizon (see Table 5.5).

Table 5.5 Predicted Sand Volume Requirements by Alternative (cy)

Year	ALT 3	ALT 4	ALT 5	ALT 6
0[1]	--	--	0.25 M[2] [a]	0.25 M[2] [a]
3[3]	1.5 M [a]	2.0 M(4) [b]	1.25 M[5] [a]	1.75 M [4] [5] [b]
12	1.5 M [c]	2.0 M [c]	1.0 M [c]	1.5 M [c]
21	1.5 M [c]	2.0 M [c]	1.0 M [c]	1.5 M [c]
30	1.5 M [c]	2.0 M [c]	1.0 M [c]	1.5 M [c]
TOTAL	6.0 M	8.0 M	4.5 M	6.5 M

[1] Federal beach disposal event
[2] Assumes phased approach with the construction of an initial 1,300-ft groin. Note that this is a conservative estimate in the event a supplemental volume is necessary to augment the fillet.
[3] Village sand placement pursuant to assumptions of federal disposal (channel maintenance assumed on an average three-year interval).
[4] Additional 0.5 Mcy sand placement requirement due to sand tube groinfield removal.
[5] Assumes construction of Phase 2 groin (up to 1,900 lf).
[a] Sand Source – Jay Bird Shoals (borrow site as delineated and permitted in 2009)
[b] Sand Source – Jay Bird Shoals (requiring expansion of the previously permitted borrow site)
[c] Sand Source – Frying Pan Shoals (new borrow site)

As depicted in Table 5.5, it is assumed that a federal beach disposal occurs at time zero (presently estimated to be spring 2015). For Alternative #5 and #6, it is assumed that the 1,300-lf Phase I groin will be constructed at time zero with a contingent volume (0.25 Mcy) of sand identified to augment the fillet, if needed. It is anticipated that under each of the four alternatives, Village-sponsored nourishment (in addition to the USACE channel maintenance dredging sand placement) would be required at Year 3, Year 12, Year 21, and Year 30. Alternative #4 would require the greatest volumes of sand for each nourishment event and cumulatively over the 30-year horizon. Alternative #5 would require the least amount of sand at each interval and thus cumulatively over the 30-year horizon.

The Applicant's preferred sand source for the four alternatives identified above is the Jay Bird Shoals borrow site. The specific borrow area identified by the Village consists of a site

that was previously authorized on June 18, 2009 for a one-time use as part of a Village-sponsored beach nourishment project. At that time, project construction was sequenced in such a way that left an undisturbed quadrant of the originally permitted borrow area. This unused portion of the borrow site is approximately 106 acres (not including the Cultural Resources Exclusion Area) and consists entirely of subtidal sandy bottom ranging in depth from – 7 ft NGVD29 to -18 ft NGVD29. According to the Applicant's engineer, approximately 1.5 Mcy of beach compatible sand (verified through geotechnical investigations performed in 2007) is present within the remaining borrow area limits developed for the 2009 Village-sponsored beach nourishment project (refer to Sheets 13 through 16 of Appendix H).

Jay Bird Shoals has been identified as a prospective sand source site to offset erosion along the Brunswick County beaches (NC DENR 2011). The Applicant's numerical modeling analyses of Oak Island (performed by Olsen Associates, Inc.) predict no quantifiable impact to littoral transport patterns or rates and associated shoreline change at that location due to either terminal groin construction or the continued use of the Jay Bird Shoal borrow area (to the limits of excavation permitted in 2009). The latter sand source was only partially dredged by the Village in 2009/10, however all modeling analyses (including the most recent Delft3D model) have assumed the borrow area has been excavated in its entirety. The Applicant's model predicts no changes in inlet hydrodynamics of significance to any stakeholder, be they federal or non-federal. Additional information regarding trends in shoreline accretion and recession on the eastern end of Oak Island is provided in the Applicant's proposed Inlet Management Plan (Appendix B). In accordance with SB 151, the Applicant has developed a plan for post-construction physical monitoring of the eastern end of Oak Island that will assist in the identification of a baseline condition to identify the need (if any) for mitigative action. Detailed modeling analysis of potential impacts to wave climate from dredging the Jay Bird Shoals site is provided in the engineering report entitled, "*Shoreline Stabilization Analysis, Bald Head Island*" (Olsen 2013).

Based upon the engineer's estimation of volume requirements for each alternative (Table 5.5 above), the sand volumes remaining within the Jay Bird Shoals borrow site would satisfactorily address sand needs for Alternative #3 and Alternative #5 through Year 3. After Year 3 (and before Year 12 at the latest), it is predicted that an alternate sand source site within Frying Pan Shoals would be developed (with requisite environmental documentation, geotechnical investigations, and cultural resource assessments performed). Implementation of Alternative #4 or #6 would exhaust the sand volumes present within the Jay Bird Shoals site and would necessitate the expansion of the Jay Bird Shoals site. As with the other alternatives, the prospective sand source beyond Year 3 would be a delineated and authorized borrow site on Frying Pan Shoals, which will require additional analysis and NEPA documentation prior to any potential use.

Smaller sand volume requirements associated with periodic maintenance of the beachfront along West Beach[2]; sand fillet renewal needs; and "emergency" responses to critically eroded areas (e.g. post-storm condition) may be addressed through the use of either (1) the proposed borrow area adjacent to, and immediately north of, the mouth of Bald Head Creek or (2) portions of the authorized federal navigation channel that are shoaled (and contain beach quality sand), but that are not routinely dredged for navigation purposes.

The proposed borrow site for Bald Head Creek Shoals consists of an approximate 65-acre area ranging in depth from +3.9 ft NGVD29 to -8 ft NGVD29. The design dredge depth would be -7.8 ft NGVD (or -6 ft. MLW) (with +1 ft dredging tolerance). As a result, the dredging will result in a direct effect to the existing bathymetry of the borrow site. The existing and proposed plan views and cross-section profiles of the Bald Head Creek borrow site are provided in Appendix H (Sheets 18 and 19).

[2] Note that the Applicant's engineer has cited the need for continued sand placement on West Beach due to recurring erosion, and states that such need exists with or without the construction of a terminal structure on the west end of South Beach.

As described in Section 4.0, sediment transport processes at the mouth of Bald Head Creek result in continual spit formation and shoaling. The accretion of the shoal is accelerated by the routine and continual sand bypassing operation of Bald Head Island Marina. This work involves repeated hydraulic dredging of the marina entrance and its immediate southern shoreline and the pumping of material to the timber groin field of Row Boat Row. From that location, sand is transported through alongshore drift northward toward the creek where it is deposited as part of the spit and associated ebb tidal shoal feature. As a result, it is expected that potential excavation within the identified borrow site will not appreciably affect the sediment composition of the substrate subsequent to dredging. Such a result has been documented in post-construction monitoring for the 100,000 cy dredge area excavated in January 2012. For that particular project, sediment composition has been demonstrated to be uniform both pre- and post dredging as well as between the post-dredge borrow site and the reference site (LMG 2013).

The potential effects to natural resources associated with the use of borrow sites for Alternatives #3 through #6 are described further in Section 5.5.3 and 5.6 below.

5.3 GENERAL ENVIRONMENTAL CONSEQUENCES

General environmental consequences are summarized for each alternative below. An alternatives matrix is provided to depict these general findings (refer to Appendix Q). Note that more detailed information is provided in the following subsections for specific resource categories located within and adjacent to the identified project area. In addition, economic benefits and costs are evaluated in Section 5.14.

5.3.1 No Action/Status Quo (Alternative #1)

Based upon modeling results, the No Action/Status Quo scenario would result in continued, acute shoreline recession of the western end of South Beach, the Point, and West Beach.

The resultant condition would create an unstable beach profile prone to episodic sand losses and associated effects to natural resources (e.g. nesting sea turtle habitat and dune habitat). While federal sand disposal (in accordance with the SMP[3]) would likely occur (pending federal funding), larger-scale Village-sponsored projects would not occur. The conditions that arise from this scenario were previously documented in an Environmental Assessment (EA) prepared by the Village of Bald Head Island in support of obtaining federal and state permit authorizations for the 2009/2010 beach restoration project. Under this alternative, emergency-level responses would be required, but likely untenable over any significant duration (i.e. greater than 5 years). Emergency-level actions would include beach scraping/bulldozing and sandbag revetments.

The calibrated Delft3D model was also used to predict long-term morphological changes along the western end of Bald Head Island under the assumption of the continued maintenance of the existing sand-filled tube groinfield in conjunction with the periodic disposal of sand on South Beach via federal navigation maintenance with beach disposal. The tube groins were not permitted to fail during the model simulation. Beach nourishment was prescribed to occur every three years (which has tended to be the average interval of federal disposal since the inception of the SMP) with a constant, assumed volume of 1.2 Mcy of sand placed each cycle.

The Delft3D model results indicate that the sand from the SMP events every three years is not sufficient to maintain the shoreline downdrift (west and north) of the sand tube groinfield. It is predicted that within nine years, there would be shoreline recession and deflation that would impact beach and dune resources. Based upon erosion patterns over the last ten years, it can be reasonably expected that the sand tube groinfield would become susceptible to an increased risk of failure. While failure was not permitted in the model

[3] Note that federal sand disposal under the current SMP is anticipated to occur on a six-year cycle with disposal occurring on two-year intervals. Under each cycle, disposal is anticipated to occur on Bald Head two out of the three channel maintenance events. As such, there is a minimum 4-year hiatus of sand disposal on the island.

simulation, the actual performance of the groinfield could be compromised to an extent that groinfield maintenance becomes either impracticable or not feasible. If not mitigated, such structure failure would be expected to propagate erosion pressures eastward potentially leading to subsequent groin failures.

The predicted physical consequences resulting from Alternative #1 would primarily affect the following resources: dry beach, dunes, and interdunal wetlands. In addition, several federally and state listed species that utilize these habitats may be adversely affected. It is likely that the extent of relatively stable dry beach which provides nesting habitat for sea turtles would be reduced along western South Beach and the Point. In addition, habitat suitable for the establishment and propagation of seabach amaranth would also be likely compromised. Frontal and primary dunes would be subject to loss from erosion (particularly in the vicinity of the Point). The associated storm protection functions and foraging and nesting habitat afforded by dunes would also be lost.

5.3.2 Retreat (Alternative #2)

The physical and environmental effects of the Retreat Alternative have been predicted utilizing Delft3D model simulations. Since this alternative would ultimately include the systematic removal or abandonment of the sand tube groinfield, there would be no stabilizing structures in place to reduce the rate of sand losses, and thus shoreline recession would likely occur at a more rapid pace. Furthermore, the lack of any stabilizing structures would result in a shoreline configuration affecting a much wider area of western South Beach. The applicant's models predict that within nine years, the shoreline will recede approximately 1,100 lf landward (in the vicinity of western South Beach) from its current position.

The following habitat types are subject to indirect impact as a result of the implementation of Alternative #2: dry beach, dune, interdunal wetland, and maritime thicket/forest. Based

upon prior shoreline monitoring during periods of rapid erosion, it is expected that the beach profile would be nearly vertical from upland dune to the mean high water line and thus offer very little (if any) habitat for species that utilize the dry beach. This condition would adversely affect nesting sea turtles and nesting shorebirds and waterbirds (including the Wilson's plover and the American oystercatcher). Foraging habitat for federally and state listed species would also be compromised as a result of acute erosion along much of western South Beach, the Point, and West Beach.

As the shoreline migrated landward, areas suitable for the establishment and growth of seabeach amaranth would be converted to intertidal or subtidal bottom. In addition, it is predicted that nearly all of the frontal dunes and primary dunes mapped within the area of study would be lost to erosion. Interdunal wetlands in the vicinity of South Bald Head Wynd would become inundated and eventually lost to open water. It can be reasonably expected that intertidal beach would migrate with the shoreline such that this type of habitat would not be adversely affected. In areas around the vicinity of the Point, intertidal beachfront could potentially expand.

5.3.3 Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place (Alternative #3)

Alternative #3 would result in similar conditions to those identified under the No Action Alternative with the exception of a shoreline loss that is periodically mitigated through a Village-sponsored nourishment action.

The increased frequency of nourishment required under this alternative would result in more frequent disturbance at both the dredge site and at the nourishment site. Use of the federal navigation channel as a source site for the sand would help to minimize any adverse environmental impacts at the dredge site, but there is unlikely to be sufficient sand in the channel for each Village-sponsored sand placement under this alternative. Use of an

offshore or nearshore borrow site would result in direct, short-term impacts to benthos and associated foraging habitat for fish. In addition, disturbance at the nourishment site would occur at a relatively high level of frequency and potentially affect benthic infaunal recruitment and community assemblages. This in turn could influence the occurrence and distribution of species utilizing the beachfront for foraging.

Seabed deflation and shoreline recession would be offset to some degree (relative to the No Action Alternative), thus resulting in the delay of impacts to natural resources. Dune overwash areas and vegetated supratidal areas in the vicinity of the Point would be susceptible to conversion to open water. However, this is a dynamic area that is continually reworked and modified by wind and wave action. It is predicted that this feature would migrate north (consistent with recent observations) and thus the net loss of this type of habitat would be minimal.

Based upon the predicted morphological response of the shoreline to the implementation of Alternative #3, dry beach and frontal dunes would be the primary habitats subject to impact. As such, some effect to nesting sea turtles and seabeach amaranth would be anticipated. However, given the relatively limited extent of predicted physical effects and the dynamic nature of these habitats, potential adverse impacts would not be considered significant.

5.3.4 Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

The residual shoreline after groin removal would be subject to littoral transport rates unaffected by stabilizing structures. In light of current inlet hydraulics and incident wave energy, the resultant condition of Alternative #4 would more closely resemble that of the Retreat Alternative identified above. The difference under this alternative would be the implementation of Village-sponsored nourishment events to help mitigate sand losses. The volume of sand required to offset these losses would necessitate Village-sponsored

nourishment events of greater size and frequency than that identified under Alternative #3. Implementation of this alternative would result in the highest level of spatial disturbance of both subtidal bottom (at the dredge site) and intertidal and dry beach habitat (at the nourishment site). Increased frequency of nourishment events would likewise have an adverse effect on benthic assemblages and recovery periods. Effects to these food sources may result in increased indirect effect to foraging birds and surf zone fishes along the affected shorelines.

Based upon a three-year schedule of implementation of the SMP used in this analysis and a Village-sponsored nourishment of approximately 1.5 Mcy, it is anticipated that by Year 9 of the Delft3D simulation that the shoreline would recede nearly 1,000 lf landward (in the vicinity of western South Beach) of its current position. As a result, the following habitat categories would be affected to an extent similar to that described for Alternative #2: dry beach, dune, interdunal wetlands, and maritime thicket/forest. Similar consequences to federally and state listed species are anticipated. In particular, the area of dry beach potentially suitable for nesting sea turtles, nesting shorebirds (in sparsely vegetated areas), and seabeach amaranth would be reduced. Foraging and nesting habitat of vegetated dunes would likewise be lost to erosion. Interdunal wetlands and maritime thicket/forest habitats would be converted to open water. Areas interior of the predicted 9-year shoreline position would be susceptible to shifts in vegetative composition due to increased exposure to coastal processes, including wind and wave energy and potential overwash (particularly during storm events).

5.3.5 Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining) (Alternative #5)

Installation of a terminal groin structure, nourishment of the updrift field (i.e. placement of a corresponding fillet), and on-going maintenance of the existing sand tube groinfield would afford the highest level of stability and retention of sand along South Beach among the

alternatives considered. Since the groin would be designed to allow sand transmissivity both through and over the structure, passage of sand would be expected continue to its lee side to some degree. As a result, habitats of the project area would be subject to decreased loss from erosion compared to the current condition.

Overall, it is anticipated that implementation of Alternative #5 would result in more stable dry beach habitats considered more favorable for sea turtle nesting. However, the footprint of the rock structure (combined phases) would replace approximately 0.1 acres of dry beach, 0.5 acres of wet beach, and 2.0 acres of marine subtidal bottom. In addition, proposed construction of the structure would necessitate work within the sea turtle moratorium. Utilizing a phased approach for construction would reduce the construction time period. However, it is presently estimated that a Phase I (1,300 ft. long) terminal groin, constructed without the need for a hydraulically placed fillet, would begin immediately following the next federal disposal event (likely in April) and would continue through the summer. While sea turtle nest monitoring would be on-going throughout construction, there may be temporal disturbance to these nesting habitats as a result of the construction.

Installation of the groin could also influence the behavior of foraging birds. Construction and burial of benthic prey items may result in the need for some birds (including federally and state-listed species) to move to other parts of the beach not influenced by project construction. The location and extent of the Phase I structure relative to the expected beach condition subsequent to federal disposal is depicted in Sheet 9 of Appendix H. It is likely that a Phase I groin construction operation can benefit from the creation of sand work pads on the structure's updrift side with the source of sand being the federal disposal berm. The purpose of the work pads is to minimize, or ideally eliminate, the need for a construction trestle. Any work pad sand placement likewise beneficially contributes to the expedited formation of an updrift fillet.

Installation of the groin structure is not anticipated to adversely affect larval fish transport into the Cape Fear River Estuary given the size of the structure relative to the large tidal hydraulic field of the river mouth. Olsen Associates utilized the Delft3D numerical model to analyze the potential differences in hydraulic pathways of particulates (hypothetical fish larvae) resulting from (1) beach fill and (2) beach fill with a semi-permeable terminal groin. The predicted alterations to tidal flow are not expected to significantly hinder the ability of suspended biota or fish larvae from nearshore waters to reach the inlet en route to the interior estuary system. The findings of the larval transport modeling conducted for this analysis are presented in Appendix R of this document.

As proposed, the terminal groin (Phase I) would be constructed immediately subsequent to the federal disposal associated with the maintenance of the Wilmington Harbor Entrance Channel. As a result, it is likely that Phase I would not require any additional sand from a supplemental source site (i.e. Jay Bird Shoals). A Phase I structure would both reduce the volume of sand required, as well as potentially the timing of updrift fillet enhancement (if necessary) by approximately six months to one year. Hydraulic dredging and placement of supplemental sand for the fillet would be performed outside of the environmental moratoriums. Direct impact and mortality to benthic infauna of the borrow site will occur from the cutter-suction dredge. However, these impacts would be considered temporary since the benthic assemblages of depositional features (i.e. shoals) tend to be adapted to disturbance and can recruit rather quickly from adjacent undisturbed sites.

Beach disposal from the federal maintenance of the adjacent Wilmington Harbor Entrance Channel is routinely performed on the South Beach shoreline. Occasionally, federal disposal has occurred on the West Beach shoreline when requested by the Applicant and deemed acceptable by the Wilmington District. Based upon the Delft3D modeling and the analysis performed by the Applicant's engineer, "emergency" fill operations in response to episodic erosion are not predicted to increase as a result of the implementation of Alternative #5.

The installation of a terminal groin is predicted to decrease both the frequency and volume requirements of non-federal beach nourishment actions (see Table 5.5). As a result, potential adverse effects to benthic invertebrate populations would be less than the other alternatives that evaluate beach nourishment as an erosion response strategy.

5.3.6 Terminal Groin with Beach Nourishment/Beach Disposal and Removal of Sand Tube Groinfield (Alternative #6)

Implementation of Alternative #6 would have similar consequences to natural resources of the study area as those identified above for Alternative #5. The predicted shoreline positions of the two alternatives are similar based upon Delft3D modeling. However, based upon volumetric analyses, Alternative #6 retains less sand within the modeled nearshore area than Alternative #5. Deflation of the beach would result in the increased risk of sand losses in areas identified as susceptible to erosion (i.e. "hot spots") of western South Beach. Increased erosion would influence the profile and width of dry beach habitat suitable for nesting sea turtles and would expose recently established frontal dunes to overwash during storm events.

5.4 THREATENED AND ENDANGERED SPECIES

5.4.1 Alternative #1: No Action/Status Quo

A. Mammals

(1) Direct Impacts

State and/or federally protected mammals known to occur within the project area include the right whale, the humpback whale, and the West Indian manatee. In-water work associated with the No-Action alternative includes dredging from the adjacent Wilmington Harbor Entrance Channel as part of on-going navigation maintenance and in conjunction with the SMP.

According to the Biological Assessment (BA) prepared for the Preconstruction Modifications of Authorized Improvements for the Wilmington Harbor Project, no direct impacts to these species are anticipated as a result of maintenance dredging and disposal events (USACE 2000). Since the dredge vessel is nearly stationary during operation, there is minimal collision threat. Additionally, a daytime whale observer is present when dredging occurs between December 1 and March 31 in accordance with previous biological opinions issued by NMFS (NMFS, 1997). Since these species do not encounter the surf zone, no impacts would occur from sand disposal on the beachfront.

The No-Action Alternative also considers the use of short-term stabilization measures (such as beach scraping and sand bag revetments) as have been employed by the Village in previous years. Since these actions are specific to the beachfront, no impacts would occur to state or federally-listed mammal species. Furthermore, maintenance of the groinfield (including reconstruction and/or minor reconfiguration) would not affect listed mammal species.

(2) Indirect Impacts

There are no indirect effects to manatee, humpback whale, or right whale resulting from maintenance dredging of the navigation channel (USACE 2000). Productivity of the nearshore ocean would not be diminished by the proposed dredging. Therefore, the food supply of federally-protected whale species would be unaffected. The diet of the West Indian manatee consists primarily of vascular plants of interior creeks. Proposed dredging of the entrance channels as part of the SMP has no effect to the physical habitat of the estuary, and overall estuarine and nearshore productivity would remain high throughout the project area (USACE 2000). Therefore, potential food resources of the manatee would not be impacted.

(3) Cumulative Impacts

Maintenance dredging and disposal of material derived from maintenance dredging of the Wilmington Harbor navigation channel onto Bald Head Island occurs per the terms of the SMP. Given the absence of any direct or indirect effects associated with these actions, there are no cumulative effects to federally-listed marine mammals when evaluated in the context of past, present, and reasonably foreseeable future projects.

B. Birds

(1) Direct Impacts

Disposal activities associated with the SMP would occur during winter months and would not affect nesting birds. Likewise it would be anticipated that other stabilization efforts that are evaluated in the context of the status quo condition (such as sand tube maintenance, installation of sand bag revetments for imminently threatened structures, and beach bulldozing/scraping) would occur during winter months and outside of the nesting season of federally and state listed birds. However, all of these actions have the potential for the temporary disturbance of feeding activities of resident and migratory birds, including the federally-listed piping plover and red knot. The Wilmington Harbor Project BA determined that beach disposal may temporarily disrupt nesting that may be attempted along the eroded beach front (USACE 2000). However, that BA evaluated a much larger project area that included Oak Island and Holden Beach. No piping plovers have been documented nesting in the vicinity of the project area on Bald Head Island. Generally, the piping plover prefers the upper edges of overwash areas adjacent to inlets. Even though it is unlikely (given the documented history) that piping plover would nest on Bald Head Island, disposal activities may affect, but are not likely to adversely affect piping plover.

The rufa red knot is most commonly observed along the beaches of Bald Head in mid-May, as it passes through the area during spring migrations (B. Watts, pers. comm.). Since the

proposed activities associated with Alternative #1 would occur during winter months, no direct impacts to the red knot are anticipated.

(2) Indirect Impacts

The piping plover and a variety of other shorebirds and colonial waterbirds are known to forage within the surf zone along Bald Head Island throughout the year. Moving sand to nourish the shoreline as well as short-term beach stabilization methods may bury intertidal macrofauna and reduce the available food resource to birds in this area. In general, beachfront fill placement results in short-term declines in species abundance, biomass, and taxa richness. While there will be a direct loss of prey species (i.e. crabs and worms) for birds following placement of the dredged sand, additional foraging impacts could result if the disposal material does not closely match the recipient beach. Sediment that is too coarse and/or contains high shell content can inhibit a bird's ability to extract food particles from the sand (ASMFC 2002). However, material from the entrance channel reaches have been demonstrated to be compatible as evidenced through several SMP events. As a result, risk of these latter effects is considered to be minimal.

Levisen and Van Dolah (1996) reported rapid recovery of beach infauna (less than 60 days) including species abundance and diversity of the overall faunal complex following beach bulldozing. This study supports similar research indicating quick recovery of invertebrate fauna with no long term changes to species composition subsequent to beach scraping (ASMFC 2002). Additionally, directly after impacts to macrofauna have occurred and numbers of these species are depressed, birds that prey upon these invertebrates, including plovers, red knots, and other state-listed bird species, would likely move to adjacent undisturbed beach areas or tidal flats for the temporary period of population re-establishment. The Wilmington Harbor Project BA determined that beach disposal may temporarily impact foraging habitat.

The American oystercatcher, least tern, and Wilson's plover (all state-listed as Species of Concern), have been documented nesting in the dry beach at Bald Head Island. These species tend to nest above the high tide line on bare sand and shell in sparsely vegetated areas of the upper beach or between smaller dunes (Johnsgard 1981; Tompkins 1944). Delft3D model results indicate that, under the No Action alternative, disposal events from the SMP (combined with regular maintenance of the existing sand tube groinfield) would not be able to keep pace with predicted sediment losses from western South Beach and the Point. Erosion is anticipated to be most severe at the Point. This feature currently consists of expansive areas of unvegetated and sparsely vegetated supratidal habitat suitable for nesting habitat. Loss of these areas is predicted by Year 9 of the Delft3D simulation (see Figure 5.1 and Figure 5.2). Refer to Table 5.6 for a summary of predicted area loss or gain (acres) by habitat type.

(3) Cumulative Impacts

The temporal separation between channel maintenance events has allowed and would continue to allow for recovery of the benthos prior to subsequent dredge events. Therefore, no cumulative impacts are anticipated.

C. Reptiles

(1) Direct Impacts

The proposed dredging of the navigation channel would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the shoreline. Because the operation of the dredge plant to be used is almost stationary, no direct impacts to foraging sea turtles are anticipated. The BA for the Wilmington Harbor Project determined that the dredging and disposal related to the maintenance of the navigation channel may adversely affect the loggerhead, Kemp's ridley, and green sea turtles because of the possibility of missing a nest where beach disposal is scheduled to occur and because survival of moved eggs may be reduced compared to undisturbed nests (USACE 2000). In consideration of the dredge and

Table 5.6. Predicted Losses or Gains by Habitat Type and Alternative.

Habitat Type	Existing Quantity	Alt 1		Alt 2		Alt 3		Alt 4		Alt 5		Alt 6	
	acres	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)
Subtidal Bottom	186.9	219.7	32.8	283.1	96.2	194.1	7.2	256.9	70.0	176.4	-10.5	183.3	-3.6
Wet Beach	20.8	21.3	0.5	18.9	-1.9	21.8	1.0	19.6	-1.2	23.5	2.7	23.1	2.3
Dry Beach	30.5	8.7	-21.8	7.1	-23.4	24.6	-5.9	11.0	-19.5	38.6	8.1	32.2	1.7
Dunes	21.1	12.6	-8.5	5.0	-16.1	18.8	-2.3	8.6	-12.5	20.9	-0.2	20.7	-0.4
Interdunal Wetlands	3.9	3.9	0.0	1.9	-2.0	3.9	0.0	1.9	-2.0	3.9	0.0	3.9	0.0
Maritime Thicket/Forest	13.7	13.7	0.0	6.6	-7.1	13.7	0.0	9.4	-4.3	13.7	0.0	13.7	0.0
Total Acres in Evaluation Area	276.9												

*Note habitat gains and losses are based upon predicted shoreline positions at Year 9 of Delft3D model simulation

disposal windows typically adhered to and the intensive monitoring of nests conducted by BHIC, potential impacts associated with disposal events are minimized.

(2) Indirect Impacts

As described above, the No Action/Status Quo scenario would result in continued shoreline recession of West Beach and the western end of South Beach[4]. The critically-eroded area would likely produce a nearly vertical profile from upland dune to the mean high water line. Unless relocated, loggerhead and green sea turtle nests that have already been laid may be lost to erosion. The Bald Head Island Conservancy (BHIC) currently monitors the beach for nesting sea turtles and relocates nests that are laid in eroded areas. Under the No-Action alternative, these relocation efforts would continue and may need to extend further east along South Beach as erosion progresses.

Based upon Delft3D modeling, nearly all of the dry beach at the Point and the extreme west end of South Beach will be converted to intertidal wet beach or subtidal bottom by Year 9 of the simulation. As a result, it is predicted that nearly 22 acres of dry beach will be lost to erosion within nine years of the implementation of Alternative #1. Additionally, deflation and recession of the shoreline would result in increase risk of inundation of nests.

In addition to the loss of habitat, physical conditions of the shoreline would likely result in additional indirect effects. Steeper beach profiles and the formation of escarpments would likely restrict access to suitable nesting areas and result in increased energy expenditure of the adult female. Eroding steep beach escarpments as well as other physical barriers often cause mature female sea turtles to select poor nesting sites at the dune toes which causes higher nestling mortality rates (Ernest & Martin 1999; NMFS 2008).

[4] Though the current SMP anticipates the disposal on adjacent beaches on two-year intervals, federal funding and other considerations may impact the timing and occurrence of maintenance and disposal events. To that end, the model assumes that actual disposal would occur in a manner similar to the past decade with placement occurring on an average three-year interval.

Sea turtle nesting habitat may also be indirectly affected by disposal events occurring under the SMP. However, the disposal events would occur outside of the sea turtle nesting season and only beach quality sand (suitable for sea turtle nesting, successful incubation, and hatchling emergence) would be disposed on the beach. Furthermore, sand of similar grain size and composition to that of the existing beach would be used to reduce any changes in physical characteristics of the beach that may affect nest survival.

(3) Cumulative Impacts

The continuation of the SMP and other short-term stabilization measures implemented by the Village are not anticipated to result in any cumulative effects.

D. Fish

(1) Direct Impacts

The federally-listed shortnose and Atlantic sturgeon are known to occur in the project area. Any individuals present would be non-spawning adults or juveniles. Under the SMP, sand would continue to be dredged from open water areas within the Wilmington Harbor during winter months. The proposed excavation work would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the shoreline. Because the operation of the dredge plant to be used would be almost stationary, no direct impacts to the shortnose or Atlantic sturgeon are anticipated.

(2) Indirect Impacts

The BA prepared for the Wilmington Harbor project determined that the food supply of the shortnose sturgeon would not be affected by the proposed schedule, location, and footprint of dredging of the Wilmington Harbor Deepening Project. While juveniles tend to feed on the bottom of deep water areas of the river, existing benthic assemblages would remain largely unchanged as a result of the implementation of the deepening and realignment project (USACE 2000). Although impacts to the Atlantic sturgeon were not evaluated in the

BA (the species was not federally protected until 2012), it feeds on similar food resources as the shortnose sturgeon. Therefore, no indirect effects to either species are anticipated as a result of the on-going maintenance dredging and beach disposal .

Other short-term stabilization measures (e.g. beach scraping and sand bag revetments) and the maintenance of the existing sand tube groinfield are confined to the beachfront and surf zone area. These actions would not result in any indirect effects to the shortnose sturgeon or the Atlantic sturgeon.

(3) Cumulative Impacts

No cumulative impacts to these protected species are anticipated as a result of the implementation of the No-Action Alternative.

E. Plants

(1) Direct Impacts

Direct effects to seabeach amaranth and other state-listed plants that occur within the dry beach habitat (e.g. seaside spurge, beach morning-glory, seabeach knotweed, and dune bluecurls) could potentially result from the supplemental short-term stabilization measures considered under the No-Action or Status-Quo Alternative. Beach scraping and sand bag revetments can potentially impact plants and cover seeds which would reduce the opportunity for germination and growth of these plants.

While habitat conditions tend to improve as a result of beach disposal or nourishment, the BA for the Wilmington Harbor project stated that disposal events that occur during the growing season may slow population recovery of seabeach amaranth over the short term. However, federal disposal events on Bald Head tend to occur during the winter months when the plants have not germinated. Placement of sand on the beach under the SMP may

deeply bury existing seabeach amaranth seeds and other rare plants located on the upper beach of the project area, which could negatively affect the population in later seasons.

(2) Indirect Impacts

Based upon Delft3D modeling, it is predicted that nearly 22 acres of dry beach and 8.5 acres of dune habitat would be lost to erosion within nine years of the implementation of this alternative. It is likely that the accelerated erosion would result in steep profiles of the shoreline from the upland dune to MHW. Therefore, habitat for seabeach amaranth and several state-listed plants along West Beach and along the western part of South Beach would be either substantially degraded or lost. This loss would be offset by continued federal disposal events associated with the SMP. Disposal on western South Beach would likely enhance the habitat requirements for seabeach amaranth. According to the USACE (2000), "new populations have been observed to follow sand placement on other beaches where sand has been disposed by the Corps of Engineers."

(3) Cumulative Impacts

While some level of impact to habitat for seabeach amaranth and state-listed plant species noted above will occur as a result of the predicted shoreline response, cumulative impacts are not anticipated as a result of the implementation of the No-Action Alternative.

5.4.2 Alternative #2: Retreat

A. Mammals

(1) Direct Impacts

In-water work associated with the Retreat alternative is essentially the same as Alternative 1 and includes dredging from the adjacent Wilmington Harbor Entrance Channel as part of on-going navigation maintenance and resulting beach disposal. Other measures employed as part of a planned shoreline retreat (including the removal of the sand tube groinfield) will

not affect listed mammal species. As a result, no direct impacts to federally-protected mammals would occur under this scenario.

(2) Indirect Impacts

As described above for the no-action alternative, no indirect impacts to whales or manatees are anticipated to take place.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with the maintenance of the Wilmington Harbor Entrance Channel and the planned retreat measures, no cumulative effects to federally-listed marine mammals would occur.

B. Birds

(1) Direct Impacts

Direct impacts to state and federally-listed birds under the Retreat Alternative are not anticipated. While continued disposal resulting from the maintenance of the federal navigation channel may continue to occur, it is likely that the USACE would shift its disposal footprint further east on South Beach so as to minimize direct loss of sand back into the channel (in the absence of any stabilization measures along western South Beach). Continued disposal events under the SMP are not expected to have direct effects on state and federally-listed species.

(2) Indirect Impacts

The Retreat Alternative would include the removal or abandonment of the sand tube groinfield. Without these stabilizing structures, shoreline recession would occur at a more rapid pace than Alternative #1. Furthermore, the lack of any stabilizing structures would result in a shoreline configuration affecting a much wider area of western South Beach. Under this alternative, the shoreline along western South Beach is predicted to recede in

excess of 1,100 lf landward from its current position. In addition, rapid erosion into uplands would result in a nearly vertical profile from upland to MHW. While some level of equilibration and profile flattening would be expected over time, there will be loss of dry beach habitat. Over a nine-year term, model simulations predict the loss of nearly 2 acres of intertidal beach, 23 acres of dry beach, 16 acres of dunes, and 2 acres of interdunal wetlands, and 7 acres of maritime thicket/forest (refer to Table 5.6). Within a natural inlet and shoal system, it would be expected that these habitat types would reform as the system equilibrated. However, the routine dredging of the federal navigation channel changes natural sand transport processes and influences the predicted conditions ensuing from the Retreat Alternative. Just as importantly, the developed nature of the adjacent upland areas of Bald Head Island prevents migration of these habitats into other portions of the Island, as they moved in the decades before island development. As a result, loss of both foraging and nesting habitat for state and federally-listed species is expected under this scenario.

As indicated above, much of the shoreline of western South Beach and the Point (including intertidal, dry beach, and foredune habitats) would be converted to subtidal bottom. Foraging habitat would be degraded or lost as a result of these changes. While benthic assemblages of the shoreline tend to be adapted to disturbance-prone conditions, habitat losses would reduce the abundance and composition of benthic assemblages available for foraging birds. Short-term protection measures (e.g. temporary sandbag revetments) could potentially influence foraging behavior. In addition, demolition, removal, or relocation of structures, roads, and utilities in close proximity to the receding shoreline could influence foraging behavior for brief periods.

The extent of erosion predicted under Alternative #2 would result in the loss of mapped maritime thicket/forest areas of the interior hind-dunes of the Island. Additional stress from wind and salt spray would likely alter the vegetative assemblage of other areas not directly

lost. Birds known to occur in this community type, including the eastern painted bunting, may be affected.

(3) Cumulative Impacts

While current bird foraging and nesting habitat is subject to loss from acute erosion, these losses are expected to be offset over time as some level of equilibrium is achieved and areas of new intertidal and dry beach habitat form. The developed nature of the island in combination with the proximity of the deep-draft navigation channel, exert considerable influence over 'natural' barrier island processes. Nonetheless, this area of shoreline is highly dynamic and it is likely that foraging, roosting, and nesting habitat will continue to exist even with the extent of erosion predicted. As a result, no cumulative impacts to state and federally-listed bird species are expected.

C. Reptiles

(1) Direct Impacts

Direct impacts to state and federally-listed reptile species are not anticipated under Alternative #2. While federal channel maintenance and disposal is expected to continue to occur, these actions do not directly impact listed species. Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Geotube removal would likely occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal. Removal of sand tubes may affect foraging and roosting of bird species, though any disturbance would be temporal. Other retreat measures (e.g. demolition and relocation of structures) would occur landward of the dry beach and thus would not affect nesting sea turtles.

(2) Indirect Impacts

As with Alternative #1, the rapid erosion predicted in this alternative could cause the loss of loggerhead and green sea turtle nests that have already been laid, unless such nests are relocated. Under this alternative, relocation efforts currently conducted by the BHI Conservancy would continue and would likely need to extend further along South Beach as erosion is predicted to affect a much wider area of western South Beach. These efforts would help reduce the scope of potential adverse effects. However, given the extent of predicted shoreline recession and loss of dry beach habitat, impacts to sea turtle nesting would likely be unavoidable.

Loss or degradation of over 23 acres of dry beach habitat along western South Beach and the Point would likely influence sea turtle nesting behavior and success. Eroding steep beach escarpments as well as other physical barriers often cause mature female sea turtles to select poor nesting sites at the dune toes which causes higher nestling mortality rates (Ernest & Martin 1999; NMFS 2008). As with Alternative #1, turtle nesting habitat along West Beach and the point would likely deteriorate, however at a more rapid rate than Alternative #1.

Removal of the sand tube groinfield has a potential beneficial effect on adult female and hatchling behavior. Hardened structures exposed above the beach or buried by accreting sand have the potential to adversely affect nesting turtles during nest site selection or during nest digging (resulting in false crawls or false digs). Groin structures may also concentrate predators (either birds or fish) and present physical impediments to hatchlings. Resultant increased energy expenditure by hatchlings can affect their ability to reach offshore developmental areas (Davis et al., 2002). Failure or flanking of sand tubes can exacerbate erosion and result in steep escarpments between groins. Any indirect positive effects resulting from removal of the sand tube groinfield would need to be considered in the context of the likelihood of increased erosion and loss of dry beach habitat. Given the

extent of dry beach losses predicted under the Retreat Alternative, the net effect of groinfield removal on nesting sea turtles is likely negative.

The extent of erosion predicted under this alternative would likely result in increased salt spray to the back dune and interdunal communities. Increased incidence of overwash has the potential for creating hypersaline conditions within interdunal wetlands or ponds. These conditions would influence the distribution and behavior of less salt-tolerant species, including the American alligator. Additionally, predicted erosion may expose maritime forest habitat to increased wind and salt spray, which can influence community composition. Several state listed reptiles, including coachwhip, southern hognose snake, and the eastern coral snake, are associated with this habitat type and may be negatively affected.

(3) Cumulative Impacts

While the predicted extent of habitat losses under this scenario are considerable, the western end of South Beach has been an area susceptible to acute erosion for many years and thus does not present high quality nesting habitat for sea turtles. Given the relatively low abundance of nests and the current practice of nest relocation for the far western portion of South Beach, implementation of the Retreat Alternative would likely not result in cumulative impacts to federally-listed turtle species. In addition, the potential indirect effects to other listed reptile species are not of a magnitude to generate cumulative impacts.

D. Fish

(1) Direct Impacts

In-water activities for the Retreat Alternative would be the same as those described for Alternative #1. As with Alternative #1, no direct impacts to the shortnose or Atlantic sturgeon are anticipated to occur.

(2) Indirect Impacts

Some food resources of sturgeons may be initially affected by dredging associated with maintenance of the Wilmington Harbor navigation channel. However, existing benthic assemblages of the maintained entrance channel are likely adapted to frequent disturbance (given the repeated shoaling and dredging characteristic of these portions of the entrance channel). Taxa that are present are anticipated to be opportunistic in nature and would thus recruit rather quickly into the affected area (Van Dolah et al. 1984). Sturgeon habitat will not be modified and feeding areas will remain largely unchanged as a result of the continuation of the channel maintenance. Furthermore, both species are mobile and would likely avoid the operation of a hydraulic cutter-suction dredge.

(3) Cumulative Impacts

No cumulative effects to listed sturgeon species are anticipated as a result of the implementation of the Retreat Alternative.

E. <u>Plants</u>

(1) Direct Impacts

Disposal activities that would continue to be conducted as part of the SMP may directly affect seabeach amaranth and other state-listed plants that occur within dry beach habitat (e.g. seaside spurge, beach morning-glory, seabeach knotweed, and dune bluecurls) However, disposal along western South Beach would likely have minimal impact on these species due to the high erosion rates and associated instability of the existing beach profile.

(2) Indirect Impacts

Under this alternative, shoreline recession would occur at a more rapid pace than Alternative #1 and would affect a much wider area of the Point and western South Beach. Modeling predicts the net loss of over 23 acres of dry beach and 16 acres dunes (Table 5.6). Beach profiles would be expected to be nearly vertical from upland dune to the mean high

water line along many areas of the receding shoreline. The resultant condition would thus offer very little habitat for rare plant species that utilize the dry beach and dune system. Therefore, this alternative would cause the loss of existing plants and/or seeds located along the dry beach and dune.

Several state listed plants, including spreading sandwort, liverwort, four-angled flatsedge, nerved witch grass, Terrell grass, coralbean, shortleaf basket grass, large-seed pellitory, cabbage palm, tough bumelia, Cuban schliessmund, and dune bluecurls, grow within maritime forest habitat. Erosion predicted to occur under this alternative would likely expose this habitat type to increased wind and salt spray, which can influence community composition and ultimately affect these species.

(3) Cumulative Impacts

No cumulative impacts to seabeach amaranth or other rare plant species are anticipated to occur under this alternative.

5.4.3 Alternative #3: Beach Nourishment/Beach Disposal with Existing Sand Tube Groinfield to Remain in Place

A. Mammals

(1) Direct Impacts

Alternative #3 would be similar to the No-Action Alternative with the exception of a shoreline loss that is periodically mitigated through a Village-sponsored nourishment action in addition to the regular disposal of sand from Federal navigation channel maintenance. It is anticipated that beach nourishment events for Alternative #3 would occur three years after the next scheduled federal disposal event and re-occur on nine year intervals through the life of the project (30 years); as noted before, this assumption does not track planned federal disposal activities, but rather assumes that actual disposal would occur in a manner similar to the past decade. For the SMP disposal, sand would be dredged from open water

areas within the Wilmington Harbor Entrance Channel. For Village-sponsored events, sand would be dredged from offshore or nearshore borrow sites including (1) reaches of the Wilmington Harbor entrance channels, (2) Jay Bird Shoals, (3) Bald Head Creek, and/or (4) Frying Pan Shoals. As described under previous alternatives, because the proposed excavation work would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the shoreline, no direct impacts to whales or manatees are anticipated.

(2) Indirect Impacts

Dredging of any one of the prospective sand source sites would result in the mortality of benthos that existed within the dredge area at the time of the work. Since manatees generally feed on aquatic vegetation of protected bays and estuaries (USFWS, 2001), no impacts to their foraging behavior or source of food would occur. The entrance channels of Wilmington Harbor are prone to disturbance from deposition and from subsequent channel maintenance. In addition, active shoals are dynamic features and similarly support disturbance-prone benthic taxa. Therefore, any benthic assemblage would likely include opportunistic species that would recruit rather quickly into the dredged site (Van Dolah et al. 1984). As a result, no indirect impacts are anticipated to the right whale or humpback whale.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with this alternative, no cumulative effects to federally-listed marine mammals are anticipated under this alternative.

B. Birds

(1) Direct Impacts

Disposal activities associated with the SMP and Village-sponsored events would occur during winter months and would not directly affect nesting birds. Nourishment would occur along

eroded segments of western South Beach and West Beach. Any overwintering birds that may be present in the nourishment area can readily move to adjacent beachfront.

(2) Indirect Impacts

Based on modeling of the shoreline over a nine year period, foraging habitat for birds such as overwash areas and vegetated supratidal areas in the vicinity of the Point would be susceptible to conversion to open water. However, this is a dynamic area that is continually reworked and modified by wind and wave action. It is predicted that the Point would migrate north (consistent with recent observations) and thus the net loss of this type of habitat would be minimal.

Disturbance at the nourishment site would occur at a higher level of frequency than previous alternatives since this alternative would include disposal from SMP events *and* supplemental Village-sponsored nourishment. The combined actions would result in more frequent burial of benthic infauna of the beachfront and could influence species assemblages. However, the Village-sponsored events would be spaced over nine-year intervals and would thus allow greater periods for recovery even when evaluated in the context of recurring SMP events. Moving sand to nourish the shoreline may bury intertidal macrofauna and reduce the available food resource to birds in this area, including the piping plover, red knot, and other state-listed species. In general, beachfront fill placement results in short-term declines in species abundance, biomass, and taxa richness. Directly after impacts to macrofauna have occurred and numbers of these species are depressed, birds that prey upon these invertebrates, including plovers, would likely move to adjacent undisturbed beach areas or tidal flats for the temporary period of population re-establishment. As stated previously, the Wilmington Harbor Project BA determined that the beach disposal associated with the SMP may temporarily impact foraging habitat and disrupt nesting that may be attempted along the eroded beach front. However, no piping plovers have been documented nesting within the project area.

Dredging at any of the prospective sand source sites is not anticipated to result in any indirect effects to state or federally-listed bird species. Proposed borrow site boundaries would avoid intertidal flats within or adjacent to the sand source site. Borrow area conditions generally consist of subtidal bottom ranging from shallow (e.g. – 1 ft MLW at Bald Head Creek) to deep water (e.g. – 40 ft +/- within shoaled areas of the federal navigation channel). Thus, potential impacts to foraging and roosting areas would be minimized or avoided entirely.

(3) Cumulative Impacts

In consideration of past, present, and reasonably foreseeable future projects, cumulative effects to state and federally-listed bird species are not anticipated. While some time crowding of disposal and nourishment events could potentially occur, it is believed that there would be sufficient time between these actions to allow for recovery of beachfront benthos. Some level of indirect effects may occur to foraging and roosting areas; however, these effects are not expected to result in additive or interactive stressors that would result in cumulative impacts.

C. Reptiles

(1) Direct Impacts

Dredging and disposal events associated with the Wilmington Harbor navigation channel are expected to continue to occur on average every three years. Village-sponsored nourishment is anticipated to occur three years after the 2014 SMP disposal and continue on approximately nine-year intervals for the remaining term of the 30-year Department of Army (DA) permit. No direct impacts to sea turtles would be anticipated to occur from the dredging activities since they would take place during winter months and would utilize a hydraulic cutter suction dredge. Nourishment events would be conducted outside of the sea turtle nesting season and would not directly impact these species.

Based upon the predicted morphological response of the shoreline to the implementation of Alternative #3, dry beach and frontal dunes would be the primary habitats subject to impact. Therefore, some loss of nesting sea turtle habitat would be anticipated. However, given the relatively limited extent of predicted physical effects and the dynamic nature of these habitats, potential direct, adverse impacts would not be considered significant.

(2) Indirect Impacts

Based upon the predicted morphological response of the shoreline to the implementation of Alternative #3, dry beach and frontal dunes would be the primary habitats subject to impact. Therefore, some loss of nesting sea turtle habitat would be anticipated. However, given the relatively limited extent of predicted physical effects and the dynamic nature of these habitats, potential adverse impacts would not be considered significant.

Sea turtle nesting habitat may be indirectly affected by periodic nourishment events if beach characteristics are altered. As with previous disposal and nourishment events, only sand suitable for sea turtle nesting, successful incubation, and hatchling emergence would be used. Furthermore, sand of similar grain size and composition to that of the existing beach would be used to reduce any changes in physical characteristics of the beach that may affect nest survival. Ultimately, nourishment would replenish the eroded beach and ultimately expand habitat for nesting sea turtles.

(3) Cumulative Impacts

In consideration of past, present, and reasonably foreseeable future actions, implementation of Alternative #3 is not anticipated to result in cumulative impacts to listed sea turtle species.

D. Fish

(1) Direct Impacts

Village-sponsored nourishment would require the use of sand source site(s) consisting of subtidal bottom within either a depositional reach of the federal channel or within a natural depositional feature (i.e. shoal). Dredging would represent direct, temporal impact to subtidal bottom. Use of the federal navigation channel as a source site would help to minimize any potential adverse effects since the channel is already a highly manipulated area subject to recurring deposition and dredging. Use of an offshore or nearshore borrow site would result in direct, short-term impacts to benthos and associated foraging habitat for fish, including sturgeon. However, the proposed excavation work would be performed with a hydraulic cutter suction dredge during acceptable environmental windows and sand would be pumped by submerged pipeline to the shoreline. Since the operation of the dredge to be used would be nearly stationary, no direct impacts to the shortnose or Atlantic sturgeon are anticipated. Sturgeon are mobile and would likely avoid the cutter head and suction mouth.

Nourishment activities would occur above the mean low water level and would not affect these species.

(2) Indirect Impacts

Some food resources of sturgeons may be initially affected by periodic dredging activities. However, given the anticipated intervals between prospective Village-sponsored nourishment, there will be sufficient time for benthic species recovery at the dredge site. As evidenced for other projects, including the Village's recent Jay Bird Shoals dredge and nourishment project, species abundance and taxa richness return to pre-construction levels and are similar to reference shoal sites within two years of dredging (LMG 2012). In general, benthos of depositional environments tend to be adapted to disturbance and can quickly reestablish via recruitment from adjacent undisturbed areas (Van Dolah et al. 1984).

(3) Cumulative Impacts

Maintenance dredging of the Wilmington Harbor navigation channel in this area has been determined to have no effect to sturgeon (USACE 2000). Village-sponsored dredge and nourishment is sufficiently spaced and not of a magnitude to yield additive or interactive stressors to sturgeon. In the context of past, present, and reasonably foreseeable future actions, cumulative impacts are not expected as a result of the implementation of Alternative #3.

E. <u>Plants</u>

(1) Direct Impacts

Periodic dredging activities would occur in open water, offshore, or nearshore areas and would not affect seabeach amaranth or other state-listed plant species known to occur in the area. Nourishment activities would occur during winter months after seabeach amaranth plants have released their seeds. The placement of sand via federal disposal and Village-sponsored nourishment may deeply bury existing seeds located on the upper beach of the project area. However, the seeds are likely to remain viable and may germinate when the imported sand washes away (Benjamin 2012). As a result, no direct impacts to seabeach amaranth are expected.

(2) Indirect Impacts

Delft3D modeling conducted for Alternative #3 predicts a loss of dry beach and frontal dunes, principally along western South Beach and the Point. Shoreline recession and deflation would be most prominent at the current location of the Point. This feature would likely migrate north. By year 9 of the model simulation, a net loss of 5.9 acres of dry beach and 2.3 acres of dune is predicted. Some areas considered suitable for the germination and growth of seabeach amaranth, seaside spurge, beach morning-glory, seabeach knotweed, dune bluecurls, and moundlily yucca would expected to be lost or degraded.

(3) Cumulative Impacts

Implementation of Alternative #3 is not expected to result in cumulative impacts to the federally-protected seabeach amaranth or other state-listed species noted above.

5.4.4 Alternative #4: Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal

A. Mammals

(1) Direct Impacts

Alternative #4 considers Village-sponsored nourishment and the removal of the sand tube groinfield. With the removal of these sand-stabilizing structures, the frequency and extent of Village-sponsored sand placement events will be significantly greater than that of Alternative #3 (as substantiated by Delft3D modeling results discussed in Section 5.0). The potential sand sources required for this alternative are the same as those identified under Alternative #3. As with previous alternatives, the proposed excavation work would be performed with a cutter suction dredge and no direct impacts to whales or manatees would be anticipated.

Increased volumes of sand required under Alternative #4 would likely require the use of a large sand source site (i.e. Frying Pan Shoals) rather than the use of Jay Bird Shoals and reaches of the federal channel which contain limited sand volumes relative to predicted need. As a result, more frequent dredging of Frying Pan Shoals would be expected. If a suitable source site exists 3 nautical miles offshore on Frying Pan Shoals, a hopper dredge would need to be used. Use of the hopper dredge could result in some increased risk of collision with protected cetaceans.

(2) Indirect Impacts

Increased frequency of dredging events would have an adverse effect on benthic assemblages of subtidal bottom of the sand source site(s). However, it is unlikely this would significantly affect the food resources of marine mammals including whale species.

(3) Cumulative Impacts

No cumulative effects to protected marine mammals would occur as a result of the implementation of Alternative #4.

B. <u>Birds</u>

(1) Direct Impacts

Impacts from disposal activities associated with the SMP and Village-sponsored nourishment events would occur in winter months and would not directly affect nesting birds.

Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Geotube removal would likely occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal. Removal of sand tubes may affect foraging and roosting of bird species, though any disturbance would be temporal.

(2) Indirect Impacts

Based upon a three-year schedule of implementation of the SMP and a Village-sponsored nourishment of approximately 1.5 Mcy, it is anticipated that by Year 9 of the Delft3D simulation that the shoreline of western South Beach would recede nearly 1,000 lf landward of its current position. The predicted extent of recession and deflation of the shoreline along western South Beach and the Point would result in the net loss of nearly 20 acres of dry beach and over 12 acres of dune within the nine-year period. Though some losses would

be mitigated via Village-nourishment, accelerated erosion would likely impact state-listed bird species (including American oystercatchers and Wilson's plovers) that nest in the upper dry beach.

Increased frequency of nourishment events predicted to occur under this alternative would have an adverse effect on the benthos of the wet and dry beach of the nourishment site. Benthic recruitment and assemblages available as prey items for foraging birds would likely be adversely affected by the need for more frequent nourishment to offset sand losses from the beachfront.

Similar to Alternative #2 above, areas of maritime thicket and maritime forest habitat would be either lost or subject to alteration via increased exposure to inundation, wind, and salt spray. Birds known to occur in this community type, including the eastern painted bunting, may be negatively affected.

(3)Cumulative Impacts

While the extent of erosion predicted as a result of the implementation of Alternative #4 would have considerable impact to dry beach and dune habitat, some level of shoreline equilibrium would be anticipated over time. Natural barrier island processes are largely prohibited due to the developed nature of the island and the proximity of the deep-draft navigation channel. Nonetheless, it is expected that these habitats would likely continue to exist to some degree along this area of shoreline and provide functional benefits to state and federally-listed species. As a result, no cumulative impacts are expected.

C. <u>Reptiles</u>

(1) Direct Impacts

Alternative #4 would include SMP and Village-sponsored disposal/nourishment events at a greater frequency than Alternative #3. However, no direct impacts to foraging and migrating

sea turtles are anticipated to occur from the dredging of sand since it would take place during winter months and a slow moving cutter suction dredge would be used.

(2) Indirect Impacts

Largely as a result of any stabilizing structure, modeling predicts that western South Beach and the Point would experience rapid erosion similar to the Retreat Alternative. Alternative #4 would result in a rapid loss of dry beach and interdunal wetlands community types along the western end of South Beach and the Point. Unless relocated, sea turtle nests that have been laid in erosion prone areas would be susceptible to loss. It is anticipated that BHIC would continue to monitor the beach for nesting sea turtles and relocate nests that are laid in eroded areas.

Eroding steep beach escarpments as well as other physical barriers often cause mature female sea turtles to select poor nesting sites at the dune toes which causes higher nestling mortality rates. Therefore, turtle nesting habitat along western South Beach would continue to deteriorate.

Sea turtle nesting habitat may also be indirectly affected by periodic nourishment events. However, the nourishment events would occur during winter months outside of the sea turtle nesting season. Additionally, only beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence shall be used for beach nourishment at the project site. Furthermore, sand of similar grain size and composition to that of the existing beach will be used to reduce any changes in physical characteristics of the beach that may affect nest survival.

Similar to Alternative #2, sand tube removal in, and of itself, could be considered a benefit by reducing predator concentration and by removing the risk of adult female false crawls and false nests. In addition, removal of the sand tubes would eliminate the risk of

interference with hatchling emergence into nearshore waters. Furthermore, failure of the sand tubes can result in intensive, localized erosion and the development of escarpments. As indicated previously, these conditions can increase energy expenditure for adult females and create unfavorable nest conditions. However, any potential benefit of groinfield removal would need to be considered in context of the increase in overall erosion rates and loss of dry beach habitat along this segment of shoreline.

The rapid erosion predicted under this alternative would likely result in increased incidence of dune overwash and salt spray to the back dune and interdunal communities. Increased salinities of depressions and ponded areas would influence the distribution and behavior of less salt-tolerant species, including the American alligator. Additionally, predicted erosion may expose maritime forest habitat to increased wind and salt spray, which can influence community composition. Several state listed reptiles, including coachwhip, southern hognose snake, and the eastern coral snake, are associated with this habitat type and may be negatively affected.

(3) Cumulative Impacts

As described above, the implementation of Alternative #4 would result in the loss of dry beach habitat. However, the western end of South Beach has been an area susceptible to acute erosion for many years and thus does not present high quality nesting habitat for sea turtles. Given the recurring compromised condition of nesting habitat, the relatively low abundance of documented nests, and the current practice of nest relocation for the far western portion of South Beach, implementation of Alternative #4 would likely not result in cumulative impacts to federally-listed turtle species. In addition, the potential indirect effects to other listed reptile species are not of a magnitude to generate cumulative impacts.

D. Fish

(1) Direct Impacts

More frequent disturbance at prospective dredge site(s) could alter bottom habitat and would result in temporal impacts to benthos. Since the dredge vessel, ladder, and cutter suction head are nearly stationary, there would be minimal collision threat with shortnose and Atlantic sturgeon.

No direct effects are anticipated with nourishment activities on the beachfront. Similarly, removal of the sand tube groinfield would have no direct effect on these species.

(2) Indirect Impacts

Some food resources may be initially affected by the dredging of deeper subtidal bottom areas where sturgeon may reside. As indicated above, these effects would be considered temporal due to the opportunistic recruitment strategies of benthic communities in disturbance-prone areas.

(3) Cumulative Impacts

No cumulative effects to protected sturgeon species are anticipated as a result of the implementation of Alternative #4.

E. Plants

(1) Direct Impacts

Similar to each of the other alternatives considered, disposal and nourishment events could potentially bury existing seeds of rare plants that may be found on the upper beach (seabeach amaranth, seaside spurge, beach morning-glory, seabeach knotweed, and dune bluecurls) of the project area. However, studies have found that seeds of seabeach amaranth are likely to remain viable and may germinate when the imported sand washes away (Benjamin 2012), which may also be true for other state-listed plants found on the

upper beach. As a result, no direct impacts to seabeach amaranth or other rare plants are expected.

(2) Indirect Impacts

Indirect impacts to seabeach amaranth and other state-listed plant mentioned above are expected as a result of extensive loss of dry beach habitat along western South Beach and the Point. The increased rate and extent of erosion associated with this alternative would result in a largely prohibitive environment for the germination and establishment of these plants.

Erosion predicted to occur under this alternative would erode areas of maritime forest habitat and likely expose other areas not lost to increased wind and salt spray, which can influence community composition. State listed plants known to occur within this habitat type (spreading sandwort, liverwort, four-angled flatsedge, nerved witch grass, Terrell grass, coralbean, shortleaf basket grass, large-seed pellitory, cabbage palm, tough bumelia, Cuban schliessmund, and dune bluecurls) may be affected.

(3) Cumulative Impacts

No cumulative impacts to seabeach amaranth or other rare plants are anticipated to occur under this alternative.

5.4.5 Alternative #5: Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining)

Note that a Biological Assessment (BA) evaluating the potential adverse effects to threatened and endangered species was submitted to both USFWS and NMFS. Through coordination with the USACE, formal ESA Section 7 consultation with USFWS was initiated in January 2014. Since that time the USFWS has issued its Biological Opinion (BO) on the effect determinations for each of the listed species. The BO contains a list of conservation

measures, reasonable and prudent measures, and terms and conditions for the proposed work that would be employed by the Applicant during and after project construction. These measures are provided in Appendix S.

ESA Section 7 informal consultation was initiated with NMFS in January 2014. The required NMFS request form, checklist, and BA was submitted to NMFS for their review and recommendations. To date, there has been no written response from NMFS regarding this request.

The following narrative provides descriptions of direct, indirect, and cumulative impacts of the proposed action on listed species known to occur within or adjacent to the project area.

A. Mammals

(1) Direct Impacts

Under Alternative #5, disposal activities would continue to occur under the SMP. Any Village-sponsored nourishment would be limited to the initial fillet (if project timing does not allow for use of the federal SMP disposal) and to periodic maintenance of the fillet and West Beach. As such, the beach nourishment volume requirements would be less than that of Alternative #3 and Alternative #4. As with prior alternatives, dredging and nourishment actions are not anticipated to have direct effects on protected marine mammals. Any supplemental filling of the proposed groin by the Applicant would be performed outside of the environmental moratoriums. Groin construction work (which will occur throughout the summer) is not expected to directly affect these species. Approximately 650 lf of the structure (Phase 1 and Phase 2 combined) would be constructed seaward of the current mean low water (MLW) shoreline position. Fillet formation and shoreline realignment resulting from the installation of the groin will further minimize the extent of the structure extending into open water. Construction would be spatially constrained and would pose minimal (if any) collision threat to migrating whales and/or manatees.

No direct impacts to whales or manatees are anticipated from dredging or terminal groin construction.

(2) Indirect Impacts

As described in the alternatives above, periodic dredging of the entrance channel and other nearshore or offshore borrow areas would not substantially affect food resources of the humpback whale, right whale or manatee. The applicant's preferred sand source for the fillet is the federal disposal associated with the SMP. Other borrow source sites include Jay Bird Shoals, Bald Head Creek Shoal, and reaches of the federal channel containing beach compatible sand. Mortality to benthic infauna of the borrow sites will occur from the cutter-suction dredge. However, these impacts would be considered temporary since the benthic assemblages of depositional features (i.e. shoals) tend to be adapted to disturbance and can recruit rather quickly from adjacent undisturbed sites.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with these actions, there are no cumulative effects to federally-listed marine mammals when evaluated in the context of past, present, and reasonably foreseeable future projects.

B. Birds

(1) Direct Impacts

The sand fillet for Alternative #5 will utilize to the maximum extent practicable sand from the federal maintenance of the Wilmington Harbor. Federal beach disposal is typically completed prior to May 1 of each year. As a result, no direct effects to nesting birds are anticipated. Work associated with the construction of the terminal groin would occur immediately after the beach fill placement. It is expected that necessary project sequencing would require work to continue well into the nesting period for several species of shorebirds and colonial waterbirds. If supplemental sand is required for the proposed groin, then this

additional nourishment is expected to occur during the winter months and outside of the shorebird nesting period.

Approximately 250 to 300 lf of the groin structure would be constructed above the 2012 MHW position (in dry beach). The affected work area is highly erosional and typically does not support viable nesting habitat. As indicated above, there have been no documented nests of piping plovers in this area of the island over several years of monitoring by NC WRC and by BHIC. In addition, the work zone represents less than 12% of the total shoreline of West Beach and South Beach on Bald Head Island. Habitat along the Point that has supported nesting of least terns, American oystercatchers, and Wilson's plovers will not be directly affected by the proposed fillet placement or groin construction.

The site of the proposed terminal groin structure (at the extreme west end of South Beach) is an area characterized by chronic erosion and instability. In the absence of nourishment, the beach profile tends to slope steeply from upland dunes to wet beach. As a result, the existing condition provides little opportunity for suitable bird nesting habitat. Post-nourishment conditions provide some level of stability and more expansive dry beach for a relatively short period of time. Since construction of the groin would occur concurrent with, and subsequent to, sand placement, it is unlikely that nests would exist at the time of construction. Therefore, construction of the groin itself would not be anticipated to have direct effects on state or federally-listed birds.

(2) Indirect Impacts

a. Effects to Food Sources: Piping plovers, red knots, and other state-listed species, tend to prefer expansive sand and mud flats for foraging and resting. During low tide, sand flats are exposed at the Point (northwest of the project area). Within the project area itself, the intertidal surf zone provides foraging habitat for wintering or migrant birds. Moving sand to construct the groin may bury intertidal macrofauna and reduce the available food resource

to birds in this area. However, the groin would be constructed within a recently-placed sand fillet. Thus, the area of construction would likely not present favorable foraging habitat for listed species.

Sand for the required fillet would be principally derived from the federal disposal event which typically occurs between November 16th and April 30th (thus avoiding the larval recruitment period of coquina clams (spring and summer) and mole crabs (early October) (Donoghue, 1999). Given the required time period for groin construction (estimate four to six months pending weather conditions), supplemental sand for the fillet (if necessary) would likely be dredged and placed within the project area the following winter (during the accepted environmental window). In addition, the supplemental disposal would occur within a spatially-confined work area that has been previously subjected to severe and chronic erosion. In general, beachfront fill placement results in short-term declines in species abundance, biomass, and taxa richness. Studies have shown that intertidal macrofauna can recolonize a nourished area within one or two seasons (Ross and Lancaster, 1996; National Research Council, 1995; Van Dolah et al. 1984; Reilly and Bellis, 1978). Directly after impacts to macrofauna have occurred and numbers of these species are depressed, birds that prey upon these invertebrates, including plovers and red knots, would likely move to adjacent undisturbed beach areas or tidal flats for the temporary period of population re-establishment.

Beach disposal from the federal maintenance of the adjacent Wilmington Harbor Entrance Channel is routinely performed on the South Beach shoreline. Occasionally, federal disposal has occurred on the West Beach shoreline when requested by the Applicant and deemed acceptable by the Wilmington District. Based upon the Delft3D modeling and the analysis performed by the Applicant's engineer, "emergency" fill operations in response to episodic erosion are not predicted to increase as a result of the implementation of Alternative #5. The installation of a terminal groin is predicted to decrease both the frequency and volume

requirements of non-federal beach nourishment actions (see Table 5.5). As a result, potential adverse effects to benthic invertebrate populations would be less than the other alternatives that evaluate beach nourishment as an erosion response strategy.

As a requirement of SB 151, mitigative measures need to be identified for West Beach to address any potential downdrift effects of the proposed structure. These measures would include hydraulically or mechanically placed sand on West Beach. Detailed engineering analyses of post-project conditions within and adjacent to the project area are provided in the report entitled, "*Shoreline Stabilization Analysis (July 2013)*" (Olsen 2013). Inclusive in this report is the prediction of any potential increase in erosion on West Beach due to the maximum length of the proposed groin. According to the Applicant's engineer, the total predicted difference is estimated to be -5200 cy/yr over nine years which he considers low in the context of the existing, erosional condition. As a result, the Applicant's engineer does not expect that Alternative #5 will result in increased sand placement on West Beach relative to the other alternatives that evaluate beach nourishment as an erosion response strategy (i.e. Alternative #3, #4, and #6). The Applicant predicts that the West Beach shorefront will potentially require beach disposal on an approximate 3-year basis with or without the implementation of the terminal structure.

b. Effects to Behavior: Nourishment and associated construction activities within the intertidal surf zone could influence foraging and resting winter residents and spring migrants. For the Mason Inlet Relocation Project (which involved the backfilling of a small tidal inlet and its relocation 3,000 ft north), piping plover spring migrants were documented to pass over the Mason Inlet shoals during construction (in 2002) and instead favor Rich Inlet to the north for foraging and resting. Likewise, fall migrants avoided Mason Inlet later in the year, stopping again at Rich Inlet before continuing southward of the study area. Since that time, expansive mud flats have developed on the backside of the relocated inlet. These

areas have become suitable foraging and resting sites for both wintering and migrant piping plovers (Webster 2006).

Construction work will occur during the bird nesting season. As a result, the stockpiling and transport of construction materials (including armor stone) within the work zone could influence the behavior of nesting shorebirds or colonial waterbirds. As described above, the work zone does not generally support viable nesting habitat, and it is unlikely that nests would occur within or immediately adjacent to the work zone. Monitoring for potential shorebird and colonial waterbird nests will be performed by trained staff of the Bald Head Island Conservancy (Conservancy) from May 1 until August 31. Any identified nests and adjacent nesting habitat will be clearly marked to alert construction personnel to maintain a minimum 50-ft distance from these areas.

c. Physical Effects to Habitats: The implementation of Alternative #5 would provide for a more stable and wider beach profile updrift of the proposed structure. The particular section of shoreline affected has been subject to chronic and pronounced erosion and thus has not provided suitable nesting habitat for state or federally listed species of birds. In the absence of nourishment, the shoreline of western South Beach is characterized by steep and narrow zone of transition from upland dune to wet beach and subtidal, nearshore bottom. According to Delft3D modeling, implementation of Alternative #5 is predicted to result in the net gain of 2.7 acres of wet beach and 8.1 acres of dry beach by Year 9 of the simulation. These predicted net gains are the highest net gains among the alternatives under consideration and would provide more expansive (wider and relatively low slope) dry beach area for nesting. However, more stable conditions can also favor the growth of upper beach or dune vegetation. Denser vegetation would provide increased predator habitat and would also limit nesting of certain species including the American oystercatcher and the Wilson's plover (CRC 2010).

It should also be noted that a wider, more stable beachfront can provide increased recreational opportunities for residents and visitors to the Island. As a result, areas that may become suitable for nesting also have the potential for increased human interference.

The proposed groin will be porous and will thus allow for sediment passage both through and over the structure. Inlet-directed sediment losses (i.e. shoaling of the adjacent federal channel) would continue to occur. In addition, the Point is expected to continue to migrate north as has been documented over the last several years. While sediment transport rates will be reduced, the Point feature will continue to exist. As a result, the intertidal and supratidal areas associated with this feature will continue to provide foraging, resting, and nesting habitat for shorebirds and colonial waterbirds. As has been observed on the south end of Wrightsville Beach, the presence of a low-profile structure designed to allow sand to bypass has not prohibited sand accretion to downdrift areas. The expanding spit in this particular area has recently become a successful nesting site for black skimmers, least terns, and American oystercatchers.

(3) Cumulative Impacts

The Applicant's engineer predicts the implementation of the terminal structure to have relatively low effect to sediment transport to West Beach. According to the Applicant's engineer, the total predicted difference is estimated to be -5200 cy/yr over nine years which he considers to be low in the context of the existing, erosional condition. As a result, any future erosion control response along West Beach is expected to be consistent with actions performed in the past and with those that would need to be implemented irrespective of the proposed action. In light of the current eroded condition of western South Beach, the proposed action is expected to increase dry beach nesting habitat. In consideration of reasonably foreseeable future actions, cumulative impacts to state and federally-listed birds are not anticipated.

C. Reptiles

(1) Direct Impacts

The sand fillet for Alternative #5 will utilize to the maximum extent practicable sand from the federal maintenance of the Wilmington Harbor Project. Federal beach disposal is typically completed prior to May 1 of each year. As a result, no direct effects to sea turtles are anticipated. Hydraulic dredging and filling for any supplemental sand (if needed) would occur during the winter months and thus avoid the sea turtle's primary migratory and nesting seasons.

Groin construction would occur immediately subsequent to the federal sand placement. While phasing of the construction would reduce the period of time necessary to complete the construction of Phase I, it is expected the groin installation work would extend throughout the summer and into the early fall (e.g. throughout much of the sea turtle moratorium). Supplemental sand for the fillet may require the dredging and disposal of up to 200,000 cy during the following winter. Construction would be spatially constrained (as described further below). Approximately 300 to 700 linear feet of the groin would be constructed above MLW, most of which would be within the recently nourished dry beach.

The proposed work zone for the fillet placement and construction of the groin represents less than 12% of the total shoreline length of West Beach and South Beach on Bald Head Island. The project area occurs within a segment of shoreline with historically lower number of nest sites relative to the more stable beach areas to the east (Appendix T). This is principally due to the narrow beach and chronic erosion within this area. Additionally, its proximity to the mouth of the Cape Fear River and associated tidal hydraulics of the inlet may influence an adult female's access to the beach. BHIC conducts nest monitoring of the beaches of Bald Head Island. If nests are laid within areas susceptible to imminent loss from erosion, BHIC staff often will relocate the nests to more stable beachfront. Intensive monitoring during site construction and methods employed to reduce the footprint of

construction activities (including clearly designated and marked construction corridors) would minimize potential encounters with adult females and nests. However, the presence of heavy equipment and trucks on the beach during groin construction would pose a potential risk to adult females and any nests within the project area that were not identified, marked, or relocated.

Through coordination with the USACE, formal ESA Section 7 consultation with USFWS was initiated in January 2014. USFWS has subsequently completed its review under Section 7 consultation and has issued its BO with supporting conservation measures, reasonable and prudent measures (RPMs), and terms and conditions for avoiding and minimizing effects to all listed species including sea turtles. The BO (with corresponding conservation measures and terms and conditions) are provided in Appendix S.

The footprint of the terminal groin above the 2012 MHW line will be approximately 250 ft to 300 ft long and approximately 18 ft wide (equivalent to 4,800 sf +/-). This section of the groin would constitute a loss of potential sea turtle nesting habitat. However, as indicated above, the current pre-nourishment condition of this area does not tend to support viable nesting habitat. In addition, this amount of area would be offset by a predicted increase of dry beach habitat of 8 acres over a nine-year model simulation.

(2) Indirect Impacts

Indirect impacts to nesting sea turtles could occur if nourishment and/or groin construction activities significantly alter nesting habitat. If the beach becomes too hard through the compaction of deposited nourishment sediments by construction equipment, it could present a physical barrier to turtle nest digging. Furthermore, beach nourishment may influence physical characteristics of beaches such as sand-grain size and shape, silt-clay content, sand compaction, moisture content, porosity/water retention, gas diffusion rates, and color of sand grains which could alter the temperature of the beach. These factors could

reduce reproductive success of nests laid in nourished areas (Crain et al., 1995; Ackerman, 1996). However, stringent sediment standards and geotechnical investigations of the sand source site to be used will minimize any potential adverse effects of the sand nourishment. In addition, the combined effects of nourishment and the installation of a terminal structure would expand suitable nesting habitat.

The terminal groin and continued maintenance and occurrence of the sand tube groinfield may result in indirect effects to both adult nesting females and emerging hatchlings. Hardened structures exposed above the beach or buried by accreting sand have the potential to adversely affect nesting turtles during nest site selection or during nest digging (resulting in false crawls or false digs). Groin structures may also concentrate predators (either birds or fish) and present physical impediments to hatchlings. Resultant increased energy expenditure by hatchlings can affect their ability to reach offshore developmental areas (Davis et al., 2002).

Overall, the presence of a terminal structure would help stabilize the shoreline of western South Beach. The result will be a wider and relatively low slope beach profile conducive to sea turtle nesting. In addition, the conservation measures, RPMs, and terms and conditions of the USFWS Biological Opinion will reduce potential indirect effects to sea turtles.

(3) Cumulative Impacts

The proposed action elements of Alternative #5 (including the potential future implementation of mitigation actions downdrift of the terminal structure) are not anticipated to generate additive or interactive adverse effects to federally-protected sea turtles. Implementation of conservation measures and terms and conditions identified during ESA Section 7 consultation with USFWS and NMFS will help to avoid and minimize potential adverse effects to sea turtles. In consideration of past, present, and reasonably foreseeable future actions, no cumulative effects are anticipated.

D. Fish

(1) Direct Impacts

As described in previous alternatives, no direct impacts to the shortnose or Atlantic sturgeon are anticipated to occur from dredging associated with nourishment events. In addition, groin construction would be spatially constrained and should not directly affect sturgeons.

Approximately 1,100 lf of the terminal groin (total for Phase 1 and Phase 2) would be placed below the 2012 eroded MLW line (refer to Appendix H, Sheet 8). However, the groin will be constructed immediately following the federal disposal thus much of the groin will actually be installed in the newly formed dry beach. In addition, post-construction equilibrium conditions will result in an extended shoreline position and reduce the net length of structure extending into open water.

No direct effects to protected sturgeon are anticipated as a result of the implementation of Alternative #5.

(2) Indirect Impacts

Some food resources of sturgeons may be initially affected by dredging of deeper channels or shoal areas where sturgeon may reside and feed. However, most invertebrates would quickly reestablish from adjacent unaffected areas or through recruitment processes (Van Dolah et al. 1984). Furthermore, the construction of the groin would help to stabilize the beach and may ultimately reduce the frequency and volume of borrow site dredging needed to offset sand losses along South Beach.

As indicated above, the head of the groin structure will be constructed within open water and may require the use of a temporary trestle for equipment and placement of rock. However, implementing the phased approach would reduce the likelihood for the need of a

trestle. Sand from the federal disposal can be used to create temporary pads from which to construct the groin.

(3) Cumulative Impacts

Implementation of Alternative #5 is not expected to generate cumulative impacts to federally-protected sturgeon.

E. Plants

(1) Direct Impacts

No impacts to amaranth or other state-listed plants would occur from the proposed dredging associated with the fillet or with future maintenance events. Disposal for the sand fillet would be derived principally from the federal maintenance of the Wilmington Harbor Entrance Channel and would take place after November 16th when most plants (including amaranth) have already released seeds. Groin construction would begin April 30th (more or less) and continue throughout the summer months. Construction actions (including the excavation and reworking of recently nourished sand) could have an effect on the germination of rare plants. However, the site of the proposed groin is within a chronically and severely eroded condition that is not well-suited for the occurrence of federally or state listed plants that utilize the dry beach.

(2) Indirect Impacts

Deeply burying existing seeds of rare plants via nourishment could negatively affect their population in later seasons. Assuming that seeds are located in the general position of former parent plants observed in past surveys, sediment placed on the beach may bury seeds and delay germination the following year.

Studies have found that groins have mixed effects on seabeach amaranth (USFWS, 1996). Immediately updrift from a groin, accretion sometimes provides or maintains habitat

suitable for seabeach amaranth. Immediately downdrift of a groin, seabeach amaranth habitat may become degraded if the area is sediment-starved. However, in 1991 Long Island's (New York) largest population occurred along a groin field. Furthermore, the porous design will allow for sand passage through and over the proposed structure to minimize any potential downdrift impacts to the upper beach.

It should be noted that updrift stabilization of the dry beach could potentially expand areas suitable for perennial vegetation that can outcompete seabeach amaranth. Overall, it is likely that a more expansive dry beach area would result in a net benefit to seabeach amaranth and other rare plants that are found within the dry beach (e.g. seaside spurge, beach morning-glory, seabeach knotweed, and dune bluecurls).

(3) Cumulative Impacts

The beach nourishment and groin construction that is to take place along the coast of Bald Head Island will occur on areas suffering from erosion and should ultimately maintain or expand potential habitat for rare plant species. No cumulative impacts are expected as a result of the implementation of Alternative #5.

5.4.6 Alternative #6: Terminal Groin with Beach Nourishment/Beach Disposal (Removal of Sand Tube Groinfield)

A. Mammals

(1) Direct Impacts

In-water work proposed for Alternative #6 is essentially the same as Alternative #5. Therefore, impacts to federally-protected mammals would be similar to those described under Alternative #5. No direct impacts to whales or manatees are anticipated from dredging, terminal groin construction, or from the removal of the sand tube groinfield.

(2) Indirect Impacts

No indirect impacts to whales and manatees are expected as a result of Alternative #6.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with these actions, no cumulative effects to federally-listed marine mammals are anticipated.

B. <u>Birds</u>

(1) Direct Impacts

Direct impacts to birds under this alternative would be the same as Alternative #5. Terminal groin construction would extend into the nesting season of several bird species. The construction itself would be a temporal condition. It is likely that potential nesting birds (including least terns, Wilson's plovers, and American oystercatchers) would favor suitable nesting habitat near the Point.

Removal of the sand tube groinfield is not anticipated to directly affect state or federally-listed species.

(2) Indirect Impacts

As described under Alternative #5, moving sand to construct the groin and nourish the shoreline may bury intertidal macrofauna and reduce the available food resource to birds in this area. Installation of the groin would also influence the behavior of foraging birds. Construction practices and burial of benthic prey items may result in the need for birds (including federally and state-listed species) to move to other parts of the beach not influenced by project construction.

Longer term changes to shoreline configuration and profile conditions could potentially result in indirect effects to state and federally-listed bird species. An expanded dry beach

habitat updrift of the structure may provide more suitable nesting habitat for these species. Potential beneficial effects may be offset by the potential for the upper beach to become more densely vegetated. Dense vegetation would preclude the use of the area by nesting pairs and would increase the risk of predation on nests in closer proximity to the vegetated areas. Furthermore, any potential downdrift impacts to the morphology of the Point could adversely affect nest success in this area that has historically supported higher occurrences of shorebird and colonial waterbird nests.

Removal of the sand tube groinfield would result in unobstructed dry beach and intertidal surf zone suitable for nesting, foraging, and resting habitat. This component of the alternative would be viewed as an indirect benefit to state and federally-listed species.

(3) Cumulative Impacts

No cumulative impacts are expected as a result of the implementation of Alternative #6.

C. Reptiles

(1) Direct Impacts

Direct impacts to sea turtles from Alternative #6 would be similar to direct impacts described under Alternative #5.

(2) Indirect Impacts

Indirect impacts of Alternative #6 would be similar to those identified above for Alternative #5. The exception would be the indirect effects of the removal of the sand tube groinfield. Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Geotube removal should ideally occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal.

Similarly, excavation of the structures – essentially in the "dry" after a fill project – would also help ensure both complete and relatively cost-effective removal.

It is anticipated that removal of the sand tubes would result in a net benefit for adult females that approach the beach and lay nests along this segment of shoreline. In general, hardened structures may physically interfere with adult females and could potentially lead to false crawls or false digs. The removal of the groinfield would also reduce the risk of physical interference to emerging hatchlings and would reduce the potential of predator concentration on or adjacent to the sand tubes.

An adverse indirect effect of the removal of the groinfield would be the potential for decreased beach profile stability east of the influence of the terminal groin. Delft3D modeling indicates moderate beach deflation along South Beach which could increase the risk of inundation and/or loss of nests in these areas.

(3) Cumulative Impacts

Implementation of Alternative #6 is not anticipated to result in cumulative impacts to migratory or nesting sea turtles.

D. Fish

(1) Direct Impacts

No direct effects to listed sturgeon are expected as a result of implementation of Alternative #6.

(2) Indirect Impacts

As with previous alternatives, dredging for the fillet or for subsequent maintenance may temporarily affect food resources of sturgeons. However, most invertebrates would quickly

reestablish from adjacent unaffected areas or through recruitment processes (Van Dolah et al. 1984).

The removal of the sand tube groinfield will not result in any indirect effects to sturgeon.

(3) Cumulative Impacts

No cumulative effects to shortnose or Atlantic sturgeon are anticipated as a result of Alternative #6.

E. <u>Plants</u>

(1) Direct Impacts

Direct impacts to seabeach amaranth and other state-protected plants would be similar to impacts described under Alternative #5.

The removal of the sand tube groinfield is not expected to generate any other direct effects to rare plants.

(2) Indirect Impacts

Alternative #6 is anticipated to have similar indirect effects to state and federally listed plant species as identified for Alternative #5. The exception would be that the removal of the sand tube groinfield may result in increased erosion and shoreline deflation beyond the updrift influence of the terminal groin. The resultant condition may influence the extent of suitable habitat for the germination and growth of these plants.

(3) Cumulative Impacts

In consideration of past, present, and reasonably foreseeable future actions, implementation of Alternative #6 is not anticipated to result in cumulative impacts to populations of seabeach amaranth or other rare plants.

5.5 PERMIT AREA HABITATS

The environmental resources that characterize the project area and the anticipated impacts of the project to those resources were researched and evaluated through numerous site-specific field studies, Delft3D modeling, aerial photography and a review of environmental research available in the scientific literature. Guidance from the Project Review Team (PRT), including Federal, State, and local environmental agencies, science professionals and other interested persons and organizations was incorporated into this document in an effort to identify project alternatives which sufficiently minimized and mitigated potential adverse environmental impacts while achieving the applicants stated purpose and need. This section describes the anticipated impacts to environmental resources within the project study area resulting from the six identified alternatives. Quantification of predicted gains or losses of each major habitat category is provided in Table 5.6. Likewise, visual representations of existing and predicted habitat areas are included as Figures 5.12 – 5.24.

5.5.1 Estuarine

A. Salt Marsh

As indicated in Section 4.0 of this document, salt marsh habitat in the vicinity of the permit area is confined to the back-barrier island areas contiguous with Bald Head Creek (east of Bald Head Island Marina and Keelson Row) and consists of high marsh (e.g. supratidal) (dominated by *Spartina patens*) and low marsh (e.g. intertidal) dominated by *Spartina alterniflora*. As a result, these areas tend to be protected from dredging and beach disposal/nourishment actions along western South Beach and West Beach.

Given the location of salt marsh relative to the permit area, no direct, indirect, or cumulative impacts are anticipated for any of the alternatives evaluated in the EIS.

5.5.2 Coastal Beach and Dune Habitats

A. Wet Beach

The wet beach habitat of Bald Head Island (particularly South Beach and West Beach) is a highly dynamic zone exposed to extreme physical forces that result in high rates of erosion and shoreline recession. These particular shorelines are affected by episodic sand disposal and nourishment events. Benthic species along the ocean beachfront are adapted to coarser-grained substrates and high-energy environments. While infaunal assemblages are rather diverse, the larger macrofaunal community in the swash zone is generally characterized by low density and low abundance due to dynamic and active wave conditions (Posey et al. 1996). The benthic community represents an important food source for many shore birds and important recreational fish species such as flounders, pompanos, mullets and kingfish. The following provides a description of potential effects of each project alternative to wet beach habitat mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: Placement of sand at the beach fill site will result in impacts to infaunal communities as the existing intertidal wet beach is converted to dry beach habitat. Species which are permanent residents of the intertidal surf zone will be more severely impacted during beach nourishment than species which migrate on and off the beach (Hurme and Pullen 1988).

Placement of sediment that closely matches the native beach sediment is vital in the minimization of adverse impacts to beach infauna. Some studies have suggested that changes in geomorphology and sediment characteristics may have a greater influence on the recovery rate of invertebrates in comparison to direct burial or mortality (NRC 1995). Prior federal channel maintenance and disposal events associated with the Wilmington Harbor navigation project have demonstrated compatibility of the disposal materials within the

nourishment area of South Beach and West Beach. As indicated above, compatibility with the nourishment site will favor benthic recolonization.

Upland erosion is anticipated even in the presence of ongoing disposal events associated with the SMP. As such, short-term stabilization measures such as the placement of emergency sand-bags, maintenance of the existing sixteen sand-tube groinfield and/or beach scraping could occur on an as needed basis. The use of heavy machinery associated with soft stabilization methods can result in direct mortality of benthic macrofauna.

As noted previously, infauna living in a high-energy environment, especially the intertidal area, are well adapted to disturbances (Van Dolah et al. 1994, Levison and Van Dolah 1996). The opportunistic nature of benthic invertebrates common to this area, compatibility of dredge materials to the target beach and avoidance of peak periods of biological activity help facilitate post-construction recovery.

b. Indirect Impacts: Removal of the benthic forage base would indirectly impact higher trophic species such as fish, birds and marine mammals utilizing the benthos for prey. However, the magnitude of indirect impacts to higher level trophic species is mitigated by the large area of habitat available beyond the nourishment site. Furthermore, peak larval recruitment periods for most benthic species are avoided by federal disposal typically occurring during winter months.

Delft3D modeling of Alternative #1 suggests that there will be shoreline erosion and recession, especially in the vicinity of the Point, and a small degree of accretion along West Beach. It is anticipated that the wet beach would shift relative to the shoreline. Impacts to the resident adult infaunal stock and larval transport are not anticipated and, as such, the infaunal community should gradually colonize the newly established intertidal habitat.

c. Cumulative Impacts: The cumulative reduction in benthic invertebrate fauna from repetitive placement of sediment on Bald Head Island could negatively impact the benthos over time. As described above, benthic communities at the recipient site should recover to pre-nourishment levels of community composition and biomass quickly given the opportunistic nature of resident infauna. Temporal separation between maintenance events should allow for infaunal recovery prior to the next dredging event such that only the area most recently dredged is affected.

(2) Retreat (Alternative #2)

a. Direct Impacts: Under Alternative #2 direct impacts resulting from dredge disposal events associated with routine maintenance of the federal navigation channel per the SMP would be the same as those discussed under Alternative #1; the primary direct effect of dredge disposal to the wet beach being the burial of benthic infauna with limited to no mobility. A retreat scenario would include the removal of the existing sand tube groinfield and the planned abandonment or relocation of infrastructure and residences. The use of heavy machinery during removal of the sand tube groinfield may result in direct mortality to resident infauna and epifauna with limited mobility.

b. Indirect Impacts: Indirect impacts associated with dredge disposal under Alternative #2 would be comparable to those discussed above. Similar to Alternative #1, the Retreat alternative would result in a rather significant change in shoreline configuration. It is anticipated that the wet beach will gradually migrate with the shoreline such that would be no widespread gains or losses of this habitat.

c. Cumulative Impacts: Cumulative impacts associated with the SMP under Alternative #2 would be comparable to those identified above.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: As previously discussed under Alternative #1, placement of sand at the beach fill site will directly impact infaunal communities as the existing intertidal wet beach is converted to dry beach habitat. Nourishment impacts would be most severe for small, relatively immobile species that are unable to burrow through the new sediment. Larger, more mobile organisms will burrow through the newly placed sediment or avoid the area of disturbance by migrating to neighboring unaffected areas.

Benthic regeneration of wet beach habitat will vary depending upon the magnitude of the disturbance, the character of the new sediment interface, rate of sediment recovery duration and timing of the dredging, the type of equipment used to extract the sediment, life history characteristics of colonizing species and water quality (Pullen and Naqvi 1983; Van Dolah et al. 1992). The recovery of the benthos at the recipient site would be reliant on immigration (active or passive) of organisms from adjacent undisturbed areas and larval recolonization from the water column.

Placement of sediment that closely matches the native beach sediment is vital in the minimization of adverse impacts to beach infauna (NRC 1995). Sediment that is either finer or coarser than the recipient beach may cause a marked degradation in habitat value and negative effects to benthic reestablishment. Recovery time for small infauna residing in the interstitial spaces between sand grains will take longer if the percentage of silt and clay is high (ASFMC 2002). Peterson et al. (2000) noted that mole crab abundances were reduced in nourished beaches in North Carolina that used finer grained sediment than the native beaches, likely attributed to burrowing and/or feeding effects. Van Dolah et al. (1992) attributed rapid benthic recovery to the similarity of fill material to existing sediments, as well as placing the fill high on the beach, well above mean sea level.

Infaunal abundance is typically lower during winter months in comparison to other seasons (Van Dolah 1978). *Donax* spp. (i.e. coquina clams) and *Emerita talpoida* (mole crab) are common residents in the lower beach and display peak larval abundance in the summer months. Peterson et al. (2000) found that densities of mole crabs and Donax spp. were 86-99% lower on nourished beaches of Bogue Banks, NC five to ten weeks following nourishment activities likely due to a poor match in sediment grade. Another study from Bogue Banks, NC indicated that while there was a complete loss of mole crabs following nourishment activities lasting from December through June, the population density recovered by mid-June, one month after completion of the project (Reilly and Bellis 1983). In this study, Reilly and Bellis found that infaunal species recruiting from pelagic larval stocks will recover if beach nourishment activities end before larval recruitment begins in the spring. Completion of construction activities during late fall and winter months prior to the peak spring larval recruitment season and when infaunal densities are comparatively low would reduce the recovery time of the wet beach community.

The Village of Bald Head Island completed a biological monitoring program in conjunction with the 2009 Bald Head Island Beach Restoration Project to assess pre-construction and post-construction populations of mole crabs and coquina clams along the beachfront of the west and south-facing beaches of Bald Head Island. This nourishment project was implemented in November 2009 and utilized Jay Bird Shoals as the source site. Baseline monitoring was conducted in June and September 2009 prior to the initiation of nourishment activities. Beachfront monitoring continued for two years upon completion of the project. No statistically significant differences were found between pre-construction and post-construction densities of coquina clams. The monitoring project yielded significant differences between pre and post-construction mole crab densities. However, these differences were also observed within reference sites and thus were attributed to seasonality (or other factors not evaluated in the study) rather than project-related nourishment activities (LMG 2010, 2011).

b. Indirect Impacts: The surf zone supports abundant fish resources comprised mainly of small species and serves as an important migratory area used by larval and juvenile fish moving in and out of inlets and estuarine nurseries as well as adults migrating parallel to the coast (Hackney et al. 1996). Fish populations in the surf zone are typically higher and more diverse in the summer and early fall. This type of intertidal habitat has been shown to support as many as 95 species within a given area (ASFMC 2002). A 1996 review by Hackney et al. found that the diets of surf zone fish may change with development stage and prey availability suggesting that surf fish are opportunistic and may be able to adapt to disturbance events such as beach nourishment.

A study conducted by Versar Inc. (working on behalf of the USACE Wilmington District) attempted to identify the effects of dredge disposal on benthic resources of Brunswick County beaches. In 2001 and 2002, the deepening and realignment of the entrance channel of the Wilmington Harbor Project resulted in the removal of 5.6 Mcy of material from the Cape Fear River navigation channel and the offshore navigation channel leading to the river entrance. This material was then disposed of on four Brunswick County beaches (including Bald Head Island) affected by erosion over the previous years. The findings of the study indicated that that were no immediate impacts in fish abundances and diversities among disturbed, undisturbed and reference stations (Versar 2004).

Based upon Delft3D modeling over a nine year period, Alternative #3 is predicted to result in continued shoreline recession at the Point, with accretion on West Beach to the north of the Point. As with previous alternatives, the wet beach is anticipated to gradually migrate with the shoreline such that would no widespread gains or losses of this habitat or resident infauna are expected. Based upon the extent of erosion predicted under this alternative, it is expected that there may be increased need for nourishment over a greater extent of shoreline than is predicted for Alternative #5. This would potentially increase indirect

effects to benthic assemblages of the wet beach and the influence the foraging behavior of surf zone fish and birds.

c. Cumulative Impacts: Utilizing sand with similar sediment characteristics to the target beach is mandated by the State of North Carolina and is vital to the minimization of adverse impacts. In addition, dredge disposal and beach nourishment tend to occur during winter months avoiding peak larval recruitment periods for many benthic species. Regional implementation of federal navigation maintenance projects and Village-sponsored nourishment efforts could potentially coincide; however, the spatial separation between projects as well as the dynamic nature of the coastal inlet system should reduce the potential for cumulative impacts to the wet beach.

(4) Alternative #4: Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal

a. Direct Impacts: Direct impacts associated with beach disposal/beach nourishment under Alternative #4 are similar, but would be greater in spatial extent, to those discussed under Alternative #3. The extent of the impact would be dependent on the volume of sediment and the total length of impacted shoreline. Based upon the engineer's estimates, implementation of Alternative #4 would result in the need of 8M cy of material over the 30-year project (compared to 6.0M cy and 4.5M cy for alternatives #3 and #5, respectively). The net effect would be increased direct disturbance to wet beach habitat from nourishment actions. Removal of the sand tube groinfield would necessitate Village-sponsored nourishment events of greater magnitude (estimated by the engineer to be 500,000 cy more per nourishment event) than that identified under Alternative #3. Mortality of benthic infauna due to sand burial and the use of heavy machinery during construction activities and sand tube groinfield removal is anticipated and largely unavoidable. However, many of the benthic organisms inhabiting these sites are relatively opportunistic, allowing them to recover quickly after disturbances such as changes to the composition of the sediment or the rate of sediment accretion/loss.

b. Indirect Impacts: Indirect impacts to wet beach habitat under Alternative #4 would likely be greater than other alternatives that likewise include beach nourishment as a component of the erosion response strategy (i.e. Alternative #3, #5, and #6). Over the life of the project it is estimated that 8M cy of sand will need to be placed (independent and additive to recurring federal disposal) to offset predicted erosion losses. The increased spatial extent of the nourishment can result in adverse effects to benthic infauna that serve as prey items for surf zone fishes and foraging birds.

Based on 9-year model simulations this alternative is predicted to reconfigure the shoreline with a significant shift landward along the westernmost segment of South Beach, West Beach and the Point. While sediment losses are predicted to be greater than sediment losses under Alternative #3, the wet beach habitat is anticipated to migrate with the shoreline such there will be no appreciable gains or losses to the community.

c. Cumulative Impacts: The volume of sand required to offset losses from removal of the sand tube groinfield would necessitate independently-sponsored nourishment events of greater magnitude (and potentially greater frequency) than that identified under Alternative #3. Repeat disposal on an annual cycle has been shown to reduce productivity of the impacted beach by preventing mole crabs and coquina clams from attaining larger sizes (Lindquist and Manning 2001). Despite the likely need for additional sand nourishment (or other future contingency measures such as sand bag revetments) to protect residences, infrastructure, and protective dunes that may be jeopardized by increased erosion, implementation of Alternative #4 is not expected to result in cumulative impacts to this resource based upon the extent of existing wet beach habitat that remain largely undisturbed along the shorelines of Bald Head Island and other barrier islands in the region.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, direct impacts associated with dredge disposal, beach nourishment, placement of the sand fillet and maintenance of the sand tube groinfield would be comparable to those discussed above. Additional impacts to the wet beach community will result from construction of the terminal groin structure. The terminal groin structure, as proposed, would have a total length (for both Phase 1 and Phase 2) of 1,900 linear ft with approximately 450 lf (or 0.5 acres) occupying the wet beach zone. The structure would be constructed of relatively large granite armor rock of varying size which would be transported to Bald Head Island by barge. Placement of the foundation mattresses and rock is generally by crane from a barge, from the upland and/or from a temporary trestle or pier constructed in close proximity to the groin structure. Such a pier is typically pile-supported and necessitates the driving or jetting of steel pile which are later retracted and removed from the site once the rock structure is completed[5]. There will be permanent loss of benthic fauna incapable of horizontal movement in the immediate footprint of the terminal groin. Heavy machinery associated with construction of the terminal groin and temporary trestle or pier construction will also result in mortality to benthic species with limited to no mobility.

b. Indirect Impacts: As previously discussed, the surf zone serves as a nursery and feeding ground for a number of finfish species that prey upon these benthic invertebrates and, in turn, are preyed upon by shorebirds, waterbirds, diving birds and marine mammals. Given the highly mobile nature of fish assemblages found to utilize the intertidal wet beach, it is expected that demersal species will relocate to other unaffected soft bottom and nearshore habitats during the period of construction activities and subsequent benthic recovery period. Finfish will return to the project area within a short period of time taking the opportunity to forage upon suspended nutrients and benthic infauna as well as utilize the new structure for resting and prey avoidance (Cenci et al. 2010).

[5] Note that by phasing the project, the need for the use of a trestle may be avoided.

After initial construction, Alternative #5 is predicted to require the least volume of sand (4.5M cy) to offset erosion losses over the life of the project relative to Alternatives #3, #4, and #6 (6.0M cy, 8.0M cy, and 6.5M cy, respectively). The net effect will be less disturbance to the wet beach associated with nourishment relative to the other alternatives that include beach nourishment as a component of the erosion response strategy.

The Applicant has identified mitigative actions for potential adverse effects to downdrift shoreline as required by SB 151. According to the Applicant's engineer, the predicted net difference to the erosion rate may be as high as -5,200 cy/yr over a nine year period (this assumes full build-out of the 1,900 lf structure). This rate is considered relatively low and manageable compared to the existing, highly erosional environment at this location. Mitigative actions identified by the Applicant include: (1) hydraulically and/or mechanically placed sand, (2) installation of a sand bag revetment in front of endangered structures, and (3) adjustment of the crest elevation of the terminal groin to allow for increased transmissivity to downdrift shorelines. Implementation of the two of the three actions identified above (sand placement and sand bag revetment) has the potential to increase direct and indirect effects to wet beach habitat. However, according to the Applicant's engineer, sand placement along West Beach will be required every 3 years irrespective of the installation of a terminal groin. This placement may be achieved through federal disposal or through Village-sponsored nourishment and would readily offset any potential increase in erosion resulting from the installation of a terminal structure.

c. Cumulative Impacts: Construction of the terminal groin would contribute to the loss of resident infauna of the wet beach community. In consideration of the net direct and indirect effects described above (including the consideration of potential mitigative actions), disturbance to wet beach is not of a magnitude that would generate cumulative impacts to this resource.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, direct impacts associated with dredge disposal, beach nourishment and placement of the sand fillet would be comparable to those discussed under Alternative #5. However, there would be some level of increased spatial disturbance to wet beach associated with the predicted increased sand volume requirements identified for this alternative (relative to Alternative #3 and #5). Direct impacts are largely attributed to burial by the terminal groin structure and during the placement of sand during dredge deposition and/or beach nourishment. Additional temporary impacts will result from heavy machinery use during removal of the sand tube groinfield and construction of the terminal groin structure. Removal of the sand tube groin field would result in a relatively small increase in wet beach (i.e. < 1 acre).

b. Indirect Impacts: Indirect impacts associated with Alternative #6 would be comparable to those discussed for Alternative #5. Some level of benefit would be realized via the removal of the sand tube groin field. Though relatively small, there would be an expanded area of wet beach available to species foraging in the surf zone. Prey items for surf zone fishes and foraging birds would be affected by the need for increased nourishment relative to Alternative #5.

c. Cumulative Impacts: Cumulative impacts to the wet beach community under Alternative #6 would be comparable to those identified above for Alternative #5.

B. Dry Beach

Biological diversity of the dry beach zone is typically low and resident fauna primarily include burrowing species well adapted to a dynamic environment. Dynamic shorelines typically display reduced species diversity in comparison to protected beaches buffered from physical extremes. The dry beach of South Beach and West Beach is subject to continual

morphological changes due to erosion. In addition to offering recreational benefits to residents of Bald Head Island and the general public, the dry beach is utilized by nesting and foraging shorebirds and waterbirds and provides a nesting ground for sea turtles. In addition, the federally-listed seabeach amaranth (*Amaranthus pumilus*) is documented to occur within the upper beach of Bald head Island (particularly in areas in the vicinity of the Point). Other state-listed plants that may occur within the upper beach habitat include seaside spurge, beach morning-glory, seabeach knotweed, and dune bluecurls. The following provides a description of potential effects of each project alternative to dry beach habitat mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: There are a number of potential effects associated with the placement of dredged materials on top of benthic communities in estuarine environments, the most immediate impact being burial (Hirsch et al. 1978). The extent and magnitude of burial effects are dependent on the thickness and composition of emplaced dredge material. Burial effects would be greatest for non-motile benthic faunal species and species displaying limited mobility. Motile benthic fauna will either migrate vertically to pre-existing sediment depths or migrate horizontally to un-impacted areas.

The ultimate recovery of benthic community is largely dependent upon the compatibility of the sediment with the target beach. Habitat modification can be a concern in instances where dredged material represents a sediment type significantly different from that of the existing beach (Mauer et al. 1978). Prior federal channel maintenance and disposal events associated with the Wilmington Harbor navigation project have demonstrated compatibility of the disposal materials with the nourishment area along Bald Head Island.

Under the No Action/Status Quo Alternative, upland erosion is anticipated even in the presence of ongoing disposal events associated with the SMP. As such, short-term

stabilization measures such as the placement of emergency sand-bags, maintenance of the existing sixteen sand-tube groinfield and/or beach scraping could occur on an as needed basis. The use of heavy machinery associated with soft stabilization methods can result in direct mortality of benthic macrofauna and sand compaction.

Lindquist and Manning (2001) documented negative impacts to some species following soft beach stabilization efforts. During the study, the ghost crab population was significantly reduced for 6 to 8 months following beach bulldozing. These findings were similar to the findings of Peterson et al. 2000 in which the number of ghost crabs in the upper beach zone were reduced by 55-65% three months following beach bulldozing at Bogue Banks, NC and 86-99% lower than on nearby reference beaches. However, other studies reported rapid recovery of beach infauna (less than 60 days) including species abundance and diversity of the overall faunal complex following beach bulldozing and no long term changes to species composition subsequent to beach scraping (ASFMC 2002).

b. Indirect Impacts: The placement of dredge disposal materials along Bald Head Island will temporarily disturb breeding, nesting and feeding activities of resident and migratory birds. Birds may be displaced by dredges, pipeline and other construction equipment. Birds which are startled by construction activities on the beach are likely to temporarily leave the immediate project area. Dredge material placed on the beach has the potential to crush nests, eggs and hatchlings. While there will be a direct loss of prey species for birds following placement of the dredge materials, additional foraging impacts could result if the disposal materials do not closely match the recipient beach. Sediment that is too coarse and/or contains high shell content can inhibit a bird's ability to extract food particles from the sand (ASFMC 2002).

Predictive results from Delft3D modeling indicate that the most pronounced seabed erosion and shoreline recession under Alternative #1 is in the vicinity of the Point with a small

degree of sediment accretion along West Beach. It is expected that the beach profile from upland dune to the mean high water line in the vicinity of the Point would be unstable and comparatively steeper than the existing profile and would offer limited habitat for species that utilize the dry beach, including threatened and endangered flora and fauna. Based upon a predictive nine-year model simulation, implementation of Alternative #1 would result in a net loss of 22 acres of dry beach. Several state- and federally-listed species would be impacted by this loss, including but not limited to: least terns, American oystercatchers, Wilson's plovers, sea turtle species, and seabeach amaranth.

c. Cumulative Impacts: Disposal events conducted under the SMP would not result in cumulative impacts to dry beach. In addition, emergency-level stabilization measures under the status quo condition would not result in widespread effects and would not be long-lasting – thus additive and interactive effects would be unlikely. While the magnitude of predicted loss of dry beach under Alternative #1 is considerable, it is not likely to produce cumulative impacts to this habitat. This is due in large part to the extent of dry beach habitat that exists along the shorelines of Bald Head Island and adjacent beaches in the region. In addition, the dry beach of western South Beach, the Point, and West Beach is subject to continual disturbance resulting from recurring erosion and overwash from storms. In the context of past, present, and reasonably foreseeable future actions, cumulative impacts are not expected as a result of the implementation of the No Action/Status Quo Alternative.

(2) Retreat (Alternative #2)

a. Direct Impacts: Under Alternative #2 direct impacts resulting from dredge disposal events associated with routine maintenance of the federal navigation channel would be the same as those discussed under Alternative #1; the primary direct effect of dredge disposal to the dry beach being the burial of benthic infauna with limited to no mobility. Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with

heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure) in place. The use of heavy machinery during removal of the sand tube groinfield could result in direct mortality to resident infauna and epifauna with limited mobility. Geotube removal would likely occur subsequent to a beach fill operation thereby reducing direct impacts to the infaunal community. In addition, any direct impacts associated with sand tube removal would be temporal.

b. Indirect Impacts: Indirect impacts associated with dredge disposal, beach nourishment and sand tube groinfield maintenance under Alternative #2 would be comparable to those discussed under Alternative #1. Ultimately, the placement of dredge disposal materials along Bald Head Island will temporarily disturb breeding, nesting and feeding activities of resident and migratory birds.

While dredge disposal activities pursuant to the SMP would continue, there would be no stabilizing structures in place to reduce the rate of sand losses. The Delft3D model predicts rapid shoreline recession along the western end of South Beach to an extent that residences are susceptible to loss (if not relocated) within the first three years. Based upon modeling and prior shoreline monitoring, it is expected that the beach profile would be nearly vertical from upland dune to the mean high water line. By year nine of the model simulation, the shoreline would recede to an extent that would result in the loss of over 23 acres of dry beach. Impacts to this habitat type would in turn adversely affect several resident and migratory fauna. In addition, the federally-listed seabeach amaranth and other state-listed plants would be negatively impacted.

c. Cumulative Impacts: As with Alternative #1 above, the loss of dry beach habitat predicted via the implementation of the Retreat Alternative is substantial (23 acres over the nine-year simulation). However, much of the area of predicted loss exists in a chronically eroded condition. While the developed nature of the island precludes unabated migration of the

shoreline, it is expected that some level of equilibrium of beach profiles will occur such that dry beach will form along segments of the shoreline under evaluation. In consideration of this, as well as the extent of existing dry beach habitat along the shorelines of Bald Head Island and other barrier islands in the region, it is expected that the implementation of the Retreat Alternative would not result in cumulative effects to this resource.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: The temporal loss of infauna as a result of sand burial (from both federal disposal and Village-sponsored nourishment) and periodic use of heavy machinery associated with the maintenance of the groin field is anticipated and largely unavoidable. Larger, more mobile species will be able to temporary relocate to unaffected areas along Bald Head Island. Impacts will be most severe for permanent faunal residents which do not migrate on and off the beach (Hurme and Pullen 1988).

Physical impacts to dry beach habitat will vary during and after dredge disposal. Studies have shown that the nourished beach may be physically altered with respect to sand compaction, shear resistance, moisture content and grain size and shape even when the sediment is compatible with the target beach (NRC 1995). Placement of sediment that closely matches the native beach sediment is vital in the minimization of adverse impacts to beach infauna.

The amount of sand overburden will vary across the width of the beach and can range from several centimeters to more than a meter. Studies of burrowing abilities of sand-dwelling species are varied. Infaunal organisms have been observed to burrow through sand burdens up to 1 meter depending on grain size characteristics (NRC 1995). As the beach fill adjusts a distinct scarp can form which can hinder or eliminate movement of macrofauna between the swash zone and the upper beach (Reilly and Bellis 1978).

Monitoring efforts conducted following the 2005 Folly Beach Nourishment Project in Folly Beach, SC indicate that nourishment activities had little effect on surficial sediment characteristics and burrowing macroinvertebrates on the beach. Overall ghost crab population size did not yield a substantial response to nourishment. While not significant, there was evidence of decreased ghost crab densities with increased beach width which was attributed to habitat fragmentation, increased risk of predator exposure and increased pedestrian traffic (Bergquist et al. 2008).

The Village of Bald Head Island completed a biological monitoring program in conjunction with the 2009 Bald Head Island Beach Restoration Project to assess pre-construction and post-construction ghost crab (*Ocypode quadrata*) populations along the beachfront of the west and south-facing beaches of Bald Head Island. The Village-sponsored nourishment project was implemented in November 2009 and utilized Jay Bird Shoals as the source site. Baseline monitoring was conducted in June and September 2009 prior to the initiation of nourishment activities. Beachfront monitoring continued for two years upon completion of the project. The monitoring project yielded significant differences between pre and post-construction ghost crab burrow hole densities. However, significant differences were also observed at reference sites – thus indicating the influence of non-project related factors including inter-year natural variability (LMG 2010, 2011, 2012).

b. Indirect Impacts: Indirect impacts associated with dredge disposal, beach nourishment and sand tube groinfield maintenance under Alternative #3 would be comparable to those discussed under Alternative #1. Ultimately, the placement of dredge disposal materials along Bald Head Island will temporarily disturb breeding, nesting and feeding activities of resident and migratory birds. Village-sponsored nourishment events would occur three years subsequent to the next federal disposal and continue on approximate nine-year intervals for the remaining life of the project. As such, indirect impacts associated with Alternative #3 could occur with greater frequency than implementation of the SMP alone

(Alternative #1). Based upon predicted erosion rates and shoreline positions for the different alternatives evaluated, implementation of Alternative #3 would require greater volumes of sand relative to Alternative #5 over each nourishment cycle. This has the potential to result in greater spatial extent of impact to dry beach during each nourishment cycle through the life of the project.

Under Alternative #3, the cumulative erosion pattern predicted in the model indicates erosional stress along discrete areas of shoreline west and north of the sand tube groin field with sediment accretion north of the Point, along West Beach. The predicted effect is the net loss of six acres of dry beach by Year 9 of the model simulation. Infaunal species of the dry beach should respond to shoreline erosion and accretion by migrating as the shoreline shifts over time.

c. Cumulative Impacts: While the implementation of Alternative #3 has the potential to result in considerable loss of dry beach from erosion, it is expected that such loss will not necessarily produce cumulative effects to this habitat type. This determination is made in large part to the condition of the existing condition of the dry beach within the area of study. Much of western South Beach experiences the effects of acute and recurring erosion (e.g. steep beach profiles and the prevalence of escarpments). While predicted shoreline recession will result in dry beach losses, some level of equilibrium would be anticipated over the long-term (i.e. beyond nine years) such that some losses may be eventually offset by the formation of dry beach habitat along sections of the shoreline under evaluation. When viewed in the context of past, present, and reasonably foreseeable projects, it is expected that the loss of dry beach predicted under Alternative #3 will not result in cumulative impacts.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: Direct impacts associated with beach disposal/beach nourishment under Alternative #4 are similar to those discussed under Alternative #3. The intensity of the impact would be dependent on the volume of sediment and the total length of impacted shoreline. Removal of the sand tube groinfield would necessitate Village-sponsored nourishment events of greater magnitude (and potentially greater frequency) than that identified under Alternative #3. Mortality of benthic infauna due to sand burial and the use of heavy machinery during sand tube groinfield removal is anticipated and largely unavoidable. In general, biological diversity of the dry beach zone is typically low and resident fauna primarily include burrowing species well adapted to a dynamic environment. Data collected on Bald Head Island following 2009 nourishment efforts indicate that fluctuations in benthic fauna (i.e. ghost crabs) inhabiting the dry beach are attributed to seasonality and other environmental factors rather than beach nourishment activities (LMG 2010, 2011, 2012). Removal of the sand tube groinfield, in and of itself, would expose dry beach that is currently covered or altered in some manner by the existing sand tubes. However, the net effect of removal would be the increased instability of the beach profile and ensuing erosion. By Year 9 of the Delft3D model simulation for this alternative, approximately 19 acres of dry beach can be expected to be lost (converted principally to subtidal bottom).

b. Indirect Impacts: Indirect impacts associated with dredge disposal, beach nourishment and sand tube groinfield maintenance under Alternative #4 would be comparable to those discussed under Alternative #3 but could occur with greater frequency following removal of the sand tube groinfield. Pending the timing of the actions proposed under this alternative, placement of dredge disposal materials along Bald Head Island and the use of heavy machinery during removal of the sand tube groinfield has the potential to temporarily disturb breeding, nesting and feeding activities of resident and migratory birds.

As described in Section 5.2, Alternative #4 would require substantially greater volumes of sand during each nourishment cycle to help offset predicted sediment losses. This has the potential for increasing the indirect effects of beach nourishment over the life of the project relative to Alternatives #3, #5, and #6. In addition, the use of other shoreline stabilization measures (including beach scraping and sand bag revetments) can be reasonably expected as residential structures and infrastructure become imminently threatened from increased erosion. Use of a sand-bag revetment would result in mortality to benthic fauna and thus has the potential to adversely affect the foraging behavior of birds. Sand bag revetments also have the potential to adversely affect nesting sea turtles by increasing the potential for false crawls; altering beach profiles to an extent that may increase the risk of nest inundation waterward of the revetment; and increasing the potential of strcture-related debris should the structure fail or break apart (which could further impede nesting turtles or their hatchlings) (USFWS 2014).

While dredge disposal activities pursuant to the SMP and additional Village-sponsored nourishment events would continue, there would be no stabilizing structures in place to reduce the rate of sand losses. The model predicts shoreline recession and associated upland damage along a portion of South Beach in the vicinity of Bald Head Wynd within the 9-year simulation. The predicted erosion would result in the loss of dry beach and thus offer limited habitat for species that utilize these areas, including threatened and endangered flora and fauna. North of the Point, the predicted shoreline migrates west resulting in sediment accretion on West Beach. However, the net effect over the first nine-year period would be a predicted net loss of 19 acres of dry beach.

c. Cumulative Impacts: If this alternative were to be implemented, it can be reasonably expected that beach nourishment or other shoreline stabilization measures (e.g. sand bag revetments) would be employed to offset increased erosion to protect endangered homes, infrastructure, and protective dunes. While considerable loss of dry beach habitat is

predicted via erosion over a nine-year period and beyond, there is extensive acreage of this type of habitat on the remaining shoreline of Bald Head Island as well as along the shorelines of adjacent barrier islands. In addition, it is expected that some level of equilibrium will occur over the long-term that would produce conditions suitable for the formation of dry beach. In consideration of the reasonably foreseeable future actions (including likely contingency and emergency shoreline stabilization measures) and the extent of existing dry beach habitat along the shorelines of Bald Head Island and other barrier islands in the region, it is expected that the implementation of Alternative #4 would not result in cumulative effects to this resource.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, direct impacts associated with dredge disposal, beach nourishment and maintenance of the sand tube groinfield would be comparable to those discussed under Alternative #3. Mortality of benthic infauna due to sand burial and the use of heavy machinery during construction activities and sand tube groinfield maintenance is anticipated and largely unavoidable.

Additional impacts to the dry beach community will result from construction of the terminal groin structure. The terminal groin structure, as proposed, would have an overall length of 1,900 linear ft (for both Phase 1 and Phase 2) with approximately 250 to 300 lf (equivalent to 4,800 sf) extending above the 2012 MHW location. The structure would be constructed of relatively large granite armor rock of varying size which would be transported to Bald Head Island by barge. Placement of the foundation mattresses and rock is generally by crane from a barge, from the upland, and/or from a temporary trestle or pier constructed in close proximity to the groin structure.[6] Upland portions of the structure tieback necessitate excavation and backfilling of beach sand in order to place the groin foundation and rock at

[6] As indicated previously, the Phase 1 structure may not require the use of a temporary construction trestle. Rather much of the work can be completed via the use of sand pads formed from the fillet.

the necessary elevations (normally below existing grade). Based upon current design, approximately 350 lf of the groin will consist of the tie-back section.

There will be mortality of benthic fauna incapable of horizontal movement in the immediate footprint of the terminal groin. Heavy machinery associated with construction of the terminal groin will also result in mortality to benthic species with limited to no mobility. The majority of the terminal groin will be covered with sand upon completion thereby maintain the relative function of dry beach habitat.

b. Indirect Impacts: The installation of the terminal groin will provide for an expanded and more stable dry beach, particularly updrift of the structure. Since the groin is designed to allow for sediment transport to its lee side, any potential adverse effects to downdrift dry beach would be minimized. Based upon Delft3D modeling, there will be a net increase of approximately 8 acres of dry beach by Year 9 of the simulation. More stable dry beach is considered more advantageous to resident and migratory fauna particularly in consideration of a chronically eroded shoreline and comparatively steep beach profiles prevalent along much of western South Beach over the last several years.

Based upon the Delft3D modeling and the analysis performed by the Applicant's engineer, "emergency" fill operations in response to episodic erosion are not predicted to increase as a result of the implementation of Alternative #5. Rather, the installation of a terminal groin is predicted to decrease both the frequency and volume requirements of non-federal beach nourishment actions (see Table 5.5). However, as a requirement of SB 151, mitigative measures need to be identified for West Beach to address any potential downdrift effects of the proposed structure. These measures would include hydraulically or mechanically placed sand on West Beach. Detailed engineering analyses of post-project conditions within and adjacent to the project area are provided in the report entitled, "*Shoreline Stabilization Analysis (July 2013)*" (Olsen 2013). Inclusive in this report is the prediction of any potential

increase in erosion on West Beach due to the maximum length of the proposed groin. According to the Applicant's engineer, the total predicted difference is conservatively estimated to be -5200 cy/yr over nine years which is considered low in the context of the existing, erosional condition. As a result, Alternative #5 is not anticipated to result in increased sand placement on West Beach relative to the other alternatives that evaluate beach nourishment as an erosion response strategy (i.e. Alternative #3, #4, and #6). It is predicted that the West Beach shorefront will potentially require beach disposal on an approximate 3-year basis with or without the implementation of the terminal structure. This placement may be achieved through regularly scheduled federal disposal or through Village-sponsored nourishment and would readily offset any potential increase in erosion resulting from the installation of a terminal structure.

The Applicant has also identified the potential use of a sand bag revetment as mitigation. Such a response (if needed) would be targeted for the specific segment of shoreline under an emergency-level condition in which structures have become imminently threatened. Use of a sand-bag revetment would result in mortality to benthic fauna and thus has the potential to adversely affect the foraging behavior of birds. Sand bag revetments also have the potential to adversely affect nesting sea turtles by increasing the potential for false crawls; altering beach profiles to an extent that may increase the risk of nest inundation waterward of the revetment; and potentially increasing debris along the beachfront should the structure fail and break apart (this in turn could further impede nesting turtles or their hatchlings) (USFWS 2014). Any potential indirect effects to sea turtles should be considered in the context of the existing condition of West Beach which is an area of shoreline with historically low nest occurrences due to its chronically eroded condition and proximity to the river mouth. Those nests that are laid are subject to inundation, and absent relocation by the Bald Head Island Conservancy, have low success.

c. Cumulative Impacts: In consideration of the proposed action and reasonably foreseeable future actions, including identified mitigative measures (such as mechanical sand placement from the updrift impoundment fillet of the groin, hydraulic placement from a compatible, beach quality sand borrow site, or sandbag revetment for small-scale emergency response), no cumulative impacts to dry beach habitat are expected as a result of the implementation of Alternative #5. The predicted extent of downdrift effects of the terminal structure is not anticipated to generate any large-scale or recurring mitigation action. As has been the case on West Beach, disposal or nourishment is expected to be needed on a recurring basis irrespective of the implementation of Alternative #5. Any direct or indirect effects of the proposed action and reasonably foreseeable future actions (including potential mitigative action) would be offset by the predicted increase in dry beach resulting from the stabilized shoreline.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, direct impacts associated with dredge disposal and beach nourishment would be comparable to those discussed under Alternative #3. Mortality of benthic infauna due to burial by sand during nourishment and burial by granite armor rock upon completion of the terminal groin structure is largely unavoidable. Similarly, there will be direct impacts to benthic species with limited to no mobility as a result of the operation of heavy machinery necessary for removal of the sand tube groinfield and construction of the terminal groin structure. Operation of equipment would be confined to construction corridors to limit disturbance where feasible.

b. Indirect Impacts: Similar to Alternative #5, the Delft3D modeling of Alternative #6 predicts an expanded dry beach updrift of the terminal structure. The Point downdrift of the groin is believed to exist more or less in its present-day condition. Given the designed porosity and profile of the structure, sediment passage through and over the groin will help

minimize potential adverse effects to downdrift dry beach. Delft3D modeling indicates the net gain of 1.7 acres of dry beach at Year 9 of the model simulation. Similar to Alternative #5, downdrift mitigation thresholds and responses must be identified in advance in accordance with SB 151. Mitigative responses include: (1) hydraulic sand placement from one of the authorized sand source sites; (2) sand bag revetment construction along targeted segments of the shoreline where threatened structures exist; (3) mechanical transport of sand from the updrift impoundment fillet of the terminal groin; and (4) adjustment of the crest elevation of the terminal groin to increase permeability. Hydraulic/mechanical placement of sand and the use of sand bag revetments downdrift of the structure have the potential for resulting in the same level of impact as described for Alternative #5.

With the removal of the sand tube groinfield, it is expected that areas of South Beach beyond the influence of the terminal groin will experience some level of deflation and thus be susceptible to increased risk of inundation and erosion. This would, in turn, affect those species inhabiting or utilizing the dry beach along this segment of shoreline. In addition, it can be reasonably anticipated that additional shoreline protection measures would be employed. These measures would include more frequent and robust hydraulic sand placement or the use of sand bag revetments. As described in Section 5.2, implementation of Alternative #6 would result in sand volume requirements for each nourishment cycle (and cumulatively over 30 years) that exceed Alternative #3 and Alternative #5. The result would be the potential for increased disturbance to dry beach that in turn would affect benthic assemblages and the foraging behavior of birds.

c. Cumulative Impacts: It is anticipated that the potential direct and indirect effects of Alternative #6 (including the potential for future contingency shoreline protection actions) would be greater than those described for Alternative #5. This is due to the predicted erosion resulting from the removal of the sand tube groinfield. It can be reasonably expected that such erosion would result in the implementation of contingency shoreline

protection measures that may include hydraulic sand placement, beach scraping, or installation of sand bag revetments. Any direct or indirect effects of Alternative #6 and reasonably foreseeable future actions (including potential contingency actions) would be offset by the predicted increase in dry beach resulting from the stabilized shoreline.

C. Dune

Dunes are dynamic features subject to alteration by natural erosion or accretion. While sufficiently stable to support various species of vegetation, including state-listed plants such as dune bluecurls, moundlily yucca, and beach morning glory, dunes can be subject to significant impact or loss from episodic storm-induced waves and wind. Actions of humans similarly can affect the condition and stability of dunes. For instance, active management (via planting and sand fencing) can help to restore or build frontal dunes, while conversely human foot traffic or intensive recreational use has been cited to adversely effect dune vegetation and structure (Rogers and Nash 2003).

The following provides a description of potential effects of each project alternative to dune habitats mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: Disposal occurring under the No Action/Status Quo alternative will not have a direct impact to dune habitat. Similarly, other short-term stabilization measures (such as sand bags and beach scraping) that have been employed to remedy localized erosion will not result in direct impacts to dune habitat. These actions tend to occur in the upper beach and avoid disturbance to dunes.

b. Indirect Impacts: Alternative #1 is predicted to have the most significant effect to the shoreline position of the Point. While some level of shoreline recession is predicted along western South Beach, sand deficits over time would have a pronounced adverse impact on

the conditions of the Point. As described in earlier sections, the Point consists of the most expansive areas of lower foredunes (newly formed features consisting of relatively sparse vegetation). Landward of these areas are the large, primary dunes of Bald Head Island. Based upon the physical Delft3D models, all of the Point and the associated dune habitat (including frontal and primary dune) as it currently exists would be loss to erosion by year 9 of the simulation.

Some level of impact is expected along recently stabilized frontal dunes of South Beach, particularly along South Bald Head Wynd in the vicinity of the Bald Head Island Club. Many of these dunes have been reestablished through an active management plan that included sand fencing and planting with sea oats (*Uniola paniculata*). As has been observed in the past, a status quo condition results in a net deficit of sand along this section of shoreline and can result in the breaching and loss of frontal dune. The Delft3D modeling completed for the no-action or status quo condition depicts a similar condition by Year 9 of the simulation.

Cumulatively, over 8 acres of dune of the total, existing 21 acres mapped in the study would be lost (converted to intertidal or subtidal bottom) within the first nine years of implementation of Alternative #1.

Deflation and recession of the shoreline along western South Beach and the Point would result in a less stable beach profile condition. In addition to the predicted habitat loss from erosion, it is anticipated that increased exposure to wind and waves would likely result in a less stable environment. Ultimately, such conditions are not conducive for the establishment and growth of dune vegetation. As such, newly formed dunes would not be as prevalent. Current primary dunes landward of the predicted 9-year shoreline position would be susceptible to storm-induced erosion and the effects of increased exposure to wind, waves, and salt spray. Overall, the indirect effects of this alternative would compromise dune function, particularly with respect to storm protection.

c. Cumulative Impacts: While some level of direct and indirect impacts to dune habitat are predicted, regional cumulative impacts to the resource are not anticipated as a result of the implementation of Alternative #1.

(2) Retreat (Alternative #2)

a. Direct Impacts: Direct impacts to dune habitat under Alternative #2 would be associated with the temporary disturbance of the sand tube removal. However, the entire sand tube groinfield was replaced in the winter of 2009-2010, and thus any vegetated dune is the result of more recent stabilization. Excavation of the landward end of the tubes could result in an impact to recently vegetated portions of the dune. Any disturbance would be temporal and spatially confined to the footprint of the sand tubes (landward ends) and the areas required for the operation of the construction equipment. No other direct impacts to dune habitat are expected under the Retreat Alternative.

b. Indirect Impacts: Under the Retreat Alternative, a systematic removal of the sand tube groinfield and demolition and/or relocation of structures would occur. In the absence of shoreline stabilization and beach nourishment, significant erosion would result over much of western South Beach, the Point, and West Beach. Shorter term (i.e. over one to three years) impacts would result from more frequent overwash and inundation. Overwash of frontal dunes would result in direct impact by effectively 'flattening' these features. The eroded dunes would not be able to become reestablished as the shoreline is predicted to retreat by as much as 1,000 lf landward of its current position. The Retreat Alternative would impact the lee side slopes and interior flats of the dunes along western South Beach and the Point. Nearly all of the frontal dunes identified in the model study area would be lost by Year 9 of the simulation. However, littoral transport would result in the migration of sand to the northwest and ultimately cause a shift northward of the Point feature. While some level of

accretion in this area could favor the development of dunes, the net predicted effect is the loss of 16.1 acres (equivalent to 76%) of dunes within the mapped study area.

As indicated for Alternative #1, the predicted physical effects of the Retreat Alternative would result in a less stable beachfront condition over the nine-year model period. Areas currently consisting of relatively high primary dunes would become beachfront features and thus subject to increased exposure to wind, waves, and salt spray. Such rigorous environmental conditions would alter species composition, decrease stability, and increase the risk of further loss to erosion over the 30-year project life.

c. Cumulative Impacts: Implementation of the Retreat Alternative is predicted to result in the indirect loss of over 16 acres of dune habitat over the nine-year model simulation. While the presence of the federally-maintained channel would continue to influence shoreline morphology and processes, it is expected that the system will achieve some level of equilibrium that will allow for the formation of dunes over the long term. As a result, no cumulative impacts are expected.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: There are no direct impacts to dune habitat associated with the implementation of Alternative #3.

b. Indirect Impacts: Based upon the predicted physical consequences of implementing Alternative 3, there would be considerably less impact to dune habitat than that predicted for Alternative #1 and Alternative #2. The principal area of risk identified under Alternative #3 is the segment of shoreline just west and north of the sand tube #16 and along the southern extent of the current Point feature. While the Point is predicted to migrate north, there will be approximately 2.3 acres of net loss of dune habitat under this alternative by Year 9 of the Delft3D model simulation. The predicted area of dune loss currently consists of

lower, sparsely vegetated foredunes. Bare or sparsely vegetated areas of the upper beach and foredunes present suitable nesting habitat for willets, American oystercatchers, and Wilson's plovers. With the exception of this area, dunes are likely to be able to exist more or less in their current condition as a result of the implementation of Alternative #3.

Indirect effects of Alternative #3 would include the potential of dune instability or loss resulting from storm-induced erosion. In particular, sand losses in the vicinity of the Point may have an adverse impact on frontal dunes of the area. Acute erosion of the upper beach and dune transition zone would result in a steeper, and less stable, berm profile. Increased exposure to wind, waves, and salt spray could influence plant species growth and composition.

c. Cumulative Impacts: Implementation of Alternative #3 is not expected to result in cumulative impacts to dune habitats of the region.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: As with Alternative #2, direct impacts to dune habitat under Alternative #4 would be associated with the temporary disturbance associated with the excavation of the landward ends of the sand tubes. Any disturbance would be temporary and would be spatially confined to the footprint of the sand tubes and the areas required for the operation of the construction equipment.

b. Indirect Impacts: Implementation of Alternative #4 would have the similar effects to dunes within the project area as that of Alternative #2. By Year 9 of the model simulation, 12.5 acres of the total dunes mapped in the study area would be lost via conversion to intertidal or subtidal bottom, equivalent to a 59% decrease. Recession of the shoreline would result in primary dunes (currently located within the interior, more protected areas of the Island) to be exposed to increased wind, waves, and salt spray. Together, with steeper

berm profiles characteristic of eroded areas, these conditions would lead to a generally less stable environment. Overall, remaining dune structure and function would potentially be compromised. Where feasible, it would be expected that the Village would pursue other shoreline stabilization measures (including more frequent and robust nourishment, beach scraping, or installation of a sand bag revetment). However, these actions (if implemented) would likely not be sufficient to offset the predicted losses.

c. Cumulative Impacts: The implementation of Alternative #4 will result in the loss of dune habitat of a magnitude and duration that has the potential to result in cumulative effects. In light of the developed nature of the island, the opportunity for dune formation as the shoreline recedes will be limited. When considered in the context of past, present, and reasonably foreseeable future actions (e.g. residential and commercial development of barrier islands), these losses may result in cumulative impacts.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Frontal and primary dunes are not anticipated to be adversely affected as a result of the implementation of Alternative #5.

b. Indirect Impacts: Based upon Delft3D modeling, no adverse, indirect impacts to dunes are anticipated as a result of the implementation of Alternative #5. As with other alternatives, there may be some change to the configuration and position of the Point feature. However, these shifts will not result in a direct impact to dunes. The installation of the groin and associated fillet will expand the area of dry beach updrift of the structure. A more stable upper beach zone could potentially result in the establishment and growth of dune grasses (e.g. bitter panicum, sea oats, salt meadow hay, etc.), which would in turn promote increased sand trapping and the potential for dune formation.

c. Cumulative Impacts: Implementation of Alternative #5 has the potential to promote the construction of residences on currently undeveloped, platted lots that are at a higher risk of erosion threat under the existing condition. The extent of the potential for this occurrence is offset to a degree by the recurring federal disposal of sand on South Beach associated with the maintenance of the Wilmington Harbor Project. As a result, the potential for increased development pressure (above the existing trend of residential lot build-out[7]) would likely be applicable to 10 or less lots. Any future construction would be subject to existing federal, state, and local regulatory requirements. In particular, NC DCMs oceanfront shoreline construction setback (measured from the Static Vegetation line) would be applicable. In consideration of past, present, and reasonably foreseeable future actions (including potential implementation of mitigative actions as identified in the Applicant's Inlet Management Plan), implementation of Alternative #5 is not expected to result in cumulative impacts to dune habitat.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Direct impacts associated with this alternative would consist of temporary and relatively confined disturbance associated with the removal of the landward ends of the sand tubes.

b. Indirect Impacts: The indirect effects for Alternative #6 are predicted to be the same as those identified above for Alternative #5. A more stable beach condition updrift of the structure could potentially promote conditions suitable for plant species establishment and growth. In turn, plant stems tend to trap wind-borne sand. In the absence of any significant erosion, these areas could potentially form into smaller foredunes near the upper beach-dune transition zone.

[7] Since 2000, the Village has issued an average of 68 building permits per year (VBHI 2012).

Note that the removal of sand tubes east of the terminal structure may result in some level of decreased stability along the section of shoreline across from the Bald Head Island Club. The frontal dunes of this segment of shoreline are relatively low and narrow. With decreased stability comes a corresponding increase of risk of loss to erosion. While the Delft3D model does not predict any direct loss during the nine-year simulation, beach deflation and instability would make the upper beach and frontal dune more susceptible to erosion, particularly during storms. Such a condition may prompt the Village to pursue other shoreline stabilization measures (including more frequent and robust nourishment, beach scraping, or installation of a sand bag revetment). However, these actions (if implemented) are not anticipated to have indirect effects on dunes.

c. Cumulative Impacts: Implementation of Alternative #6 would result in similar effects to dune habitat as described for Alternative #5. In consideration of past, present, and reasonably foreseeable future actions (including potential implementation of mitigative actions as identified in the Applicant's Inlet Management Plan), implementation of Alternative #6 is not expected to result in cumulative impacts to dune habitat.

D. Interdunal Wetlands

As described in Section 4.0 of the document, interdunal wetlands occupy depressions within the dune complex of the island. Interdunal wetlands have been mapped in the study area and are depicted in Figure 5.12. Given the proximity of these features to the shoreline of South Beach, these wetland types may be susceptible to impact via overwash or loss to marine waters under the different alternatives considered. The following provides a description of potential effects of each alternative to interdunal wetlands mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: No direct impacts are expected as a result of the implementation of Alternative #1.

b. Indirect Impacts: Under Alternative #1, much of the shoreline of South Beach would continue to exist along a similar position as it does today with the exception of documented areas of persistent, acute erosion (i.e. immediately adjacent to South Bald Head Wynd across from the Bald Head Island Club). Provided that the frequency and volume of federal disposal events are similar to that which has occurred over the last decade and that the performance of the existing groinfield is maintained, then the shoreline of South Beach updrift of Sand Tube #16 would not be subject to the degree of recession predicted for other alternatives (e.g. Alternative #2 and Alternative #4).

While there are no significant changes in shoreline configuration predicted for much of South Beach, some level of sediment loss and deflation is anticipated. Overwash of the primary dunes and tidal inundation in the vicinity of South Bald Head Wynd is anticipated during storm events. Increased susceptibility to overwash can alter substrate elevations within interior wetland areas and modify the hydrologic regime of the wetland. In addition, floodwaters that do not recede can become hypersaline and result in shifts in the vegetative composition of the wetland. It is important to note that while some periodic overwash is not uncommon for these types of wetlands (depending upon proximity to the shoreline), increased frequency of duration of tidal inundation can result in indirect impacts to wetland structure and function. For instance refuge or foraging habitat for characteristic fauna may be lost or modified to an extent that may force certain species to relocate to interior wetlands on the Island. Species less tolerant of mesohaline or euhaline conditions (such as the American alligator) in particular would be susceptible to displacement.

Cumulative Impacts: In consideration of past, present, and reasonably foreseeable future projects in the region, no cumulative effects to interdunal wetlands are anticipated in conjunction with Alternative #1.

(2) Retreat (Alternative #2)

a. Direct Impacts: No direct impacts to interdunal wetlands are expected as a result of the implementation of Alternative #2.

b. Indirect Impacts: The Retreat Alternative would include the systematic removal of the sand tube groinfield and the demolition and/or relocation of structures. In the absence of shoreline stabilization and beach nourishment, significant erosion would result over much of western South Beach, the Point, and West Beach. Shorter term (i.e. over one to three years) impacts would result from more frequent overwash and inundation. Overwash of frontal dunes would result in the deposition within back dune depressions and wetlands. Similar to the effects identified above, saltwater inundation could create hypersaline conditions and result in the dieback of species of low to moderate salt tolerance. Shifts in both the hydrologic regime and species composition would be anticipated over the short-term.

Based upon Delft3D modeling, the shoreline of western South Beach and the Point is anticipated to recede over 1000 lf by Year 9 of the model simulation. Shoreline recession to this extent would result in the direct loss of 2 acres (equivalent to 50%) of the interdunal wetlands mapped within the area of study. These areas would be converted to intertidal or subtidal areas within nine years of the implementation of this alternative. It is anticipated that some state of quasi-equilibrium would be reached over a longer term period, such that interdunal wetlands of the interior areas of Bald Head would likely remain unaffected.

As indicated above, some level of equilibrium would ultimately be reached under the Retreat Alternative. While indirect loss of current, interdunal wetlands is predicted, it is likely that

other interdune swales and flats (that are not currently identified as wetlands) would develop. Overall, the dune and backdune areas of barrier islands are dynamic environments that shift in response to varying physical conditions, including erosion and accretion. While the location and extent of this community type would likely be altered, it is anticipated that losses would be offset to some degree by the inundation of other sloughs/depressions in the landscape.

Species less tolerant of mesohaline or euhaline conditions (such as the American alligator, green tree frog, squirrel tree frog, or various species of snakes) may be displaced. However, more mobile species would readily relocate to interior areas protected from periodic overwash.

c. Cumulative Impacts: The predicted loss of interdunal wetlands under Alternative #2 will be offset to a degree by the expansion of wetlands within lower elevation areas not presently considered jurisdictional wetlands. Future relocation of residences to interior lots has the potential to result in lot construction at a more rapid pace than what would be expected to occur through gradual build-out of platted lots in the absence of a planned retreat. Current ordinances through the Village of Bald Head Island typically require avoidance of wetland impacts for residential lot construction. Any wetland disturbances in the future as a result of relocation of homes may be characterized by cart-path crossings (over wetlands) or the clearing, grubbing, and maintenance of vegetation for a piling supported home. Such activities do not remove jurisdictional wetland status. However, the clearing of vegetation can compromise some wetland function (including niche habitat). Any wetland impacts that are proposed must satisfy the requirements of Section 404 of the Clean Water Act (CWA) which include demonstration of avoidance and minimization of jurisdictional wetlands. Compensatory mitigation for wetland impacts that are determined to be unavoidable is also required. In consideration of the type of wetland disturbance that may occur through future lot construction and the avoidance and mitigative measures that

are required both through local ordinance and through Section 404 of the CWA, no cumulative impacts to wetlands are expected as a result of the implementation of Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: Actions implemented under Alternative #3 would not have a direct effect on interdunal wetlands of the permit area.

b. Indirect Impacts: Based upon the predicted physical consequences of implementing Alternative 3, there will likely be no short-term impacts to interdunal wetlands in the vicinity of the project area. The combination of nourishment and maintenance of the existing groinfield would likely provide sufficient stabilization of the shoreline so as not to adversely affect backdune flats and wetlands in the near term. However, Delft3D modeling predicts the deflation of the area around the Point by Year 9 of the simulation. If erosion and deflation is significant enough to result in more frequent inundation of backdune areas, then interdunal wetlands are susceptible to some change in hydrology and species composition (as described above for Alternative #1 and Alternative #2).

Indirect effects would be the result of the potential for greater frequency and amplitude of tidal inundation during storm events. As described above, such conditions would alter hydrology and salinity of interdunal wetlands and give rise to shifts in species composition. Given the dynamic nature of these environments, it is anticipated that such shifts would not significantly adverse the function of this community type.

c. Cumulative Impacts: No cumulative impacts to interdunal wetlands are expected as a result of the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: Similar to the three alternatives above, no direct impacts to interdunal wetlands are expected as a result of the implementation of Alternative #4.

b. Indirect Impacts: Implementation of Alternative #4 would have similar indirect effects to interdunal wetlands as Alternative #2. By Year 9 of the model simulation, 2 acres (equivalent to 50%) of the wetlands mapped in the study area would be lost via conversion to intertidal or subtidal bottom. Loss from erosion may be offset to a degree as other low areas of the interior dunes are subject to increased hydrologic input from overwash. Over time these areas may develop hydroperiods of sufficient duration to be considered wetlands.

c. Cumulative Impacts: Predicted impacts to interdunal wetlands would likely be offset to a degree by the expansion of wetlands resulting from erosion and inundation. Alternative #4 is not expected to generate additive or interactive effects that would result in cumulative impacts.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: The installation of the terminal groin and maintenance of the existing sand tube groinfield is not anticipated to result in any direct impacts to interdunal wetlands. As described in prior sections, this wetland type occupies depressions of the interior backdunes and flats.

b. Indirect Impacts: Given the general increased stability of the shoreline associated with Alternative #5, no indirect impacts to interdunal wetlands are anticipated.

c. Cumulative Impacts: The implementation of a long-term solution to erosion on western South Beach has the potential for influencing build out trends of currently platted, undeveloped lots. Construction that may have been indefinitely delayed due to the risk of

erosion may be considered to be a safer investment for individual lot owners. The extent of the potential for this occurrence is offset to a degree by the recurring federal disposal of sand on South Beach associated with the maintenance of the Wilmington Harbor Project. There are approximately 4 acres of interdunal wetlands that are mapped within lots of the project area. Current ordinances through the Village of Bald Head Island typically require avoidance of wetland impacts for residential lot construction. Any wetland disturbances in the future as a result of single-family construction may be characterized by cart-path crossings (over wetlands) or the clearing, grubbing, and maintenance of vegetation for a piling supported home. Such activities do not remove jurisdictional wetland status. However, the clearing of vegetation can compromise some wetland function (including niche habitat). Any wetland impacts that are proposed must satisfy the requirements of Section 404 of the Clean Water Act (CWA) which include demonstration of avoidance and minimization of jurisdictional wetlands. Compensatory mitigation for wetland impacts that are determined to be unavoidable is also required.

Cumulative impacts associated with past, present, and reasonably foreseeable future actions are not expected due to the following: (1) the overall limited extent of interdunal wetlands mapped in the project area relative to the extent of interdunal wetlands occurring throughout the Bald Head Island complex; (2) the requirements to avoid and minimize disturbance to wetlands to the maximum extent practicable; (3) the type of disturbances (if any) that may occur (likely consisting of limited clearing of vegetation); and (4) required compensatory mitigation for any permitted wetland impacts.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: The installation of the terminal groin and *removal* of the existing sand tube groinfield is not anticipated to result in any direct impacts to interdunal wetlands.

Overall, the predicted consequences of this alternative to habitat types landward of the frontal dunes are the same as those of Alternative #5.

b. Indirect Impacts: Overall, there will be increased stability of the shoreline associated with Alternative #6. However, some level of beachfront deflation may occur as a result of the removal of the sand tube groinfield. This deflation increases the risk for overwash of frontal dunes along South Bald Head Wynd in front of the BHI Club. This has the potential to affect interdunal wetlands closer to the beachfront. The effects of such are considered relatively minor.

c. Cumulative Impacts: Alternative #6 is expected to result in similar level of effects to interdunal wetlands as Alternative #5. In consideration of past, present, and reasonably foreseeable future actions, there are no cumulative impacts associated with the implementation of this alternative.

E. Maritime Thicket/Forest

Maritime thicket and maritime forests[8] are prevalent within undeveloped areas of the interior hind-dunes of the Island. More mature canopy maritime forest exists well east of the Point, particularly in the vicinity of Muscadine Wynd and points east. Maritime forests on the island support an assortment of rare plants and animals. Given that these areas exist within interior sections of the Island (generally 1,000 lf or greater landward of the beachfront), most of the alternatives under consideration pose no direct threat to this habitat type. Potential consequences (direct or indirect) for each alternative are described further below.

[8]Due to the close association of these community types and overlapping species occurrence, maritime thicket and maritime forest have been grouped under one category for the purpose of this evaluation.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: There would be no direct impacts to maritime thicket/forest as a result of the No Action/Status Quo alternative. While significant dry beach and dune loss is anticipated in the vicinity of the Point, maritime thicket/forest habitat will not be directly affected.

b. Indirect Impacts: Erosion into the primary dune along the western end of South Beach and the Point (as predicted by Year 9 of the Delft3D model simulation) could potentially have indirect effects to maritime thicket/forest habitats. Erosion to this extent would likely expose this habitat to greater physical stresses, including increased wind and salt spray. Exposure to increased wind and salt spray can influence plant species growth and community composition. Shifts in community composition can in turn adversely affect habitat functions.

c. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to maritime thicket/forest. Other than the indirect effects of the No Action/Status Quo alternative, there are no other known actions that would have any appreciable effect on this resource.

(2) Retreat (Alternative #2)

a. Direct Impacts*:* No direct impacts are anticipated as a result of the implementation of the Retreat Alternative.

b. Indirect Impacts: The extent of erosion predicted under Alternative #2 would result in the loss of mapped maritime thicket/forest areas of the interior hind-dunes of the Island. Based upon Delft3D modeling and baseline resource mapping, it is anticipated that approximately 7.1 acres (of the total 13.7 acres mapped) of maritime thicket/forest would be lost to erosion by Year 9 post-project implementation via conversion to intertidal beach

or subtidal bottom. Areas not converted to open water or intertidal beach would be susceptible to loss from storm-induced tides and waves.

During storm events, those hammock areas in closer proximity to the mean high water line (as a result of the extent shoreline recession and deflation) would be at risk of inundation during storm events. Inundation would alter the hydrologic regime and physiochemistry of the habitat and alter species composition. Inundation would also likely result in the deposition of sand, altering the microtopography of the habitat. Furthermore, increase exposure to wind and salt spray would also influence the growth and survivorship of characteristic species. The combined effect of these stressors would be a shift in species composition from species (such as live oak) adapted to more protected and stable conditions, to species adapted to more dynamic dune conditions (such as wax myrtle, groundsel tree, greenbrier, and various sedges and grasses).

Since the Retreat Alternative includes the planned relocation of structures (e.g. roads, utilities, and residential/commercial properties), additional indirect effects to maritime thicket/forest habitat would be expected as a result of providing additional right-of-ways, easements, and building sites for the relocated structures. Much of the current, undeveloped property contains maritime communities of varying age and condition susceptible to disturbance through future development. Those residences that are relocated would be moved to existing, platted lots. Thus, these impacts would be expected either way at some point in the future. However, relocation of South Bald Head Wynd and other roads would likely require the acquisition of new right-of-ways not currently platted.

c. Cumulative Impacts: Maritime forest represents one of the most endangered habitat types of North Carolina (Schafale and Weakley 1990). The principal cause of loss is habitat fragmentation from barrier island residential and commercial development. Future relocation of residences to interior lots has the potential to result in lot construction at a

more rapid pace than what would be expected to occur through gradual build-out of platted lots in the absence of a planned retreat. A planned retreat would likely disproportionately affect areas of the island considered more stable from future erosion (e.g. those areas stable enough for a sufficient period of time to promote the occurrence of maritime thicket/forest vegetation) This, in turn, may exert greater pressure on clearing of maritime thicket/forest vegetation. However, current Village development ordinances require preservation of the natural environment to the maximum extent practicable for new construction. In addition, construction activities would be limited to existing platted lots that over time would be expected to be built upon irrespective of a planned relocation strategy.

The principal threat to maritime forest under Alternative #2 is habitat loss and degradation through erosion. This is expected to be of a magnitude and duration (i.e. long-lasting or permanent loss) that may result in cumulative effects to this resource and the species relying on the resource for foraging, nesting, or refuge. Given the current condition of this habitat type and the susceptibility to loss in coastal North Carolina, its capacity to sustain additional impacts is relatively low. Therefore, cumulative impacts would be expected.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct and Indirect Impacts: Based upon the predicted physical effects, there would be no direct or indirect impacts to maritime thicket/forest habitat resulting from Alternative #3. The combination of beach nourishment and the continued maintenance of the groinfield will provide sufficient protection as to avoid erosion to nearly all of the upland areas landward of the current shoreline position.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no cumulative impacts to maritime thicket/forest resulting from the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: As with each of the alternatives described above, no direct impacts to maritime thicket/forest are anticipated as a result of the implementation of Alternative #4.

b. Indirect Impacts: It is predicted that approximately 4.3 acres of mapped maritime thicket/forest is susceptible to loss from erosion (conversion to intertidal beach or open water). Many areas not lost to erosion would be subject to alteration via increased exposure to inundation, wind, and salt spray. The combined effects of these physical stressors would likely result in a shift in species composition from those adapted to more stable conditions to those adapted to dynamic conditions of the shoreline and its immediate environs. In other words, as the shoreline migrates, maritime thicket/forest once protected by primary dunes would now be directly exposed to the rigorous environment of the oceanfront.

c. Cumulative Impacts: The extent of predicted impacts to maritime forest/shrub habitat is of a magnitude and duration that may result in cumulative impacts. As stated for Alternative #2, this habitat type has relatively low capacity to sustain additional impacts in consideration of the threat of its loss from barrier island development. Therefore, any permanent losses (as expected for Alternative #4) would result in additive effects when viewed in the context of other past, present, and reasonably foreseeable future actions in the region.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct and Indirect Impacts: There would be no direct or indirect impacts to maritime thicket/forest resulting from Alternative #5.

b. Cumulative Impacts: The implementation of a long-term solution to erosion on western South Beach has the potential for influencing build out trends of currently platted, undeveloped lots. Construction that may have been indefinitely delayed due to the risk of erosion may be considered to be a safer investment for individual lot owners. The extent of

the potential for this occurrence is offset to a degree by the recurring federal disposal of sand on South Beach associated with the maintenance of the Wilmington Harbor Project. Any increased development pressure would likely be evident within those areas that would be susceptible to risk absent an effective, long-term erosion control plan. Maritime thicket/forest vegetation is not prevalent within such areas. Within the larger mapped project area depicted in Figure 4.7, there are approximately 13.7 acres of maritime thicket/forest mapped within platted lots. Construction of homes on current undeveloped lots may result in the clearing of maritime thicket/forest vegetation. However, Village development ordinances require preservation of the natural environment to the maximum extent practicable for new construction and restrict the built-upon area for individual lots. In addition, construction activities would be limited to existing platted lots. Those lots currently consisting of maritime thicket/forest vegetation are generally more protected from the risk of erosion and would be expected to be built upon over time (consistent with the development trends of the island) for many of the scenarios considered in this EIS (with the exception of Alternative #2 and Alternative #4).

In conjunction with other past, present, or reasonably foreseeable future actions (including potential increased rate of home construction on existing, platted lots), no cumulative impacts to this habitat are anticipated.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct and Indirect Impacts: There would be no direct or indirect impacts to maritime thicket/forest resulting from Alternative #5.

b. Cumulative Impacts: Alternative #6 is expected to result in similar level of effects to maritime thicket/forest as Alternative #5. In consideration of past, present, and reasonably

foreseeable future actions, there are no cumulative impacts associated with the implementation of this alternative.

5.5.3 Marine Habitats

A. Soft Bottom Communities

Soft bottom is characterized by a number of physiochemical factors including sediment grain size and distribution, water depth, hydrography as well as water quality (dissolved oxygen and salinity). Specific habitats identified in the study area include subtidal bottom of the Cape Fear River and Atlantic Ocean and estuarine and marine intertidal flats and shoals. Soft bottom located upstream of the inlet complex (beyond the study area) and within semi-protected areas of the estuary are more stable and support a larger, more diverse benthic community. The dynamic nature of the Cape Fear River inlet system and the relative instability of sediment can create an inhospitable environment for the benthic community and thus favors the occurrence and predominance of species adapted to disturbance-prone conditions.

Soft bottom habitat is an important component of primary nursery areas, anadromous fish spawning areas and anadromous nursery areas. Together, the benthic microalgal and invertebrate populations within subtidal bottom may serve as an important food source for many juvenile fish. Additionally, intertidal shoals provide important foraging and roosting habitat for a variety of shorebirds and waterbirds.

1. Soft Bottom Effects at Borrow Sites:

Since four of the six alternatives include sand volume requirements beyond that supplied by federal disposal of material dredged from the Wilmington Harbor navigation channel, a summary of borrow site impacts specific to soft bottom communities is presented below.

As described in Section 5.2.4, sand volume requirements are variable between alternatives with Alternative #4 requiring the greatest volume of sand (estimated to be 8 Mcy) over the 30-year project life. Conversely, Alternative #5 would require the least volume (estimated to be 4.5 Mcy) over the 30-year period. The applicant's preferred borrow source of sand for alternatives that include nourishment would be the undredged portion of the Jay Bird Shoals borrow site included within the permit limits for the Village-sponsored beach nourishment project constructed in the winter of 2009/2010. Other sources of sand for fillet maintenance and maintenance of West Beach include the federal navigation channel and the ebb tidal shoal of Bald Head Creek. Frying Pan Shoals has been identified as a future borrow source for nourishment beyond Year 3 (particularly for anticipated nourishment needs in Year 12, 21, and 30). While dredging of any of the identified sand source sites will result in direct physical effect to marine subtidal bottom, the biological impacts may vary depending upon the existing condition of the borrow site and the anticipated conditions post-dredging.

Alteration of wave dynamics and sediment transport mechanisms following dredge events can lead to physical changes in the geomorphology at the dredge site. Physical changes observed following dredging can include: decreased sand content, increased silt/clay content, greater variation in sediment grain size (poor sorting) and accumulation of fine sediment (ASFMC 2002). Changes in sediment characteristics are cited as a principle causal factor restricting benthic re-population (NRC 1995) as such changes may reduce the suitability for larval settlement and recruitment. Dredging can also expose anaerobic sediment that may alter the rate of nutrient exchange between the sediment and the water column thereby impacting benthic recolonization. In addition, the creation of a bathymetric depression following dredging can reduce light penetration resulting in depressed rates of primary production. The rate of sediment recovery will fluctuate based on location, time of dredging, volume of sediment removed, sediment transport rate and storm characteristics following dredge events.

Studies have reported a decrease in mean grain size and, in some cases, an increase in silt and clay following dredge events (Bergquist et al. 2008, NRC 1995, Van Dolah et al. 1994). In the dredged area used to nourish Folly Beach, SC in 1993, silt and clay increased from 3% to 10% (Van Dolah et al. 1994). Similar sediment trends were observed in the borrow area used to nourish Hilton Head Island, SC in 1990. Sand content declined 31% and silt and clay content increased post-dredge (Van Dolah et al. 1992; Jutte and Van Dolah 2000). In all of these studies fine grained sediment remained elevated at the borrow site for at least one year following dredging.

In high energy sandy environments, the effects of sediment alteration are often minimized (Saloman et al. 1982, Pullen and Naqvi 1983). Studies have documented recovery of sediment characteristics within several months (Bowen and Marsh 1988). In South Carolina, borrow sites located in depositional shoals at the southern terminus of barrier islands represent more sustainable locations than borrow sites at the northern end due to the direction of the dominant longshore currents (ASFMC 2002). Another study evaluated borrow area sediments located at the southern end of Myrtle Beach (South Carolina) that had been excavated with a hopper dredge and found that there was no change in sediment characteristics post-dredging. In addition, the borrow site refilled rapidly with infill rates estimated at 47-100% after two years. In comparison a borrow area centrally located along the coastline of Myrtle Beach that was excavated with a hydraulic pipeline dredge exhibited modified sediment characteristics upwards of two years post-dredging and refilled slowly with infill rates estimated at 0-16% after two years (ASFMC 2002).

The recovery of the benthos at the recipient site would be reliant on immigration (active or passive) of organisms from the adjacent undisturbed areas and larval recolonization from the water column. A number of studies have indicated relatively rapid recolonization and recovery of the benthos subsequent to dredging operations provided that the post-dredge environment is favorable for colonization and peak periods of larval recruitment are avoided

(Pullen and Naqvi 1983; NRC 1995; Hackney et al. 1996; Schaffner et al. 1996; Bergquist et al. 2008). While species abundances has been shown to return to pre-dredging conditions rather quickly, species composition and diversity indices may remain altered for a period of time subsequent to excavation. Posey and Alphin (2002) concluded that the rapid infilling of a borrow site (resulting from strong water currents and dynamic sand movement) contributed to a relatively quick species recovery. Based upon the results of this study, interannual variability contributed more to the observed differences in species abundance than the sediment removal effects (Posey and Alphin 2002). Saloman et al. (1982) concluded that faunal abundance of a dredge site recovered within three months subsequent to dredging. The authors also determined that species diversity and faunal composition had returned to pre-dredge conditions within nine months.

Bergquist et al. (2008) evaluated the physical and biological characteristics at beach and borrow areas following 2005 renourishment efforts in Folly Beach, SC. In the borrow area, neither the sediment characteristics nor the biological community recovered to pre-dredge conditions within the first 12 months following dredging. The sediment at the borrow site shifted toward finer grained sediment post-dredging, silt/clay increased, and CaCo3 (shell and carbonate rock rubble typically) decreased. The overall benthic community structure shifted substantially at the borrow area, independent of any seasonal cycles. A similar phenomenon has been documented in other South Carolina based studies. These studies indicated that mollusks and "other taxa" failed to recover within 12-18 months at one borrow site and that higher taxonomic groups required approximately 19-28 months to recover at a second borrow area (ASFMC 2002).

Jay Bird Shoals and Bald Head Creek Shoal have both been utilized for previous Village-sponsored nourishment events. In conjuction with the Bald Head Island Beach Restoration Project (SAW-2007-2699), the Village of Bald Head Island intitiated a biological monitoring program to characterize the benthic macrofuanal communities inhabiting nearshore soft

bottom habitat including, Jay Bird Shoals and assess the response and recovery of benthic populations at this subtidal borrow site. Data collected over the four-year course of study indicate that the benthic community inhabiting the Jay Bird Shoals borrow site recovered quickly from any potential deleterious effects of project activities (LMG 2011, 2012, 2013). During pre-construction and post-construction monitoring, Jay Bird Shoals was dominated by amphipods, particularly *Protohaustorius wigley*, and other taxa which are adapted to life in environments prone to natural disturbance. These taxa presumably recolonized quickly after project construction and were joined by other taxa that may have capitalized on the reduced competition for space associated with recently disturbed habitats. While there were noticeable dominance patterns throughout the course of study, there was some deviation in the species present between years, likely a reflection of natural inter-annual variability typical of benthic infaunal communities. The rapid re-colonization of Jay Bird Shoals resulted in a relatively stable benthic community assemblage which persisted during subsequent monitoring events (LMG 2013).

Similar benthic recolonization patterns have been reported subsequent to dredging of the Bald Head Creek Shoal in January 2012 (LMG 2013). As with Jay Bird Shoals, the borrow site consisted of a sandy depositional environment. After dredging, the substrate continued to consist of sandy sediments (mean percent sand by weight = 96%) with no statistical difference in sediment texture between the dredged site and the reference site (LMG 2013). Benthic infaunal sampling and analyses indicated that the benthic communities inhabiting these sites are highly resilient. Diversity, richness, and mean total abundance at the borrow site did not differ significantly between pre-construction sampling and Year 1 post-construction sampling. Diversity and richness were both significantly greater at the borrow site than at the reference site during both monitoring events. Based upon pre- and post-construction monitoring to date, it appears as though there were no long-term adverse effects on benthic populations resulting from project dredging.

Based upon the information above, it is expected the excavation of sand from any one of the proposed borrow sites would not result in any long-term impacts to soft bottom communities. All four proposed sand source sites are highly depositional environments prone to disturbance. As such, the benthic communities tend to consist of opportunistic taxa. Undisturbed shoals in close proximity to each of the proposed borrow sites (particularly Jay Bird Shoals, Bald Head Creek Shoal, and Frying Pan Shoals) will provide a source for recolonization of the dredged areas.

Given the predicted interval of dredging required for each of the four alternatives that include Village-sponsored beach nourishment and favorable conditions for benthic recruitment, it is expected that benthic communities of each of the proposed borrow sites will recover rather quickly.

2. Soft Bottom Effects at Nourishment Site

Placement of sand at the beach fill site will bury the majority of benthic infauna as existing soft bottom habitat is converted to dry beach and wet beach habitat. Nourishment impacts on the target beach would be most severe for small, relatively immobile species that are unable to burrow through the new sediment. Larger, more mobile organisms will burrow through the newly placed sediment or avoid the area of disturbance by migrating to neighboring unaffected areas. As a result of the dredge and pump processes, it is likely that disposal materials will be devoid of live benthic species. The fecundity and opportunistic nature of benthic invertebrates common to this area and project avoidance of peak periods of biological activity help facilitate post-dredging recovery.

(1) No Action/Status Quo: Alternative #1

a. Direct Impacts*:* The impacts to soft bottom communities as described below are associated with federal maintenance of the Wilmington Harbor Entrance Channels and associated disposal in accordance with the SMP. These effects have been assessed in the

Wilmington Harbor Deepening Project FEIS (USACE 1996) and the subsequent EA for pre-construction modifications to the alignment of the entrance channel (USACE 2000).

Ongoing channel maintenance operations of the harbor disturb benthic populations in the existing deep water channel and nearby side slopes. Benthic infauna (e.g. polychaete worms, amphipods, and mollusks) are subject to adverse impacts associated with the removal of sand and entrainment of infaunal and non-motile epibenthic organisms during maintenance operations. Impacts to sessile, slow moving taxa that cannot escape the suction field of the dredge are anticipated.

Disposal of sand at the beach fill site will bury benthic infauna as existing soft bottom habitat is converted to dry beach and wet beach habitat. The fecundity and opportunistic nature of benthic invertebrates common to this area and project avoidance of peak periods of biological activity help facilitate post-dredging recovery.

b. Indirect Impacts: Finfish inhabiting the soft bottom, such as black sea bass and summer flounder, would temporarily exit the disturbed area upon commencement of dredging, and would return shortly after dredging operations cease. It is possible that a small number of these fish will become entrained in the dredging equipment. In addition, a number of benthic prey species inhabiting the sediment surface layer will be smothered during sand placement. Intertidal and subtidal soft bottom serves as a nursery and feeding ground for a number of finfish species that prey upon these benthic invertebrates and, in turn, are preyed upon by shorebirds, waterbirds, diving birds and marine mammals.

The physical consequences resulting from Alternative #1 include continued shoreline recession of the western end of South Beach, the Point and West Beach. The erosional losses of dry beach habitat resulting from landward migration of the shoreline would

ultimately lead to the creation of subtidal bottom. Benthic infauna would gradually colonize the expanded soft bottom habitat.

c. Cumulative Impacts: The inlet system of the Cape Fear River and it adjacent beaches is a dynamic environment prone to both anthropogenic and natural disturbances. The opportunistic nature of species inhabiting this environment allows for rapid recolonization following a high frequency of disturbance events. The anticipated disposal interval associated with the SMP should allow for sufficient time for repopulation and succession of the soft bottom habitat. In addition, the alternative would result in the increase of soft-bottom habitat as beach and dune habitats are lost to erosion (particularly in the area of the Point). As a result, there are no cumulative impacts expected as a result of the implementation of Alternative #1.

(2) Retreat: Alternative #2

a. Direct Impacts: Under Alternative #2 direct impacts resulting from dredge and disposal events associated with routine maintenance of the federal navigation channel per the SMP would be the same as those discussed under Alternative #1. The primary direct effect of dredge activities is the removal of sand and entrainment of infaunal and non-motile epibenthic organisms and subsequent burial of benthic infauna during placement of the dredge materials.

b. Indirect Impacts: Under Alternative #2, indirect impacts to intertidal and subtidal soft bottom habitat associated with disposal of dredged material pursuant to the SMP would be similar to those described in Alternative #1. In addition, the extent of predicted shoreline recession associated with the retreat alternative would result in widespread increases in soft bottom habitat as other intertidal and supratidal habitats are lost to open water. Increase of soft bottom area would expand habitat suitable for colonization by benthic meoifauna and macrofauna.

c. Cumulative Impacts: In consideration of past, present, and reasonably foreseeable future actions, implementation of Alternative #2 is not expected to generate cumulative impacts.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: As described at the beginning of this section, there will be direct impacts to soft bottom communities at the borrow sites. Benthic infauna (e.g. polychaete worms, amphipods, and mollusks) will be subject to immediate adverse impacts associated with the removal of sand and entrainment of infaunal and non-motile epibenthic organisms. Impacts to sessile, slow moving taxa that cannot escape the suction field of the dredge are anticipated. Removal of sediments will result in reduced abundance, diversity, and biomass of the resident benthic community. Studies along the East, Gulf and West Coasts of the United States document 84% to 90% decrease in the number of benthic organisms post-dredge (ASFMC 2002). The benthic assemblages characteristic of accreting subtidal bottom of the Cape Fear region (including the prospective sand source sites) tend to be dominated by opportunistic species prone to natural and/or anthropogenic disturbance. While populations of these species have been documented to recover rather quickly, later successional species may not fully recover for two to three years (Wilber and Stern 1992).

b. Indirect Impacts: The lower Cape Fear River and associated sandy shoals serve as a conduit for passage of larval, juvenile, and adult fish species as well as organisms of lower trophic levels (e.g. phytoplankton and zooplankton) between the open ocean environment and the estuarine environment. The increased frequency of nourishment required under Alternative #3 would result in more frequent disturbance at the nourishment site which, in turn, could influence the occurrence and distribution of species utilizing the beachfront for foraging.

Alternative #3 would result in similar physical conditions to those identified under the No Action Alternative with the exception of a shoreline loss that is periodically mitigated through a Village-sponsored nourishment action. As discussed previously, the loss of dry beach would lead to the addition of soft bottom habitat.

c. Cumulative Impacts: Village-sponsored nourishment efforts on Bald Head Island considered under Alternative #3 would result in direct and indirect impacts to soft bottom communities at the borrow sites. However, these impacts represent a relatively small area of disturbance (106 acres and 65 acres for Jay Bird Shoals and Bald Head Creek Shoal, respectively) relative to the overall area of soft bottom habitat in the vicinity of the mouth of the Cape Fear River. In addition, the benthic communities of depositional shoals tend to be adapted to disturbance and recolonize over a relatively short period of time. The extent of the potential adverse impact relative to the amount of soft bottom habitat on a regional scale, in conjunction with the capacity of this type of habitat to accommodate additive effects, would avoid the potential for cumulative effects. As a result, the implementation of Alternative #3 is not expected to generate cumulative impacts to soft bottom communities.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: The types of impacts to soft bottom habitat at the dredge and nourishment sites under Alternative #4 would be comparable to those identified for Alternative #3 above.

b. Indirect Impacts: Under Alternative #4, indirect impacts to soft bottom habitat would be the same as those described in Alternative #3.

c. Cumulative Impacts: No cumulative impacts to soft bottom communities are expected as a result of the implementation of Alternative #4.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, direct impacts associated with dredging, beach nourishment (including the placement of the sand fillet), and maintenance of the sand tube groinfield would be comparable to those discussed under Alternative #3. Additional impacts to the wet beach community will result from construction of the terminal groin structure. The terminal groin structure, as proposed, would have an overall length (combined Phase 1 and Phase 2) of 1,900 linear ft with approximately 1,600 lf (stem and head sections) occupying the nearshore soft bottom. Given the proposed length of these sections, approximately 2.0 acres of soft bottom habitat would be covered by the structure. There will be permanent loss of benthic fauna incapable of horizontal movement in the immediate footprint of the terminal groin.

The proposed groin would be constructed of relatively large granite armor rock of varying size placed on a geotextile foundation mattress. Rock would be placed either by crane from a barge, from sand pads (shaped from sand from the federal disposal), and/or from a temporary trestle or pier constructed in close proximity to the groin structure. Phasing of the structure would reduce the need for the temporary trestle as much of the work could be accomplished with equipment operating from temporary sand pads. Depending upon the construction method, there is a potential for additional disturbance to soft bottom in the immediate vicinity of the groin.

b. Indirect Impacts: As previously discussed, intertidal and shallow subtidal soft bottom serve as a nursery and feeding ground for a number of finfish species that prey upon these benthic invertebrates and, in turn, are preyed upon by shorebirds, waterbirds, diving birds and marine mammals. Given the highly mobile nature of fish assemblages that typically utilize the subtidal areas of the prospective borrow sites and the nourishment site, it is expected that demersal species would relocate to other unaffected soft bottom and nearshore habitats during the period of construction activities and subsequent benthic

recovery period. Finfish would likely return to the project area to forage upon suspended nutrients and benthic infauna as well as to utilize the proposed groin structure for resting and refuge (Cenci et al. 2010).

Installation of a terminal groin structure; nourishment of the updrift field (i.e. placement of a corresponding fillet); and on-going maintenance of the existing sand tube groinfield would afford the highest level of stability and retention of sand. Creation of a stable beachfront and the addition of the sand fillet would result in a loss of soft bottom habitat within the immediate project area. By Year 9 of the Delft3D simulation, approximately 10.5 acres of subtidal bottom would be converted to intertidal surf zone or dry beach.

c. Cumulative Impacts: Soft bottom habitat along the seaward end of the rock terminal groin footprint would be filled by the proposed groin structure while the remainder of the structure footprint would be covered with sand. While construction of the terminal groin would contribute to the loss of benthos, the cumulative loss of benthic infauna associated with construction of hard structures is offset by the amount of undisturbed soft bottom along the coast of the Cape Fear region. The extent of existing soft bottom habitat in conjunction with its resilience to disturbance (either natural or anthropogenic) reduces the risk of cumulative impacts. As a result, Alternative #5 is not anticipated to generate cumulative impacts to soft bottom communities.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, direct impacts to soft bottom habitat associated with the dredge and disposal/nourishment site and construction of the terminal groin would be the same as those described in Alternative #5. Removal of the sand tube groinfield has the potential to decrease the anticipated maximum life of the project thereby creating the need for more frequent beach nourishment. Temporal spacing between maintenance/nourishment activities should, however, allow for full recovery of the benthos

prior to subsequent events. The footprint of the sand tubes to be removed (albeit small) will result in the immediate expansion of soft bottom habitat.

b. Indirect Impacts: Indirect impacts to soft bottom habitat under Alternative #6 would be comparable to impacts described in Alternative #5. Implementation of Alternative #6 would also have similar physical consequences to habitat types of the study area as those identified above for Alternative #5 (i.e. expansion of a more stable dry beach), ultimately resulting in a net loss of soft bottom habitat.

c. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #6.

B. Hardbottom Communities

Ocean-bottom surveys conducted by the USACE in the vicinity of the new channel alignment for the Wilmington Harbor Navigation Project did not indicate the presence of hard bottoms within the path of the federal channel (USACE 2000). However, hard bottoms have been identified near the seaward limit of the former federal navigation channel (approximately five miles offshore). Other hard bottom points have been identified greater than three miles west of Jay Bird Shoals (Deaton et al. 2010).

Given the lack of observed hard bottom near the study area, it is anticipated that implementation of any of the alternatives considered in this EIS would not have any direct, indirect, or cumulative impacts to hard bottom communities.

5.6 WATER COLUMN

The water column provides a basic ecological role in the assimilation of energy and nutrients at the base of the food chain through primary productivity, largely by phytoplankton, and

benthic-pelagic coupling. The water column also serves as habitat for pelagic species in varying life stages while providing a corridor for numerous anadromous and catadromous species.

A. Water Column Effects at Borrow Sites

Since four of the six alternatives include sand volume requirements beyond that supplied by federal disposal pursuant to the SMP, a summary of water column effects for the borrow sites is presented below.

As described in prior sections (including Section 5.2.4), sand volume requirements are variable between alternatives with Alternative #4 requiring the greatest volume of sand (estimated to be 8 Mcy) over the 30-year project life. Conversely, Alternative #5 would require the least volume (estimated to be 4.5 Mcy) over the 30-year period. The applicant's preferred source of sand for alternatives that include nourishment would be the remaining portion of the Jay Bird Shoals borrow site previously permitted for the Village-sponsored beach nourishment project constructed in the winter of 2009/2010. Other borrow sources of sand for fillet maintenance and maintenance of West Beach include the federal navigation channel and the ebb tidal shoal of Bald Head Creek. Frying Pan Shoals has been identified as a future borrow source for nourishment beyond Year 3 (particularly for anticipated nourishment needs in Year 12, 21, and 30).

Impacts to the water column associated with dredging are associated principally with the entrainment of infauna, epifauna, and demersal species. Mortality of organisms (i.e. plankton, pelagic eggs and larvae to pre-flexion stage individuals) within the water column that lack the ability to escape the suction field of an operating dredge and subsequent entrainment in the flow of water and sediment passing through its pumping equipment is likely. However, the effect is believed to be negligible based upon: (1) the very small volumes of water pumped by dredges relative to the total amount of water in the water in

the vicinity of the operating dredge; (2) the extremely large numbers of larvae that are produced by most estuarine-dependent species; and (3) the high natural mortality rate for early life stages of many fish species (USACE 2000). The risk of entrainment has been evaluated for the Cape Fear River mouth itself. The USACE (2000) estimated that the amount of water intercepted by the largest operating hydraulic dredge (30-inch diameter pipe) is less than 8/10ths of 1% of the average daily river flow. Motile organisms, including most fish assemblages capable of escaping the suction field will likely relocate to other areas while dredging activities take place.

Localized turbidity impacts are anticipated by the removal of substrate from the borrow site as well as overspill associated with the dewatering of dredge sediment. While the identified borrow sites are characterized as high-energy, sandy environments, background turbidity levels are expected to increase during project implementation. However, these effects are expected to be localized and short-term. Turbidity levels in waters outside of the immediate vicinity of the operating dredge should be less than 25 NTUs (USACE 2000).

Pullen and Naqvi (1983) found that motile animals were the least affected by dredging and concluded that benthic and fish utilization likely depends upon water quality of the dredge area. Provided the dredge area does not form an anaerobic pit of organic-laden sediment, biological communities may be restored rather quickly. In addition, multiple studies have indicated rapid recovery of fish utilization at locations with high water and sediment dynamics such as tidal channels (Pullen and Naqvi 1983; Van Der Veer et al. 1985; Musick 1998; Schaffer et al. 1996). The prospective sand source sites considered for Village-sponsored nourishment are sandy, depositional features and thus should not be susceptible to water column impairments nor to the subsequent secondary effects on benthic and fish resources.

B. Water Column Effects at Nourishment Site

The potential effects to water column in the littoral zone during nourishment are minimized through the use of beach-compatible sediments consisting of more than 90% sand (USACE 1997). In general, the spatial scale of elevated turbidity related to beachfront disposal is very small (USACE 2001). Federal disposal actions have demonstrated to utilize beach-compatible sand since much of the source material is derived from the adjacent beaches. Prior to use of any sand source site by the Village, minimum state sediment compatibility standards must be met. Available sediment data from each of the four prospective sites indicate the presence of beach-compatible sand in sufficient volumes for nourishment. Each of the sites consists of sediments characterized by a high percentage of sand by percent weight and low percentage of fines (see Olsen 2007, Athena Technologies 2009, Catlin 2010, and LMG 2013). Thus, effects to the water column from nourishment are expected to be spatially confined and temporal.

The indirect impact of turbidity on mortality, growth, and spawning behavior for surf zone fish is not well documented but is likely not significant since most adult fish are mobile enough to avoid areas of highest turbidity. Given the avoidance behavior of mobile species, nourishment is expected to influence fish distribution. However, many surf zone species are adapted to relatively high ambient turbidity levels and it is largely inferred in the literature that impacts to fish are more closely related to changes in and/or loss of benthic prey resources than temporary changes in water column characteristics (USACE 2001; Hackney et al. 1996). Ross and Lancaster (2002) reported that species (such as pompano and kingfish) that utilize the surf zone for nursery areas exhibit high site fidelity and are therefore more vulnerable to localized effects to benthic assemblages (Ross and Lancaster 2002). Increases in suspended sediments may also adversely affect the feeding behavior of visually-orienting fish (Wilber et al. 2003).

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: Continual maintenance of Wilmington Harbor began in 1870 and harbor dimensions have been increased incrementally for over 100 years. Ongoing channel maintenance operations of the harbor, development of the upland watershed and storm events lead to perturbations of the water column. Since its inception, the SMP has resulted in disposal of beach compatible sand on Bald Head Island and Oak Island.

Localized turbidity impacts will result during the placement of sand associated with federal disposal. However, these actions will be limited both temporally and spatially and are minimized by the use of material derived from the existing littoral system of the region. Fine-grained sediment content has been demonstrated to be below 10%. This material is compatible with the recipient beach since the adjacent beaches are the source of the sediment within these channel reaches (USACE 2000). Turbidity levels tend to decrease rapidly subsequent to dredging and disposal through simple mixing and dilution processes (associated with longshore and tidal currents, wind and surf).

Implementation of other components of this alternative, such as beach bulldozing and temporary sand bags, is not expected to result in any direct effects to the water column since these activities are conducted above the MHW line of the beachfront.

b. Indirect Impacts: While increased turbidity levels have the potential to influence fish behavior (including foraging) and distribution patterns, the extent of the effect will be localized and short-term.

c. Cumulative Impacts: The hydrodynamics of the lower Cape Fear Estuary create a dynamic environment. The water column is subject to wind and current induced mixing and daily tidal exchange with the Atlantic Ocean. In consideration of other past, present, and

reasonably foreseeable future actions in the coastal Cape Fear region, no cumulative impacts to the water column are expected as a result of the implementation of Alternative #1.

(2) Retreat (Alternative #2)

a. Direct and Indirect Impacts: Under Alternative #2, impacts to the water column associated with the dredging of the Wilmington Harbor channel and resulting beach disposal would be the same as those described in Alternative #1. The Village would additionally identify high-risk areas for the development and implementation of a managed shoreline retreat and provide for the demolition or relocation of residences, roads, and infrastructure, if land and funds are available, in advance of the shoreline recession. Thresholds would be identified to trigger the demolition or relocation of specific structures such that removal of anthropogenic debris (concrete, rubble, asphalt, steel, etc.) would be completed, primarily, above MHW thereby limiting potential impacts to the water column.

Due to the extent of predicted shoreline recession, the demolition and relocation of residences and infrastructure (including roads and sub-grade utilities) would be required. If the relocation efforts do not keep pace with erosion, then there is a potential for structural damage to homes and infrastructure with ensuing exposure of material debris, septic tanks, and sewer lines to open water. While the alternative assumes relocation, the predicted rate and extent of erosion would make these areas vulnerable to damage particularly during storm events and would increase the risk of impairments to the water column.

b. Cumulative Impacts: No cumulative impacts are expected as a result of Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct and Indirect Impacts: Impacts to the water column associated with federal maintenance dredging and Village-sponsored dredging of prospective sand source sites and subsequent nourishment of the beachfront are described above.

Prior to use of any sand source site by the Village, minimum state sediment compatibility standards must be met. Jay Bird Shoals, Bald Head Creek Shoals, and the entrance channel reaches of the Wilmington Harbor Project have all been demonstrated to contain beach compatible sand (as evidenced through both geotechnical investigations and through beach placement and post-nourishment conditions on the beach). In addition, based on compatibility analysis criteria for percent silt content, percent shell content, and mean grain size, sediments sampled within Frying Pan Shoals have been demonstrated to be largely compatible with the native beach material (Catlin 2010).

The indirect impact of turbidity on mortality, growth, and spawning behavior for surf zone fish is not well documented but is likely not significant since most adult fish are mobile enough to avoid areas of highest turbidity. Given the avoidance behavior of mobile species, nourishment is expected to influence fish distribution. However, many surf zone species are adapted to relatively high ambient turbidity levels and it is largely inferred in the literature that impacts to fish are more closely related to changes in and/or loss of benthic prey resources than temporary changes in water column characteristics (USACE 2001; Hackney et al. 1996). Ross and Lancaster (2002) reported that species (such as pompano and kingfish) that utilize the surf zone for nursery areas exhibit high site fidelity and are therefore more vulnerable to localized effects to benthic assemblages (Ross and Lancaster 2002). Increases in suspended sediments may also adversely affect the feeding behavior of visually-orienting fish (Wilber et al. 2003).

b. Cumulative Impacts: Implementation of Alternative #3 is not expected to result in any cumulative impacts to the water column.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct and Indirect Impacts: Due to the removal of the sand tube groinfield and subsequent increased erosion of western South Beach, Alternative #4 would require greater

volumes and frequency of dredge and nourishment actions by the Village. While the type of direct and indirect impacts to the water column would be similar to those discussed above, the frequency of occurrence of these effects would be greater under this alternative.

As described for Alternative #2, the predicted rate and extent of erosion would make residences and infrastructure vulnerable to damage from inundation and conversion to open water. While not specifically evaluated under a managed retreat, it is likely that the Village would implement a program to relocate structures, roads, and sub-grade utilities in advance of the erosion to minimize public safety concerns. However, under this alternative there is increased risk of exposure of structures (including septic tanks and sewer lines) and debris to the water column. The result would be the potential for localized water quality impairments and associated effects on resident and migratory fauna.

b. Cumulative Impacts: Given the capacity for the water column resource to accommodate localized stressors, no cumulative impacts are expected as a result of the implementation of Alternative #4.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Impacts to the water column within and in the vicinity of the dredge and nourishment sites for Alternative #5 would result in similar localized effects as those described for Alternative #3.

The construction of the terminal groin is proposed to take place concurrent with, and subsequent to, the placement of the fillet. A portion of the stem section and all of the head section will likely be constructed in open water. Placement of the armor stone would be accomplished using a barge and crane or potentially through the use of a temporary trestle structure constructed parallel to the terminal groin. The trestle would be supported by steel pilings jetted into the substrate and removed once construction is complete. However,

phasing of the project would reduce the need for the use of a trestle. Depending upon conditions at the time of the groin installation, it is likely that equipment will be able to be operated from sand pads formed from the fillet. Any effects to the water column as a result of increased turbidity from construction would be expected to be localized and short-lived.

Due to their mobility and range, surf zone fishes utilizing the project area to forage upon benthic macrofauna (e.g. mole crabs and coquina clams) would move to adjacent undisturbed beach areas and other suitable feeding zones for the temporary period of construction. Surf zone conditions would resume a pre-construction mode relatively quickly.

It has been reported that shore-perpendicular structures such as groins or jetties have the potential to impede longshore transport of larvae and natural passage into estuaries or sounds and thus negatively impact recruitment success (Blanton et al. 1999; Hare et al. 1999). It has been suggested that the presence of jetties may result in the deflection of larvae to an extent that would eliminate the opportunity for the larvae to be entrained into the estuary. For the Oregon Inlet project, it was asserted that construction of duel jetties would result in the reduction of ocean-spawned larvae from reaching estuarine nursery areas (USACE 1999).

While a dual jetty system of an inlet presents a vastly different set of physical and biological conditions than that of the proposed terminal groin on Bald Head Island near the mouth of the Cape Fear River, hypothetical particle ingress into the Cape Fear River estuary was nonetheless simulated via Delft3D modeling by Olsen Associates. The drogue simulations were intended to represent larval fish pathways into the estuary under two scenarios: (1) ingress with beach fill; and (2) ingress with beach fill and a terminal groin in place. The presence of the terminal groin appears to have no significant limiting influence on the ability of particles (hypothetical larval fish) to enter the estuary. The complete model report of findings is provided in Appendix R. The size of the structure relative to the hydraulic field of

the Cape Fear River mouth is negligible. As a result, larval entrainment into the Cape Fear River estuary will remain unaffected. In addition, the post-construction template would result in a shoreline configuration that effectively extends the shoreline to the waterward extent of the structure. Given these considerations, it is believed that the post-construction condition would be conducive for unimpeded passage of fish and larvae into the Cape Fear River estuary.

b. Indirect Impacts: The terminal structure will likely provide foraging and shelter opportunities for surf zone fishes thus adding to species abundance and richness to the soft bottom community (Peters and Nelson 1987; Clark et al. 1996). Cenci et al.'s (2010) study focused on installation of shoreline stabilization structures in areas characterized by soft bottom habitats. The data collected on fish populations indicates that during the early stages following new groin construction, species diversity and richness increased dramatically. These new structures become fish "producers" by providing habitat for local and transient fish assemblages. However, introduction of artificial structures may also be viewed as a habitat trade-off in which species assemblages may be altered. In addition, hardened structures have been cited as being susceptible to invasion by non-native species (Bulleri and Chapman 2010).

c. Cumulative Impacts: Given the temporal and localized effects on the water column and the capacity for this habitat to accommodate these effects, cumulative impacts are not expected.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct and Indirect Impacts: Direct and indirect impacts resulting from Alternative #6 would be comparable to those identified for Alternative #5.

b. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #6.

5.7 WATER QUALITY

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: Marine and estuarine waters may experience elevated, localized turbidity as a result of the placement of disposal materials on the beach as well as dredging activities in the channel. In accordance with the SMP, beach-compatible dredged material (sands) dredged from the ocean bar or river channel is placed on the recipient beach. Turbidity effects from fill placement are directly related to grain size. The high percentage of sand in the dredged material will allow for more rapid settling of sediment following placement activities. In addition, the tidal currents and hydrodynamics of the Cape Fear River estuary provide a means for water mixing and dilution. Turbidity created by the disposal operation normally does not persist beyond more than one or two tidal cycles (12 to 24 hours) following the cessation of the disposal operation (USACE 2000).

b. Indirect Impacts: Dredging and associated suspended sediment plumes can have short-term and localized effects on water quality. These include chemical transformations resulting from the oxidation of sulfides and of ferrous iron (Fe^{2+}) which in turn can lead to reductions in dissolved oxygen (DO). Oxidation of sulfides can also lead to localized reduction in pH levels in the water column (Jabusch et al. 2008). DO levels over the dredge site can also be suppressed via the release of oxygen-demanding material (e.g. organics). However, bottom sediments of the proposed borrow sites exhibit a high percentage of sand by weight with low percent organic matter. In addition, the waters at the mouth of the Cape Fear River tend to be well-oxygenated (Mallin et al. 2012) and thus less susceptible to impairment from any localized increases in DO.

c. Cumulative Impacts: Disturbance activities associated with maintenance of the Wilmington Harbor navigation channel (i.e. dredging and dredge disposal) would occur within the open waters of the Cape Fear River estuary where hydrodynamics of the water column are subject to semi-diurnal tidal exchange as well as wind and current induced mixing. Elevated turbidity levels would be localized and temporary due to mixing and dilution. The incremental contribution to cumulative water resource impacts from Alternative #1 in combination with other regional navigation projects and water dependent development activities would be negligible.

(2) Retreat (Alternative #2)

a. Direct Impacts: The frequency of dredge disposal events under Alternative #2 are dependent upon funding and other considerations, but would be anticipated to occur generally as described in the SMP. The types of direct impacts to water quality associated with dredge disposal would be similar to those discussed under Alternative #1.

Under the Retreat Alternative, the Village would identify high-risk areas for the development and implementation of a managed shoreline retreat and provide for the demolition or relocation of residences, roads, and infrastructure, if land and funds are available, in advance of the shoreline recession. Thresholds would be identified to trigger the demolition or relocation of specific structures such that anthropogenic debris (concrete, rubble, asphalt, steel, etc.) and infrastructure (sanitary sewer) would not lead to degradation of water quality.

b. Indirect Impacts: Due to the extent of predicted shoreline recession, the demolition and relocation of residences and infrastructure (including roads and sub-grade utilities) would be required. If the relocation efforts do not keep pace with erosion, then there is a potential for structural damage to homes and infrastructure with ensuing exposure of material debris, septic tanks, and sewer lines to open water. While the alternative assumes relocation, the

predicted rate and extent of erosion would make these areas vulnerable to damage particularly during storm events and would increase the risk of water quality impairments.

Alternative #2 is predicted to result in the loss of interdunal wetlands regulated under Section 404 of the Clean Water Act (CWA). Given the water quality functions (e.g. sediment retention and nutrient/contaminant uptake and transformation) ascribed to wetlands, some level of impairment could potentially result from the loss of these habitats. However, as the shoreline recedes, it can be expected that other low-lying areas of the back-barrier dune system would be able to provide similar functions. As a result, any adverse effect resulting from wetland losses would be relatively minor.

c. Cumulative Impacts: No cumulative impacts to water quality are expected as a result of the implementation of Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts and Indirect Effects: Under Alternative #3, impacts to water quality would be comparable to Alternative #1 during dredging and sand placement activities. While this alternative includes periodic nourishment by the Village, water quality impairment of both the dredge site and the nourishment site would be localized and short-term.

b. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: Under Alternative #4, water quality impacts would be comparable to Alternative #1 and Alternative #3 during dredging and sand placement activities. Given the increased need for beach nourishment events required under this alternative, there is an increased risk of water quality impairments. However, these effects would be localized and

short-term as physical mixing and dilution would minimize the extent of turbidity and suspended sediment concentrations.

b. Indirect Impacts: As described for Alternative #2, the predicted rate and extent of erosion would make residences and infrastructure along western South Beach vulnerable to damage from inundation and conversion to open water. While not specifically evaluated under a managed retreat, it is likely that the Village would implement a program to relocate structures, roads, and sub-grade utilities in advance of the erosion to minimize public safety concerns. However, under this alternative there is increased risk of exposure of structures (including septic tanks and sewer lines) and debris to the water column. The result would be the potential for localized water quality impairments and associated effects on resident and migratory fauna.

c. Cumulative Impacts: Given the capacity for nearshore waters to accommodate the type of stressors outlined above, no cumulative impacts to water quality are anticipated.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, impacts to water quality would be comparable to Alternative #1 during dredging and sand placement activities. The construction of the terminal groin is proposed to take place immediately following the completion of the federal beach fill disposal. Placement of the armor stone would be accomplished via barge and crane or via land-based equipment operating on sand fill pads. Depending upon conditions at the time of construction, the use of a temporary pier structure constructed parallel to the terminal groin may be necessary. This is a piling-supported trestle utilizing steel pilings jetted into the substrate and removed once construction is complete. Localized, temporary impacts to the water quality would be expected through increased turbidity during construction, but these effects would dissipate rapidly and are considered relatively minor.

b. Indirect Impacts: Indirect impacts under Alternative #5 would be similar to impacts associated with Alternative #1 and Alternative #3.

c. Cumulative Impacts: No cumulative impacts to water quality are expected as a result of the implementation of Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, water quality impacts would be comparable to Alternative #5 during dredging, sand placement activities and groin construction. Given the increased frequency of beach nourishment events under this alternative there is a greater potential for impacts to water quality. However, turbidity effects would be localized and relatively short-lived.

b. Indirect Impacts: Indirect impacts under Alternative #6 would be similar to impacts associated with Alternative #1, Alternative #3, and Alternative #5.

c. Cumulative Impacts: No cumulative impacts to water quality are expected for this alternative.

5.8 AIR QUALITY

(1) No Action/Status Quo (Alternative #1)

a. Direct and Indirect Impacts: Impacts to air quality associated with this alternative are present only during periods when heavy machinery is in use for maintenance of the federal channel, dredge disposal and sand tube groinfield maintenance. During channel maintenance and dredge disposal, diesel emissions would be generated from the barge during transit, dredging, pumping of sand to the beach and placement of fill material. Beach

fill activities will require the use of a bulldozer for sand placement and additional heavy equipment would be utilized as necessary during maintenance of the sand tube groinfield. While there will be temporary and localized increases in pollutants to the ambient air during active construction, the concentration of emissions coupled with the short period of time (months) is not anticipated to affect compliance with the National Ambient Air Quality Standards (NAAQS).

b. Cumulative Impacts: Construction related activities associated with the SMP and soft stabilization methods on Bald Head Island (i.e. sand bags, beach scraping, maintenance of sand tube groinfield) are unlikely to lead to a violation of NAAQS. Cumulative emissions resulting from the SMP, soft stabilization on the island, and regional navigation and nourishment projects will be minimal and short-term and are not anticipated to appreciably affect local or regional air quality.

(2) Retreat (Alternative #2)

a. Direct and Indirect Impacts: Impacts associated with Alternative #2 would be similar to Alternative #1. In addition, implementation of a managed retreat would result in demolition of threatened structures and infrastructure. Diesel emissions would be generated from the use of demolition equipment (bulldozer, bobcat, etc.) as well haul-off equipment (dump truck, light truck, etc.). The demolition and haul-off process could also generate particulates such as dust. However, the posted speed limits throughout the VBHI would keep construction-related machinery at slow speeds thereby reducing the level of incident particulates during haul-off. The concentration of emissions associated with demolition and haul-off is not anticipated to affect compliance with the NAAQS.

b. Cumulative Impacts: No cumulative impacts to air quality are expected as a result of the implementation of Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct and Indirect Impacts: Impacts associated with Alternative #3 would be similar to similar to those identified for Alternative #1 and Alternative #2 above.

b. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct and Indirect Impacts: Impacts associated with Alternative #4 would be similar to Alternatives #1 through #3 above.

b. Cumulative Impacts: Implementation of Alternative #4 will not result in cumulative impacts to air quality.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct and Indirect Impacts: Air quality impacts associated with Alternative #5 would be comparable to each of the alternatives discussed above.

b. Cumulative Impacts: Cumulative impacts to air quality are not expected as a result of the implementation of Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct and Indirect Impacts: Air quality impacts associated with Alternative #6 would be comparable to those of all the other alternatives.

b. Cumulative Impacts: No cumulative effects to air quality are expected under Alternative #6.

5.9 PUBLIC SAFETY

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: Dredges, barges and associated marine craft would be on-site for several months during the maintenance of the Wilmington Harbor navigation channel and associated beach disposal. Placement of dredge materials would result in the use of dredge pipeline, bulldozers and associated vehicles. Recreational and commercial boaters would need to use caution and maintain no wake speeds to assure safe passage while in the project work area. Use of heavy machinery during placement and grading of disposal materials would increase the potential for safety issues to beach pedestrians. It is likely that recreational access to the beach would be restricted within the active construction area. It should be noted that federal channel maintenance and other short-term stabilization measures are likely to occur during periods of the year when tourism and recreation in general is low thereby reducing the potential for impacts to public safety. No cumulative impacts are anticipated.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: Public safety concerns associated with the use of heavy machinery during dredging, placement of disposal materials and removal of the sand tube groinfield under Alternative #2 would be the same as those discussed under Alternative #1. There are additional public safety issues associated with heavy machinery use during relocation and/or demolition of residences and infrastructure and exposure of utilities including sanitary services and public water supply.

South Bald Head Wynd has been identified as a primary evacuation route for residents and guests of Bald Head Island. Unimpeded shoreline recession would compromise the integrity of existing roads and ultimately lead to demolition of a number of roadways, including South Bald Head Wynd. Removal of a primary evacuation route would increase the potential for

public safety concerns as alternate roads could be overloaded and reduce evacuation efficiency during emergent situations. The Retreat Alternative would likely necessitate acquisition of replacement right-of-ways to preserve adequate emergency evacuation routes for Island residents and visitors.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #3 would be comparable to those for Alternative #1. No cumulative impacts are expected.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #4 would be comparable to those for Alternative #2. The predicted extent of erosion along South Bald Head Wynd would present similar public safety concerns as the structural integrity of roads and sub-grade utilities would become compromised. In the absence of adequate planning and relocation efforts, the loss or exposure of these structures to open water would present a public safety and health hazard.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #5 would be comparable to those identified above. Prior to initiation or construction of the terminal groin, the USACE to would coordinate with the US Coast Guard to assure that the new structure is placed on the appropriate maps and is equipped with appropriate navigation aids, as needed (NCDCM 2010). The proposed limits of work are depicted on Figure 3.3. All work areas would be clearly marked and cordoned off to protect public health and safety.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #6 would be comparable to those identified for Alternative #5.

5.10 AESTHETIC RESOURCES

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: The presence of construction equipment and personnel during disposal of material on the beach would temporarily detract from the aesthetics of the beach. Dredges, barges and associated marine craft would be on-site for several months during maintenance of the federal channel. Placement of dredge materials would result in the use of dredge pipeline, bulldozers and associated vehicles. The use of water-dependent and land based heavy machinery would result in additional noise in the project area and would detract from the normal aesthetics of the beach. Federal channel maintenance is likely to occur during periods of the year when tourism and recreation in general is low. Upon completion of construction activities, increased beach area and restoration of the natural shoreline would result in an overall improved aesthetic quality.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with dredge disposal activities under Alternative #2 would be comparable to those described for Alternative #1. There is also the potential for aesthetic depreciation associated with unabated beach erosion under Alternative #2. Reduced beach widths with steep, nearly vertical profiles may be considered an aesthetic detriment by some users. A retreat scenario would include the removal of the existing sand tube groinfield and the planned abandonment or relocation of infrastructure and residences. The presence of heavy machinery and personnel during relocation and/or demolition of residences and infrastructure would detract from the

aesthetics of the area. In addition, erosion would be of a magnitude that will likely require the relocation of the Bald Head Island Clubhouse and some of the associated amenities. As the shoreline receded to a maximum extent, some level of equilibrium would be expected such that any adverse aesthetic effects would not be permanent.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #3 would be comparable to those identified under Alternative #1.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

b. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #4 would be comparable to those identified above. In the absence of a planned demolition and relocation effort, the extent of erosion would compromise the structural integrity of roads and expose sub-grade utilities along western South Beach. Exposure of any infrastructure due to erosion of the shoreline would diminish the aesthetic appeal of the beach. However, removal of the sand tubes would help to increase beach aesthetics.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Impacts associated dredge disposal and beach nourishment under Alternative #5 would be comparable to those identified above. Construction of the terminal groin could lead to reduced aesthetic appeal for property owners due to loss of unimpeded view corridor from shoreward- and waterward-facing perspectives. Properties with views of the associated area may have reduced amenity value relative to that which would exist with a natural shoreline as man-made features contrast with the natural features of the island. To the extent that the structure serves to attract recreationists, property owners in the vicinity may experience crowding and reduced aesthetic appeal. The terminal groin may also have an adverse effect of trapping floating debris and trash thereby creating an unwanted view.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #6 would be comparable to those identified for Alternative #5.

5.11 RECREATIONAL RESOURCES

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: During dredge disposal, portions of the Bald Head Island beachfront will become an active construction area unavailable for daily recreational uses. Individuals seeking recreational opportunities along the beachfront will have to utilize unimpacted areas, principally eastern South Beach and East Beach which offers comparable beachfront. Daily recreational activities are expected to continue upon completion of dredge disposal and construction. In addition, federal channel maintenance will take place during periods of the year when tourism and recreation in general are low. Immediately following dredge disposal, recreation is likely to be enhanced for a period of time as a larger, more stable beachfront will be established.

The lower Cape Fear River and nearshore waters of the Atlantic Ocean are popular recreational fishing areas. While active dredging is underway, recreational vessels would avoid the immediate area of excavation as well as the pipeline or barge receiving excavated materials. Weather permitting, the dredge will remain moored in the river until project completion. The vast expanse of waters in the lower Cape Fear River and Atlantic Ocean will remain unaffected during project implementation.

Delft3D modeling predicts deflation and recession of the shoreline along western South Beach and the Point resulting in less dry beach area. The loss of 22 acres of dry beach would reduce recreational opportunities of this public resource.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: Delft3D model predictions indicate that continued sand placement per the SMP will not be sufficient to prevent high rates of erosion and resultant shoreline recession. While construction-related impacts associated with federal channel maintenance (Alternative #1) would be comparable under this alternative, the loss of beachfront would also reduce recreational use of this public resource. In addition, the predicted extent of erosion would impact recreational uses of the Bald Head Island Club. In particular, tennis courts, swimming pools, and portions of the golf course would be loss to erosion. During the period of relocation, Club services would likely be interrupted or diminished in some capacity. Removal of the sand tube groinfield may provide some recreational benefit for beachcombing or beach walking in general.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct, Indirect and Cumulative Impacts: Under Alternative #3, impacts to land-based and water-dependent recreation would be comparable to those discussed under Alternative #1. The predicted physical effects of this alternative would also result in an unstable beachfront condition over the nine-year model period which would adversely affect beachfront recreation.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: Under Alternative #4, impacts to land-based and water-dependent recreation would be comparable to those identified for Alternative #1 and Alternative #3 above. Removal of the sand tube groinfield would result in the increased loss

of dry beach. However, some recreational benefit may occur for beach walking and beachcombing via the removal of the sand tubes.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Under Alternative #5, impacts to land-based and water-dependent recreation associated with dredge disposal and terminal groin construction would be comparable to Alternative #1, #3, and #4 above. Short-term adverse effects may include limiting or blocking access to the beachfront during project construction and subsequent nourishment and maintenance actions (NCDENR DCM 2010). The proposed limits of work are depicted on Figure 3.3. All work areas would be clearly marked and cordoned off to protect public health and safety.

Rock structures, such as terminal groins, jetties, etc. can provide ideal habitat for crustaceans and small fish which are commonly utilized as bait for recreational and commercial fishermen. The creation of hard structure in an area that is presently devoid of such habitat has the potential to enhance fishing opportunities around the terminal groin.

Coupled with periodic nourishment, the terminal groin would likely expand beachfront suitable for a number of recreational uses. The continued presence of the sand tubes along the beachfront have the potential to hinder beachcombing and beach walking particularly as the sand tubes become exposed subsequent to erosion. Reduced erosion rates along western South Beach as a result of the installation of the terminal groin will decrease the frequency and extent of sand tube exposure.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Under Alternative #6, impacts to land-based and water-dependent recreation would be comparable to those discussed under Alternative #5.

Removal of the sand tubes under this alternative would result in increased susceptibility of erosion and loss of dry beach. However, some level of recreational benefit may be gained by the removal of sand tubes which can currently obstruct or hinder beach walking and beachcombing (particularly when the sand tubes become exposed during an eroded condition).

5.12 NAVIGATION

5.12.1 Background

The Wilmington Harbor Navigation Project is authorized at a current design depth of -42 ft (MLLW) with two additional feet across the ocean bar. It extends from the Atlantic Ocean 38 miles up the Cape Fear River to the Port of Wilmington and beyond. Continuous maintenance of the harbor by the federal government began in 1870 and harbor dimensions have increased incrementally for over 100 years. Today, the Port of Wilmington is a major contributor to the economies of Brunswick and New Hanover Counties, moving some $6.4B in goods in 2010.

As expected, the navigation channel likewise serves local recreational and commercial fishing interests as well as small vessel traffic entering and exiting the Atlantic Intracoastal Waterway which passes through the lower reach of the Cape Fear River near the town of Southport.

The following analyses identify if any of the six (6) alternatives under consideration would adversely affect navigation of the Wilmington Harbor federal channel. Specifically, potential consequences to navigability resulting from major changes in currents, waves or shoaling from any of the alternatives are evaluated.

5.12.2 Waves

Of the six alternatives under consideration, only the two structural alternatives (which propose a barrier which could affect incident wave energy at/or near the western extremity of South Beach) would be capable of modifying wave climatology within the navigation channel. In that instance however, wave energy was actually reduced, thereby eliminating the potential for adverse impacts to vessels.

The predicted effects of each of the six alternatives considered are below:

- Alternative 1 – This alternative does not include the provision of a structure extending beyond the existing shoreline. Hence it will have no effect on localized wave climatology.
- Alternative 2 – Identical to Alternative No. 1.
- Alternative 3 – Identical to Alternative No. 1.
- Alternative 4 – Identical to Alternative No. 1.
- Alternative 5 – This alternative proposes the construction of a terminal structure which could potentially serve to modify wave energy along the abutting navigation project centerline. In that regard, the alternative is predicted to result in a small net reduction in local wave height to the west of the structure. This should be considered as net beneficial to navigation interests.
- Alternative 6 – Identical to Alternative No. 5.

5.12.3 Currents

Commercial vessels entering or exiting the Cape Fear River Entrance Channel are often faced with cross-currents and/or difficult turns associated with a varying channel alignment at, or immediately northward of Bald Head Island. Hence, the potential effect of any alternative on current speed or direction is of interest with respect to commercial vessel traffic passing Bald Head Island.

As quantified in Section 5.19, the only alternatives which could potentially alter current magnitude or direction are those which would construct an impediment to the existing flow regimen. That is to say, any such alternative would include placement of a structure extending into the present day inlet flow field, or any flow field serving the inlet's margins – such as the nearshore area seaward of Bald Head Island's westernmost segment of South Beach. Such is the case for Alternatives 5 and 6 which propose the installation of a terminal groin extending seaward of the existing shoreline. Any such groin would require sand fill which likewise artificially extends the shoreline seaward.

Figure 5.25 predicts that the construction of a terminal groin results in a modest decrease in *peak* ebb tidal velocities immediately offshore of a terminal structure's seaward end. No changes of consequence are noted within the navigation channel, per se.

Conversely, computer modeling of changes in *peak* flood tidal velocities and magnitudes under the "with terminal groin" conditions are somewhat greater than ebb effects. This is predominately due to (a) the reclamation of the shoreline updrift and eastward of a terminal groin, and (b) the physical reduction or modification of flood tidal flows by the structure's seaward tip. As shown by Figure 5.26, peak velocity increases, or decreases within the limits of the navigation channel are predicted to be .1m/sec., or less. Such an increase in *peak* velocity would result in minimal effects.

The predicted effects on hydrodynamics of each of the six alternatives considered, are as follows:

- Alternative 1 – This alternative does not include the provision of a structure extending beyond the existing shoreline. Hence, it will have no effect on inlet hydrodynamics.

- Alternative 2 – Identical to Alternative No. 1.
- Alternative 3 – Identical to Alternative No. 1.
- Alternative 4 – Identical to Alternative No. 1.
- Alternative 5 – This alternative proposes the construction of a physical impediment to the existing flow field bordering the inlet. As a result both ebb and flood current regimens are slightly modified. A comparison of before and after conditions for each tidal condition (peak ebb or peak flood) are presented by Figure 5.27. No changes to peak ebb tidal velocities are predicted within the navigation channel. Only minor changes in peak flood tidal velocities are computed, i.e. .1m/sec or less – within the navigation channel westward of the Point. As a result, no significant adverse consequences to navigational interests are predicted to occur subsequent to alternative implementation.
- Alternative 6 – Identical to Alternative No. 5.

5.12.4 Shoaling

Shoaling within the innermost three segments of the Ocean Entrance channel of the Wilmington Harbor navigation project typically averages about 1 Mcy, mol. every two (2) years. Beach quality sand excavated from these three reaches is subject to beach disposal in accordance with the Wilmington Harbor Sand Management Plan. Although the preferred maintenance interval is biennial, dredging to restore the authorized navigable depths within the channel at this location has occurred closer to every three years on average since harbor deepening and realignment in 2000. The most recent channel maintenance occurred early in 2013 with the removal of over 1.617 Mcy of sediment from channel segments Bald Head Reaches 1 & 2 and the Smith Island Channel. Prior to the 2013 contract, the prior maintenance operation had occurred in 2009 – 4 years earlier. A small scale dredging of a portion of Bald Head Reach 2 was necessary in 2012 to ensure reliable commercial vessel passage at that location. The need for maintenance dredging in 2013 (at year 4) was approaching critical. Accordingly, as predictions regarding Congressional appropriations are

difficult to make, we have elected to model the next nine years based upon the average disposal amounts and frequencies experienced over the past decade.

The predicted average annual volume of sand shoaling the federal navigation channel was quantified for each alternative over a 9-year modeling simulation. The residual shoreline locations for each alternative modeled over the subject 9-year period were previously presented by Figure 5.1. In all alternatives, channel shoaling is predicted to derive from sand moving off Bald Head Island, encroachment of the Point in some alternatives, as well as continued deflation of the ebb tidal platform seaward of Bald Head Island, known as Bald Head Shoals. Because the Delft3D model is incapable of simulating avalanching side slopes of sediment within the channel cross section, it is not possible to predict the final destination or particular morphological shape of channel shoals. Predicted channel shoaling patterns in each alternative reflect steep-banked, large-scale shoal features within the channel. In reality slope avalanching would likely cause shoaling to extend further west and be even more diffuse than what is indicated by the results. Even considering these inherent limitations of the model, there is no indication that any analyzed alternative produces a "pinch" point, or area of concentrated shoaling, within the channel. The model results indicate no significant change in the post-terminal groin distribution of shoaling material between dredge cuts. That is the distribution of material entering Baldhead Shoal Channel 1 and 2 remains relatively constant between simulations containing fill stabilization (i.e., Alt 3 vs. Alt 5). It should be noted that portions of the existing navigation channel have depths well exceeding the project design depth. Hence, any shoaling predicted to occur in those areas – associated with a specific alternative under consideration – may not result in the requirement for maintenance dredging.

Figure 5.28 plots the predicted cumulative shoaling volume within the limits of Bald Head Shoal 1 and 2 channel reaches. *Relative* comparison of the results suggests that channel shoaling is predicted to be lowest under Alternative 5 (terminal groin, existing tube groins,

and beach fill). That is, the terminal groin with the existing tube groins is not expected to negatively alter the shoaling rates within the federal channel – over today's conditions. The model predicts that under Alternative 5, the channel adjustment to Bald Head Island will shoal with about 3.33 Mcy over 9 years. Conversely, Alternative 4, fill at years 0, 3 and 6 but the sand tube groinfield removed results in the highest rate of shoaling over the period of simulation. It should be noted that Alternative No. 3 as well as Alternative No. 6, rank closely and only slightly greater in magnitude than Alternatives 1 and 5.

For purposes of depicting *relative* merit, Figure 5.29 plots the percent change in shoaling within Baldhead Shoal Channels 1 and 2 relative to Alternative 5, the option with the lowest predicted value. From this depiction, the ranking of each alternative can be more easily derived. If one considers Alternative 3 to be the status quo over the last decade, then judgments can be made regarding whether the other alternatives result in a net improvement – or a net impact over "existing conditions." Note that for modeling purposes, volume was directly placed into the fillet initially and at every disposal event until reaching a maximum berm elevation. Upon reaching a maximum berm elevation, remaining volume was then distributed evenly throughout the rest of the fill limits.

In summary, the predicted affects of each alternative on shoaling within the navigation channel closest to Bald Head Island (i.e. Bald Head Reaches 1 & 2) are as follows:

- Alternative 5 is predicted to result in the lowest rate of annual shoaling over a nine-year period of analysis.
- Alternative 1 is predicted to result in a modest increase (0.5%) in the rate of shoaling relative to Alternative 5.
- Alternative 3 is predicted to result in a 4.5% increase in the rate of shoaling relative to Alternative 5.

- Alternative 6 is predicted to have a 4.8% increase in the rate of shoaling relative to Alternative 5.
- Alternative 2 is predicted to have a 20% increase in the rate of shoaling relative to Alternative 5.
- Alternative 4 is predicted to have a 28% increase in the rate of shoaling relative to Alternative 5.

5.13 HISTORIC PROPERTIES AND CULTURAL RESOURCES

(1) No Action/Status Quo (Alternative #1)

a. Direct and Indirect Impacts: The USACE Wilmington District investigated the Wilmington Harbor entrance channel and the Ocean Dredged Material Disposal Site (ODMDS) for potential cultural resources as part of the February 2000 Environmental Assessment of modifications to entrance channel and placement of dredged sand (USACE 2000). This effort was completed in cooperation with the NC Division of Archives and History through the Underwater Archaeology Unit (UAU) and the State Historic Preservation Officer (SHPO). Remote sensing analysis performed during the investigation identified 113 magnetic and/or acoustic anomalies of which 35 were considered for potential association with a significant cultural resource. A diver survey of these anomalies confirmed one target as a shipwreck located on Jay Bird Shoal. The UAU has also investigated an additional shipwreck site, the Fort Caswell Steamer, located near Southport. Both of the identified shipwrecks are beyond the limits of the harbor channel. As such, it was determined during agency review of the Environmental Assessment there would be no direct impacts to existing historic properties and/or cultural resources.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to historic properties and/or cultural resources resulting from Alternative #1.

(2) Retreat (Alternative #2)

a. Direct and Indirect Impacts: Given the lack of identified cultural resources within the footprint of the federal navigation channel it is anticipated that dredging and beach disposal activities associated with the maintenance of the Wilmington Harbor Channel will not adversely affect historic properties or cultural resources.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no anticipated cumulative impacts to historic properties and/or cultural resources resulting from Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

a. Direct and Indirect Impacts: It has been previously established that there are no direct impacts to cultural resources resulting from maintenance of the federal channel (USACE 2000). Three potential sand source sites have been evaluated in the event that the Wilmington Harbor Entrance Channel is unavailable at the time of an independently-sponsored nourishment action. Potential source sites include; (1) Jay Bird Shoals; (2) Bald Head Creek Shoal; and (3) Frying Pan Shoals.

The VBHI contracted with Tidewater Atlantic Research, Inc. (TAR) to perform an archaeological survey and assessment of the Jay Bird Shoal borrow area as part of the Environmental Assessment for the 2009 beach nourishment event on Bald Head Island. TAR conducted magnetometer and side-scan surveys of the proposed borrow area within Jay Bird Shoal. Analysis of this data indicated a total of 49 magnetic anomalies. None of these anomalies had an associated acoustic signature. All but seven of these targets appear to have been generated by modern debris such as fish and crab traps, pipes, cable, chain, small boat anchors, etc. The remaining seven targets were investigated via diver reconnaissance. Five of these anomalies were associated with modern debris as well. The remaining two anomalies could not be located or identified by probing depths of up to 15 ft below the

bottom surface. The signatures of these anomalies however were consistent with potential shipwreck material, and as a result, a 200-ft buffer area was maintained around these anomalies during excavation of the borrow site in 2009. The same 200-ft buffer would be maintained for any further dredging to be performed at this site. Given the avoidance measures to be employed, future excavation is not anticipated to result in direct or indirect impacts to the two anomalies identified. Additional consultation with the UAU and SHPO would be required prior to excavation of Jay Bird Shoal such that there would be no impact to historical properties or cultural resources.

An archaeological survey of the Bald Head Creek Shoal borrow area was also performed by TAR as part of the Environmental Assessment (LMG 2010) for the January 2012 beach nourishment project. Background research gathered from the NC State Historic and Preservation Office (SHPO) indicated that there are no known resources listed or eligible for listing in the National Register of Historic Places in the vicinity of the Bald Head Creel borrow site. Analysis of remote-sensing data collected by TAR in the area identified 17 magnetic anomalies. A cluster of four magnetic anomalies and an associated acoustic signature were created by a modern reinforced concrete range platform. Signatures of the remaining targets appear to have been generated by modern debris such as fish and crab traps, pipes, small diameter rods, cable, wire rope, chain, rebar or small boat anchors. No potentially significant anomalies were identified in the survey area (TAR 2009).

More recently, TAR completed an investigation of the expanded Bald Head Creek Shoals site (including a 37.6-acre area to the north). Based upon the historical and remote sensing survey data collected as part of this effort, no NRHP eligible submerged cultural resources were identified in the 2014 survey area. The shallow area north of the mouth of Bald Head Creek is reported to have been the location of a number of channel range markers. TAR recommended that in the event dredging exposes the remains of one or more range beacons the NC Underwater Archaeology Branch (UAB) at Fort Fisher should be informed so

that an assessment of the structures' historical significance can be assessed and remains documented. Based upon the findings of this survey, no further investigation was recommended by TAR. SHPO has since provided a letter of concurrence on the findings and recommendations of the TAR report (refer to Appendix G).

As previously discussed, the USACE has identified Frying Pan Shoals as a potential source site for the Brunswick County Beaches Coastal Storm Damage Reduction Project. An archeological study was completed as part of the environmental review process of the *Integrated General Reevaluation Report and Environmental Impact Statement for Brunswick County Beach, North Carolina* (in press). Three remote sensing targets were identified within the proposed Frying Pan Shoal borrow area with the use of side-scan sonar, marine magnetometer and sub-bottom profiler. One remote sensing target was identified during the extended hardbottom sonar survey, however, this target was located beyond the limits of the proposed borrow area. Identified targets were further analyzed by video, and surficial sediments we collected at each site. The Frying Pan Shoal borrow area identified for the Brunswick County Beaches Coastal Storm Damage Reduction Project appears to consist of fluvial sediment deposits. In addition, no hardbottom was recorded in the survey area or within 500 meters adjacent to the proposed borrow area (USACE pers. comm.).

Prior to the delineation of a specific borrow site on Frying Pan Shoals, the Applicant will perform comprehensive cultural resource investigations and coordinate with SHPO to ensure avoidance to any documented submerged cultural resources. Requisite permit authorizations would be sought by the Applicant prior to any future use of a borrow site on Frying Pan Shoals, and additional NEPA documentation and analysis, and EFH/ESA coordination is expected to be necessary before this area can be used as a borrow source.

b. Cumulative Impacts: In consultation with SHPO and UAU, any documented submerged cultural resources or anomalies with signatures indicative of shipwreck material will be

avoided during excavation. As a result, it is anticipated that in conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to historic properties and/or cultural resources resulting from Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct and Indirect Impacts: The impacts and consultation discussed under Alternative #4 would be the same under Alternative #3.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to historic properties and/or cultural resources resulting from Alternative #4.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct and Indirect Impacts: A 2012 marine remote-sensing survey conducted in the coastal waters near Bald Head Island and the mouth of the Cape Fear River identified the remains of a 160- to 190-ft sailing vessel within the VBHI Shoreline Protection Project Study area. Historical research indicates that three documented vessels remains could be candidates for association with the wreck, the most-likely being 639-ton schooner *Charles H. Valentine* which wrecked off Bald Head Point on Smith Island in 1911. Based upon consultation with NC SHPO, the groin structure is designed to create a minimum of 150 ft of clearance from the identified vessel remains. During construction, the contractor would be made aware of the location of the wreck and would be required that vessels engaged in construction of the groin will not infringe on the 150-ft buffer created to preserve the surviving vessel remains. The groin structure, as proposed, would result in accretion of sediment along the southwestern shoreline of Bald Head Island. It is likely that the wreck remains would be covered by several feet of sediment. Burial of the remains would offer protection from further degradation thereby resulting in a positive impact to the archeological site. Annual physical monitoring of the area would confirm burial of the

remains over the life of the project. Consultation with the SHPO to identify proper contingency measures would be initiated should the remains of the wreck become exposed.

With respect to the prospective sand source sites, the anticipated direct and indirect effects would be the same as those identified for Alternative #3 and Alternative #4.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no cumulative impacts to historic properties and/or cultural resources resulting from Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

Alternative #6 would involve the construction of a single, low-profile terminal groin as described in Alternative #5 above. However, upon completion of the installation of the terminal groin, the Village would begin the systematic removal of the existing sand-tube groinfield on South Beach. Sand placement via Village-sponsored nourishment projects and federal beach disposal would continue on periodic intervals (potentially on a greater frequency then would occur under Alternative #5).

a. Direct and Indirect Impacts: The impacts and consultation discussed under Alternative #5 would be the same under Alternative #6.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no cumulative impacts to historic properties and/or cultural resources resulting from Alternative #6.

5.14 SOCIO-ECONOMIC CONSIDERATIONS[9]

5.14.1 Introduction

Alternative actions for the Village of Bald Head Island Shoreline Protection Project each create a unique array of costs and benefits. These include market costs, such as any construction or engineering costs associated with active mitigation, potential economic losses associated with upland damage to coastal real estate and infrastructure, as well as non-market costs and benefits, such as those associated with effects on the natural environment, aesthetic appeal, habitats and species.

The purpose of this section is to describe the potential scope of these values for each of the six alternative actions under consideration for the Bald Head Shoreline Protection Project. Monetary measures for values are provided that are readily identifiable and measurable based on existing data, such as construction and maintenance costs for the alternatives that involve nourishment or a terminal groin as well as assessed tax values of at-risk properties. These values should not be considered definitive and should not be used as the sole basis for choice or ranking of alternatives.

It is important to note that this section should not be considered a formal cost-benefit analysis. There is no attempt to monetize all aspects of the range of non-market costs and benefits that are associated with alternative actions such as those associated with aesthetics, opportunities for recreation or services provided by the natural environment. Based on results in the literature, these values are known to be substantial. However, in the absence of formal valuation efforts, their magnitude remains unknown. As such, the select monetary values that are provided herein should not be considered to be a representation of the true economic worth associated with the alternatives. Given the lack of formal valuation and the inherent uncertainties regarding specific performance of alternatives over

[9] Note that Section 5.14 was prepared for the USACE by Dr. Peter Schuhmann. Construction and maintenance costs for the economic analysis were provided by the applicant's engineer, Olsen Associates, Inc.

a 30-year project horizon, providing an estimate of total costs, total benefits or net gains is not possible. Further, ranking of the alternatives based on their relative economic values is not possible.

In many cases, the benefits associated with alternatives that mitigate the effects of erosion can be considered costs of alternatives that do not mitigate erosion. For example, the benefits of shoreline stabilization via nourishment or hardened structures include maintaining the integrity of the Bald Head Island shoreline and the associated real estate. These economic values may be partially or wholly sacrificed in the absence of active measures to offset erosion. Hence, the costs of retreat should account for declinations in the economic value of associated real estate due to lost shoreline integrity as well as losses associated with effects on use and non-use values associated with recreation and tourism on Bald Head Island. Likewise, the benefits of inaction may include values associated with maintenance of environmental conditions that would be subject to alteration by active shoreline protection measures. It is important to note however, that in the case of Bald Head Island, it is likely that inaction or retreat will have additional adverse effects on environmental conditions. That is, strategies that do not protect the shoreline from continued erosion are not expected to maintain environmental conditions in the study area, and the developed nature of the island does not allow for the landward migration of biological communities.

Cost and benefit values described below include explicit and implicit values. Affected stakeholders include employees of VBHI, Bald Head Island Limited, Bald Head Island Club, property owners, business owners, visitors, taxpayers of North Carolina and individuals who value coastal species and ecosystems and existence of the current character of Bald Head Island. The incidence of costs and benefits across these stakeholder groups will vary across the alternatives. As noted in Landry and Hindsley (2011), stakeholders can be expected to have different perceptions of the effectiveness of natural and man-made storm and erosion

buffers and variable evaluations of beach characteristics in terms of aesthetics, recreation, and leisure. Hence, the alternative actions can be expected to convey net economic gains to some user groups and impose economic losses on others.

Explicit costs associated with alternative actions include physical construction costs associated with shoreline nourishment activities, construction of a terminal groin, maintenance costs associated with the existing sand tube groinfield, and costs associated with destruction and/or removal of existing properties and infrastructure. Implicit costs include losses to the economic value to coastal property and public infrastructure associated with degradation of the character of the shoreline and proximate coastal and marine ecosystems, as well as reductions in use and non-use values associated with recreation, aesthetics and changes in the quantity and quality of habitats and species.

Construction and maintenance costs detailed herein are those incurred by VBHI and are based on estimates provided by the applicant's agent, Erik J. Olsen, P.E., as part of an engineering analysis of project alternatives (Olsen 2013). These estimates were constructed using a 30-year time horizon beginning in year 2015 and a 4.125 discount rate to current dollar value expenditures in order to provide cost estimates in discounted present value terms. It is important to note that due to the current low interest rate environment, a discount rate of 4.125 percent may be perceived as an overestimate of the opportunity cost of public funds. Indeed, at the time of this writing, long-term rates on U.S. Treasury Bills are lower than 2 percent. However, because the public is generally risk-averse with regard to spending on projects with uncertain outcomes, it can be argued that higher discount rates are more appropriate. Therefore, the present value of future expenditures associated with the alternatives is also examined using discount rates of 2 percent, 4.125 percent and 6 percent. Lower discount rates result in higher estimated present values for future expenditures, and causes alternatives that involve more future outlays to appear less

favorable. Likewise, higher discount rates result in lower present values for future expenditures.

Cost estimates are based upon recent project experience associated with sand tube maintenance and locally sponsored beach fill construction at Bald Head Island as follows:

- Sand Tube Groinfield (16 Structures)
    - Removal - $250K
    - Replacement - $2M
    - Maintenance - $130K + $115K/sand tube groin (per maintenance event)

      Note – each action must occur subsequent to a beach fill project.
- Terminal Groin Construction
    - Initial Cost - $8M (AE&D included)
- Beach Fill by Village
    - $2M + $8.00/cy + AE&D: Fills greater than 1 Mcy
    - $1M + $10.00/cy + AE&D: Fills less than 1 Mcy; greater than 0.5 Mcy

Sand placement on Bald Head Island via the Wilmington Harbor Sand Management Plan (SMP) is assumed on a three-year interval for two events.[10] A six-year gap is then assumed prior to the next disposal event.[11] Alternatives that include the construction of a terminal groin involve large initial costs associated with construction, but considerably lower costs associated with beach nourishment. This cost saving is due to the smaller quantity of sand that would be placed during each episode, rather than a decreased frequency of episodes.

In the case of alternatives that are projected to provide some level of shoreline stabilization (i.e. Alternative Nos. 1, 3, 5 and 6), benefits include the maintenance/protection or

[10] The 3-year interval represents roughly the average interval that disposal events have actually taken place on Bald Head Island in the past, and can be considered a conservative estimate of disposal timing. Federal disposal cannot be assumed or relied upon by the Village for stabilization purposes, as stabilization of the Bald Head shoreline is not the intent or objective of the Wilmington Harbor Sand Management Plan.

[11] As noted in Landry (2011), the fixed costs associated with beach replenishment can be significant (e.g. costs of mobilizing and demobilizing dredging equipment).

enhancement of coastal real estate, which may include values associated with residential, commercial and infrastructure assets. These values can also be interpreted as representing potential costs of Alternative Nos. 2 and 4, which involve a projection of extensive upland losses to erosion.

To understand the relative scope of potential impacts on coastal property, the most recent (2011) assessed tax values for at-risk properties are used. It is important to note that the current assessed tax values may not be reflective of current market values. To the extent that risk of future erosion is known to market participants, market values could be considerably lower than assessed tax value. Given the dynamic nature of the shoreline in recent years and uncertainty regarding the potential for mitigating action, it seems logical that current market values for at-risk properties on Bald Head Island will have capitalized a sense of future risk. More generally, changes in the real estate market that have transpired since the most recent assessment may affect market values. These changes include general market trends as well as modifications to insurance rates specific to properties in the coastal zone. While the general market trend since 2011 seems upward, such enhancements are not homogenous across locations and may not be conferred upon properties at risk of erosion. Recent trends in insurance rates as part of the N.C. Beach Plan have been generally unfavorable for properties in the coastal zone. Expected or realized additional costs may decrease demand for coastal properties offsetting some of the general market improvements experienced in recent months. Moreover, it can be argued that the appropriate values to be used in understanding the possible effects of alternative shoreline management actions are the values that exist at the time of the associated environmental change. As noted above, and with the important exception of acute change due to damage from storms, anticipated changes in coastal environments are likely to be capitalized into the market value of real estate far in advance of actual change (Landry and Hindsley, 2011; Landry, 2011).

In the absence of contemporaneous sales data for at risk properties and without a formal hedonic study for the properties in the subject area, an appropriate means of determining the true market value of at-risk real estate is lacking. The assessed tax values of at-risk properties should therefore be used only as a means of appreciating the relative magnitude of the management alternatives, rather than the absolute value that is at risk. Even in terms of their relative magnitudes, these values should be used with caution. As noted in Landry and Hindsley (2011), if active mitigation creates an expectation of improved conditions over time, value estimates should be interpreted as lower bounds on true value. If instead, conditions are expected to degrade, value estimates should be interpreted as upper bounds on true value.

It should also be noted that impending property loss due to erosion may result in some structures being demolished and some being moved further inland. There is no attempt to monetize the value of the transition losses associated with destruction or location of property, nor is there an attempt to monetize the gains in value that will be realized by currently unimproved parcels that are subsequently improved when structures are relocated. While it is important to acknowledge that such effects will transpire in the case of some alternatives, forecasting the magnitude, timing and location of such transitions is beyond the scope of this report.

As described in Section 3.0 of Appendix U, economic value extends beyond the prices and quantities of goods and services traded in markets. An extensive body of literature is associated with the definition and estimation of non-market and non-use values. Portions of this literature that are germane to shoreline change are reviewed in Appendix U. Recognition of these values suggests that alternatives that induce long term enhancements to beach width or beach quality will convey additional economic benefits associated with tourism, recreation and aesthetics. Stabilized shorelines may also convey additional use and non-use values associated with protecting coastal habitats and species. Non-use values such

as existence values, option values and bequest values may also accrue to past and potential visitors to Bald Head Island who derive benefits from maintenance of favorable conditions at the site. Actions that involve the construction of a terminal groin (i.e. Alternative Nos. 5 and 6) may create economic benefits in terms of enhanced recreational fishing opportunities, though these gains may be more than offset by diminished aesthetic appeal and/or any unforeseen adverse environmental effects produced by permanent physical alteration of the shoreline. Alternatives that maintain the existing sand tube groin field (i.e. Alternative Nos. 1, 3, and 5) are also likely to involve loss of aesthetic appeal (particularly as sand tubes become exposed) as well as diminished recreation value due to the physical constraints that the structures impose on beach activities, especially at low tide.

Alternative No. 2 (retreat) may produce economic benefits to a set of individuals who place economic value on unimpeded ecosystem function and change. These values are probably best described as non-use values, though some use value losses may also transpire. A critical assumption with regard to these values is that baseline environmental conditions are naturally occurring. This assumption seems unlikely in the case of Bald Head Island, given the highly modified conditions of the study area that have resulted from long-term and short-term anthropogenic alterations of the coastal area. Without formal valuation studies directed at estimating these values, it is impossible to form conclusions regarding net gains or losses in economic value.

5.14.2 Cost Considerations of Alternative Actions[12]

(1) No Action (Alternative #1)

The "No Action" alternative entails sand placement associated with the SMP and maintenance of the existing 16 structure sand-tube groinfield by VBHI. Larger-scale projects sponsored by VBHI would not occur under this alternative. The resultant condition would create an unstable beach profile prone to sand losses, necessitating short term emergency-level responses such as beach scraping/bulldozing and sandbag revetments.

a. Costs: Construction and maintenance costs of this alternative are expected to total $9.7 million under a 3-year interval scenario over a 30-year planning horizon. Discounted present values of these expenditures are approximately $7.33 million, $5.63 million and $4.59 million assuming discount rates of 2 percent, 4.125 percent and 6 percent respectively.

The "no action" alternative is expected to adversely affect the market value of several properties near the Point. Seventeen (17) parcels are projected to be at risk using 9-year simulations of the projected mean higher high water (MHHW) shoreline position (refer to Figures 5.30 and 5.31). Of these parcels, 15 (88 percent) are improved. Most recent (2011) assessed tax values for these properties range from approximately $518,000 to $1.8 million for the improved parcels and from $350,000 to $560,000 for the unimproved parcels. The total assessed tax value of these properties is approximately $18.2 million.

[12] Note that the following narrative includes an analysis of at-risk lots under each alternative considered. For the purpose of this analysis, a lot is considered at risk if any portion of the lot is within 20 ft of the predicted MHHW line at the end of a nine-year model simulation. Given the inherent limitations of the numerical modeling, the total values of at-risk lots should not be considered absolute but are presented rather as a means to provide a relative comparison between alternatives. The total lot values at risk do not necessarily equate to a loss, since the position of the MHHW line at the edge of a lot would not necessarily render a lot useless and thus devoid of value. In addition, this analysis does not account for any beach stabilization measures (i.e. supplemental nourishment or use of sandbags) for protection of property other than those measures defined in each project alternative.

A portion of this market value can be expected to transfer to properties currently located further inland as newly beachfront properties realize value improvements. However, to the extent that the "no action" alternative conveys a sense of future erosion risk to market participants, this additional value may be limited to temporary proximity value rather than long term improvements in market value. Even with partial or complete relocation of physical property, or the continued use for those properties not lost entirely, the decrease in value associated with these 17 parcels can be expected to have a net adverse effect on the tax base of the Island, *ceteris paribus*[13].

The "no action" alternative is expected to result in moderate near term loss of beach volume near the Point. While it seems logical to conclude that recreation opportunities will be diminished as a result of this volumetric loss, the total length of shoreline and area of beach available for recreation may remain unchanged. Hence, this alternative may fit the case discussed by Parsons and Powell (2001), where the shoreline is relocated further inland with no meaningful changes to other beach characteristics. If this is the case, total welfare derived from recreationists under Alternative No. 1 may be unchanged relative to status quo conditions. An important caveat here is that the recreational value of the Point is of the same magnitude as other beach areas in the vicinity. The Point is currently the most expansive area of dry beach available to beachgoers in the vicinity of western South Beach and West Beach. Its anticipated wholesale loss would likely result in a more direct impact to recreation than loss of beach between existing sand tubes. Another important caveat pertains to the potential loss of dune structure or function in the vicinity of the Point, which may result in additional loss of beach width and/or volume. If dune function is compromised, recreational values may modestly diminish relative to status quo conditions. The risk of dune loss is heightened by the probability of progressive groinfield failure, the occurrence of which was not accounted for in model simulations.

[13] *Ceteris paribus* is a Latin phrase translated to "holding other things constant" and is typically rendered in English as "all else being equal". In economics, the term is used as a way of indicating the effect of one economic variable on another, holding constant all other variables.

In terms of environmental values, calibrated Delft3D modeling of Alternative No. 1 suggests that there will be considerable shoreline recession and deflation within nine years, directly impacting dry beach, dunes and interdunal wetlands. In addition to a reduction in the storm protection function of dunes, several federally and state listed species that utilize these habitats may be adversely affected, including sea turtles and seabeach amaranth. Estimating the economic value of these changes is beyond the scope of this report. However, it should be noted that use and non-use values associated with the protection of habitats have been shown to be large, as highlighted in Appendix U.

b. Benefits: The benefits of Alternative No. 1 can in large part be construed as maintenance of the current stock and flow of market and non-market goods and services, subject to caveats noted above. It should also be noted that potential adverse effects that result from the use of a hardened structure will be avoided. These effects include the possibility of environmental damages to adjacent or proximate shorelines, aesthetic disamenity to coastal property owners and recreationists and economic value realized by the segment of the population that values unfettered ecosystem function.

(2) Retreat (Alternative #2)

The "Retreat" alternative involves continuation of federal beach disposal activities, but does not include maintenance of the existing sand tube groinfield, or large scale shore protection projects by the Village of Bald Head Island. Shoreline recession is expected to occur at a more rapid pace, with the shoreline moving up to 1,100 feet landward from its current position along western South Beach within nine years (refer to Figure 5.1).

Considerable upland losses are expected due to erosion along the westernmost segment of South Beach, West Beach and the Point. A large volumetric reduction in beach area is expected, with a moderate improvement in beach width along a small section of West Beach

as the Point feature migrates northward. Dune habitat losses are expected to be noteworthy.

a. Costs: Excluding transition costs associated with relocation of structures and infrastructure (discussed below), construction and maintenance costs associated with this alternative are expected to be negligible. Contemporaneous costs associated with removal of the sand tube field are expected to be approximately $250,000.

The expected reconfiguration of Bald Head Island's shorefront associated with this alternative involves a major shift landward, with notable upland impacts on existing properties and infrastructure. As a result of the extent of shoreline recession and deflation associated with this alternative, substantial adverse effects to habitats are predicted as described elsewhere in this section. These include effects on dry beach, dunes, interdunal wetlands and maritime thicket/forest habitats. Existing interdunal wetlands are expected to be inundated, altering species composition and wetland function. The beach profile is expected to be nearly vertical from upland dune to the mean high water line. This new profile is expected to adversely impact available habitat for species that utilize the dry beach as well as diminishing nesting area for sea turtles, shorebirds and waterbirds. Areas currently suitable for seabeach amaranth are expected to be converted to intertidal or subtidal bottom. While estimating the change in economic value associated with such impacts is beyond the scope of this report, an extensive literature search suggests that adverse changes to ecosystems, habitats and species can be expected to result in the loss of economic value associated with use and non-use benefits derived from these amenities. Examples of such values are detailed in Appendix U.

Under this alternative, it is predicted that nearly all of the frontal dunes and primary dunes mapped within the area of study would be lost to erosion. Unlike wet and dry beach habitat, it is not expected that dune habitat will naturally relocate or regenerate in the near term. In

addition to important loss of habitat function, the protection service provided by dunes is expected to be seriously compromised under this alternative. As described in Appendix U, the shoreline protection services afforded by dunes and other coastal habitats convey real economic value by preventing damage to coastal land and property. While non-market valuation techniques could be applied to estimate these values, such analysis is beyond the scope of this report.

The upland losses associated with the retreat strategy are expected to adversely affect the market value of numerous private properties near the Point. Approximately 95 parcels are projected to be impacted using 9-year simulations of the projected mean high water line. Of these 95 parcels, 65 (68 percent) are improved (Brunswick County GIS 2013). Current tax assessed values for these properties range from $334,000 to $4.9 million for the improved parcels and from $150,000 to $643,000 for the unimproved parcels. The total assessed tax value of these properties is approximately $63.4 million. As noted in Landry (2011), as the market capitalizes the expectation of continued shoreline erosion into the value of these properties, market values may be driven toward zero. Inland relocation of structures will offset some of these losses but will involve substantial transition costs. Again, it is reasonable to expect that a portion of the lost market value will transfer to properties currently located further inland. However, a strategy of retreat is likely to convey an expectation of risk from future erosion losses to shoreline properties. Newly beachfront properties might reasonably be considered newly at-risk properties. The market capitalization of this additional risk may offset much of the gains in amenity value. While proximity benefits associated with recreation and aesthetics will likely accrue to property owners in the near term, it seems unlikely that such values will be capitalized into market values due to long term uncertainty and risk.

Additional costs will be associated with relocation or demolition and removal of existing properties as acute loss to erosion becomes imminent. There is no attempt to estimate the

monetary value of these transition costs, but it should be noted that in addition to physical costs associated with the removal and transport of materials[14], aesthetic costs associated with noise, equipment and congestion can be expected as part of this alternative. These additional costs will temporarily impact specific locations - largely be concentrated around the Point - as individual structures are removed. Physical removal of materials from the Island may involve substantial transport costs. Generally, these adverse effects can be expected to persist for the duration of the landward shift of the shoreline.

In addition to loss of private property, the predicted landward shift of the shoreline associated with this alternative is also expected to result in a large physical loss of land and property currently contained within the 151 acres of the Bald Head Island Club and golf course (as shown in Figure 5.16). In addition to physical capital (Club House facilities, pools, tennis courts), at least two holes of the golf course are projected to be inundated under this alternative. There is no attempt to monetize the magnitude of the economic costs associated with these losses, but it should be recognized that the current economic impact of the Bald Head Island Club is considerable. The Club generates $10M in revenue annually and, as a not-for-profit entity, spends approximately the same amount each year.

In addition to a championship golf course, the Club houses a pool, fitness facility, tennis courts and two restaurants. Because the Club serves as the foundation for recreation and social activity island wide, the gross domestic product (GDP) of the Island is strongly associated with the Club, its associated activities, and the resultant effect on home purchases and rentals on the Island. On average, twenty-thousand rounds of golf are played each year on the Club's championship eighteen-hole golf course. A majority of these rounds (63%) are played by non-members that rent Island residences. It is estimated that 500 homes are rented each year (equivalent to $5,700 weekly in rental income) as a direct result

[14] Such transition costs can be expected to be higher than those encountered on the mainland, because Bald Head Island is accessible only by boat, ferry or barge.

of the amenities offered by the Club. Over 81,000 full meals were served at the club in 2011, totaling roughly $3 million in food and beverage sales. All of the Club's seafood and produce are locally sourced. The Club is also the second largest employer on the Island, employing 151 people during the summer and 75 people during the off-season. None of the Club's employees are Island residents. The Club's largest expense is payroll (accounting for an average of 57% of accounts payable) in most years. The Club is one of the largest single tax payers on the Island, paying approximately $140,000 per year in property taxes, in addition to sales taxes on approximately $5 million in Club revenues and $500,000 in ferry ticket purchases. The Club also pays approximately $20,000 in sales taxes on out-of-state purchases. The current economic impact of the Club is not known, but clearly extends to surrounding municipalities and states.

It is unknown whether the Club could relocate all displaced amenities further inland, or if land of sufficient size and condition suitable for relocation is available, should the retreat strategy be adopted. Hence, it is unknown whether the economic impact and economic value of the Club will be lost in their entirety under a strategy of retreat. Such relocation efforts would involve considerable transition costs, similar in nature to those described above for private properties, but likely considerably larger in scope given the existing footprint of the Club and the amount of standing physical capital that is at risk. Revenue losses should also be expected during the period of relocation. The extent to which relocation might affect the ability of the Club to provide the same level and quality of amenities is unknown.

The major landward shift of the shoreline associated with alternative No. 2 will also result in loss of existing Island subgrade infrastructure, including roadways, water lines, sewer lines, fire suppression, power and communications. Nine-year modeling of the affected shorelines suggests that approximately 3500 linear feet of road, water, sewer and power lines (including portions of W. Bald Head Wynd and Cape Fear Trail) will be lost (as shown in

Figure 5.16). It is reasonable to assume that a portion of the economic value associated with this infrastructure has been capitalized into the value of the properties that rely on it for support. Some of the infrastructure value, however, accrues to the public that uses the roads to gain access to beaches. Moreover, the at-risk infrastructure that runs below Bald Head Wynd provides utility service that is ultimately distributed throughout other (inland) areas of the Island. Bald Head Wynd is also the primary route for evacuation and emergency vehicles. Hence, relocation of the physical capital that provides these service flows will be necessary in the case of loss as predicted under this alternative. A lower bound[15] on the value of this infrastructure can be provided using the replacement cost method. The estimation is based on NCCRC (2010a), and value at risk infrastructure using construction costs of $568 per foot for roads, $55 per foot for water lines and $150 per foot for sewer lines, assuming that the length of affected water and sewer lines is coincident with affected length of road.[16] Applying these values to the 3500 linear feet of anticipated infrastructure impact under Alternative No. 2 suggests a replacement cost of approximately $2.7 million over the nine year simulation period. This estimate does not include infrastructure associated with power and communications and does not include costs associated with land acquisition for ROW.

The predicted large scale increase in beach erosion associated with the affected shoreline segments under this alternative is also expected to increase the volume of sand entering the Wilmington Harbor Entrance channel. As a result, there are expected to be additional channel maintenance costs associated with this alternative. The Applicant's engineer has

[15] These estimates are considered a lower bound on value for several reasons. First, as noted in the review above, the cost associated with new construction is likely smaller than the discounted present value of the benefits flowing from the intact infrastructure over its lifetime. Second, transport of materials and labor to an island only reachable by boat will involve additional costs not included in standard replacement costs calculations. Finally, additional costs associated with the physical removed and off-site transport of the materials that comprise the at-risk infrastructure will create additional transition costs.

[16] The replacement cost estimate for roads is based North Carolina Department of Transportation Construction Cost Estimates for 2008. Water and sewer construction costs are based on estimates from the Cape Fear Public Utility Authority and Wrightsville Beach public works department (NCCRC 2010a). It is not known whether acquisition, engineering, permitting costs are accounted for in the NCCRC estimation.

predicted the percent change in shoaling within the federal channel relative to Alternative No. 5. Comparison of the results suggests that channel shoaling is predicted to be 20% higher for Alternative No. 2 relative to Alternative No. 5 (refer to Section 5.12.4 and Figure 5.28). In addition, cumulative sedimentation and erosion changes have been modeled and graphically depicted in Figures 5.30 through 5.36 for each alternative. A more detailed analysis is provided within the Engineering Report (Olsen 2013).

While there is no attempt to quantify the monetary value of losses under this or any alternative, it seems clear that this alternative involves the greatest scope of foreseeable market and non-market costs. Market losses include land loss, capital (structure) loss, proximity loss, and transition loss affecting both privately held real estate and real estate owned by VBHI. Non-market losses include the use and non-use values associated with affected species and habitats, most notably, dune habitat and species nesting areas.

b. Benefits: The retreat alternative can be construed as the alternative where "natural processes" are permitted to continue unimpeded by human activity or intervention. As noted in Judge, Osborne and Smith (1995), some individuals have preference for non-interventionist approaches that allow unimpeded erosion to take place. These individuals may derive real economic value from the existence of unfettered coastal ecosystems. As noted above, a critical assumption with regard to these values is that baseline environmental conditions are naturally occurring. This assumption seems unlikely in this case, given the highly modified conditions of the study area that have resulted from long-term maintenance of the adjacent federal channel. Such activities (continued dredging and disposal) will continue even with a strategy of retreat. Hence, without a thorough (non-market) valuation study directed at understanding the scope and magnitude of these benefits it is difficult to characterize their nature or extent. It should be noted that in a sample of North Carolina beachgoers, Whitehead et al. (2008) found that a majority of respondents favored beach

nourishment as a means of maintaining beach width, and 18 percent felt that beach width should not be altered by people.

Because this alternative involves the removal of the existing sand tube groin field, improved aesthetic appeal as well as enhanced recreation value may also be created. However, it is unknown whether removal of the aesthetic disamenity and physical constraints associated with the groin field will be offset by losses associated with reduced beach width.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

Alternative #3 is predicted to result in continued beach erosion at the Point, with potential accretion on the shoreline to the north of the Point. Conditions similar to those identified under the Alternative No. 1 are predicted, with the exception of shoreline loss that is periodically mitigated through a Village-sponsored renourishment. Nine-year modeling of projected changes under this alternative suggests a net increase in total volume over a 9-year time period in the vicinity of the Point.

a. Costs: Alternative No. 3 is expected to involve construction and maintenance costs totaling $72.9 million under a 3-year interval scenario over a 30-year planning horizon. Assuming 6, 4.125 percent and 2 percent discount rates, the discounted present values of these expenditures are $33.04 million, $40.71 million $53.72 million respectively.

Under this alternative, continued diminished beach width at the Point will likely have an adverse impact on the market value of a limited number of properties. Based upon the 9-year model simulation, one improved parcel (Parcel ID No. 2641D026) would be directly affected by land loss and potential capital (structure) loss. The total assessed value of this parcel is $518,532. Other neighboring parcels (along Sandpiper Trail) would be subject to increased risk of impact from erosion under this alternative as well. Failure of any one or

more of the geotextile sand tubes protecting this segment of shoreline (e.g. during a storm) would immediately place additional lots at risk.

Parcels in the immediate vicinity of the Point will likely suffer losses due to decreased aesthetic appeal and loss of recreational values as beach width in that area is diminished over time. As with other alternatives, it is reasonable to expect that with shoreline erosion a portion of the lost proximity value currently capitalized into at-risk properties will transfer to properties currently located further inland. That is, newly beachfront properties will realize value improvements due to enhanced proximity values, including those associated with recreation and aesthetics. However, to the extent that this alternative is viewed as a temporary measure, continued perceptions of risk to shoreline properties may diminish the extent to which this value can be realized in the marketplace. Indeed, given the dynamic nature of beaches near the Point in recent history, it seems likely that such risks are currently capitalized into existing, at-risk shorefront properties. If this is the case, private recreation and aesthetic values will likely accrue to some property owners in the near term, but it seems unlikely that such values will be capitalized into market values due to long term uncertainty and risk.

Public recreational values may be affected under this alternative to the extent that the northward sand accretion affects recreation around the Point. Based on 9-year simulations, the volume/width will be transferred only a short distance to an area with similar characteristics. Hence, it seems likely that public recreation values will be largely unaffected by this alternative. Maintenance of the existing sand tube groin field may also create recreation losses due to diminished aesthetic appeal and physical constraints on recreation activities, especially at low tide.

This alternative is expected to result in a modest increase (4% increase relative to the no-action alternative) in shoaling volume within the maintained federal navigation channel. Thus, there may be some additional costs associated with channel maintenance.

The increased frequency of nourishment required under this alternative is expected to result in more frequent environmental disturbance at both the dredge site and at the nourishment site relative to Alternative No. 1. Short-term impacts on foraging habitat for fish are expected at the dredge site, though these effects may be mitigated by using the federal navigation channel as a sand source. Estimating the economic value of such changes to commercial and recreational fisheries is beyond the scope of this report. The occurrence and distribution of species that utilize wet and dry beach for foraging may be temporarily impacted at the nourishment site, which may diminish the value of associated recreation. Potential adverse effects to dry beach and frontal dune habitats are expected to be relatively minor.

b. Benefits: As with Alternative No. 1, the benefits of Alternative No. 3 can be construed as maintenance of the current stock and flow of market and non-market goods and services. Accretion on beaches to the north of the Point will confer some benefits on property values in the immediate vicinity. Other benefits include the avoidance of adverse effects resulting from the use of a hardened structure. These effects include potential environmental damages to immediately adjacent or proximate downdrift shorelines, aesthetic disamenity to coastal property owners and recreationists and economic value realized by the segment of the population that values unfettered ecosystem function.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

Removal of the sand tube groinfield under Alternative No. 4 is expected to necessitate the implementation of larger scale Village-sponsored nourishment events to help mitigate sand losses. Sediment losses on South Beach are expected to be larger than Alternative No. 3 due

to the absence of the stabilizing effects of the sand tube groinfield. Based on the 9-year simulations, alternative No. 4 is expected to result in a reconfiguration of Bald Head Island's shorefront with a shift landward along the westernmost segment of South Beach, West Beach and the Point. Assuming a three-year schedule of implementation of the SMP coupled with Village-sponsored nourishment of approximately 1.5 Mcy, the Delft3D simulation predicts that by Year 9 the shoreline will have receded approximately 1,000 feet landward of its current position.

a. Costs: Alternative No. 4 is expected to involve construction and maintenance costs associated with beach nourishment and disposal totaling approximately $79.45 million under a 3-year interval over a 30-year planning horizon. The discounted present values of these costs are $35.99 million, $44.34 million and $58.51 million using discount rates of 6 percent, 4.125 percent and 2 percent respectively. These estimates include costs associated with removal of the sand tube field in the initial year, expected to total approximately $250,000.

Resulting upland losses under this alternative are expected to be considerable, involving loss or degradation of 71 parcels, of which 46 (approximately 65 percent) are improved (see Figure 5.34). Current assessed values of these properties range from $350,000 to $4.9 million for the improved parcels and from $150,000 to $643,000 for the unimproved parcels. Total value of these lots (both improved and unimproved) is $49.2 million.

As is the case with Alternative No. 2, to the extent that projected shoreline erosion is anticipated by market participants, the near term market value of these properties may be driven toward zero. Again, due to the realization or expectation of enhanced proximity values, it is reasonable to expect that a portion of this market value will transfer to properties located further inland. However, similar to the retreat strategy, a strategy

involving the removal of the groinfield is likely to convey an expectation of additional future risk of loss from erosion, potentially offsetting long term gains in amenity value.

Additional costs of this alternative will be associated with relocation or demolition and removal of existing properties. Physical costs associated with the removal and transport of materials, aesthetic costs associated with noise, equipment and congestion can be expected as part of this alternative. As above, an estimate of the monetary value of such costs is not attempted. These adverse effects can be expected to persist for the duration of the landward shift of the shoreline.

In addition to loss of private property, Alternative No. 4 is expected to result in physical loss of land and property currently occupied by the Bald Head Island Club and golf course, though the total land loss under this alternative is less severe than that which is expected under Alternative No. 2. As stated previously, estimating the economic impact of the land and property loss associated with this alternative is beyond the scope of this report, and it is unknown whether the Club would relocate affected amenities. Nonetheless, given the economic importance of the Club to the Island and surrounding communities, it is safe to assume that transition losses would be considerable.

Based upon Delft3D model simulations, a considerable volumetric reduction in beach area is expected under this alternative, with a moderate improvement in beach width along a small section of West Beach as the Point migrates northward. As a result of the extent of shoreline recession and deflation associated with this alternative, and similar to the effects described for Alternative #2, adverse effects to dry beach, dune, interdunal wetlands, and maritime thicket/forest habitats are predicted. Existing interdunal wetlands and maritime thicket/forest habitats would likely be inundated, altering species composition. Impacts on federally and state listed species are anticipated. The area of dry beach available for nesting sea turtles, shorebirds and seabeach amaranth are expected to be reduced, potentially

creating economic losses associated with diminished aesthetics and recreation opportunities, as well as non-use value losses. The increased frequency of nourishment events necessitated by this alternative is expected to have adverse effects at the dredge site and the nourishment site. These effects are likely to reduce economic values associated with direct and indirect uses as well as non-use values associated with these species and habitats. While estimation of the magnitudes of the associated economic losses is beyond the scope of this report, an extensive literature (reviewed in Appendix U) suggests that such economic values are likely to be considerable.

As with Alternative No. 2, the landward shift of the shoreline associated with alternative No. 4 will result in loss of existing Island infrastructure, including roads, water lines and sewer lines. Nine-year modeling of the affected shorelines suggests that approximately 3050 linear feet of road, water lines and sewer lines (including portions of W. Bald Head Wynd and Cape Fear Trail) will be lost, resulting in economic costs associated with removal and transport of the materials that comprise this infrastructure (see Figure 5.21). Again, because the at-risk infrastructure that runs below Bald Head Wynd provides utility service that is distributed throughout the Island, relocation of the physical capital that provides these service flows will be necessary in the case of loss. A lower bound on the value of this infrastructure can be provided using the replacement cost method. Following the estimation used by NCCRC (2010a), and assuming that the length of affected water and sewer lines is coincident with affected length of road, the 3050 linear feet of predicted infrastructure impact under Alternative No. 4 suggests a replacement cost of approximately $2.36 million. This does not include infrastructure associated with power and communications and does not account for additional costs associated with transporting materials and labor to Bald Head Island.

Beach erosion under this alternative is also expected to increase the volume of sand entering the inlet by approximately 28% than the no-action alternative. As a result, there may be

increased channel maintenance costs associated with this alternative relative to current 'baseline' conditions.

b. Benefits: Similar to Alternative No. 2, alternative No. 4 can be construed as allowing natural processes to continue largely unimpeded by human activity or intervention. As such, the portion of the population that values dynamic but unobstructed beaches will derive economic value from this alternative. Further, under this alternative, any adverse effects that result from the use of the sandtube groinfield and terminal groin structure will be avoided.

Because this alternative involves the removal of the existing sand tube groin field, improved aesthetic appeal as well as enhanced recreation value would also be created. It is unknown whether removal of the aesthetic disamenity and physical constraints associated with the groin field will be offset by losses associated with reduced beach width.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

The terminal structure associated with Alternative No. 5 is expected to reorient the westernmost segment of the South Beach shoreline in a manner that reduces annualized sand losses following beach fill placement operations. It is predicted that overall beach stabilization will be enhanced with some level of sand tube groinfield remaining functional, particularly those sand tubes that are beyond the effective footprint of the terminal structure's fillet of sand.

a. Costs: It is currently assumed that the westernmost 3 to 6 sand tube groins would be candidates for eventual removal under this Alternative. Costs associated with removal of these sand tubes are expected to be approximately $100,000.

Over a 30 year planning horizon, other construction and maintenance costs associated with Alternative No. 5 are expected to total approximately $63.10 million under the 3-year interval scenario. The discounted present values of these costs are $37.3 million using a 6 percent discount rate, $42.29 million using a 4.125 percent discount rate and $50.72 million using a 2 percent discount rate. These values include an expected cost of $8 million for construction of the terminal structure in the initial year.

Based upon the 9-year model simulation and prediction of the MHHW location, marginally diminished beach width along West Beach could potentially affect the market value of two (improved) parcels (Parcel ID Nos. 2604F004 and 2604F006). The current assessed value of these parcels is approximately $3.4 million. Based upon the requirements of the state terminal groin legislation, mitigation action (e.g. nourishment along West Beach) would limit any potential for future loss of use or value should these lots be threatened. Parcels in the immediate vicinity of the Point may suffer losses due to decreased aesthetic appeal and loss of recreational values as beach width in that area fluctuates over time.

During construction of the terminal structure, reduced recreation value and aesthetic appeal is anticipated due to the presence of construction equipment and associated noise and disruption. To the extent that the terminal structure itself may be viewed as aesthetically lacking, properties with views of the associated area may have reduced amenity value relative to that which would exist with a natural and stable shoreline. Further, to the extent that the structure serves to attract recreationists (i.e. fishermen), property owners in the vicinity may suffer economic losses due to crowding and reduced aesthetic appeal. Shoreward-facing visual impacts should also be anticipated. Maintenance of the existing sand tube groin field may also create recreation additional losses due to diminished aesthetic appeal and physical constraints on recreation activities, especially at low tide.

Construction of the terminal groin and accompanying nourishment has the potential to create short-term and long-term impacts on the natural environment, including effects caused by dredging, sediment transfer, physical contact, physical barriers and placement of material (NCCRC 2010a). Adverse effects are to be expected for some species and habitats, while other species and habitats may be promoted or restored. Adverse impacts will include those induced by volumetric losses to beaches on the lee side of the structure and benthic habitat losses in the footprint of the structure and from the introduction of rocky bottom material (NCCRC 2010a). Disturbance to the nesting habitat of sea turtles may result during construction of the groin. Groin Installation is also expected to temporarily influence the behavior of foraging birds, including federally and state-listed species. Dredging associated with obtaining sand for the groin fillet may result in adverse habitat effects as well as direct mortality to benthic species at the borrow site. As suggested by an extensive body of literature (reviewed in Appendix U), changes to the quantity, quality or character of species, ecosystems and habitats result in real changes in economic value and human wellbeing. As such, these adverse effects can be expected to result in real economic losses associated with diminished use and non-use values. Understanding the magnitude of these losses would require the application of non-market valuation methods, which is beyond the scope of this report.

The use of a hardened structure to mitigate erosion will confer economic losses on the segment of the population that values unfettered ecosystem function. Even if harmful effects on proximate or adjacent coastlines are never realized, it is safe to conclude that some people may remain opposed to the use of hardened structures for erosion control. In the case of the proposed terminal groin on Bald Head Island, such sentiments may be partially mitigated by the understanding that the terminal groin is designed to minimize the potential of adverse effects to navigation in the adjacent channel. In addition, the projected

need to nourish will be reduced, resulting in fewer of the environmental consequences associated with dredging and sand placement in general.[17]

In the event of unanticipated negative impacts to the coastal and marine environment, removal of the groin structure may be necessary. According to the Applicant's engineer, the total cost associated with groin removal is estimated to be $2 million. Additional costs will include reduced recreation, diminished aesthetic appeal and habitat disturbance during the removal process. It should be noted that 100 percent removal of the proposed rock structure may not be feasible or desirable given the nature of the marine environment and substrate.

b. Benefits: As noted in NCCRC (2010a) the use of a terminal groin in concert with a shoreline protection plan may provide a host of benefits, including long-term infrastructure protection, enhanced beach width and volume, and enhanced recreation opportunities for the public. The principle benefit associated with Alternative No. 5 is the anticipated stability and reduced erosion potential along the western sections of South Beach and the Point, relative to existing conditions and relative to that which would result under Alternative Nos. 2 and 4. Similarly, it is expected that Alternative No. 5 would reduce shoaling within the adjacent federal navigation channel and thus reduce channel maintenance costs. According to the Applicant's engineer, implementation of Alternative No. 5 is predicted to result in the lowest rate of potential annualized shoaling of all the alternatives considered (4.5% less than Alternative 3, 20% less than Alternative 2, and 28% less than Alternative 4). Refer to Section 5.12.4 for additional information regarding predicted shoaling by alternative.

[17] As noted in NCCRC (2010a), inlet dredging can have large effects on neighboring beach volume and behavior, as the channel cuts through bar formations and alters sediment flow and transport. This concern seems particularly germane to the case of BHI, as channel maintenance has occurred for over 150 years at mouth of the Cape Fear River.

To the extent that the public views the terminal structure as reducing the risk of future erosion, this added stability should serve to enhance property values along these stretches of the Island. An estimate of the magnitude of these benefits is not attempted in this assessment, but based on the associated literature it is reasonable to expect that property values will be enhanced as far as 300 meters inland. Associated benefits are likely to include increased rental revenues and higher tax revenues.

As noted in Parsons and Powell (2001), active mitigation efforts such as beach armoring may also serve to encourage additional use and/or development. Such additional development can reasonably be anticipated in the case of the Bald Head Island Club, in the form of a planned $6 million expansion which is unlikely to transpire absent a long-term solution to the chronic erosion that characterizes South Beach. Provided that such development does not compromise the integrity and value of the adjacent beaches, this expansion is expected to generate additional economic impacts relative to the status quo in the form of increased tourism demand, employment and spending.

The terminal groin may create enhanced recreation values as a result of (predicted) gains in beach width and stability as well as the creation of rocky bottom area that may increase species diversity and enhance the quality of recreational fishing near the structure. Indirect and non-use values may also be created, enhanced or preserved as a result of reduced erosion. In particular, a more stable dry beach habitat eastward of the groin would be expected to create conditions considered more favorable for sea turtle nesting (footprint of the structure notwithstanding). It is important to note that benefits may be offset to varying degrees by potential adverse effects including: increased risk of interference with nesting females (resulting in the potential for increased energy expenditure and false crawls); increased risk of interference with hatchling egress to nearshore waters; and increased predator concentration (both birds and fish).

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

As with Alternative No. 5, the terminal structure associated with Alternative No. 6 is expected to reduce annualized sand losses nearest the Point following beach fill placement operations. However, without the added stability associated with the easternmost segment of the sand tube groinfield, the maximum extent of benefit of the terminal groin will be diminished, resulting in increased sediment losses and beach recession along the segment of South Beach that is not within the structure's permanent fillet.

a. Costs: Over a 30 year planning horizon, projected construction and maintenance costs are expected to be $77.6 million under the 3-year interval scenario, with discounted present values of $43.79 million, $50.29 million $61.32 million assuming discount rates of 6 percent, 4.125 percent and 2 percent respectively. These values include initial year cost of $8 million for construction of the terminal groin structure and $250,000 associated with the removal of sand tubes outside of the structure's fillet.

As is the case with alternative No. 5, alternative No. 6 is expected to result in marginally diminished beach width along West Beach. Subsequent erosion has the potential to impact the market value of three (improved) parcels (Parcel Nos. 2604F006, 2604F004, 2641D026) due to land loss and potential capital (structure) loss. The current assessed value of these parcels is approximately $3.9 million. Similar to Alternative No. 6, mitigation action (e.g. nourishment along West Beach) as required by state legislation would limit any potential for future loss of use or value. Again, other parcels in the immediate vicinity of the Point will likely suffer losses due to decreased aesthetic appeal and loss of recreational values as beach width in that area is diminished over time.

Environmental effects of this alternative are expected to be similar to those described for Alternative No. 5. Exceptions include an anticipation of increased erosion that may

adversely affect the profile and width of dry beach habitat suitable for nesting sea turtles and expose frontal dunes to impact and overwash during storm events. Further, removal of the sand tube groins may alter or diminish nesting benefits associated with a more stable beach. However, to the extent that the presence of the sand tubes may currently be affecting nesting behavior, or inducing anthropogenic relocation of sea turtle nests their removal may induce benefits.

Construction of the terminal structure will induce temporarily reduced recreation value and aesthetic appeal due to the presence of construction equipment and associated noise and congestion. The aesthetic quality of the structure itself may also impact property values in the area. Further, to the extent that the structure serves to attract recreationists, property owners in the vicinity may suffer losses associated with crowding and reduced aesthetic appeal.

The negative effect on the segment of shorefront from removal of stabilizing sand tube structures outside of the terminal groin's fillet is expected to increase both beach fill requirements and littoral transport westward, toward the navigation channel. Hence, some level of additional shoaling within the navigation project could potentially result as a result of this alternative. The project engineer has quantified volumes of sand retained on the beaches adjacent to the federal channel by alternative over the first three years (refer to Section 5.2). These relative volumes are proportional to the volume of sand that may shoal into the navigation channel (refer to Section 5.12.4). In addition, cumulative sedimentation and erosion changes have been modeled and graphically depicted in Figures 5.30 through 5.36 for each alternative. Based upon the engineer's analysis, Alternative No. 6 is expected to result in a 4.8% increase in shoaling relative to Alternative No. 5. A more detailed analysis is provided within the Engineering Report (Olsen 2013).

Relative to alternative No. 4, Alternative No. 6 is expected to result in less erosion and associated adverse effects. However, based upon engineering assessments, the shoreline beyond the limits of the updrift benefits of the terminal groin would be susceptible to increased instability and erosion - compromising beach profile and beach widths - and potentially compromising dune habitats.

If unanticipated negative impacts to the coastal and marine environment necessitate groin removal, it is estimated by the Applicant's engineer that physical costs for removal will total approximately $2 million. Additional temporary costs due to reduced recreation and aesthetic appeal should also be anticipated.

b. Benefits: As is the case with Alternative No. 5, the use of a terminal groin coupled with a shoreline protection plan is expected to provide long-term infrastructure protection, enhanced beach width and volume, enhanced recreation opportunities, and increased rental and tax revenues nearest the Point. These benefits are not expected to be as large without the additional stabilizing function provided by the sand tube groinfield. However, the removal of the existing sand tube groin field can be expected to improve aesthetic appeal as well as enhance recreation value due to removal of the physical constraints imposed by the structures.

Further, given the location of the Club relative to the existing footprint of the groinfield, it is not known whether the proposed future expansion will take place under Alternative No. 6.
As with Alternative No. 5, the terminal groin could result in a small net reduction in local wave height and energy to the west of the structure. Such a modification to wave climatology would be expected to be result in aggregate net benefits to commercial and recreational vessels.

5.14.3 Summary of Economic Analysis

This economic analysis has outlined the nature, scope and complexities associated with the costs and benefits of the proposed alternatives for the Bald Head Shoreline Stabilization Project. Table 5.7 below provides a conceptual framework for understanding the scope of the alternatives.

Each alternative action creates a unique set of costs and benefits. Consideration of these values conveys an obvious sense that no matter the choice, tradeoffs are unavoidable. Complicating the analysis of the available alternatives is the fact that many important outcomes are highly unpredictable. Alternatives that involve the construction of a terminal groin provide an improved probability of shoreline stability, enhanced property values and associated economic impacts and cost savings due to reduced future need for nourishment. However, the terminal groin may result in unanticipated deleterious effects on adjacent or proximate shorelines of Bald Head Island. Absent the terminal groin, there will be a great deal of uncertainty pertaining to the future economic condition of physical capital on Bald Head Island and an array of associated economic value and activity.

5.15 LAND USE

The Village has developed a CAMA Land Use Plan and has adopted its own policies regarding planning and resource management. These policies promote natural resource protection and management and guide responsible development. The Village supports state and federal laws designed to manage development in Ocean Hazard Areas of Environmental Concern and Estuarine Shoreline Areas of Environmental Concern (AECs).

Specific upland uses within the project study include low- and medium- residential, recreational, government, Association Owned Property (AOP) and a few properties acquired by the Smith Island Land Trust (SILT). The Conservation Trust of North Carolina has placed conservation easements on SILT properties.

Table 5.7: Scope of Costs and Benefits by Alternative.

Costs (*ceteris paribus*)						
Alternative	**1**	**2**	**3**	**4**	**5**	**6**
Construction and Maintenance (NPV[18])	$4.59 – $7.33 M	$250,000	$33.04 - $53.72 M	$35.99 - $58.51 M	$37.3 – $50.72 M	$43.79 - $61.32 M
Additional channel maintenance	Low	High	Intermediate	Highest	Low	Intermediate
Reduction in tax base	Intermediate	Highest	Low	High	Low	Low
Parcels affected	17	95	1[19]	64	2	3
Transition costs	Intermediate	Highest	Low	High	None	None
Diminished recreation value	Intermediate[a]	High[b]	Intermediate[a]	High[b]	Intermediate[a]	Low[a]
Diminished aesthetic value	Intermediate[c]	High[b]	Intermediate[c]	High[b]	High[c,d]	Intermediate[d]
Environmental damage	Range of potential beneficial and adverse effects for each alternative described in EIS. Relative effect determination pending completion of NEPA analysis.					
Public non-use value losses (nature)	Low	Intermediate	Low	High	Highest	High
Public non-use value losses (BHI)	Intermediate	Highest	Low	High	Low	Low

Benefits (*ceteris paribus*)						
Alternative	**1**	**2**	**3**	**4**	**5**	**6**
Reduction in future nourishment expense	Intermediate	N/A	Low	Low	Highest	High
Enhanced property value	None	None	Intermediate	None	High	High
Enhanced Recreation value	None	Low	None	Low	High	Highest
Environmental condition	See Table 5.6 and Appendix Q					
Public non-use value (nature)	Intermediate	Highest	Intermediate	High	Intermediate	Low

[18] Lower value in range corresponds to discounted present value of current and future costs calculated using a 6 percent discount rate. Higher value corresponds to 2 percent discount rate.

[19] Assumes that sand tubes are not allowed to fail. If any one of the sand tubes does fail (e.g. during a storm) then several other neighboring lots are placed at risk.

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: The Village supports the efforts of the US Army Corps of Engineers in its efforts to dispose of sand in accordance with the SMP (VBHI 2006). As such construction activities associated with the SMP would be in compliance with the Village's Land Use Plan.

Predictive results from Delft3D modeling indicate that the most pronounced seabed erosion and shoreline recession under Alternative #1 is in the vicinity of the Point with a small degree of sediment accretion along West Beach. The implementation of this alternative adversely impacts residential uses located immediately eastward of the Point.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: The anticipated shoreline recession rates predicted under the Retreat alternative would result in significant upland losses and direct impacts to land use. There will be a loss of a number of residential homes, thereby impacting residential uses, and AOP owned property. There will also be a loss of recreational uses associated with Bald Head Island Club and golf course. The Village supports the relocation of structures endangered by erosion given that all relocated structures are in compliance with designated use policies and regulations, including the flood plain ordinance.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

a. Direct, Indirect and Cumulative Impacts: Alternative #3 would result in similar conditions to those identified under the No Action Alternative with the exception of a shoreline loss that is periodically mitigated through a Village-sponsored nourishment action. While there would be endangerment of several residential structures fronting the Point by Year 9 of the model simulation, there are no direct impacts to existing upland uses.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: It is the Village's intention to conserve and maintain shorelines, floodplains, major dune ridges and other coastal features for natural storm protection functions and natural resources giving recognition to public health, safety and welfare issues (VBHI 2006). As such, beach disposal or fill (either through federal SMP disposal or through Village-sponsored action) would be in compliance with the local land use ordinances.

Similar to the Retreat Alternative, Alternative #4 Delft3D modeling results predict that within nine years, there would be substantial shoreline recession which would directly impact upland uses including residential uses, recreational uses, AOP properties, as well as roads and infrastructure supporting upland land use. Relocation efforts would be supported given that all relocated structures and infrastructure are in compliance with the designated land use of that area.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Similar to above, beach nourishment/beach disposal and terminal groin construction would aid the Village in its effort to conserve and maintain shorelines, floodplains, major dune ridges and other coastal features for natural storm protection functions and natural resources. Installation of a terminal groin would ultimately serve to maintain existing upland uses. Alternative #5 results in no predicted impacts to local land use.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Impacts to land use resulting from Alternatives #6 would be comparable to those identified above (Alternative #5) with the exception of

potential indirect effects to land use associated with the endangerment of infrastructure along portions of South Bald Head Wynd.

5.16 HYDRODYNAMICS

Refer to Section 5.12 (Navigation) for a discussion of predicted hydrodynamic conditions under each alternative.

5.17 INFRASTRUCTURE

5.17.1 Background

The present day array of commonly owned (i.e. "public") infrastructure potentially affected by beach erosion and associated shoreline recession at Bald Head Island in proximity to the Cape Fear River is comprised of roadways and sub-grade utilities including sewer, water distribution, fire suppression, power, communications, and stormwater ponds. Note that there are 16 groundwater well sites that, in combination with Brunswick County water main line, provide the Island residents and visitors with potable water. In addition, there are privately held infrastructure components associated with the facilities at the Bald Head Island (BHI) Club. While wastewater is primarily collected via sewer and treated by a package treatment system, there are a few individual septic tanks for single-family residences that are still in existence. In particular, there are privately-owned and operated septic tanks and attendant lines for four homes on Cape Fear Trail (located within the permit study area and in close proximity to the Point). Figure 5.37 depicts the location and extent of the existing road, sewer line, and water line network on the Island. The locations of the 16 groundwater wells are also depicted.

Most major utilities run below, or immediately abutting, the primary thoroughfares utilized for daily commuting or work vehicles known as "Wynds" (i.e. North Bald Head Wynd, or

South Bald Head Wynd, or West Bald Head Wynd). Utilities are ultimately distributed throughout a network of secondary thoroughfares that are residential hard-surfaced streets, or "trails." Similarly, privately-owned infrastructure endangered by erosional processes is principally associated with major habitable structures, furnishings, pools, outbuildings, over-walks, pavilions, etc. It should be noted that South Bald Head Wynd (SBHW), West Bald Head Wynd (WBHW), and North Bald Head Wynd (NBHW) are the primary evacuation routes, as well as emergency services routes, for portions of the oceanfront and riverfront residential properties.

5.17.2 Predicted Effects to Infrastructure

The principal source of predicted future effects of shoreline change on existing infrastructure is the 9-year numerical simulation of future MHHW location(s) presented in Section 5.2.1 (ref. Figure 5.8). Based upon these results, the predicted relative effects for each of the six alternatives are described below.

(1) No Action/Status Quo (Alternative #1)

The implementation of this alternative adversely impacts numerous residential structures located immediately eastward of the Point as it exists today. It is predicted that the Point's present-day configuration would be lost to erosion by Year 9 of the simulation. As a result, Cape Fear Trail and associated sub-grade utilities would be subject to loss. Without action and capital expense by the Village to remove and relocate these utilities, sewer lines and water lines could become exposed to open water. In addition, all four of the existing private septic tanks would become exposed due as a result of the extent of erosion predicted along this area of shoreline.

(2) Retreat (Alternative #2)

The predicted effects of Alternative #2 over the 9-year period of numerical analysis result in a large-scale land loss of 48.6 acres of existing uplands located along western South Beach,

the Point, and West Beach. The associated impacts would include the loss of over one mile of roadways, including portions (or all of) the following streets: Water Thrush Court, Royal Tern Court, Cape Fear Trail, Sandpiper Trail, SBHW, and WBHW. Under this alternative, the Village would implement a management plan to relocate critical right-of-ways and utilities. Other secondary streets would likely be removed in advance of the erosion and not relocated. For instance, Sandpiper Trail, Water Thrush Court, and portions of Cape Fear Trail and Royal Tern Court would likely be removed at an expense to the Village. Affected portions of SBHW and WBHW would likely need to be relocated a significant distance landward of the predicted nine-year shoreline position. To do so would necessitate the acquisition of right-of-way corridors on land currently owned and utilized by the BHI Club. New right-of-way corridors would also need to provide the necessary easement areas for new utility lines.

In addition to roads and utility lines, the relocation or demolition of several single-family homes and boardwalks would be required as part of this alternative. Furthermore, at least four septic tanks and attendant lines (for homes located on Cape Fear Trail) would need to be removed in advance of erosion.

Amenities and utilities owned by BHI Club are also subject to direct loss via erosion within the nine-year simulation. These features include a swimming pool, tennis courts, ingress and egress roads, parking lots, the Club facility itself, golf course greens and fairways, and permitted stormwater ponds.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

For the period of analysis modeled, implementation of Alternative #3 would not cause any direct impact to infrastructure. However, as evidenced in prior years, Village-sponsored nourishment would not be able to keep pace with sand deficits along western South Beach. The net result would be the endangerment of several residential structures fronting the

Point by Year 9 of the model simulation. In addition, deflation of the beach profile in front of BHI Club would place this segment of SBHW at risk of inundation and loss during storm events. Associated utility lines may likewise be susceptible to damage or loss at this location during storms.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

Alternative #4 would result in large-scale upland losses with accompanying major damage to private and public infrastructure. The extent and nature of infrastructure losses associated with this alternative would be very similar (and only slight less) than those associated with Alternative #2. For instance, for Alternative #4 would result in the loss of nearly 5,000 lf of right-of-ways (approximately 930 lf less than that predicted for Alternative #2). Much of the critical infrastructure and amenities for the BHI Club would not likely be subject to direct loss (at least within the first nine years of the model simulation). However, portions of one stormwater pond would likely be converted to subtidal bottom as a result of the extent of shoreline erosion. Furthermore, deflation of the beach profile would likely result in more frequent overwash, inundation, and subsequent indirect impact to permitted stormwater ponds of the Club.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

Alternative #5 results in no predicted or imminent loss of private or public infrastructure.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

Alternative #6 likewise results in no numerically *predicted* impacts to private or public infrastructure over the period of analysis. However, beyond Year 9 of the model it should be assumed that the segment of SBHW and any abutting sub-grade utilities, would be endangered in the area lying southward of the BHI Club facility. Simplistically, those impacts would be experienced sometime beyond year 9 due to the removal of the sand tube

groinfield which artificially stabilizes the shoreline segment of predicted impact. The latter coincides with a point of inflection in shoreline orientation which lies eastward of the zone of predicted benefit associated with a terminal structure. As such, the subject section of South Beach shorefront is an area of documented high erosional stress.

5.18 URBAN QUALITY

The location of the project study area is within the Cape Fear River estuary and nearshore waters of the Atlantic Ocean. There are no urban quality impacts associated with implementation of any of the six alternatives considered for the Village of Bald Head Island Shoreline Protection Project.

5.19 SOLID WASTE

Project alternatives evaluated as part of this EIS would be limited to open waters of the Cape Fear River estuary and the immediate beachfront of Bald Head Island. Disposal of any solid waste material into area waters will not be permitted. However, implementation of Alternative #2 (Retreat) would require demolition of infrastructure and residences as the shoreline recedes into existing developed uplands. The demolition and transport of these materials to an approved solid waste facility would require a solid waste disposal plan in advance of the eroding shoreline. Furthermore, implementation of Alternative #4 (which is predicted to result in considerable upland erosion without planned retreat) would pose a risk of solid waste coming into contact with surface waters as structures (including homes, decking, roads, sub-grade utilities, etc.) become susceptible to loss from acute erosion.

5.20 DRINKING WATER

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: Maintenance of the Wilmington Harbor navigation channel would be limited to open waters of the Cape Fear River estuary and the immediate beachfront of Bald Head Island. Municipal and private water supplies are not located within the limits of the SMP impact area therefore; drinking water would not be impacted by construction activities associated with the SMP.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: The predicted approximate location of the MLLW shoreline at the end of a nine-year simulation of Alternative #2 indicates that seabed erosion will extend into the existing infrastructure along West Beach and South Beach. The potable water is supplied to Bald Head Island through a forced water main from mainland Brunswick County as well as a series of state approved groundwater supply wells. It is anticipated that threatened utility services, including potable water lines, would be relocated or removed in advance of erosional losses to prevent contamination of the VBHI drinking water supply. Likewise, the Village's groundwater wells are beyond the limits of the nine-year simulated impact area and will therefore likely remain unaffected.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

a. Direct, Indirect and Cumulative Impacts: Both implementation of the SMP and beach nourishment associated with an independently-sponsored nourishment project would be limited to open waters of the Cape Fear River estuary, nearshore waters of the Atlantic Ocean and the immediate beachfront of Bald Head Island. Municipal and private water supplies are not located within the limits of the SMP impact area therefore; drinking water would not be impacted by construction activities associated with the SMP.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: Given that this alternative considers the implementation of a managed shoreline retreat, it is not expected that Alternative #4 would result in the direct impact to the drinking water supply on the island. However, several potable water lines within existing right-of-ways in proximity to South Beach and the Point would be susceptible to erosion-related impact over the nine-year simulation and beyond. These lines would need to be removed and relocated as the shoreline receded. Given the fact that those lines that supply water to several residences may remain unaffected by erosion, some disruption to the drinking water supply is possible during the period that lines are repaired or replaced. In the context of past, present, and reasonably foreseeable future projects, no cumulative impacts to the drinking water supply is expected.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

Construction of the terminal groin structure would be limited to open waters of the Cape Fear River estuary and the immediate beachfront of Bald Head Island. In addition, concurrent placement of a sand fillet utilizing either derived materials from maintenance of the federal channel or a nearshore borrow area would be limited to open waters of the Cape Fear River estuary, the Atlantic Ocean and the immediate beachfront of Bald Head Island. No direct, indirect, or cumulative impacts are expected as a result of the implementation of Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

No direct, indirect, or cumulative impacts are expected as a result of the implementation of Alternative #6.

5.21 NON-RELEVANT RESOURCES

5.21.1 Hazardous, Toxic and Radioactive Waste

There are no known hazardous, toxic or radioactive wastes in the project study area. There is a potential for hydrocarbon spills from heavy machinery associated with construction and/or demolition activities associated with each of the alternatives. Implementation of Best Management Practices for equipment fueling and maintenance as well as established spill prevention and control measures within the contract specifications would reduce the potential for hydrocarbon spills.

For Alternative #2, it is anticipated that threatened residences and infrastructure (including sub-grade utilities) would be relocated or removed in advance of erosion to reduce the potential for releases of hazardous wastes.

For Alternative #4 (which is predicted to result in acute erosion to South Beach and the Point without planned retreat), residences and infrastructure (including remaining septic tanks) would become susceptible to loss and exposure to open water. As a result, there is potential for the release of hazardous waste under this alternative.

No other adverse effects related to hazardous, toxic, and radioactive waste are predicted for the remaining alternatives.

5.21.2 Noise

Under each of the alternatives considered, there would be temporary increases in noise levels associated with the operation of heavy equipment during dredging, disposal/nourishment, and associated construction work (including demolition and relocation work for Alternative #2). Noise levels should not exceed those of a typical construction site or passing commercial vessel (including daily-operated ferries that arrive and leave from the Bald Head Island Marina). Noise levels would return to ambient levels

upon project completion. Baseline underwater sound levels at the dredge site would temporarily increase during active dredge operations.

5.22 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The Applicant will comply with all applicable federal and state laws (refer to Section 1.0 for summaries of laws applicable to the proposed action). No construction will occur until such time a Record of Decision (ROD) and Department of Army (DA) permit has been issued for work in Section 10 and Section 404 regulated waters of the United States. The DA permit will also include a Section 404(b)(1) evaluation. A separate Section 401 Water Quality Certification will be required from the North Carolina Division of Water Resources (DWR). The Applicant has been asked about other planned activities to reduce erosion in the project area, and has stated that no other actions are contemplated or planned. Therefore, the proposed action is considered a single and complete project. Future stabilization actions not evaluated in the EIS would be subject to NEPA review. Additionally, use of Frying Pan Shoals as a borrow site would require additional environmental review and NEPA consideration.

A CAMA Major Permit application will be submitted to the NC Division of Coastal Management (DCM) to ensure compliance with the NC Coastal Area Management Act; the NC Dredge and Fill Law; and the requirements of SB 151. The requirements of SB 151 are outlined in Section 1.0 of the EIS. A copy of the entire legislation is provided in Appendix A. In response to these requirements, the Applicant and its engineered have developed an Inlet Management Plan (refer to Appendix B). The Inlet Management Plan was submitted to NC DCM for review and comment. Based upon comments received from DCM, the Applicant revised the document. DCM has indicated that latest version of the plan is sufficient to satisfy the inlet management plan requirements of Session Law 2013-384 (Senate Bill 151). However, DCM will take into consideration any comments received on the plan during the permit application review process, and if necessary, will initiate further coordination with

the Applicant prior to taking final action on the permit application. In addition, proof of financial assurance has been submitted to the State of NC for verification of compliance with SB 151 and G.S. 113A-115.1(h) in the form of a general obligation bond and local government taxing or assessment authority adequate to cover the cost of the proposed action including: long-term maintenance and monitoring of the terminal groin, implementation of mitigation measures, and modification or removal of the terminal groin. No work will be conducted until such time all applicable federal and state authorizations have been issued.

The EIS complies with the guidelines set forth in Executive Order 11988 regarding work conducted within the Special Flood Hazard Area. The Applicant's proposed action (installation of the terminal groin with the required sand fillet) will occur within the 100-year floodplain. The federal NEPA review has allowed for public review via scoping, public meetings, and public notices. The nature of the project (shoreline protection) warrants work within the 100-year floodplain. However, as is the case with beach restoration, the proposed activity will reduce potential flood damage from both storm surge and wave activity through the creation of wider and more stable beaches seaward of habitable structures. Alternatives to location within the floodplain have been considered.

In accordance with Title III of the Civil Right Act of 1964 and Executive Order 12898, it has been determined that the proposed action would not directly or through contractual or other arrangements, use criteria, methods, or practices that discriminate on the basis of race, color, or national origin nor would it have a disproportionate effect on minority or low-income communities. According to the Environmental Protection Agency's EJView Mapper, less than 10% of the population in the vicinity of the project area is minority, and the average per capita income is $64,000. According to the 2010 US Census Bureau, 14.7% of the population of Brunswick County is minority, and the per capita income of Brunswick County is $27,100.

SECTION 6.0 – AVOIDANCE, MINIMIZATION AND MITIGATIVE MEASURES

CEQ regulations (40 CFR 1508.20) define mitigation to include: (1) avoiding the impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the lifetime of the action; and (5) compensating for the impact by replacing or providing substitute resources or environments.

The following section describes the avoidance, minimization and mitigation measures related to terminal groin design, construction, monitoring, threatened and endangered species, and cultural resources. The Applicant has completed an Inlet Management Plan (IMP) that provides detailed information regarding required plan components including: (1) determination and type of data to define the baseline condition; (2) post-construction monitoring to compare baseline data and assess potential adverse impacts; (3) timeframes for post-construction monitoring; (4) identification of thresholds for implementation of mitigation measures; and (5) mitigation measures that may be implemented. The complete IMP (Appendix B) has been determined to be compliant with SB 151 per NCDCM review and concurrence. Elements of this plan are discussed in Section 6.3 below.

6.1 TERMINAL GROIN DESIGN

The Applicant's engineer (Olsen Associates, Inc.) considered and evaluated several design parameters influencing structure performance while concurrently minimizing potential adverse effects to resources of the project area. Varying options related to structure template (length and width), elevation, and permeability have been evaluated to determine the level of performance relative to the design goals (see Appendix I and Engineering Report – Olsen 2013). Design goals relevant to reducing adverse effects included, but were not limited to, the following: (1) reduce sediment transport rates from the westernmost segment of South Beach to the Cape Fear River and thus avoid potential navigation impacts associated with increased shoaling; (2) minimize the potential for adverse impacts to a downdrift shoreline (e.g. West Beach); (3) preclude impacts to other coastal barrier islands; (4) minimize or reduce future maintenance requirements for portions of an existing sand tube groinfield located along South Beach; (5) reduce the need for future dredge and fill projects by extending the effective life and benefit level of federal disposal and Village-sponsored nourishment.

In order to achieve the design goals as outlined above, the following design precepts were considered and evaluated:

(1) Porosity – the structure should be sufficiently permeable (or "leaky") as to limit its effectiveness in the long-term impoundment of sand.

(2) Template (length and width) – the direct, as well as synergistic effects of the groin structure should provide an equilibrated profile or template for the stabilization of the updrift South Beach shoreline sufficient to last between federal beach disposal events, *i.e.*, nominally two to three years. The beach profile is expected to progressively reduce in size between sand placement events.

(3) Elevation – portions of the groin should be sufficiently low such that wave overtopping and resultant sediment transport can occur past the structure during periods of energetic wave conditions.

(4) Settlement – the structure should have a foundation designed to be highly resistant to long-term settlement so as to substantially reduce future maintenance requirements.

(5) Adjustment – the structure should be capable of post-construction "tuning" if deemed necessary to refine performance characteristics.

(6) Constructability – the structure should be adequately robust so as to resist damage during low probability storm events, but at the same time sufficiently straight forward in design to assure cost-effective constructability in a highly energetic and dynamic environment.

The precepts above have been used by the applicant's engineer to develop a structural design that meets the applicant's goals regarding optimal performance while concurrently reducing potential adverse effects to both natural resources and the human environment. The design process itself considers various structural characteristics that ultimately define performance relative to the design goals. Evaluations of design characteristics such as permeability and length are described in Appendix I and the Engineering Report (Olsen 2013).

The engineer has identified a 1,900 lf terminal groin as the most appropriate length offering an apparent acceptable balance between maintaining the updrift objective of the structure while minimizing the possibility of downdrift impacts (Olsen 2012). In contrast to conventional groin or jetty structures which are typically designed to be sand-tight, the proposed terminal groin is relatively permeable, or leaky, allowing some level of sand and water transport over and through the structure. The mid-length structure coupled with a semi-permeable design would avoid any potential adverse effects to active and passage migration of surf zone fishes and larvae and minimize potential erosion to downdrift beaches. In addition, the Applicant proposes to construct the groin in two phases, with the

Phase I structure being approximately 1,300 lf in length. The phased construction approach is discussed further below as well as in Section 3.2.5.

6.2 CONSTRUCTION METHODS AND SEQUENCING

It is the intent of the applicant to utilize sand from the next Wilmington Harbor maintenance event as the principal source to meet the sand fillet requirement of SB 151. Doing so would potentially avoid, or at least minimize disturbance to other potential sand source sites and would make use of a disposal event that will occur irrespective of the Village's Shoreline Protection Project. Maintenance dredging of the Wilmington Harbor navigation project and associated disposal is conducted in accordance with environmental commitments identified in the Environmental Assessment (EA) for preconstruction modifications of the authorized improvements to Wilmington Harbor (USACE 2000). In addition, federal disposal would allow retention of material within the littoral system and thus likewise ensure the placement of beach-compatible sand on recipient sites.

In the event that the Village is unable to make use of, or is required to supplement a SMP disposal event for the sand fillet, four prospective sand source sites have been identified (as described in prior sections of this EIS). All of the borrow sites are depositional features containing sediments of high sand content (>90%). As such, the site conditions are more favorable for both physical recovery (through infilling of sediments of similar texture) and biological recovery (through recruitment of benthic infauna of adjacent undisturbed areas) (Pullen and Naqvi 1983; Posey and Alphin 2002). Site-specific geotechnical data is available for the Jay Bird Shoals, Bald Head Creek Shoals, and the Wilmington Harbor Entrance Channels (see Section 4.0). In addition, geotechnical evaluations of sediments within Frying Pan Shoals were conducted by the USACE as part of the General Reevaluation Report (GRR) for this 50-year project. The findings of these analyses were reported in the Brunswick County Beaches Renourishment Study (Catlin 2010). Based on compatibility analysis criteria

for percent silt content, percent shell content, mean grain size and standard deviation from sediment sampling within Frying Pan Shoals, the material from the borrow area identified in the GRR is largely compatible with the native beach material (Catlin 2010)[1]. Post-dredging physical monitoring for any of the shoal sand source sites would also be performed to evaluate physical recovery rate of the dredged site.

All beach fill material would comply with the State of North Carolina Technical Standards for Beach Fill Projects (15A NCAC 07H .0312). The Technical Standards require the characterization of sediments from the recipient beach and the proposed borrow sites. Sediment characteristics that are considered include percent weight of fine-grained sediment, percent weight of granular sediment, percent weight of gravel, and percent weight of calcium carbonate. Temporary shore-parallel dikes would be constructed in the immediate construction area as needed to control the effluent, decrease turbidity levels in the water, and maximize the settling of sediments from the discharge before entering the ocean.

The timing and sequencing of nourishment actions for both the initial required fillet and for subsequent adaptive management would reduce potential adverse impacts to natural resources. Federal disposal operations are generally confined to the period of the year between November 15th and April 1st. The proposed groin construction would occur immediately subsequent to the federal disposal of sand on South Beach. Based upon coordination with the USACE Wilmington District Navigation Branch, the Village will not perform any groin construction activities on South Beach until the USACE dredging contractor has completed the federal channel maintenance disposal project and has demobilized all equipment and pipeline from that location. As a result, actual groin construction is expected to begin April 2015 and continue for four to six months (pending

[1] The Village would be required to collect sufficient site-specific geotechnical data to ensure compatibility of the dredge sediments with the recipient beaches and to comply with state sediment criteria.

weather conditions and the specific method of construction employed by the contractor). The start of groin construction immediately following federal disposal will theoretically allow for sand to be transported westward toward the structure and will help minimize its lee side effects. Supplemental sand that may be needed for fillet formation is anticipated to be obtained from the Jay Bird Shoals borrow site, since the Federal channel will have been recently dredged to authorized dimensions and will therefore be unavailable as a borrow source. Based upon the anticipated schedule for groin construction, any supplemental nourishment action (for fillet enhancement) would occur during the following winter.

Specific construction practices will be employed to minimize the potential adverse effects of construction activities on the beachfront and nearshore waters during the late spring and summer months. These include: (1) phased construction of the terminal groin (as described in more detail below); (2) utilization of high quality beach compatible material for the fillet; (3) utilization of a foundation mattress that will reduce the rock volume in the water and minimize maintenance actions; (4) individual placement of armor stone (rather than dumping of stone which would otherwise introduce debris into the water); and (5) restricting work to daylight hours. In addition, the Applicant has coordinated with the USFWS and NMFS (in accordance ESA Section 7 consultation requirements) for specific conservation measures and reasonable and prudent measures (RPMs) to be employed to minimize potential adverse effects to endangered species (including sea turtles). These measures are described further in Section 6.5 below. A list of all USFWS conservation measures, RPMs, and terms and conditions are provided in the project Biological Opinion (BO) in Appendix S.

The Applicant proposes to construct the groin in two phases, with Phase I consisting of the installation of an approximate 1,300 lf structure. The phased approach would reduce the sand volume requirement for the fillet and thus minimizes the need for any supplemental sand from the proposed sand source sites for the initial construction. The Phase I structure

would require considerably less rock and therefore would reduce the time necessary for construction. This, in turn, would help to limit the period of work performed during the bird and turtle nesting seasons. Phasing would also promote more rapid activation of sand bypassing and limit any potential downdrift effects to West Beach. Lastly, the Phase I structure would provide the opportunity for monitoring to determine the timing and physical extent of the Phase II structure (which would not exceed a combined 1,900 lf).

The Applicant has identified the proposed limits of work including the proposed material staging area, transport corridor, and work limits for the fillet formation (see Figure 3.3). All project-related construction activities would remain within the established construction area to minimize impacts to environmental resources. The terminal groin and fillet work area would be limited to the westernmost 2,500 lf of South Beach (an area of documented chronic erosion). This constitutes less than 12% of the total West Beach and South Beach shoreline length.

If supplemental sand is necessary for the fillet, all construction pipes that would be placed on the beach would be located as far landward as possible without compromising the integrity of the dune system. The Applicant would seek to perform any dredging associated with the terminal groin fillet construction or maintenance, outside of the sea turtle moratorium – unless necessitated by an emergency condition. The Applicant would also limit all terminal groin construction activities to daylight hours only. Specific construction practices intended to avoid and minimize potential adverse effects to threatened and endangered species are provided in Appendix S.

6.3 INLET MANAGEMENT PLAN

In accordance with the requirements of SB 151, the Village formulated an Inlet Management Plan (IMP) for management and monitoring of the inlet, estuarine and ocean shorelines immediately adjacent to and under the influence of the inlet. The IMP (Appendix B) details the following monitoring and mitigation actions:

1. Describes the post-construction activities that the applicant will undertake to monitor the impacts on coastal resources;

2. Defines the baseline for assessing any adverse impacts and the thresholds for when the adverse impacts must be mitigated;

3. Provides for mitigation measures to be implemented if adverse impacts reach the thresholds defined in the plan; and

4. Provides for modification or removal of the terminal groin if the adverse impacts cannot be mitigated.

6.3.1 Post-Construction Physical Monitoring

The Village of Bald Head Island, NC (Village) has performed comprehensive beach monitoring of South Beach, The Point and West Beach since 1999. Prior to that date, less formal surveys of the "dry" beach (only) were also accomplished at varying dates in time. In 2008, East Beach was added to the current monitoring plan. Elements of the present day survey program under the SMP include the nearshore portions of Bald Head Shoal and the abutting federal navigation project. Borrow sites are likewise monitored for a typical three-year period post-excavation. Post-construction monitoring (both biological and physical) has been conducted by the Village for prior nourishment projects that utilized sand from Jay Bird Shoals and from the shoals of Bald Head Creek. More complete information regarding the existing survey work performed by both the Village and the USACE (for the Wilmington Harbor Deepening Project) is provided in the IMP.

6.3.1.1 Beach Surveys

Bald Head Island

The Applicant will continue to perform comprehensive annual beach monitoring as carried out over the past thirteen (13) years at Bald Head Island. The survey baseline for this work is depicted by Figure 1 of the IMP. Several additional profile lines will be added to the existing survey program in the vicinity of the terminal structure (see Figure 2 of IMP). In addition, the project surveyor will be required to annually perform an approximate MHWL survey between Sta. 0+00 and 75+00 (see Figure 3 of IMP). Each survey will be compared to prior surveys and utilized for trend analysis. Digitally controlled aerial photography taken at approximate 6-month intervals will likewise be used to supplement analysis of the post-terminal groin shoreline condition.

According to the plan, the first post-construction MHWL survey will be performed within 30 days of the completion of the proposed terminal groin and updrift beach fill, thereby documenting the as-built shoreline condition. The entire island-wide monitoring surveys will be performed on a six-month basis at the same approximate time as previous seasonal survey program addressed by the existing (pre-terminal groin) comprehensive island-wide beach monitoring program.

Oak Island

For approximately the past 12 years, the Wilmington District, USACE has performed comprehensive physical monitoring which included both the Oak Island and Bald Head Island shorelines. As a result, a comprehensive data base has been developed which portrays shoreline changes at both locations for over a decade. For purposes of assessing post-construction oceanfront shoreline conditions on the eastern end of Oak Island, the Village's coastal engineering consultant will utilize publicly available survey data acquired by the Wilmington District, USACE (see Figure 4 of IMP). Similarly, the consultant will access and utilize relevant federal aerial photography of the Oak Island area of interest.

Should the USACE terminate the annual acquisition of survey data on Oak Island, the Village will survey annually the east end of the island from Sta. 60 through Sta. 30, including half stations. The number of beach profiles surveyed is not anticipated to exceed seven (7). That data would be added to the database of information acquired by the Wilmington District beginning in 2000.

The Village proposes that its responsibility for analysis of post-groin physical surveying on Oak Island would terminate if six (6) years of monitoring subsequent to terminal groin structure completion fails to indicate a cause and effect relationship between structure installation, or borrow-site utilization, and oceanfront shoreline change at the eastern end of Oak Island immediately adjacent to and under the influence of the inlet.

6.3.1.2 Borrow Site Monitoring Surveys

The previously authorized borrow area located on Jay Bird Shoals was surveyed both immediately prior to and after construction of the 2009/10 Village-sponsored 1.8 Mcy beach restoration project. Subsequent surveys are being performed at 12-, 24- and 36-months and biennially thereafter. The area surveyed includes a minimum of 500-ft. of coverage outside the permit limits of the borrow site. Subsequent to a Post-Irene emergency dredging project at South and West Beach constructed in 2011/12, a Bald Head Creek borrow site is subject to annual surveys beginning in January 2013.

Subsequent to sand placements which may be required by the construction of the terminal groin based upon the borrowing of sand from within the unexcavated portion of the Jay Bird Shoal borrow site (previously authorized in 2009); the northward expansion of the borrow site at the entrance to Bald Head Creek; the Smith Island Range of the federal navigation channel, or any other permitted site, annual monitoring of that site will be performed pursuant to the terms of the associated Permit(s). Monitoring results will be addressed in each subsequent Village annual monitoring report.

6.3.1.3 Aerial Photography

The Village of Bald Head Island will continue to perform controlled (color) rectified digital aerial photography of the island shoreline(s) twice a year – usually coincident with the timing of each seasonal beach survey. The present minimum areas of coverage are the West Beach, South Beach and East Beach shorelines. Oblique low altitude photography is likewise performed periodically as required to document the occurrences of any storm, or man-made event of interest.

6.3.2 Mitigation Thresholds

6.3.2.1 West Beach

According to the Applicant's engineer, it is anticipated (and supported by in-depth modeling) that a portion of the West Beach shorefront will potentially require beach disposal on a 3-year basis – *with or without* terminal structure implementation. The proposed principal borrow source for interim small scale sand placement at that location (if necessary) will be the expanded Bald Head Creek borrow site. The assignment of "impact" on West Beach due to a terminal structure will therefore need to weigh the following site specific factors potentially affecting shoreline conditions downdrift of the groin:

- Interval between sand placement projects?
- Have average annual shoreline recession rates (volumes and MHWL location) increased by over 50%? Has beach fill equilibration been accounted for? Is the duneline being impacted?
- Can a documented cause and effect relationship be assigned to downdrift shoreline reconfiguration, or is any newly developed "hot spot" isolated and therefore not the result of a quantifiable trend?
- Do numerical modeling results support or refute the observed shoreline erosion trends?
- Can extraordinary meteorological conditions be defined as a cause of accelerated erosion?

- Have navigation channel maintenance operations changed in frequency or scope?

The baseline for action along West Beach (Sta 0+00 – Sta 24+00 by definition) will be determined by analysis of historical surveys along this reach acquired on almost a 6-month basis since 2000. Over this 14 year period, either the Village or the USACE have placed sand when the limit of erosion reached "critical" condition portions (in most cases where the limit of erosion was located at/or within the primary dune). All such landward limits of erosion locations are well documented by survey. Therefore, the "baseline" for remedial actions by the Village along West Beach will be the point at which the limit of upland erosion reaches its historical worst case condition – as documented by survey since 2000 – or is projected to reach such a condition in the next 6 months.

6.3.2.2 Oak Island (Fort Caswell)

According to the Applicant's engineer, in depth numerical modeling analyses of Oak Island predict no quantifiable impact to littoral transport patterns or rates and associated shoreline change at that location due to either terminal groin construction or the continued use of the Jay Bird Shoal borrow area (to the limits of excavation permitted in 2009). Nonetheless, the Village proposes a "baseline" for the initiation of "mitigation" pursuant to SB 151 from Sta. 60 to Sta. 30, the oceanfront shoreline immediately adjacent to and under the influence of the inlet. The Village has committed to delivering annually to DCM a report of its monitoring results. In the event the monitoring results disclose any potential shoreline change exceeding a baseline trigger, the Applicant proposes that a Technical Advisory Committee (TAC) be consulted. The proposed TAC would be comprised of a NC licensed professional engineer with substantial expertise and employment experience in coastal engineering from the Village, Oak Island Stakeholders and DCM (one from each, for three (3) total engineers) to review the results of the monitoring and analyses and to consider whether there is any terminal groin related impact on shoreline change exceeding the

baseline trigger. The TAC is proposed to be formally established prior to the completion of construction of the terminal groin project.

According to the Applicant's proposal, if the majority of the TAC finds that a shoreline impact exists because of the terminal groin, and not because of other causes, the Village would work with the TAC and affected interests at Fort Caswell to determine and implement appropriate adaptive response measures, consistent with the reasonableness and cost-benefit precepts of SB 151, or subsequent law.

The Applicant proposes that, should annual computed shoreline recession rates exceed by 50%, or more, the maximum measured annual recession rate (since 2000) at one or more of the designated survey locations, the TAC will be requested to evaluate and determine the source of the additional erosion. Similarly, if the updated long term trend rate varies by 50%, or more from its last published value, the TAC will be requested to evaluate and determine the source of the additional erosion or reduction in accretion (since 2000). In either event, a specific determination will be made, and a report submitted to DCM, regarding any expectation that the causation of additional erosion is related to the terminal groin project.

6.3.3 Mitigation

6.3.3.1 West Beach

Priority for any required mitigation on West Beach would be alongshore sand placement sufficient to protect endangered residential structures and the total loss of protective dune formations. The timing of a mitigative sand placement, however, may be adversely affected by factors such as design document formulation, dredge availability, and public project bid requirements. As a result, the following interim actions may likewise need to be considered: (1) sand bag revetment construction along the section of shorefront where threatened structures exist; (2) temporary borrowing of sand mechanically from the updrift

impoundment fillet of the terminal groin and placement along the affected shorefront; or (3) both actions.

Structure modification would also be considered as part of any remedial action plan. In most instances, such an action would consist of rock removal from the structure crest sufficient to increase its transmissivity to sand transport. That is to say, its permeability (or "leakiness") would be increased. Such an action would not be expected to result in immediate benefits. Hence, it should be considered to be a secondary response in the hierarchy of remedial actions. Note that terminal structure alteration is summarized briefly below and in more detail within the Applicant's IMP (Appendix B).

6.3.3.2 Oak Island (Fort Caswell)

According to the Applicant's engineer, comprehensive numerical modeling analyses indicate no probability of shoreline change at Oak Island as a result of the proposed action. As a result, the Applicant has proposed the use of a TAC which would be authorized to make a shoreline impact determination in lieu of just the Applicant (or its engineer). Any recorded increase in erosion on the eastern section of Oak Island that exceeds the baseline and is determined by the TAC to be caused by the Bald Head Island Shoreline Protection Project would most likely need to be mitigated through direct sand placement. The Applicant's hope is that mitigation could occur through a reapportionment of some portion of the federal disposal sand to that hot spot, rather than placement of the sand at a more stable or accreting location on Oak Island to the west of Fort Caswell. The USACE has not committed to, or considered, such a potential response. If the altered USACE disposal alternative is not available, the Village may consider, in consultation with the TAC, other measures to address the erosion, such as a sand push, sand stockpiling of disposal sand, sandbag or other revetment, sand placement redesign of the federal disposal project limits of fill, or, in an extreme circumstance and absent more reasonable, cost-effective alternatives, reduction in size or removal of the terminal groin.

6.3.3.3 Terminal Structure Alteration

As discussed in Section 3.0 and 5.0 of the FEIS, the proposed terminal groin is to be constructed as a "leaky" structure with some level of reduced sediment transport continuing to occur either through and/or over the structure crest. As a rubble mound structure, sand permeability can be physically increased through the removal of stones. Any reduction in effective structural elevation will increase sediment transport across the groin. Increased transport would be conducive to spit or dry beach growth on the downdrift side of the structure which, in effect, would be expected to increase sediment transport to West Beach. Such "tuning" of a permeable structure is often desirable even if mitigation is not required. Normally, tuning would not occur without the benefit of significant post-construction monitoring, since the transmissivity of such a structure varies over time – dependent upon the condition (*i.e.* size and elevation) of the updrift sand fillet, seasonal wave climatology, storm effects and other site specific factors. In an extreme circumstance, and absent more reasonable, cost-effective alternatives, effective "removal" or major dismantling of the structure may be required.

6.4 NATURAL RESOURCE MONITORING

The Applicant and USACE have coordinated with both NMFS and USFWS for Section 7 ESA consultation. As a result of the consultation process, a number of conservation measures have been developed in an effort to avoid and minimize potential adverse effects to listed species. Conservation measures, reasonable and prudent measures (RPM's) and terms and conditions of the USFWS Biological Opinion (BO) are provided in Appendix S.

The following is the summary of proposed natural resource monitoring (both during and after project construction). Additional mitigative measures are outlined in Section 6.5.

6.4.1 Sea Turtles

Intensive sea turtle nest monitoring will be performed by qualified personnel of the Bald Head Island Conservancy (Conservancy) within and immediately adjacent to the project area (including western South Beach and the Point). The monitoring will be performed throughout the portion of the construction time period occurring between May 1 and November 30 and will include the following elements:

a. Monitoring within the work areas will be performed at night in a regular, routine fashion by qualified sea turtle monitoring personnel;
b. Any nesting sea turtle encountered by Conservancy personnel will be tagged per standard operating procedures for the organization's Sea Turtle Protection Program as permitted by the NC Wildlife Resources Commission. BHI Conservancy will relocate all nests in the project area to eastern South Beach or to East Beach within two to three hours of nesting. Note that it is likely that these nests would have been relocated regardless of the project's timeline because of severe erosion in this area. These nests will be relocated to more stable, suitable nesting habitat located further east to ensure that no sea turtle nests are impacted from construction activities;
c. For any nests that have not been relocated, monitoring for emerging nests or hatchlings shall be conducted prior to initiating work and regularly thereafter;
d. If nest or hatchlings are within an area obstructed by equipment or nourishment activities, hatchlings will be transported by qualified Conservancy personnel to an area outside of the work boundaries. The hatchlings will be released at least 15 feet above the current water line and allowed to crawl into the ocean.

Immediately after completion of this project and prior to May 1 for three subsequent years, sand compaction will be monitored in the area of restoration in accordance with a protocol agreed to by the Service, the State regulatory agency, and Bald Head Island. If required, the area will be tilled to a depth of 36 inches. All tilling activity shall be completed prior to May 1. A report on the results of compaction monitoring will be submitted to the Service prior to

any tilling actions being taken. An annual summary of compaction assessments and the actions taken will be submitted to the USFWS. This condition will be evaluated annually and may be modified if necessary to address sand compaction problems identified during the previous year.

Visual surveys for escarpments along the project area shall be made immediately after completion of the beach nourishment project and prior to May 1 for three subsequent years. Results of the surveys will be submitted to the USFWS prior to any action being taken. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet will be leveled to the natural beach contour by May 1. The USFWS will be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service will provide a brief written authorization that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken will be submitted to the USFWS.

The sand-filled geotubes within the project area will be monitored to determine the depth at which each geotube lies beneath the sand, and the potential impacts to nesting sea turtles. Prior to May 1 each year, the Applicant will monitor the location and depth of each sand-filled geotube located within 2,500 lf of either side of the groin field. The depth from the top of the sand vertically to the top of the sand-geotube shall be measured at two locations for each geotube: the landward end and near the center (125-175 feet from the landward end, depending on the length of the geotube).

Sand tubes demonstrated to be non-functional via long-term burial, and as verified through a minimum of three years of monitoring, may be removed.

6.4.2 Shorebirds and Colonial Waterbirds

A bird monitoring plan will be developed to monitor piping plover, red knot, waterbirds, colonial waterbirds and other shorebirds during and after construction. Bald Head Island Conservancy (Conservancy) performs monitoring of the beaches and the Point during shorebird nesting season. The Applicant will coordinate with the Conservancy to ensure that bird monitoring is compliant with the terms and conditions of the USFWS Biological Opinion (BO). Monitoring will be conducted for a minimum of three (3) full years past the completion of both phases of groin construction, or until the end of the shorebird nesting season (August 31) of the third year after construction, whichever is later. Post-construction monitoring will only be ceased after the review of at least three years' worth of data and approval by the USACE, USFWS, NCDCM, and NCWRC.

During construction of both phases, bird monitoring will be conducted weekly. Between construction phases and for at least three years after construction is completed, bimonthly (twice-monthly) bird surveys will be conducted in all intertidal and shoreline areas along South Beach and West Beach. Field observations will be conducted during daylight hours, and primarily during high tide. Specific monitoring protocol is provided in the attached conservation measures, RPMs, and terms and conditions of the USFWS' BO (Appendix S).

6.5 ADDITIONAL MITIGATIVE MEASURES

As described above, the Applicant and USACE have coordinated with NMFS and USFWS through Section 7 ESA consultation. By way of this consultation, several conservation measures, RPMs, and terms and conditions have been identified to avoid and minimize potential adverse effects to threatened and endangered species. The following is a list of some of the measures drafted (organized by listed species). The list below is additive to the natural resource monitoring described above. For a complete list of conservation measures, RPMs, and terms and conditions, refer to Appendix S.

6.5.1 Loggerhead and Green Sea Turtles

•Only beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence shall be used for beach nourishment at the project site. Furthermore, sand of similar grain size and composition to that of the existing beach will be used to reduce any changes in physical characteristics of the beach that may affect nest survival. This material will meet the Technical Standards for Beach Fill Projects as published in the North Carolina Administrative Code (15A NCAC 07H .0312).

•Channel maintenance and beach disposal associated with the federal Sand Management Plan (SMP) are planned to be completed by April 30th.

•Staging areas for construction equipment will be located primarily on the northern and western riverfront shorelines (and not on South Beach). All construction materials that are placed on the beach will be located as far landward as possible without compromising the integrity of the dune system. Temporary storage of construction materials on the beach will be in such a manner so as not to compromise the integrity of the dune systems.

•To the maximum extent practicable, all excavations and temporary alteration of beach topography resulting from groin construction will be filled or leveled to the natural beach profile prior to dusk each day. During any periods when excavated trenches must remain on the beach at night, a barrier (e.g., hay bales, silt fencing) sufficient to prevent adult and hatchling sea turtles from accessing excavated trenches, etc., would be placed around the footprint of each groin segment above MHW.

•The Applicant will seek to perform any dredging associated with the terminal groin fillet construction or maintenance, outside of the sea turtle moratorium – unless necessitated by an emergency condition.

•The Applicant will limit all terminal groin construction activities to daylight hours only.

6.5.2 Manatees

•Proposed excavation work would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the western end of Bald Head Island.

•Groin construction would be spatially constrained to reduce the possibility of a collision.

•The majority of the dredging would occur during fall and winter months when populations of manatees are lower.

•The contractor will follow the USFWS' *Guidelines for Avoiding Impacts to the West Indian Manatee: Precautionary Measures for Construction Activities in North Carolina Waters*. Minimization and avoidance efforts identified in these guidelines include actions such as; educating personnel on manatee identification and observance, avoidance and civil penalties for harming, harassing or killing manatees under the Marine Mammal Protection Act and the Endangered Species Act. These guidelines also detail specific actions required in the event that a manatee is identified in the project area and resultant documentation regarding sightings, construction related collisions and/or injuries.

6.5.3 Sturgeon

Avoidance and minimization efforts for impacts to Atlantic and shortnose sturgeon are mainly related to minimization of impacts to foraging habitat. Beach quality sand with similar grain size and composition to that of the existing beach will be utilized for nourishment efforts reducing impacts to potential prey species and facilitating recovery of the benthos. Additional conservation measures including the use of temporary dikes to control effluent would further reduce foraging impacts. Maintaining slow speeds during

mobilization to the dredge site and during active dredging would also minimize the likelihood of collision.

6.5.4 Piping Plover and Red Knot

•All construction equipment would be prohibited from entering upland beaches associated with the Cape Fear spit feature as well as East Beach. Additionally, a specific construction corridor for the terminal groin would be established along the Point on dry beach between the dune line and MHW. These actions would provide readily available substitute habitat areas for any birds displaced by construction activities. Note that the proposed work area, including the material staging area, rock transport corridor, and fillet work area are depicted in Figure 3.3.

•To reduce changes in physical characteristics of the beach that may affect nourishment impacts on invertebrates, sand of similar grain size to the existing beach will be used.

•Although the direct footprint of the terminal groin may result in a permanent loss of foraging habitat, beach nourishment and groin construction would occur within highly eroded areas and would ultimately increase foraging habitat within the project area.

6.5.5 Seabeach Amaranth

•Beach disposal associated with the federal SMP would take place after November 15th, after amaranth plants have already released seeds.

•Seabeach amaranth surveys will be conducted in the project area, including at least 2,500 lf on each side of the groin along South Beach and West Beach, for a minimum of three years after completion of groin construction. Habitat known to support this species, including the upper edges of the beach, lower foredunes, and overwash flats will be visually surveyed for

the plant. Annual reports should include numbers of plants, latitude/longitude, and habitat type.

6.6 CULTURAL RESOURCE AVOIDANCE

A 2012 marine remote-sensing survey identified the remains of a 160 to 190 ft sailing vessel within the VBHI Shoreline Protection Project Study area. The groin structure is designed to create a minimum of 150 ft of clearance from the identified vessel remains. During construction, the contractor will be made aware of the location of the wreck and be required to maintain a minimum 150 ft buffer to the wreck, as required by the NC SHPO. The groin structure, as proposed, will result in accretion of sediment along the southwestern shoreline of Bald Head Island. Burial of the remains will offer protection from further degradation thereby resulting in a positive impact to the archeological site. Post-construction monitoring of the shoreline updrift of the groin would identify if any of the shipwreck remains were to become exposed at any point in the future. If this were to occur, the Village would contact SHPO and the USACE to identify appropriate protective measures.

In addition to the archaeological investigations of the proposed terminal groin site, TAR has completed surveys of both the Jay Bird Shoals and the Bald Head Creek Shoals sand source sites. The investigation of the Jay Bird Shoals site was completed as part of the Bald Head Island Beach Nourishment Project authorized in 2009 and constructed in 2010. The findings of this investigation were presented within the project EA (LMG 2008). Magnetometer and side-scan sonar surveys (conducted by TAR) indicated two groups of magnetic anomalies exhibiting characteristics consistent with potential shipwreck material and/or significant cultural resources. As a result, a 200-ft buffer will be maintained to avoid dredging impacts and secondary effects of erosion.

More recently, TAR completed an investigation of the Bald Head Creek Shoals site (including the 37.6-acre proposed expansion to the north). Based upon the historical and remote sensing survey data collected as part of this effort, no NRHP eligible submerged cultural resources were identified in the 2014 survey area. The shallow area north of the mouth of Bald Head Creek is reported to have been the location of a number of channel range markers. TAR recommended that in the event that dredging exposes the remains of one or more range beacons, the NC Underwater Archaeology Branch (UAB) at Fort Fisher should be informed so that an assessment of the structures' historical significance can be assessed and its remains documented.

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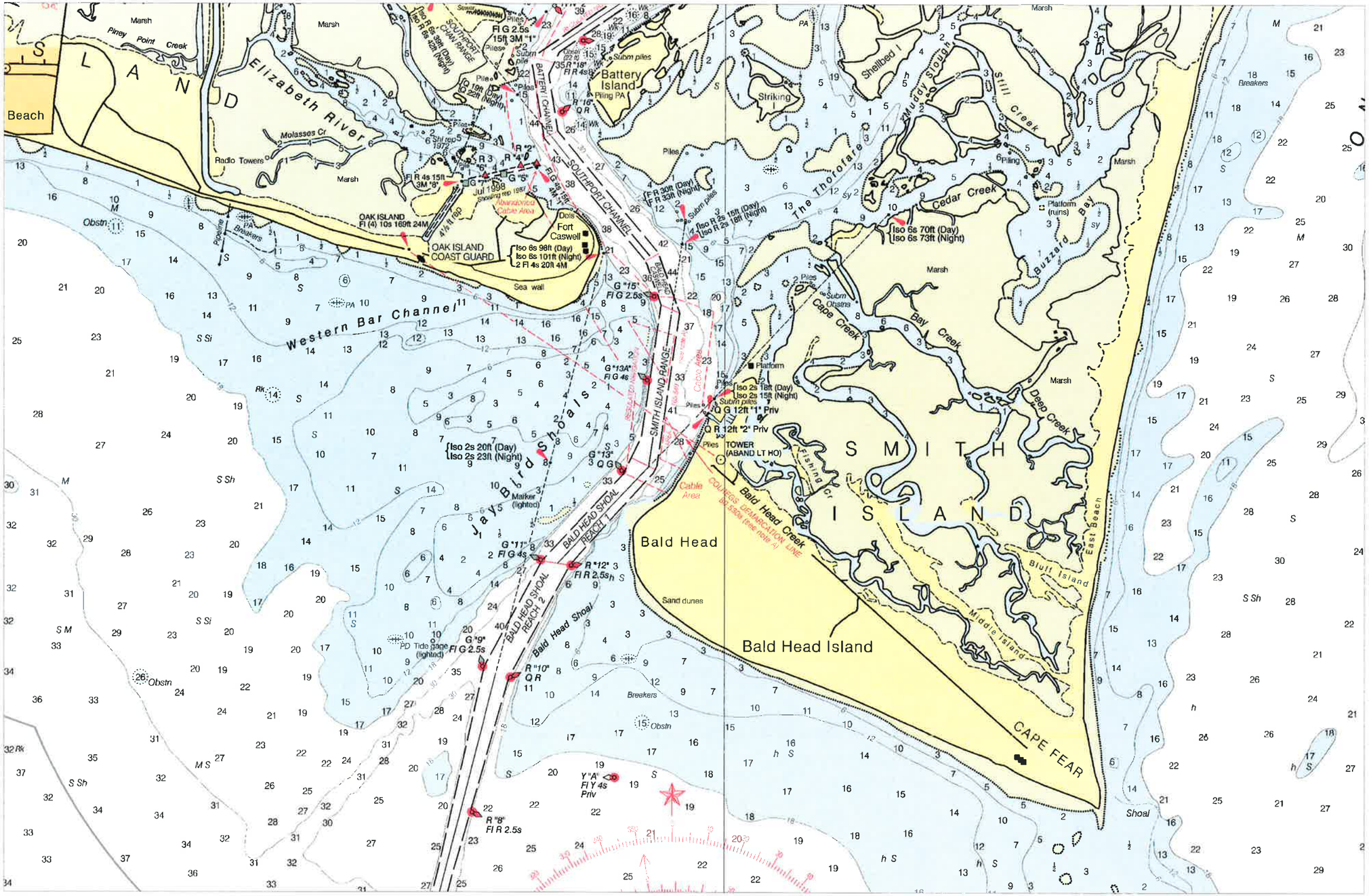
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FIGURES



Base map is NOAA navigation chart 11537 obtained from www.charts.noaa.gov (ENC chart US5NC12M).

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Project: **Village of Bald Head Island Shoreline Protection Project** Draft Environmental Impact Statement		Date: 12/2012	Revision Date: NA
		Scale: 1"= 0.5 NAUTICAL MILE	Job Number: 40-11-238
Title: ***VICINITY MAP***		Drawn By: LES	Figure: **Figure 1.1**

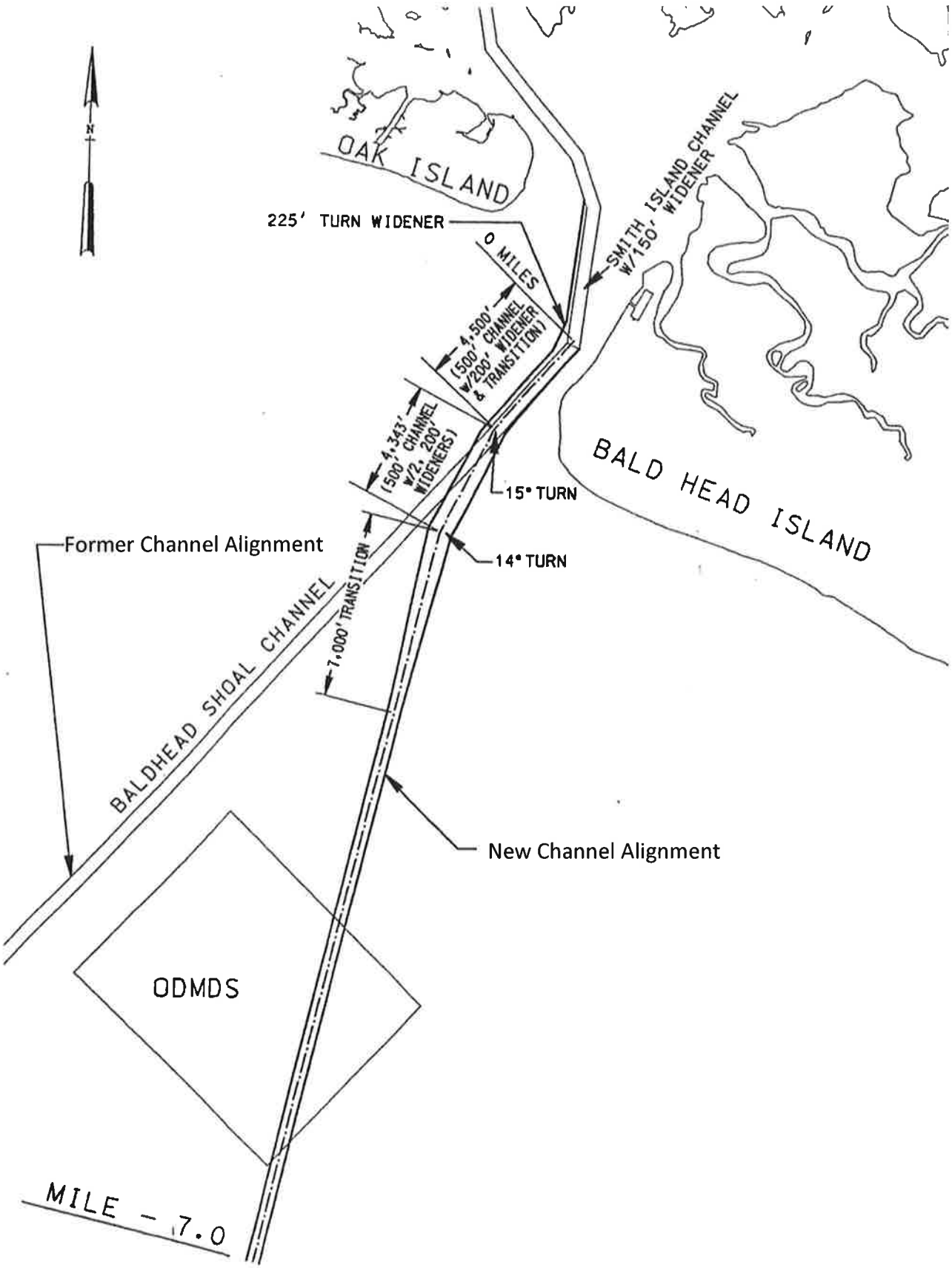


Figure 1.2. Wilmington Harbor Ocean Bar Channel Realignment (from USACE 2000)



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Project: ***Village of Bald Head Island Shoreline Protection Project***
Draft Environmental Impact Statement

Title: ***Sand Tube Groin Field***

Date:	Revision Date:
12/2012	NA
Scale: ***1"=800'***	Job Number: 40-11-238
Drawn By: LES	Figure: **Figure 1.3**

L:\WETLANDS\2011 WETLANDS FILES\40-11-238 --- VBHI Terminal Groin, Chris McCall VBHI\ACAD\EIS_Figure_Sheet_Sets\EIS_MASTER_recover.dwg



20' off Predicted MHHW Alternative # 2

Unimproved Parcels Available for Retreat

Total Number of Available Parcels = 64
Minimum Value - $100,000
Maximum Value - $500,000
Average Value - $280,000

Total Average Value = $17,920,000

0 400 800 1600

Aerial photography is dated 12/14/2012.

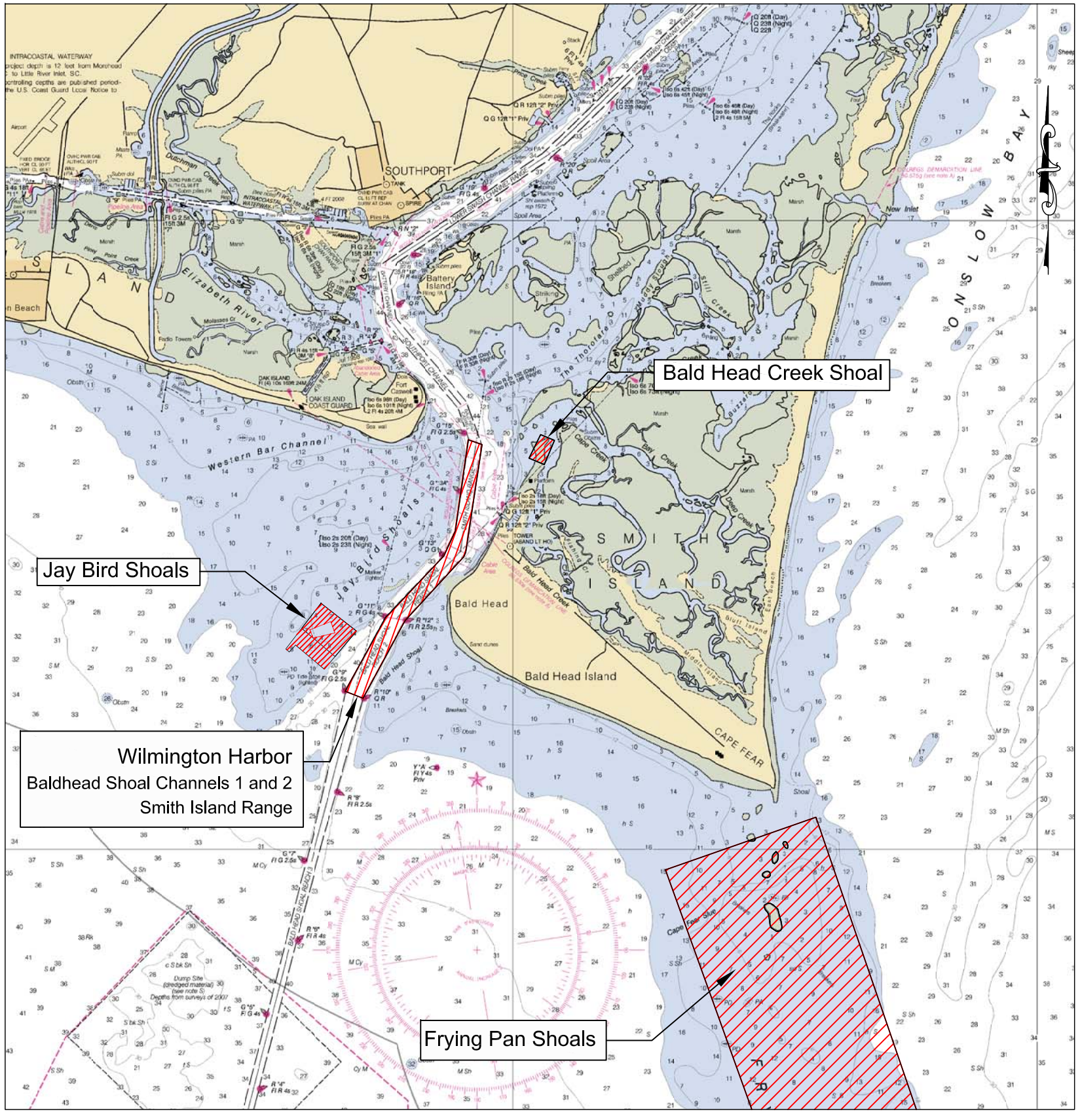
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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***Lots Available for Relocation Retreat Alternative #2***

Date:	Revision Date:
4/2013	NA
Scale: **1"=800'**	Job Number: 40-11-238
Drawn By:	Figure: **Figure 3.1**



Note: This is not an engineered or surveyed drawing. This drawing is intended to show the approximate locations of potential sand source areas and is not intended to depict specific borrow area limits. Refer to design drawings of the project DEIS for more detailed information.

Base map is NOAA navigation chart 11537 obtained from www.charts.noaa.gov (ENC chart US5NC12M).

0 0.5 1.0 2.0

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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***Vicinity Map of Potential Sand Sources***

Date: 4/8/2013
Revision Date: 12/10/2013
Scale: 1"= 1 NAUTICAL MILE
Job Number: 40-11-238
Drawn By:
Sheet Number: **Figure 3.2**

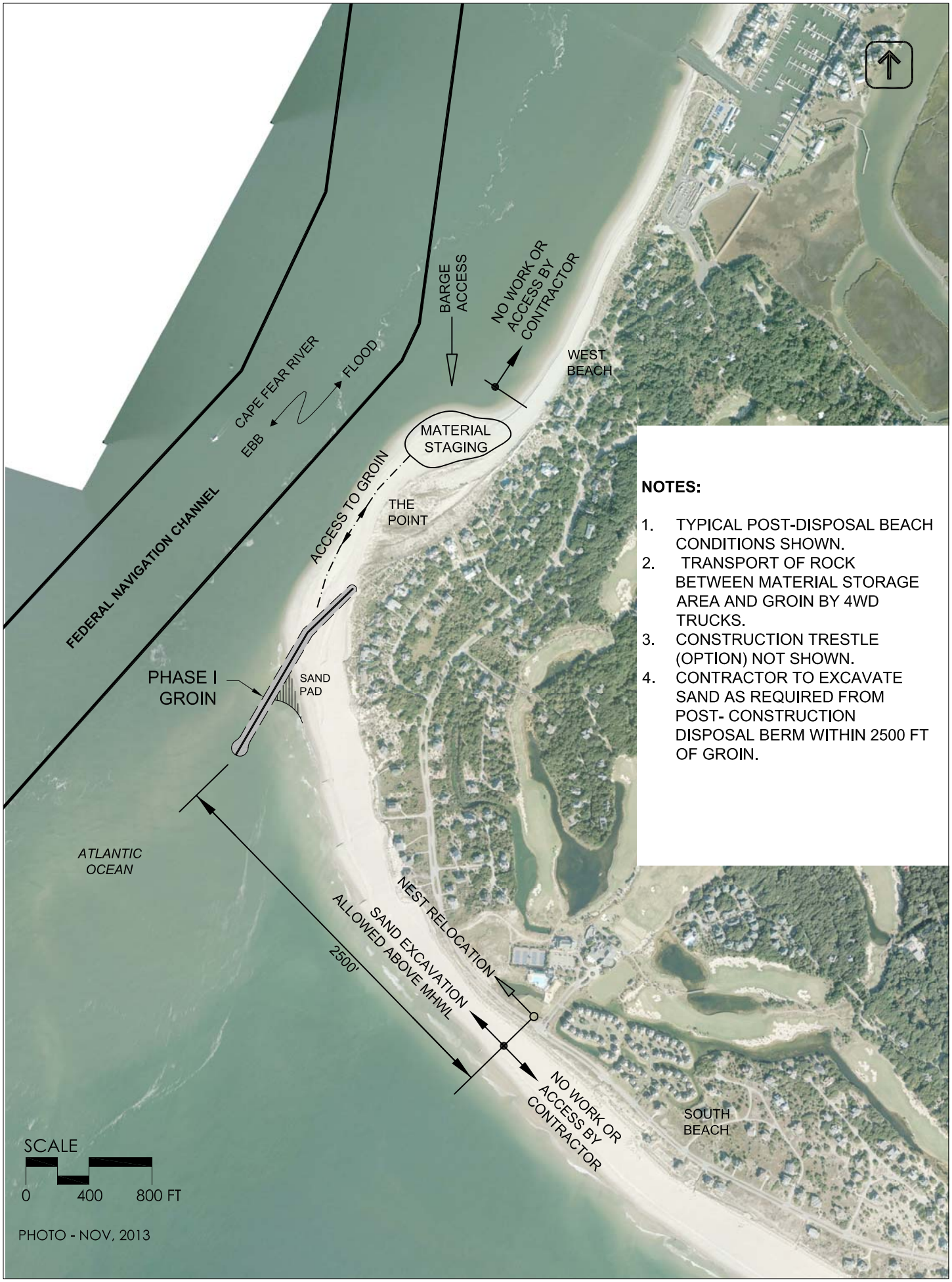
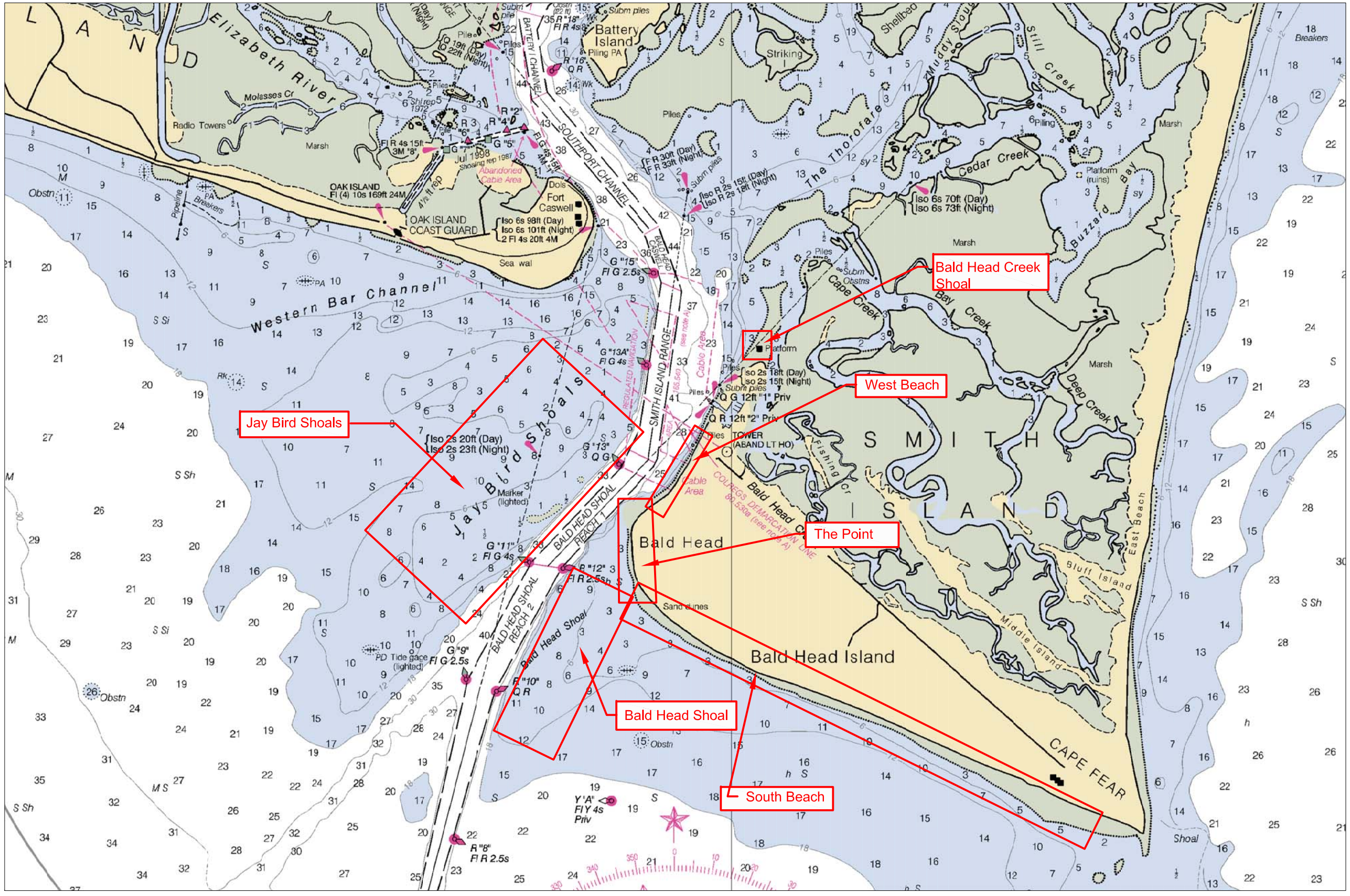


Figure 3.3. Terminal Groin/Fillet Work Area and Groin Construction Activities (Phase I)
(courtesy Olsen Associates, Inc.)

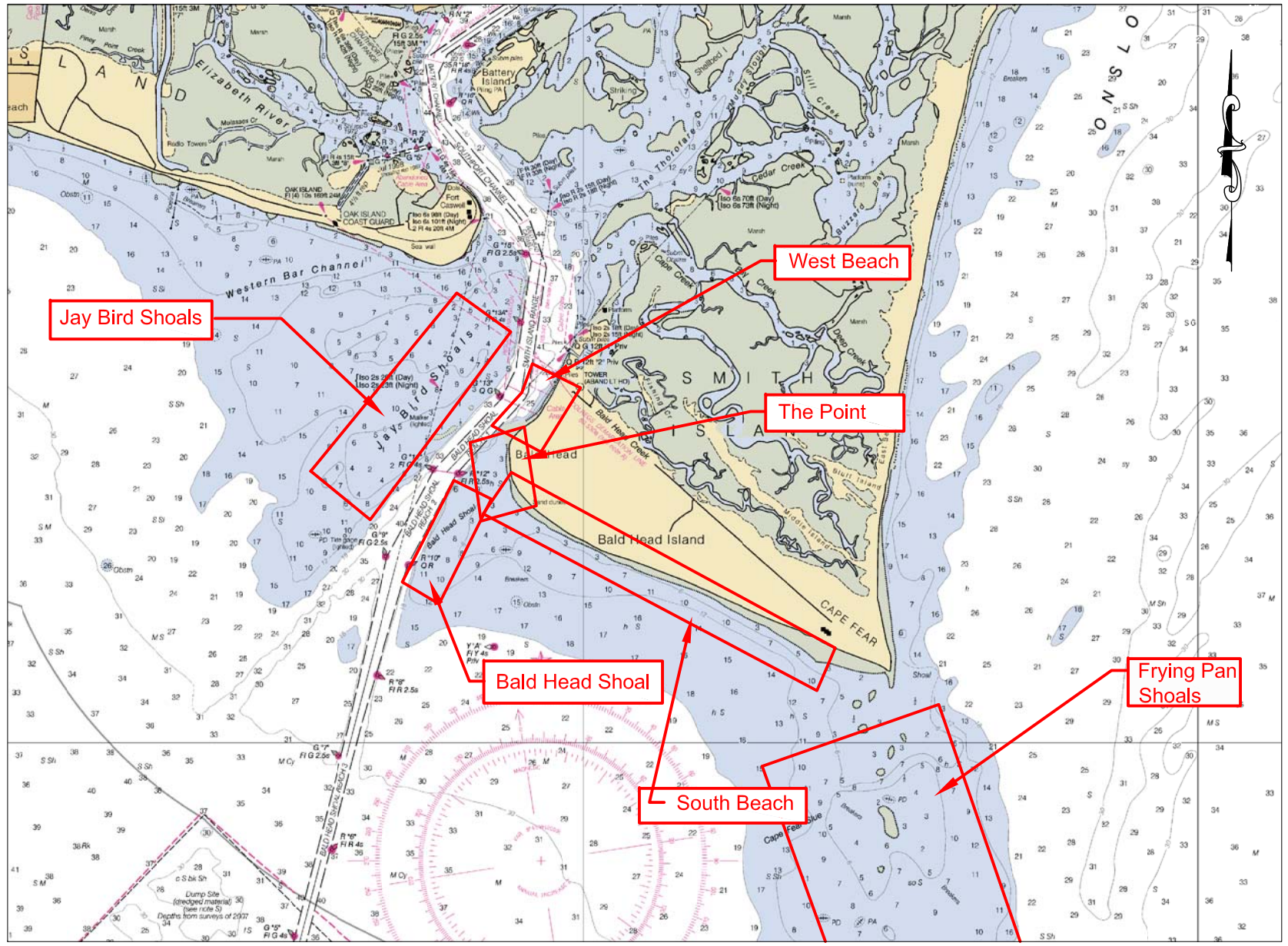


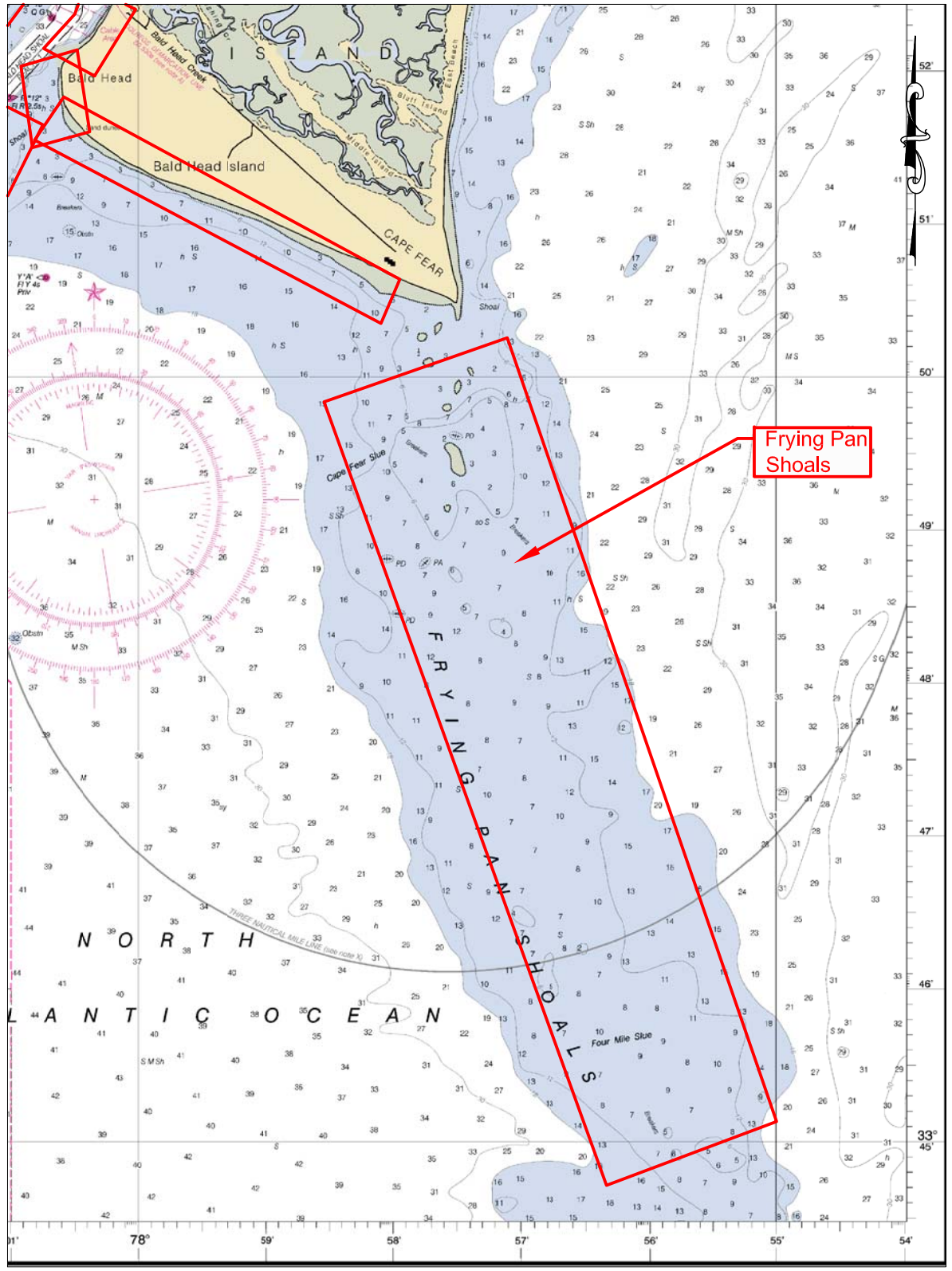
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Base map is NOAA navigation chart 11537 obtained from www.charts.noaa.gov (ENC chart US5NC12M).

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Project: **Village of Bald Head Island Shoreline Protection Project** Final Environmental Impact Statement	Date: 4/8/2013
	Revision Date: NA
Title: ***Study Area Biological Resources***	Scale: 1"= 0.5 NAUTICAL MILE
	Job Number: 40-11-238
	Drawn By:
	Sheet Number: **Figure 4.1**





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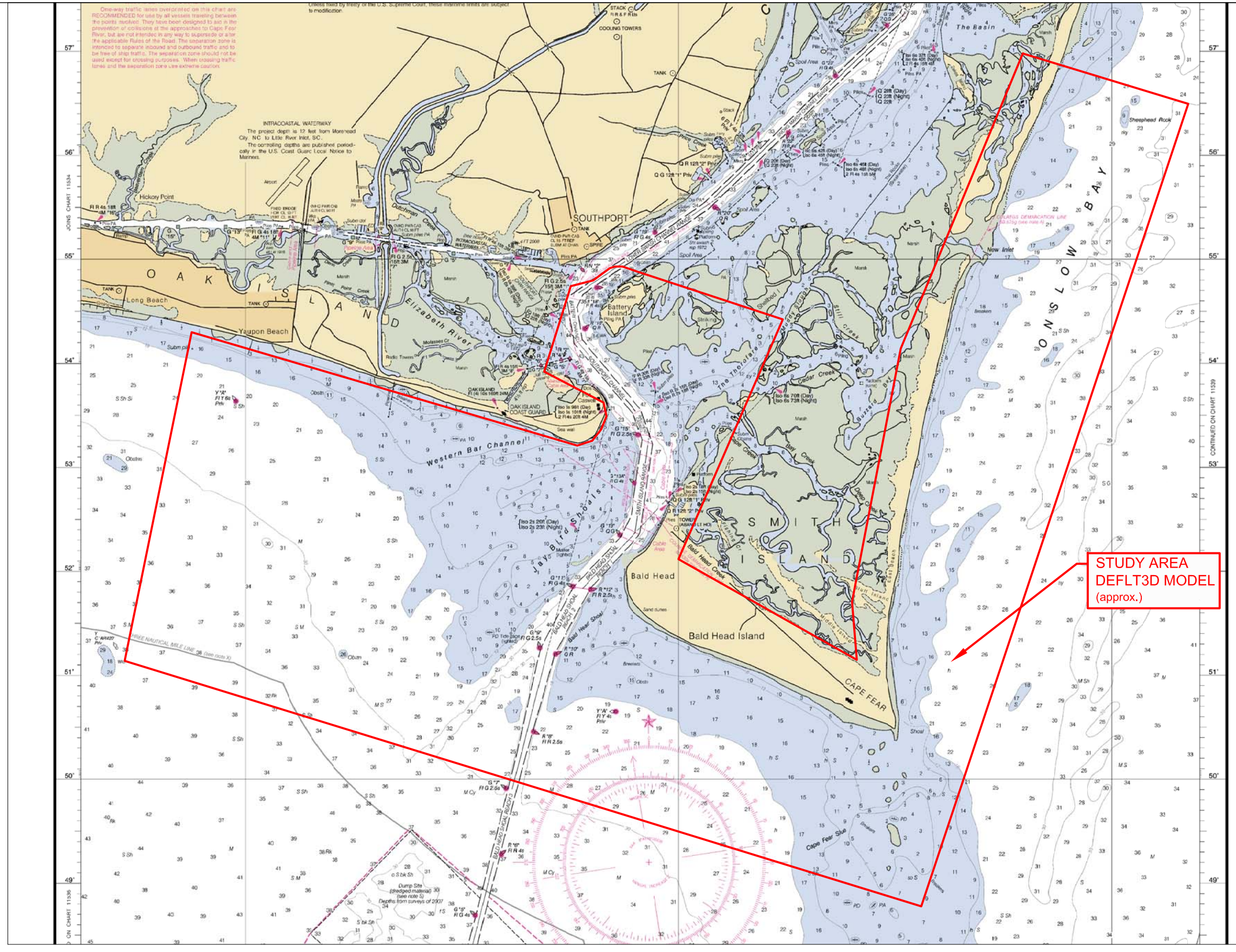
Base map is NOAA navigation chart 11537 obtained from www.charts.noaa.gov (ENC chart US5NC12M).

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Project: **Village of Bald Head Island Shoreline Protection Project**

Title: ***Study Area Physical Monitoring (Village and/or Corps)***

Date:	Revision Date:
4/2013	NA
Scale:	**Job Number:**
1"= 1 NAUTICAL MILE	40-11-238
Drawn By:	**Sheet Number:**
	Figure 4.2



0 0.5 1.0 2.0

Base map is NOAA navigation chart 11537 obtained from www.charts.noaa.gov (ENC chart US5NC12M).

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Project: **Village of Bald Head Island Shoreline Protection Project**	
Title: ***Study Area Delft 3D Modeling***	
Date: 4/8/2013	Revision Date: NA
Scale: 1"= 1 NAUTICAL MILE	Job Number: 40-11-238
Drawn By:	Sheet Number: **Figure 4.3**



Figure 4.4. Bald Head Island Shoreline Positions (1855 to 1926) (Source: USACE Wilmington Harbor Monitoring Report No. 1 – 2004)

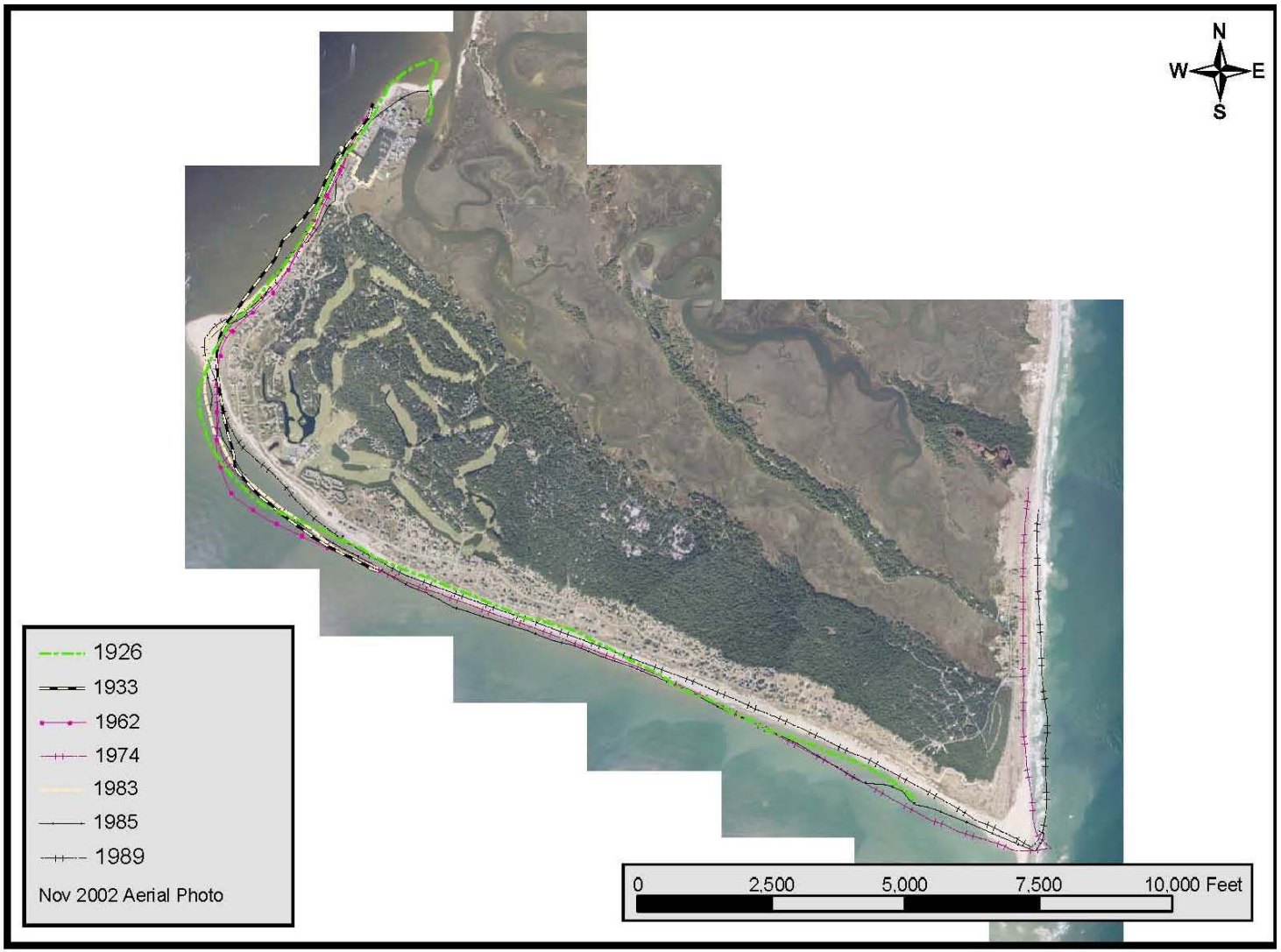
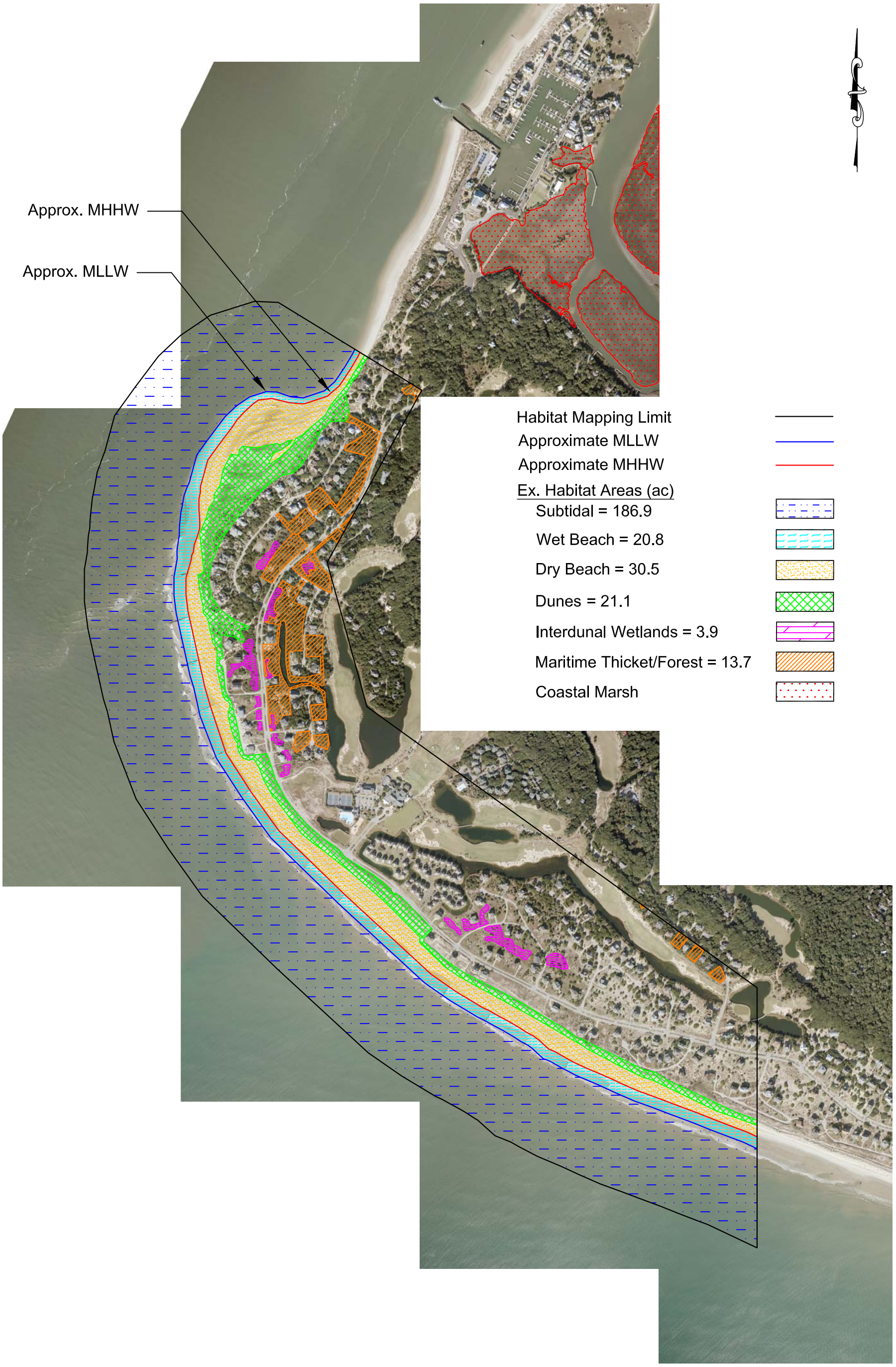


Figure 4.5. Bald Head Island Shoreline Positions (1926-1989) (Source: USACE Wilmington Harbor Monitoring Report No. 1 – 2004)



Figure 4.6. Bald Head Island Shoreline Positions (1989 and 1996) (Source: USACE Wilmington Harbor Monitoring Report No. 1 – 2004)



Aerial photography is dated 12/14/2012.

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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***Existing Habitat Area Mapping***

Date: 5/13/2013

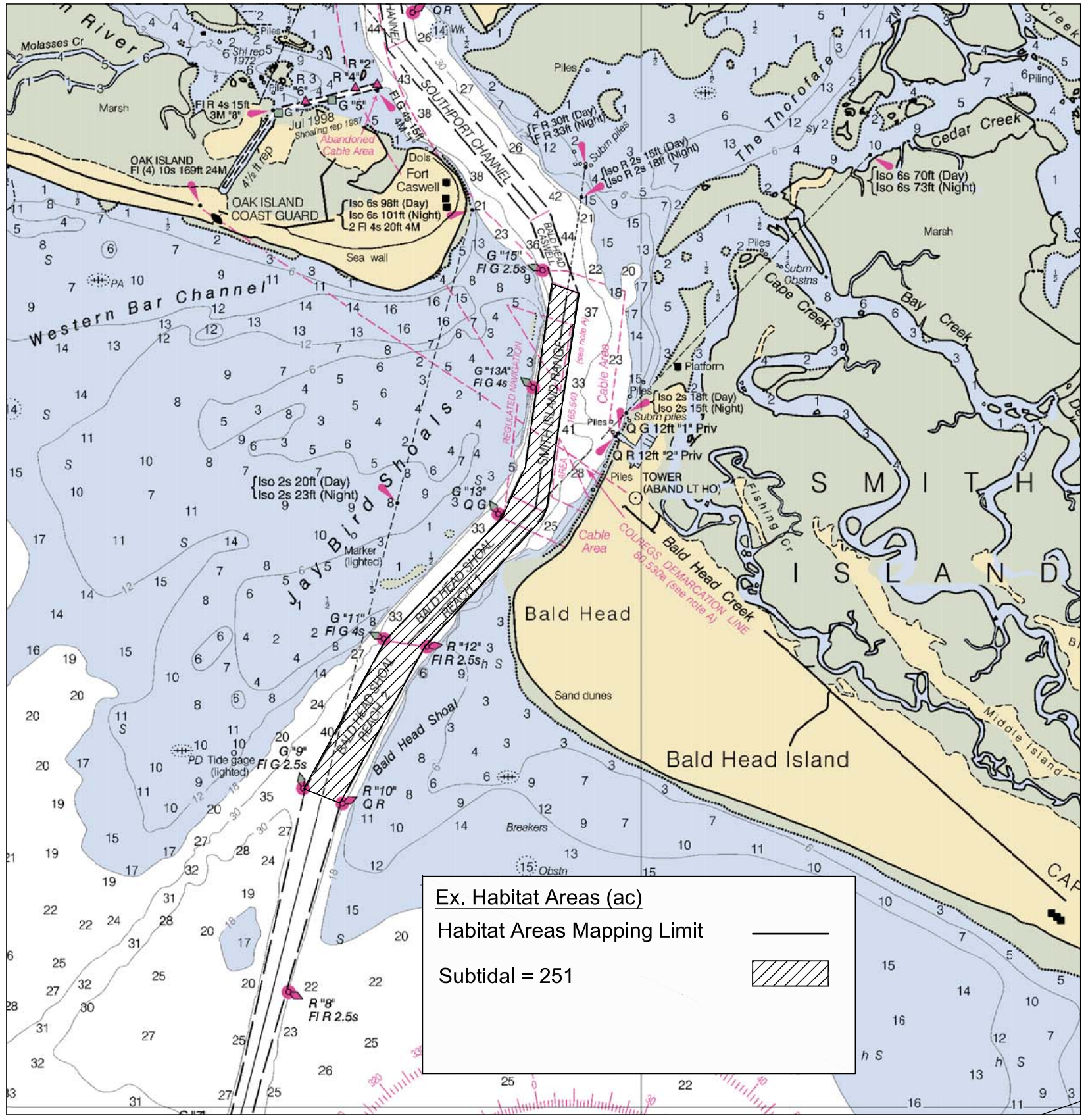
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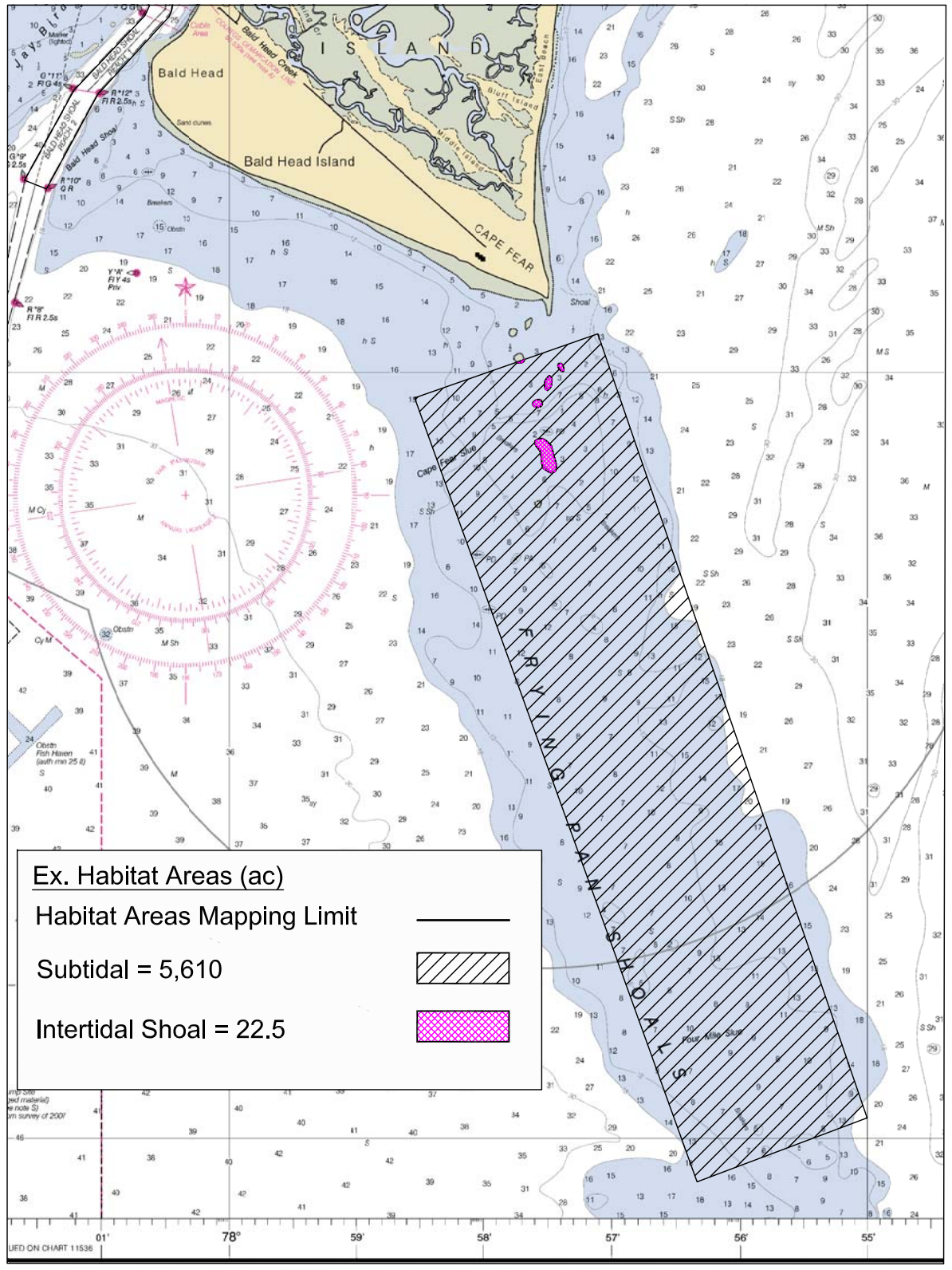
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Drawn By:

Sheet Number: **Figure 4.7**



WILMINGTON HARBOR
1"= 0.5 NAUTICAL MILE

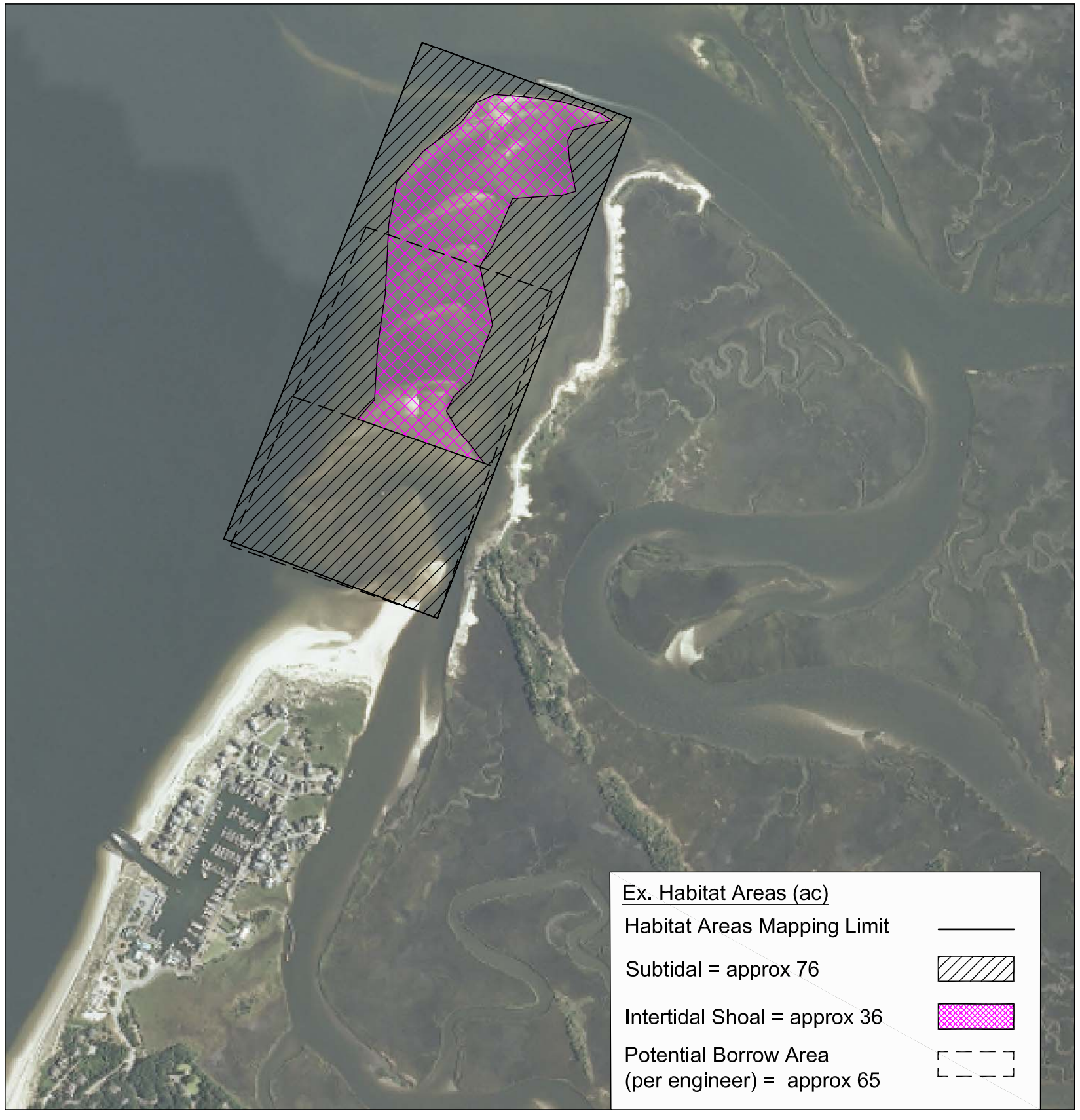


FRYING PAN SHOALS
1"= 1 NAUTICAL MILE

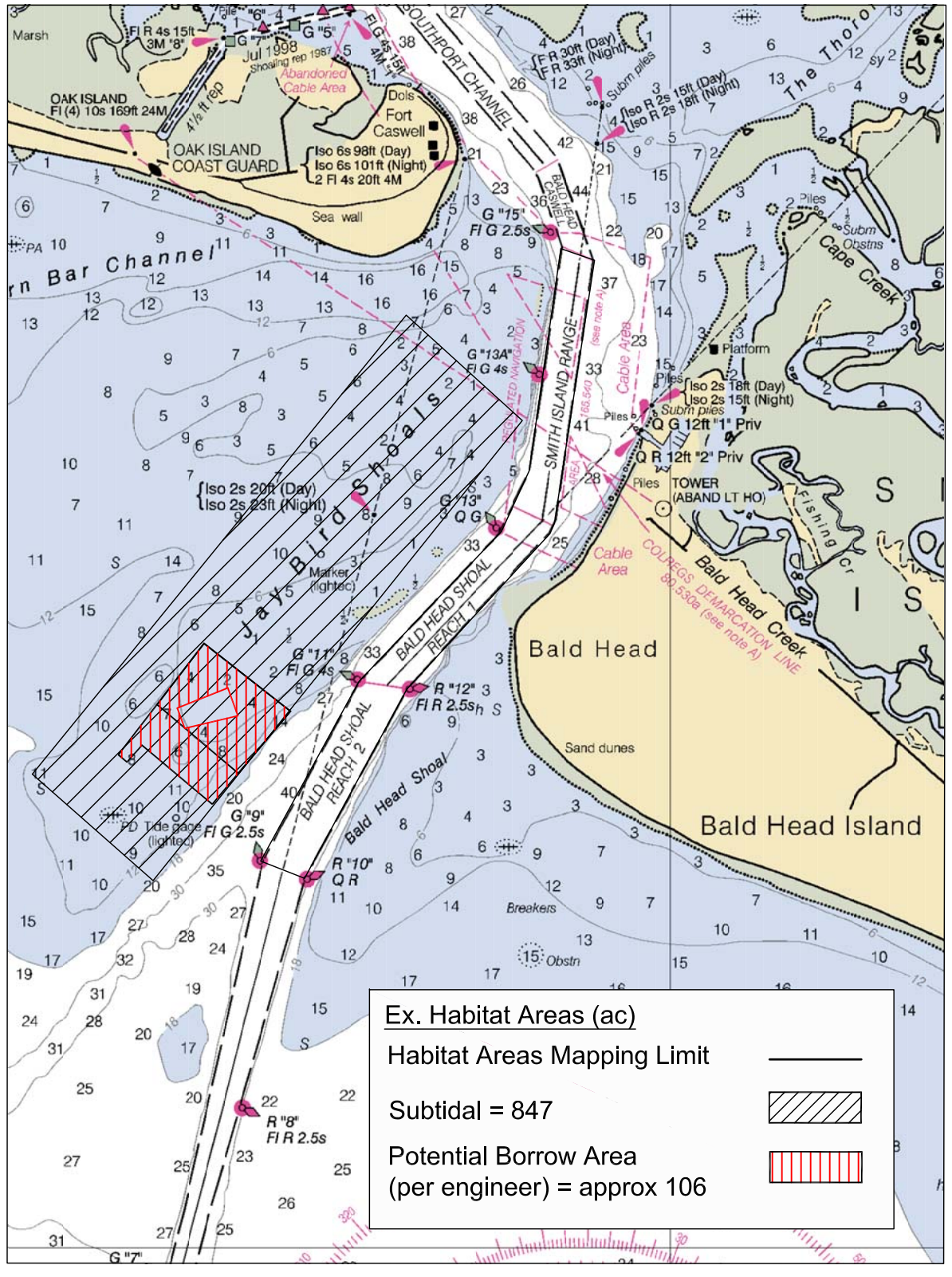
Base map is NOAA navigation chart 11537 obtained from www.charts.nooa.gov (ENC chart US5NC12M).

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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**		Date: 4/8/2013	Revision Date: NA
		Scale: varies	Job Number: 40-11-238
Title: ***Habitat Area Mapping Potential Sand Sources***		Drawn By:	Sheet Number: **Figure 4.8**



BALD HEAD CREEK
1"= 800'



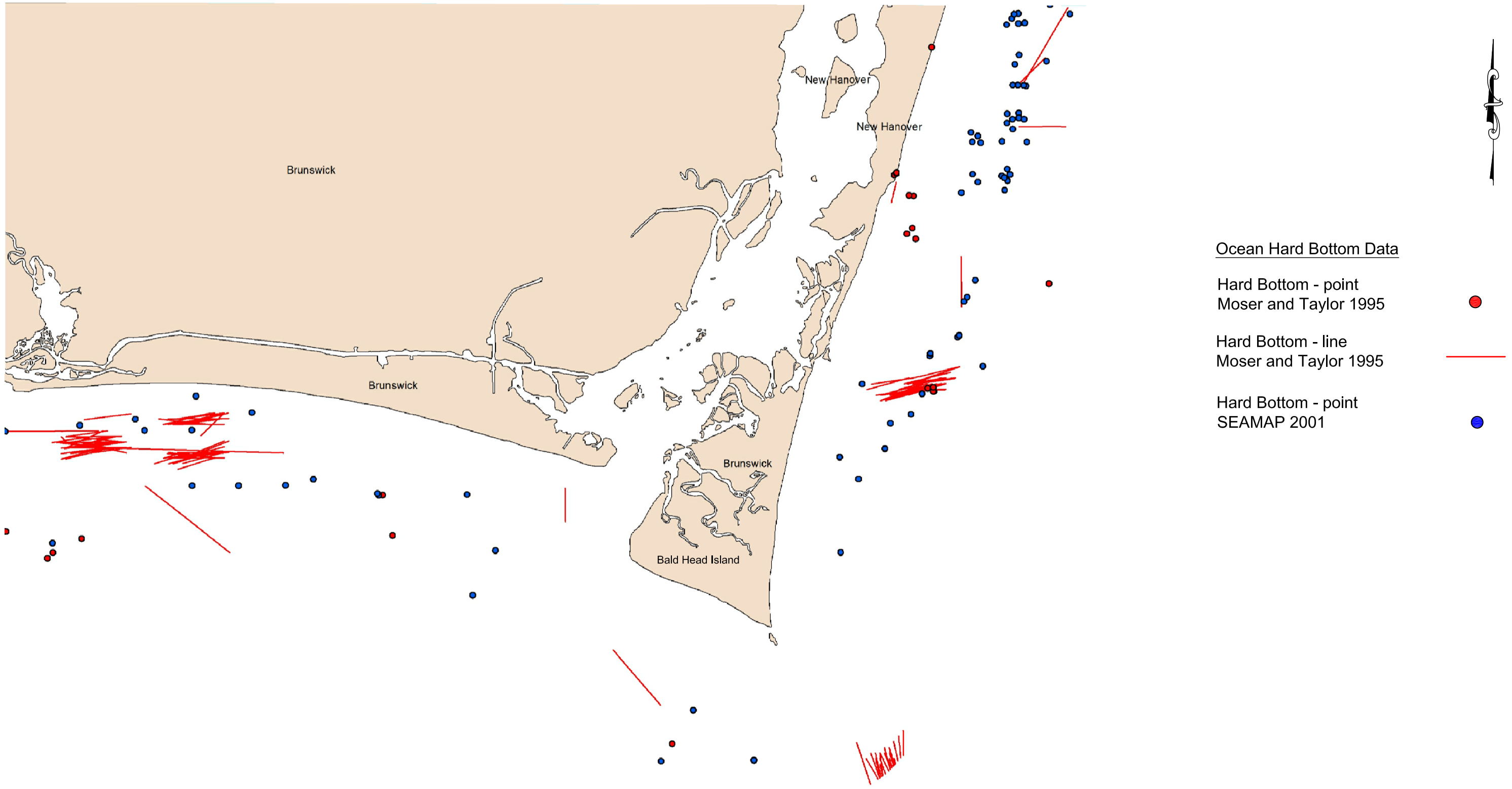
JAYBIRD SHOALS
1"= 0.5 NAUTICAL MILE

Base maps are NOAA navigation chart 11537 obtained from www.charts.nooa.gov (ENC chart US5NC12M) and 2010 aerial photograph.

This is not an engineered or surveyed drawing. Borrow area limits for each potential sand source is approximate and would be finalized by the project engineer.

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Project: **Village of Bald Head Island Shoreline Protection Project**		Date: 4/8/2013	Revision Date: 12/31/2013
		Scale: varies	Job Number: 40-11-238
Title: ***Habitat Area Mapping Potential Sand Sources***		Drawn By:	Sheet Number: **Figure 4.9**



Ocean Hard Bottom Data

Hard Bottom - point
Moser and Taylor 1995

Hard Bottom - line
Moser and Taylor 1995

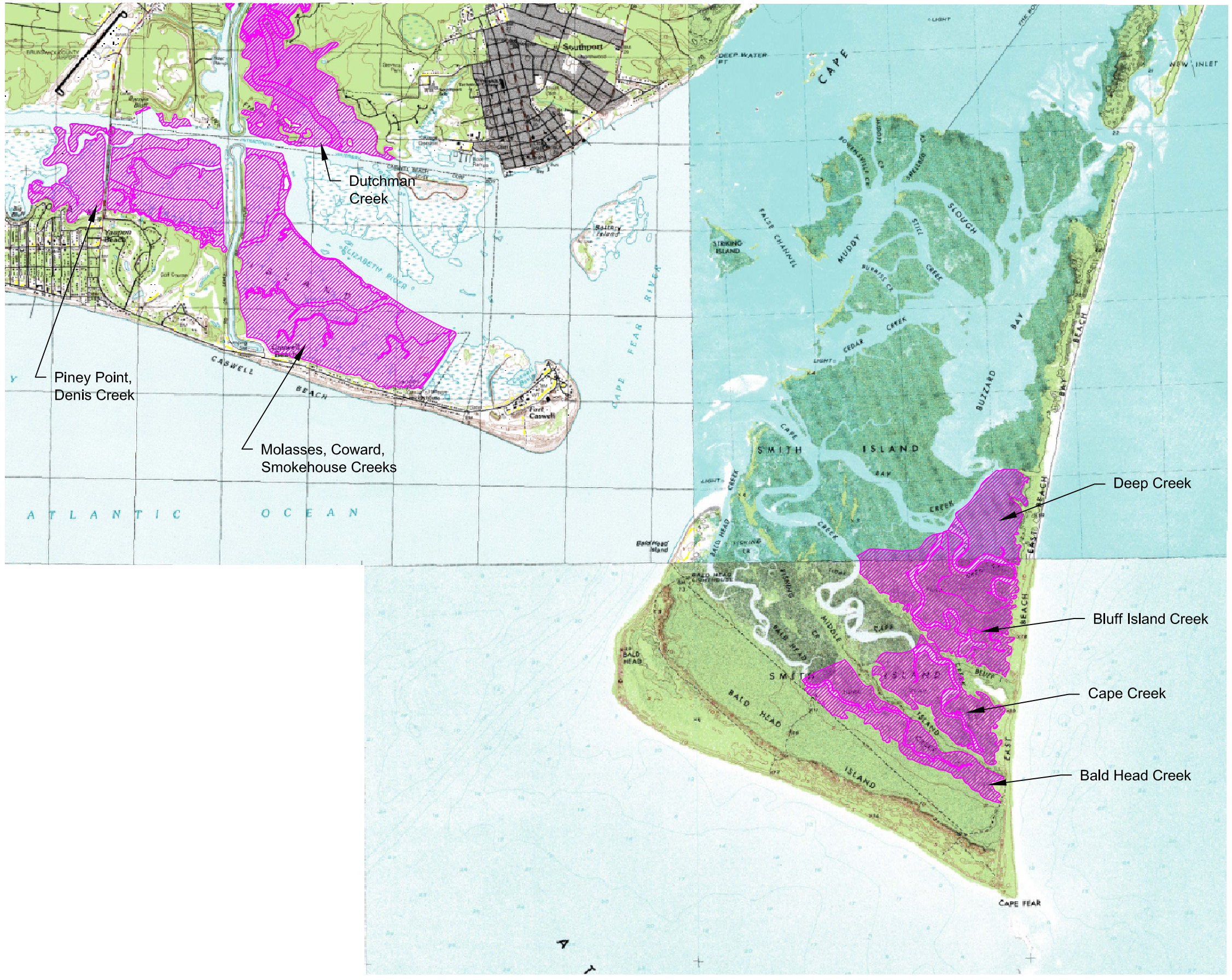
Hard Bottom - point
SEAMAP 2001

0 1 2 4

Hard bottom mapping combined from SEAMAP-SA (Southeast Area Monitoring and Assessment Program). 2001. South Atlantic Bight Hard Bottom Mapping. SEAMAP South Atlantic Bottom Mapping Workgroup, Charleston, South Carolina, 166p. And
Moser, M. L. and B. L. Taylor. 1995. Hard bottom habitat in North Carolina state waters: a survey of available data. Final Report to NC Division of Coastal Management. Unpub. doc., 20p.
As shown in the NC Coastal Habitat Protection Plan. Data provided by NC DMF.

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Project: **Village of Bald Head Island Shoreline Protection Project**		Date: 4/8/2013	Revision Date: NA
		Scale: **1"= 2 miles**	Job Number: 40-11-238
Title: ***Ocean Hard Bottom Mapping Moser and Taylor and SEAMAP Data***		Drawn By:	Sheet Number: **Figure 4.10**



Primary Fishery Nursery Area mapping data obtained from NC DENR.
USGS topographic map obtained from USDA.

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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**	Date: 4/8/2013
	Revision Date: NA
	Scale: **1"=4000'**
	Job Number: 40-11-238
Title: ***NC Marine Fisheries Commission Primary Nursery Area Mapping***	Drawn By:
	Sheet Number: **Figure 4.11**



Primary Fishery Nursery Area data obtained from NC DENR.
2010 Aerial photography, Brunswick County GIS data.

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Project: **Village of Bald Head Island Shoreline Protection Project**		Date: 4/8/2013	Revision Date: NA
		Scale: **1"=2000'**	Job Number: 40-11-238
Title: ***NC Marine Fisheries Commission Primary Nursery Area Mapping***		Drawn By:	Sheet Number: **Figure 4.12**



0 5 10 20

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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***Lower Cape Fear River Watershed, Basin 03030005***

Date:	Revision Date:
5/2013	NA
Scale: **1" = 10 miles**	Job Number: 40-11-238
Drawn By:	Figure: **Figure 4.13**



0 1.5 3 6

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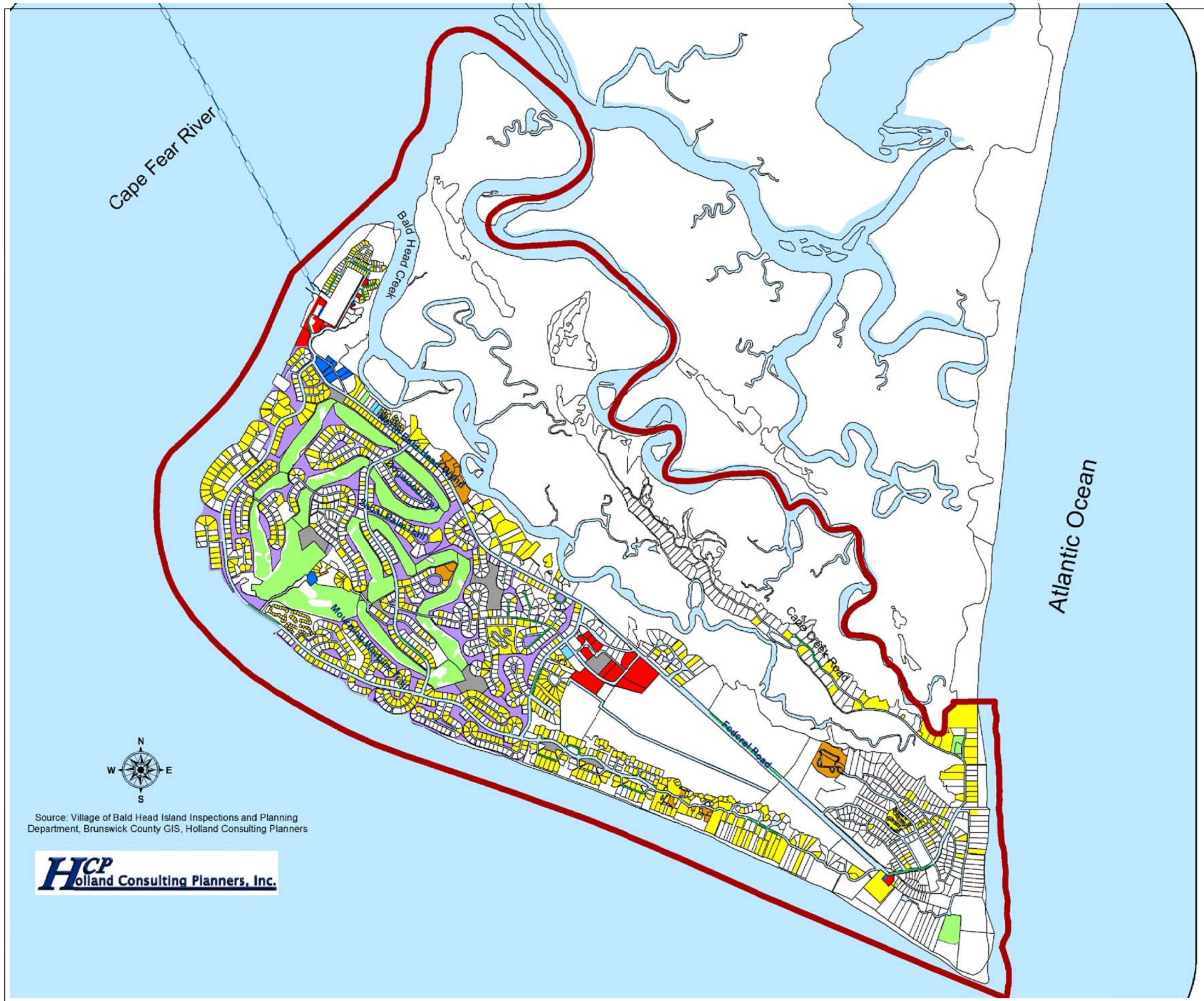
Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project** **Final Environmental Impact Statement**	Date: 5/2013
	Revision Date: NA
	Scale: **1" = 3 miles**
	Job Number: 40-11-238
Title: ***Lower Cape Fear River Subasin 03030005050010***	Drawn By:
	Figure: **Figure 4.14**

Village of Bald Head Island

Land Use Plan

Existing Land Use



Legend

- Village of Bald Head Island Corporate Limits

Existing Land Use

- Association Owned Property
- Commercial
- Government
- Multi-Family
- Office & Institutional
- Recreation
- Single-Family Residential
- Utilities
- Vacant
- Bald Head Island Ferry Route
- Hydrology

Source: Village of Bald Head Island Inspections and Planning Department, Brunswick County GIS, Holland Consulting Planners

HCP Holland Consulting Planners, Inc.

The preparation of this map was financed in part through a grant provided by the North Carolina Coastal Management Program, through funds provided by the Coastal Zone Management Act of 1972, as amended, which is administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration.

Map provided by Holland Consulting Planners, Inc. Scale modifications by LMG.

0 1000 2000 4000

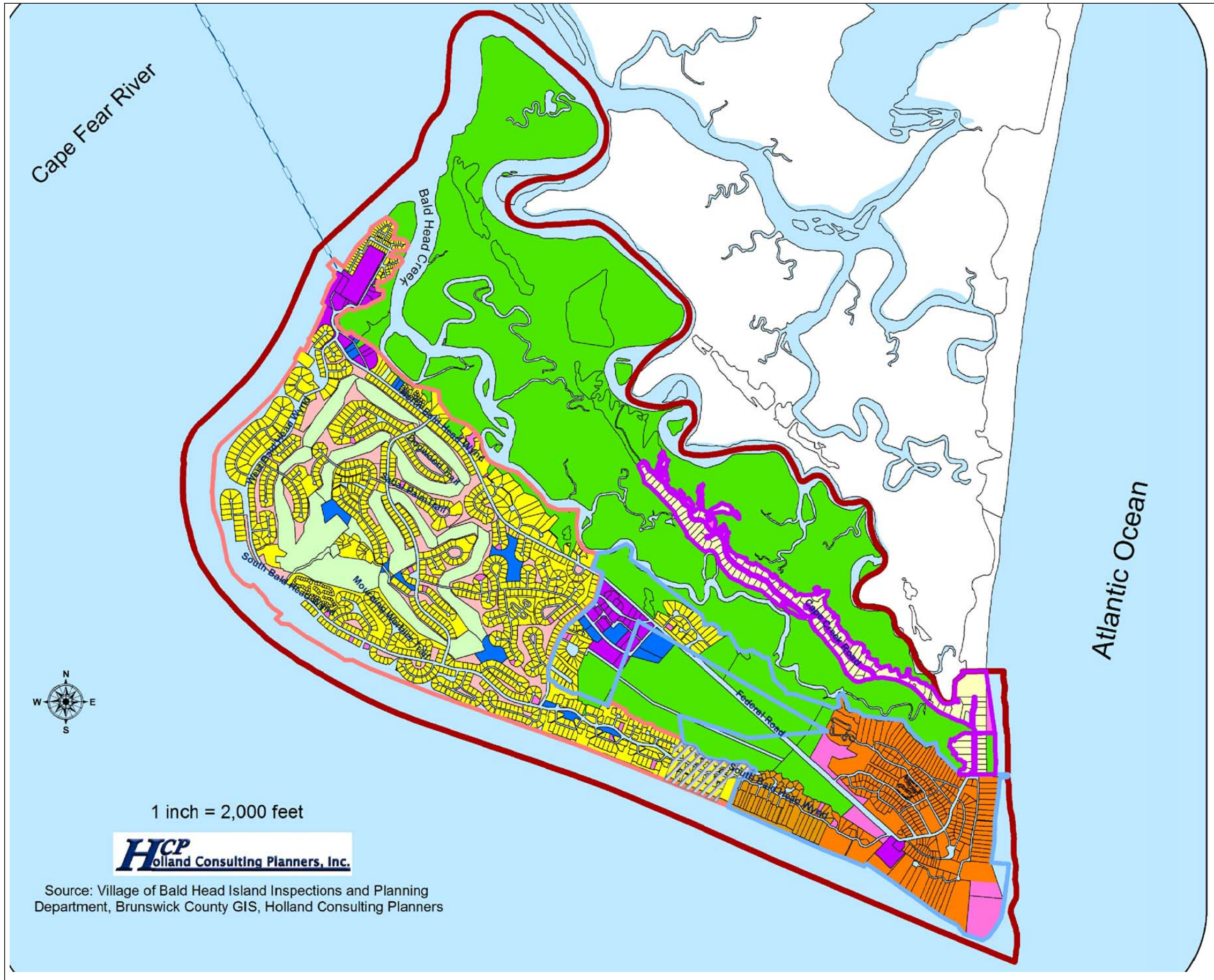
LMG Land Management Group Inc. Environmental Consultants
Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**		Date: 4/2013	Revision Date: NA
		Scale: **1"=2000'**	Job Number: 40-11-238
Title: ***CAMA Land Use Plan Existing Land Use Map***		Drawn By:	Figure: **Figure 4.15**

Village of Bald Head Island

Land Use Plan

Future Land Use



1 inch = 2,000 feet

HCP Holland Consulting Planners, Inc.

Source: Village of Bald Head Island Inspections and Planning Department, Brunswick County GIS, Holland Consulting Planners

Legend

- Village of Bald Head Island Corporate Limits
- Bald Head Island Ferry Route
- Hydrology
- Stage I
- Stage II
- Stage 1 and 2
- Middle Island

Future Land Use

- AOP
- Conservation
- Government
- LDR
- Medium Density Residential 2
- Medium Density Residential I
- Mixed Use
- PUD
- REC
- SILT Tracts

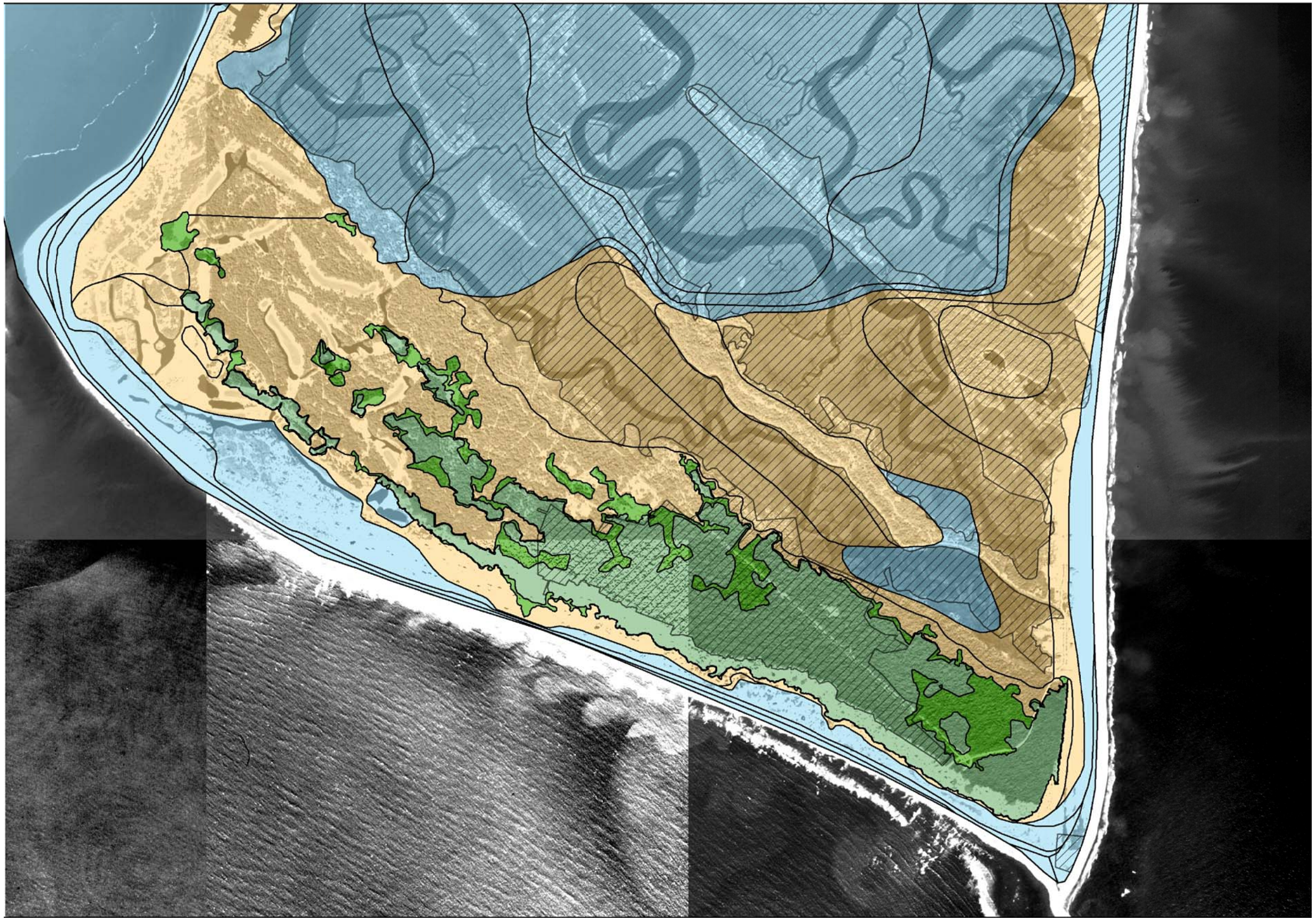
The preparation of this map was financed in part through a grant provided by the North Carolina Coastal Management Program, through funds provided by the Coastal Zone Management Act of 1972, as amended, which is administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration.

Map provided by Holland Consulting Planners, Inc. Scale modifications by LMG.

0 1000 2000 4000

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Project: **Village of Bald Head Island Shoreline Protection Project**		Date: 4/2013	Revision Date: NA
		Scale: **1"=2000'**	Job Number: 40-11-238
Title: ***CAMA Land Use Plan Future Land Use Map***		Drawn By:	Figure: **Figure 4.16**



Floodzone VE

Floodzone AE

Floodzone X
(Areas of 0.2% annual flood)

Floodzone X
(Areas outside of 0.2% annual flood)

Coastal Barrier Resource System Area (CBRA)

Flood Area and Base Flood Elevation Boundary

0 750 1500 3000

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Project: **Village of Bald Head Island Shoreline Protection Project**

Title: ***FEMA Floodzone and CBRA Mapping***

Date: 5/2013

Revision Date: NA

Scale: **1" = 1500'**

Job Number: 40-11-238

Drawn By:

Figure: **Figure 4.17**

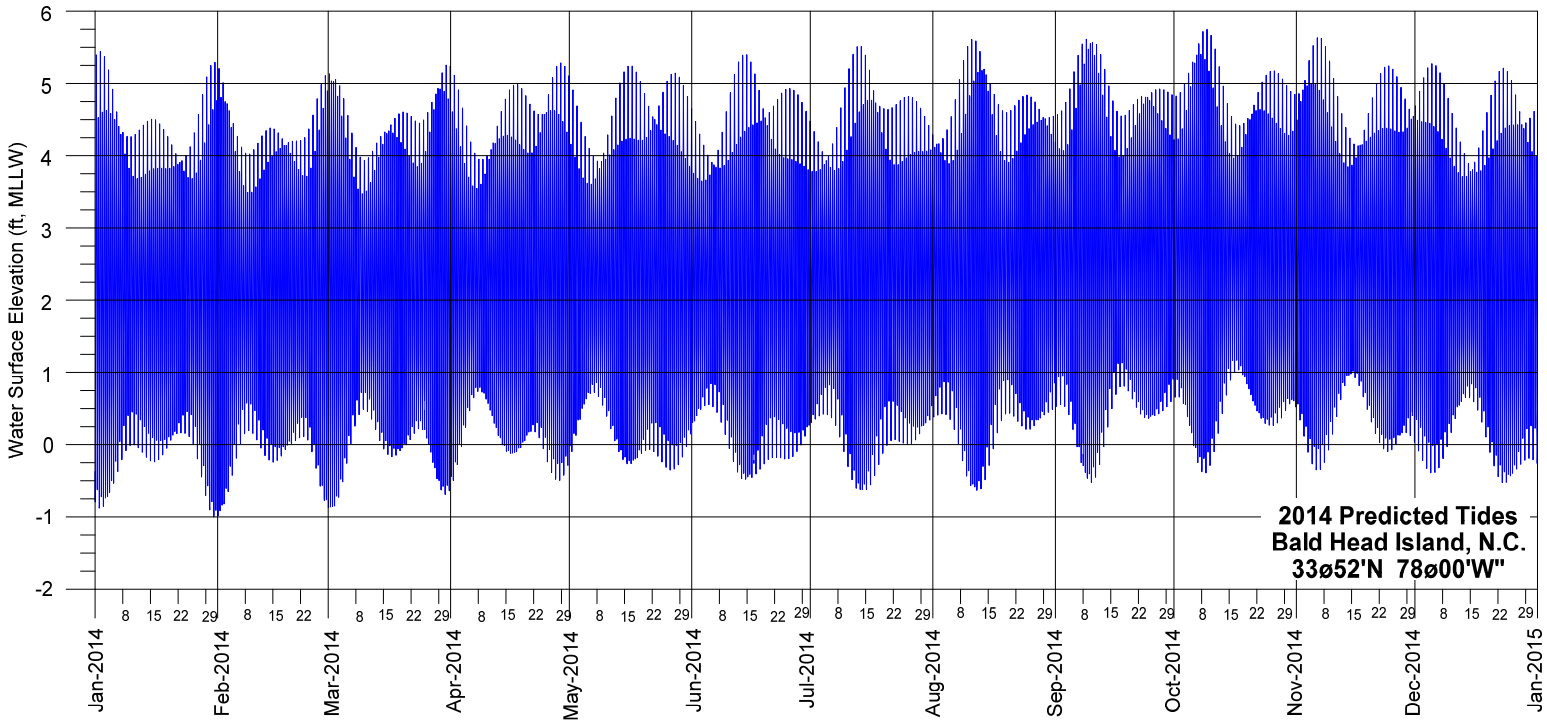


Figure 4.18. Predicted Tides for 2014.

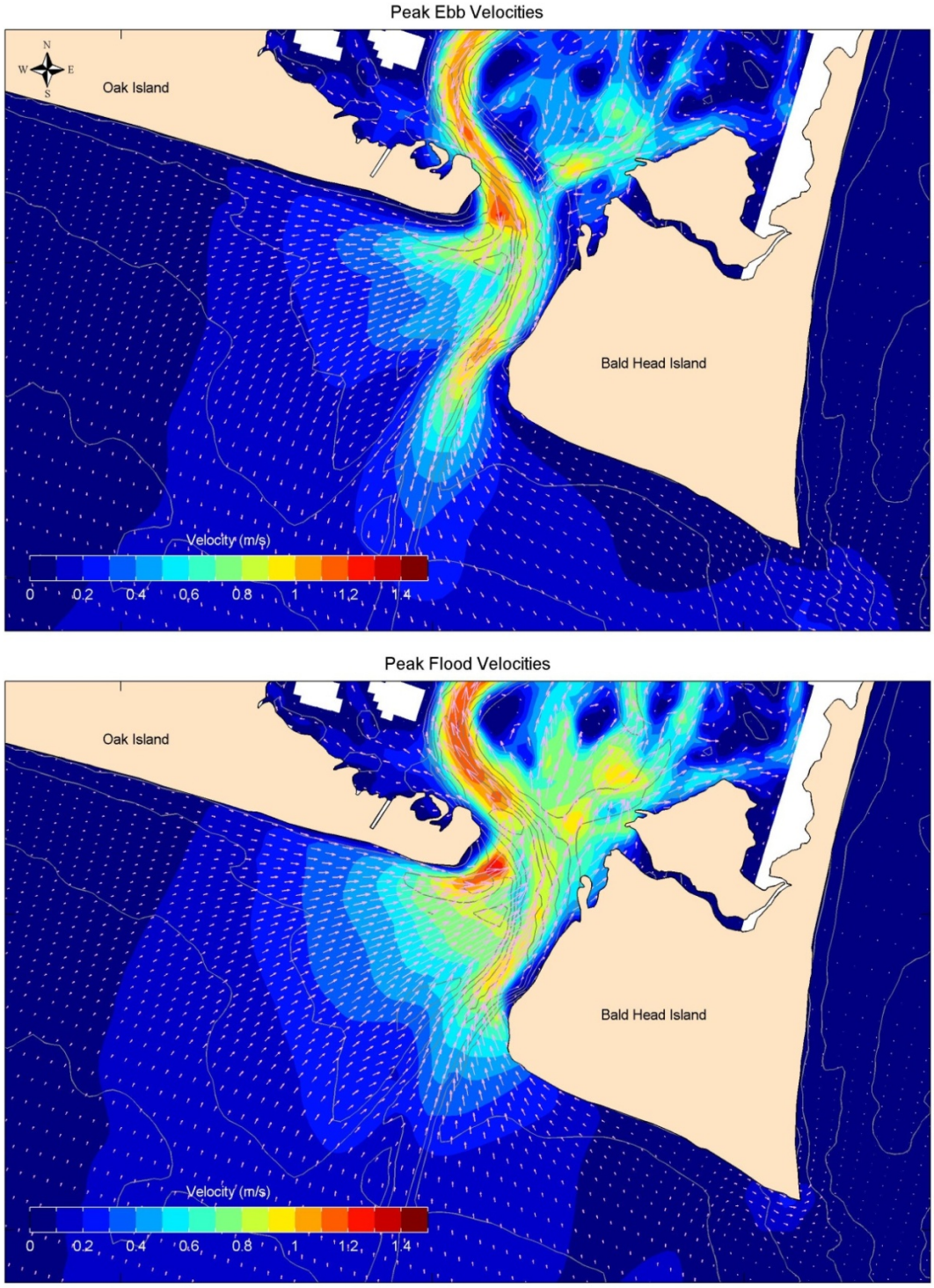


Figure 4.19. Ebb and Flood Velocities computed by FLOW on April 25, 2009.

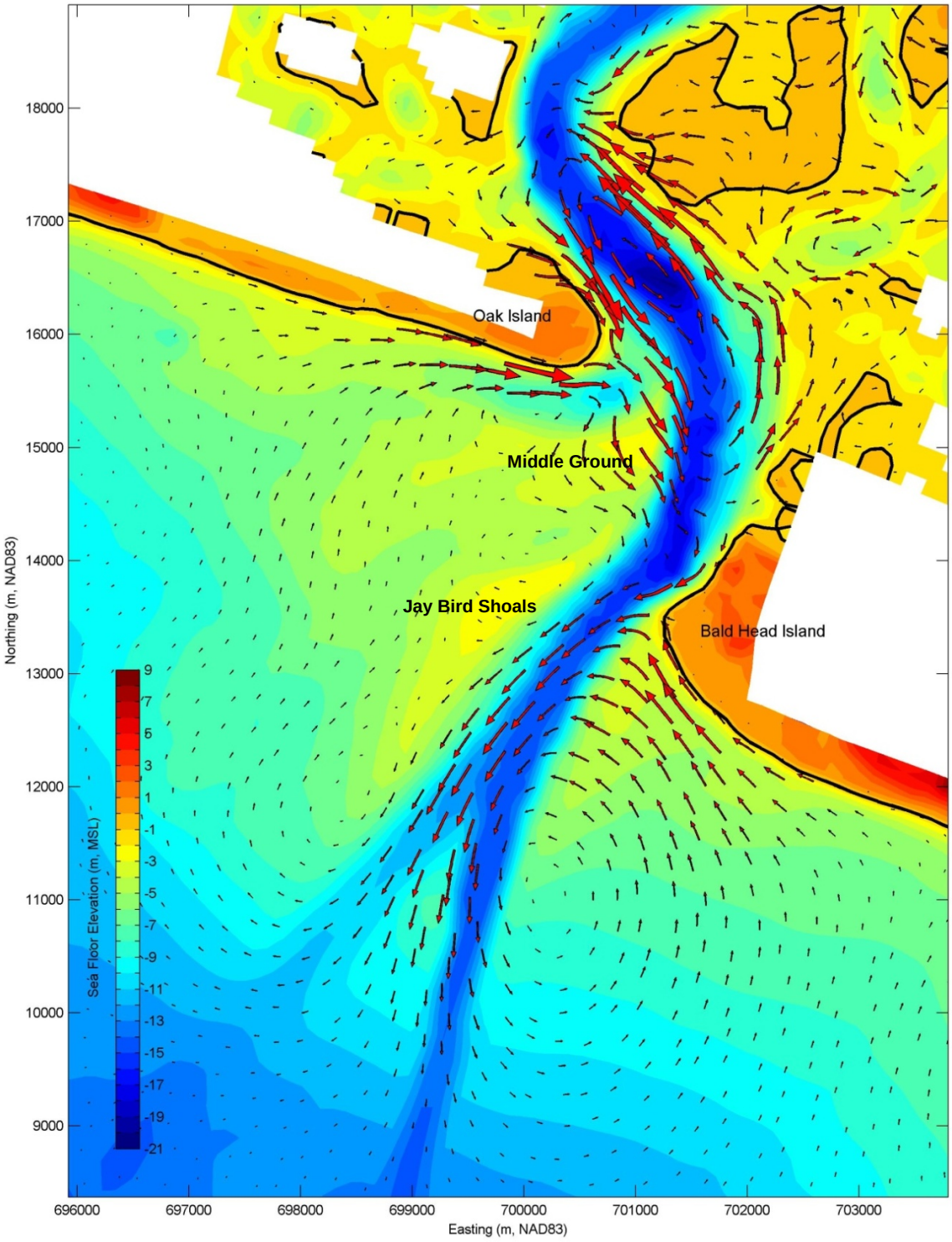


Figure 4.20. Residual Flow Vectors Computed for a One-Month, Tide Only Simulation.

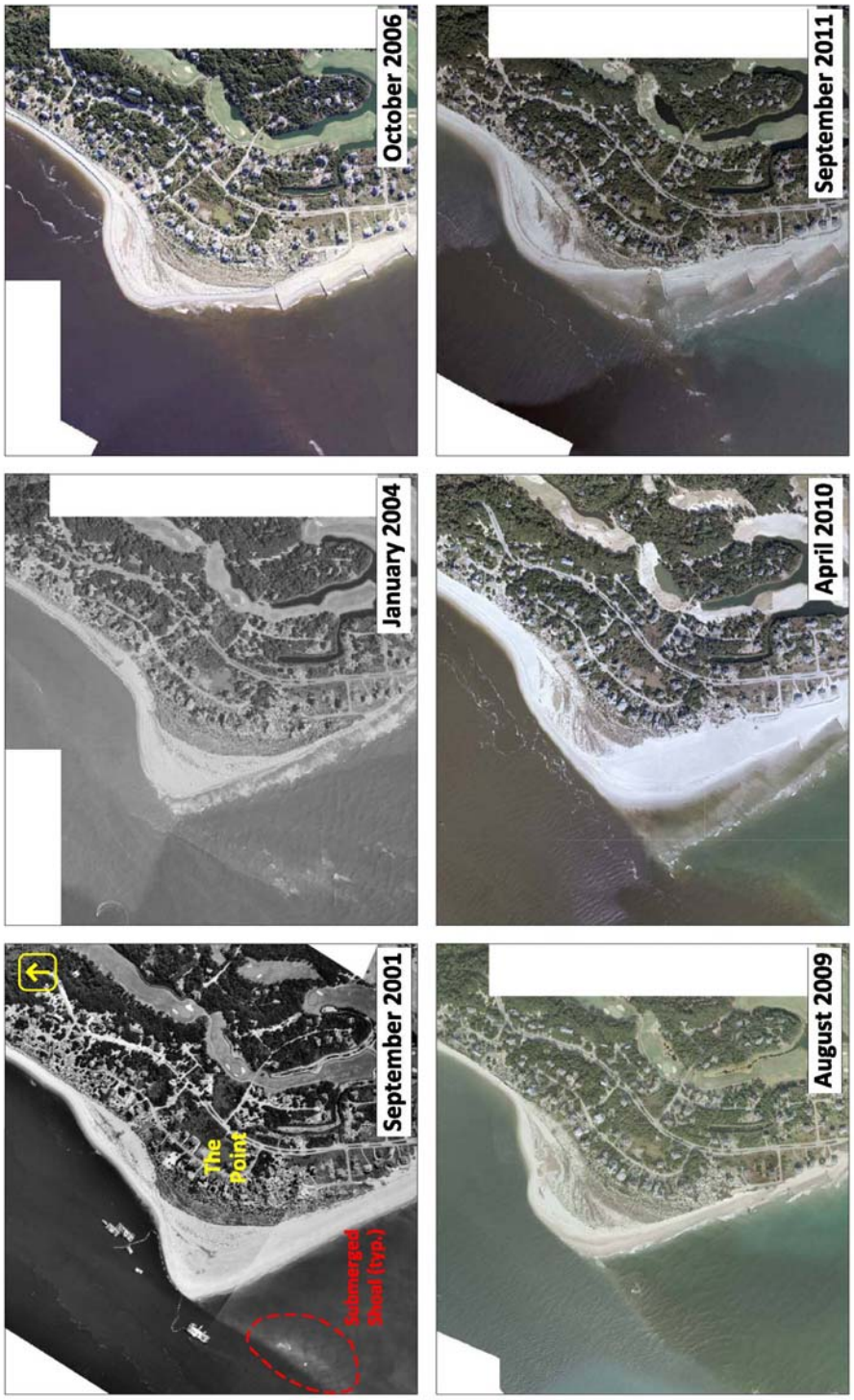


Figure 4.21. 2001-2011 Aerial Photographs of Bald Head Island. A persistent submerged spit shoal, resulting from offshore transport is evident off the tip of the island.

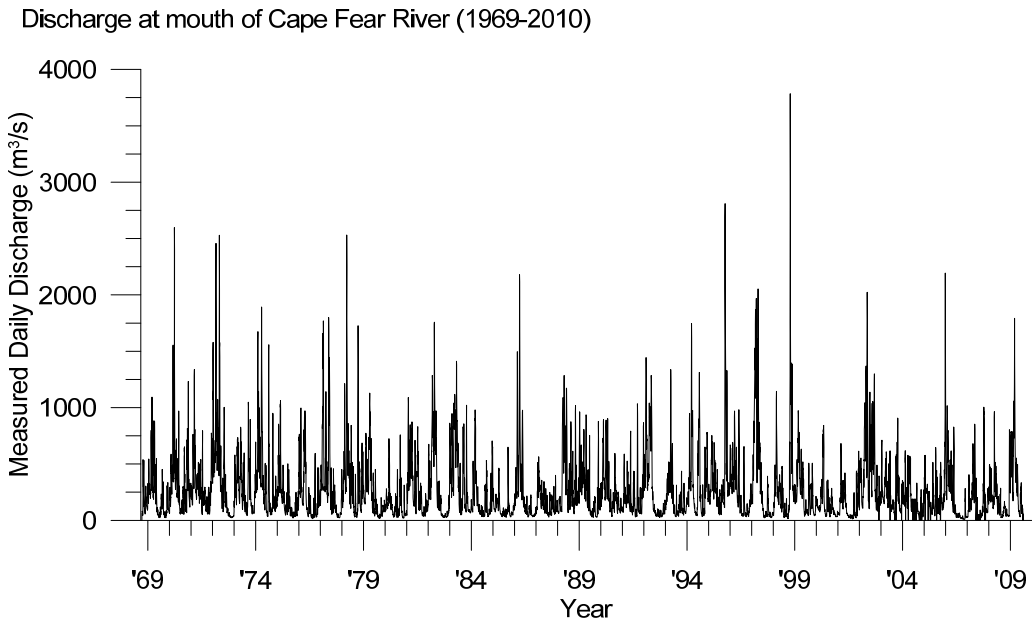


Figure 4.22. Measured Daily Discharge at the Cape Fear River, 1969-2010. (Olsen, 2012)

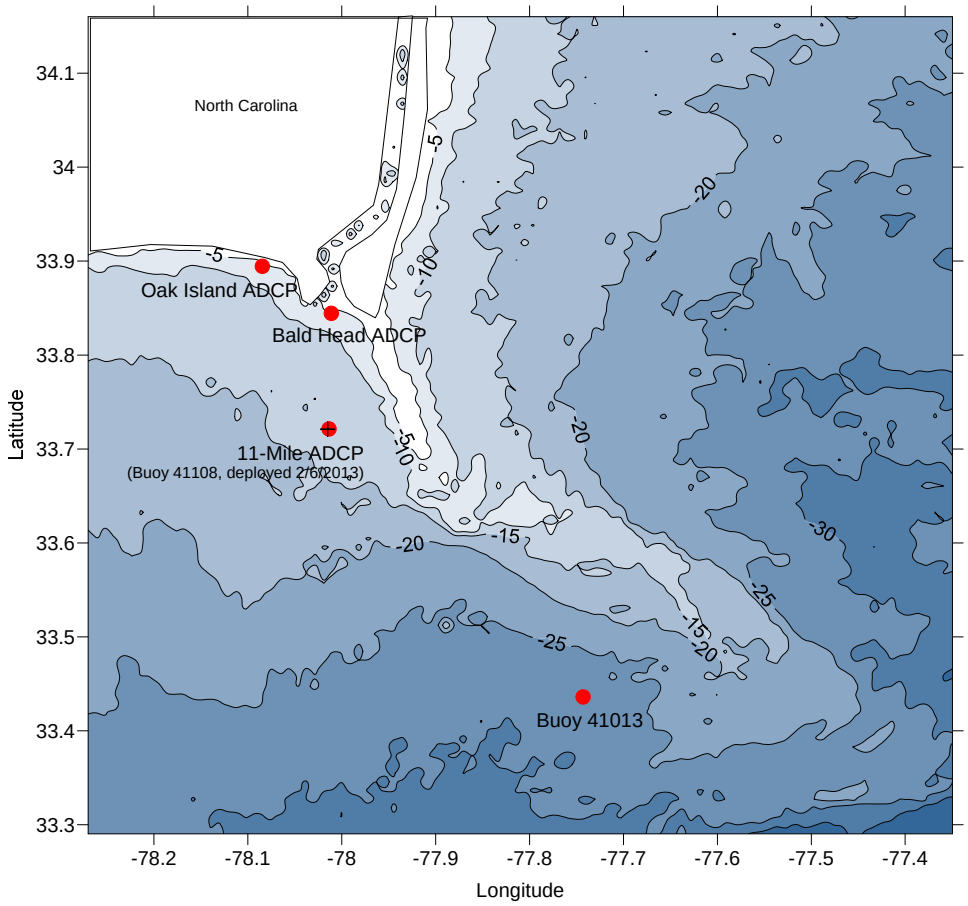
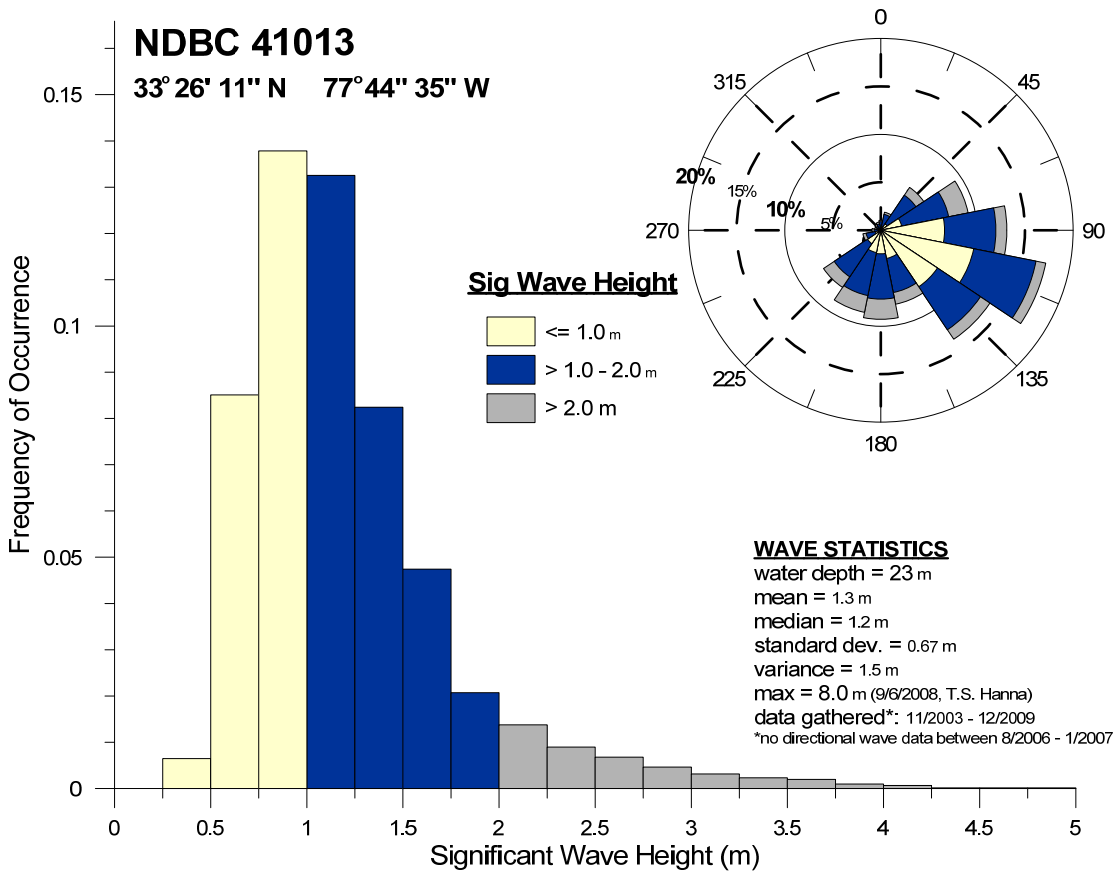


Figure 4.23. Location of Wave and/or Wind Measurement Stations. Buoy 41108 was deployed near the 11-Mile ADCP gauge on 2/6/2013. Buoy location is denoted as a black cross. Contours are meters.



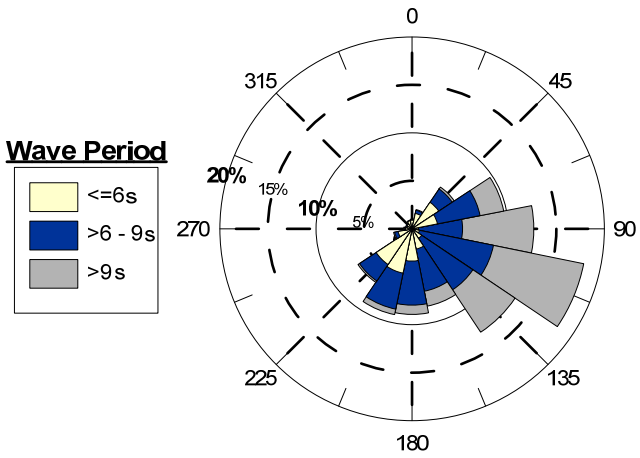


Figure 4-24. Wave Data at NOAA Buoy 41013 located Southeast of Frying Pan Shoals. (Olsen, 2012)

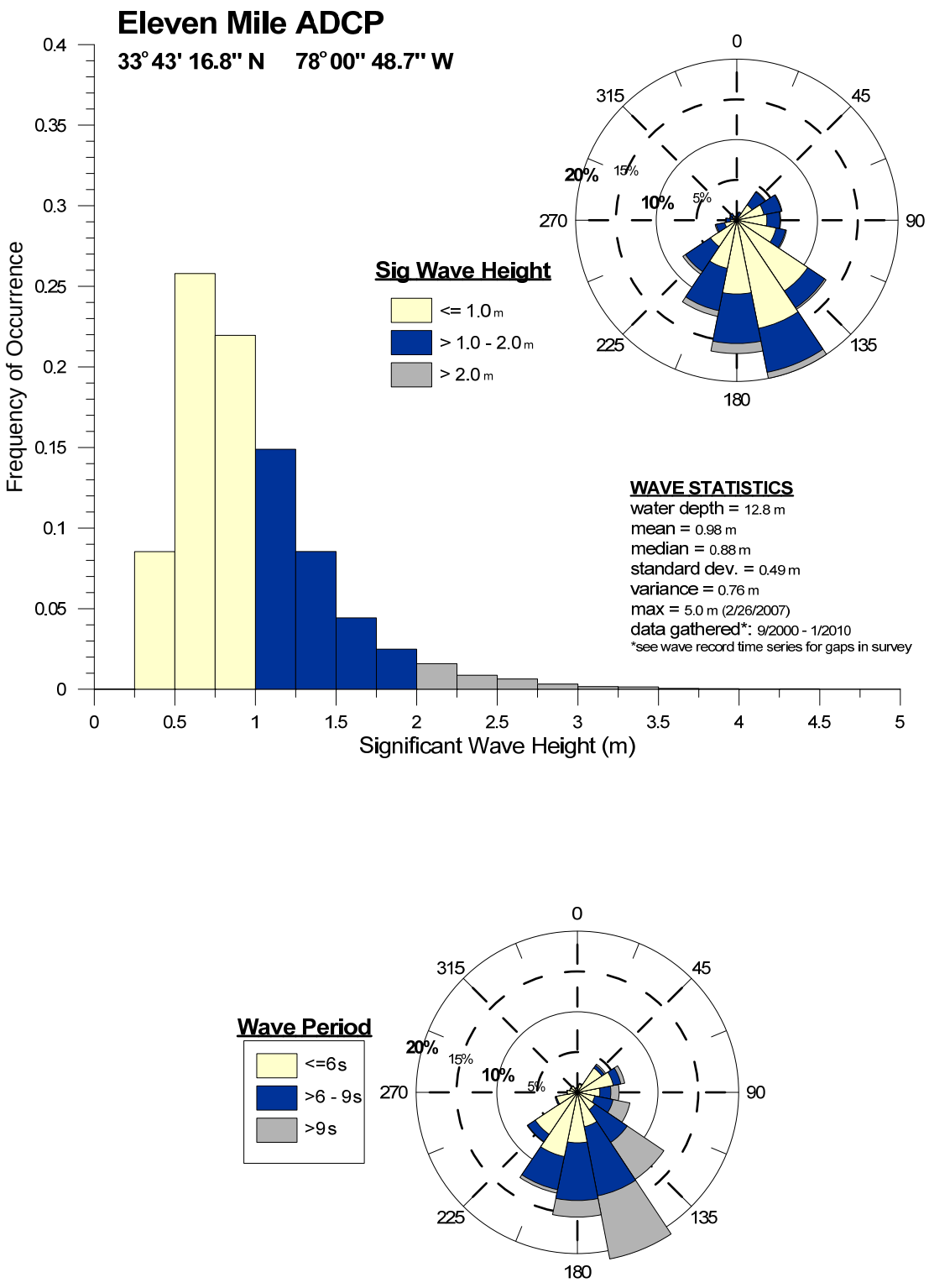
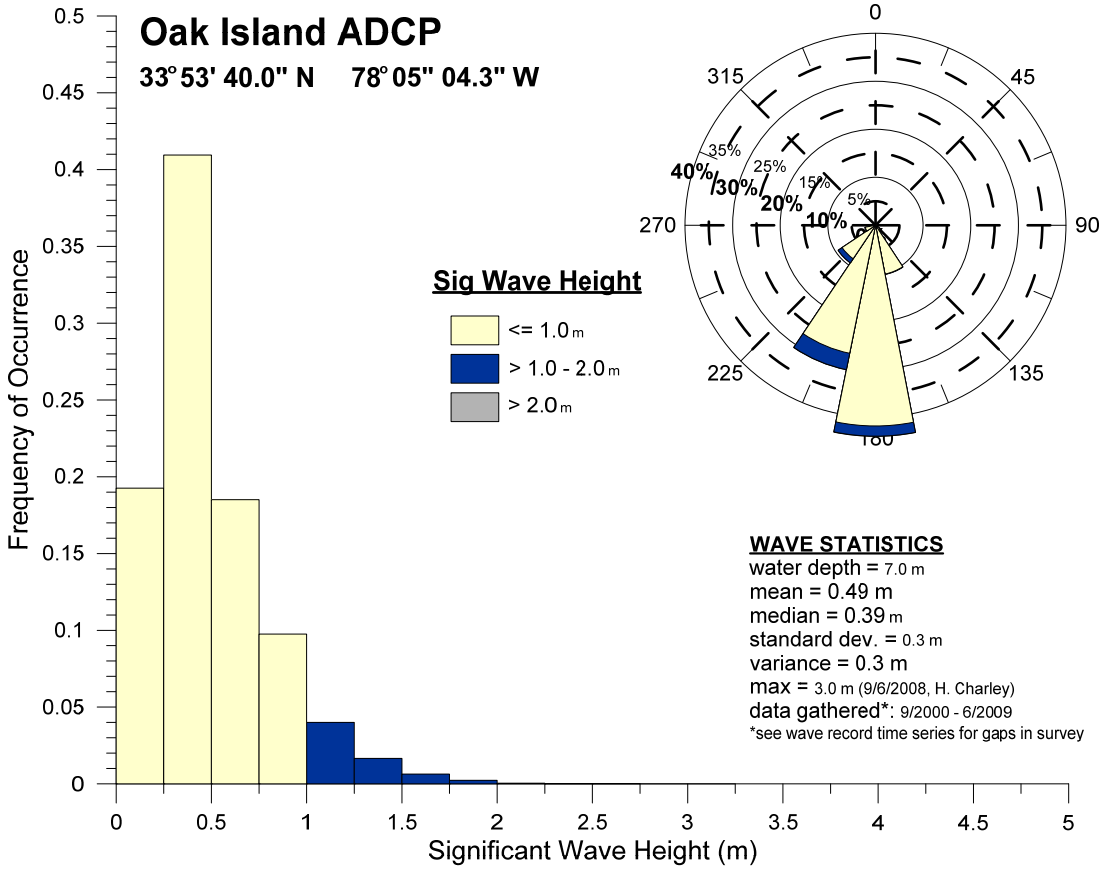


Figure 4.25. Wave Data at the USACE 11-mile ADCP Gauge located inside Frying Pan Shoals (but in relatively unprotected waters). (Olsen, 2012).



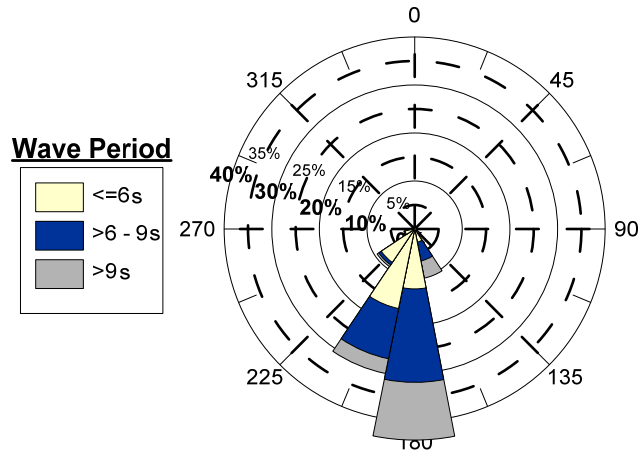
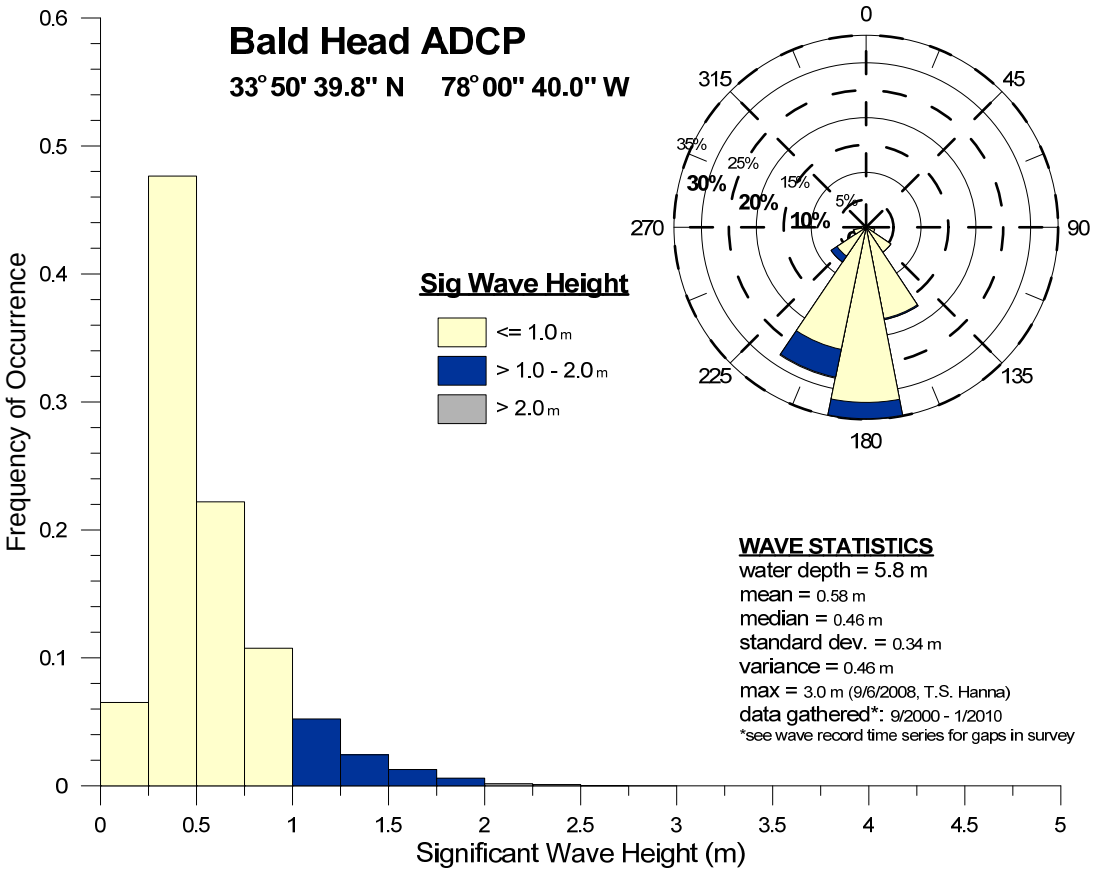


Figure 4.26. Wave Data at the Oak Island ADCP Gauge located inside Frying Pan Shoals (in protected nearshore waters). Olsen, 2012)



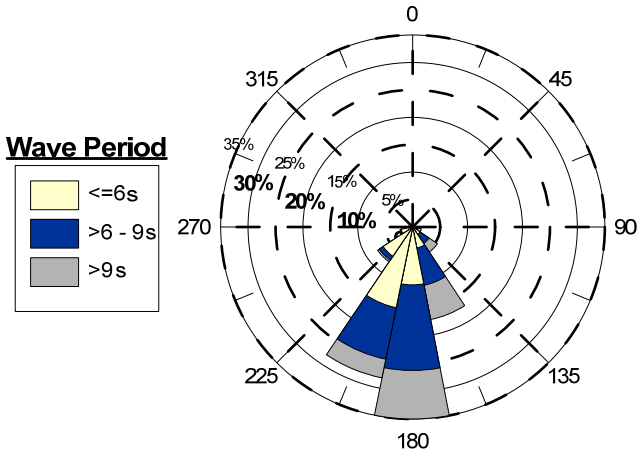


Figure 4.27. Wave Data at the Bald Head ADCP Gauge located inside Frying Pan Shoals (in protected nearshore waters). (Olsen, 2012)

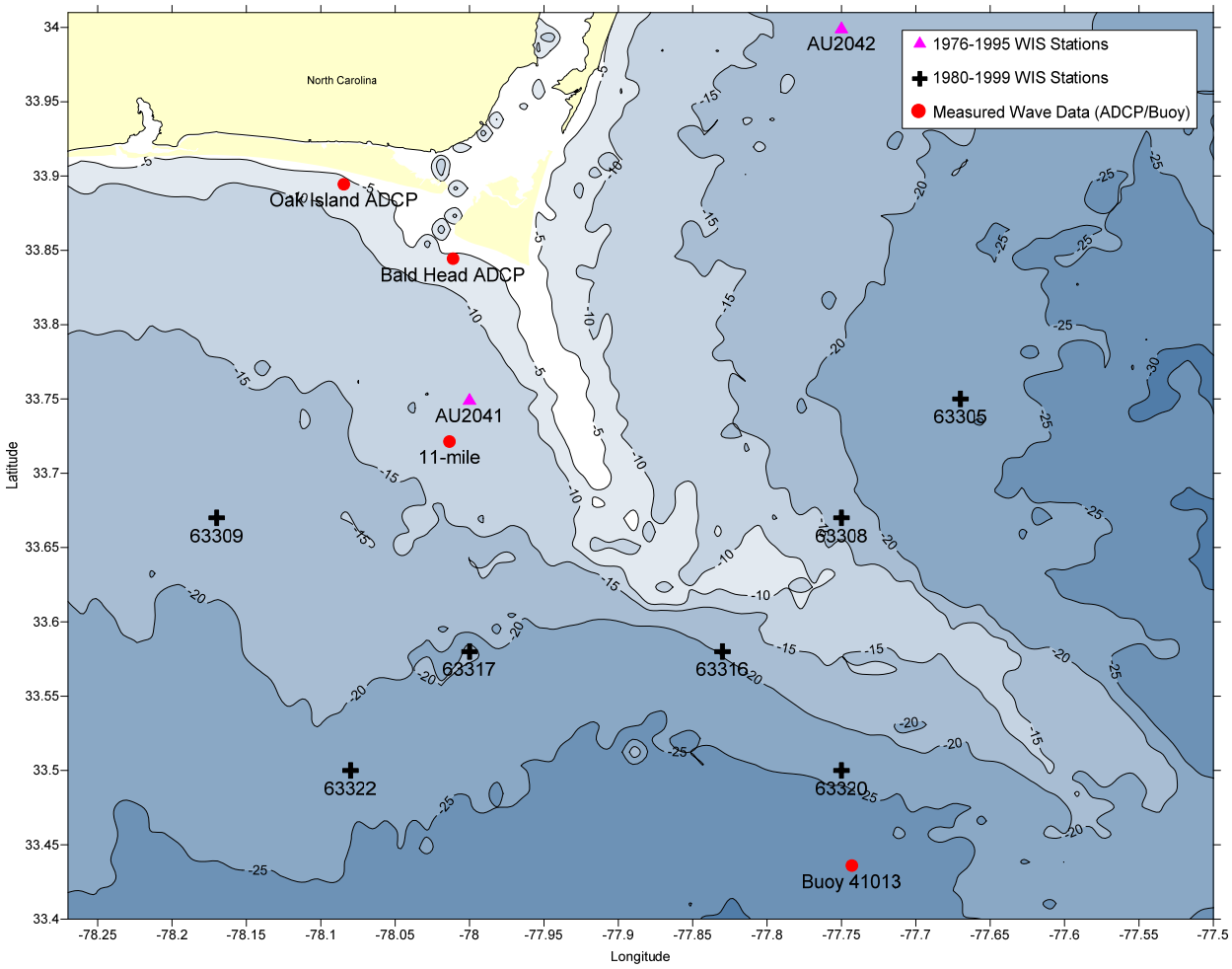


Figure 4.28. WIS Hindcast Stations relative to the Cape Fear Entrance and Measured Data. (Olsen, 2012)

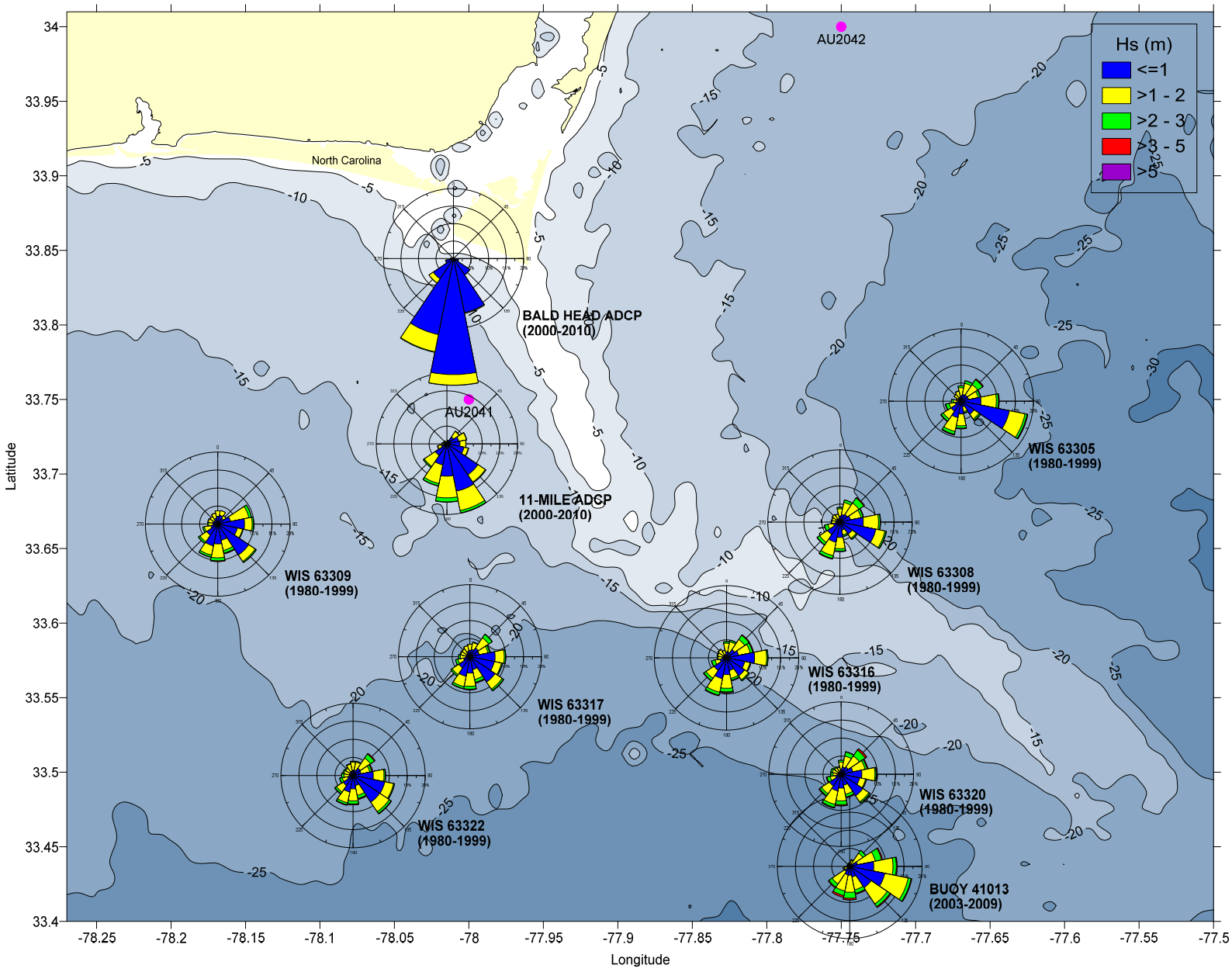


Figure 4.29. Wave Roses Depicting Hindcast and Measured Wave Conditions in the Study Area. (Olsen 2012)

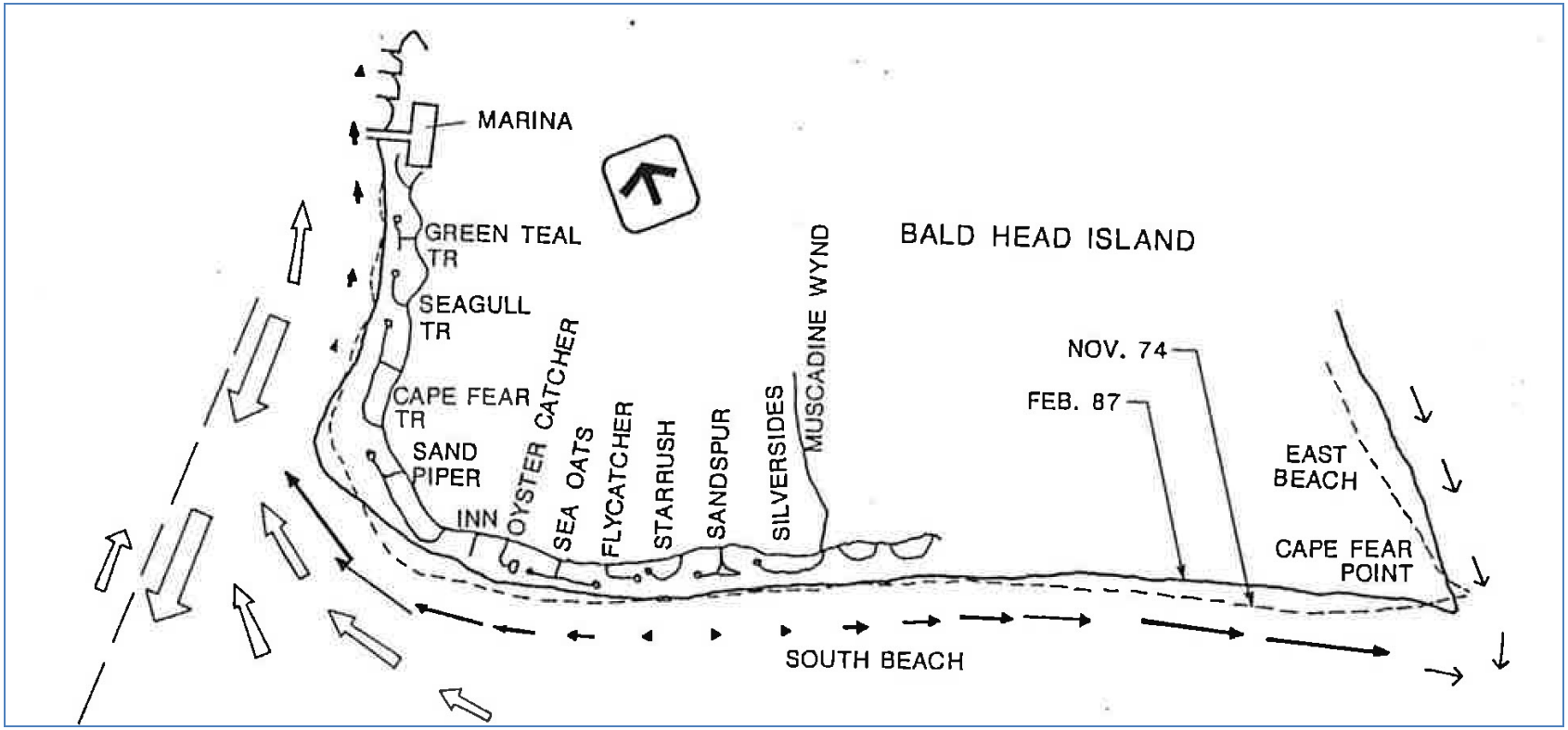


Figure 4.30. Computed sediment transport patterns along Bald Head Island (Olsen, 1989).

(Note: The interpretative arrows in this figure are of a qualitative nature given the date of the report (i.e. 1989). Identical, but highly quantitative littoral transport predictions along South Beach on Bald Head Island resulting from the project-specific Delft 3D modeling are included in Olsen, 2013.)

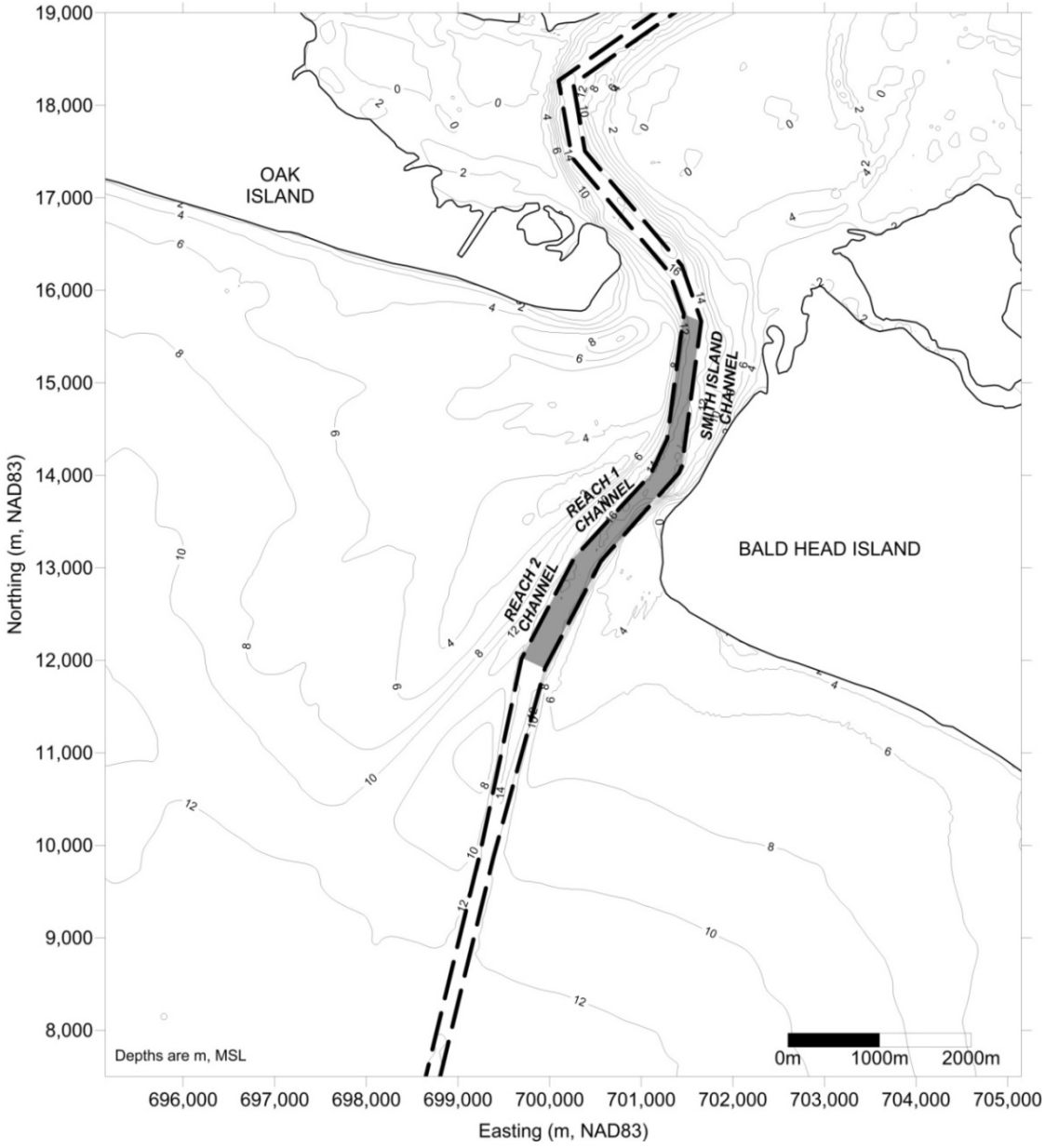


Figure 4.31. Reaches of the Federal Navigation Channel which Routinely Shoal with Beach Compatible Material (Olsen 2012).

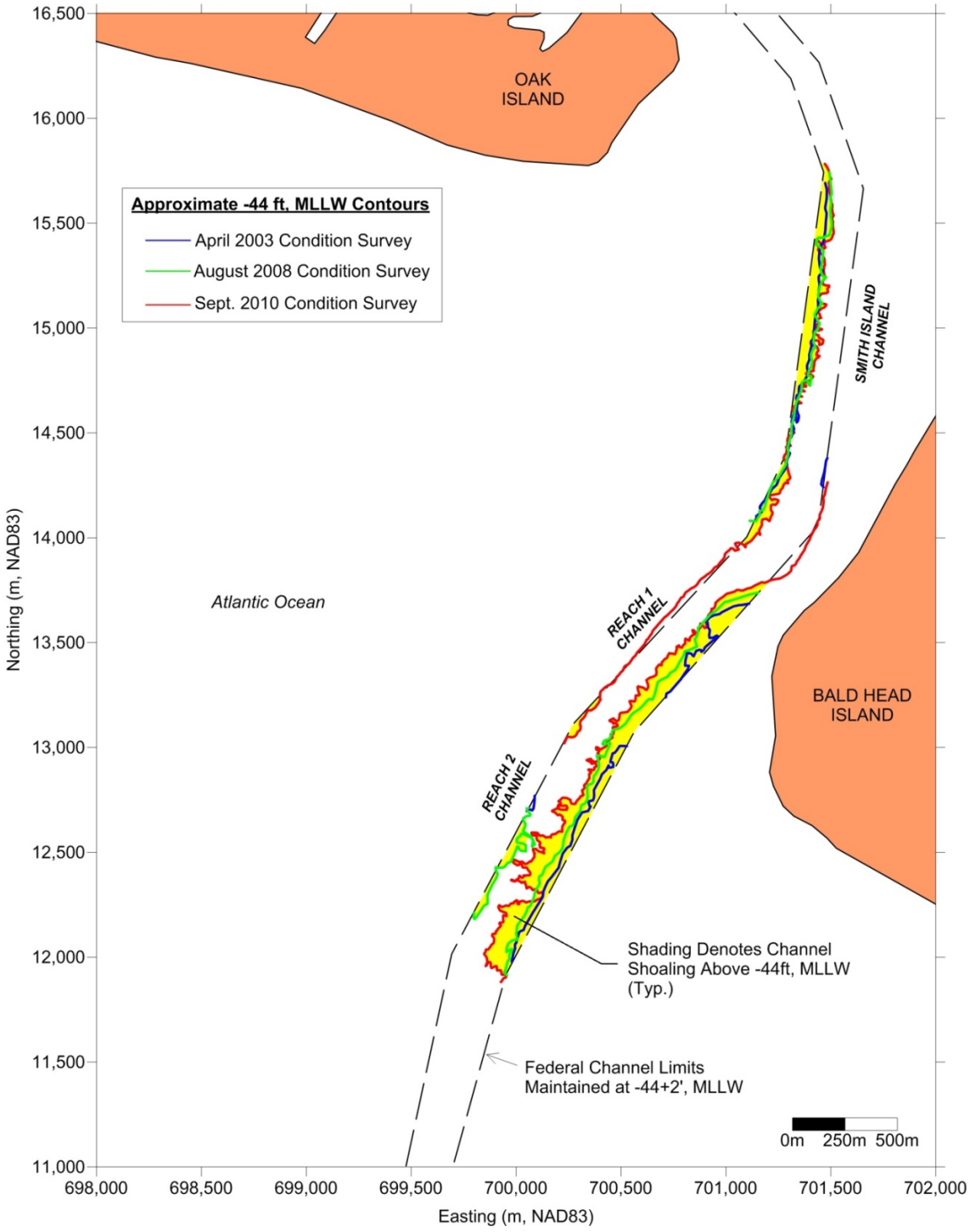


Figure 4.32. USACE Condition Surveys of the Navigation Channel in the Cape Fear Entrance, 2003 to Present (Olsen 2012). Note that shaded areas inside the channel limits depict shoaling above -44 ft, MLLW as indicated in the surveys.

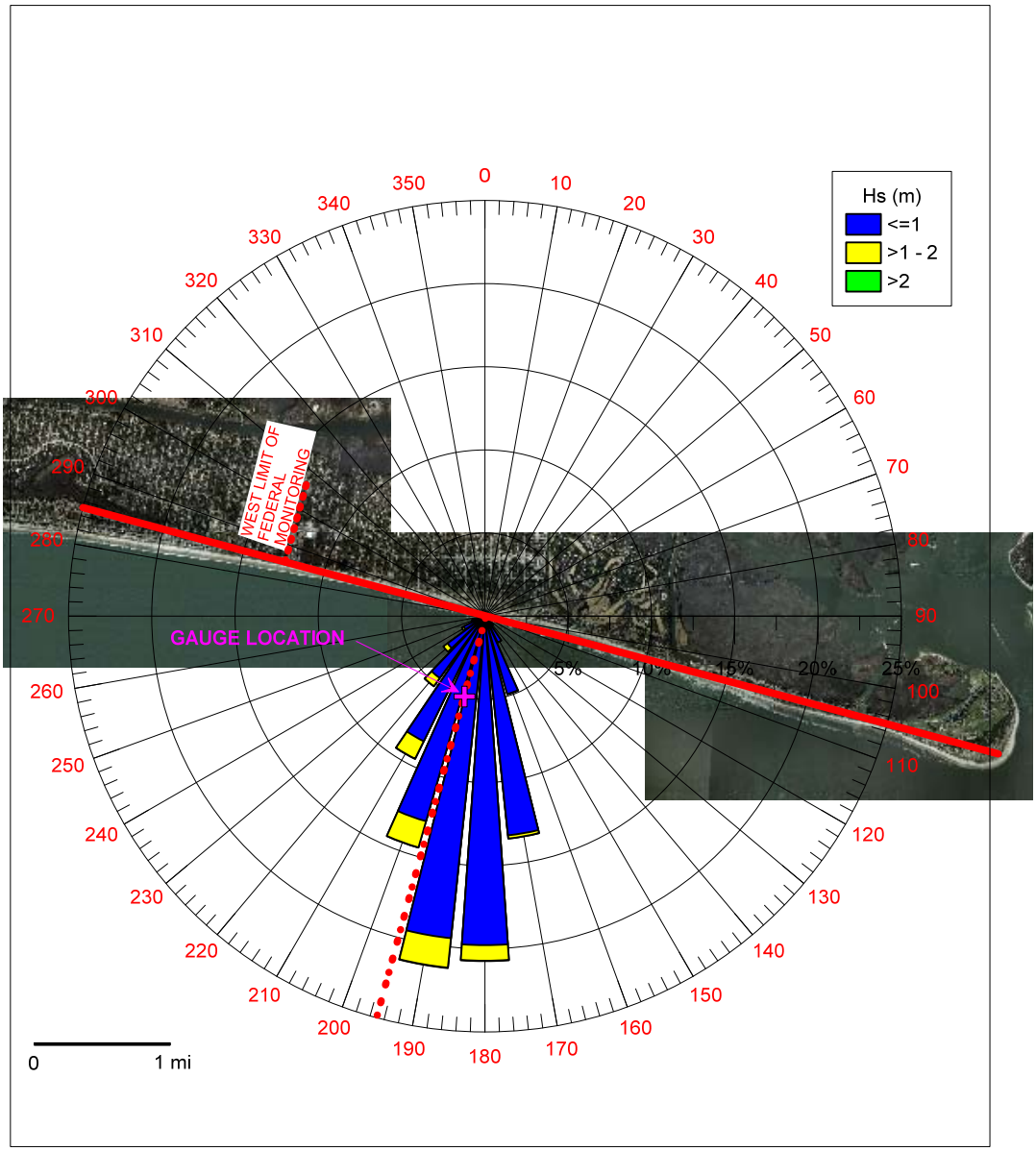


Figure 4.33. Directional Distribution of Wave Height at the Oak Island ADCP relative to the Island's Dominant Shoreline Orientation of 15 degrees.

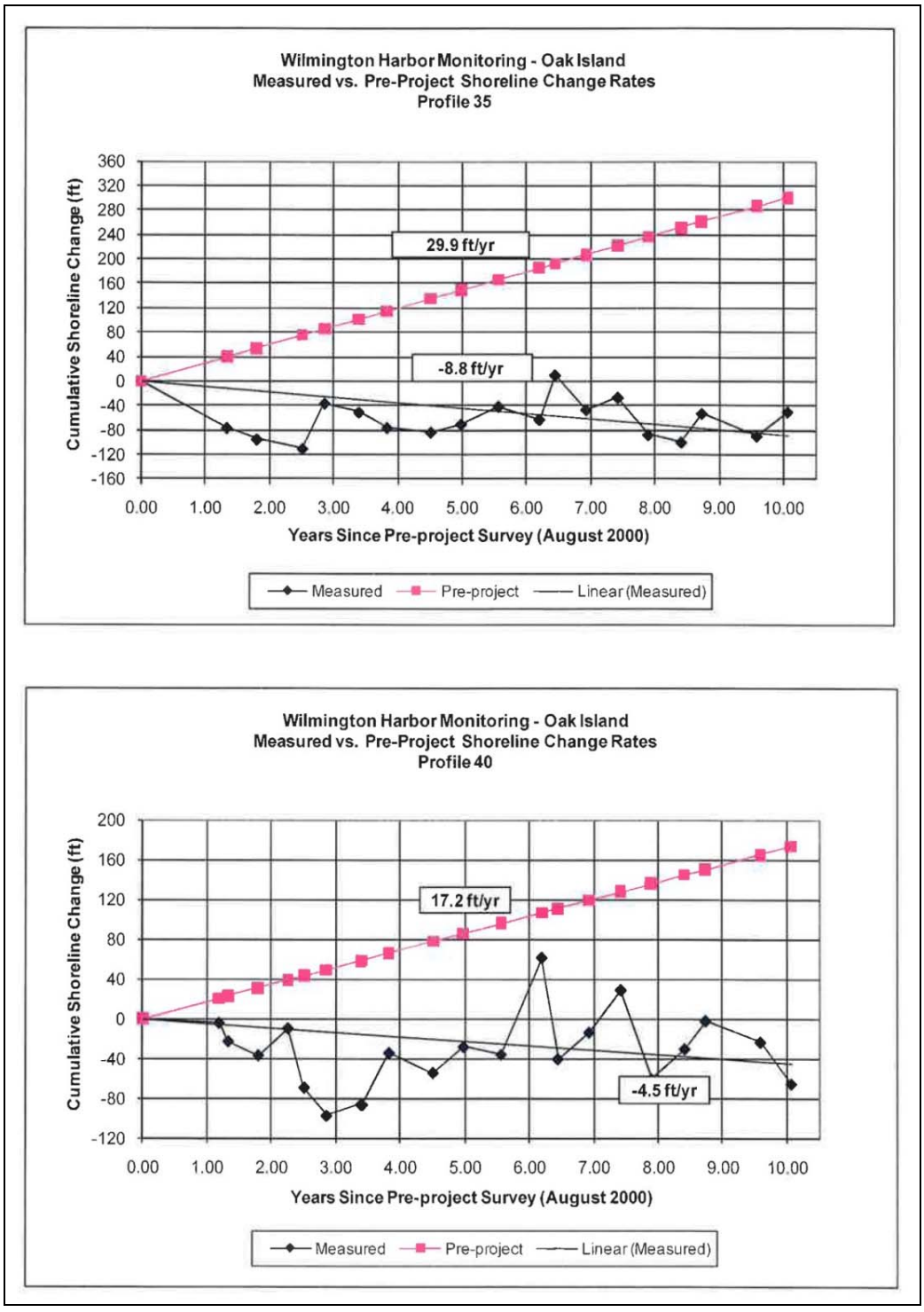


Figure 4.34. Physical Monitoring Data Collected and Published by USACE at the Hot Spot along Caswell Beach (adapted from USACE, 2011a).

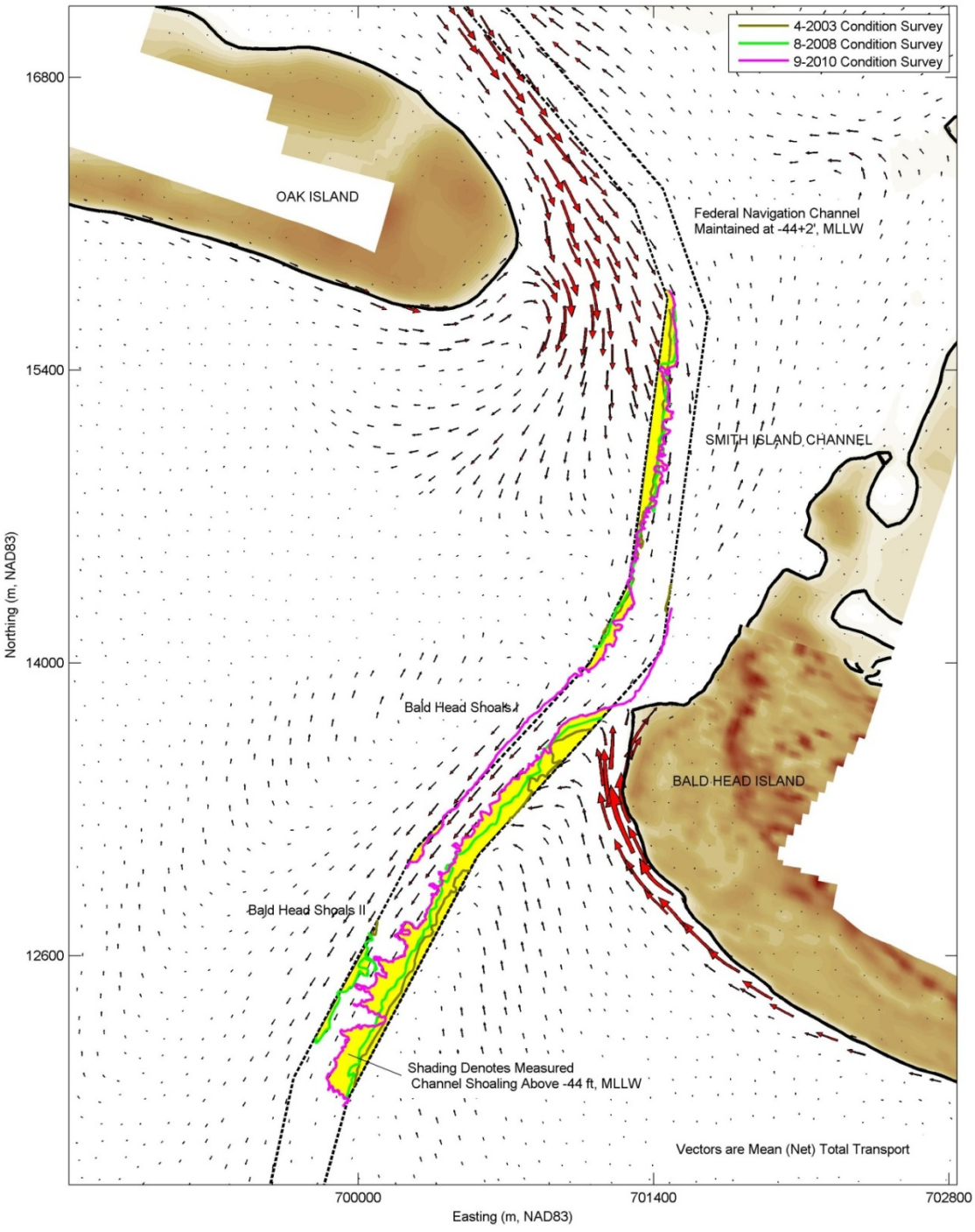


Figure 4.35. Overlay of Measured Areas of Chronic Channel Shoaling along with Predicted Vectors of Sediment Transport (Olsen, 2012). (Note that vectors are scaled by the magnitude of sediment transport.)

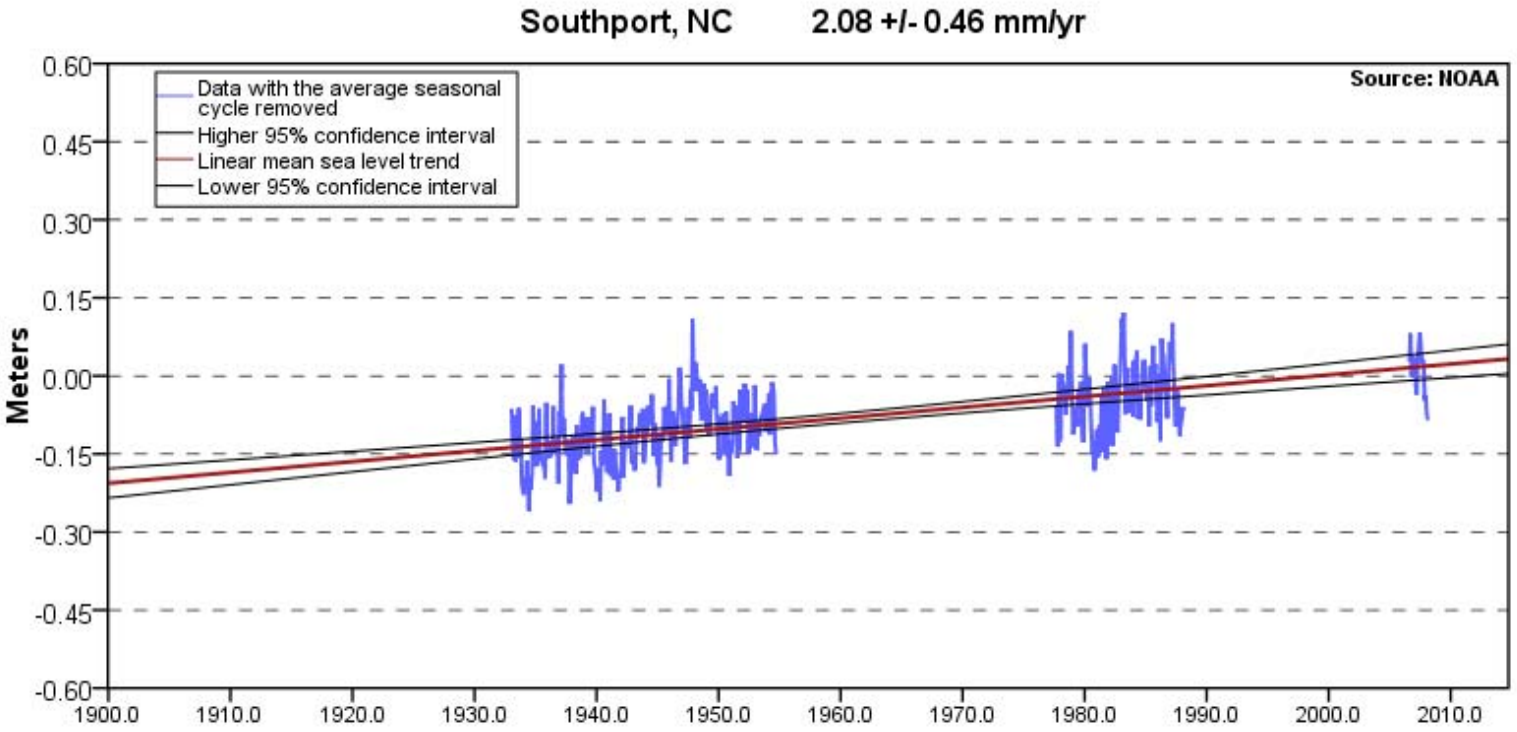
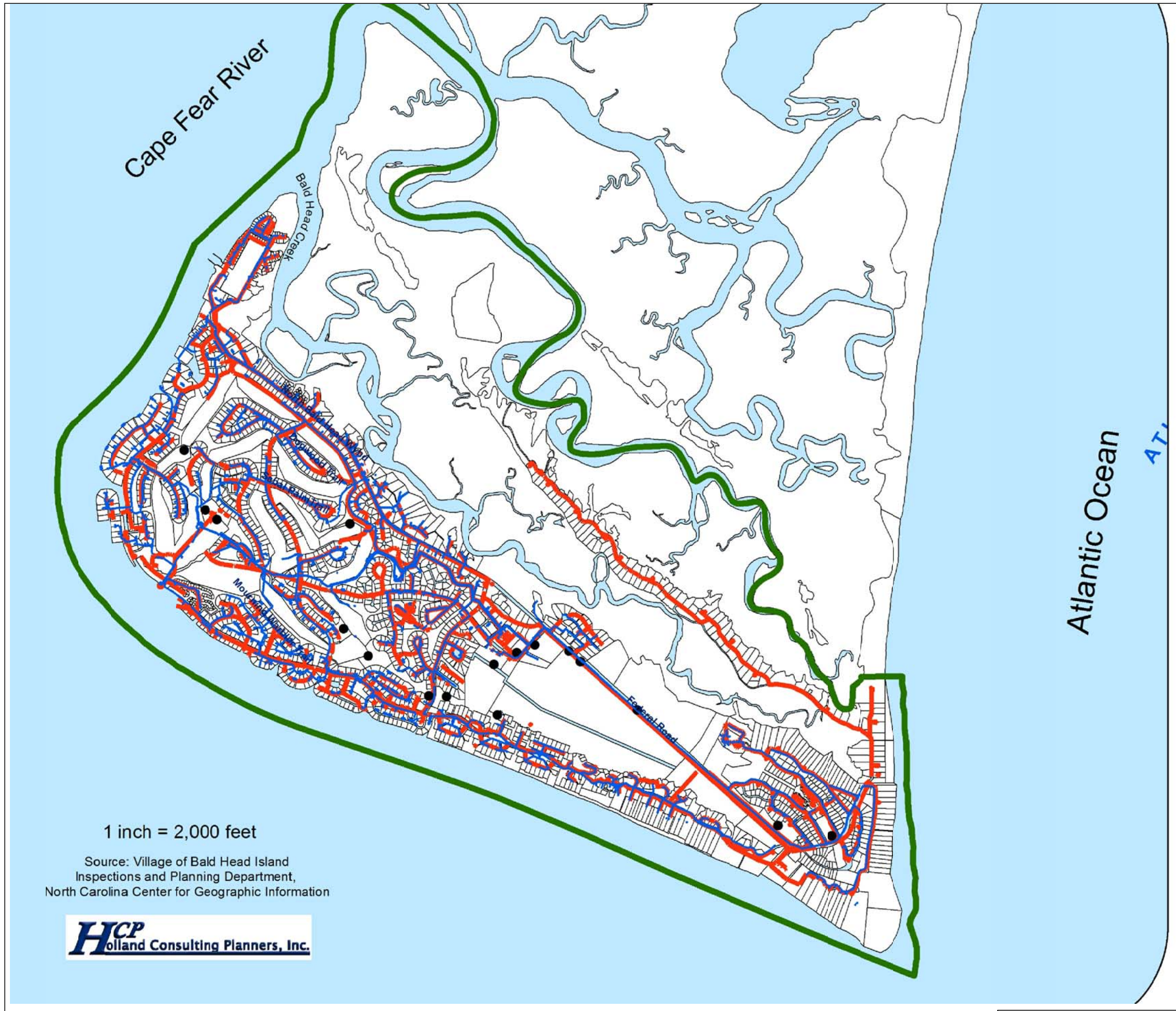


Figure 4.36. Sea Level Trends at Southport, NC (1933-2006) – adapted from the NOAA online data archive.

Village of Bald Head Island

Land Use Plan

Existing Infrastructure



Legend

- Existing Sewer Lines
- Groundwater Supply Wells
- Existing Water Lines
- Village of Bald Head Island Corporate Limits
- Hydrology

N
W E
S

The preparation of this map was financed in part through a grant provided by the North Carolina Coastal Management Program, through funds provided by the Coastal Zone Management Act of 1972, as amended, which is administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration.

Map provided by Holland Consulting Planners, Inc. Groundwater supply wells added by LMG. Scale modifications by LMG.

0 1000 2000 4000

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Project: **Village of Bald Head Island Shoreline Protection Project**		Date: 4/2013	Revision Date: NA
		Scale: **1"=2000'**	Job Number: 40-11-238
Title: ***CAMA Land Use Plan Infrastructure Map***		Drawn By:	Figure: **Figure 4.37**

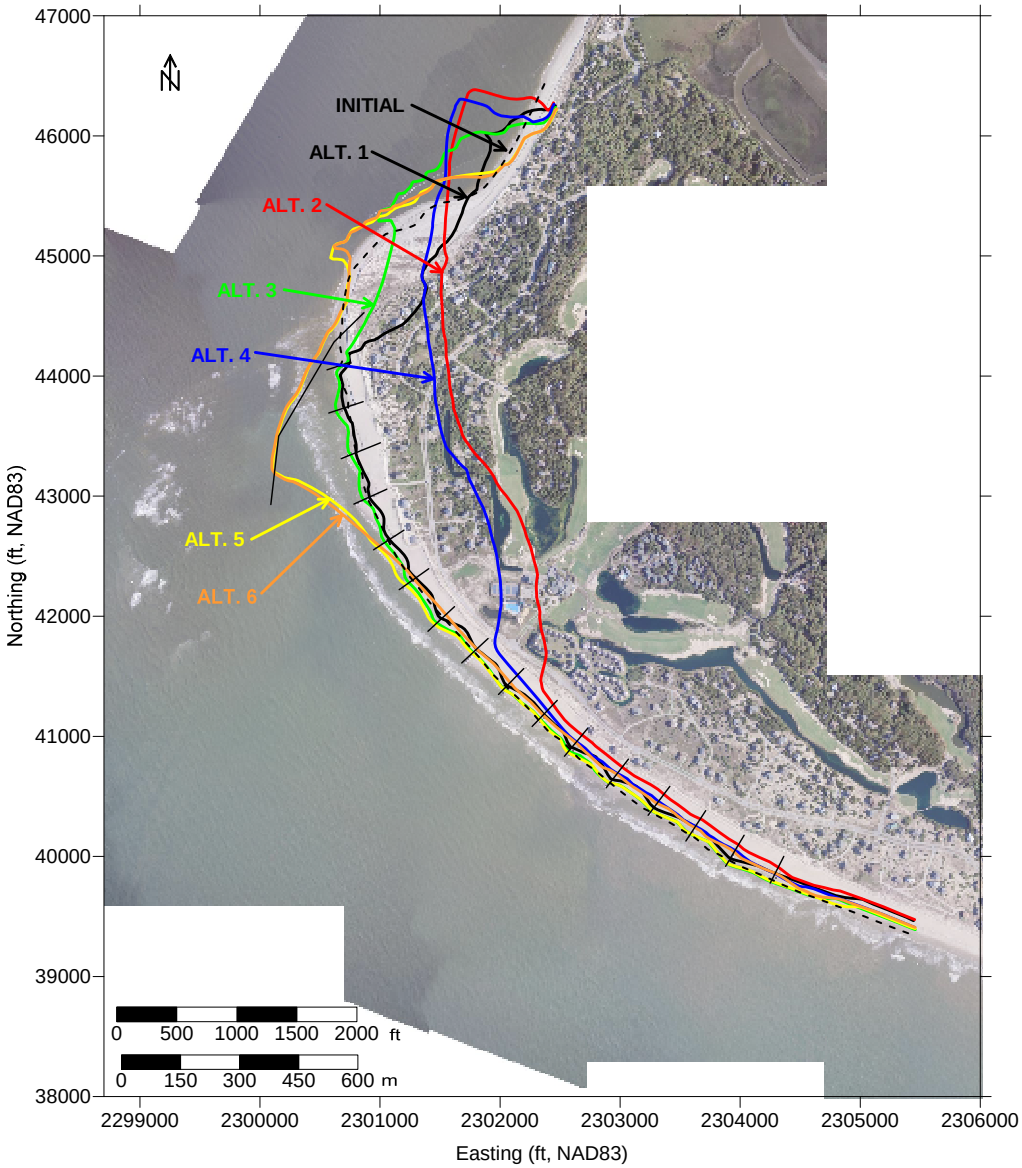


Figure 5.1. Predicted MLLW Shoreline after a 9-Year Simulation for Each Alternative. Note units are feet. (April 2011 Aerial Photograph)

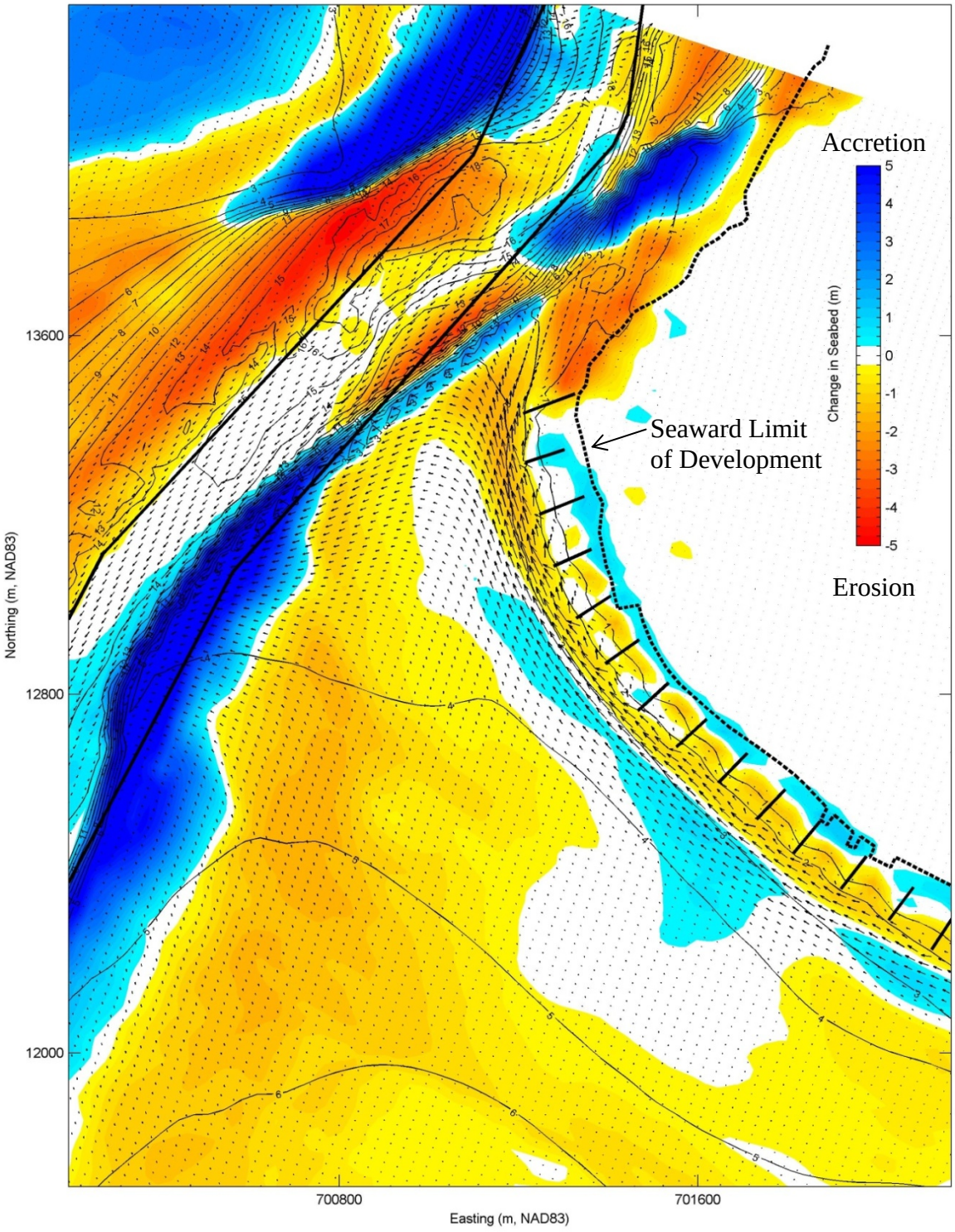


Figure 5.2. Predicted Sedimentation (blue) and Erosion (yellow/red) after 9 Years (prior to the next dredge/fill event) for Alternative 1.

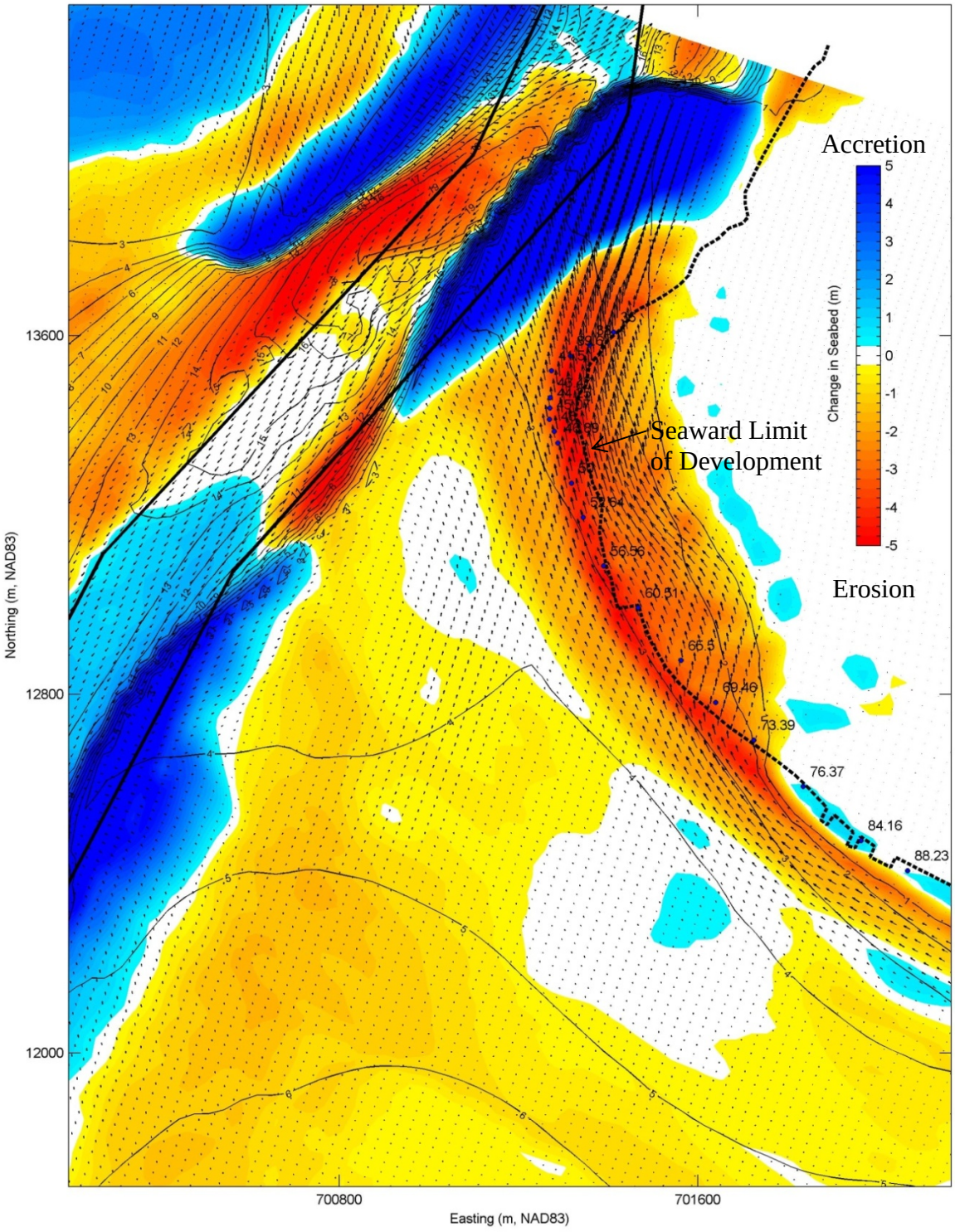


Figure 5.3. Cumulative Sedimentation (blue) and Erosion (red/yellow) Predicted after 9 Years for Alternative 2.

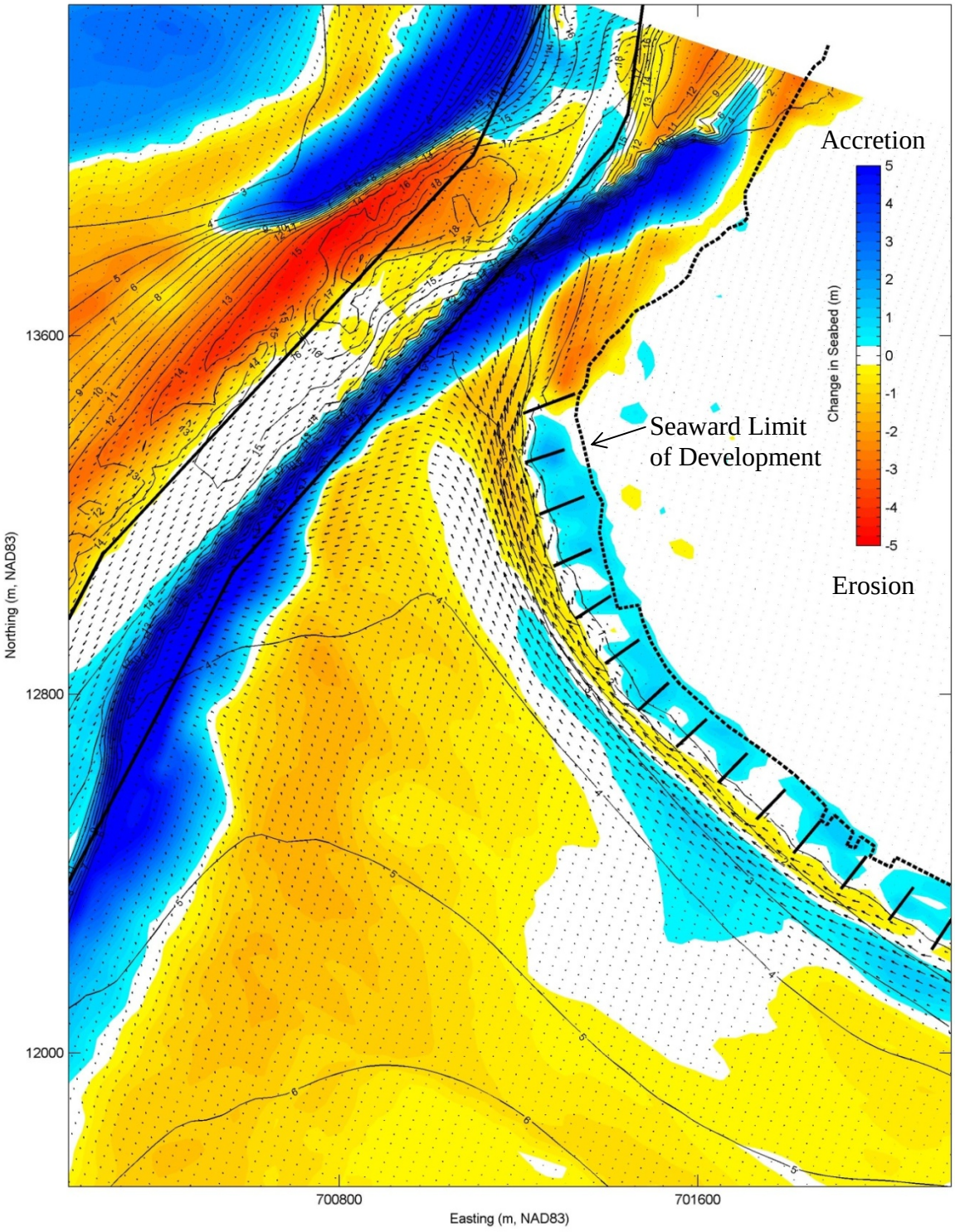


Figure 5.4. Predicted Sedimentation (blue) and Erosion (yellow/red) after 9 Years (prior to the next dredge/fill event) for Alternative 3.

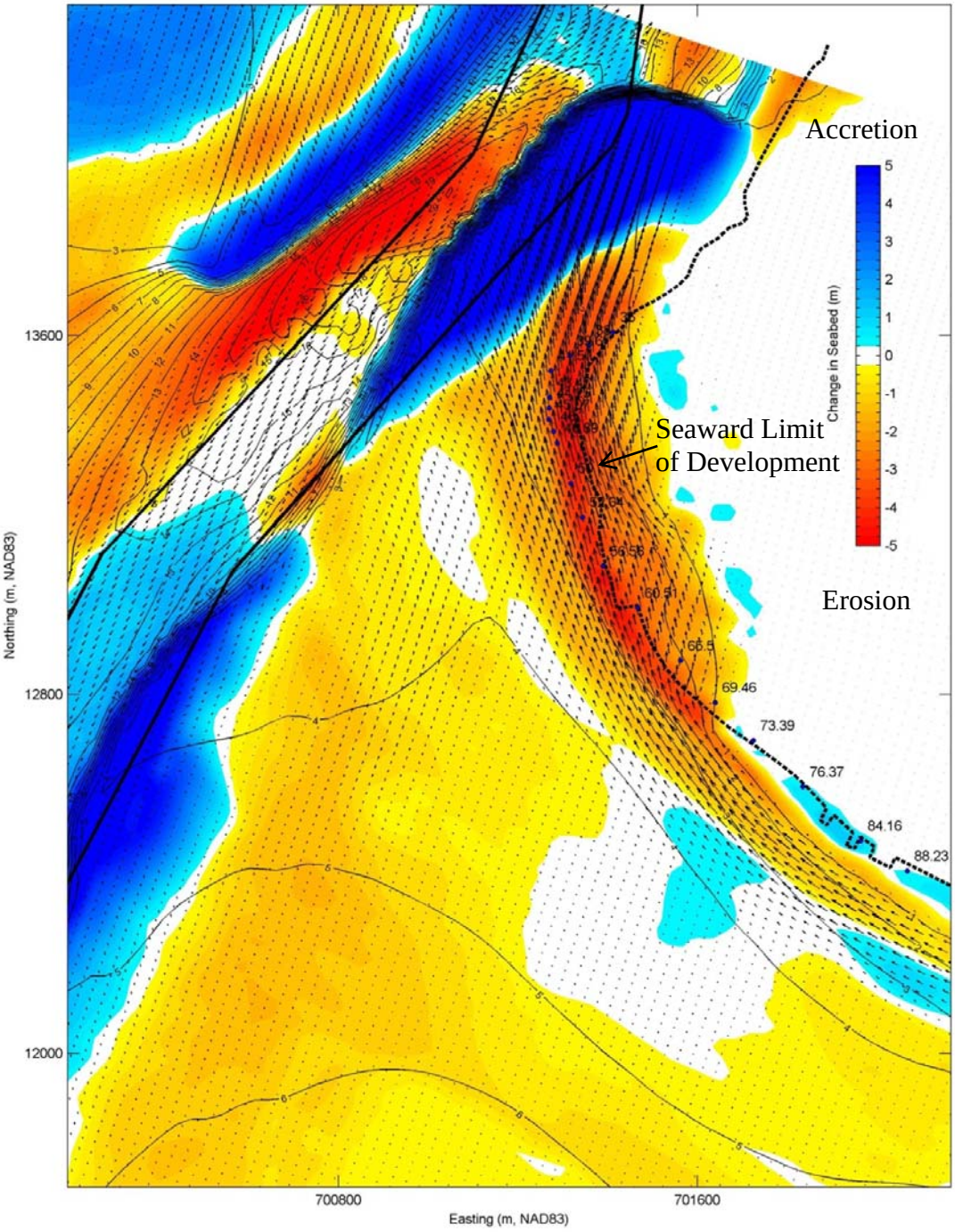


Figure 5.5. Cumulative Sedimentation (blue) and Erosion (red/yellow) Predicted after 9 Years for Alternative 4.

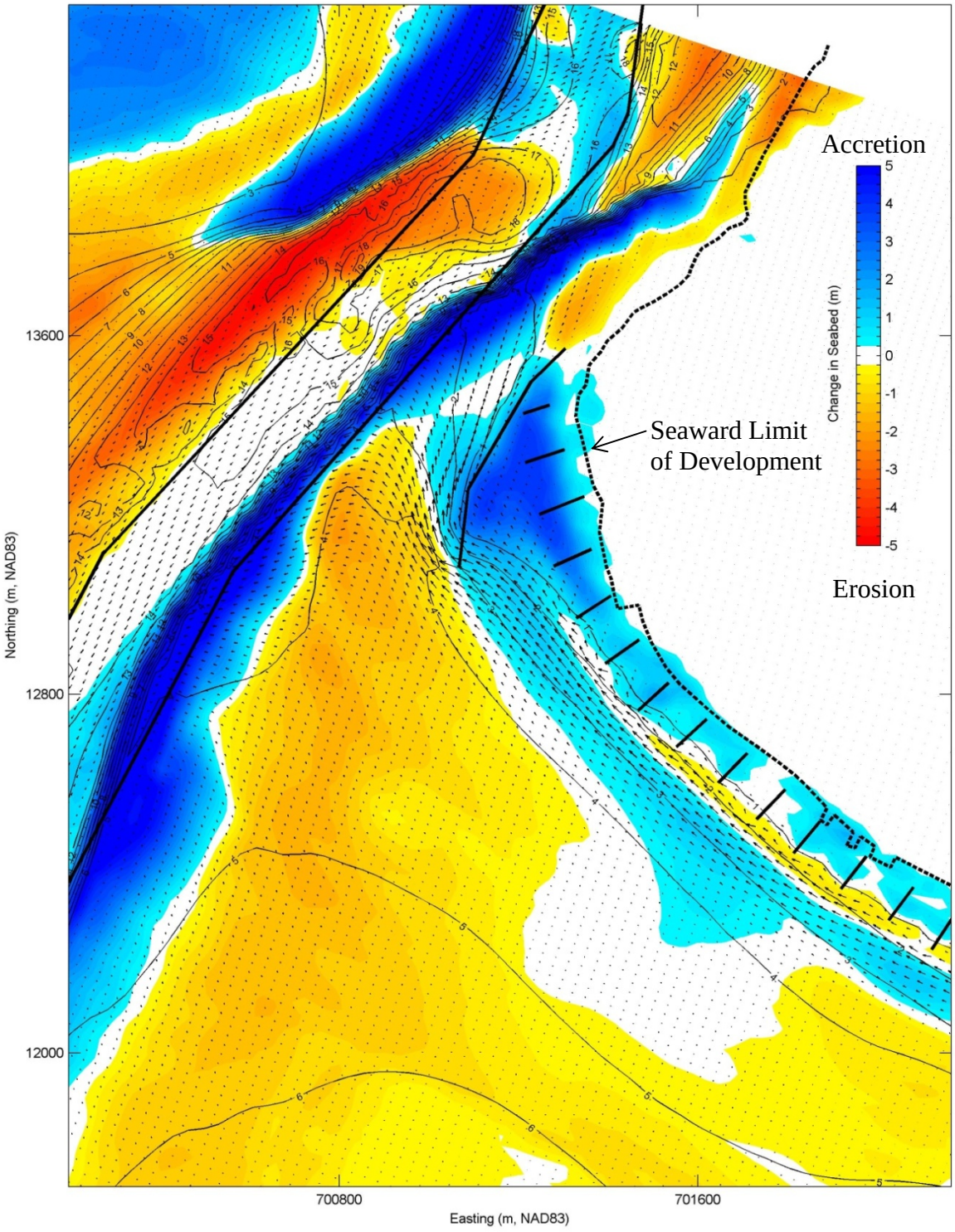


Figure 5.6. Cumulative Sedimentation and Erosion after 9 Years (prior to next dredge/fill event) for Alternative 5.

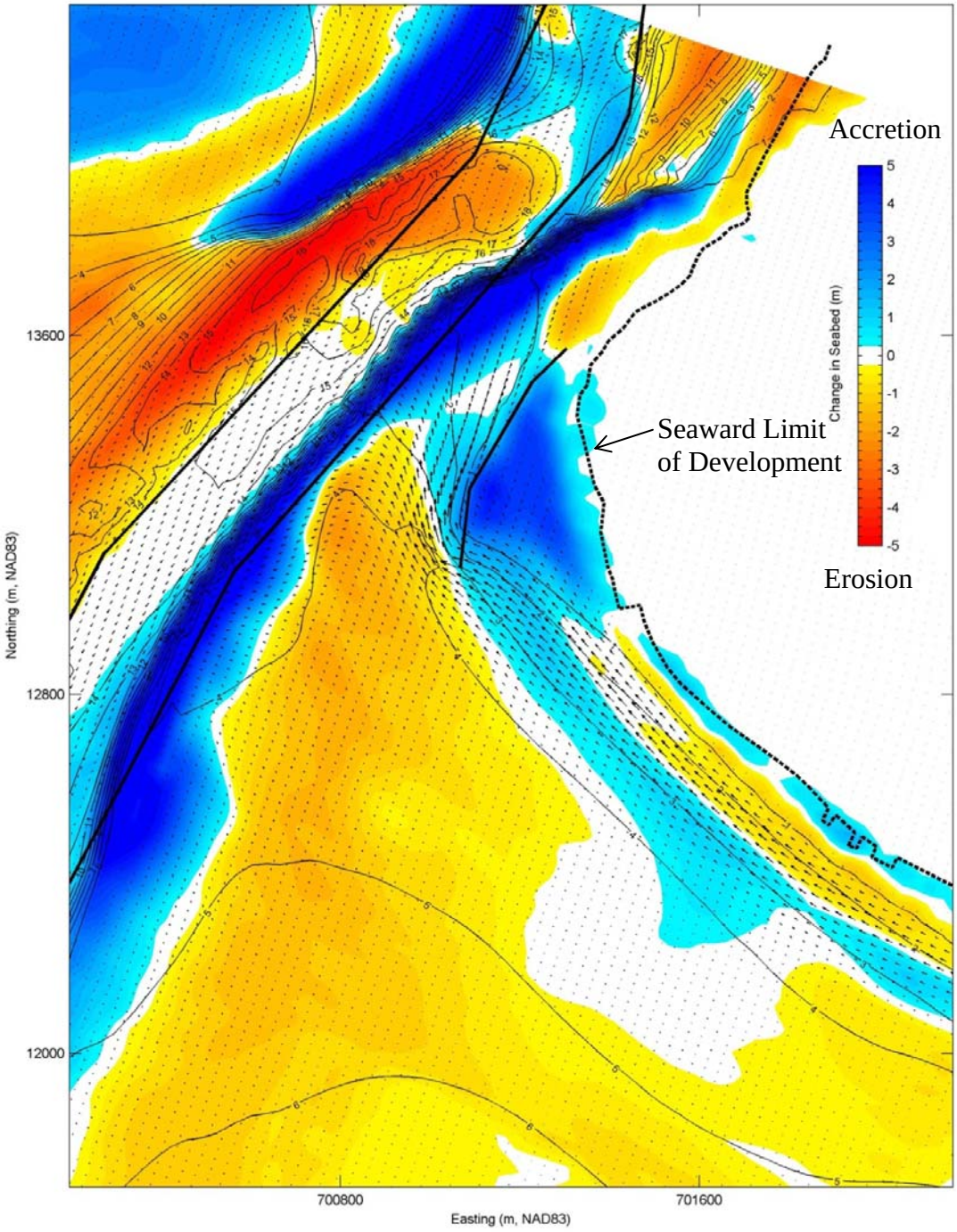


Figure 5.7. Predicted Cumulative Sedimentation and Erosion after 9 Years (prior to next dredge/fill event) for Alternative 6.

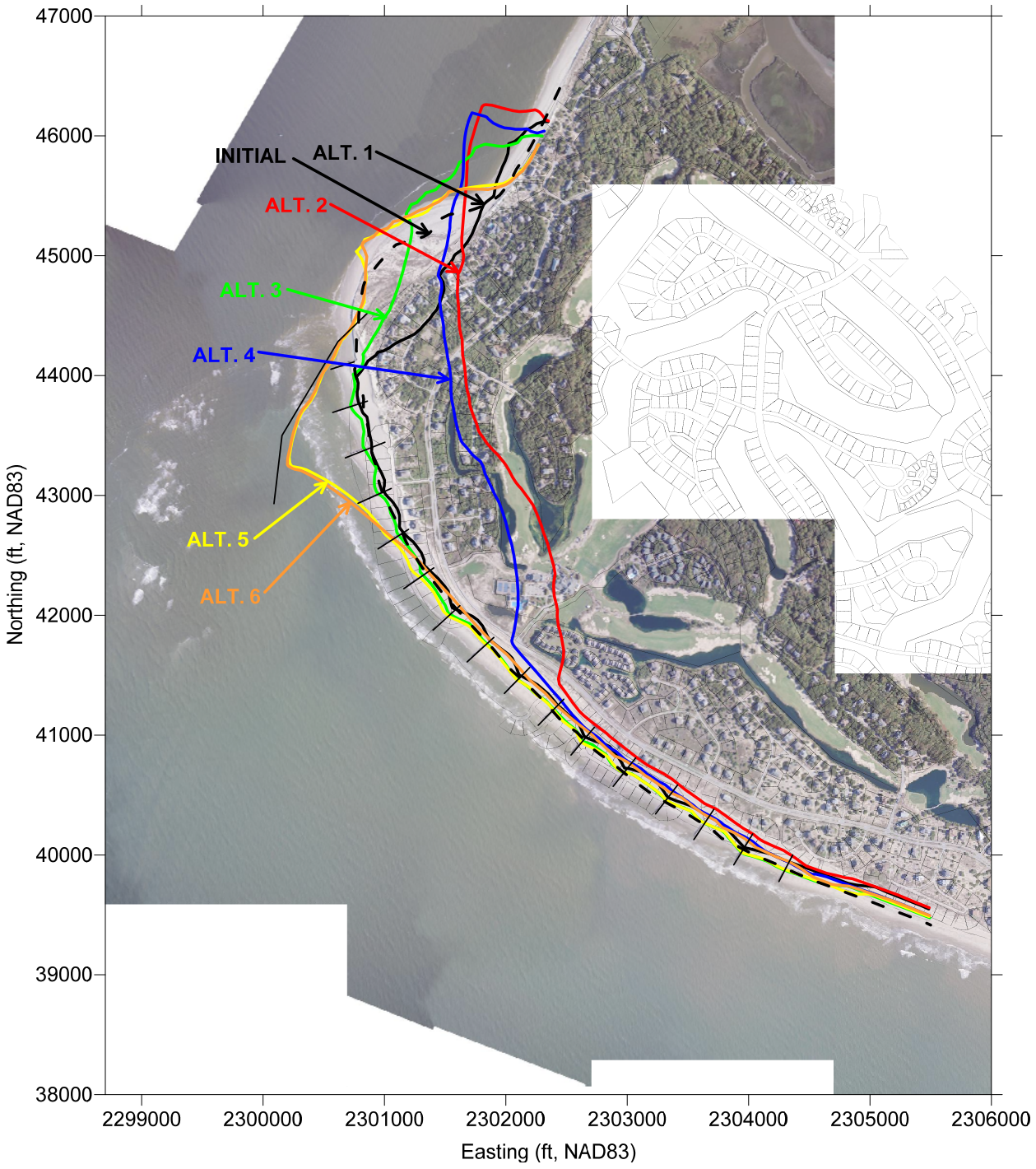


Figure 5.8. Estimated MHHW Shorelines after a 9-Year Simulation of Each Alternative. (Note that units are feet.)

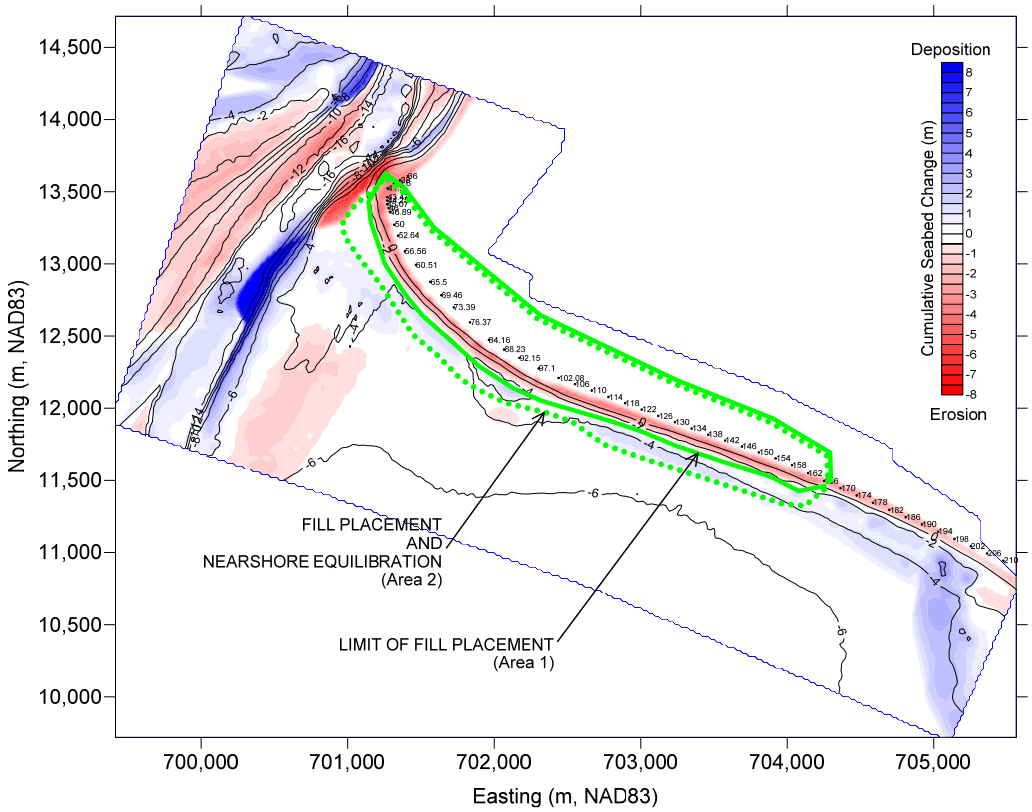


Figure 5.9. Predicted 3-Year Cumulative Erosion (red) and Sedimentation (blue) for the Sand-Filled Tube Groin plus Beach Fill Scenario. The limits for the two relative volumetric computations are indicated.

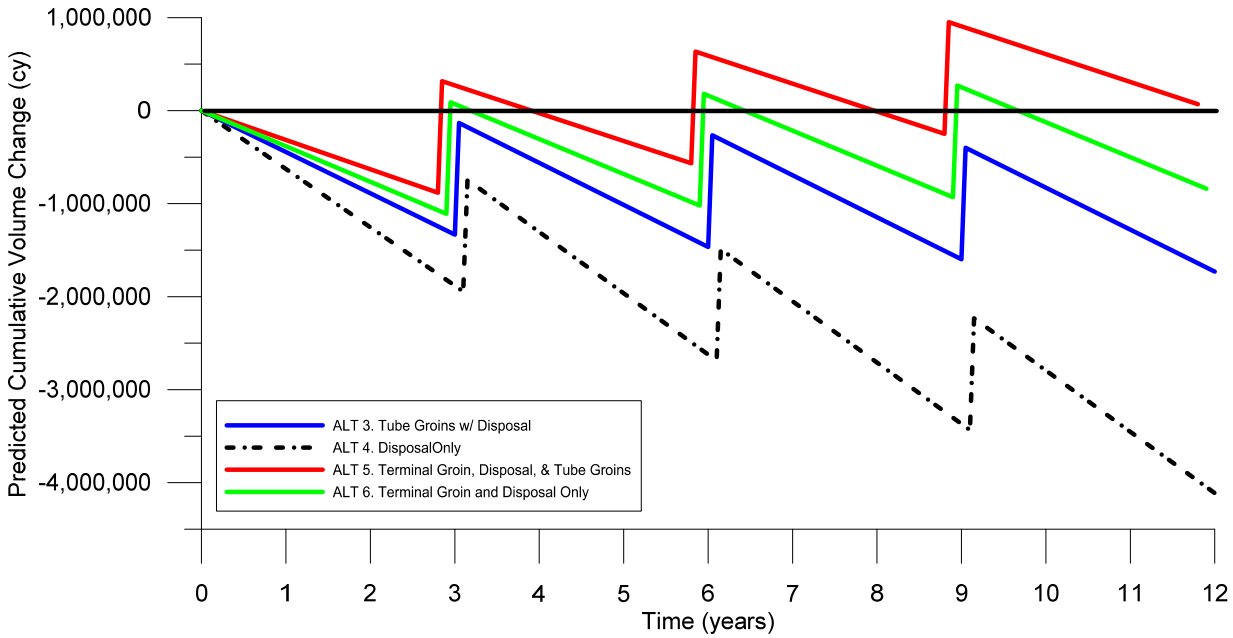


Figure 5.10. Hypothetical Cumulative Volume Changes along the Respective Fill Placement Areas for Project Alternatives 3-6.

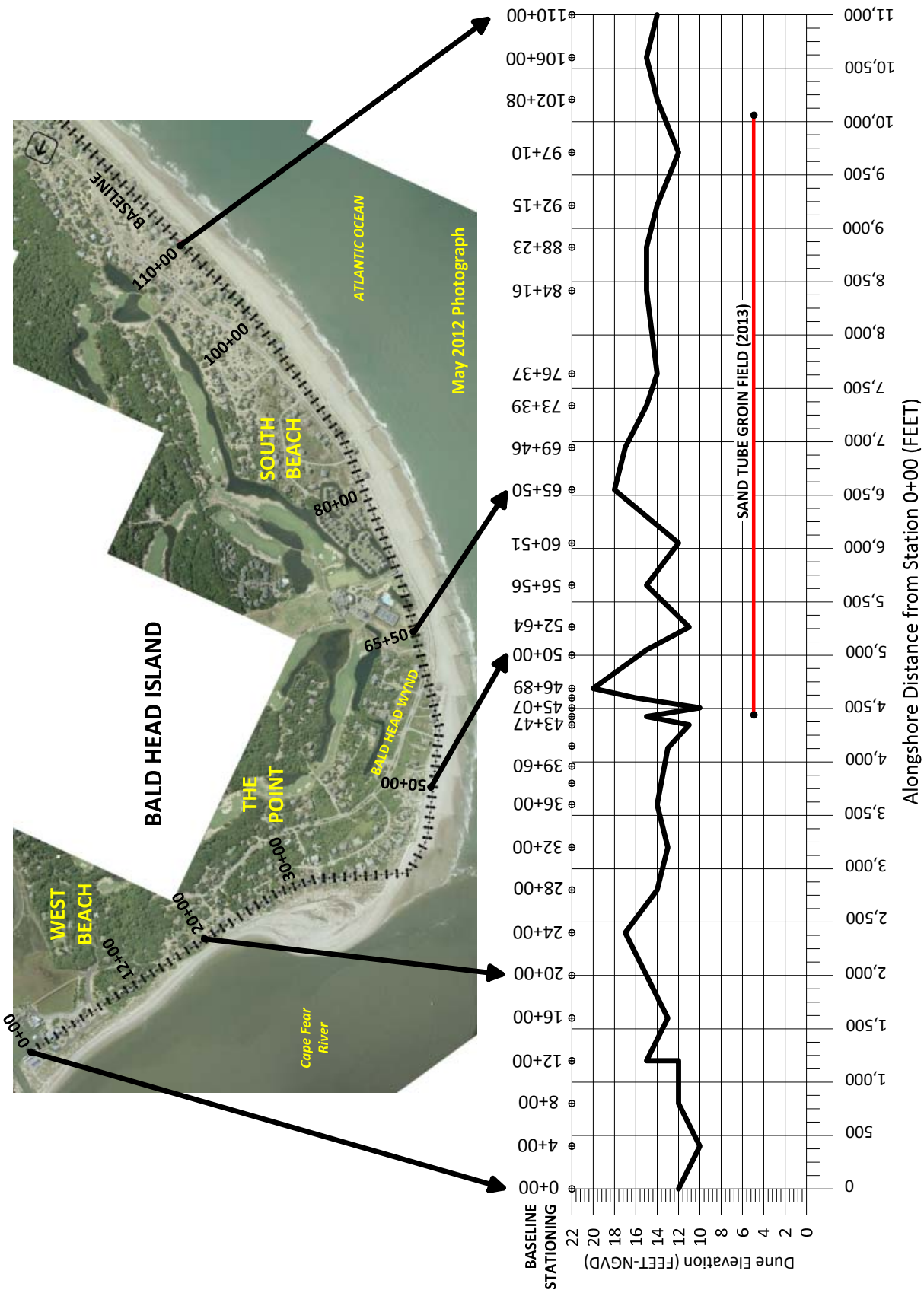
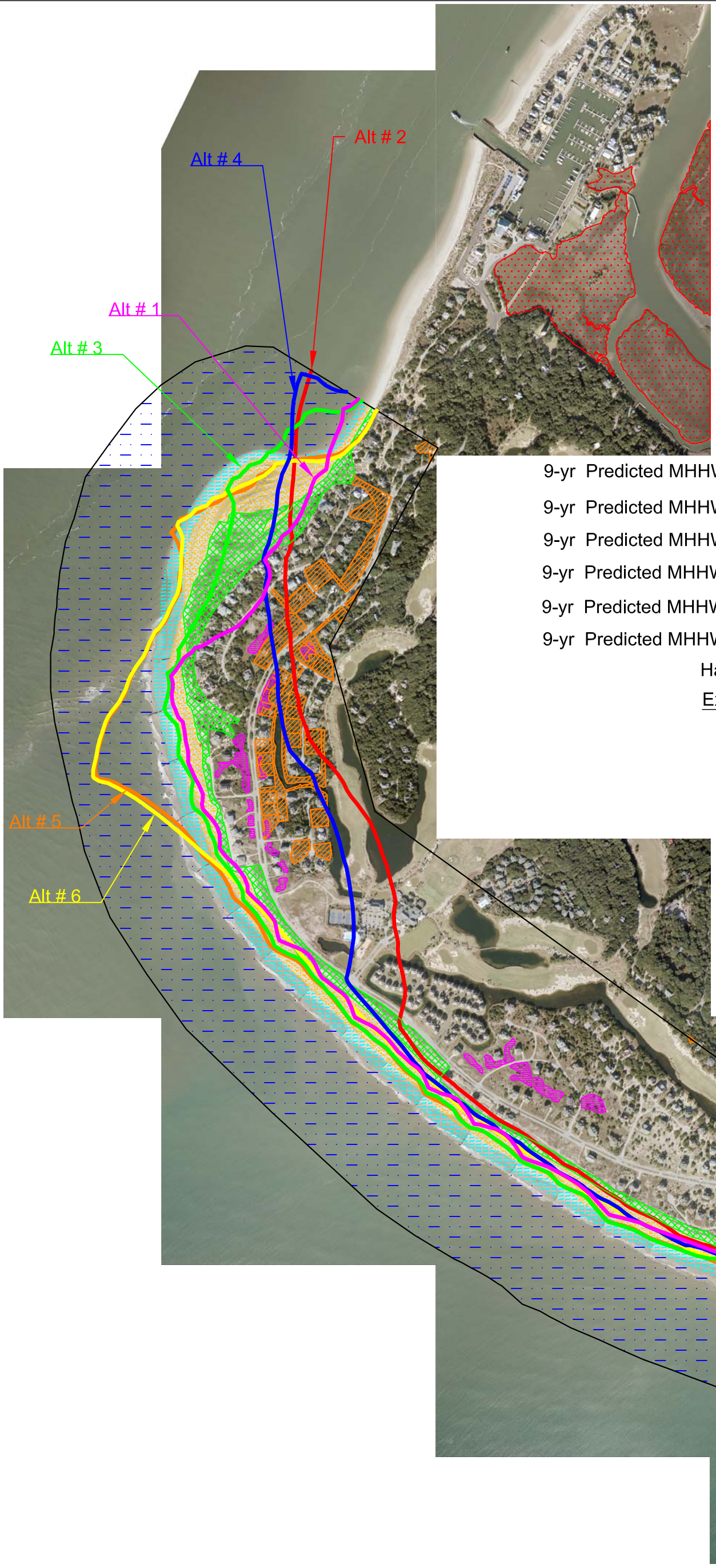


Figure 5.11. Maximum Apparent Dune Elevation Between Baseline STA 0+00 and STA 106+00.



9-yr Predicted MHHW Shoreline, Alternative # 1

9-yr Predicted MHHW Shoreline, Alternative # 2

9-yr Predicted MHHW Shoreline, Alternative # 3

9-yr Predicted MHHW Shoreline, Alternative # 4

9-yr Predicted MHHW Shoreline, Alternative # 5

9-yr Predicted MHHW Shoreline, Alternative # 6

Habitat Mapping Limit

Ex. Habitat Areas (ac)

Subtidal = 186.9

Wet Beach = 20.8

Dry Beach = 30.5

Dunes = 21.1

Interdunal Wetlands = 3.9

Maritime Thicket/Forest = 13.7

Coastal Marsh

0 400 800 1600

Aerial photography is dated 12/14/2012.

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Post Office Box 2522
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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***Current Habitat Area Mapping & Predicted 9-yr MHHW Shorelines***

Date: 5/13/2013

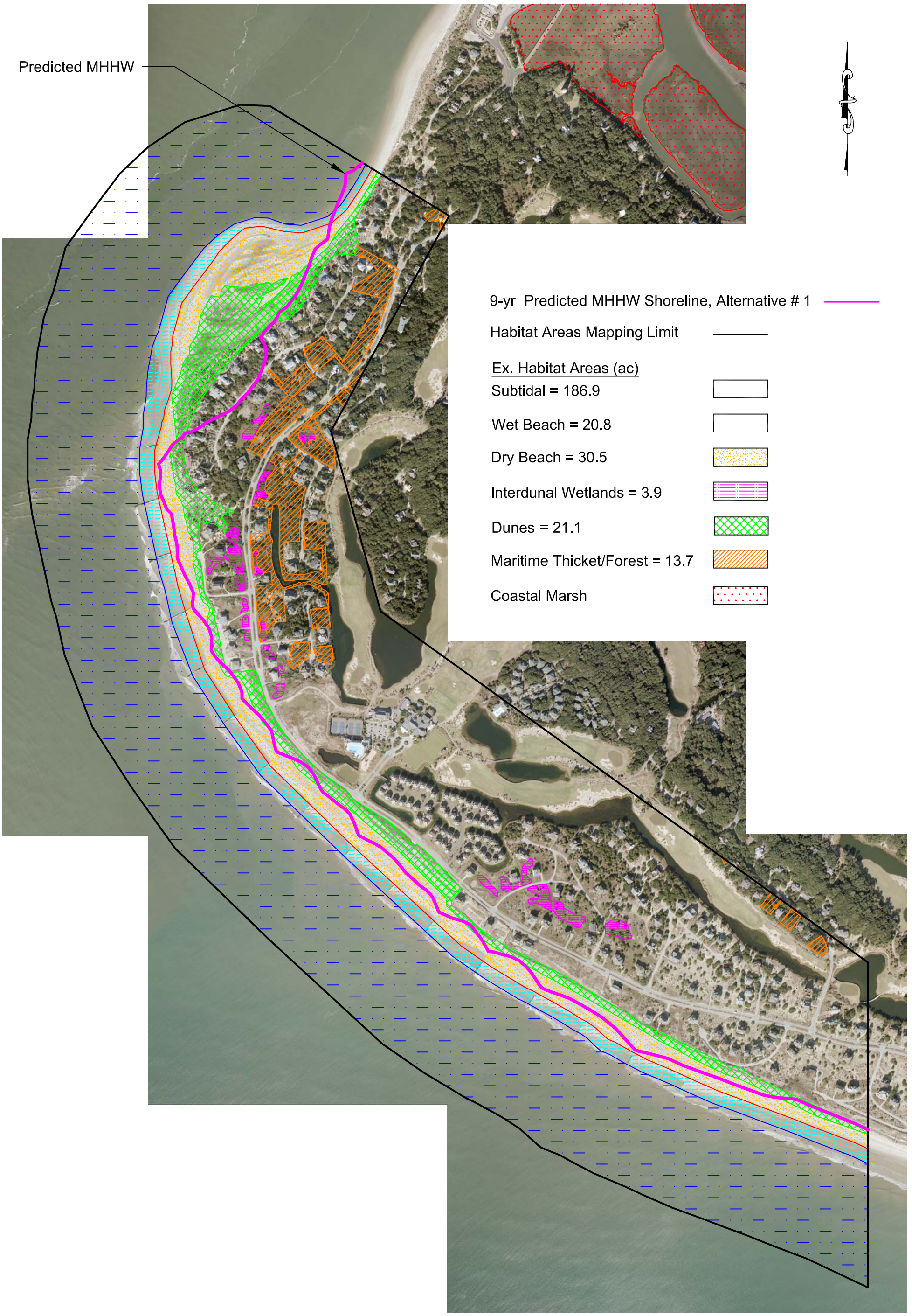
Revision Date: NA

Scale: **1"=800'**

Job Number: 40-11-238

Drawn By:

Sheet Number: **Figure 5.12**



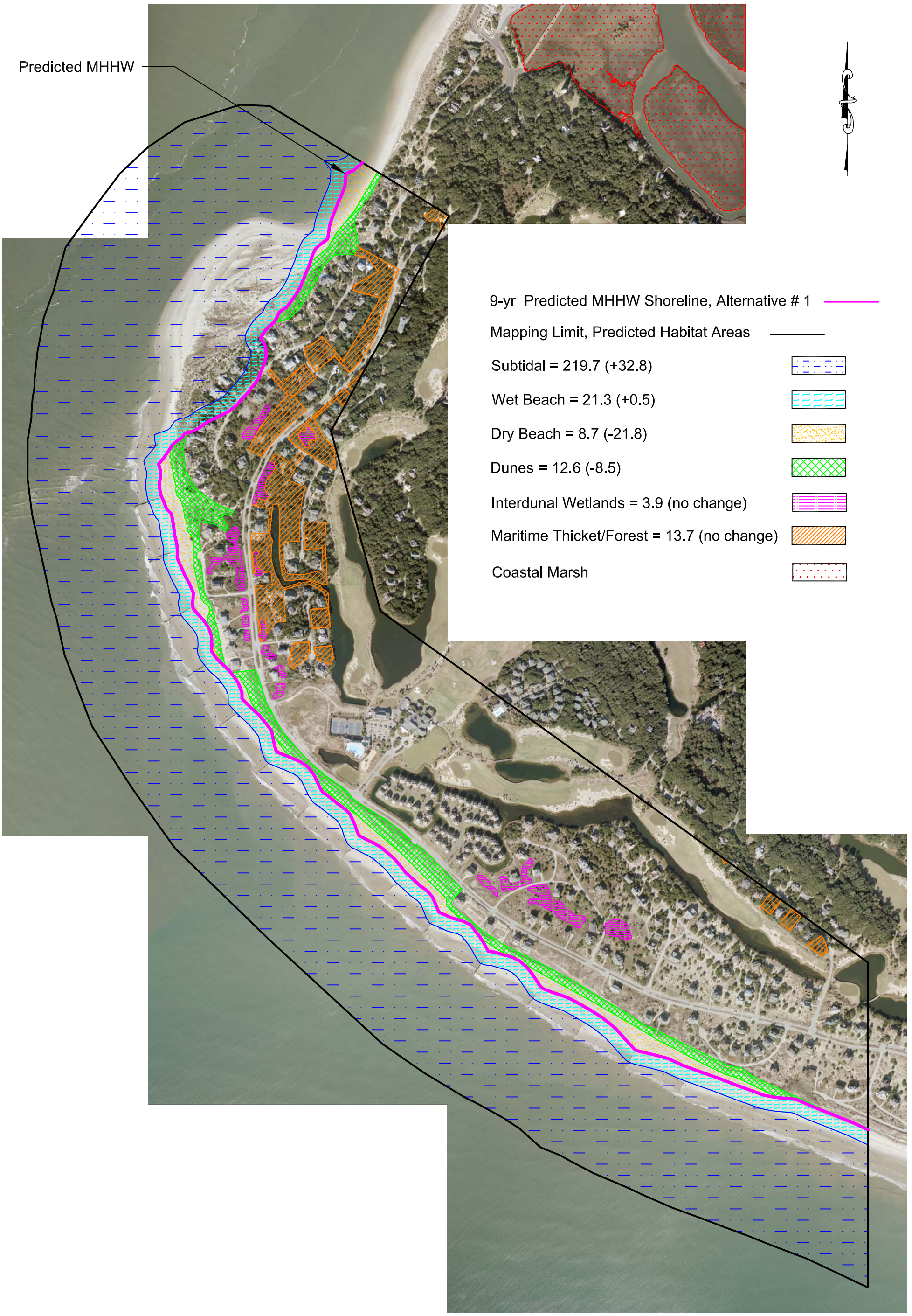
Aerial photography is dated 12/14/2012.

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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***9-yr MHHW Alternative # 1 Existing Habitat Areas***

Date:	Revision Date:
4/8/2013	5/29/2013
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Sheet Number: **Figure 5.13**



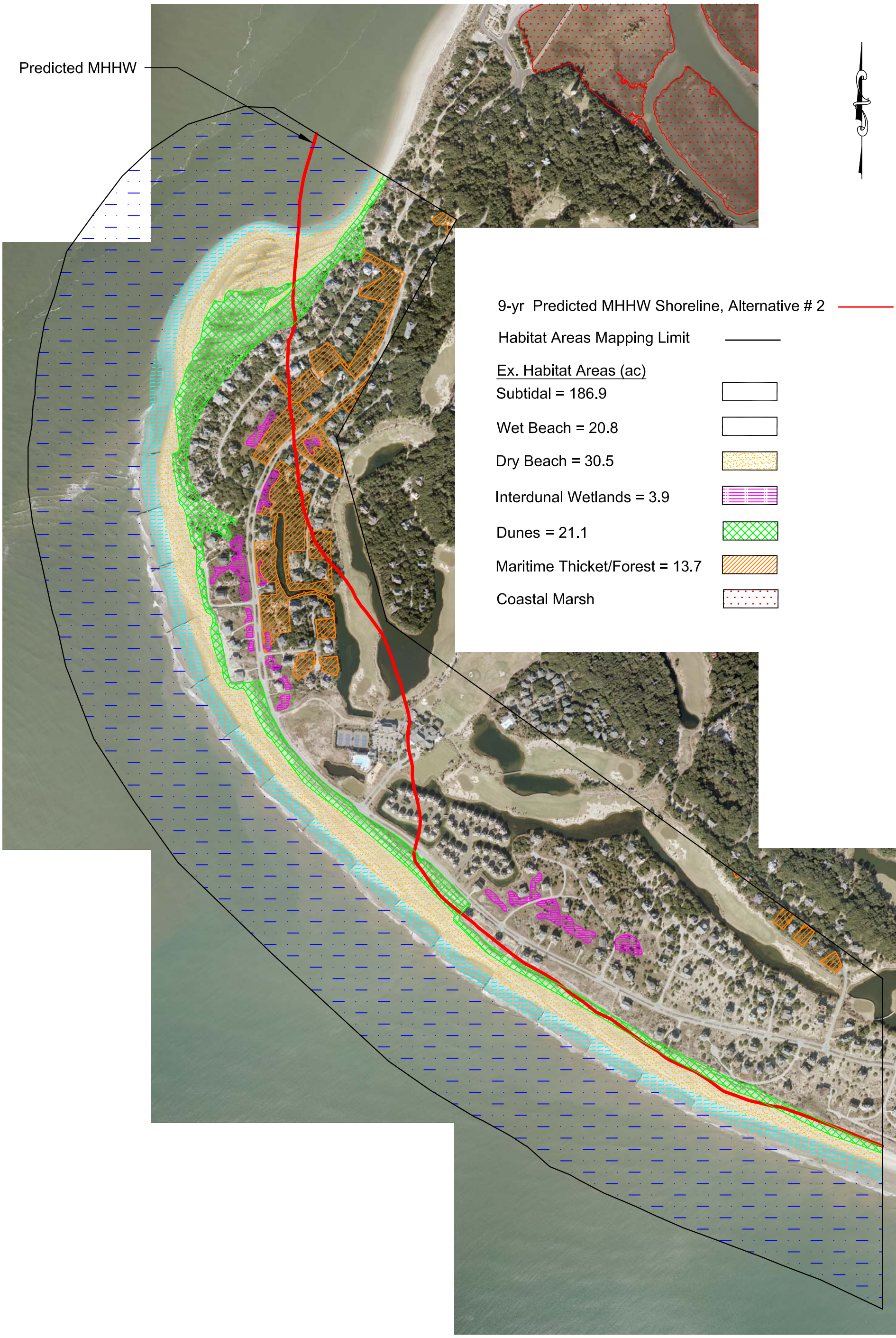
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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***9-yr MHHW Alternative # 1 Predicted Habitat Areas***

Date: 4/8/2013	Revision Date: 5/29/2013
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Sheet Number: **Figure 5.14**



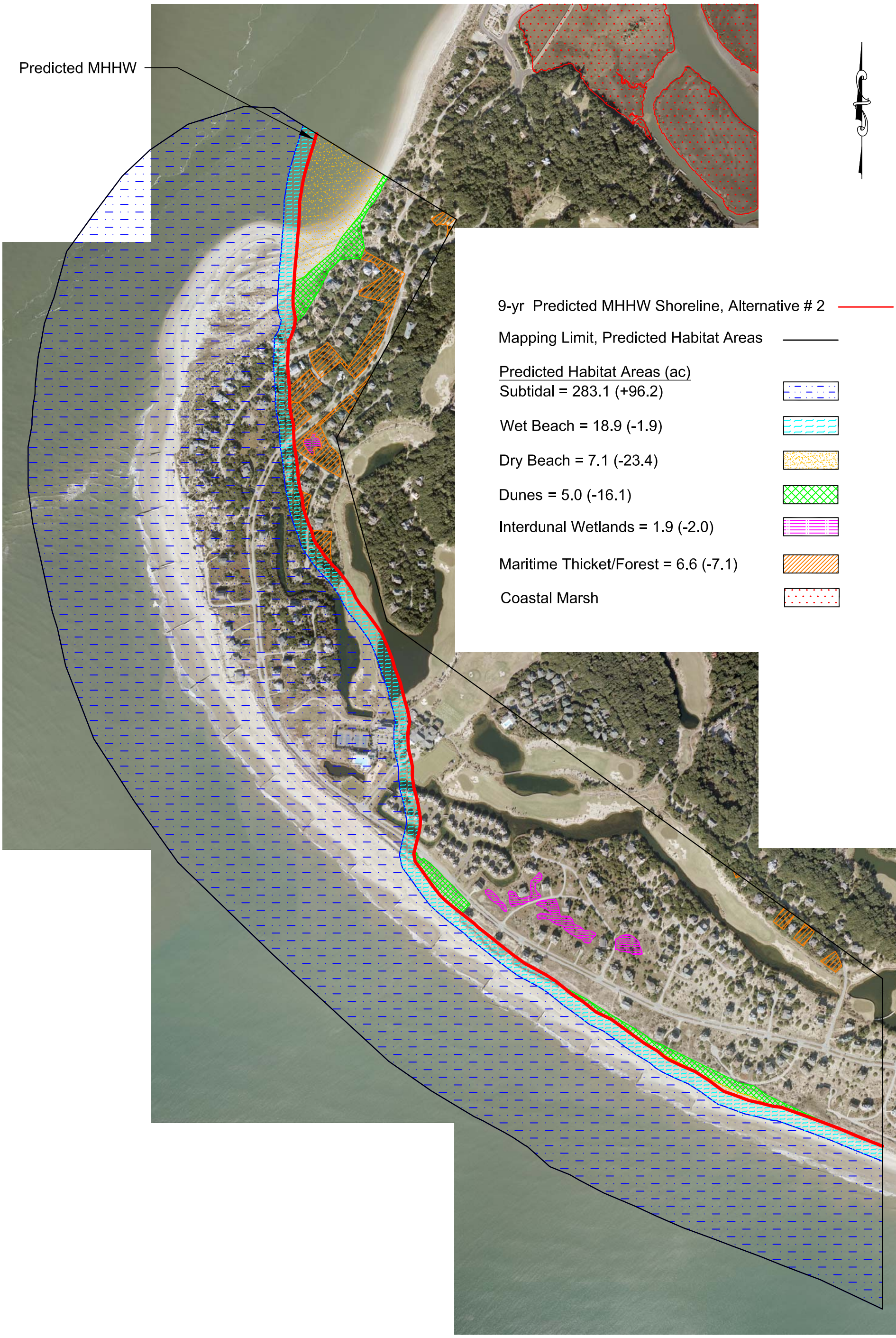
Aerial photography is dated 12/14/2012.

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Environmental Consultants
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Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***9-yr MHHW Alternative # 2 Existing Habitat Areas***

Date:	Revision Date:
4/8/2013	5/29/2013
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Sheet Number: **Figure 5.15**



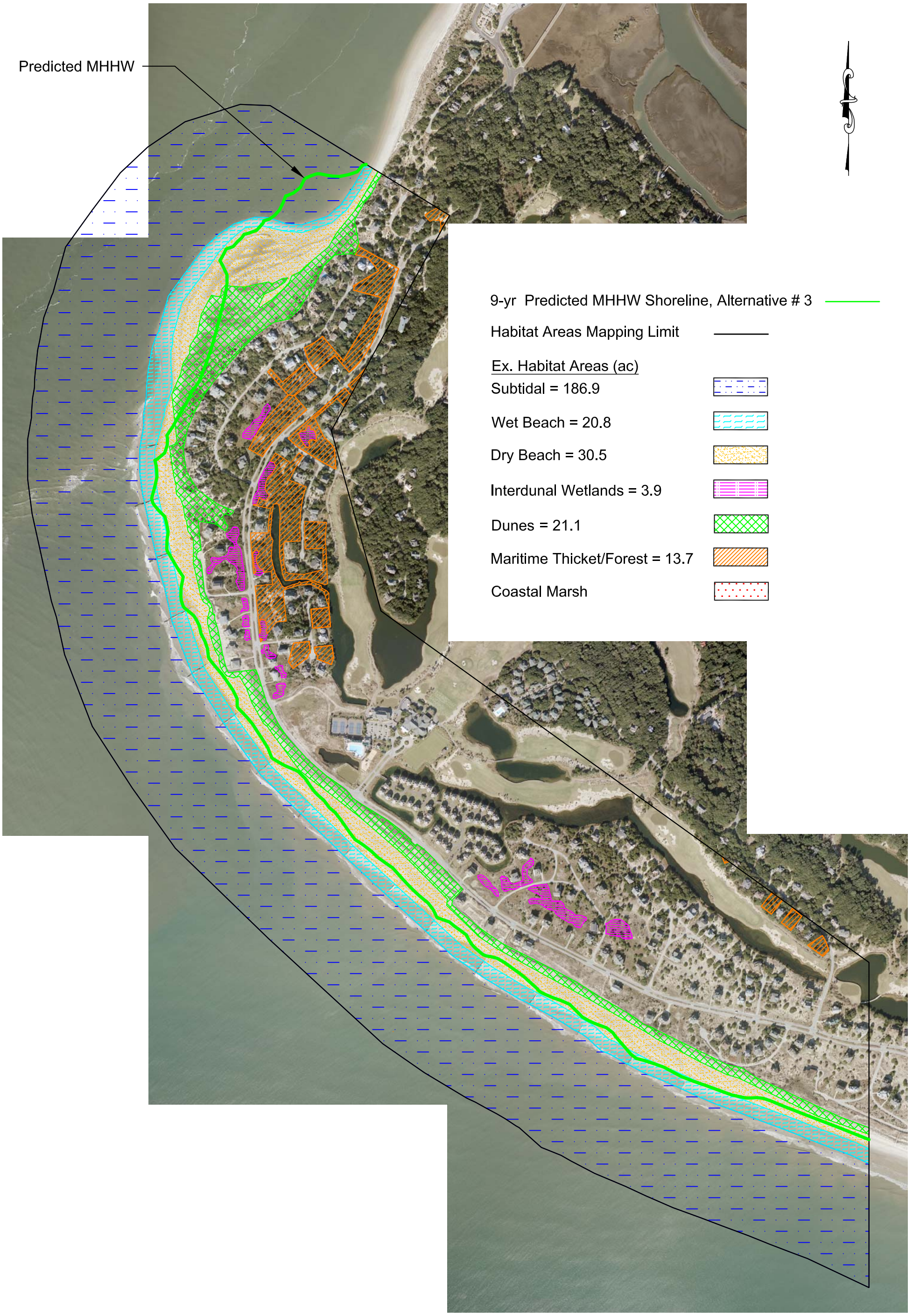
Aerial photography is dated 12/14/2012.

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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***9-yr MHHW Alternative # 2 Predicted Habitat Areas***

Date:	Revision Date:
4/8/2013	5/29/2013
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Sheet Number: **Figure 5.16**



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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***9-yr MHHW Alternative # 3 Existing Habitat Areas***

Date:	Revision Date:
4/8/2013	5/29/2013
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Sheet Number: **Figure 5.17**



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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: *9-yr MHHW Alternative # 3 Predicted Habitat Areas*

Date: 4/8/2013

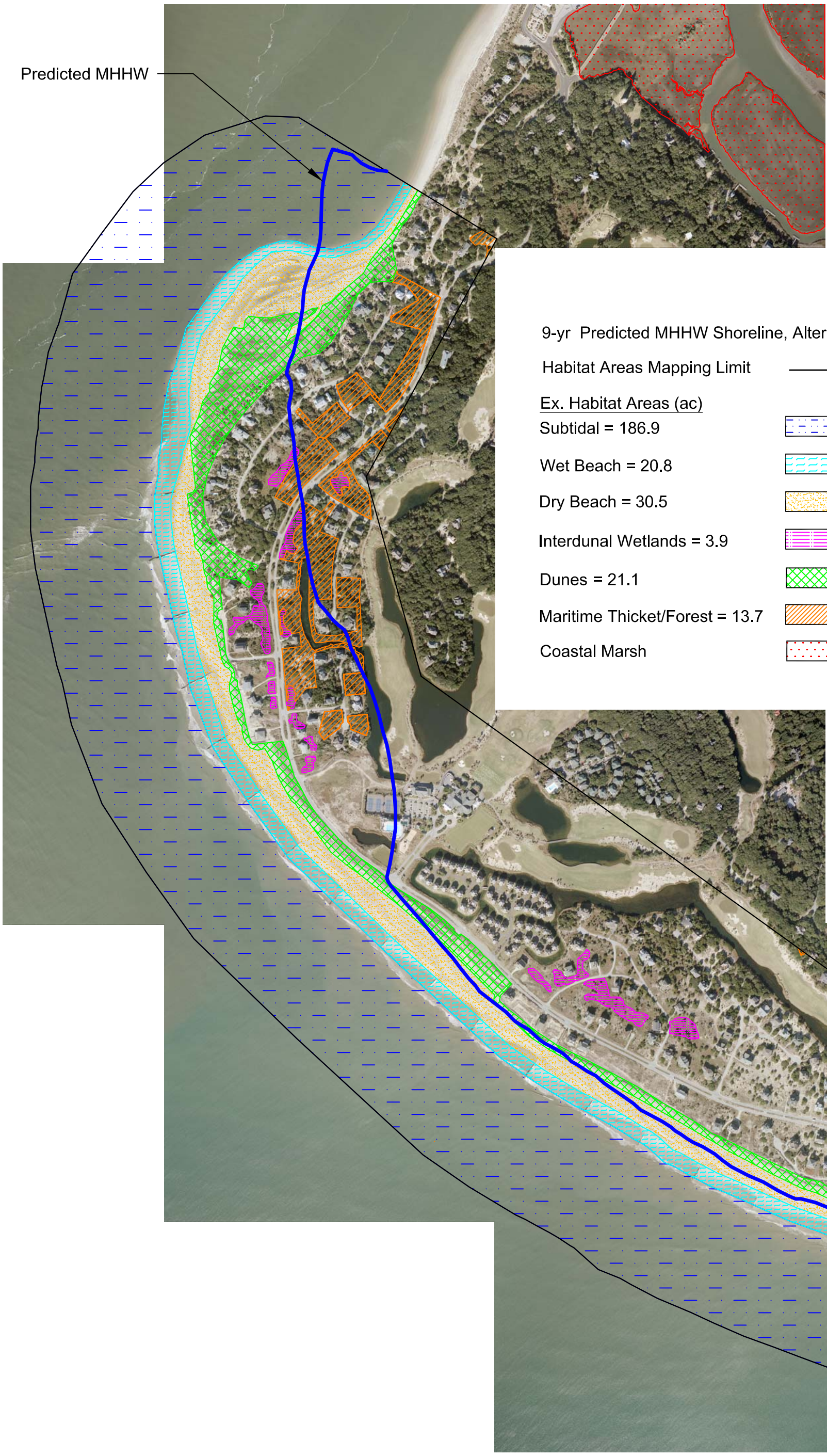
Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Sheet Number: **Figure 5.18**



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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: *Predicted 9-yr MHHW Alt # 4 Existing Habitat Areas*

Date: 4/8/2013

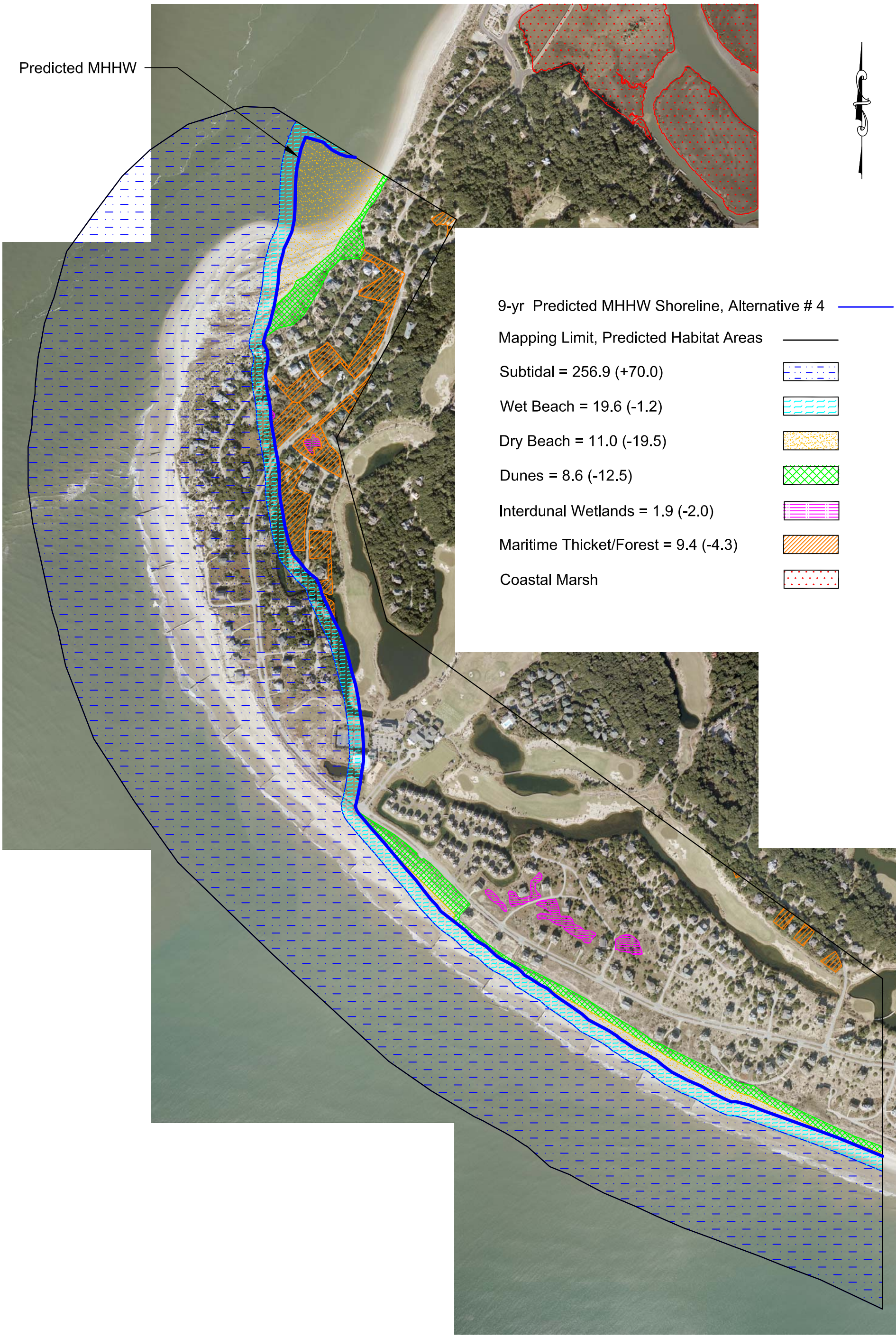
Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Sheet Number: **Figure 5.19**



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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: *9-yr MHHW Alternative # 4 Predicted Habitat Areas*

Date: 4/8/2013

Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Sheet Number: **Figure 5.20**



9-yr Predicted MHHW Shoreline, Alternative # 5

Habitat Areas Mapping Limit

Ex. Habitat Areas (ac)

Subtidal = 186.9

Wet Beach = 20.8

Dry Beach = 30.5

Interdunal Wetlands = 3.9

Dunes = 21.1

Maritime Thicket/Forest = 13.7

Coastal Marsh

0 300 600 1200

Aerial photography is dated 12/14/2012.

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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: *Predicted 9-yr MHHW Alt # 5 Existing Habitat Areas*

Date: 4/8/2013

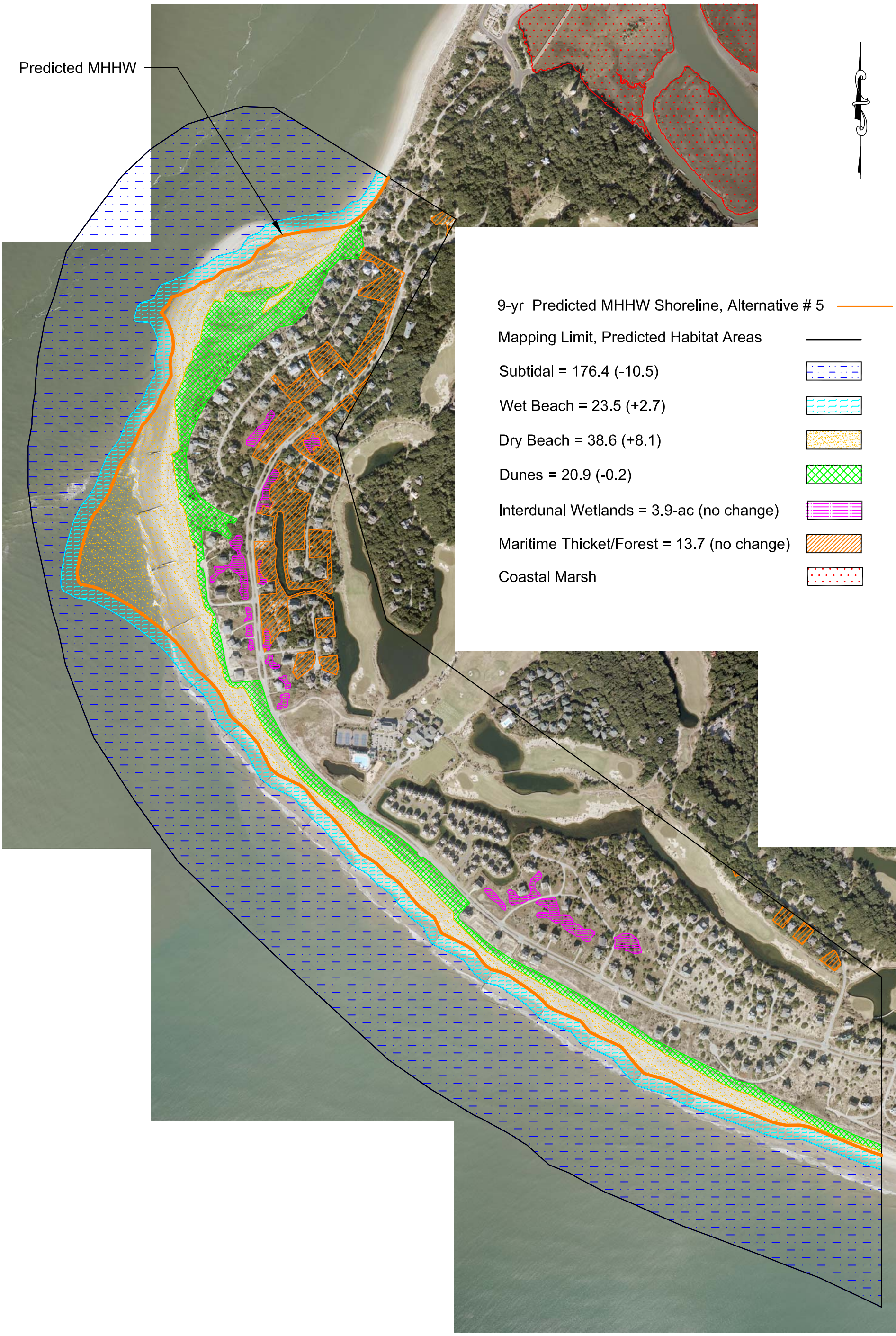
Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Sheet Number: **Figure 5.21**



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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: *Predicted 9-yr MHHW Alt # 5 Predicted Habitat Areas*

Date: 4/8/2013

Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Sheet Number: **Figure 5.22**



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Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: *Predicted 9-yr MHHW Alt # 6 Existing Habitat Areas*

Date:	Revision Date:
4/8/2013	NA
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Sheet Number: **Figure 5.23**



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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: *Predicted 9-yr MHHW Alt # 6 Predicted Habitat Areas*

Date: 4/8/2013

Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Sheet Number: **Figure 5.24**

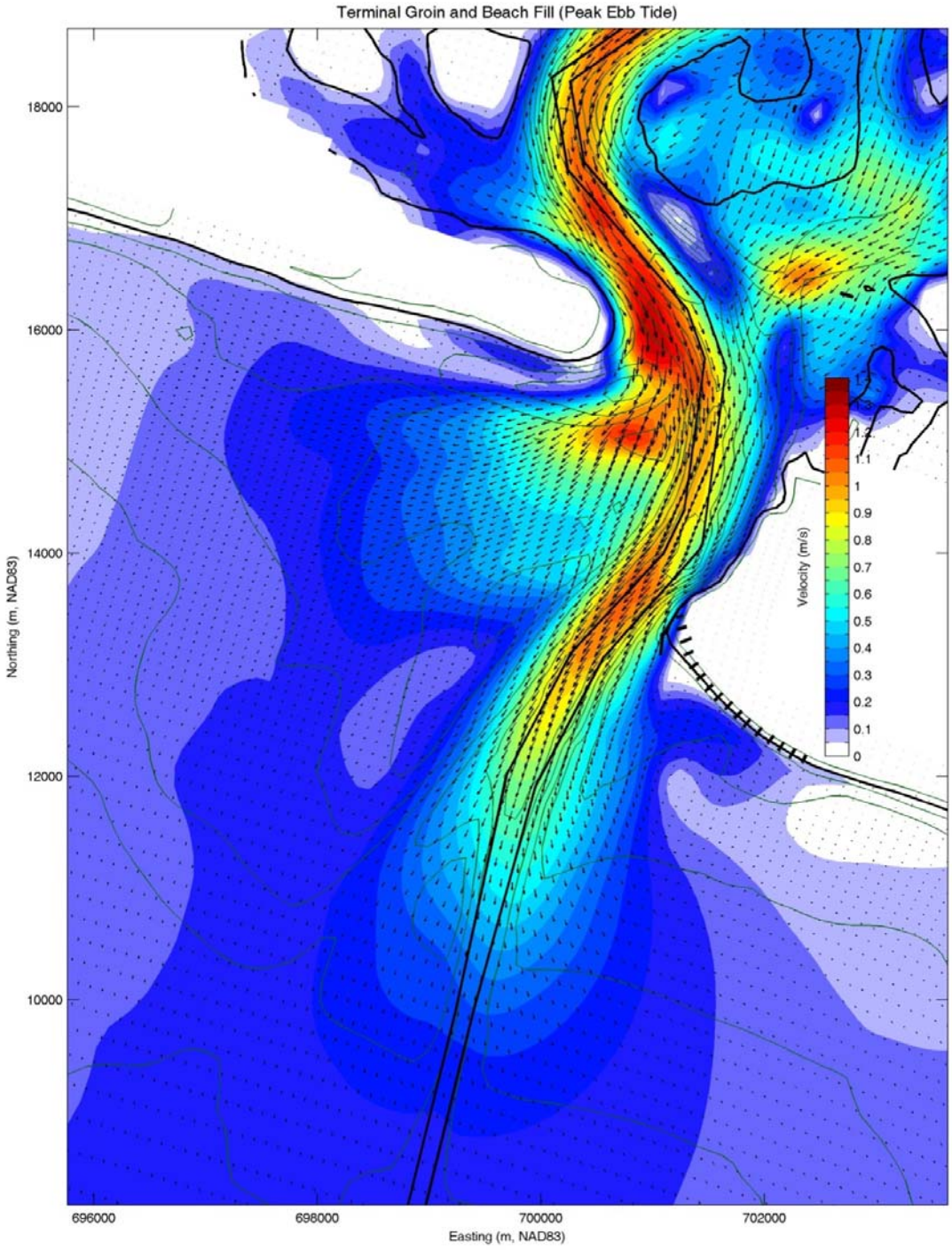


Figure 5.25. Peak Ebb Tidal Flow Computed following 1-Month Tide Only Simulation under Terminal Groin with 1.2Mcy Beach Fill and Tube Groins Conditions.

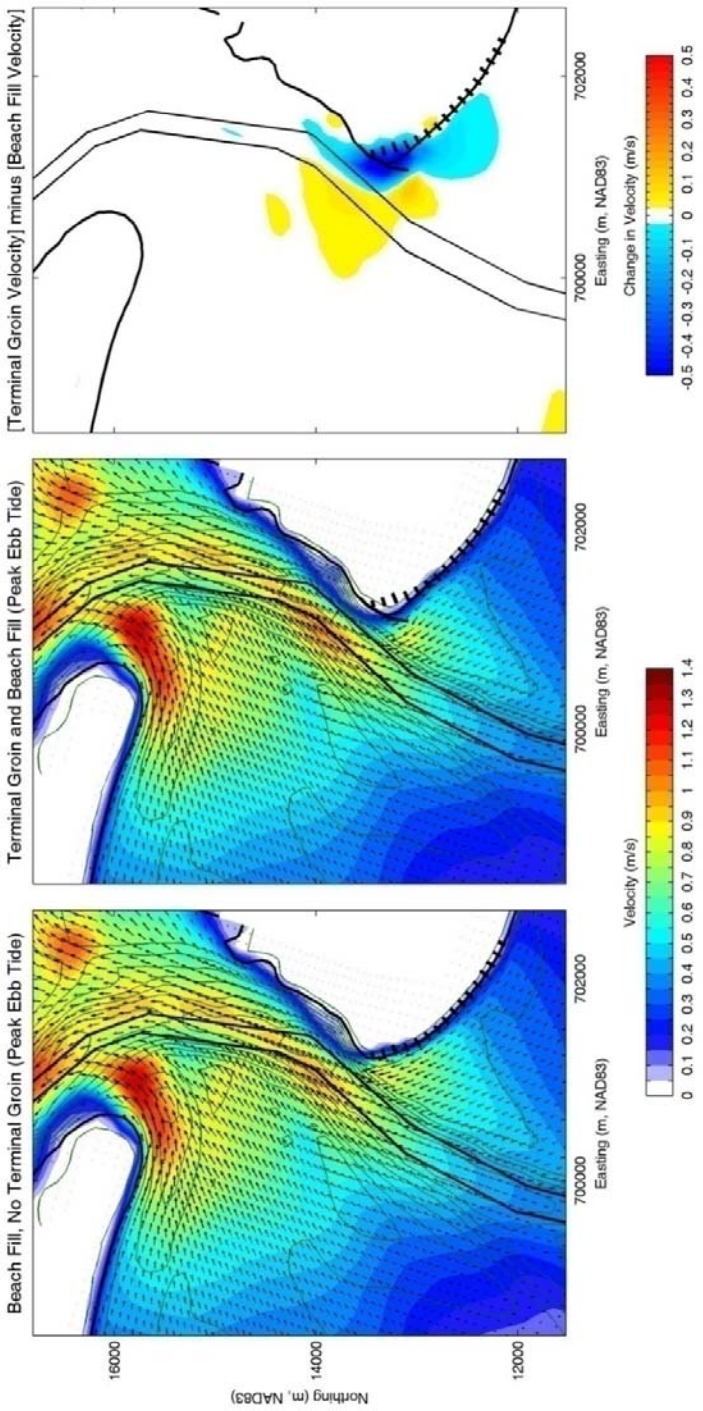


Figure 5.26. Direct Comparison of Peak Flood Velocities for With- and Without Terminal Groin Conditions.

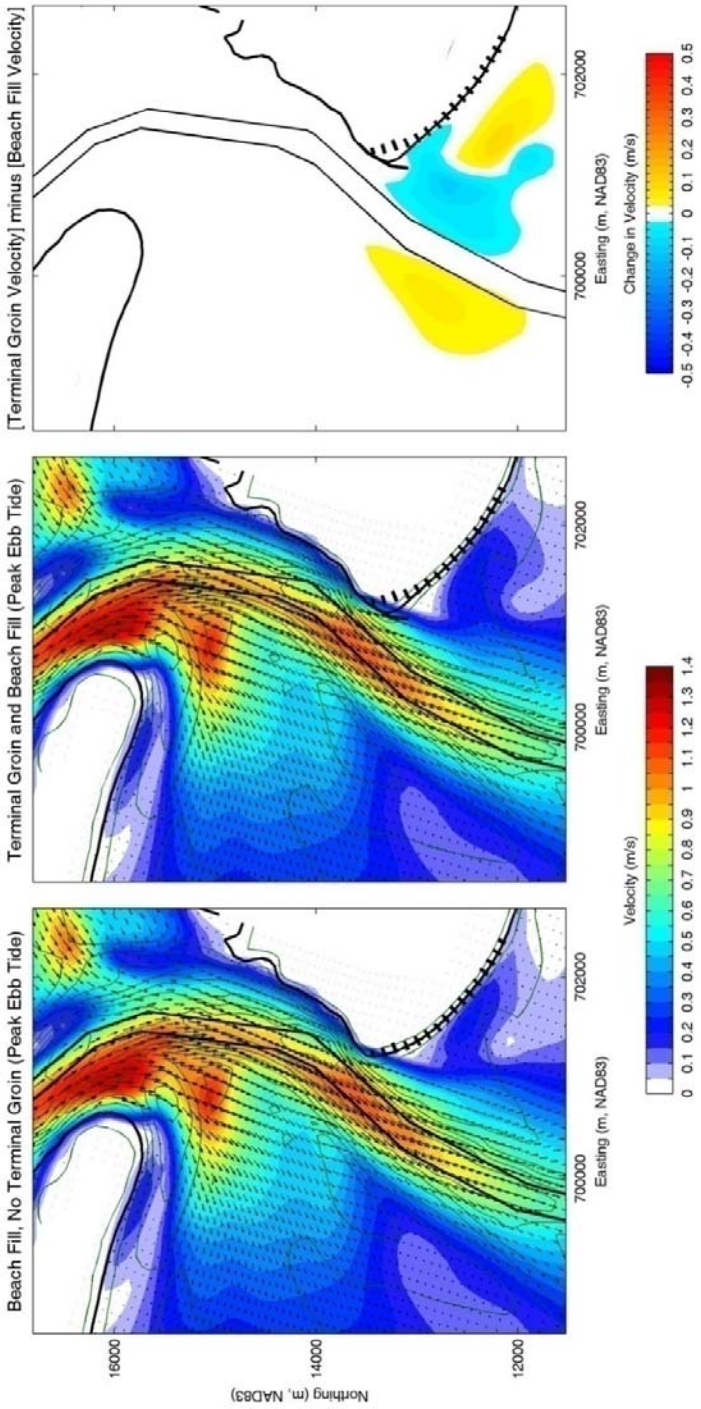


Figure 5.27. Direct Comparison of Peak Ebb Flows for With- and Without-Terminal Groin Conditions.

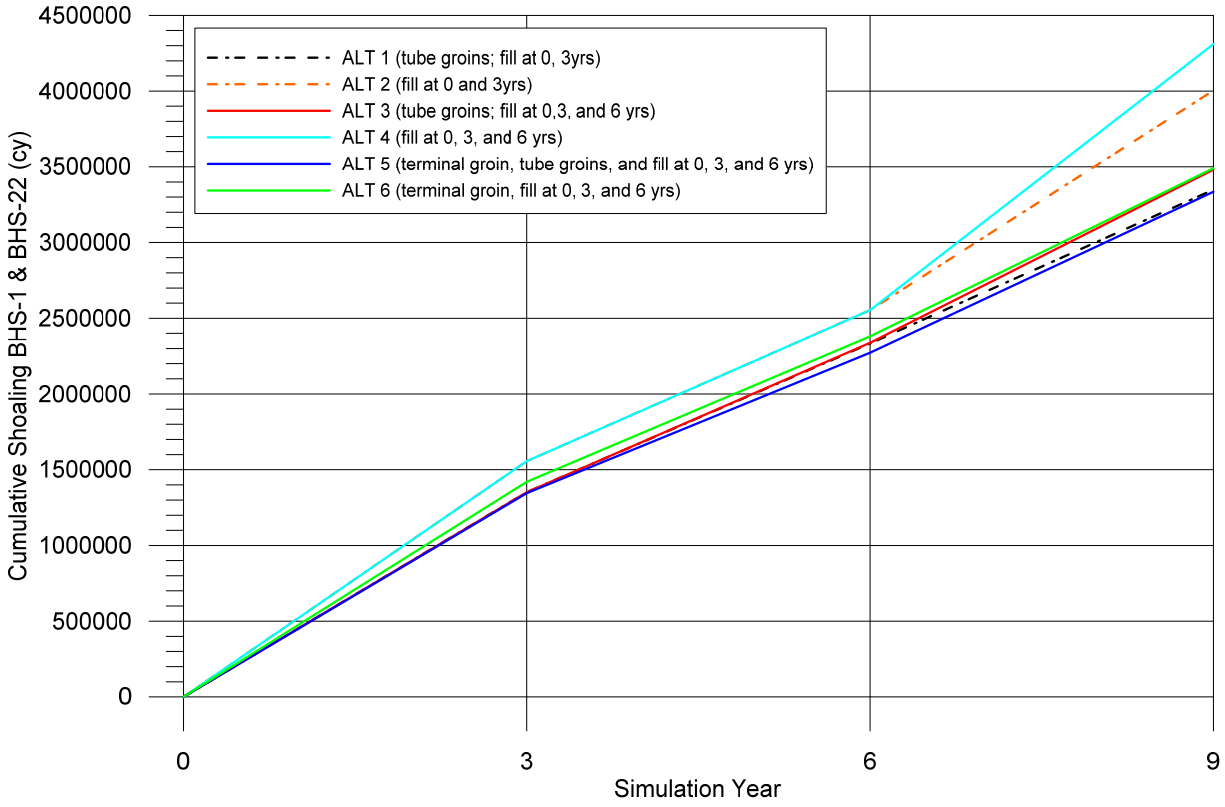


Figure 5.28. Predicted Cumulative Channel Shoaling within the Limits of Bald Head Shoals 1 and 2 after 9 Years for Each Alternative.

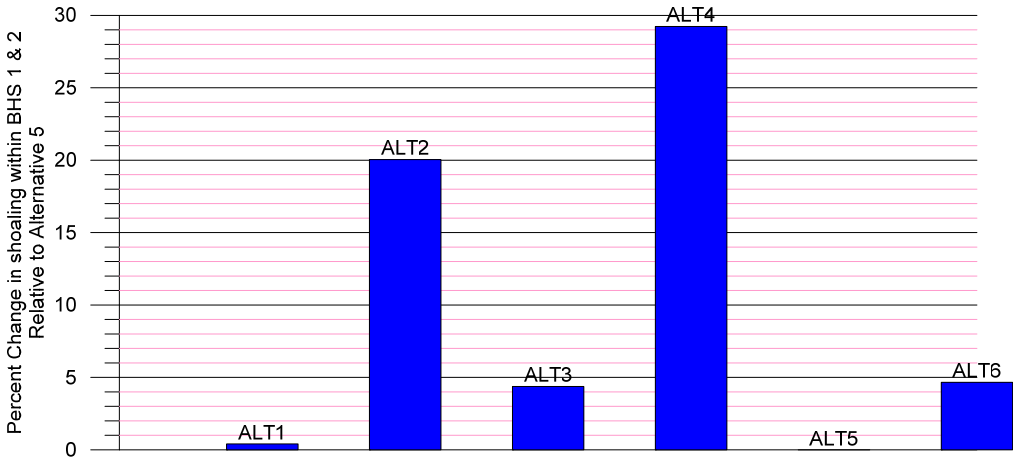
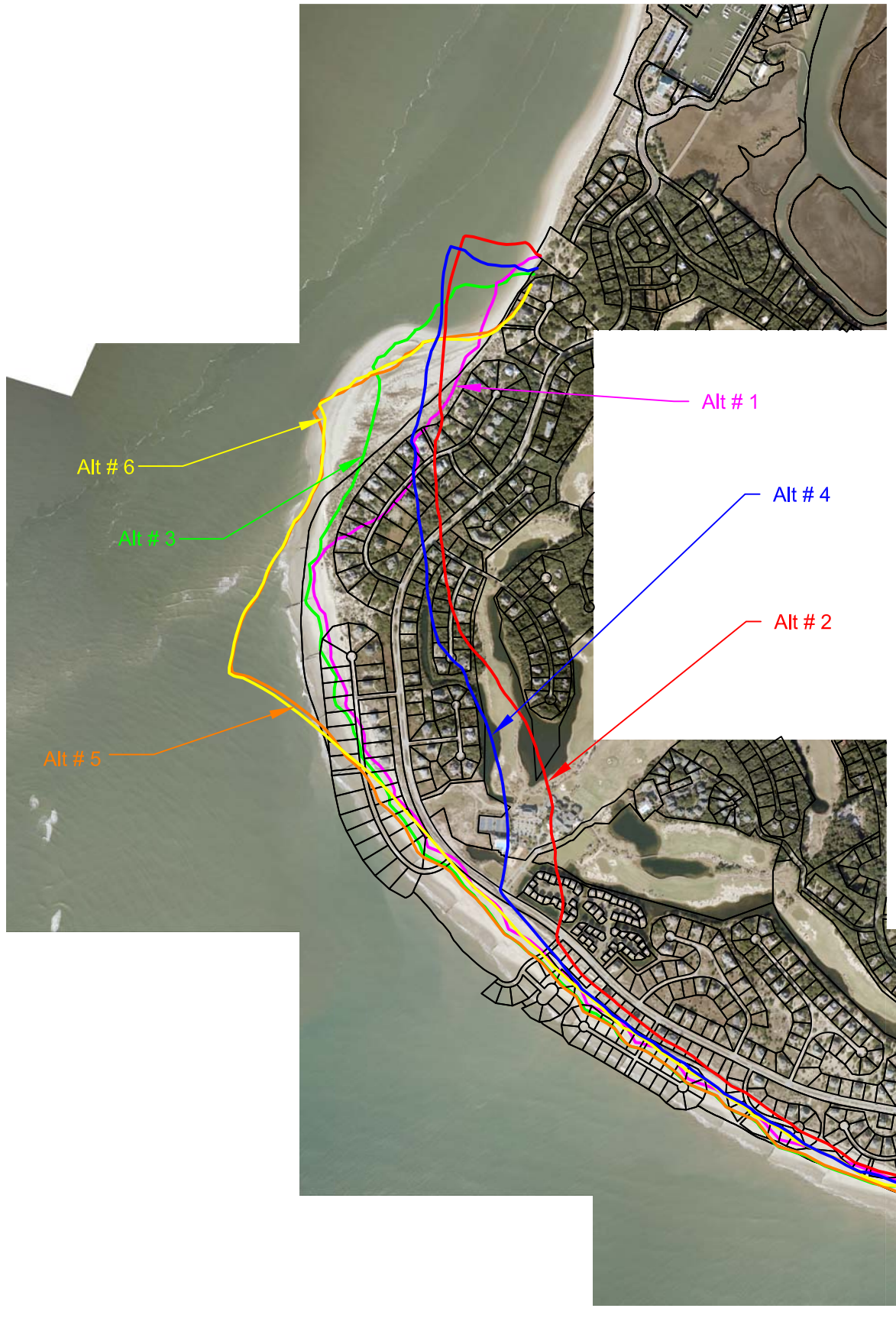


Figure 5.29. Predicted Change in Channel Shoaling within Bald Head Shoals 1 and 2 Relative to that Predicted for Alternative 5 (terminal groin, tube groins, and periodic fill).



20' off Predicted MHHW Alternative # 1

20' off Predicted MHHW Alternative # 2

20' off Predicted MHHW Alternative # 3

20' off Predicted MHHW Alternative # 4

20' off Predicted MHHW Alternative # 5

20' off Predicted MHHW Alternative # 6

Parcel Boundaries, Brunswick County GIS

0 500 1000 2000

Aerial photography is dated 12/14/2012.

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Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***At-Risk Property Assessment***
Predicted Shorelines-All Alternatives

Date: 4/2013

Revision Date: NA

Scale: **1"=1000'**

Job Number: 40-11-238

Drawn By:

Figure: **Figure 5.30**



20' off Predicted MHHW Alternative # 1

Parcel Boundaries, Brunswick County GIS

At-Risk Properties

Parcel #	Improved	Assessed Tax Value
2604G011	No	$560,000
2604G033	No	$350,000
2604G005	Yes	$1,743,049
2604G006	Yes	$1,797,270
2604G007	Yes	$1,085,760
2604G008	Yes	$1,474,048
2604G009	Yes	$1,371,279
2604G010	Yes	$1,655,623
2604G012	Yes	$1,113,270
2604G013	Yes	$1,410,349
2604G014	Yes	$1,436,041
2604G031	Yes	$667,860
2604G032	Yes	$1,256,040
2641D023	Yes	$611,701
2641D024	Yes	$559,809
2641D025	Yes	$540,650
2641D026	Yes	$518,532
TOTAL ASSESSED VALUE		$18,151,281

0 300 600 1200

Oceanfront lots considered unbuildable due to regulatory setbacks not included.

Aerial photography is dated 12/14/2012.

LMG LAND MANAGEMENT GROUP INC. Environmental Consultants

Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***At Risk Property Alternative # 1***

Date: 12/2012	Revision Date: NA
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Figure: **Figure 5.31**



20' off Predicted MHHW Alternative # 2

Parcel Boundaries, Brunswick County GIS

At-Risk Properties

Parcel #	Improved	Assessed Tax Value
2604G001	No	$350,000
2604G002	No	$350,000
2604G011	No	$560,000
2604G029	No	$450,000
2604G033	No	$350,000
2604G034	No	$350,000
2641D020	No	$200,000
2641D022	No	$200,000
2641E001	No	$250,000
2641E032	No	$210,000
2641E033	No	$210,000
2641E037	No	$150,000
2641E038	No	$250,000
2641E039	No	$262,500
2641E040	No	$250,000
2641E041	No	$250,000
2641E045	No	$250,000
2641E046	No	$250,000
2641E047	No	$250,000
2641E048	No	$250,000
2641E051	No	$250,000
2641E052	No	$250,000
2641E053	No	$250,000
2641F001	No	$500,000
2641F002	No	$350,000
2641F003	No	$350,000
2641F011	No	$180,000
2641F014	No	$225,000
2641F017	No	$325,000
2641F02304	No	$643,500
2604G003	Yes	$1,273,704
2604G004	Yes	$1,128,083
2604G005	Yes	$1,743,049
2604G006	Yes	$1,797,270
2604G007	Yes	$1,085,760
2604G008	Yes	$1,474,048
2604G009	Yes	$1,371,279
2604G010	Yes	$1,655,623
2604G012	Yes	$1,113,270
2604G013	Yes	$1,410,349
2604G014	Yes	$1,436,041
2604G015	Yes	$842,850
2604G030	Yes	$1,375,868
2604G031	Yes	$667,860
2604G032	Yes	$1,256,040
2604G035	Yes	$654,410
2604G036	Yes	$759,700
2641A029	Yes	$489,978
2641B005	Yes	$459,407
2641B006	Yes	$430,277
2641B033	Yes	$587,930
2641B036	Yes	$671,461
2641D018	Yes	$971,600
2641D019	Yes	$978,861
2641D021	Yes	$1,158,077
2641D023	Yes	$611,701
2641D024	Yes	$559,809
2641D025	Yes	$540,650
2641D026	Yes	$518,532
2641E031	Yes	$547,350
2641E034	Yes	$841,799
2641E036	Yes	$581,900
2641E042	Yes	$937,330
2641E043	Yes	$803,120
2641E044	Yes	$661,438
2641E049	Yes	$529,664
2641E050	Yes	$731,174
2641E054	Yes	$508,670
2641F004	Yes	$861,496
2641F005	Yes	$861,932
2641F006	Yes	$1,144,450
2641F008	Yes	$1,019,140
2641F009	Yes	$718,429
2641F010	Yes	$483,679
2641F013	Yes	$893,350
2641F015	Yes	$633,754
2641F016	Yes	$664,267
2641F018	Yes	$680,490
2641F020	Yes	$789,240
2641F021	Yes	$681,951
2641F022	Yes	$350,000
2641G00101	Yes	$4,916,267
2641Q042	Yes	$422,170
2641Q043	Yes	$402,120
2641Q044	Yes	$422,170
2641Q045	Yes	$395,100
2641Q046	Yes	$421,120
2641Q047	Yes	$410,150
2641Q048	Yes	$395,100
2641Q049	Yes	$334,150
2641Q050	Yes	$340,150
2641Q051	Yes	$340,150
2641Q052	Yes	$346,940
2641Q053	Yes	$346,940
TOTAL ASSESSED VALUE		$63,406,637

0 300 600 1200

Oceanfront lots considered unbuildable due to regulatory setbacks not included.

Aerial photography is dated 12/14/2012.

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Environmental Consultants

Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***At Risk Property Alternative # 2***

Date: 12/2012

Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Figure: **Figure 5.32**



20' off Predicted MHHW Alternative # 3

Parcel Boundaries, Brunswick County GIS

At-Risk Properties

Parcel #	Improved	Assessed Tax Value
2841D026	Yes	$518,532
TOTAL ASSESSED VALUE		$518,532

0 300 600 1200

Oceanfront lots considered unbuildable due to regulatory setbacks not included.

Aerial photography is dated 12/14/2012.

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Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***At Risk Property Alternative # 3***

Date: 12/2012

Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Figure: **Figure 5.33**



20' off Predicted MHHW Alternative # 4

Parcel Boundaries, Brunswick County GIS

At-Risk Properties

Parcel #	Improved	Assessed Tax Value
2604G001	No	$350,000
2604G002	No	$350,000
2604G011	No	$560,000
2604G033	No	$350,000
2604G034	No	$350,000
2641D020	No	$200,000
2641D022	No	$200,000
2641E037	No	$150,000
2641E038	No	$250,000
2641E039	No	$262,500
2641E045	No	$250,000
2641E046	No	$250,000
2641E047	No	$250,000
2641E048	No	$250,000
2641E051	No	$250,000
2641E052	No	$250,000
2641E053	No	$250,000
2641F001	No	$500,000
2641F002	No	$350,000
2641F003	No	$350,000
2641F011	No	$180,000
2641F014	No	$225,000
2641F017	No	$325,000
2641F02304	No	$643,500
2604G003	Yes	$1,273,704
2604G004	Yes	$1,128,083
2604G005	Yes	$1,743,049
2604G006	Yes	$1,797,270
2604G007	Yes	$1,085,760
2604G008	Yes	$1,474,048
2604G009	Yes	$1,371,279
2604G010	Yes	$1,655,623
2604G012	Yes	$1,113,270
2604G013	Yes	$1,410,349
2604G031	Yes	$667,860
2604G032	Yes	$1,256,040
2604G035	Yes	$654,410
2604G036	Yes	$759,700
2641B033	Yes	$587,930
2641D018	Yes	$971,600
2641D019	Yes	$978,861
2641D021	Yes	$1,158,077
2641D023	Yes	$611,701
2641D024	Yes	$559,809
2641D025	Yes	$540,650
2641D026	Yes	$518,532
2641E034	Yes	$841,799
2641E036	Yes	$581,900
2641E044	Yes	$661,438
2641E049	Yes	$529,664
2641E050	Yes	$731,174
2641E054	Yes	$508,670
2641F004	Yes	$861,496
2641F005	Yes	$861,932
2641F006	Yes	$1,144,450
2641F008	Yes	$1,019,140
2641F009	Yes	$718,429
2641F010	Yes	$483,679
2641F013	Yes	$893,350
2641F015	Yes	$633,754
2641F016	Yes	$664,267
2641F018	Yes	$680,490
2641F020	Yes	$789,240
2641F021	Yes	$681,951
2641F022	Yes	$350,000
2641G00101	Yes	$4,916,267
TOTAL ASSESSED VALUE		$49,216,695

0 300 600 1200

Oceanfront lots considered unbuildable due to regulatory setbacks not included.

Aerial photography is dated 12/14/2012.

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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***Private Property At Risk, Alternative # 4***

Date: 11/2013

Revision Date: NA

Scale: **1"=600'**

Job Number: 40-11-238

Drawn By:

Figure: **Figure 5.34**



20' off Predicted MHHW Alternative # 5

Parcel Boundaries, Brunswick County GIS

At-Risk Properties

Parcel #	Improved	Assessed Tax Value
2604F006	Yes	$1,979,410
2604F004	Yes	$1,455,920
TOTAL ASSESSED VALUE		$3,435,330

0 300 600 1200

Oceanfront lots considered unbuildable due to regulatory setbacks not included.

Aerial photography is dated 12/14/2012.

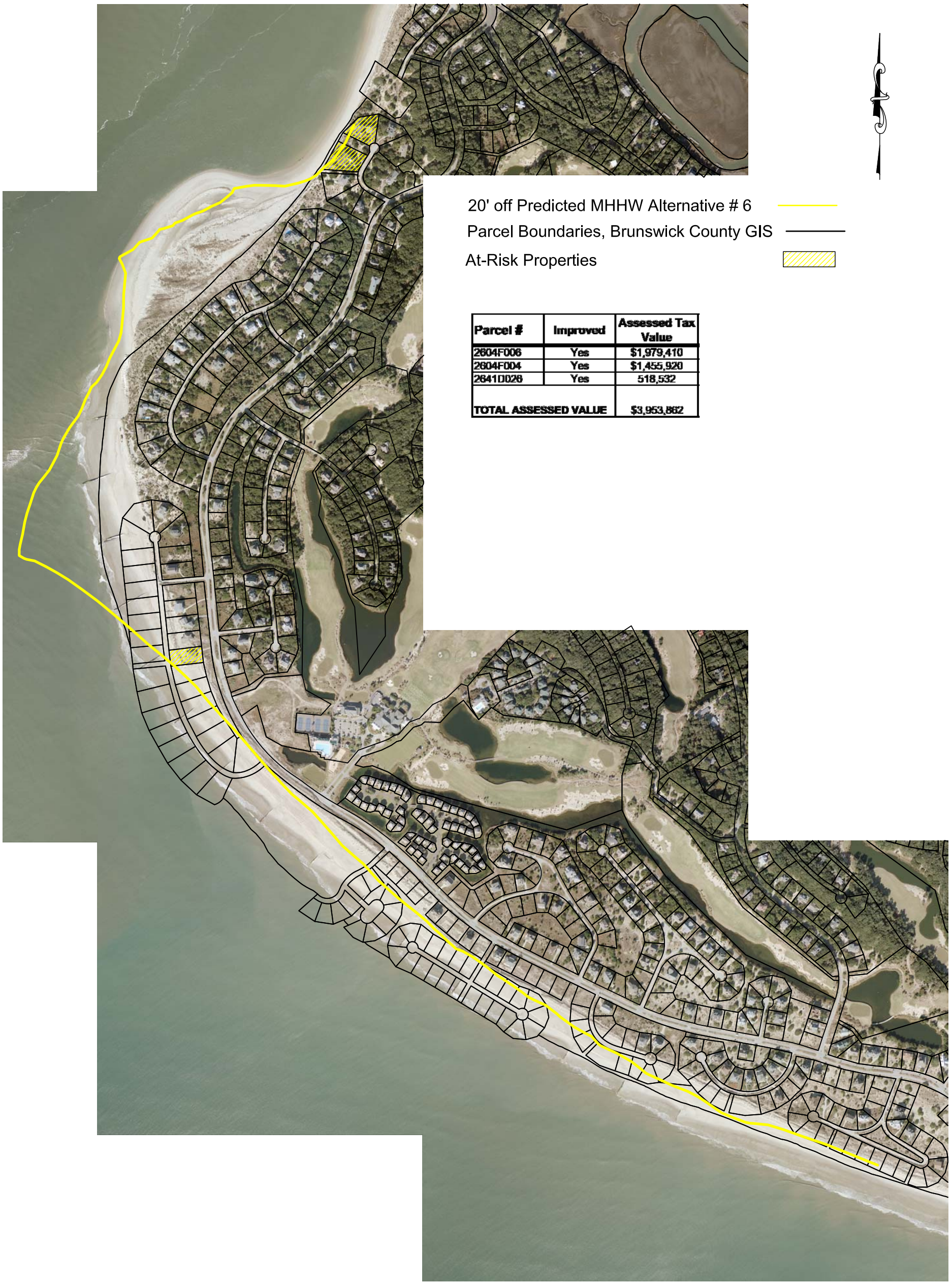
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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***At Risk Property Alternative # 5***

Date:	Revision Date:
12/2012	NA
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Figure: **Figure 5.35**



20' off Predicted MHHW Alternative # 6

Parcel Boundaries, Brunswick County GIS

At-Risk Properties

Parcel #	Improved	Assessed Tax Value
2604F006	Yes	$1,979,410
2604F004	Yes	$1,455,920
2641D026	Yes	518,532
TOTAL ASSESSED VALUE		$3,953,862

0 300 600 1200

Oceanfront lots considered unbuildable due to regulatory setbacks not included.

Aerial photography is dated 12/14/2012.

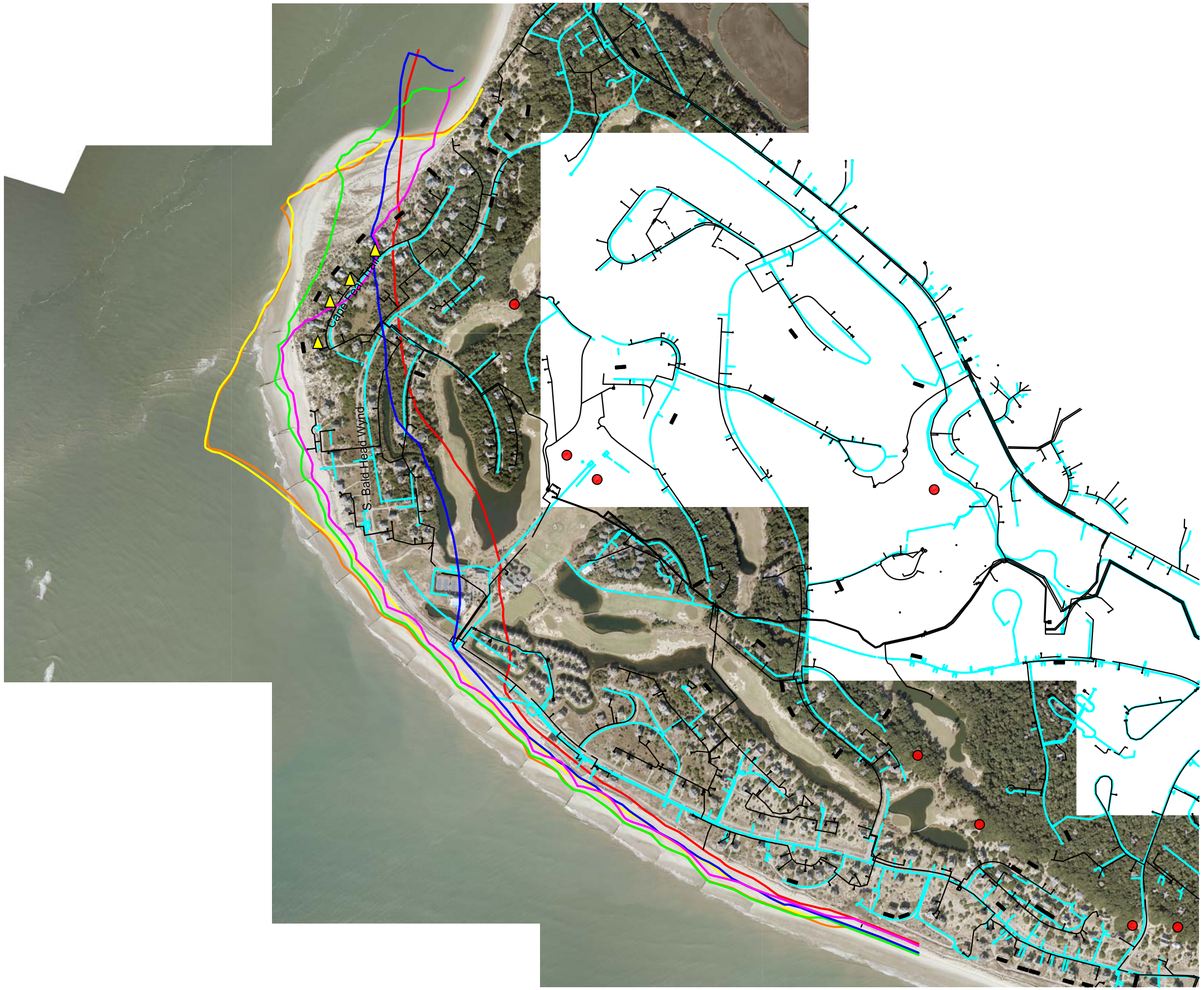
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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***At Risk Property Alternative # 6***

Date:	Revision Date:
12/2012	NA
Scale: **1"=600'**	Job Number: 40-11-238
Drawn By:	Figure: **Figure 5.36**



Predicted MHHW Alternative # 1
Predicted MHHW Alternative # 2
Predicted MHHW Alternative # 3
Predicted MHHW Alternative # 4
Predicted MHHW Alternative # 5
Predicted MHHW Alternative # 6
Existing Water Lines
Existing Sewer Lines
Existing Septic Systems
Existing Groundwater Supply Wells

0 500 1000 2000

Aerial photography is dated 12/14/2012.

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Project: **Village of Bald Head Island Shoreline Protection Project**
Final Environmental Impact Statement

Title: ***Infrastructure Impacts***
Predicted Shorelines-All Alternatives

Date:	Revision Date:
4/2013	NA
Scale: **1"=800'**	Job Number: 40-11-238
Drawn By:	Figure: **Figure 5.37**