Wilmington Harbor, North Carolina Navigation Improvement Project

Integrated
Section 203 Study
&
Environmental Report

INTEGRATED MAIN REPORT

February 2020

Executive Summary

1. Study Information

Study Authority: Construction of the Federal navigation channel to its current dimensions was originally authorized as three separate projects by the Water Resources Development Acts of 1986 (WRDA 86) Public Law 99-662 and 1996 (WRDA 96) Public Law 104-303. Public Law 105-62, The Energy and Water Development Appropriations Act of 1998, combined the Wilmington Harbor Northeast Cape Fear River Project (WRDA 1986), the Wilmington Harbor Channel Widening Project (WRDA 1996), and the Cape Fear-Northeast (Cape Fear) Rivers Project (WRDA 1996) under a single project known as the Wilmington Harbor 96 Act Project.

This study of potential navigation improvements to the Wilmington Harbor Federal navigation channel leading from the Atlantic Ocean to the Port of Wilmington, North Carolina has been prepared by the North Carolina State Ports Authority (NCSPA) under the authority granted by Section 203 of Water Resources Development Act (WRDA) of 1986 (P.L. 99-662), as amended.

Study Sponsor: The non-Federal interest is the State of North Carolina, acting through the North Carolina State Ports Authority (NCSPA).

Study Purpose and Scope: The NCSPA has conducted this Section 203 study to determine the feasibility of improvements to the Federal navigation project at Wilmington Harbor. The purpose of this study is to identify and evaluate alternatives to increase transportation efficiencies for the current and future fleet of container vessels operating at the Port of Wilmington and to improve overall conditions for vessel operations and safety.

Since the last major channel improvements were completed by the Corps of Engineers in 2002, the Port of Wilmington has experienced significant growth in cargo volume, and in the size of vessels calling at the port. Over the intervening years, the NCSPA has made major investments in landside infrastructure to accommodate growth at the Port of Wilmington and the region that it serves. At the present time, the Port of Wilmington is the largest port in North Carolina and is a major component of the State's economy. The NCSPA is currently implementing Master Plan recommendations valued at $240 million for yard, gate, and terminal operations improvements to increase annual throughput capacity to 1 million TEUs per year.

Inadequate channel capacity currently impacts transportation efficiency at the Port of Wilmington and is projected to have a greater detrimental impact in the future, providing the impetus for the NCSPA to conduct this Section 203 study. Pursuant to Section 203 of WRDA 1986, this study is intended to determine the feasibility of the project and whether there is a Federal interest sufficient for Federal participation and Congressional authorization of improvements to the federal Wilmington Harbor navigation channel, consistent with the federal objective of maximizing contributions to National Economic Development (NED), and consistent with protecting the nation's environment.

Project Location/Congressional District: The Port of Wilmington, in southeastern North Carolina, is approximately 28 miles up the Cape Fear River from the Atlantic Ocean. The Cape Fear River borders Brunswick County to the west and New Hanover County to the east. The Port has excellent intermodal transportation connections. Interstate Highway 40 connects Wilmington with the state capital Raleigh, and to Interstate 95. State highway 74 and Interstate highway 74 connect the port to Charlotte, the state's most populous city. The CSX rail system connects the Port of Wilmington directly to intermodal transfer facilities in Charlotte. The Port of Wilmington is also connected to the CSX Carolina Connector rail hub. The project is located in the 7th Congressional District of North Carolina

Prior Reports and Existing Water Projects: The federal channel from the Atlantic Ocean to Wilmington has been incrementally improved for more than 100 years (USACE 1996). Over that time many reports have been developed. The most recent reports include the three reports combined by the Energy and Water Development Appropriations Act of 1998 into a single project known as the Wilmington Harbor 96 Act Project:

- U.S. Army Engineer District, Wilmington. 1990. Final Supplement to the Final Environmental Impact Statement for Wilmington Harbor – Northeast Cape Fear River, North Carolina. February 1996.
- Interim Feasibility Report and Environmental Impact Statement on Improvement of Navigation, Wilmington Harbor Channel Widening, USACE Wilmington District, March 1994. The recommended plan consists of widening the channel from 400 feet to 600 feet for a length of 6.2 miles to provide a passing lane. The Chief's Report is dated 24 June 1994. The work was completed in 2003.
- Final Feasibility Report and Environmental Impact Statement on Improvement of Navigation, Cape Fear – Northeast Cape Fear Rivers Comprehensive Study, Wilmington, North Carolina, USACE Wilmington District, June 1996. The recommended plan consists of:
    - Deepening the channel from the Atlantic Ocean to Wilmington from a depth of 38 feet to a depth of 42 feet, including the Anchorage Basin; along with deepening the ocean bar channel from 40 to 44 feet;
    - Deepening the 32-foot and 25-foot channel reaches in the upriver portion of the harbor to 38 feet and 34 feet, respectively; along with widening the channel from the existing width of 200 feet to 250 feet; and
    - Deepening the Turning Basin at the upper project limit in the Northeast Cape Fear River from 25 to 34 feet; along with widening the upper Turning Basin from 700 to 800 feet.

The Chief's Report is dated 09 September 1996. The project up to the Cape Fear Memorial Bridge was completed in 2003. The remaining authorized improvements from the Cape Fear Memorial Bridge to the upper project limit (deepening the 32-foot and 25-foot channel reaches in the upriver portion of the harbor) were deferred due to a marginal cost to benefit ratio.

In 2011, USACE developed a Reconnaissance Report (Section 905(b) Report), which recommended that a Feasibility Study for additional improvements be performed. The Feasibility Study (2018) recommended realignment of the Entrance Channel, widening of the Battery Island channel, and assorted modifications that increase the radius of the turn at Battery Island.

- Section 905 (b) Analysis Wilmington Harbor Navigation Improvements, New Hanover and Brunswick Counties, North Carolina, USACE Wilmington District, April 2011. The section 905 (b) analysis recommended that the Wilmington Harbor Navigation Improvement study proceed into the feasibility phase only for channel widening, turning basin enlargement, and other modifications at the existing project depth.

- Final Integrated Feasibility Report and Environmental Assessment Wilmington Harbor Navigation Improvements, USACE Wilmington District, October 2018. The recommended plan combines the following components to increase the available turning radius of the Battery Island turn from 2,850 feet to 3,900 feet[1]:
  - Realignment of the Entrance Channel reach 1 westward away from a shoal that forms to the east of the channel;
  - Widen Battery Island channel from 500 feet to 750 feet;
  - Provide additional tapers where Southport and Lower Swash channel join Battery Island Channel; and
  - Provide a 750 feet-wide by 1,300 feet long cutoff between Battery Island channel and Lower Swash channel.

In addition, a previous draft version of this report was reviewed by the Office of the Secretary of the Army for Civil Works (OASACW) and the Headquarters, US Army Corps of Engineers (USACE) staff and by the USACE Wilmington District. Independent peer review of technical work products was also performed for economics, cost engineering, hydrodynamic modeling, and ship simulation modeling. Reviewer comments and responses are provided in Appendix S: Quality Control Report. Compliance with federal statutes, such as the National Environmental Policy Act (NEPA), the Endangered Species Act, and other federal environmental, cultural, and historic resource statutes will be completed by USACE if the ASA(CW) determines that there is a Federal interest sufficient for Federal participation and Congress authorizes improvements to the Federal Wilmington Harbor navigation channel

Federal Interest: This Section 203 Integrated Feasibility Study and Environmental Report supports the federal interest in the Wilmington Harbor Navigation Improvement Project based on $51.3 million average annual equivalent net National Economic Development benefits resulting from transportation cost savings.

2. Study Objectives

Problems and Opportunities: The problem addressed by this analysis is that the width and depth of the Federal channel at Wilmington Harbor cause transportation inefficiencies for the existing and projected future containership fleet. The projected future fleet includes vessels with dimensions of 138,000 dead weight tons, 1,200 feet length overall, 158 feet beam, and 50 feet

[1] Note that the design vessel for the October 2018 study is the same design vessel used in the 1996 report, which supported the recommended plan constructed in 2003. That design vessel is substantially smaller than the design vessel for this study.

draft. The existing channel was designed for a vessel with 65,000 dead weight tons, 965 feet length overall, 106 feet beam and 40 feet draft.

The ongoing implementation of the Port's Master Plan includes a total of more than $240 million in container yard, reefer yard, truck gate, and intermodal yard improvements. These improvements enable the container terminal the Port of Wilmington to handle the projected future containership fleet. Opportunities for increased transportation efficiencies due to improvements to the Federal navigation channel include:

- Allow existing and projected future cargo vessels to have less restricted access to berths and terminals, reducing delays and increasing the efficiency of port operations;
- Allow existing and projected future cargo vessels to be loaded more efficiently;
- Allow larger cargo vessels to be used that can deliver more cargo at lower unit costs; and
- Achieve the full capability and efficiency of terminal and infrastructure improvements at the Port of Wilmington.

Planning Objectives: The primary planning goal for this study is to recommend a plan for Wilmington Harbor that contributes to the Federal objective, which is to contribute to national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are the direct net economic benefits that accrue in the planning area and in the rest of the nation. NED benefits for deep draft navigation projects are calculated as the transportation cost savings that typically result from improvements to general navigation features, such as channels, dredged material disposal facilities, turning basins, etc. Transportation cost savings are calculated as reductions in the cost of transporting goods from their ultimate origin to their ultimate destination, consistent with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 10 May 1983).

In addition to the Federal objective, project-specific planning objectives have been identified, and these objectives guided the plan formulation process in this study. Based on the problems posed by channel dimensions and the opportunities available through channel improvements, the following planning objectives have been established to assist in the development of management measures and evaluation of alternative plans:

Planning Objective 1: Contribute to NED by reducing origin to destination transportation costs, at the Port of Wilmington from 2027 to 2076;

Planning Objective 2: Contribute to NED by reducing trucking miles and trucking costs for the Port of Wilmington's hinterland cargo, from 2027 to 2076; and

Planning Objective 3: Contribute to NED by reducing waterborne transportation costs at the Wilmington Harbor Federal navigation project by accommodating the transit of larger and more efficient vessels, from 2027 to 2076.

Planning Constraints: In addition to the typical general constraints which impact the planning process, this analysis was also impacted by a set of project specific constraints. These planning constraints restrict the set of alternative plans developed and also influence the technical investigations conducted during the analysis. Constraints on the formulation of alternatives include:

- Avoid impacts to groundwater resources;
- Avoid impacts to existing waterfront infrastructure;
- Avoid impacts to marine facilities at MOTSU;
- Avoid or minimize impacts to recreational boaters and commercial fishing vessels using the channel; and
- Avoid or minimize impacts to natural and historic resources within the study area.

3. Alternatives

Plan Formulation Rationale: This study used the same project-specific planning criteria used in USACE project planning, to the extent possible by a non-Federal interest, as guided by the Principles and Guidelines (1983), the Planning Guidance Notebook, ER 1105-2-100 (22 Apr 2000), and The National Environmental Policy Act (NEPA) of 1969, and Procedures for Implementing NEPA, ER 200-2-2 (4 Mar 1988). The Technical Working Groups, including Federal and state agencies have assisted in the development of evaluation criteria for this study. In addition, reviewer comments from all sources have greatly improved the plan formulation process.

Management Measure Identification and Evaluation: Management measures were developed with information gathered during discussions and interviews with Port of Wilmington operations and management personnel, Cape Fear River Pilots Association, terminal operators, shipping agents, and tugboat operators that work in Wilmington Harbor. Several management measures were identified to address the navigation-related problems at Wilmington Harbor including non-structural measures, local service facility improvements, and structural measures that modify the Federally authorized channel.

Each measure was screened to determine if the measure should be retained for further, more detailed, evaluation. Screening was based on each measure’s ability to perform based on effectiveness, efficiency, technical feasibility, and acceptability metrics. Note that none of the measures in question would be able to realize all the planning objectives and therefore a completeness metric was not developed. The management measures advanced for more detailed evaluation would be combined into preliminary alternatives prior to additional evaluation.

Table ES-1
Objectives – Measures Matrix

Non-Structural Measures	Effectiveness	Efficiency	Technical Feasibility	Acceptability	Total	Retained
Reduce vessel speed	1	1	2	3	7	No
Additional tug assistance	1	1	2	3	7	No
Relocate aids to navigation	1	1	3	2	7	No
Tidal advantage	2	3	3	3	11	Yes
Lightering	1	1	1	1	4	No
Structural Measures	**Effectiveness**	**Efficiency**	**Technical Feasibility**	**Acceptability**	**Total**	**Retained**
Channel deepening	3	3	3	2	11	Yes
Stepped channel	1	1	3	2	7	No
Turning basin expansion	1	1	3	1	6	No
Turning basin deepening	3	3	3	2	11	Yes
Anchorage basin	1	1	3	2	7	No
Channel widening to reduce navigation restrictions	3	3	3	2	11	Yes
Channel widening to accommodate vessel meeting	1	1	3	2	7	No
Local Service Facility Improvements	**Effectiveness**	**Efficiency**	**Technical Feasibility**	**Acceptability**	**Total**	**Retained**
Container terminal improvements	1	1	3	2	7	No
Relocate cargo terminals	1	1	3	1	6	No
Berth deepening	3	3	3	3	12	Yes
Bulk terminal improvements	1	1	3	2	7	No
Breakbulk/General cargo improvements	1	1	3	2	7	No

Array of Alternatives: The measures identified for further evaluation may be implemented individually or in combination. Under without-project conditions (No Action Plan) the most efficient containership that could call at the Port of Wilmington would be a PPX3 vessel operating with draft restrictions (Row 1 in Table ES-2 below). Channel widening may be implemented individually or in combination with project deepening. Channel widening implemented as an individual alternative would allow the design vessel (PPX3Max) to use the channel on a regular basis, but the design vessel would be operating with draft restrictions (Row 2). All three elements of deepening the existing project (channel deepening, turning basin deepening, and berth deepening) are required for deepening to be effective, but without channel widening the most efficient vessel would be a PPX3 (Row3). The combination of deepening and widening allows the design vessel to operate in the channel and load more fully based on the depth of the alternative (Row4). Use of tidal advantage is assumed to be implemented in combination with all alternatives.

The combination of widening and deepening reduces transportation costs per TEU more than either widening or deepening reduces transportation costs individually. Therefore, the combination of widening and deepening is forwarded for more detailed evaluation.

Table ES-2
Weighted Average Unit Costs ($/TEU/1,000 miles) for Structural Measures

Row	Measures (Vessel Class)	Channel Depth					
		42	44	45	46	47	48
1	W/out Project (PPX3)	$51.51	-	-	-	-	-
2	Widening Only (PPX3Max)	$47.45	-	-	-	-	-
3	Deepening Only (PPX3)	-	$46.49	$44.25	$42.20	$39.37	$37.95
4	Widening & Deepening (PPX3Max)	-	$43.06	$41.10	$39.27	$36.62	$35.23

Final Array of Alternatives: The alternatives that are the most effective in reducing unit transportation costs are alternatives that combine channel widening to allow regular transit of the design vessel and channel, turning basin, and berth deepening to allow greater vessel operating drafts. Note that berth deepening is a local service facility improvement that is the responsibility of the NCSPA and not a component of the Federal General Navigation Features. The amount of channel widening was determined by ship simulation modeling of the design vessel and does not change appreciably for any of the action alternatives therefore, the action alternatives are identified by their incremental project depth:

- No Action Alternative – no improvements are made to the federal channel and economic conditions are described by the without-project condition;
- 44-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -44 feet, the entrance channel is deepened to -46 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling;
- 45-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -45 feet, the entrance channel is deepened to -47 feet and extended to meet

project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling;

- 46-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -46 feet, the entrance channel is deepened to -48 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling;
- 47-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -47 feet, the entrance channel is deepened to -49 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling; and
- 48-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -48 feet, the entrance channel is deepened to -50 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling.

Alternative project depth increments start at -44 feet because there is no non-federal interest in a one-foot deepening resulting in a -43-foot channel. Alternative project depth increments are truncated at -48 feet because at this depth vessel operating drafts at Wilmington would be constrained at the same level as vessel operating drafts at the prior and next US ports on the two containership services projected to deploy PPX3Max vessels under without-project and with-project conditions. A channel deeper than -48 feet would not be expected to provide appreciable additional benefits because vessel operating drafts would be constrained by depths at the prior and next US ports on the two services (Boston -48 feet, Savannah and Jacksonville -47 feet).

Dredging quantities (Table ES-3) were calculated based on the channel configurations developed through ship simulation modeling Dredging in-situ volumes are based on the required dredge depth, which consists of the proposed channel dimensions and a one-foot rock buffer in areas where rock is encountered. Two feet of allowable over-depth has been included in the project volume estimates. Dredging quantities and costs in Table ES-3 include local service facility berth dredging to project depth. Dredging costs include mobilization and de-mobilization costs.

Table ES-3
Dredged Material Construction Volumes (cy) and Costs ($FY20)

Project Depth	Dredging Quantities			Total Cost
	Rock	Non-Rock	Total Quantity	
-44	1,315,653	12,156,737	13,472,390	$285,626,229
-45	2,266,484	15,665,991	17,932,475	$373,528,298
-46	3,217,315	19,175,245	22,392,560	$461,430,367
-47	4,168,146	22,684,499	26,852,645	$549,332,436
-48	5,826,091	26,550,219	32,376,311	$670,853,654

There are no utility relocations required for the project however, there are two inactive four-inch pipelines at a depth of ~47 feet MLLW that need to be removed and one active six-inch line is at a depth of ~49 feet MLLW that needs to be relocated. Pursuant to Section 101(a) of the Water Resources Development Act of 1986 (WRDA 86), as amended, the non-Federal Sponsor is responsible for performing, or assuring the performance, of all relocations, including utility relocations, which are necessary for the navigation improvement project. All relocations, including utility relocations, are to be accomplished at no cost to the Federal Government. The estimated cost of one six-inch pipeline relocation is $2,000,000. This cost is included in the project cost as a 100% non-federal expense and the non-Federal Sponsor will receive equivalent credit toward its additional 10 percent cash payment required by Section 101(a)(4) of WRDA 86.

The two four-inch pipelines do not need to be relocated because they are no longer active. The non-Federal Sponsor has contacted the owner to reach a determination as to whether the owner has an interest in the existing line for which compensation is owed by the non-Federal Sponsor. If the owner has a compensable interest, the non-Federal Sponsor, as part of its requirement to provide lands, easements, and rights-of-way required for the navigation improvement project, will be responsible for acquiring this interest, at no cost to the Federal Government. At this time, it appears that there is no compensable interest in these pipelines.

Comparison of the Final Array of Alternatives: Each alternative is evaluated with respect to their effects on the four accounts (NED, Regional Economic Development, Other Social Effects, and Environmental Quality). The Regional Economic Development account evaluation is based on effects to regional revenues, employment, and wages. The Other Social Effects account is not projected to be affected in any substantial way and further evaluation is deferred to development of the DEIS, which will include the benefit of additional public involvement. Effects to the Environmental Quality account were evaluated for each alternative based on projected impacts to 35 categories of resources. The resulting impacts informed the objectives of the preliminary mitigation, monitoring, and adaptive management plan.

The following presentation of alternative plan costs, benefits, and net benefits addresses effect on the NED account. Note that interest during construction (IDC) was calculated using the FY20 federal discount rate (2.75%).

Table ES-4
Alternative Plan Costs with Contingency at 21.4% (FY2020 Dollars)

Cost Item	-44 feet	-45 feet	-46 feet	-47 feet	-48 feet
Land	$14,568,000	$25,470,000	$25,470,000	$25,470,000	$34,575,000
Relocations	$2,792,000	$2,792,000	$2,792,000	$2,792,000	$2,792,000
Dredging	$346,046,000	$452,055,000	$558,768,000	$665,129,000	$812,304,000
ATON	$10,531,000	$10,531,000	$10,531,000	$10,531,000	$10,531,000
LSF Berths	$704,000	$1,056,000	$1,408,000	$1,760,000	$2,112,000
Const. Mgt.	$13,111,000	$13,111,000	$13,111,000	$13,111,000	$16,389,000
PED	$25,615,000	$25,615,000	$25,615,000	$25,615,000	$25,615,000
Mitigation	$40,426,000	$44,918,000	$71,869,000	$89,836,000	$112,295,000
Monitoring	$12,140,000	$12,140,000	$12,140,000	$12,140,000	$12,140,000
IDC	$19,228,000	$26,059,000	$31,810,000	$37,287,000	$54,290,000
Total	**$485,161,000**	**$613,747,000**	**$753,514,000**	**$883,671,000**	**$1,083,043,000**

The projected future commodity tonnage and the projected future fleet are the same under without- and with-project conditions. Under future without-project conditions the high cost to the carriers imposed by vessel operating constraints at the Port of Wilmington cause the two Asia services to by-pass Wilmington for less constrained ports. Wilmington's hinterland importers and exporters are projected use Savannah as an alternative port under without-project conditions (a sensitivity analysis is performed that includes Charleston and Savannah as the without-project condition ports).

Under with-project conditions, which incrementally increase vessel operational efficiency at Wilmington, the port shift projected to occur is based on the demand for transportation services at the Port of Wilmington. This demand is represented by a willingness-to-pay schedule for the Port of Wilmington's hinterland Asia TEUs importers and exporters that use Savannah under without-project conditions. The willingness-to-pay (demand) schedule identifies the potential landside transportation cost savings for each Port of Wilmington's hinterland Asia import or export TEU that would have used Savannah under without-project conditions. TEUs from each Port of Wilmington hinterland origin or destination were ranked by total potential savings from greatest savings to no savings (indifferent to using Wilmington or Savannah) and shifted from Savannah to Wilmington in order of potential savings. In this manner, TEUs with the highest potential savings (highest willingness-to-pay) were the first boxes to shift to Wilmington followed by boxes with the next highest potential savings and so on until the potential for savings had been exhausted (Figure ES-1). The demand schedule was developed from PIERS data for Asia imports and exports for calendar years 2017 and 2018 (loaded TEUs only).

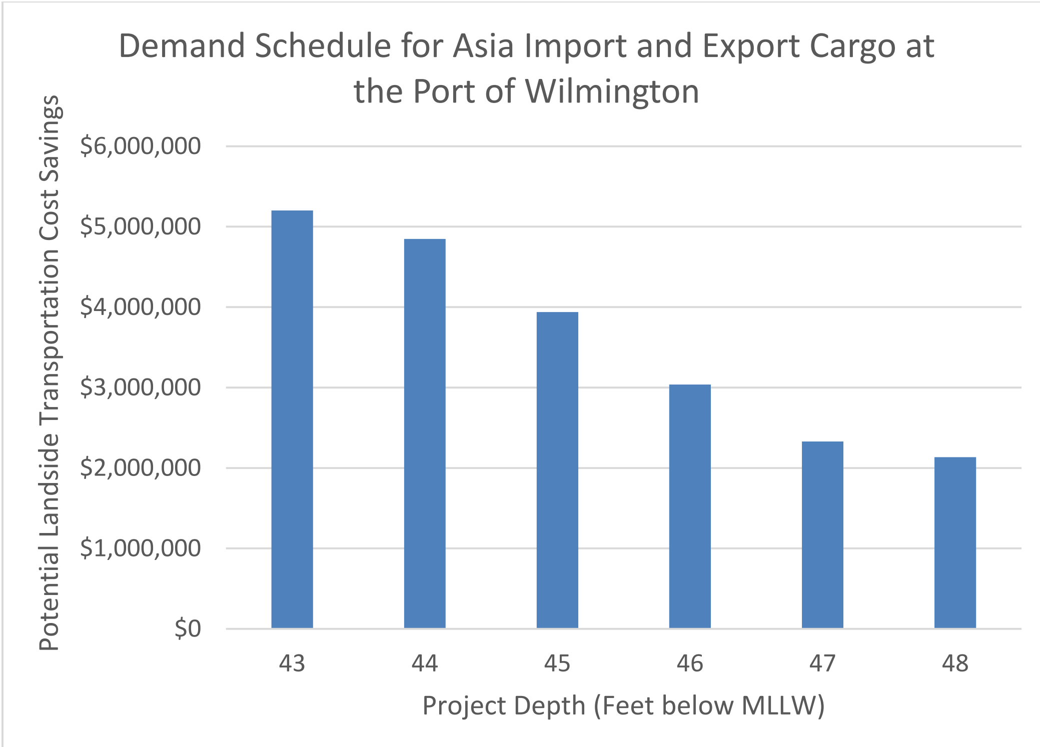

Figure ES-1
Demand Schedule for Asia Import and Export Cargo at the Port of Wilmington

The boxes with the highest potential savings (potential consumer surplus) would be the first boxes to shift to the vessel capacity made available by the additional project depth, based on the standard economic assumption of resource allocation to the highest value. At each project depth increment more of the Port of Wilmington's hinterland containerized Asia cargo is using the Port of Wilmington and less of that cargo is using Savannah. The incremental shift in cargo to Wilmington results in fewer truck hauls from the Port of Wilmington's hinterland to Savannah. At each project depth increment, the reduction in truck hauls to Savannah and total miles traveled also reduces total landside transportation costs. Note that waterborne transportation costs increase as more cargo shifts to Wilmington because there is a slight increase in the distance traveled by ships adding Wilmington to the port rotation. Figure ES-2 presents a summary of landside and waterborne transportation costs at incremental project depths.

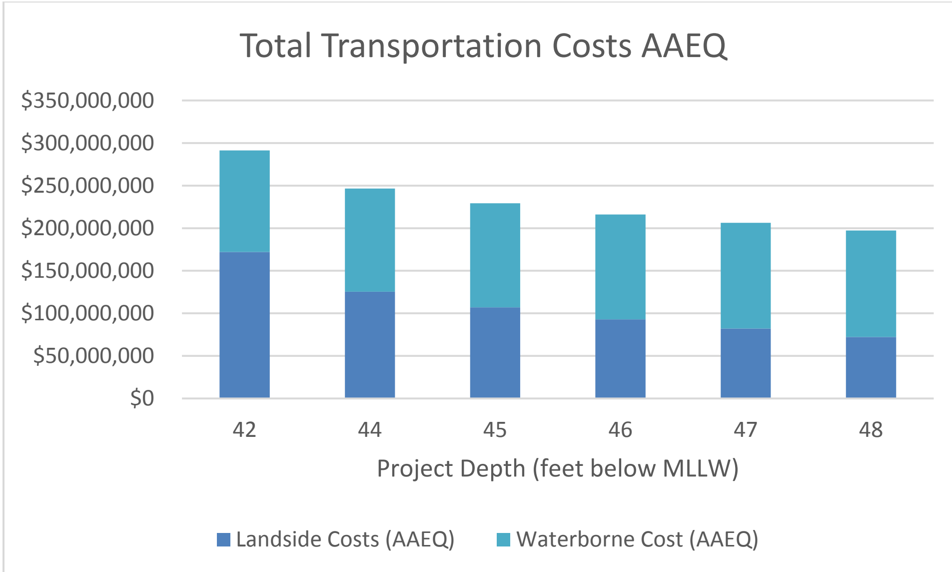

Figure ES-2
Total Transportation Costs at Incremental Project Depths

3. Tentatively Selected Plan

Plan Selection – NED Plan: The Planning Guidance Notebook (PGN) states that:

- for all project purposes, except ecosystem restoration, the NED Plan shall be the recommended plan, and
- the NED Plan is defined as "the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment" (USACE, 2000 page 2-7).

Although the largest net benefits accrue to the -48-foot plan (Figure ES-3 and Table ES-5), it requires $199.4 million more in construction costs than the -47-foot plan to generate $1.3 million more in average annual equivalent net benefits. The -47-foot plan by comparison, requires $130.2 million more in construction costs than the -46-foot plan to generate $4.8 million more in average annual equivalent benefits. The relatively small and costly incremental increase in net benefits provided by -48-foot plan indicates that the next smallest plan, the -47-foot plan, is the plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment. The Tentatively Selected Plan is the -47-foot plan, the NED Plan.

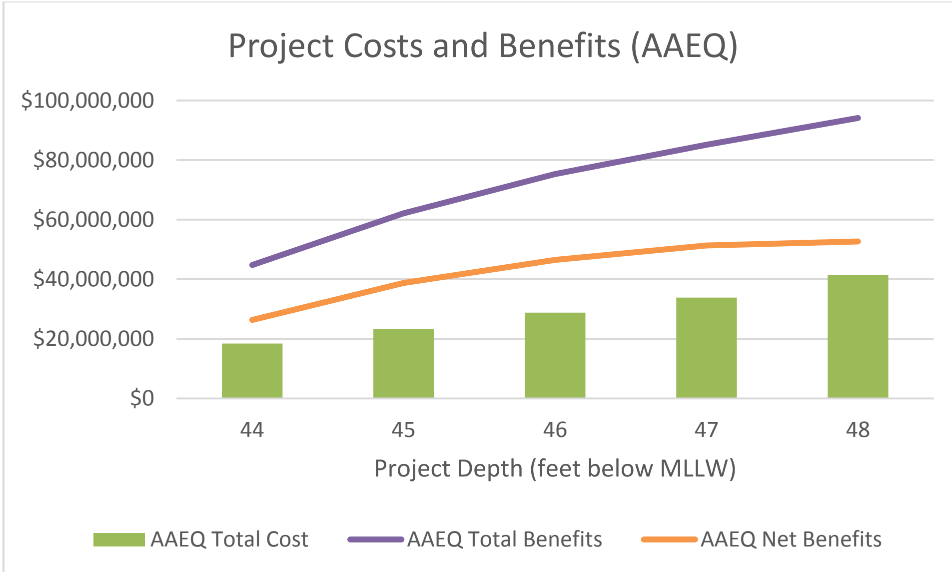

Figure ES-3
Project Costs, Benefits, and Net Benefits at Incremental Project Depths

Table ES-5
Project Net Benefits (FY2020 Dollars and Discount Rate)

Depth	AAEQ Total Cost	AAEQ Total Benefits	AAEQ Net Benefits	Benefit/Cost Ratio
-44	$18,434,000	$44,791,000	$26,357,000	2.43
-45	$23,426,000	$62,121,000	$38,695,000	2.65
-46	$28,838,000	$75,291,000	$46,453,000	2.61
-47	$33,890,000	$85,161,000	$51,271,000	2.51
-48	$41,512,000	$94,131,000	$52,619,000	2.27

Environmental Impacts of the Tentatively Selected Plan: Alternative plans have been formulated and evaluated to ensure that project-related adverse environmental impacts have been avoided or minimized to the extent practicable and that remaining unavoidable significant adverse impacts are mitigated. Avoidance and minimization were pursued wherever feasible. Avoidance and minimization efforts were integral to project planning and influenced channel design, dredged material placement locations, dredged material placement techniques, and mitigation plan formulation.

The environmental impacts of the Tentatively Selected Plan include:

- **Tidal amplitude** – Hydrodynamic modeling results indicate that channel deepening and associated increases in hydraulic efficiency will cause small changes in MHW, MLW, and tidal range. The largest projected MHW increase is ~1.3 inches in the vicinity of downtown Wilmington. MLW is projected to decrease, with a maximum decrease of ~2.0 inches projected to occur in the vicinity of Wilmington. The net effect of the projected MHW and MLW changes is a maximum increase in tidal range of 3.4 inches at Wilmington. Projected effects on MHW, MLW, and tidal range are reduced through the up-estuary and down-estuary reaches above and below Wilmington;

- **Salinity** - Hydrodynamic modeling results indicate that channel deepening would increase surface, mid-depth, and bottom salinities; with the largest increases occurring at mid to bottom depths in the vicinity of downtown Wilmington. Under typical river flow conditions; average annual surface, mid-depth, and bottom salinities are projected to increase by 1.2 ppt, 3.9 ppt, and 4.1 ppt at Wilmington, respectively. Projected effects on salinity are reduced through the up-estuary and down-estuary reaches above and below Wilmington;
- **Dissolved oxygen** – Hydrodynamic modeling results indicate that channel deepening would have negligible effects on dissolved oxygen (DO) concentrations, with projected decreases of 0.3 mg/L or less throughout the estuary. Maximum decreases are projected to occur during the winter months when estuarine DO concentrations are typically the highest; providing further indication that projected decreases would not have any significant effect on estuarine biological resources;
- **Tidal wetlands** – Channel deepening would not have any direct impacts on wetlands. Hydrodynamic modeling results indicate that channel deepening would cause small increases in average annual surface salinity of 0.3 ppt or less at the upper ends of existing salinity gradients in the estuary. Projected salinity increases of 0.3 ppt or less may have minor effects on the composition of tidal freshwater marsh and swamp forest communities in the upper estuary; but would not be expected to convert tidal swamp forests to tidal marsh communities;
- **Estuarine shoreline erosion** - Modeling results indicate that transits by larger container vessels would result in increased bed shear stress along the shoreline northeast of Southport, the southern shoreline of Battery Island, and at isolated shoreline locations in the vicinity of Orton Point. Projected increases in bed shear stress indicate the potential for increased shoreline erosion. Potential erosional effects will be investigated further during development of the DEIS and the PED project phase;
- **Beach erosion** - Wave transformation and shoreline change modeling results indicate that channel deepening would have minor to negligible effects on the shorelines of Bald Head Island and Oak Island. On Bald Head Island, channel deepening is projected to have minor adverse effects on the central South Beach shoreline and minor beneficial effects on the western South Beach shoreline. Erosion rates (net of any beach nourishment activity) along the central South Beach shoreline are projected to increase by 0.6 ft/yr or less, while erosion rates along the western South Beach shoreline are projected to decrease by ~1.3 ft/yr. Erosion rate increases (net of any beach nourishment activity) of 0.1 ft/yr or less are projected along most of Oak Island, with an increase of ~0.2 ft/yr projected along the east end of Caswell Beach;
- **Benthic softbottom habitat** - New dredging would impact ~925 acres of relatively undisturbed softbottom habitat in the channel widening areas and the new entrance

channel extension reach; including ~368 ac of offshore marine softbottom habitat and ~557 acres of inshore estuarine softbottom habitat. The vast majority of the impacts would consist of temporary effects on existing deepwater habitats that are presently subject to frequent disturbance and depth limitations on productivity. New dredging would affect just 5.9 acres of highly productive shallow (<6 ft) softbottom habitat, including just 3.5 acres of softbottom PNA habitat;

- **Fisheries and Essential Fish Habitat** - New dredging impacts on softbottom habitats and associated benthic invertebrate communities would have primarily short-term effects on benthic prey base for predatory demersal fishes. New dredging impacts on 5.9 acres of highly productive shallow (<6 ft) softbottom habitat, including 3.5 acres of softbottom PNA habitat may have longer term effects on nursery habitat functions and estuarine dependent juveniles. However, the project would impact a small fraction of the estimated 37,800 acres of <6 ft shallow softbottom habitat in the CFR estuary. The effects of blasting on fisheries may include direct injury and mortality; however, these impacts would be minimized through the development and implementation of an effective blast mitigation protection program;
- **Coastal waterbirds** - Beach placement of dredged material would affect coastal waterbirds through disturbance and temporary losses of intertidal benthic invertebrate prey resources; and
- **Protected species** - Dredging may have short-term effects on Atlantic and shortnose sturgeon through softbottom foraging habitat disturbance and temporary losses of benthic prey resources. The effects of blasting on Atlantic and shortnose sturgeon may include direct injury and mortality; however, these impacts would be minimized through the development and implementation of an effective blast mitigation protection program. Projected increases in salinity would shift the average position of the salt front upstream, potentially affecting habitat suitability in the vicinity of Wilmington where known concentration areas for sturgeon are located. Atlantic and shortnose sturgeons could experience a loss of habitat or a reduction in habitat suitability. The projected salinity increases may adversely affect critical habitat for the Atlantic sturgeon.

Preliminary Mitigation, Monitoring, and Adaptive Management Plan: The preliminary mitigation, monitoring, and adaptive management plan indicates that the appropriate level of mitigation is available for the Tentatively Selected Plan at a reasonable cost. Final mitigation planning will be performed in coordination with USACE, during development of the DEIS. Preliminary mitigation measures developed as compensation for direct and indirect effects of the Tentatively Selected Plan are summarized below.

- **Tidal Wetland Mitigation** - Preservation and restoration of the Black River Wetland Mitigation Site would provide protection of 3,685 acres of tidal swamp and pocosin pond pine woodlands contiguous with the tidal floodplain/bottomland area, conservation of an additional 470 acres of pocosin wetlands and 800 acres of upland buffers, and restoration of 25 acres of wetlands from existing timber roads and ditches.
- **Shallow Water Estuarine Habitat Mitigation** - Mitigation includes restoring 12.1 acres of subtidal shallow water estuarine habitat (7,000 linear ft and less than 6 ft deep) of the historic the Alligator Creek channel, enhancing 22 ac of fringing tidal marshes

(currently Phragmites) along both sides of the restored channel reach, and enhancing 6.8 acres of tidal pools and creeks for juvenile fish refugia from Phragmites habitat,

- **Fish Habitat Suitability Mitigation** - Mitigation for salinity effects on anadromous species would include construction of fish passages at Lock and Dam 2 and Lock and Dam 3 on the Cape Fear River, thus allowing anadromous fish species access to natal spawning grounds for the first time in almost a century. The balance of credits also provide compensation for other indirect effects such blasting, interruption of migration during construction, and due to the long construction period.
- **Bird Island Enhancement** - Mitigation for erosional effects on three significant managed bird islands in the LCFR would include expanding the subaerial footprint of Ferry Slip and South Pelican Islands to 15 acres each through placement of 250,000 CY of dredged material and sand placement on the western shoreline of Battery Island to protect waterbird nesting habitat against ongoing and future erosion.
- **Vessel Wake Attenuation and Mitigation** - Mitigation measures to reduce the effects of vessel wakes on areas along the western shoreline of the LCFR include construction of a rock sill along 2,150 linear ft of shoreline at Orton Point, construction of a 2,600 linear ft rock sill and 700 ft Reef-maker section along the Brunswick Town shoreline area and construction of 1,700 linear ft of living marine shoreline adjacent to the north end of Southport. Additional areas may be added following additional modelling and analysis performed during development of the DEIS.

4. Expected Project Performance

Cost Sharing: Cost sharing for the Selected NED Plan will be done in accordance with Section 101 of the WRDA 1986, as amended, and cost shared as a General Navigation Feature. Project cost sharing between the Federal government and the non-Federal sponsor (Table ES-8) is based on 100% of the project having a controlling depth less than -50 feet MLLW, indicating the project would be cost-shared 75% Federal / 25% non-Federal.

Table ES-8
Project Cost Shares

Cost Item	Total Cost	75% Federal	25% Non-Federal
Dredging Cost	$547,882,000	$410,912,000	$136,971,000
Mitigation & Monitor	$84,000,000	$63,000,000	$21,000,000
Construction S&A	$10,800,000	$8,100,000	$2,700,000
PED	$21,100,000	$15,825,000	$5,275,000
Contingency (21.4%)	$142,049,000	$106,537,000	$35,512,000
Total Construction of GNF	**$805,831,000**	**$604,373,000**	**$201,458,000**
Lands & Damages	$28,262,000	$0	$28,262,000
Total Project First Costs	**$834,093,000**	**$604,373,000**	**$229,720,000**
Berthing Area Dredging Costs	$1,760,000	$0	$1,760,000
Aids to Navigation	$10,531,000	$10,531,000	$0
10% GNF Non-Federal		-$52,321,000	$52,321,000
Total Cost	**$846,384,000**	**$562,583,000**	**$283,801,000**

Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R): Additional annual maintenance costs to the United States are estimated to be $1,160,000 (FY 2019). Maintenance of any non-Federal ancillary facilities is a 100% non-Federal responsibility.

Environmental Compliance: Environmental Compliance will be completed by USACE upon direction of the ASA(CW).

State and Agency Review: State and Agency Review will be coordinated by USACE upon direction of the ASA(CW).

Certification of Peer and Legal Review: Certification of Peer and Legal Review will be completed by USACE upon direction of the ASA(CW).

Policy Compliance Review: USACE Policy Compliance Review will be completed by USACE upon direction of the ASA(CW).

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1 INTRODUCTION

This Integrated Section 203 Study and Environmental Report presents an analysis of potential navigational improvements to the Wilmington Harbor Federal navigation channel leading from the Atlantic Ocean to the Port of Wilmington, North Carolina. The plan recommended in this integrated report is economically justified, technically feasible, consistent with protecting the nation's environment, and publicly acceptable.

1.1 Existing Federal Project

The existing federal project at Wilmington Harbor (Figure 1-1) consists of the Eagle Island Dredged Material Disposal Site, the New Wilmington Ocean Dredged Material Disposal Site (ODMDS), the Upper and Lower Anchorage basins, and the system of federal channels from the ocean up to the channel's terminus upstream of the Hilton Bridge. The federal channel extends for approximately 38 miles beginning offshore of the outer ocean bar at the mouth of the Cape Fear River in Brunswick County, NC, and extends upwards to the City of Wilmington in New Hanover County, NC, where it services the Port of Wilmington. The authorized depth of the channel is -44 ft MLLW[2] at the ocean bar and entrance channel, then -42 ft for the channel up to the Cape Fear Memorial Bridge. Upstream of the Cape Fear Memorial Bridge, the authorized depth decreases to 38 ft in the channel up to 750 ft above the Hilton Bridge and in the Turning Basin inside the mouth of the Northeast Cape Fear River. The authorized depth decreases further to 36 feet from 750 ft upstream of the Hilton Bridge through the Turning Basin at the upper project limit in the Northeast Cape Fear River (Table 1-1). Existing water depths upstream of the Cape Fear Memorial Bridge, however, are lower than the project dimensions, as these were not dredged due to lack of users (USACE, 2014). The reaches above the existing turning basin, located in the lower section of the anchorage basin reach, are not included in this proposed project.

Construction of the Federal navigation channel to its current dimensions (Table 1-1) was originally authorized as three separate projects by the Water Resources Development Acts of 1986 (WRDA 86) Public Law 99-662[3] and 1996 (WRDA 96) Public Law 104-303[1]. Public Law 105-62[4], The Energy and Water Development Appropriations Act of 1998, combined the Wilmington Harbor Northeast Cape Fear River Project (WRDA 1986), the Wilmington Harbor Channel Widening Project (WRDA 1996), and the Cape Fear-Northeast (Cape Fear) Rivers Project (WRDA 1996) under a single project known as the Wilmington Harbor 96 Act Project. Completed improvements under the Wilmington Harbor 96 Act Project include deepening the ocean bar and entrance channels from the authorized depth of 40 feet to 44 feet; deepening the

[2] Note all depths will be presented throughout referenced to MLLW

[3] Section 201 - WILMINGTON HARBOR-NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA - The project for navigation, Wilmington Harbor-Northeast Cape Fear River, North Carolina: Report of the Chief of Engineers, dated September 16, 1980, at a total cost of $10,000,000, with an estimated first Federal cost of $8,300,000 and an estimated first non-Federal cost of $1,700,000.

[4] Provided further, That the Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to combine the Wilmington Harbor—Northeast Cape Fear River, North Carolina, project authorized in section 202(a) of the Water Resources Development Act of 1986, the Wilmington Harbor, Channel Widening, North Carolina, project authorized in section 101(a)(23) of the Water Resources Development Act of 1996, and the Cape Fear—Northeast (Cape Fear) Rivers, North Carolina, project authorized in section 101(a)(22) of the Water Resources Development Act of 1996 into a single project with one Project Cooperation Agreement based on cost sharing as a single project:

authorized 38-foot project to 42 feet through the Cape Fear Memorial Bridge (including the anchorage basin); widening the existing 400-foot wide channel to 600 feet over a total length of 6.2 miles, including the Lower and Upper Midnight and Lower Lilliput reaches; widening five turns and bends by 100 to 200 feet; and widening the Fourth East Jetty channel to 500 feet over a total length of 1.5 miles. Additional authorized improvements to the Federal channel from the Cape Fear Memorial Bridge to the upper project limit in the Northeast Cape Fear River were deferred due to a marginal cost to benefit ratio.

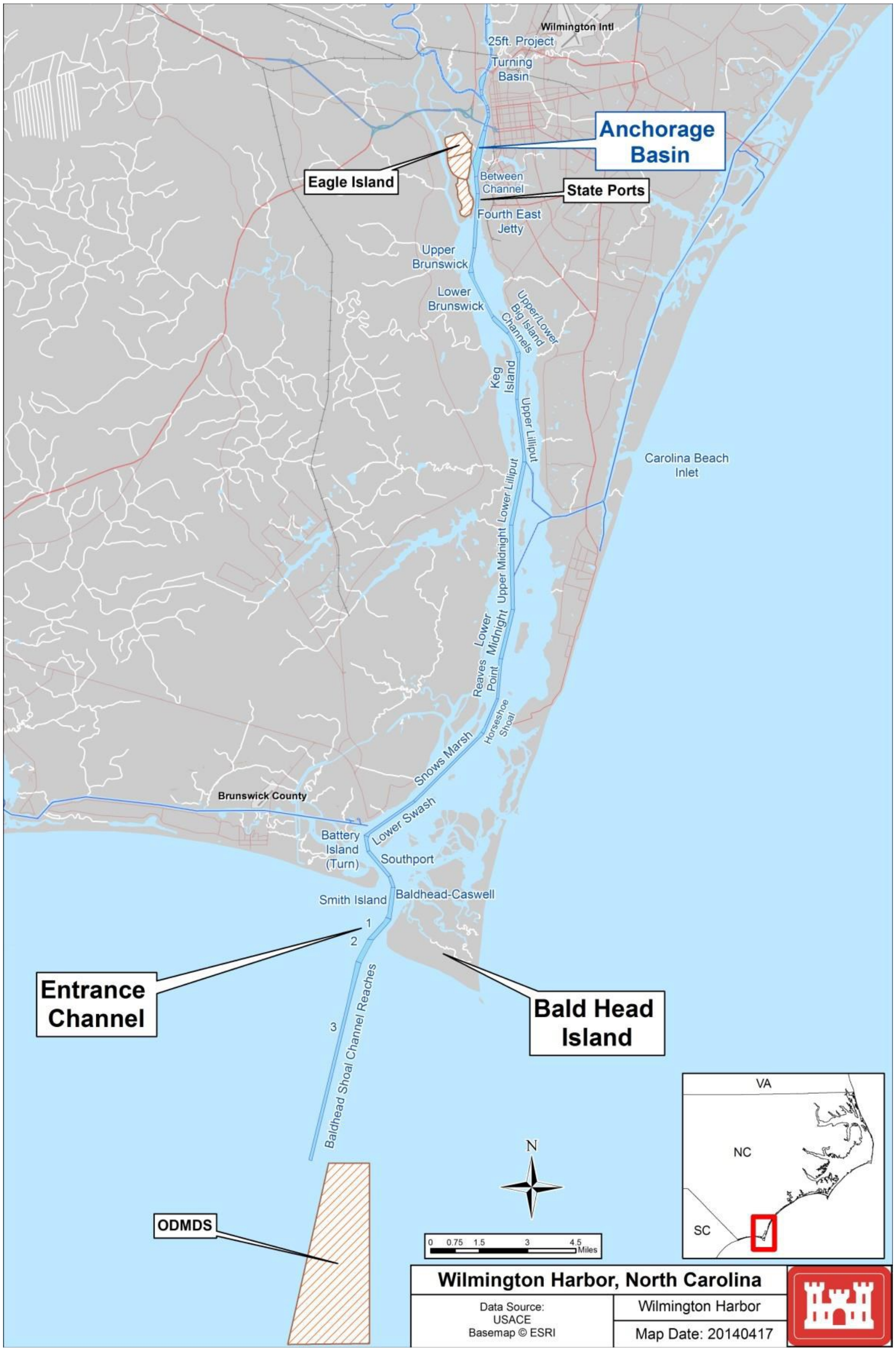

Figure 1-1
Wilmington Harbor Federal Navigation Project

Table 1-1
Wilmington Harbor Federal Navigation Channel Reach Dimensions

Reach Name	Length (ft)	Width (ft)	Maintained Depth	Maintained Depth Plus Overdepth
Baldhead Shoal Reach 3	26,658	500 – 900	44	46
Baldhead Shoal Reach 2	4,342	900	44	46
Baldhead Shoal Reach 1	4,500	700 – 785	44	46
Smith Island	5,100	650	44	46
Baldhead-Caswell	1,921	500	44	46
Southport	5,363	500	44	46
Battery Island	2,589	500	44	46
Lower Swash	9,789	400	42	44
Snows Marsh	15,775	400	42	44
Horseshoe Shoal	6,102	400	42	44
Reaves Point	6,531	400	42	44
Lower Midnight[4]	8,241	600	42	44
Upper Midnight[4]	13,736	600	42	44
Lower Lilliput[4]	10,825	600	42	44
Upper Lilliput	10,217	400	42	44
Keg Island	7,726	400	42	44
Lower Big Island	3,616	400	42	44
Upper Big Island	3,533	510 – 700	42	44
Lower Brunswick	8,161	400	42	44
Upper Brunswick	4,079	400	42	44
Fourth East Jetty	8,852	500	42	44
Between	2,827	400	42	44
Anchorage Basin Station 8+00 to 84+81	7,681	550 – 1,400[5]	42	44
Anchorage Basin Station 0+00 to 8+00	3,970	450 – 550	38	44
Memorial Bridge – Isabel Holmes Bridge	9,573	400	32	40
Isabel Holmes Bridge – Hilton RR Bridge	2,559	200 – 300	32	40
Hilton RR Bridge – Project Limit	6,718	200	25	36
Total Length in Feet	**200,984**			
Total Length in Miles	**38.1**			

1 Width shown is widest point at basins, and includes the channel width
2 Channel depths are at mean lower low water
3 Allowable Overdepth is two feet
4 This channel reach included the Passing Lane
5 Updated for 2019 Turning Basin Expansion

1.2 Study Authority

This study of potential navigation improvements to the Wilmington Harbor Federal navigation channel leading from the Atlantic Ocean to the Port of Wilmington, North Carolina has been prepared by the North Carolina State Ports Authority (NCSPA) under the authority granted by Section 203 of Water Resources Development Act (WRDA) of 1986 (P.L. 99-662), as amended.

Section 203 of WRDA 86, as amended, states:

SEC 203. STUDIES OF PROJECTS BY NON-FEDERAL INTERESTS.
PUBLIC LAW 99-662, NOV. 17, 1986. 33 USC 2231.

(a) SUBMISSION TO SECRETARY

1 *In general. A non-Federal interest may on its own undertake a federally authorized feasibility study of a proposed water resources development project and submit the study to the Secretary.*

2 *Guidelines. To assist non-Federal interests, the Secretary shall, as soon as practicable, issue guidelines for feasibility studies of water resources development projects to provide sufficient information for the formulation of studies.*

(b) REVIEW BY SECRETARY - The Secretary shall review each feasibility study received under subsection (a) (1) for the purpose of determining whether or not the study, and the process under which the study was developed, each comply with Federal laws and regulations applicable to feasibility studies of water resources development projects.

(c) SUBMISSION TO CONGRESS =

(1)REVIEW AND SUBMISSION OF STUDIES TO CONGRESS - Not later than 180 days after the date of receipt of a feasibility study of a project under subsection (a) (1), the Secretary shall submit to the Committee on Environment and Public Works of the Senate and the Committee on Transportation and Infrastructure of the House of representatives a report that describes

(A) the results of the Secretary's review of the study under subsection (b), including a determination of whether the project is feasible;

(B) any recommendations the Secretary may have concerning the plan or design of the project; and

(C) any conditions the Secretary may require for construction of the project.

(2) LIMITATION – The completion for the review by the Secretary of a feasibility study that has been submitted under subsection (a)(1)may not be delayed as a result of consideration being given to changes in policy or priority with respect to project consideration;

(d) CREDIT. If a project for which a feasibility study has been submitted under subsection (a) (1) is authorized by a Federal law enacted after the date of the submission to Congress under subsection (c), the Secretary shall credit toward the non-Federal share of the cost of construction of the project an amount equal to the portion of the cost

of developing the study that would have been the responsibility of the United States if the study had been developed by the Secretary.

(e) REVIEW AND TECHNICAL ASSISTANCE. –

(1) REVIEW – The Secretary may accept and expend funds provided by non-federal interests to undertake reviews, inspections, certifications, and other activities that are the responsibility of the Secretary in carrying out this section.

(2) TECHNICAL ASSISTANCE - At the request of a non-Federal interest, the Secretary may provide to the non-Federal interest technical assistance relating to any aspect of a feasibility study if the non-Federal interest contracts with the Secretary to pay all costs of providing such technical assistance.

(3) LIMITATION – Funds provided by non-Federal interests under this subsection shall not be eligible for credit under subsection (d) or reimbursement.

(4) IMPARTIAL DECISIONMAKING – In carrying out this section, the Secretary shall ensure that the use of funds accepted from a non-Federal interest will not affect the impartial decisionmaking of the Secretary, either substantively or procedurally.

(5) SAVINGS PROVISION – The provision of technical assistance by the Secretary under paragraph (2) –

(A) shall not be considered to be an approval or endorsement of the feasibility study; and

(B) shall not affect the responsibilities of the Secretary under subsections (b) and (c).

This report has been developed based on the policy guidance provided in:

- ER 1165-2-209 (04 February 2016), which provides guidance for implementation of Section 203 of WRDA 1986, as amended by Section 1014(a) of WRRDA 2014;
- Memorandum for Commanding General U.S. Army Corps of Engineers (21 June 2018): Implementation Guidance for Section 1126 of WRDA 2016 – Study of Water Resources Development Projects by Non-Federal Interests (Revised); and
- Implementation Guidance for Section 1152 of the Water Resources Development of 2018, Studies of Water Resources Development Projects by Non-Federal Interests," dated 2 May 2019.

In following this policy guidance, the U.S. Army Corps of Engineers (USACE) cooperated in the development of this report by providing:

- available information;
- clarification of existing technical guidance;
- clarification of USACE review process; and
- HarborSym modeling outputs based on inputs provided by the NCSPA.

In addition, a previous draft version of this report was reviewed by the Office of the Secretary of the Army for Civil Works (OASACW) and the Headquarters, US Army Corps of Engineers

(USACE) staff and by the USACE Wilmington District. Independent peer review of technical work products was also performed for economics, cost engineering, hydrodynamic modeling, and ship simulation modeling. Reviewer comments and responses are provided in Appendix S: Quality Control Report. Compliance with federal statutes, such as the National Environmental Policy Act (NEPA), the Endangered Species Act, and other federal environmental, cultural, and historic resource statutes will be completed by USACE if the ASA(CW) determines that there is a Federal interest sufficient for Federal participation and Congress authorizes improvements to the Federal Wilmington Harbor navigation channel.

This report includes information typically included in an Environmental Impact Statement (EIS), but this report cannot be considered an EIS because official involvement by USACE, which is the lead federal agency for the purpose of compliance with federal statutes, did not begin until after the first submittal of the report to the ASA(CW) and issuance of a subsequent Notice of Intent (13Sep20). The NCSPA held informational sessions with federal and state agencies and with the public prior to USACE official involvement, as described in subsequent chapters for the purposes of obtaining public input to the plan formulation and selection process.

1.3 Study Purpose and Need

The NCSPA has conducted this Section 203 study to determine the feasibility of improvements to the Federal navigation project at Wilmington Harbor. The purpose of this study is to identify and evaluate alternatives to increase transportation efficiencies for the current and future fleet of container vessels operating at the Port of Wilmington and to improve overall conditions for vessel operations and safety. Potential improvements include deepening and widening of the Federal navigational channel, extending the ocean entrance channel farther offshore, expansion of the Turning Basin, and expanded wideners at turns along the channel.

Since the last major channel improvements were completed by the Corps of Engineers in 2002, the Port of Wilmington has experienced significant growth in cargo volume, and in the size of vessels calling at the port. Over the intervening years, the NCSPA has made major investments in landside infrastructure to accommodate growth at the Port of Wilmington and the region that it serves. At the present time, the Port of Wilmington is the largest port in North Carolina and is a major component of the State's economy.

The need for the proposed action is to address the transportation inefficiencies at the Port of Wilmington. Inadequate channel capacity currently impacts vessel operations at the Port of Wilmington and is projected to have a greater detrimental impact on vessel operations in the future, providing the impetus for the NCSPA to conduct this Section 203 study. Pursuant to Section 203 of WRDA 1986, this study is intended to determine the feasibility of the project and whether there is a Federal interest sufficient for Federal participation and Congressional authorization of improvements to the federal Wilmington Harbor navigation channel, consistent with the federal objective of maximizing contributions to National Economic Development (NED), and consistent with protecting the nation's environment.

1.4 Location and General Description of the Study Area

The Port of Wilmington is located in southeastern North Carolina, approximately 28 miles up the Cape Fear River from the Atlantic Ocean. The Cape Fear River borders Brunswick County to the west and New Hanover County to the east. The Port has excellent intermodal transportation connections. Interstate Highway 40 connects Wilmington with the state capital Raleigh, and to

Interstate 95. State highway 74 and Interstate highway 74 connect the port to Charlotte, the state's most populous city. The CSX rail system connects the Port of Wilmington directly to intermodal transfer facilities in Charlotte. The Port of Wilmington is also connected to the CSX Carolina Connector rail hub.

1.5 Prior Reports

The federal channel from the Atlantic Ocean to Wilmington has been incrementally improved for more than 100 years (USACE 1996). Over that time many reports have been developed. The following describes the reports leading to the most recent improvements and describes reports subsequent to those improvements.

A resolution by the Committee on Public Works and Transportation of the United States House of representatives dated 08 September 1988 requested review of reports on Wilmington Harbor, North Carolina to determine whether modifications were advisable with particular reference to commercial navigation needs. Resulting USACE recommendations ultimately led to the development and authorization of three separate harbor improvement projects; including the Wilmington Harbor Northeast Cape Fear River Project (WRDA 1986), the Wilmington Harbor Channel Widening Project (WRDA 1996), and the Cape Fear-Northeast (Cape Fear) Rivers Project (WRDA 1996). The Energy and Water Development Appropriations Act of 1998 combined the three projects under a single project known as the Wilmington Harbor 96 Act Project. The three components of the combined project were evaluated in separate reports described below.

- U.S. Army Engineer District, Wilmington. 1990. Final Supplement to the Final Environmental Impact Statement for Wilmington Harbor – Northeast Cape Fear River, North Carolina. February 1996.
- Interim Feasibility Report and Environmental Impact Statement on Improvement of Navigation, Wilmington Harbor Channel Widening, USACE Wilmington District, March 1994. The recommended plan consists of widening the channel from 400 feet to 600 feet for a length of 6.2 miles to provide a passing lane. The Chief's Report is dated 24 June 1994. The work was completed in 2002.
- Final Feasibility Report and Environmental Impact Statement on Improvement of Navigation, Cape Fear – Northeast Cape Fear Rivers Comprehensive Study, Wilmington, North Carolina, USACE Wilmington District, June 1996. The recommended plan consists of:
    - Deepening the channel from the Atlantic Ocean to Wilmington from a depth of 38 feet to a depth of 42 feet, including the Anchorage Basin; along with deepening the ocean bar channel from 40 to 44 feet;
    - Deepening the 32-foot and 25-foot channel reaches in the upriver portion of the harbor to 38 feet and 34 feet, respectively; along with widening the channel from the existing width of 200 feet to 250 feet; and
    - Deepening the Turning Basin at the upper project limit in the Northeast Cape Fear River from 25 to 34 feet; along with widening the upper Turning Basin from 700 to 800 feet.

The Chief's Report is dated 09 September 1996. The project up to within 800 feet of the Cape Fear Memorial Bridge was completed in 2013. The remaining authorized improvements from the Cape Fear Memorial Bridge to the upper project limit were deferred due to a marginal cost to benefit ratio.

In 2011, USACE developed a Reconnaissance Report (Section 905(b) Report), which recommended that a Feasibility Study for additional improvements be performed. The Feasibility Study (2014) recommended realignment of the Entrance Channel, widening of the Battery Island channel, and assorted modifications that increase the radius of the turn at Battery Island.

- Section 905 (b) Analysis Wilmington Harbor Navigation Improvements, New Hanover and Brunswick Counties, North Carolina, USACE Wilmington District, April 2011. The section 905 (b) analysis recommended that the Wilmington Harbor Navigation Improvement study proceed into the feasibility phase only for channel widening, turning basin enlargement, and other modifications at the existing project depth.
- Final Integrated Feasibility Report and Environmental Assessment Wilmington Harbor Navigation Improvements, USACE Wilmington District, October 2018. The recommended plan combines the following components to increase the available turning radius of the Battery Island turn from 2,850 feet to 3,900 feet[5]:
    - Realignment of the Entrance Channel reach 1 westward away from a shoal that forms to the east of the channel;
    - Widen Battery Island channel from 500 feet to 750 feet;
    - Provide additional tapers where Southport and Lower Swash channel join Battery Island Channel; and
    - Provide a 750 feet-wide by 1,300 feet long cutoff between Battery Island channel and Lower Swash channel.

1.6 Public Involvement

Public involvement in development of the Section 203 Feasibility Study and Environmental Report is divided into two phases. The first phase consists of early public involvement activities performed by the NCSPA prior to federal participation in public involvement. The second phase of public involvement began when USACE published a Notice of Intent to prepare an EIS pursuant to the National Environmental Policy Act (NEPA) on 13 September 2019 Although this Section 203 Feasibility Study and Environmental Report is a non-federal study, the NCSPA has developed this Report in accordance with USACE planning and environmental compliance guidelines to facilitate the USACE ongoing development of a Draft EIS (DEIS) for the 203 Study. The NCSPA believes that its first phase public and agency involvement activities meet the spirit of NEPA in regard to the inclusion of public input in the plan formulation and selection process.

The NCSPA provided initial public notice of the Section 203 Study through an announcement that was posted on the NCSPA web site on 20 June 2018 and published in the local newspaper,

[5] Note that the design vessel for the October 2018 study is the same design vessel as the 1996 and 2002 studies, which is substantially smaller than the design vessel for this study.

the Star News, on 01 July 2018. The first public and state/federal agency meetings were held in Wilmington on 08 and 09 August 2018, respectively. During the initial inter-agency meeting on 09 August 2018, three technical working groups (TWGs) were formed to provide a mechanism for local agency subject matter experts to offer technical guidance and input towards assessing the effects of the proposed project on:

- tidal wetlands;
- fisheries and fish habitat; and
- beneficial use of dredged material.

The overall TWG framework consists of 1) the review of available data sources for baseline conditions, 2) concurrence on impact assessment methods to be used, 3) the provision of technical review and input on existing conditions and effects analysis for tidal wetlands and fisheries/fish habitat, and 4) the consideration and discussion of potential options for mitigating any adverse effects. The overall goal of the Beneficial Use TWG is enlist local subject matter experts to identify potential beneficial uses of dredged material derived from channel construction; including beach placement, waterbird nesting island restoration, marine resource restoration/enhancement; and other potential uses; which would be further assessed for inclusion in future dredged material management practices.

To date, six TWG meetings have occurred to discuss tidal wetlands, fisheries/fish habitat, and beneficial use. These meetings have been held over a period of approximately 12 months (Table 1-2). The NCSPA study team has prepared tidal wetland and fisheries technical memorandum reports[6], for review and comment by the respective TWGs, that describe affected resource baseline conditions, impact analysis methods, and the anticipated impacts of the alternatives. For the Beneficial Use TWG, a summary of recommendations was prepared for further use by the NCSPA study team in developing the overall beneficial use study report. The USACE involvement since the publication of the Notice of Intent on 13 September 2019 has included an initial EIS public scoping meeting in Wilmington, the formation of a WHNIP 203 Study Stakeholder Group, and the coordination of three Stakeholder Group meetings in Wilmington during November 2019 through January 2020. Public involvement efforts by the USACE and the NCSPA are ongoing and will continue throughout the development of the DEIS.

[6] TWG membership and reports are included as an attachment to the Environmental Appendix.

Table 1-2
Public Involvement

Public Involvement – Phase 1	
6/20/2018	NCSPA 203 Study announcement on NCSPA website
7/1/2018	NCSPA 203 Study announcement published in Star News
8/8/2018	First NCSPA Public Information Meeting
8/9/2018	First NCSPA Interagency Meeting (state/federal Agencies)
12/20/2018	First Wetland and Fisheries TWG Meetings. Baseline data collection and mapping, potential impact analysis methods, and integration of hydrodynamic modeling results.
2/19/2019	First Beneficial Use TWG Meeting - Proposed and potential beneficial uses of dredged material
4/10/2019	Second Wetland and Fisheries TWG Meetings - Preliminary results of salinity isopleth shift analysis and determination of fish species to be included in Habitat Suitability Index (HSI) Modeling
8/14/2019	Third Wetland and Fisheries TWG Meetings. Preliminary quantification of salinity affected wetlands and potential methods of assessing impacts on wetland functions. Preliminary results of fisheries HIS modeling.
Public Involvement – Phase 2	
9/13/2019	USACE publishes Notice of Intent in Federal Register, Public Scoping Letters are sent.
10/8/2019	Fourth Wetland and Fisheries TWG Meetings – Final wetland impacts and further discussion of potential impacts on function. Revised HSI modeling and discussion of initial Habitat Evaluation Procedure (HEP) analysis and results. USACE participation
9/26/2019	USACE EIS Public Scoping Meeting, Wilmington
11/20/2019	First USACE WHNIP 203 Stakeholder Group Meeting
12/10/2019	Fifth Wetland and Fisheries TWG Meetings - Discussion of Uniform Mitigation Assessment Method (UMAM). USACE participation
12/18/2019	Second USACE WHNIP 203 Stakeholder Group Meeting
1/15/2020	Third USACE WHNIP 203 Stakeholder Group Meeting

Note: NCSPA = North Carolina State Ports Authority, TWG = Technical Working group, WHNIP = Wilmington Harbor Navigation Improvement Project

1.7 Planning Process and Report Organization

The planning process employed by the NCSPA for the Wilmington Harbor Section 203 Study has followed the Corps of Engineers' six step planning process as described in the Corps' Planning Guidance Notebook (ER 1105-2-100, dated 22 April 2000). These steps include:

1) specify water resources problems and opportunities;
2) inventory, forecast, and analyze the water and related land resource conditions within the study area;
3) formulate alternative plans which address the identified problems and take advantage of the opportunities;
4) evaluate the effect of alternative plans;
5) compare alternative plans; and
6) select the recommended plan.

The Principles and Guidelines (P&G) adopted by the Water Resources Council guide the formulation and evaluation of Federal water resource projects. P&G requires that the plan recommended for Federal action will be the alternative plan with the greatest net economic benefit consistent with protecting the nation's environment [the National Economic Development (NED) plan], unless the Secretary of Army grants an exception to this rule.

Planning for the Wilmington Harbor Section 203 Study has been a dynamic process resulting in multiple iterations of the six-step planning process. Through iterations of the six-step planning process, the study has been refined and has resulted in a recommendation for Federal action that is consistent with the Principles and Guidelines and ER 1105-2-100. The remainder of this report documents the results of the six-step planning process.

The report is organized similarly to a USACE Integrated Feasibility Report and Environmental Impact Statement, in order to facilitate review and processing by the ASA(CW). Official NEPA compliance was initiated by USACE after submission of the first draft of this report to the ASA(CW) in June 2019. This report includes the results of initial public and agency involvement, environmental impact analyses, a preliminary mitigation, monitoring, and adaptive management plan, and an evaluation of alternatives. It is the intent of the NCSPA that sufficient information and analysis is included in this report to support completion of a Draft Environmental Impact Statement (DEIS) by USACE and other federal statute compliance upon a positive recommendation to Congress and subsequent authorization.

The remainder of the Section 203 Study report is organized as follows:

Section 2 – Existing Navigation and Trade Conditions

Section 3 – Baseline Conditions/Affected Environment

Section 4 – Without-project Conditions

Section 5 – Problems, Opportunities, and Constraints

Section 6 – Formulation and Evaluation of Alternatives

Section 7 – Effects of Tentatively Selected Plan on Existing Navigation Infrastructure

Section 8 – Environmental Consequences

Section 9 – Tentatively Selected Plan

Section 10 – Compliance with Environmental Commitments

Section 11 – Public / Agency Participation and Comments

Section 12 – Recommendations

Section 13 – List of Preparers and Reviewers

Section 14 – References

Section 15 – Index

2 EXISTING NAVIGATION AND TRADE CONDITIONS

2.1 Navigation Features

The Port of Wilmington includes a container terminal that supports the Nation's import and export trade worldwide, with an emphasis on trade with Asia. The NCSPA is constructing a $200 million capital improvement plan that upgrades terminal facilities to handle projected future vessels and cargo. The Federal navigation channel at Wilmington Harbor was last improved in the early 2000's and was designed for Panamax vessels with a length, beam, and draft of 965 feet, 106 feet, and 40 feet respectively. Vessels currently calling at the port have length, beam, and draft dimensions of more than 1,100 feet, 140 feet, and 50 feet respectively. Vessel operations for the fleet currently calling at the Port of Wilmington are constrained by channel dimensions.

2.1.1 Channels and Turning Basins

The existing navigation channel to the Port of Wilmington is approximately 33 miles long from the Cape Fear River pilot boarding area near 78.05°W, 33.77°N through 22 channel reaches to the Port of Wilmington facilities (Table 1-1). The existing channel geometry is published in the current nautical charts for the Cape Fear River. Nautical charts published by NOAA relevant to this area include the following:

- NOAA Nautical Chart number 11537 (Figures 2-1 and 2-2); and
- NOAA Electronic Nautical Chart (ENC) tile US5NC12M.

For reference in discussion of channel locations throughout this report, channel stationing is provided on Figures 2-1 and 2-2. To facilitate discussion of the project geometry introduced later in this document, the channel stationing starts offshore of the current pilot boarding area, where the new channel is expected to end. Table 1-1 provides approximate (i.e., +/- about 100 ft) range lengths based on the stationing shown in Figures 2-1 and 2-2.

The channel widths are provided in Table 1-1 for each reach of the existing channel. Beginning offshore, the existing channel is 500 ft wide at the pilot boarding station and widens to 900 ft approaching the first bend at Bald Head Shoal. Through the following several reaches, the channel narrows back to 500 ft before entering the large turn around Battery Island. Upstream of Battery Island, the channel narrows to a typical width of 400 ft, with three exceptions:

- A 600 ft wide passing area extending from Lower Midnight Reach to Lower Lilliput Reach.
- Upper Big Island Reach, which is 660 ft wide.
- Fourth East Jetty Reach, and the channel adjacent to the Wilmington terminal facilities, which are 500 ft wide.

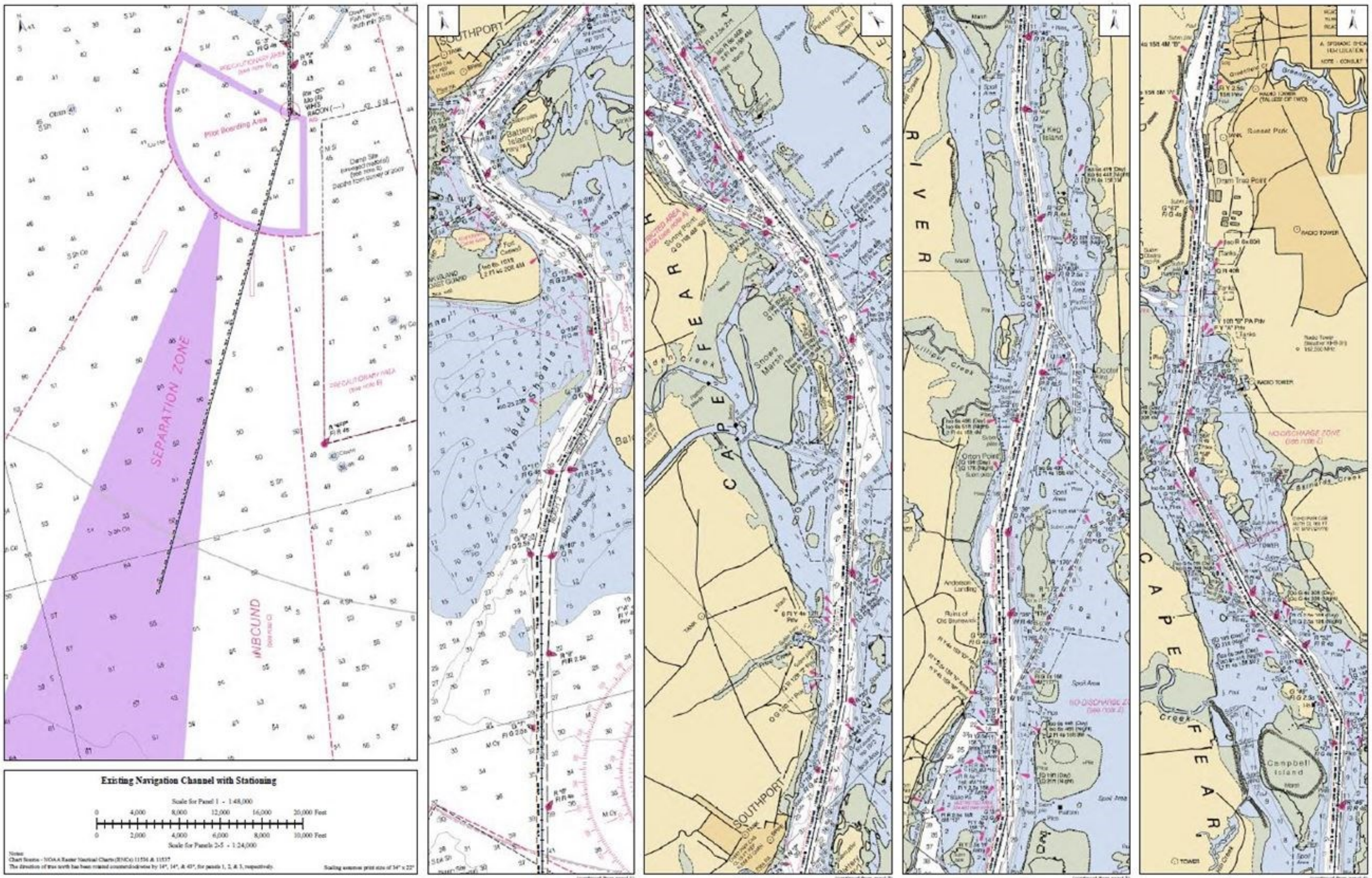

Figure 2-1
NOAA Nautical Chart number 11537

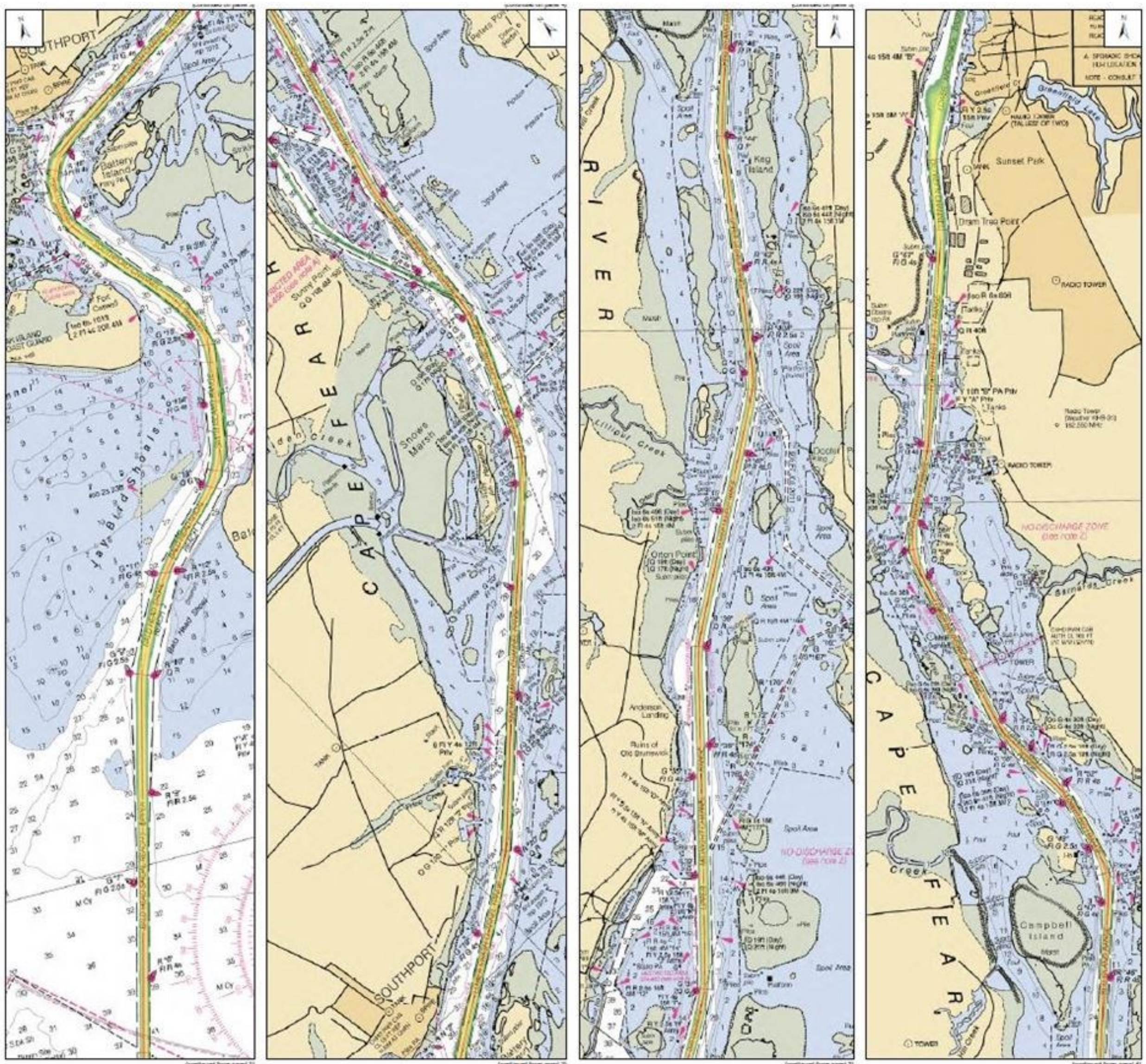

Figure 2-2
Continuation of NOAA Nautical Chart number 11537

2.1.2 Channel Maintenance

Maintenance dredging of the Federal navigation channel was described in detail by the USACE (2007). Updated information will be included as it becomes available. Per USACE (2007):

> *The Wilmington Harbor navigation channel is divided into "reaches" or segments of river and dredging methods and disposal options vary depending on the reach location and quality of material to be dredged. Maintenance dredging in Wilmington Harbor is currently performed by varying methods depending on the location of the River reach and disposal of maintenance dredged material from the Harbor varies based on sediment quality and location.*

Table 1-10 [**provided in this document as Table 2-1**] *contains a summary of all current maintenance dredging activities and includes dredging and disposal methods, sediment volumes, dredging frequency, and sediment classification. Sediment classification is based on the Engineering Unified Soil Classification System. Sand is described as a material where 50 % or more of the material lies between the number 4 sieve (4.76 mm) and the number 200 sieve (0.074mm). Silty sand is defined has a sand material with more than 12% of the material (silt) passing the number 200 sieve. Beach disposable sand is defined as sand material with less than 10% passing the number 200 sieve.*

As shown in Table 2-24, material from the Outer Ocean Bar (Reach 3 of Bald Head Shoal) Channel is dredged annually by hopper dredge and deposited in the Ocean Dredged Material Disposal Site (ODMDS). Material from the Inner Ocean Bar Channel (Bald Head Shoal Channel reaches 1 and 2) and Smith Island Channel is dredged with an ocean certified pipeline dredge every other year and pumped to the beach at either Bald Head Island or Oak Island in accordance with the Sand Management Plan (SMP) that was incorporated in the Environmental Assessment, Preconstruction Modifications of Authorized Improvements, Wilmington Harbor, NC, 2000. The 2000 SMP is based on a 6- year cycle and remains in effect until the Phase III DMMP is completed.

Although the Phase III DMMP may not recommend any changes to the 2000 SMP, the Phase III DMMP will supersede the Sand Management Plan. Material from Bald Head-Caswell Channel, Southport Channel and Battery Island Channel is dredged about once every 4 years by hopper dredge and deposited in the ODMDS. Material from Snows Marsh Channel to Lower Big Island Channel is dredged once every 2 years by bucket and barge or by hopper dredge and deposited in the ODMDS. If nearby bird nesting islands, South Pelican Island and Ferry Slip Island, are in need of sand due to erosion, material from Snows Marsh Channel and Horseshoe Shoal Channel may be pumped to these islands by pipeline dredge. Also, DA-3 and DA-4 are alternative disposal areas available for disposal of dredged material by pipeline dredge from Bald Head-Caswell Channel through Horseshoe Shoal Channel. Upstream of Lower Big Island Channel to the upstream limits of the project, dredging is performed by pipeline dredge and material is pumped to the Eagle Island Disposal Area. Maintenance dredging in Upper Big Island Channel upstream through Fourth East Jetty Channel is performed every 2 years. Between Channel and the Anchorage Basin are dredged annually. The project area upstream of the Anchorage Basin to the upstream limits of the project is dredged about once every 5 years.

Table 2-1
Summary of Current Dredging and Disposal Practices (USACE 2007)

Reaches	Channel Reaches	Shoaling Cubic Yards Per Year	Frequency of Dredging (years)	Disposal Location	Dredge Type	Sediment Type
Upper	Upstream Limits of Project to 750 ft above Chemserve	12,600	3	EI Cells 2/3	pipeline	silt
Upper	750 ft above Chemserve to NC 133 Bridge	70,600	3	EI Cells 2/3	pipeline	silt
Upper	NC 133 Bridge to Cape Fear Mem Bridge	14,100	3	EI Cells 2/3	pipeline	silt
Upper	Anchorage Basin	1,200,000	1	EI Cells 1/2/3	pipeline	silt
Upper	Between Channel	60,000	1	EI Cells 1/2/3	pipeline	silt
Upper	Fourth East Jetty	30,000	2	EI Cells 1/2/3	pipeline	silt
Upper	Upper Brunswick	67,000	2	EI Cells 1/2	pipeline	silt
Upper	Lower Brunswick	60,000	2	EI Cells 1/2	pipeline	silt
Mid River	Upper Big Island	22,500	2	ODMDS / DA-10	B&B or Hopper, Pipe	sandy silt
Mid River	Lower Big Island	35,900	2	ODMDS / DA-10	B&B or Hopper, Pipe	sandy silt
Mid River	Keg Island	34,100	2	ODMDS / DA-10	B&B or Hopper, Pipe	sandy silt
Mid River	Upper Lilliput	48,900	2	ODMDS / DA-10	B&B or Hopper, Pipe	sandy silt
Mid River	Lower Lilliput	43,000	2	ODMDS / DA-10	B&B or Hopper, Pipe	sandy silt
Mid River	Upper Midnight	107,000	2	ODMDS / DA-8	B&B or Hopper, Pipe	sandy silt
Mid River	Lower Midnight	25,500	2	ODMDS / DA-8	B&B or Hopper, Pipe	sandy silt
Mid River	Reaves Point	1,000	9	ODMDS / DA-8	B&B or Hopper, Pipe	Silty sand
Mid River	Horseshoe Shoal	40,000	3	Bird Island / DA-3/4	pipeline	sand
Mid River	Snows Marsh	15,000	3	Bird Island / DA-3/4	pipeline	sand
Mid River	Lower Swash	0	2	ODMDS/DA-3/4	B&B or Hopper, Pipe	sand
Inner OB	Battery Island	7,000	2	ODMDS/DA-3/4	B&B or Hopper, Pipe	sand
Inner OB	Southport	5,000	4	ODMDS/DA-3/4	B&B or Hopper, Pipe	sand
Inner OB	Baldhead-Caswell	11,000	4	ODMDS/DA-3/4	B&B or Hopper, Pipe	sand
Inner OB	Smith Island	257,800	2	BHI/CB/WOI beaches	pipeline	sand
Inner OB	Ocean Bar Entrance Channel	545,000	2	BHI/CB/WOI beaches	Pipeline	sand & silt
Outer OB	Ocean Bar Outer Channels	538,000	1	ODMDS	Hopper	silt
	TOTAL	**3,151,000**				

EI=Eagle Island, ODMDS=Ocean Dredged Material Disposal, BHI=Bald Head Island, CB=Caswell Beach, WOI=West Oak Island, B&B=Bucket and Barge

USACE (2014) also calculated the annual volume change rate in the existing Anchorage Basin based on the historic channel survey data taken by the USACE ranging from January 2008 to July 2012. The projected shoaling volume for the Anchorage Basin is approximately 1,251,804 cy/yr. The estimated annual shoaling rate was also calculated from the dredge records for 2004 through 2011. The total dredged volume from the Anchorage Basin between 2004 and 2011(8 events) was 9,253,556 cy which corresponds to an annual dredging volume of 1,156,694 cy/yr (USACE 2014).

2.1.3 Dredged Material Placement Areas

Dredged material from the Federal channel is typically placed either at:

- the New Wilmington Harbor ODMDS;
- the Eagle Island Confined Disposal Facility (CDF);
- Bald Head Island and Oak Island as beach replenishment; and
- South Pelican Island and Ferry Slip Island as bird nesting island restoration.

2.1.3.1 New Wilmington Harbor ODMDS

The Site Management and Monitoring Plan for the New Wilmington ODMDS was originally finalized in July 2002 and an SMMP update was approved in January 2013. The 2013 updated SMMP remains in effect. Dredged material from the ocean bar channel of the Wilmington Harbor Federal navigation project and from the access channel and berths at the Military Ocean terminal at Sunny Point (MOTSU) are placed at the New Wilmington ODMDS. The updated SMMP indicates that 2 to 3 million cubic yards of dredged material is anticipated to be placed at the ODMDS annually (USACE and EPA, 2013).

Material from Bald Head-Caswell Channel, Southport Channel and Battery Island Channel is dredged about once every four years by hopper dredge and deposited in the ODMDS. Material from Snows Marsh Channel to Lower Big Island Channel is dredged once every two years by bucket and barge or by hopper dredge and deposited in the ODMDS.

The New Wilmington ODMDS has an area of approximately 9.4 square nautical miles. Existing depths range from -35 feet MLLW to -52 ft Mean Low Low Water (MLLW). The disposal depth limitation is -30 feet MLLW (USACE and EPA, 2013). Based on bathymetry taken in 2017, the existing static dredged material disposal capacity at the New Wilmington ODMDS is 386 million cubic yards.

2.1.3.2 Eagle Island Confined Disposal Facility

The Eagle Island Confined Disposal Facility is situated on a 1,473-acre tract of land that forms a peninsula between the Cape Fear and Brunswick Rivers. Eagle Island CDF is operated in a three-cell configuration. Cell 1 consists of 230 acres, Cell 2 is approximately 260 acres, and Cell 3 is approximately 265 acres, for a total of 755 acres of diked uplands. Maximum dike height is currently 40 feet above mean sea level for Cell 1 and 42 feet for Cells 2 and 3 (USACE 2017).

Eagle Island CDF historically receives silty material from the upper reaches of the channel (from the Lower Brunswick channel reach to the upstream limits of the federal navigation project). Dredged material from the upper channel reaches is placed into the Eagle Island CDF with varying frequency (USACE 2007). Upstream of Lower Big Island Channel to the upstream limits of the project, dredging is performed by pipeline dredge and material is pumped to the Eagle Island Disposal Area. Maintenance dredging in Upper Big Island Channel upstream through Upper Brunswick Channel is performed every 2 years. Between Channel and the Anchorage Basin are dredged annually. The project area upstream of the Anchorage Basin to the upstream limits of the project is dredged about once every 5 years. The dikes for cell 2 are proposed to be raised to 50 feet above mean sea level (NAVD 88) and stability analyses are currently being performed for cells 1 and 3 to determine the appropriate improvement to dike height. The useful life of Eagle Island CDF was projected to be extended to 2032 (USACE 2017), however more recent analyses indicate that the footprint for cell 2 may be smaller than identified in the 2017 report and the results of the stability analyses may affect the useful life estimate.

2.1.3.3 Beach Placement at Bald Head Island and Oak Island

Bald Head Island and Oak Island form the mouth of the Cape Fear River on the east and west boundaries, respectively. Beach management at Bald Head Island and Oak Island has been an ongoing process. The Wilmington Harbor Sand Management Plan (USACE 2000) stipulated that these islands would share material from maintenance dredging on a regular basis for the purpose of shore protection. Based on the terms of that management plan, Bald Head Island receives material in years two and four; while Oak Island receives material in year-six of an overall six-year interval (USACE 2000). In 2013, the results of a comprehensive annual beach monitoring program of Bald Head Island, which started in 2000, came to the conclusion that beach placement alone could not successfully offset navigation channel impacts from erosion. Construction of a terminal groin was completed in 2015 to mitigate for these increased erosion rates and the results of recent surveys in 2017 and 2018 showed that the groin is performing as expected by reducing sediment losses and beach erosion. However, sand placement is still an essential factor to maintain the existing beaches given their proximity to the high energy environment of the Cape Fear River (Olsen Associates Inc. 2018).

2.1.3.4 South Pelican Island and Ferry Slip Island Restoration and Expansion

South Pelican Island and Ferry Slip Islands are artificial, dredged-sand islands located in the lower Cape Fear River south of Wilmington, which were created in the early 1970s (Personal communication, L. Addison, Audubon NC March 2019). The islands have been a haven for nesting pelicans, gulls, and terns for more than two decades. The two islands are the most important nesting areas for royal and sandwich terns and support the largest colony of brown pelicans in the southeast region of North Carolina (National Audubon Society 2010b and c).

Each island is permitted to a size of seven acres above mean high water (MHW). Both islands currently occupy less than five acres each above MHW. They are periodically nourished and need sand replenishment approximately every four to seven years in order to maintain avian habitats. Material from Snows Marsh Channel and Horseshoe Shoal Channel may be pumped to these islands by pipeline dredge. However, recent trends have resulted in the majority of clean, beach-quality sand being diverted to local beaches instead, so these islands have been receding due to lack of nourishment. This lack of available material poses a threat to the avian species that use these islands for nesting; as these islands have been subject to erosion, vegetative encroachment, and human disturbance.

2.2 Terminal Facilities

The Wilmington Harbor federal navigation channel provides deep draft access to MOTSU, liquid bulk, and dry bulk terminals and to the container terminal at the Port of Wilmington. The effects of channel constraints on containership traffic at the Port of Wilmington are the focus of this report. Other vessel traffic and terminals are presented for reference.

2.2.1 Container Terminal

The existing terminal at the Port of Wilmington consists of 284 acres along the Cape Fear River 26 miles from the Atlantic Ocean. In total, there are nine berths providing 6,740 ft of wharf frontage with on-dock rail. Depth at the Berths 1 and 2 is -38 ft MLLW and depth at Berths 3 – 9 is -42 ft MLLW. Maximum air draft along the approaching channel is restricted to 210 ft above Mean High High Water (MHHW) due to electric cable crossing.

There are three containership berths providing a total berth length of 2,650 feet:

- Berth 7 – 700 feet;
- Berth 8 – 1,050 feet; and
- Berth 9 – 900 feet.

Currently, containership berths are being rehabilitated to provide 2,650 feet of contiguous berth capable of simultaneously accommodating one 1,200-foot long vessel and one 965-foot long vessel. Current berth utilization is approximately 28%, which is below the 50% utilization rate threshold for berth-induced delays.

The three containership berths are currently serviced by two Panamax ship-to-shore cranes (13-box wide), four post-Panamax ship-to-shore cranes (18-box wide) and three super post-Panamax ship-to-shore cranes (22-box wide).

Current Twenty-Foot Equivalent Units (TEUs) throughput capacity is 600,000 TEUs. Existing berths and cranes are capable of an annual capacity of 1.4 million TEUs and do not constrain terminal throughput (NCSPA 2018). The NCSPA is currently implementing Master Plan recommendations valued at $240 million for yard, gate, and operations improvements to increase annual throughput capacity to one million TEUs per year (see Section 4.2 Without-Project Conditions, Wilmington Harbor Terminal Facilities).

These without-project condition terminal improvements enhance terminal operations and efficiency regardless of improvements to the federal channel. The NCSPA is currently realizing benefits of larger and faster cranes, improved mooring facilities, and yard configuration. Planned future improvements will further increase the efficiency of cargo flow at the terminal.

2.2.2 Bulk Terminals

A baseline understanding of the existing terminals along the Cape Fear River is provided here as a reference. Vessels calling at these terminals contribute to vessel traffic in the channel but are not constrained by existing channel dimensions. Terminals along the Cape Fear River (Figure 2-3) between the mouth of the river and the Anchorage at Wilmington include:

- **Archer Daniels Midland (ADM) Terminal**: The ADM terminal is located on the green side of the Snows Marsh range (Station 1180+00). This terminal receives tankers up to Panamax size.

- **Military Ocean Terminal Sunny Point (MOTSU)**: This terminal is located on a restricted side channel on the Reaves Point Range (Station 1370+00). This terminal is located sufficiently far from the channel that moored vessels are not of concern to the channel widening project.

- **National Gypsum Terminal**: The National Gypsum Terminal is located on the red side of the channel approximately 1 mile south of the Port of Wilmington Berth 9. This is the first of five private terminals encountered on the red side of the channel for inbound transit immediately south of the Port of Wilmington Berth 9. This terminal is not presently in use but can facilitate up to Panamax class vessels.

- **Kinder Morgan River Road Terminal**: This terminal is immediately north of the National Gypsum Terminal and receives Panamax tankers.

- **Chemserve / Blue Knight Energy**: This terminal is shared, with multiple users. Vessels calling at this terminal include Articulated Tug Barges (ATBs) and Panamax tankers.

- **Carolina Marine Terminal**: This is a bulk handling terminal, which takes vessels up to Panamax size.

- **Apex Oil Terminal**: The Apex terminal takes tankers up to Panamax size.

- **Port of Wilmington Facility**: The Port of Wilmington facility consists of nine berths. Berths 1 to 6 are used for a combination of general cargo, bulker, and tanker traffic. Berth 7 may be used for general cargo, bulker, and container vessels. Berths 8 and 9 are used for container vessels.

- **Kinder Morgan Terminal**: The Kinder Morgan Terminal is immediately north of the Port of Wilmington facility and was recently modified to make room for a larger turning basin. The vessels for this terminal now berth at Port of Wilmington Berth 1.

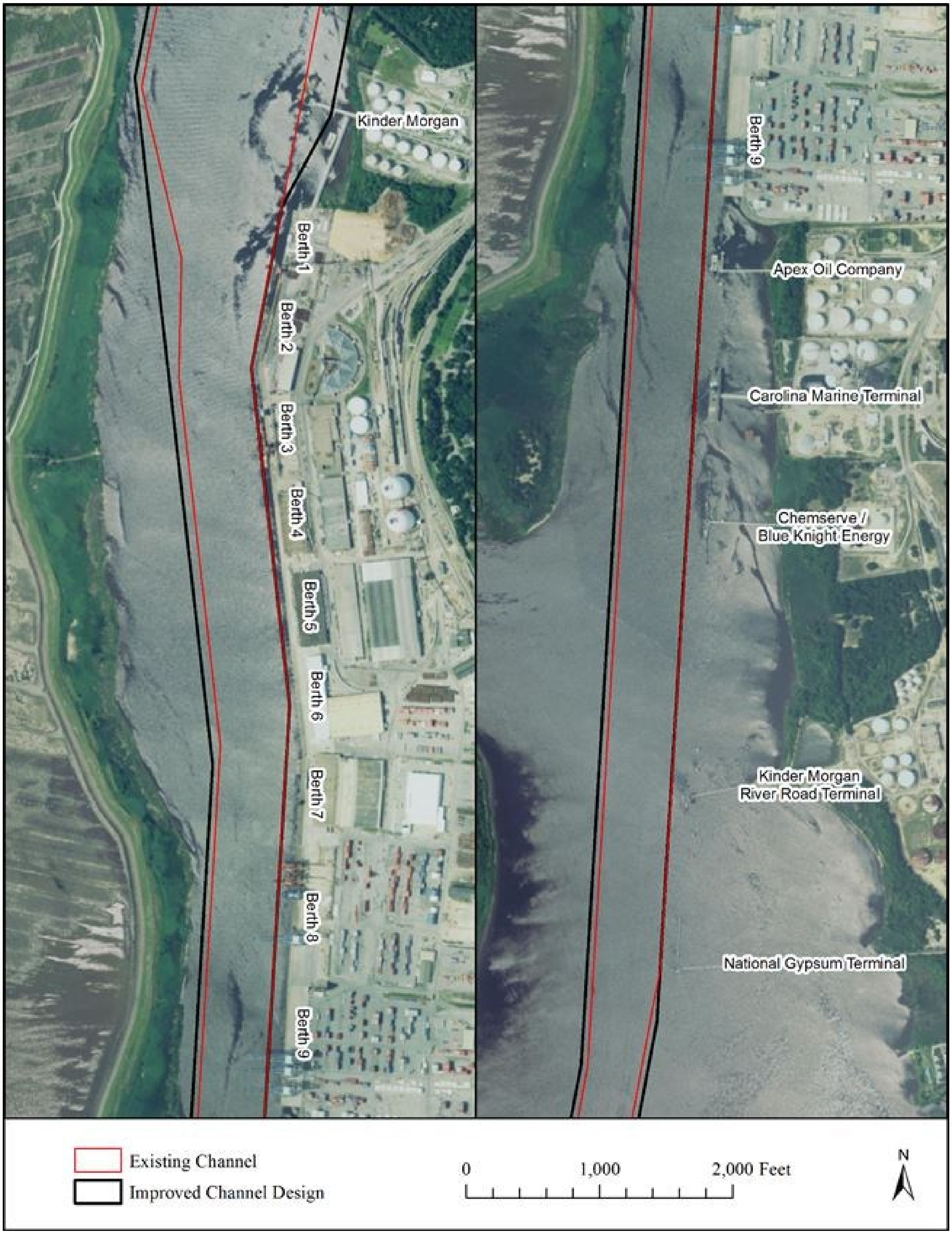

Figure 2-3
Identification of Terminals

2.3 Landside Access

The Port of Wilmington accesses the Interstate Highway System via state highways 17 and 74. Interstate Highway 40 provides direct access to Raleigh, the state capital and second largest city, which is approximately 125 miles from the Port. Interstate Highway 95, the major north/south corridor on the US east coast, can be accessed via Interstate Highway 40, or numerous state highways. Population centers along Interstate Highway 95 are Fayetteville and Rocky Mount. The state's largest city, Charlotte, is accessed from the Port via state and Interstate Highway 74. Charlotte is approximately 200 miles from the Port. Other population centers in the state include cities along the Interstate Highway 85 corridor such as Durham, Chapel Hill, Greensboro, and Winston-Salem, which are all accessible via a combination of state and interstate highways.

On-dock rail at the Port of Wilmington is provided by CSX via the Queen City Service, which provides the only daily service to the CSX intermodal facility Charlotte from an east coast port. The Queen City Service will also provide daily service to the CSX Carolina Connector intermodal facility, currently under construction in Rocky Mount, NC. The CSX Carolina Connector hub will connect the Port of Wilmington with the entire CSX network.

2.4 Port Hinterland

Vessel cargo data provided by PIERS for all vessels calling at the Port of Wilmington during 2017 and 2018 was analyzed to assess the TEUs transported, hinterland origin and/or destination of commodities, and characteristics of vessels used to transport goods. To locate the hinterland origin or destination of cargo transiting through the Port of Wilmington, the company name and location information provided were reviewed for all companies transporting a total of at least 10 TEUs of commodities during the two-year span.

Company locations in North Carolina, but not associated with a withheld company name nor associated with a 3PL company, were assumed to be accurate. This assumption was based on the geographic proximity of Wilmington to alternative ports in Norfolk, VA and Charleston, SC and relative efficiency of using the Port of Wilmington for the transport of goods to or from destinations in North Carolina. The city and state provided in the PIERS data for many shipments is a corporate headquarters rather than a manufacturing facility or distribution center and does not likely reflect the actual origin or destination of goods. For this reason, all companies with a location outside of North Carolina and transporting goods through the Port were evaluated for regional offices, production facilities, or distribution centers closer to the Port and assigned the more proximal location if found. If no alternative location could be found, the location provided in the PIERS database was used.

As shown in Table 2-2, the PIERS database contains 6,644 unique combinations of company name and location for cargo transiting through the Port of Wilmington in 2017 and 2018. Although 4,777 distinct company names were found in the data, many companies were associated with multiple locations, including some city or state identification of "XX" or no value provided. In addition, some company names were repeated using various spellings or abbreviations. Of the 4,777 unique companies, 591 were identified as withheld or 3PL and the associated 1,138 company locations were excluded from mapping. The PIERS data identified 2,001 companies with locations within North Carolina and 3,505 company locations outside of North Carolina.

Table 2-2
Company Locations in the PIERS Database

Designation	Company Locations
Third Party Logistics	1,138
North Carolina	2,001
Not within North Carolina and not 3PL	3,505
Total	6,644

Those company locations outside of North Carolina with more than 10 TEUs of cargo transiting the port in 2017 and 2018 were reviewed (see Table 2-3). Corrected locations within North Carolina were found for 1,460 company locations and 493 company locations were verified to be outside North Carolina, with a mean total TEUs for company locations of 33 and 25.8, respectively. The remaining 1,552 company locations (44% of the 3,505 locations outside North Carolina) could not be verified and the location provided in the PIERS database was used; however, the mean TEU total for these locations is 5.6 TEUs over two years.

Table 2-3
PIERS Database Company Locations Outside North Carolina

Designation	Company Locations	Percent	Mean TEUs at Locations
Location found within NC	1,460	42%	25.8
Verified not within NC	493	14%	33.0
Used PIERS location	1,552	44%	5.6
Total	3,505	100%	

The landside geographic distribution of cargoes transiting through the Port of Wilmington was assessed by distributing all TEUs associated with mapped company locations (Table 2-4). About two-thirds of all TEUs were mapped. For mapping purposes, North Carolina was divided into seven regions as groups of counties and TEU totals were summed for each region (Figure 2-4).

Table 2-4
Geographic Distribution of TEUs Transiting the Port of Wilmington

Hinterland	Import	Export	Total TEUs	Percent Total
Charlotte	19,077	11,193	30,270	11.9%
East	3,169	7,977	11,146	4.4%
Northeast	174	12,273	12,446	4.9%
Piedmont Triad	35,343	6,058	41,401	16.2%
Research Triangle	22,020	9,281	31,301	12.3%
Southeast	14,820	74,962	89,783	35.2%
West	4,371	799	5,171	2.0%
Not North Carolina	22,109	11,260	33,370	13.1%
Total Mapped TEUs	**121,084**	**133,804**	**254,887**	**100%**

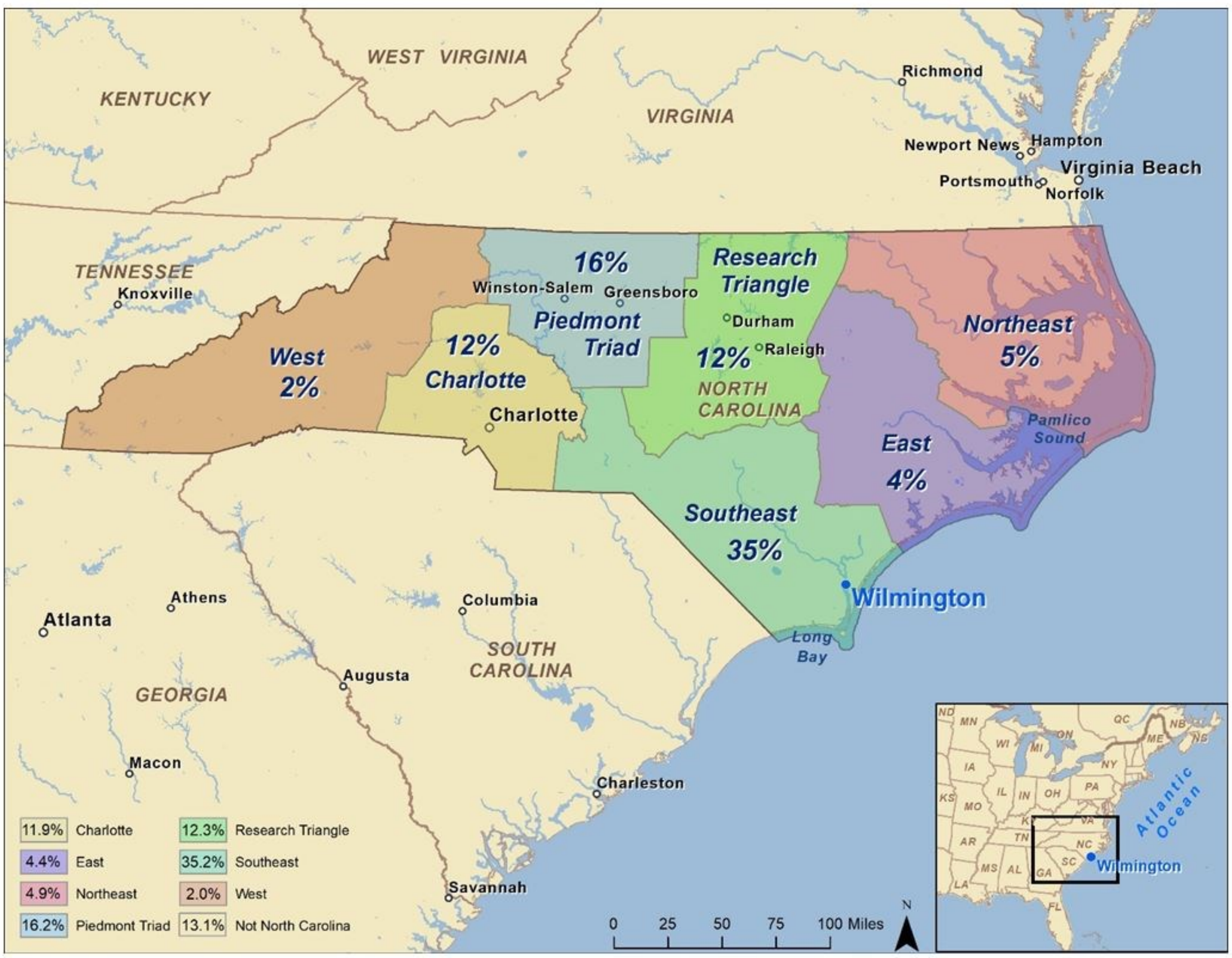

Figure 2-4
Geographic Distribution of TEUs Transiting the Port of Wilmington

It is important to note that 33,370 TEUs (13.1%) of the mapped TEUs are located outside North Carolina; however, this total includes those company locations that could not be identified as more proximal to the Port of Wilmington and is likely an overestimate. Some portion of these TEUs are likely imported to or exported from North Carolina.

2.5 Port of Wilmington Operations

The Port of Wilmington is the largest terminal complex at Wilmington Harbor. The Port handles break bulk and bulk commodities and is the only container terminal at Wilmington Harbor. The project depth at Wilmington Harbor is -42 feet MLLW. Historically, the maximum sailing draft is -41 feet, which is confirmed through pilot interviews and pilot log data. Vessels with drafts greater than 38 feet are required to transit using tidal advantage. Up to four feet of tidal advantage is available, but vessels very seldomly load to 42 feet[7] because of the infrequency of such a high tide.

The majority of the deepest draft vessels calling at Wilmington Harbor are containerships on U. S. East Coast to Asia (USEC-Asia) services (Table 2-5). All of the deeply loaded vessels included in Table 2-5 were engaged in international trade with the dry bulkers, general cargo, and wood chip vessels arriving light and departing loaded (exports). Liquid bulkers arrived loaded and departed light (imports). Seventy-seven percent of the deeply loaded containerships had drafts deeper on departure.

Table 2-5
Vessel Calls with Drafts Greater Than 37 feet (2018)

Vessel Draft (ft)	Containerships	Bulk
41	5	7
40	10	5
39	18	15
38	13	2
37	21	9
Total	67	38

The analysis of vessel operations focused on containerships on the USEC-Asia services operating at the Port of Wilmington. In 2018, 60% of all containerized cargo at the Port of Wilmington was on USEC-Asia services. The remaining containerized cargo was on services to Europe, the Mid-East, and Central and South America that are not constrained by existing channel dimensions. Bulk commodities and non-Asia containership services are identified briefly as background information. Bulk and non-Asia containership operations are not projected to change substantially under with-project alternatives. Although some dry bulk and liquid bulk vessels may load more deeply under with-project conditions, the small number of annual vessel calls that might take advantage of deeper depths would have only a marginal influence on

[7] In 2018, two containerships and one bulk vessel loaded to 41.66 feet.

economic justification and would not influence plan selection (see Section 5: Formulation and Preliminary Evaluation of Alternatives).

2.5.1 Existing Cargo Characterization

Commodity types moved through Wilmington Harbor (Tables 2-6 through 2-9) are categorized as breakbulk, bulk, and containerized cargo. Breakbulk cargo consists of cargo, which is handled as individual pieces, palletized cargo, bundled cargo or cargo that is packaged as individual units. Breakbulk cargo which regularly moves through Wilmington Harbor includes forest products, metal products, bagged fertilizers, bagged cement, logs and wood pulp.

Bulk cargo is typically handled through a conveyance system, which may include pipelines, conveyor belts, augers, and bucket systems. Bulk cargo handled at Wilmington Harbor includes ores, stone products, wood chips and pellets, feeds and agricultural products, and chemicals.

Containerized cargo includes a great variety of commodities, including raw materials, manufactured products, liquids, agricultural products, and refrigerated goods. The container terminal at the Port of Wilmington moves loaded and empty containers. Filling and emptying containers (stuffing and stripping) also occurs at the Port. The number of containers handled at the Port of Wilmington has increased recently (Table 2-9) due to the increased capacity of vessels calling at the port.

Table 2-6
Total Foreign Trade Tonnage Wilmington Harbor 2000-2016
Thousands of Short Tons

Year	Imports	Exports	Total
2000	1,852	1,098	2,950
2001	2,203	898	3,101
2002	1,914	877	2,791
2003	2,532	761	3,293
2004	3,181	859	4,040
2005	3,555	912	4,467
2006	3,957	979	4,936
2007	3,694	1,206	4,900
2008	3,500	1,005	4,505
2009	3,363	1,334	4,697
2010	3,596	1,230	4,826
2011	3,427	1,418	4,845
2012	4,252	1,304	5,556
2013	4,006	1,826	5,832
2014	3,510	1,872	5,382
2015	3,200	1,698	4,898
2016	3,138	1,699	4,837

Source: WCSC

Table 2-7
Wilmington Harbor Import Tonnage Major Commodities
Thousands of Short Tons

Import Commodity	2016	2015	2014	2013	2012
Other Chemicals and Related Products	581	692	847	901	924
All Manufactured Equipment, Machinery and Products	530	601	553	509	547
Fertilizers	530	700	618	510	653
Wheat	318	0	80	0	213
Sulphur (Dry), Clay & Salt	247	2	2	3	2
Primary Iron and Steel Products (Ingots,Bars,Rods,etc.)	186	78	77	72	196
Primary Non-Ferrous Metal Prods;Fabricated Metal Prods.	134	168	158	149	171
Corn	121	167	0	677	572
Other Agricultural Products; Food and Kindred Products	80	78	138	45	104
Forest Products, Lumber, Logs, Woodchips	70	70	34	60	84

Source: WCSC

Table 2-8
Wilmington Harbor Export Tonnage Major Commodities
Thousands of Short Tons

Export Commodity	2016	2015	2014	2013	2012
Forest Products, Lumber, Logs, Woodchips	510	519	501	499	333
Pulp and Waste Paper	415	334	392	462	356
All Manufactured Equipment, Machinery and Products	273	302	384	221	170
Other Agricultural Products; Food and Kindred Products	137	122	120	143	100
Other Chemicals and Related Products	98	127	137	150	124
Paper & Allied Products	88	96	92	104	58
Unknown or Not Elsewhere Classified	41	45	78	51	16
Primary Iron and Steel Products (Ingots,Bars,Rods,etc.)	31	21	20	44	16

Source: WCSC

Table 2-9
Port of Wilmington Annual TEUs

Year	TEUs	Year	TEUs
1990	92,720	2005	148,784
1991	83,651	2006	177,634
1992	106,786	2007	191,070
1993	110,425	2008	196,040
1994	98,667	2009	225,176
1995	104,038	2010	265,074
1996	103,579	2011	287,469
1997	105,786	2012	270,792
1998	112,940	2013	260,363
1999	133,926	2014	278,962
2000	105,110	2015	291,843
2001	107,374	2016	260,195
2002	100,170	2017	259,819
2003	96,453	2018	331,793
2004	104,122		

Source: AAPA and NCSPA

2.5.2 Existing Containership Fleet

For more than twenty years, there has been a continuous growth in the size of container ships, including length, beam, draft, deadweight tonnage, and TEU capacity. Details of this increase in vessel size is presented in the following sections for the world fleet, the fleet that services the USEC and Asia, and the fleet that services the Port of Wilmington and Asia. Some of the increase in vessel size can be attributed to the 2016 expansion of the locks at the Panama Canal, which increased maximum vessel size at the improved locks from approximately 965 feet length over all (LOA), 106 feet beam, and 40 feet draft to 1,200 feet LOA, 160 feet beam, and 50 feet draft[8].

The benchmark for container ship size used in this analysis is the vessel size classification system (Table 2-10) used by the DDNPCX in the Norfolk Harbor Channel Deepening Study (USACE 2018). The Panamax reference used in the DDNPCX classification is the maximum vessel size of vessels accommodated by the old locks at the Panama Canal. The Post-Panamax designation refers to all vessels larger than Panamax vessels. The Panama Canal size

[8] Panama Canal Authority Vessel Requirements, OP Notice to Shipping No. N-1-2018, 01 January 2018.

restrictions, old and new, are a major factor in containership design because passage through the Panama Canal is the shortest route for vessels traveling from Asian ports east of Vietnam to the USEC[9]. As presented in following sections, containership traffic through the Panama Canal gravitates towards the largest vessels that can fit through the canal because of the economic efficiencies of moving as much cargo as possible on a single vessel.

Table 2-10
Vessel Size Classification System

Name	Class	Min Beam (ft)	Max Beam (ft)	Max TEU
Sub-Panamax	SPX	76	98	2,824
Panamax	PX	99	106	5,089
Post-Panamax Generation 1	PPX1	107	132	6,732
Post-Panamax Generation 2	PPX2	133	142	8,648
Post-Panamax Generation 3	PPX3	143	158	10,100
Post-Panamax Generation 3 Max	PPX3Max	158	168	14,036
Post-Panamax Generation 4	PPX4	158	194	21,413

The DDNPCX classification system used in the Norfolk Harbor Channel Deepening Study includes SPX to PPX3Max vessels. The classification scheme used in this analysis is augmented by the addition of the PPX4, which includes all vessels larger than PPX3Max. Sub-Panamax vessels (SPX) are not included in the characterization of existing and future fleets because they do not participate in the major liner services, which are the focus of this analysis.

2.5.2.1 Existing Conditions: World Fleet

The characteristics of the world container ship fleet (Table 2-11) indicate that the larger vessels in the fleet are also the newest vessels. The progression of increase in vessel size since 1995 (Table 2-12) is exhibited by the average TEU capacity and vessel draft for vessels built from 1995 - 2018. The average TEU capacity of vessels built in 2018 is three times larger than the average TEU capacity of vessels built in 1995. Vessels currently identified in the "New Build" category include vessels on order, under design, or under construction. These vessels are predominantly PPX3Max and PPX4 vessels (Table 2-13). When these new build vessels are added to the world fleet (2 to 3 years), and assuming no scrapping of older vessels, the two largest vessel classes will account for 46% of the fleet's TEU capacity (Table 2-14). Currently, the average age of vessels in the PPX3Max and PPX4 classes are 6 year and 3 years, respectively.

[9] The distance from Saigon to the Port of Wilmington is 11,121 nautical miles via the Suez Canal and 11,470 nautical miles via the Panama Canal (source:www.sea-distances.org)

Table 2-11
Existing World Container Ship Fleet Characteristics

Class	Number of Vessels	Average Year Built	Average Draft	Average TEU Capacity
PX	549	2007	42	4,466
PPX1	399	2005	45	6,041
PPX2	325	2008	46	7,938
PPX3	282	2013	47	9,362
PPX3Max	275	2013	50	12,725
PPX4	163	2016	51	17,400

Source: www.Lloydslistintelligence.com accessed 01Jan2019

Table 2-12
Average Vessel Characteristics by Year Built

Year Built	Average TEU Capacity	Average Draft
1995	4,890	45
2000	5,581	45
2005	6,014	45
2010	7,608	45
2015	10,946	48
2018	14,913	49

Source: www.Lloydslistintelligence.com accessed 01Jan2019

Table 2-13
New Build Vessel Characteristics

Class	Number of Vessels	Average TEU Capacity
PX	40	3,733
PPX1	1	6,500
PPX2	0	0
PPX3	2	8,800
PPX3Max	59	12,014
PPX4	88	18,811

Source: www.Lloydslistintelligence.com accessed 01Jan2019

Table 2-14
Existing and New Build TEU Capacity Allocation

Class	Number of Vessels	Total TEU Capacity	% TEU Capacity
PX	589	2,601,039	14%
PPX1	400	2,416,810	13%
PPX2	325	2,579,798	14%
PPX3	284	2,657,682	14%
PPX3Max	334	4,208,297	22%
PPX4	251	4,491,627	24%

Source: www.Lloydslistintelligence.com accessed 01Jan2019

2.5.2.2 Existing Conditions: USEC to Asia Fleet

The shift to larger vessels experienced in the world fleet has also occurred in the fleet servicing the USEC and Asia (Tables 2-15 through 2-17). The three international ports shown in Tables 2-15 through 2-17 are all east of Viet Nam, therefore the shortest distance to east coast ports is through the Panama Canal. Nonetheless, carriers found it in their economic interest to use Post-Panamax vessels traveling to the USEC via the Suez Canal, as the data shows for 2013. The shift to larger vessels continued through 2018 with PPX3 and PPX3Max vessels typically able to use either the Panama Canal or the Suez Canal. Panamax vessels have all but disappeared from these routes due to the superior economic advantage of larger vessels.

Table 2-15
Vessel Class Distribution for Container Ships Transiting from Charleston to Hong Kong

Class	2009	2013	2018
SPX	4%	0%	0%
PX	91%	30%	2%
PPX1	5%	24%	11%
PPX2	0%	31%	15%
PPX3	0%	16%	38%
PPX3Max	0%	0%	34%

Source: www.lloydslistintelligence.con accessed 14Feb19

Table 2-16
Vessel Class Distribution for Container Ships Transiting from Savannah to Qingdao

Class	2009	2013	2018
SPX	1%	0%	0%
PX	99%	82%	7%
PPX1	0%	13%	3%
PPX2	0%	5%	27%
PPX3	0%	0%	31%
PPX3Max	0%	0%	32%

Source: www.lloydslistintelligence.con accessed 14Feb19

Table 2-17
Vessel Class Distribution for Container Ships Transiting from Busan to New York

Class	2009	2013	2018
SPX	0%	0%	0%
PX	96%	81%	3%
PPX1	4%	10%	12%
PPX2	0%	4%	28%
PPX3	0%	6%	24%
PPX3Max	0%	0%	34%

Source: www.lloydslistintelligence.con accessed 14Feb19

The economic advantage of larger vessels is the major factor in the increase in vessel size. Containerized shipping among the world's major ports is extremely competitive with each carrier offering very similar on-time weekly service. Each major port is served by multiple carriers providing a similar service, which makes containerized shipping very price competitive. Without the ability to increase prices higher than competitors, carriers have been reducing shipping costs through fleet modernization and substantial increases in vessel size. Based on 2017 USACE Vessel Operating Costs developed by the Institute for Water Resources, with vessels traveling at service speed and at 85% TEU capacity, the cost of moving a TEU on a 13,000 TEU vessel (PPX3) is 57% of the cost of moving that TEU a similar distance on a 4,800 TEU vessel (PX). This extraordinary cost difference explains the replacement of PX vessels with larger post-Panamax vessels on the major USEC to Asia services exhibited in Tables 2-15 through 2-17.

USEC ports are modernizing to better handle PPX3, PPX3Max, and PPX4 vessels though landside improvements such as larger cranes, longer and deeper berths, terminal automation and densification, and through navigation channel improvements. Current examples of landside improvements include the Port of Savannah's facility improvement plan enabling six 14,000

TEU vessels to be services simultaneously[10] and the Port of Jacksonville's planned improvements to service two post-Panamax vessels simultaneously[11]. The combination of ongoing terminal and navigation channel improvements described in the without project condition will ensure continuance of the trends exhibited in Tables 2-15 through 2-17.

2.5.2.3 Existing Conditions: Wilmington Fleet Servicing Asia

The shift to larger vessels on the USEC to Asia services has also occurred at the Port of Wilmington. Despite the bankruptcy of Hanjin[12] in August 2016, which was the dominant carrier at the Port of Wilmington, the carriers providing service from Wilmington to Asia have consistently increase vessel size to the extent that conditions at the Port of Wilmington allow (Table 2-18). However, these larger vessels cannot operate to their full efficiency at Wilmington, due to existing channel constraints.

Table 2-18
Vessel Class Distribution for Container Ships Asia Services Calling at the Port of Wilmington

Class	2009	2013	2018	2019	2020
SPX	1%	1%	0%	0%	0%
PX	99%	99%	33%	0%	0%
PPX1	0%	0%	5%	0%	0%
PPX2	0%	0%	41%	20%	0%
PPX3	0%	0%	21%	74%	78%
PPX3Max	0%	0%	0%	6%	22%

Sources: www.lloydslistintelligence.con accessed 14Feb19; NCSPA Data; https://www.zim.com/schedules/schedule-by-port accessed 23Feb19 and 30Jan20; and https://www.one-line.com/ accessed 23Feb19 and 30Jan20

The Port of Wilmington data for 2018 reflect the transitions in Asia services, which began that year. Two substantive changes occurred in 2018, which shifted the size of the fleet servicing Asia. The first change was the integration of the three major Japanese carriers (K-Line, MOL, and NYK) into the Ocean Network Express (ONE), which together with Yang Ming, Hyundai Merchant Marine, Hapag-Lloyd, and United Arab Shipping Corporation (UASC) comprise THE Alliance. The increased cooperation among carriers allows the deployment of large vessels with high utilization rates.

The second change that occurred in 2018 was the commencement of strategic operational cooperation in USEC-Asia trade by Zim and members of the 2M Alliance (Maersk, MSC, and Hamburg-Sud). This cooperation includes the carriers operating five USEC-Asia services together, with Zim operating one service and 2M operating the other four services. The Zim

[10] Port Technology International 06Feb19
[11] Port Technology International 05Mar19
[12] Note that at the time of Hanjin's bankruptcy it had approximately 60% of it's capacity in vessels sized PPX2 and smaller with no PPX3Max or PPX4 vessels, which made it difficult for Hanjin to compete on major services.

service calls at the Port of Wilmington. This change consolidated two services, one operated by Maersk and one operated by Zim, into one service with larger vessels.

The result of the changes that began in 2018 can be seen in the vessel size distribution for the Port of Wilmington in 2020. The 2020 data is based on vessel schedules published on the Zim and ONE websites for vessel calls from January 2020 through April 2020. The schedules include vessels from members of the two alliances (THE and 2M). Vessels in the current schedule for the EC2 service range in TEU capacity from 9,978 TEUs to 10,100 TEUs, with an average capacity of 10,070 TEUs. Vessels on the current schedule for the ZCP service range in TEU capacity from 9,178 TEUs to 11,010 TEUS, with an average capacity of 10,286 TEUs. On January 1, 2020 the THE Alliance announced that it will transitions the EC2 service into vessels with 13,100 TEU capacity starting in April 2020. The ports-of-call for the two USEC-Asia services calling at the Port of Wilmington are presented in Table 2-19.

Table 2-19
Existing Conditions: Ports-of-Call for Asia Services Calling at the Port of Wilmington

ZCP Service (Zim/2M)	EC2 Service (ONE)
Tianjing Xingang	Qingdao
Qingdao	Ningbo
Ningbo	Shanghai
Shanghai	Busan
Pusan	Panama Canal
Panama Canal	Manzanillo (PA)
Kingston	New York, NY
Savannah	Boston, MA
Charleston	**Wilmington, NC**
Wilmington, NC	Savannah, GA
Jacksonville	Charleston, SC
Kingston	Manzanillo (PA)
Panama Canal	Panama Canal
Slavyanka	Qingdao
Pusan	
Tianjing Xingang	

3 BASELINE CONDITIONS/AFFECTED ENVIRONMENT

The study area encompasses areas potentially affected by proposed harbor channel modifications and associated dredged material disposal activities; including the Cape Fear River estuary and surrounding areas, the barrier island beaches of Bald Head Island and Oak Island, and offshore areas encompassing the ocean entrance channel and Wilmington ODMDS (Figure 3-1).

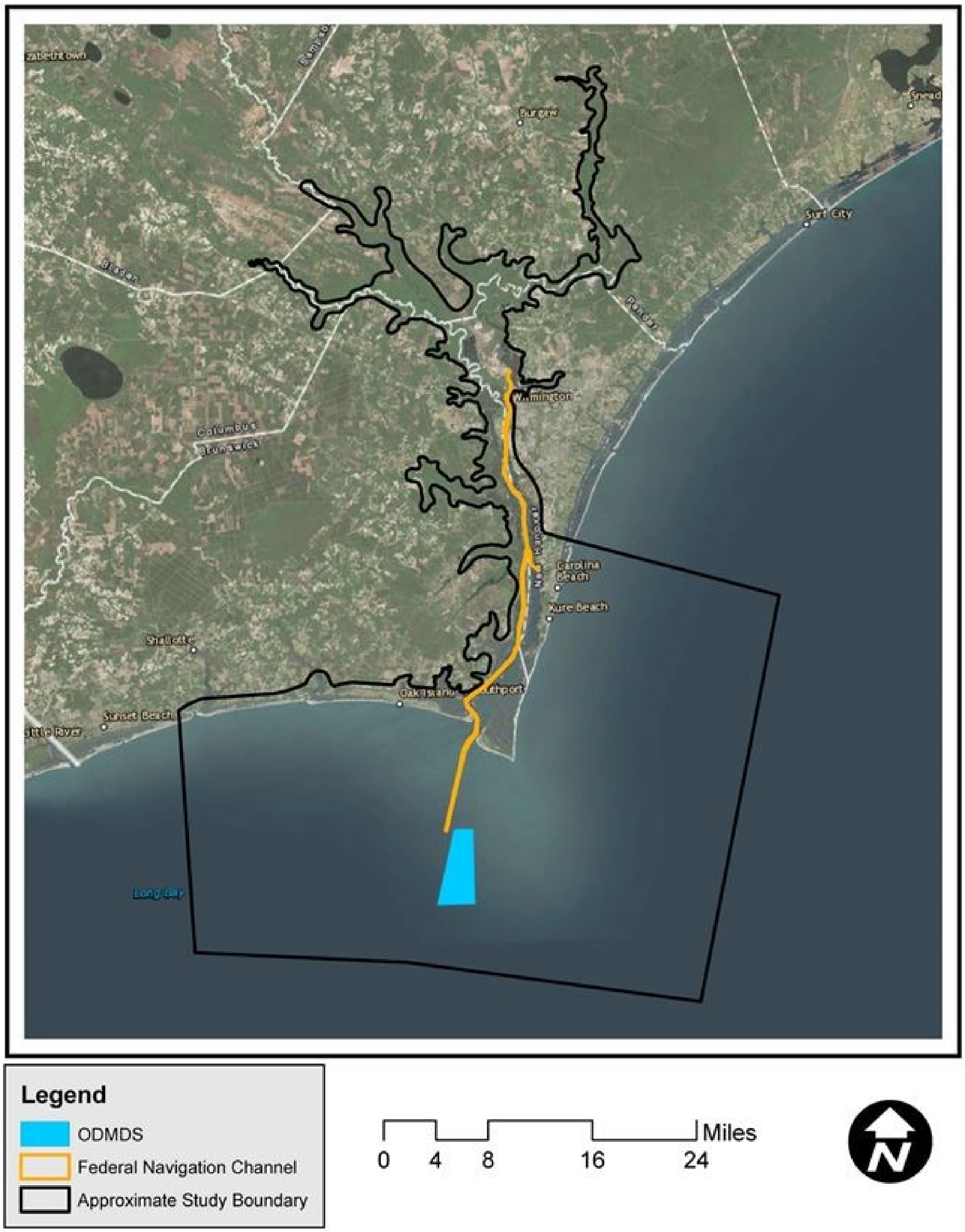

Figure 3-1
Study Area – Wilmington Harbor Navigation Improvement Project

As defined for purposes of this study, the Cape Fear River estuary encompasses the tidally affected river systems and wetlands of the lower Cape Fear River basin; including the mainstem Cape Fear River from the Atlantic Ocean up to Lock and Dam #1 at Kelly, NC [approximately (~) 60 river miles], the Northeast Cape Fear River from its confluence with the Cape Fear River up to NC HWY 53 (~48 river miles), and the Black River from its confluence with the Cape Fear River up to NC HWY 53 (~24 river miles).

3.1 Geology, Soils, and Sediments

The lower Cape Fear River valley between Fayetteville and Wilmington trends northeast to southwest across a crystalline basement ridge known as the Cape Fear arch. Overlying the Cape Fear arch are Upper Cretaceous sediments of the Cape Fear, Black Creek, and Peedee formations. The Cretaceous formations are overlain by Cenozoic marine sediments deposited during cycles of transgression and regression caused by episodic sea level fluctuations. Uplift of the Cape Fear arch since the late Pliocene has caused the river to migrate southwestward to its current position against the southwest wall of the river valley. As a result, the modern floodplain, river terraces, and most of the river's tributaries are located northeast of the present day mainstem Cape Fear River channel (Soller 1988). The lower Cape Fear River floodplain above the mouth of the Black River exhibits a complex depositional structure that is characteristic of large Piedmont-draining brownwater rivers, with areas directly bordering the river consisting of natural upland levees that isolate the floodplain from the river's tidal influence. The levees slope downward and away from the river to non-tidal wet sloughs and complex ridge and swale systems on the outer floodplain. Soils on the levees are mapped by the Natural Resources Conservation Service (NRCS) as Congaree silt loam, which is a well-drained to moderately well-drained soil formed in loamy fluvial sediment (USDA 1990). The Cape Fear River below the mouth of the Black River is characterized by a broad flat tidal floodplain that receives overbank tidal flow directly from the mainstem channel. Tidal floodplain soils of the upper estuary are mapped by the NRCS as Chowan silt loam and Dorovan muck, while tidal floodplain soils of the lower estuary below Eagle Island are predominantly mapped as Bohicket silty clay loam.

The Cape Fear River mainstem is a major Piedmont-draining brownwater river that carries a relatively large suspended sediment load consisting predominantly of Piedmont-derived silt and clay sized particles. The average suspended sediment load at Lock and Dam #1 is ~590 cubic yards (cy)/day or ~215,000 cy/yr, with silt and clay sized particles comprising more than 90 percent of the average load (Giese et al. 1985). In contrast, the Black River and Northeast Cape Fear River blackwater systems are characterized by relatively small suspended sediment loads consisting almost entirely of eroded marine terrace sands.

According to Benedetti et al. (2006), the combined annual suspended sediment yield of the Black River and Northeast Cape Fear River sub-basins probably does not exceed 22,500 cy. Although sands are a major component of sediment loads in the Piedmont tributaries of the upper Cape Fear River basin, the majority of the sand fraction is lost to floodplain storage and deposition behind dams during fluvial transport across the Coastal Plain. Depositional sand losses are attributable to low stream gradients and flow velocities across the Coastal Plain. As a result, sand comprises less than 20% of the suspended load in the Coastal Plain, even during storm events (Benedetti et al 2006). Analyses of floodplain sediments indicate that very little of the sand in the estuary below Lock and Dam #1 is derived from the Piedmont via the mainstem Cape

Fear River (Benedetti et al 2006). The mineralogy of sands in the estuary closely resembles that of marine sands; indicating that the material is derived from alternate sources such as the blackwater subbasins, local estuarine sources, and/or littoral transport from the ocean. Similarly, Giese et al. (1985) noted that the annual rate of sediment removal from the lower estuary via dredging (~2,238,000 cy/yr) greatly exceeds annual sediment input at Lock and Dam #1 (~215,000 cy/yr); indicating that large volumes of sediment in the estuary must be derived from local estuarine sources such as channel slumping or shoreline erosion and/or the ocean via littoral transport. Sediment delivery from the Cape Fear River estuary to the ocean is generally low (Benedetti et al. 2006). However, plumes of organic-rich mud are occasionally discharged from the Cape Fear River onto the inner continental shelf following storms (Bales et al. 2000).

The inner continental shelf of Long Bay is a sediment-starved environment with a geological framework dominated by Cretaceous and Tertiary rock units. Inputs of new sediment to the inner-shelf/barrier island system are minimal, resulting in characteristically thin subaerial barriers that are perched on top of older rock units that constitute the shoreface (Riggs et al. 1995). The older shoreface/inner-shelf geologic units have a thin covering of modern sediment that is derived primarily from the erosion and reworking of the underlying hard strata. The shoreface along the adjoining beaches of Bald Head Island and Oak Island is dominated by Cretaceous to Eocene Age sandstones and limestones that are covered by a thin and discontinuous veneer of modern sediment (Cleary 2008). The hard strata are frequently exposed on the shoreface forming extensive hardbottom areas (Marden and Cleary 1999). Vibracore data indicate that the shoreface sediments along Oak Island consist predominantly of gravelly muddy sands and muddy sandy gravels intercalated with muds and muddy sands (Cleary 1999; Cleary et al. 2001). The thickness of the modern sediment layer ranges from less than one inch in hardbottom areas to more than 11 ft in intervening areas.

Fugro (2017) characterized subsurface conditions in the various harbor channel reaches based on analyses of seismic survey data and existing geotechnical data (Table 3-1). Subsurface conditions are generally characterized by thin layers of recent alluvial material overlying older geologic formations of Cretaceous to Pleistocene age. The geologic formations are predominantly limestone units that are generally at or near the surface in the center of the channel. The Peedee and Castle Hayne formations alternately comprise the uppermost geologic unit underlying the ~31-mile inner harbor channel. The ~7-mile Bald Head Shoal ocean entrance channel is underlain by the Castle Hayne Formation (Reach 3) and a Turritelline-dominated limestone unit that was described by Harris and Laws (1994) and Harris (2000) as the Bald Head Shoals Formation (Reaches 1 and 2). The lithology of the underlying formations has been described by Harris (2000). The Peedee Formation in the vicinity of the Wilmington Harbor is composed of two stratigraphic units, the upper Rocky Point Member and the lower typical Peedee Formation. The Rocky Point Member in the Wilmington Harbor area consists of two principal lithologies, an upper sandy pelecypod-mold grainstone layer and a lower interbedded calcite cemented quartz sand and grainstone layer. Induration and hardness are more developed in the upper layer where well lithified sandy, pelecypod-mold grainstone is most common. The typical Peedee Formation consists primarily of unconsolidated dark gray to green very fine to fine muddy sand with minor thin consolidated layers of calcite cemented quartz sand. The lithology of the Castle Hayne Limestone varies from dense well lithified wackestone/packstone to soft friable cross-bedded grainstone. The Bald Head Shoals Formation is a moderately to well indurated, medium to dark gray sandy molluscan-mold mudstone, wackestone, to packstone; with packstone being the most common lithology.

Table 3-1
Geology and Sediment Characteristics of the Wilmington Harbor Navigation Channel

Channel Reach	Length (ft)	Uppermost Formation	Top of Rock (Ft MLLW)	Surficial Sediments
N. Project Limit - Hilton RR Brg	6,718	Peedee		Thin layer of loose sediment over silty/gravelly sand
Hilton RR Brg - Isabel Holmes Brg	2559	Peedee		Thin layer of loose sediment over silty/gravelly sand
Isabel Holmes Brg - Memorial Brg	9,573	Peedee		Thin layer of silty/gravelly sand
Anchorage Basin	11.651	Peedee	-41 to -52	Thin layer of silty/gravelly sand in channel center, thick clay/silt layer on channel flanks
Between	2,827	Peedee	-41 to -54	Thin layer of silt in channel center, thick clay/silt layer on channel flanks
Fourth East Jetty	8,852	Peedee	-47 to -54	Interbedded layers of fine material and sand on channel flanks
Upper Brunswick	4,079	Peedee	-47 to -57	Clay layer over sand on channel flanks
Lower Brunswick	8,161	Peedee	-47 to -55	Thin silt layer over sand on channel flanks
Upper Big Island	3,533	Castle Hayne	-45 to -50	Layer of fine material over sand on channel flanks
Lower Big Island	3,616	Castle Hayne	-47 to -52	Silty/gravelly sand on channel flanks
Keg Island	7,726	Peedee		Silty sand
Upper Lilliput	10,217	Peedee		Thin layer of fine material over silty sand
Lower Lilliput	10,825	Peedee		Thin layer of fine material over silty sand
Upper Midnight	13,736	Peedee		Layer of fine material over sand
Lower Midnight	8,241	Peedee		Layer of fine material over sand
Reaves Point	6,531	Peedee		Sand w/occasional interbedded fine-grained material
Horseshoe Shoal	6,102	Peedee		Sand
Snows Marsh	15,775	Peedee	-47 to -59	Thin layer of silty fine sand
Lower Swash	9,789	Castle Hayne		Sand w/occasional interbedded fine-grained material
Battery Island	2,589	Castle Hayne	-47 to -52	Sand to clayey sand on channel flanks
Southport	5,363			No data
Baldhead-Caswell	1,921			No data
Smith Island	5,100			No data
Baldhead Shoal Reach 1	4,500	Turritellid Limestone		Interbedded deposits of fine-grained material and sand
Baldhead Shoal Reach 2	4,342	Turritellid Limestone		No data
Baldhead Shoal Reach 3	26,658	Castle Hayne		No data
Total (Feet)	**200,984**			
Total (Miles)	**38.1**			

3.2 Shoreline Erosion

Long-term shoreline erosion trends along the western South Beach of Bald Head Island and the east end of Oak Island have been attributed to navigation dredging modifications and associated changes in the configuration of the Cape Fear River inlet ebb channel and ebb tidal delta (Thompson et al. 1999, Cleary 2008). As described by Cleary (2008), a natural ebb channel realignment event in the late 1880s and the subsequent initiation of major navigation dredging modifications divided the ebb tidal delta into distinct eastern (Bald Head Shoal) and western (Jay Bird Shoal) segments. The subsequent ebb tidal delta reconfiguration process initially caused some onshore migration of sediments, resulting in accretion of the western Bald Head Island shoreline adjacent to the inlet. However, channel deepening and stabilization disrupted eastward inlet sediment bypassing, resulting in deflation of the eastern Bald Head Shoal. Since the late 1800s, the Bald Head Shoal has lost an estimated 28.8 million cubic yards (mcy) of sediment. The South Beach shoreline of Bald Head Island entered an erosional phase in the early 1960s that has continued to date. Conversely, the western Jay Bird Shoal has gained significant sediment volume since the late 1880s, apparently at the expense of shoreline erosion along eastern Oak Island. Similarly, modeling by Thompson et al. (1999) showed a much larger eastern ebb shoal lobe along Bald Head Island and a smaller ebb shoal lobe along Oak Island under simulated historical (1872) bathymetric conditions. Furthermore, rates of eastward transport along the east end of Oak Island and westward transport along the west end of Bald Head were substantially lower, resulting in reduced transport into river mouth. Based on analyses of sediments and shoaling patterns in the navigation channels, the USACE has determined that sediments deposited in Reaches 1 and 2 of the Baldhead Shoal Channel are derived from Bald Head Island, while sediments deposited in the Smith Island Range are derived from Oak Island via Jay Bird Shoals (USACE 2018). The Wilmington Harbor Sand Management Plan provides for the placement of dredged beach quality sand on the beaches of Bald Head and Oak Island in proportion with volumetric losses from the two islands, as determined through a long-term shoreline monitoring program.

The seaward extent of significant fair-weather sediment mobilization (i.e., depth of closure) occurs at a depth of approximately 30 ft along the Brunswick County beaches (Cleary et al. 2001). Sediments mobilized on the shoreface by onshore waves are picked up by longshore currents and transported along the beach in a process known as longshore or littoral drift. Depending on incident wave conditions, longshore sediment transport along the Brunswick County beaches occurs in both westward and eastward directions. However, potential westward longshore transport rates generally exceed eastward transport rates, resulting in a regional longshore transport pattern that is predominantly westward (Thompson et al. 1999, OCTI 2008). Along the Oak Island beaches west of Cape Fear River inlet, westward transport rates predominantly range from ~250,000 to ~500,000 cy/yr, while eastward transport rates are ~100,000 cy/yr (Thompson et al. 1999). However, a reversal of the net westward transport pattern occurs along the easternmost ~9,000-linear-ft shoreline reach immediately adjacent to the inlet, where westward transport drops to near zero and eastward transport spikes to ~700,000 cy/yr. Thompson et al. (1999) attribute the spike in eastern transport to the presence of Jay Bird Shoals. Across the inlet along the westernmost South Beach shoreline of Bald Head Island, eastward transport drops to near zero and very gradually increases moving east along the South Beach shoreline towards Cape Fear. Conversely, westward transport rates along Bald Head Island are high at the river mouth and steadily decline along the shoreline leading east to Cape Fear, where the sheltering effect of the cape on the dominant eastward wave approach pattern is greatest. Seaward of the active shoreface (~30-ft contour), significant sediment mobilization on the inner shelf of Long Bay is strongly related to the passage of high-energy storms and associated increases in wave orbital velocities (Davis 2006). Although fine-grained [~0.125 millimeters (mm)] sediments are frequently suspended during the passage of routine cold/warm fronts and low pressure systems, full suspension conditions involving coarse sand particles are primarily associated with hurricanes and nor'easters (Warner et al. 2012, Davis 2006).

3.3 Hydrogeology

The major aquifers of the lower Cape Fear River basin from upper to lower include the surficial, Castle Hayne, Peedee, Black Creek, upper Cape Fear, and lower Cape Fear (Winner and Coble 1996; Lautier 1998). The upper half of the Peedee aquifer is the lowermost freshwater bearing zone, whereas the lower Peedee and underlying Black Creek and Cape Fear aquifers contain brackish water. Vertical groundwater flow is generally downward in the surficial, Castle Hayne, and Peedee aquifers; and upward in the Black Creek and Cape Fear aquifers. Recharge occurs predominantly through rainfall, which enters the surficial aquifer in interstream areas. On average, the lower Cape Fear River basin receives 50 inches of precipitation annually, of which approximately eight inches are lost to overland flow and ~32 inches are taken up by evapotranspiration. Of the remaining ten inches that enter the surficial aquifer as recharge, approximately nine inches are discharged laterally to rivers and streams, with just one inch or less entering the deeper confined aquifers as recharge. The seaward limit of freshwater varies for each aquifer according to hydraulic properties, recharge rates, hydraulic gradients, and the properties of the overlying confining units. The general pattern of freshwater flow is seaward from inland recharge areas to costal discharge areas; however, heavy pumping can cause the saltwater interface to move inland towards the pumping areas. Areas where the unconfined surficial aquifer contains saltwater include the barrier islands of New Hanover and Pender Counties, fringing coastline areas, and other areas where high tides cause natural salt water intrusion.

The surficial, Castle Hayne, and Peedee aquifers in Brunswick and New Hanover Counties exhibit a discharge relationship with the Cape Fear River, thus limiting the potential for salinity intrusion via lateral movements of saline river water [Lautier 1998, Groundwater Management Associates, Inc (GMA) 2018]. However, the upward vertical hydraulic gradient in the lower saline Black Creek and Cape Fear aquifers indicates the potential for upward migration of saline water under artesian pressure in the vicinity of pumping areas [United States Geological Survey (USGS)-Harden et al. 2003). An evaluation of Brunswick and New Hanover County well data conducted for the Wilmington Harbor 96 Act project showed two locations, Military Ocean Terminal at Sunny Point (MOTSU) and the NC State Aquarium, with chloride concentrations in excess of the 250 parts per million state drinking water threshold (Lautier 1998). High chloride concentrations at MOTSU were attributed to dredged material disposal lagoons, whereas high concentrations at the NC Aquarium were attributed to its proximity to the ocean. An additional well at Carolina Beach had an elevated sub-threshold chloride concentration of 210 parts per million. Otherwise, chloride concentrations were low throughout Brunswick and New Hanover Counties.

Baseline groundwater modeling for the currently proposed harbor project identified two areas near the Cape Fear River channel where pumping has lowered groundwater heads below sea level, indicating the potential for surface water to migrate downward into the groundwater system (GMA 2018). The identified areas include Southport, in the vicinity of the Capital Power Corporation withdrawal, and an area in the vicinity of the Carolina Beach/Kure Beach water-supply wells. A monitoring well along the Cape Fear River in Southport indicates that pumping from the Capital Power Corporation wellfield has lowered groundwater heads in the Upper Peedee Aquifer to approximately four feet below mean sea level (MSL). However, sampling has not detected any saline water, thus indicating that the Upper Peedee Aquifer is well-confined in the area. Furthermore, muted tidal fluctuations in the well indicate that the aquifer is not directly connected to tidal surface water in the Cape Fear River. The Carolina Beach/Kure Beach wellfield is located near a paleochannel where erosion has removed the confining layer and exposed the Castle Hayne Aquifer to enhanced local recharge from the surficial aquifer. The confining layer between the Castle Hayne and underlying Upper Peedee Aquifer is thinning and discontinuous in the area. Groundwater pumping has lowered the potentiometric surfaces of the aquifers below sea level, and the lack of confinement has allowed water from the surficial aquifer and adjacent water bodies (ocean and Cape Fear River) to move downward into the Castle Hayne and Peedee Aquifers. Localized saltwater intrusion at Carolina Beach appears to be unrelated to the Cape Fear River navigation channel, as the lowered surface below sea level does not extend beneath the current river to the navigation channel.

3.4 Surface Water Hydrology, Tides, and Currents

The Cape Fear River basin originates in the north-central Piedmont above Greensboro and extends ~300 miles southeastward to the Atlantic Ocean below Wilmington. The basin is the largest in NC, encompassing ~9,149 square miles and an estimated 6,300 miles of streams. Major tributary subbasins include the Haw and Deep River subbasins in the Piedmont and the Black River and Northeast Cape Fear River subbasins in the Coastal Plain. The Cape Fear River mainstem originates at the confluence of the Haw and Deep Rivers in Chatham County and flows ~200 miles southeastward to the ocean below Wilmington. Major hydrological modifications that affect flow in the lower Cape Fear River include the B. Everett Jordan Lake Dam located on the Haw River just above its confluence with the Deep River and three low-head navigation lock and dam structures on the Cape Fear River mainstem in Bladen County. Flow in the Cape Fear River has been regulated by operations at the Jordan Lake dam since 1982. Water storage in Jordan Lake is managed for water supply (Raleigh-Durham), flood control, and maintenance of downstream flow. Flow releases are typically adjusted within a range of 130-200 cf/s to maintain a minimum low flow discharge of 600 cubic feet per second (cfs) in the Cape Fear River mainstem at Lillington, NC.

The USACE operates three low-head navigation lock and dam structures on the mainstem Cape Fear River in Bladen County. The lowermost Lock and Dam #1 structure is located ~39 river miles above Wilmington and marks the upper limit of tidal influence in the mainstem Cape Fear River. The impounded mainstem reach above Lock and Dam #1 serves as the water supply for the Wilmington metropolitan area. Seasonal fluctuations in flow at Lock and Dam #1 are characterized by low flow conditions from mid-summer to mid-fall and high flow conditions during the winter and early spring. During low flow conditions, there is typically an 11-ft head difference between the above and below dam pools at Lock and Dam #1. The head difference decreases with increasing flow, and at flows >25,000 cfs is reduced to just two feet with ≥ 7 ft of water over the dam. The 2-ft head difference corresponds to a river surface water elevation of ~19.1 ft (NGVD 29). River waters reach flood stage at an elevation of ~21.1 ft (NGVD 29), which corresponds to a discharge of ~42,200 cfs. The long-term mean discharge at Lock and

Dam #1 under regulated flow conditions (1982-2016) is 5,065 cfs; with annual means ranging from 10,740 cfs (2003) to 1,833 cfs (2002) (Table 3-2). The Black River joins the Cape Fear River mainstem ~26 miles below Lock and Dam #1. The Black River drains a watershed of 1,574 square miles that is contained entirely within the Coastal Plain. Long-term (1982-2016) average discharge at the Black River USGS gage near Tomahawk is 765 cfs (Table 3-2). The Northeast Cape Fear River joins the Cape Fear River mainstem ~39 miles below Lock and Dam #1 at Wilmington. The Northeast Cape Fear River drains a watershed of 1,741 square miles that is also entirely within the Coastal Plain. Average discharge for the period of 1982-2016 at the Northeast Cape Fear River USGS gage near Burgaw was 687 cfs (Table 3-2 and Figure 3-2). The Cape Fear River mainstem, Black River, and Northeast Cape Fear River comprise the principal sources of freshwater inflow to the Cape Fear River estuary, contributing a combined long-term mean discharge of 6,517 cfs based on the USGS gage data described above. The estuary receives additional relatively minor freshwater inputs from numerous tidal creeks; notably Sturgeon Creek, Smith Creek, Barnards Creek, Town Creek, and Lilliput Creek.

The Cape Fear River estuary is strongly affected by lunar semidiurnal ocean tides that propagate ~60 miles up the Cape Fear River mainstem to Lock and Dam #1 near Kelly, ~25 miles up the Black River to the vicinity of the NC HWY 53 Bridge, and ~50 miles up the Northeast Cape Fear River to the vicinity of Holly Shelter Creek. Mean tidal range increases from 4.3 ft at the river mouth to 5.1 ft at Wilmington. Mean tidal range in the mainstem Cape Fear River steadily declines above Wilmington, reaching a low of approximately one foot at Lock and Dam #1. The diurnal tidal cycle drives regular reversals of flow in the river, except during periods of high freshwater discharge. Strong tidal currents can exceed three feet per second in the relatively narrow Cape Fear River channel above Wilmington. The Cape Fear River estuary may exhibit partial mixing under some flow conditions, but generally exhibits a well-defined salinity gradient with depth. Upstream density currents along the channel bottom have been observed in the lower estuary. Tide gauge records show a near doubling of the mean tidal range at Wilmington [river kilometer (rkm) 47] from 2.8 ft to 5.1 ft since the late 1800s, but only a slight increase of 0.2 ft near the ocean at Southport since the 1920s (Famikhalili and Talke 2016). Similarly, mean high water (MHW) at Wilmington has increased at a rate of 1.38 ft/century since the mid-1930s, more than double the rate of sea level rise at Wilmington (0.66 ft/century) during the same period (Flick et al. 2003). A recent modeling study indicates that the disproportionate increase in tidal range at Wilmington is predominantly attributable to the incremental deepening of the harbor channel since the late 1800s (Famikhalili and Talke 2016).

Table 3-2
1982-2016 Mean Annual Discharge at USGS Gage Stations[1] on the Cape Fear River at Lock and Dam 1, the Black River near Tomahawk, and the Northeast Cape Fear River near Burgaw

Water Year[2]	Mean Discharge (cfs)		
	Cape Fear River	Black	Northeast Cape Fear River
1982	5906	738	522
1983	6080	1070	1075
1984	8529	1093	817
1985	3557	526	398
1986	3110	327	338
1987	5258	870	793
1988	2865	465	349
1989	7019	802	554
1990	6415	687	650
1991	5430	814	711
1992	3552	657	558
1993	7003	1005	785
1994	4476	535	358
1995	5999	991	644
1996	7695	1083	940
1997	6238	898	803
1998	8428	1289	1234
1999	4207	973	1101
2000	5826	1175	1010
2001	3006	468	544
2002	1833	403	319
2003	10740	1265	1096
2004	4499	760	818
2005	4152	447	423
2006	3301	683	964
2007	5119	713	724
2008	3201	630	394
2009	3720	611	364
2010	5560	852	760
2011	2013	460	522
2012	2224	334	539
2013	4561	554	637
2014	4844	660	791
2015	3685	789	756
2016	7236	1161	757
Average Discharge 1982-2016	**5065**	**765**	**687**

[1]USGS Gage Stations 02105769 (Cape Fear River), 02106500 (Black River), and 02108566 (Northeast Cape Fear River)
[2]USGS water years run from 1 Oct - 30 Sept and are designated by the calendar year in which they end.

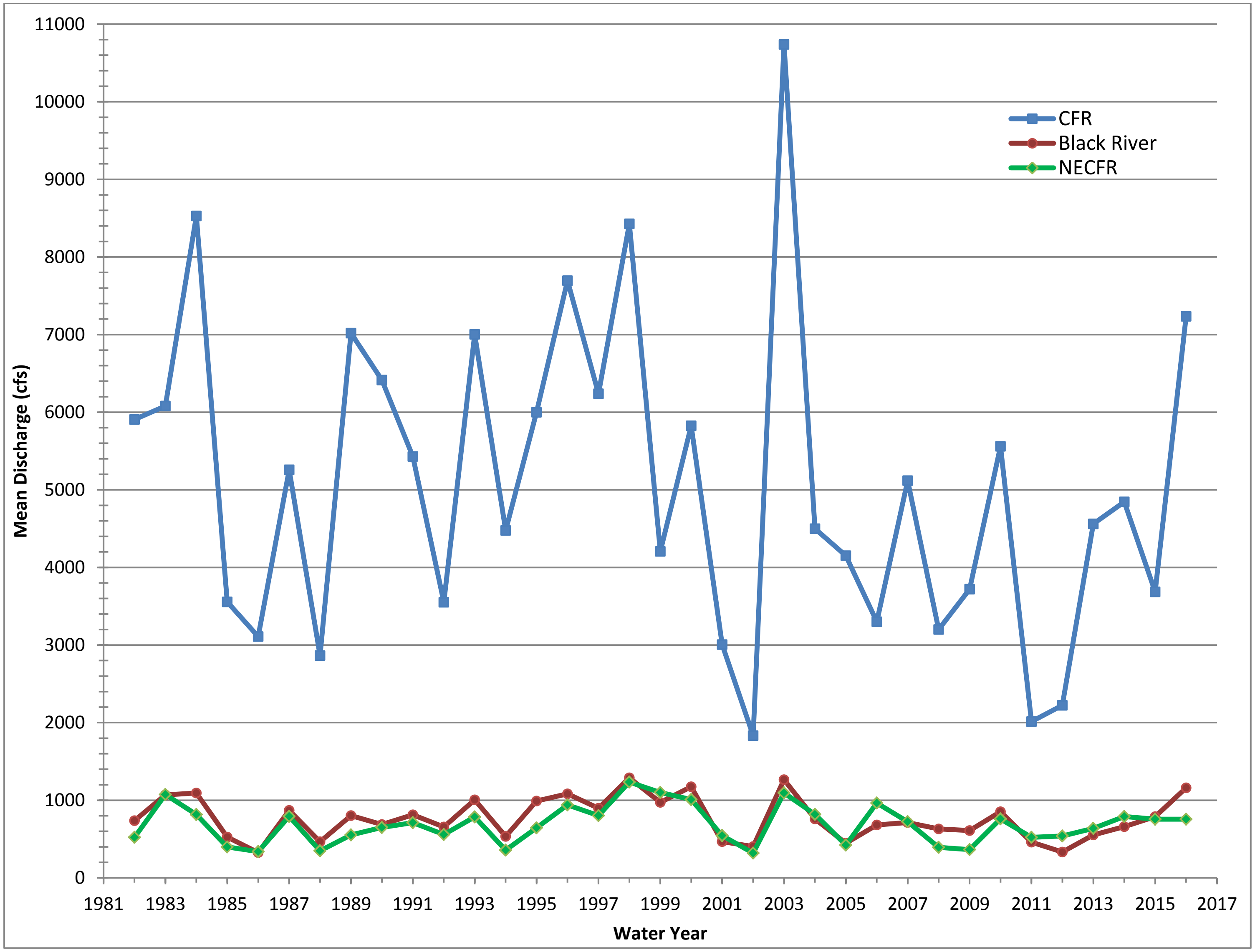

Figure 3-2 Mean Annual Discharge at USGS Gage Stations on the Cape Fear River, Northeast Cape Fear River, and Black River

3.5 Wind and Wave Climate

On the inner shelf [depths <20 meters (m)] of Long Bay, local wind stress is the principal driver of alongshore currents, while tides are responsible for much of the cross-shelf current (Pietrafesa et al. 1985a and 1985b). Wind-driven currents are strongly correlated with synoptic scale (2 to 14 days) wind events that are driven by low/high pressure systems and associated cold/warm fronts. Results from wave hindcast studies indicate that the ocean wave climate along the western flank of Cape Fear is dominated by small (mean = three feet), short period (mean = 5.2 seconds) wind waves out of the southeast sector (Jensen 2010). During the spring and summer, prevailing winds are out of the southwest, and the predominant direction of wave approach is from the south. As the prevailing winds shift to the northeast in the fall, the predominant direction of wave approach shifts to the southeast. During the winter, the prevailing winds are out of the north-northwest, and the predominant direction of wave approach is from the east. The wave climate is influenced by Cape Fear and its associated shoal complex (Frying Pan Shoals), which shelter the west-adjacent Brunswick County beaches from the high-energy northeast winds and waves that otherwise dominate the region. The sheltering effect results in a relatively low-energy nearshore wave regime dominated by small, short-period, southerly waves (Jensen 2010).

3.6 Sea Level Rise

Based on tide gauge sea level data from 1935-2017, the relative sea level trend at Wilmington is 2.3 mm/yr or 0.75 ft/century. The National Oceanic and Atmospheric Administration (NOAA) sea level rise trends are based on sea level changes relative to a local fixed reference point on land, and thus are referred to as relative sea level rise (RSLR). Per USACE guidance (ER 1100-2-8162), this study considers a range of potential future sea level rise scenarios (low, intermediate, and high). The "low" scenario represents future sea level rise at the measured historical rate. Per USACE guidance, sea level change rates for the "intermediate" and "high" scenarios were derived from the extrapolation of rate curves developed by the National Research Council (NRC) (1987). Projected future sea level changes through the end of the proposed project's design life (2077) range from 0.34 ft under the low scenario to 2.57 ft under the high scenario (Table 3-3).

Table 3-3
Relative Sea Level Change at Wilmington through 2077

Relative Sea Level Rise Scenario	Relative Sea Level Rise (ft)
Low	0.34
Intermediate	0.88
High	2.57

3.7 Salinity Levels

Salinity levels and the position of the upper mixing zone boundary in the Cape Fear River estuary are continually changing in response to variability in tidal conditions and freshwater inflow. During ten years (2000-2010) of salinity monitoring in the estuary for the Wilmington

Harbor 96 Act Project, periods of drought-induced low flow and extreme flooding significantly impacted water levels, tidal conditions, and salinities in the Cape Fear River and Northeast Cape Fear River; especially at the uppermost monitoring stations where substantial effects on water levels were observed (Leonard et al. 2011). During normal to high flow conditions, salinities in the mainstem Cape Fear River at stations above Eagle Island [Indian Creek (P7), Dollisons Landing (P8), Black River (P9)] were generally less than 0.3 parts per thousand (ppt). During a 12-month period (June 2004-May 2005), when discharge was comparable to the 30-yr average, salinities at the upper P8 and P9 stations did not exceed 0.2 ppt; while salinities at the lower P7 station exceeded 0.2 ppt only during the month of August (max=1.8 ppt). In contrast, during 2007-2008, a period of severe drought, flow releases from Jordan Lake were reduced and salinities as high as 9.8 and 10.5 ppt were measured at the P7 and P8 stations, respectively. Salinities at the uppermost Cape Fear River station (P9) near the mouth of the Black River did not exceed 0.2 ppt during 2007/2008.

Giese et al. (1985) estimated that salinity intrusion ≥0.2 ppt in the Cape Fear River as far upstream as the mouth of the Black River would require the simultaneous occurrence of an exceptionally high tide and an exceptionally low inflow rate. Under flow conditions representing the minimum Jordan Lake release rate and a 100-yr low flow rate between Lillington and the Cape Fear River mouth, the upper limit of the 0.2 ppt salt front in the Cape Fear River was estimated to occur approximately eight miles above Wilmington in the vicinity of Indian Creek. Although these estimates preceded the Wilmington Harbor 96 Act deepening project by 15 years, measured salinities at the upper P9 station on the Cape Fear River appear to be consistent with the assertion that regulated flow releases from Jordan Lake are likely to confine salinity intrusion to waters below the Black River. Conversely, measured salinity intrusion at the Indian Creek (P7) and Dollisons Landing (P8) stations during drought-induced low flow periods greatly exceeded the upper limit of the 0.2 ppt salt front predicted by Giese et al. under a minimum water release/100-yr low flow event scenario. The results of the ten-year salinity monitoring study suggest that the uppermost extent of salinity intrusion in the Cape Fear River during drought-induced low flow conditions is likely to fall somewhere between Dollisons Landing and the mouth of the Black River. The data also suggest that the uppermost extent of salinity intrusion during more typical flow conditions is likely to fall somewhere between Indian Creek and Dollisons Landing.

Upper monitoring stations in the Northeast Cape Fear River at Fishing Creek (P13) and Prince George Creek (P14) were more susceptible to salinity intrusion during the ten-year monitoring period (Leonard et al. 2011). During the more typical discharge period of June 2004-May 2005, salinities at the uppermost P14 station did not exceed 0.2 ppt; however, salinities as high as 8.6 ppt were measured at P13 during the fall. During the drought-induced low flow year of 2007-2008, salinities as high as 20.1 and 9.4 ppt were detected at stations P13 and P14, respectively.

3.8 Surface Water Quality

All water bodies in NC are assigned a surface water classification that defines the best uses to be protected (e.g., water supply, swimming, fishing). Each classification is subject to a specific set of water quality standards that are designed to protect the designated uses. The waters of the mainstem Cape Fear River immediately upstream and downstream of Lock and Dam #1 are classified as Water Supply IV (WS-IV). This WS-IV classification is assigned to waters that are used as a water source for drinking, culinary use, and/or for food processing where a more protective classification (WS-I, II, or III) is not feasible due to watershed development. The waters immediately above Lock and Dam #1 are also classified as a Critical Area (CA) because they are proximal to a water supply intake or reservoir where the risk of pollution has greater consequences. The impounded Cape Fear River reach above Lock and Dam #1 serves as the principal water supply for New Hanover, Brunswick, and Pender Counties. Both the CFPUA and the LCFWSA have water intakes above Lock and Dam #1. These entities service approximately 250,000 residents in southeastern NC and pull approximately 20 million gallons of raw, untreated water each day through 36 miles of raw water mains (CFPUA 2017).

The WS-IV waters below Lock and Dam #1 to the Federal Paperboard water supply intake at Riegelwood have been assigned a supplemental classification of Swamp Waters (Sw). This classification is associated with slow moving reaches that are flatter in topography than adjacent waters (NCDEQ 2018a). The Cape Fear River mainstem waters from Riegelwood to Navassa are Class C waters with a supplemental classification of Swamp Waters (Sw). Class C waters are protected for secondary recreation, fishing, wildlife, fish consumption, and aquatic life propagation and survival. The mainstem waters from Navassa to Federal Point are Class SC tidal saltwaters protected for secondary recreation, fish and non-commercial shellfish consumption, wildlife, and aquatic life propagation and survival. The remaining mainstem Cape Fear River waters below from Federal Point to the ocean are classified as SA waters. SA waters are protected for commercial shellfishing along with all designated SC uses. SA waters are assigned a supplemental classification of HQW (High Quality Waters) that is intended to protect waters that are rated excellent based on biological and physical/chemical characteristics.

The ~4-mile mainstem Cape Fear River reach below Riegelwood is designated as an impaired water body on the NC 2016 303d list based on exceedance of the benthos criteria (NCDEQ 2018b) (Table 3-4). The Cape Fear River from Navassa to Southport, along with the Brunswick River and the lower reach of the Northeast Cape Fear River, are designated as impaired waters based on various reach-specific exceedances of state standards. Generally, the standards for pH and DO are exceeded in the mainstem Cape Fear River reach between Navassa and Motts Creek, while the state standards for Copper, Nickel, and Arsenic are exceeded in the mainstem between Greenfield Creek and Southport. The DO standard is also exceeded in the Brunswick River, and the state standard for Copper is also exceeded in the lower Northeast Cape Fear River between Ness Creek and the Cape Fear River. Class SA commercial shellfishing waters in the Cape Fear River below Federal Point are assigned a Shellfish Growing Area Status of Approved, Conditional, or Prohibited based on North Carolina Division of Marine Fisheries (NCDMF) Shellfish Sanitation fecal coliform criteria. A total of 1,200 acres of SA waters in the lower estuary along with a number of additional areas in tidal creeks are designated as Prohibited on the NC 2016 303d list.

Table 3-4
Impaired Waters in the Cape Fear River Estuary - 2016 NC 303d List

Water Body	Impaired Reach	Surface Water Classification	Exceeded Criteria
Cape Fear River Subbasin			
Cape Fear River	Riegelwood to Bryant Mill Creek	C;Sw	Benthos
Cape Fear River	Toomers Creek to Navassa railroad bridge	SC	pH, DO
Cape Fear River	Navassa railroad bridge to Greenfield Creek	SC	pH, DO
Cape Fear River	Greenfield Creek to Barnards Creek	SC	Copper, pH, DO
Cape Fear River	Barnards Creek to 0.6 mile downstream	SC	pH, DO
Cape Fear River	0.6 mile downstream of Barnards Creek to 1.9 miles downstream of Motts Creek	SC	DO, Copper
Cape Fear River	1.9 miles downstream of Motts Creek to line between Snows Cut and Lilliput Creek	SC	Copper
Cape Fear River	Line between Snows Cut and Lilliput Creek to line between Walden Creek and Basin	SC	Copper Nickel Arsenic
Cape Fear River	Prohibited area north of Southport Restricted Area and west of ICWW	SA;HQW	Copper Nickel Arsenic Mercury
Cape Fear River	Southport Restricted Area	SC	Copper Nickel Arsenic
Northeast Cape Fear River Subbasin			
Northeast Cape Fear River	Ness Creek to Cape Fear River	SC;Sw	Copper
Burgaw Creek	Osgood Branch to Northeast Cape Fear River	C;Sw	Copper Benthos
Burnt Mill Creek	Source to Smith Creek	C;Sw	Benthos
Lillington Creek	Source to Northeast Cape Fear River	C;Sw	pH
Long Creek	Source to Cypress Creek	C;Sw	Benthos
Brunswick River	Source to Cape Fear River	SC	DO

Source: NCDEQ 2016

3.9 Tidal Wetlands

Human activities and sea level rise over the last two centuries have dramatically altered the composition and distribution of tidal wetland communities in the Cape Fear River estuary (Hackney and Yelverton 1990). The initial impact of European settlement, beginning in the late

1700s, was the conversion of essentially all tidal freshwater swamp forests in the lower to middle estuary to rice plantations. In the late 1800s, the USACE initiated major navigation dredging modifications of river channel for access to the Port of Wilmington. Incremental channel deepening and sea level rise since the late 1800s have increased the tidal range in Cape Fear River, resulting in salinity intrusion and the conversion of tidal freshwater swamp forests to brackish marsh along the middle to upper reaches of the estuary. Hackney and Yelverton (1990) suggest that the distribution of former rice fields is a reliable indicator of the pre-settlement extent of tidal freshwater wetlands along the river, as rice is incapable of growing in fields that are flooded by saline water >1 ppt. Based on this indicator, tidal freshwater wetlands would have been present at least as far downriver as Orton Plantation ~12 miles above the river mouth.

Baseline studies for the currently proposed project included the development of an updated baseline tidal wetland classification for the study area (Appendix F: Wetland Impact Assessment). ENVI image analysis software and field surveys were employed in a Geographic Information System (GIS)-based supervised classification of the entire tidally affected estuarine/freshwater river-floodplain system. The final classification identified 66,671 acres of tidal wetlands distributed among six wetland classes (Table 3-5).

Table 3-5
Study Area Tidal Wetland Classification

Tidal Wetland Class	Area (acres)	Percent
Smooth Cordgrass Dominant	12,733	19.1
Brackish Mix	696	1.0
Cattail Dominant	6,066	9.1
Common Reed	2,403	3.6
Freshwater Marsh	1,379	2.1
Swamp Forest	43,394	65.1
Total	**66,671**	**100**

Figure 3-3 depicts an overview of the classification results for the entire assessment area. An indexed map series along with a full description of the methods employed can be found in Appendix F: Wetland Impact Assessment. The remainder of this section describes the composition of the tidal wetland classes and the general sequence of salinity driven community-level changes within the estuary.

The composition of tidal wetland communities in the Cape Fear River estuary is largely determined by their position along salinity gradients. Salt marshes consisting of nearly monospecific stands of smooth cordgrass (*Spartina alterniflora*) strongly dominate the contiguous tidal floodplains along the polyhaline and lower mesohaline reaches of the Cape Fear River mainstem from the river mouth up to Barnards Creek (~21 river miles). Well-defined high marsh zones are generally absent along the lower mainstem, with typical high marsh species such as black needlerush (*Juncus roemerianus*) and saltmeadow cordgrass (*S. patens*) generally comprising only a narrow and discontinuous fringe along the outer margins of the tidal floodplain. Along the upper portion of the mesohaline salt marsh reach, small patches of black

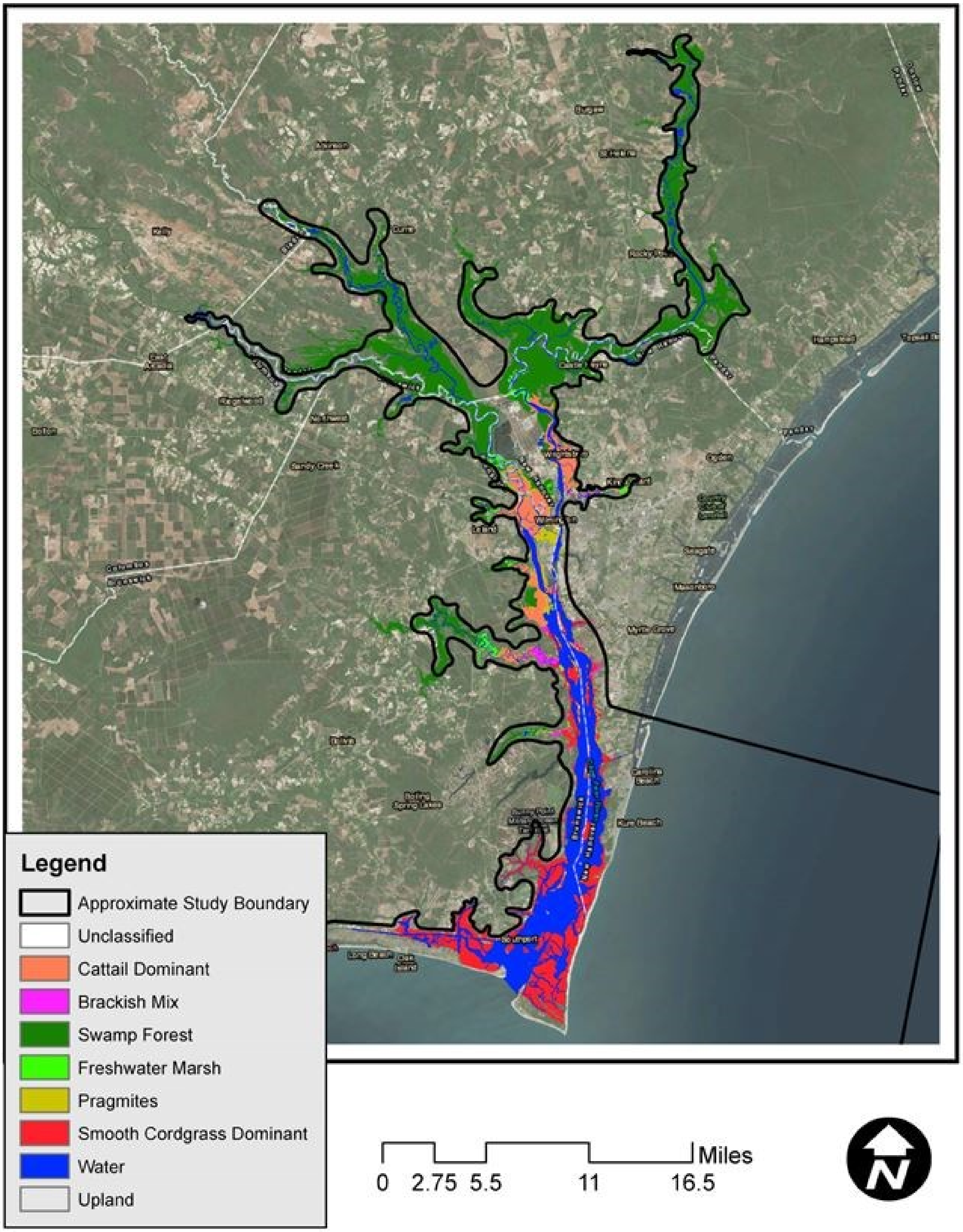

Figure 3-3
Tidal Wetland Classification

needlerush are interspersed among the smooth cordgrass marshes, and big cordgrass (*S. cynosuroides*) and saltmarsh bulrush (*Bolboschoenus robustus*) occur intermittently on the slightly elevated river banks immediately adjacent to the channel. Dense patches of non-native common reed (*Phragmites australis australis*) are interspersed throughout the salt marshes of the lower reach. Common reed is restricted to deposits of dredged material and other fill that are slightly higher than the natural tidal floodplain and somewhat protected from exposure to high salinity waters.

The reach above Barnards Creek is characterized by the decline of smooth cordgrass and the rapid establishment of narrow-leaved cattail (*Typha angustifolia*) as the primary dominant species. The marshes above Barnards Creek exhibit distinct vegetation zones; including a narrow fringing smooth cordgrass zone along the edge of the river channel; a narrow top-of-bank zone dominated by big cordgrass and salt-marsh bulrush; and a broad outer marsh zone dominated by narrow-leaved cattail. Cattail is a strong dominant of the oligohaline brackish marshes along the ~10-mile mainstem reach above Barnards Creek, forming vast monospecific stands across large sections of the tidal floodplain. The cattail-dominated marshes are interspersed with dense patches of common reed and areas of mixed brackish marsh that are dominated by variable combinations of cattail, common reed, black needlerush, big cordgrass, and salt-marsh bulrush. Along the upper portion of the mainstem Cape Fear River oligohaline reach (above the mouth of the Northeast Cape Fear River), species that are characteristic of more diverse freshwater marsh communities begin to occur sporadically along the margins of the channel; including wild rice (*Zizania aquatica*), bull-tongue arrowhead (*Sagittaria lancifolia*), pickerelweed (*Pontederia cordata*), and arrow-arum (*Peltandra virginica*). Freshwater species occur with increasing regularity toward the upper end of the brackish reach, eventually becoming a consistent component of the marsh fringe and gradually moving landward into the main body of the marsh.

The I-140 Bridge marks the approximate transition from cattail-dominated brackish marshes to tidal freshwater marsh and swamp forest communities along the Cape Fear River mainstem. Freshwater marshes are primarily confined to a narrow (~100-ft-wide) zone along the edge of the channel, with freshwater swamp forests occupying the vast majority of tidal floodplain. Fringing tidal freshwater marshes occur intermittently along the ~4-mile river reach above the I-140 Bridge before being displaced entirely by tidal swamp forests. The tidal freshwater marshes are characterized by a diverse assemblage of species; including wild rice, bull-tongue arrowhead, arrow-arum, pickerelweed, sawgrass (*Cladium jamaicense*), Olney's three-square (*Schoenoplectus americanus*), dotted smartweed (*Persicaria punctatum*), tussock sedge (*Carex stricta*), water parsnip (*Sium suave*), marsh mallow (*Kosteletzkya pentacarpos*), salt-marsh fleabane (*Pluchea odorata*), salt-marsh aster (*Symphyotrichum tenuifolium*), water primrose (*Ludwigia bonariensis*), and salt-marsh water-hemp (*Amaranthus cannabinus*). The tidal swamp forest communities are strongly dominated by bald cypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), and swamp tupelo (*N. biflora*).

Tidal wetlands along the Northeast Cape Fear River are characterized by a brackish marsh to freshwater marsh/swamp forest gradient similar to that of the Cape Fear River mainstem. Cattail marshes dominate the tidal floodplain along the lower ~8-mile oligohaline reach of the Northeast Cape Fear River. As in the case of the Cape Fear River, the transition to freshwater marsh occurs concurrently with the establishment of expansive tidal freshwater swamp forests along the Northeast Cape Fear River. The freshwater marshes are generally confined to a narrow zone along the edge of the channel, with freshwater swamp forests occupying the broad landward portion of the tidal floodplain. Fringing tidal freshwater marshes occur intermittently along the ~4-mile river reach above the brackish reach before being displaced entirely by tidal swamp forests. As described in Appendix F: Wetland Impact Assessment, similar tidal wetland communities and patterns of vegetation change occur along the tidal creeks that join the mesohaline to oligohaline reaches of Cape Fear River and Northeast Cape Fear River.

3.10 Benthic Communities

3.10.1 Soft Bottom

Estuarine soft bottom consisting of unvegetated, unconsolidated sediments comprises all of the subtidal benthic habitat in the existing inner harbor channel reaches and proposed channel expansion areas, as well as the vast majority of the subtidal benthic habitat in the overall Cape Fear River estuary. The Cape Fear coastal region is estimated to contain ~37,800 acres of estuarine softbottom habitat in waters less than six feet deep and ~188,549 acres in waters greater than six feet (NCDEQ 2016). Estuarine intertidal flats and shallow subtidal soft bottom habitats support a highly productive benthic microalgal community. Benthic microalgae, along with imported primary production in the form of phytoplankton and detritus, support a diverse community of benthic infaunal and epifaunal invertebrates; including nematodes, copepods, polychaetes, amphipods, decapods, bivalves, gastropods, and echinoderms [South Atlantic Fishery Management Council (SAFMC) 1998, Peterson and Peterson 1979]. Large mobile invertebrates such as blue crabs and penaeid shrimp move between intertidal and subtidal habitats with the changing tides. Mobile predatory gastropods (e.g., whelks and moon snails) occur along the lower margins of submerged tidal flats, and fiddler crabs (*Uca* spp.) are common on exposed flats during low tide (Peterson and Peterson 1979). Benthic invertebrates are an important food source for numerous predatory fishes that move between intertidal and subtidal habitats; including spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), flounders (*Paralichthys albigutta, P. dentatus, and P. lethostigma*), inshore lizardfish (*Synodus foetens*), pinfish (*Lagodon rhomboides*), red drum (*Sciaenops ocellatus*), and southern kingfish (*Menticirrhus americanus*). Shallow unvegetated flats provide an abundant food source and are relatively inaccessible to large predators (SAFMC 1998). Intertidal and subtidal flats function as an important nursery area for numerous benthic oriented estuarine-dependent species, especially Atlantic croaker, flounder, spot, and penaeid shrimp.

Marine unconsolidated soft bottom comprises essentially all of the subtidal benthic habitat in the existing ocean entrance channel and proposed offshore extension reach, as well as the vast majority of the ocean subtidal benthic habitat within the overall study area. Marine soft bottom habitats support a diverse community of benthic invertebrate infauna (burrowing organisms that live within the sediment) and epifauna (organisms that live on the surface of the sediment). Nearshore soft bottom communities along the southeastern NC coast are dominated by deposit- and filter-feeding invertebrates, including polychaetes, bivalve mollusks, nematodes, amphipod crustaceans, echinoderms (sand dollars), and gastropods (snails) (Hague and Massa 2010, Posey and Alphin 2002, Peterson and Wells 2000, and Peterson et al. 1999). Soft bottom sites also provide important habitat for large, mobile decapod crustaceans (e.g., crabs and shrimp). Based on annual trawl surveys conducted by Posey and Alphin (2002), the large decapod assemblage in nearshore Long Bay is dominated by white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), and the iridescent swimming crab (*Portunus gibbesii*). Offshore benthic sampling conducted by the USACE as part of the new Wilmington ODMDS site selection process identified 311 taxa within a 28-nm^2 area (Rickman 2000). Polychaetes accounted for 39.7% of the total taxa richness, followed by arthropod malacostracans (23.7%), gastropods (14.1%), and bivalves (1.9%). Total abundance was dominated by gastropods (34.3%), polychaetes (30.7%), and bivalves (18.4%). Dominant species included the gastropod *Caecum pulchellum*, the bivalve *Lucina radians*, and the polychaete *Apoprionospio pygmaea*. Mean densities ranged from 538 to 6,019 organisms per square meter and generally increased with distance from shore. Statistical analysis showed a significant inverse relationship between total density and sediment grain size (i.e., higher densities were associated with fine sediments). Marine soft bottom habitats and their associated benthic invertebrate communities provide important habitat and food resources for many species of demersal (bottom-dwelling) fishes.

3.10.2 Hardbottom

Hardbottom habitats exhibit varying degrees of colonization by marine algae and sessile invertebrates (e.g., sponges, soft corals, and hard corals). Marine macroalgae are the dominant colonizing organisms on NC hardbottoms with attached, sessile invertebrates typically accounting for ten percent or less of the total coverage (Peckol and Searles 1984). Dominant large, attached invertebrates include the soft corals *Titandeum frauenfeldii* and *Telesto fructiculosa* and the hard coral *Oculina arbuscula*. The small macroinvertebrate community is dominated by mollusks, polychaetes, and amphipods (Kirby-Smith 1989), and the most common large mobile invertebrates are the purple-spined sea urchin (*Arbacia punctulata*) and the green sea urchin (*Lytechinus variegatus*). Hard and soft corals are less prevalent on nearshore hardbottoms in NC compared to offshore and more southerly hardbottoms. In the nearshore environment, cooler water temperatures limit the growth of tropical corals (Kirby-Smith 1989, Fraser and Sedberry 2008), and macroalgae outcompete the dominant hard coral (Miller and Hay 1996). Along the NC coast, tropical reef-building corals are restricted to deep offshore waters (>20 miles from shore) (MacIntyre and Pilkey 1969, MacIntyre 2003).

Hardbottoms along the NC coast provide important foraging habitat and protective cover for tropical, subtropical, and warm-temperate reef fishes. Inner-shelf hardbottoms support a higher proportion of temperate species such as black sea bass, spottail pinfish (*Diplodus holbrookii*), and estuarine-dependent migratory species (Huntsman and Manooch 1978, Grimes et al. 1982). Lindquist et al. (1989) reported 30 species representing 14 families at a nearshore hardbottom site in Onslow Bay. Common species included juvenile grunts (*Haemulidae* spp.), round scad (*Decapterus punctatus*), tomtate (*Haemulon aurolineatum*), spottail pinfish, black sea bass, scup (*Stenotomus* spp.), pigfish, cubbyu (*Equetus umbrosus*), belted sandfish (*Serranus subligarius*), and sand perch (*Diplectrum formosum*). Nearshore hardbottom sites support spawning of smaller and more temperate reef species such as black sea bass and sand perch, and also provide larval settlement sites and juvenile nursery habitats for reef-associated fishes, including taxa that are thought to spawn in deeper offshore waters (Powell and Robins 1998).

The northern section of Long Bay between Cape Fear and Shallotte Inlet contains one of the highest concentrations of known hardbottom sites along the NC coast (NCDEQ 2016). Hardbottoms consisting of Cretaceous and Paleocene Age limestones and sandstones are frequently exposed on the Oak Island shoreface and adjoining inner shelf (Marden and Cleary 1999). Comprehensive remote sensing hardbottom surveys of the existing navigation channel and proposed channel expansion areas were conducted in 2017 and 2018 (Appendix H:

Hardbottom Resources). Analysis of the survey data did not identify any natural hardbottom habitats within the existing or proposed channel areas; however, several identified deposits of dredged rubble material along the west side of the existing channel in the old ODMDS (Figure 3-4) have relief up to 1.5 meters and support typical hardbottom benthic assemblages (Appendix H: Hardbottom Resources). Additional loosely scattered rocks along the margins of the old ODMDS channel reach have varying degrees of sessile invertebrate coverage. Based on towed video surveys, these naturalized hardbottom features have been colonized by marine algae, tunicates (*Urochordata* spp.), echinoderms (*Arbacia punctulata*, *Luidia clathrate*) octocorals (*Leptogorgia vergulata*, *L. hebes*, *Phyllangia americana*, *Astrangia* sp.) and other sessile and motile invertebrates that are common to natural nearshore hardbottom habitats. Several fish species that are typical of nearshore hardbottoms were also observed; including black sea bass (*Centropristis striata*), sheepshead (*Archosargus probatocephalus)*, belted sand fish (*Serranus subligarius*), and pinfish (*Lagodon rhomboides*). These naturalized hardbottom habitats in the old ODMDS were the only hardbottom features identified within the existing and proposed channel areas. Prior remote sensing surveys conducted by the USACE did not identify any hardbottom habitats within the new ODMDS or a 500-meter surrounding buffer zone (USACE TBD). Figure 3-5 depicts additional study area hardbottom survey data that were compiled by the USACE during the new ODMDS site selection process. Although study area survey coverage is not comprehensive, the distribution of identified hardbottoms is restricted to areas approximately two to three miles west of the existing ocean entrance channel and proposed offshore extension reach.

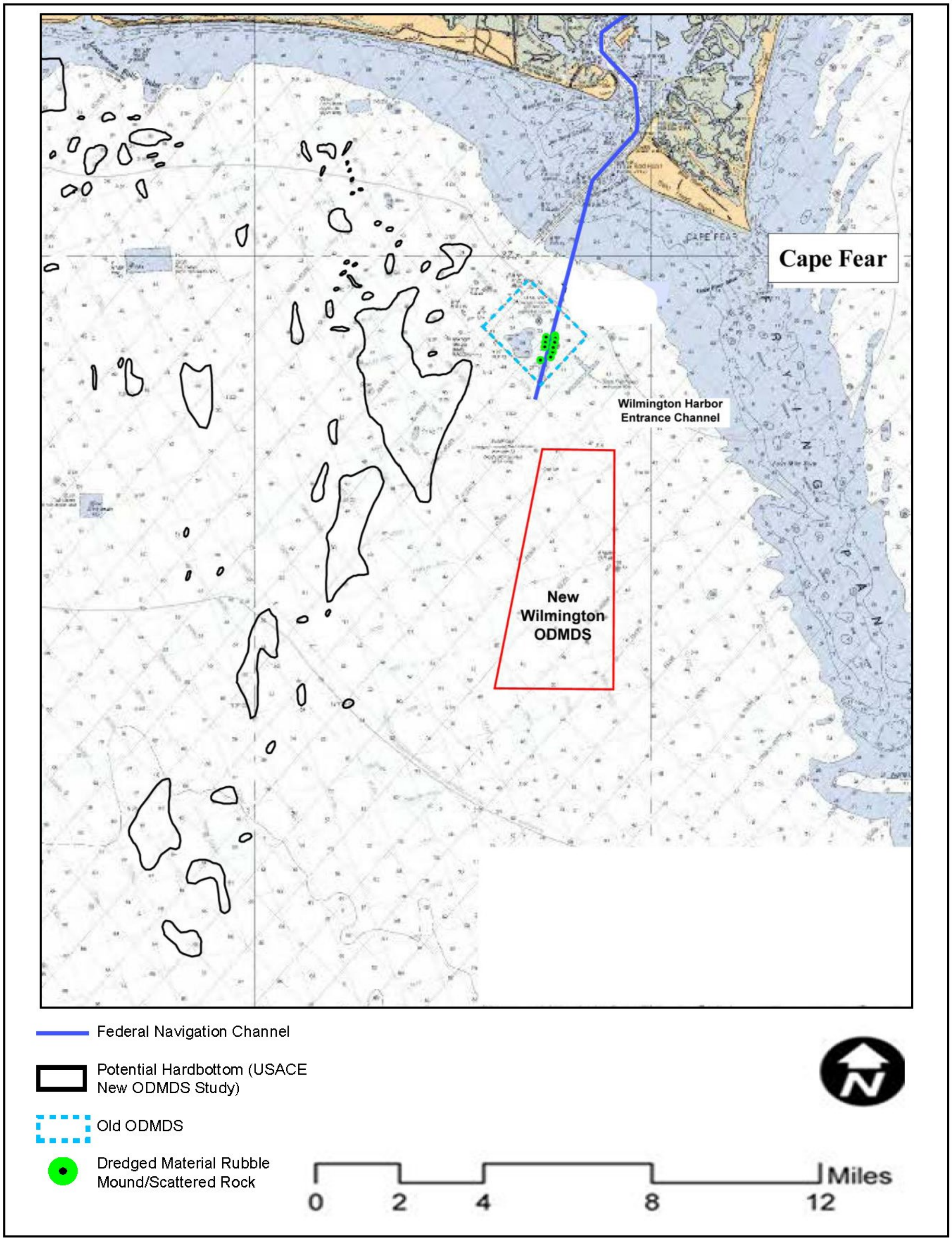

Figure 3-4
Potential Hardbottom Areas in Vicinity of the Study Area

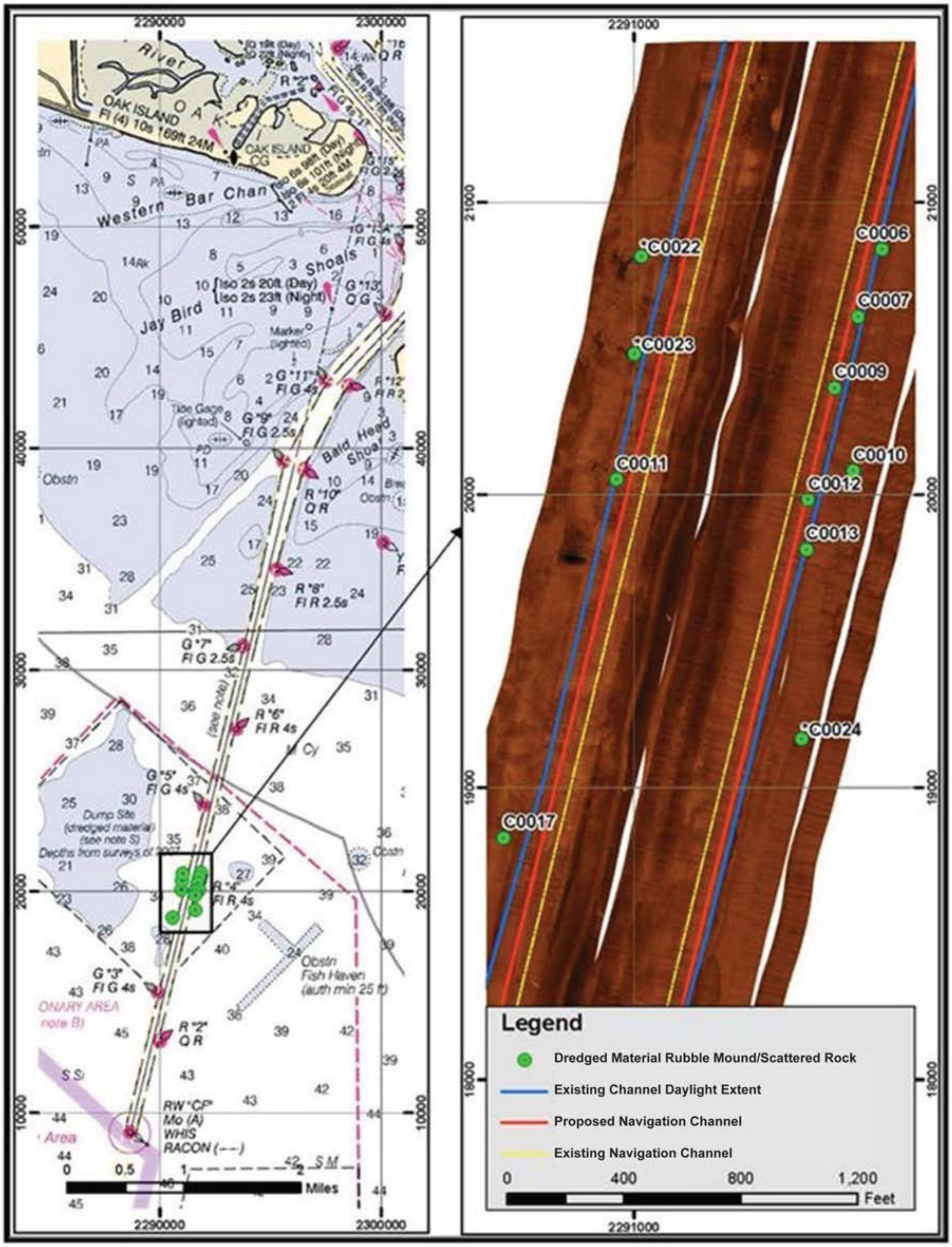

Figure 3-5
Side-scan Sonar Targets Identified in the Old ODMDS, Existing Channel, and Proposed Channel Widening Locations

3.10.3 Shell Bottom

Shell bottom habitats include oyster reefs, aggregations of non-reef-building shellfish species [e.g., clams and scallops (*Argopecten irradians*, *A. gibbus*)], and surface concentrations of broken shell (i.e., shell hash). The eastern oyster (*Crassostrea virginica*) is the dominant and principal reef-building species of estuarine shell bottom habitats in NC. Non-reef-building shellfish species that occur at densities sufficient to provide structural habitat for other organisms include scallops, pen shells [saw-toothed (*Atrina seratta*) and stiff (*A. rigida*)] and rangia clams (*Rangia cuneata*) (SAFMC 2009). Shell bottom habitats perform important ecological functions such as water filtration, benthic-pelagic coupling, sediment stabilization, and erosion reduction (NCDEQ 2016, SAFMC 2009, and Coen et al. 2007). By filtering and consuming particulate matter, phytoplankton and microbes; oysters and other suspension-feeding bivalves reduce turbidity and transfer material and energy from the water column to the benthic community. Shell bottom structural relief moderates waves and currents, traps sediments, and reduces shoreline erosion. Existing shell bottom habitats function as important larval settlement and accumulation sites for recruiting oysters and other shellfish (NCDMF 2008). Shell bottom structure concentrates macroinvertebrates [e.g., grass shrimp (*Palaemonetes* spp.), and mud crabs (*Scylla* spp.)] and small forage fishes (pinfish and gobies) which, in turn, attract larger predatory fish such as Atlantic croaker, black drum (*Pogonias cromis*), pigfish, (*Orthopristis chrysoptera*), southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), and spotted seatrout (*Cynoscion nebulosus*). Numerous finfish and decapod crustaceans including anchovies, black sea bass (*Centropristis striata*), blennies, gobies, oyster toadfish (*Opsanus tau*), pinfish, red drum, sheepshead (*Archosargus probatocephalus*), spot, weakfish (*C. regalis*), penaeid shrimp, blue crabs (*Callinectes sapidus*), and stone crabs (*Menippe mercenaria*) also utilize shell bottom habitats as nursery areas (NCDEQ 2016).

Shell bottom habitats in the Cape Fear River estuary are generally confined to the lower estuary below Snows Cut. The distribution of oyster reefs in the estuary is limited by salinity and a lack of hard substrate for larval settlement. Live oyster reefs that provide the structural functions described above are confined to the lowermost ~10-mile reach of the estuary from Peters Point to the river mouth. Rodriguez (2009) indicates that the absence of live functional oyster reefs in the estuary above Peters Point is likely related to extended periods of low salinity. Although oysters can tolerate salinities ranging from five to 35 ppt, they are unable to survive at salinities below five ppt. Furthermore, it has been reported that the mortality rate of oyster larvae in waters ≤10 ppt is 100% within two weeks (Davis 1958). According to Rodriguez (2009), over the course of six years (2000–2003, 2005–2007) of salinity monitoring at Lower Cape Fear River Program Station M35 between Snows Cut and Peters Point, mean monthly salinities of less than five ppt were measured during 11 months. The optimal salinity range for oysters is 12 to 25 ppt (NCDMF 2011). The waters below Federal Point are designated Class SA commercial shellfishing waters. SA waters are assigned a Shellfish Growing Area status of approved, conditional, or prohibited based on NCDMF Shellfish Sanitation fecal coliform criteria. A total of 1,200 acres of SA waters in the lower estuary along with a number of additional areas in tidal creeks are designated as Prohibited on the NC 2016 303d list. NCDMF benthic habitat maps depict two areas of shell bottom habitat between Snows Cut and Federal Point; including one area along the western margin of the existing Upper Midnight channel reach, and a second area ~2,500 ft east of the Reaves Point channel reach (Figure 3-6). NCDMF shell bottom habitat mapping has not been completed for the remainder of the lower estuary below Federal Point;

however, analyses of remote sensing survey data did not identify any structural shell bottom habitats within the existing or proposed channel areas.

Figure 3-6
Mapped Shell Bottom Habitats in the CFR Estuary (NCDMF 2019)

3.10.4 Submerged Aquatic Vegetation

Submerged Aquatic Vegetation (SAV) encompasses several species of rooted aquatic vascular plants that occur in North Carolina estuaries; including eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*), and widgeon grass (*Ruppia maritima*). Submerged Aquatic Vegetation beds occur on subtidal and occasionally intertidal sediments in sheltered estuarine waters. Environmental requirements include unconsolidated sediments for root and rhizome development, adequate light reaching the bottom, and moderate to negligible current velocities (Thayer et al. 1984, Ferguson and Wood 1994). Submerged Aquatic Vegetation beds provide important structural fish habitat and perform important ecological functions such as primary production, sediment and shoreline stabilization, and nutrient cycling (NCDEQ 2016). Submerged Aquatic Vegetation habitats are important nursery areas for the juveniles of ocean-spawned estuarine-dependent species; including many important commercial and recreational species such as Atlantic croaker, black sea bass, bluefish (*Pomatomus saltatrix*), flounders, gag grouper (*Mycteroperca microlepis*), herrings, mullets, red drum, snappers (*Lutjanidae* spp.), spot, spotted seatrout, weakfish, southern kingfish, and penaeid shrimp. Bay scallops, hard clams, and blue crabs are also strongly associated with SAV; and large predatory species such as bluefish, flounders, red drum, and spotted seatrout are attracted to SAV beds for their concentrations of juvenile finfish and shellfish prey (Thayer et al. 1984). NCDMF benthic habitat maps show small scattered patches of SAV throughout the lower Cape Fear River estuary; however, NCDMF has determined that the mapped occurrences are aerial imagery-based misidentifications of marine macroalgae (Personal communication, Ann Deaton, NCDMF Habitat Protection and Enhancement Section, 19 Feb 2019). NCDMF has concluded that SAV are absent from the lower estuary. The only confirmed SAV beds in the Cape Fear River estuary, consisting of slender naiad (*Najas gracillima*), are located in the Brunswick River near the US HWY 74/76 Bridge. Slender naiad is a species of tidal freshwater to oligohaline habitats (Brush and Hilgartner 2000). Identified beds in the Brunswick River occupy shallow subtidal flats along the shoreline of Eagle Island.

3.11 Fisheries

3.11.1 Estuarine Nursery Areas

As previously described, the Cape Fear River estuary is an important nursery area for many estuarine-dependent fish and invertebrate species that spawn offshore and use estuarine habitats for juvenile development. Ocean-spawned larvae are transported shoreward by the prevailing currents and eventually pass through tidal inlets and settle in estuarine nursery habitats. Juveniles remain in the estuarine nursery areas for one or more years before moving offshore and joining the adult spawning stock (NCDEQ 2016). The majority of the waters in the estuary above Lilliput Creek are state-designated Primary Nursery Areas (PNAs) (Figure 3-7). Additionally, waters east of the navigation channel in the lower estuary between Federal Point and Snow's Cut are a state-designated Special Secondary Nursery Area (SSNA). Primary Nursery Areas are defined as "those areas in the estuarine system where initial post-larval development takes place" [15 North Carolina Administrative Code (NCAC) 3I .0101(b)(20)(E)]. Primary Nursery Areas support uniform populations of very early juveniles and are typically located in the upper reaches of the estuarine system. In the case of many estuarine-dependent species, larval settlement occurs in the uppermost reaches of shallow tidal creek systems

Figure 3-7
Fishery Nursery Areas

(Weinstein 1979, Ross and Epperly 1985). Secondary Nursery Areas (SNAs) are defined as "those areas in the estuarine system where later juvenile development takes place." Secondary Nursery Areas support uniform populations of developing subadults that have moved from PNAs to the middle portion of the estuarine system. The majority of the Primary and Secondary Nursery Areas in NC are located in soft bottom areas surrounded by salt/brackish marsh (NCDEQ 2016).

Weinstein et al. (1979, 1980) described the nekton communities of shallow nursery habitats in the ~21-mile reach of the lower Cape Fear River estuary between Bald Head Island and Barnards Creek. Sixteen taxa accounted for over 96% of the total combined catch at 17 stations, with ocean-spawning estuarine-dependent species comprising 70% of the dominants (Table 3-6). The overall dominant species were generally ubiquitous to the lower estuary but had centers of abundance that varied along salinity gradients. Pigfish, white mullet (*Mugil curema*), red drum, and southern blue crab; along with two permanent marsh residents [Atlantic silverside (*Menidia menidia*) and striped killifish (*Fundulus majalis]*); were primarily associated with high salinity waters of the lower estuary. Additionally, a number of seasonally present marine species were restricted to the lower polyhaline estuary [sergeant major (*Abudefduf saxatilis*), barracuda, Atlantic spadefish (*Chaetodipterus faber*), lookdown (*Selene vomer*), lane snapper (*Lutjanus synagris*), gag grouper, and others). Although not numerically dominant, the seasonal presence of marine species contributed to relatively high species richness at the lowermost Bald Head (n=56) and Battery Island (n=63) stations. Species exhibiting a preference for low salinity waters at the upper stations (Walden Creek and Barnards Creek) included Atlantic croaker, southern flounder, 0 year class Atlantic menhaden (*Brevoortia tyrannus*),, and inland silverside (*M. beryllina*). Also associated with the low salinity sites were freshwater species that were seasonally present at salinities up to 5.1 ppt; including largemouth bass (*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), bluegill (*L. macrochirus*), yellow perch (*Perca flavescens*), white catfish (*Ictalurus catus*), and golden shiner (*Notemigonus crysoleucas*).

Table 3-6
Pooled Species Abundances

Common Name	Scientific Name	Percent
Atlantic menhaden	*Brevoortia tyrannus*	39.3
Spot	*Leiostomus xanthurus*	18.3
Mummichog	*Fundulus heteroclitus*	10.8
Atlantic silverside	*Menidia menidia*	7.6
Bay anchovy	*Anchoa mitchilli*	5.9
Striped mullet	*Mugil cephalus*	3.3
White mullet	*Mugil curema*	2.2
Brown shrimp	*Penaeus aztecus*	1.9
Flounder	*Paralichthys* spp.	1.7
Blue crab	*Callinectes sapidus*	1.3
Striped killifish	*Fundulus majalis*	1.0
Inland silverside	*Menidia beryllina*	0.9
Silver perch	*Bairdiella chrysoura*	0.6
Pinfish	*Lagodon rhomboides*	0.6
Eastern mosquitofish	*Gambusia holbrooki*	0.5
Naked gobi	*Gobiosoma bosc*	0.5
Total		**96.2**

Source: Weinstein et al. 1980

Rozas and Hackney (1984) and Ross (2003) indicate that oligohaline marshes of the upper estuary are also important nursery habitats for estuarine dependent species. These studies indicate that densities of juvenile spot, Atlantic croaker, flounder, and other estuarine dependent species in the upper oligohaline marshes and creeks are comparable to or higher than densities in the salt marshes and mesohaline to polyhaline creeks of the mid to lower estuary. In the specific case of spot and croaker, Ross (2003) reported that the upper oligohaline nursery areas were the most valuable for juvenile development. Rozas and Hackney (1984) reported three seasonal peaks in numerical abundance in oligohaline marsh rivulets; including a spring peak associated with the influx of juvenile spot, Atlantic menhaden, Atlantic croaker, and southern flounder; a summer peak attributable to high numbers of grass shrimp; and fall peak attributable to high numbers of bay anchovy and grass shrimp. The most abundant species were spot, grass shrimp, bay anchovy (*Anchoa mitchilli*), and Atlantic menhaden. Average densities of spot and Atlantic menhaden in the oligohaline rivulets at the peak of juvenile recruitment were comparable to those reported for salt marshes.

3.11.2 Nearshore Marine

The Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) has conducted annual nearshore (depths 15-60 ft) trawl surveys for demersal fishes in Long Bay since 1986. Catches have been consistently dominated by sciaenid fish which utilize estuaries during part of their life cycle (SEAMAP-SA 2000). Overall patterns of demersal fish abundance are strongly influenced by the high abundance of spot and Atlantic croaker. These two species have been consistently dominant, accounting for more than 36% of the total catch between 1990 and 1999. Other abundant demersal fishes in this region include the Atlantic bumper (*Chloroscombrus chrysurus*), scup, pinfish, star drum (*Stellifer lanceolatus*), banded drum (*Larimus fasciatus*), gray trout (*Cynoscion regalis*), silver seatrout (*C. nothus*), southern kingfish, and inshore lizardfish (SEAMAP-SA 2000). Many of the demersal fishes associated with nearshore soft bottom habitats are ocean-spawning estuarine-dependent species that use the Cape Fear River estuary for juvenile development before moving into the ocean as adults. During the fall and winter, large numbers of these species leave the estuary and enter the nearshore ocean zone (NCDEQ 2016).

Peterson and Wells (2000) documented seasonal variations (November, February, and May) in demersal fish communities at inshore (approximately one mile) and offshore (approximately five miles) soft bottom sites off the southern NC coast. In November, catches at the offshore sites were dominated by spot (>50% of total catch), pinfish, pigfish, and croaker; while the inshore sites were dominated by croaker, silver perch (*Bidyanus bidyanus*), Atlantic silversides, pinfish, and striped mullet (*Mugil cephalus*). In February, total catches at the offshore and inshore sites were reduced by 96% and 59%, respectively. Pinfish, Atlantic menhaden, and silversides collectively accounted for 96.4% of the total combined inshore/offshore catch in February. The combined inshore/offshore totals for spot and croaker were reduced by 98.9% and 99.8%, respectively, and catches of all other taxa decreased sharply, with the exception of silversides and pinfish at the inshore sites. During the May sampling period, large numbers of Atlantic silversides and Atlantic threadfin herring (*Opisthonema oglinum*) increased the total inshore catch. Peterson and Wells (2000) also analyzed the stomach contents of demersal fishes that were caught during the November sampling period and found that croakers and pinfish were primarily consuming polychaete worms, bivalves, grass shrimp, and pinnotherid crabs. Silver perch, pigfish, and spot consumed polychaetes, grass shrimp, and other small bottom-dwelling crustaceans. Gray trout consumed grass shrimp, penaeid shrimp, and portunid crabs; whereas kingfishes primarily consumed pinnotherid crabs, portunid crabs, and large polychaete worms.

3.11.3 Anadromous Fishes

Anadromous species that undertake annual migrations from coastal waters to spawning grounds in the upper freshwater reaches of the Cape Fear River include Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), shortnose sturgeon (*A. brevirostrum*), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), blueback herring (*A. aestivalis*), and alewife (*A. pseudoharengus*). Additionally, elvers of the catadromous American eel (*Anguilla rostrata*) migrate upriver to freshwater juvenile nursery areas in the upper Cape Fear River system (USACE 2010). The North Carolina Marine Fisheries Commission and the North Carolina Wildlife Resources Commission (NCWRC) have designated the middle to upper portions of the Cape Fear River estuary from Lilliput Creek northward as Anadromous Fish Spawning Areas (AFSAs) (Figure 3-8). Anadromous Fish Spawning Areas are defined as areas where evidence of spawning of anadromous fish have been documented through direct observation of spawning, capture of running ripe females, or capture of eggs or early larvae (15A NCAC 03N .0106, 15A10C .0602).

Historically, anadromous fish spawning runs extended ~180 miles upstream of the river mouth to Smiley Falls near Lillington (Stevenson 1899). Between 1915 and 1935, the USACE constructed three low-head lock and dam structures on the Cape Fear River for the purpose of commercial navigation. The structures prevented anadromous species from reaching upstream spawning grounds, except during boat lockages and periods of sustained high flow. Although each of the dams was equipped with a ladder-type fishway, the ladders were ineffective at passing anadromous species. The loss of access to spawning and nursery grounds led to dramatic declines in commercial catches (Nichols and Louder 1970). By 1965, the average annual shad commercial catch had been reduced to ~177,000 pounds, a decline of 44 percent in relation to catches of ~315,000 pounds in 1896 and 1904 (Nichols and Louder 1970). In 1962, the United States Fish and Wildlife Service (USFWS) Bureau of Commercial Fisheries initiated a four-year field investigation to determine the feasibility of providing fish passage through the lock chambers (Nichols and Louder 1970). This study led to the initiation of annual spawning season fish locking procedures at the three lock and dam structures.

Although the fish locking procedures were effective at passing some shad and striped bass, studies indicated that a substantial proportion of the fish that approached Lock and Dam #1 were not accessing upstream spawning areas. Furthermore, no passage by Atlantic or shortnose sturgeon was detected. In 1998, a steep pass fishway was constructed at Lock and Dam #1 in an effort to augment the fish locking procedures; however, the structure proved to be ineffective (Moser et al. 2000). The focus of subsequent efforts shifted to the design of a natural fishway structure that would be more effective at passing the full assemblage of anadromous species that spawn in the Cape Fear River. These efforts led to the design and construction of a nature-like, rock arch rapids fishway structure at Lock and Dam #1 during 2011/2012. Construction of the rock arch rapids fulfilled a mitigation commitment made by the USACE for the Wilmington Harbor 96 Act Project (USACE 2000). Recent studies (Raabe 2017) indicate that of those fish that approach Lock and Dam #1 in an apparent attempt to pass, ~53 - 65% of American shad and ~19 - 25% of striped bass are successful at passing the dam and continuing upstream. Modifications to the rock arch rapids have been proposed to increase the rate of striped bass

Figure 3-8
Anadromous Fish Spawning Areas

passage. The proposed design involves the construction of three linear corridors across the surface of the existing structure. Each corridor would consist of a series of deep pools that are designed to accommodate larger fish.

3.12 Managed Fisheries and Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), as amended by the Sustainable Fisheries Act of 1996, requires federal agencies to address the effects of their actions on Essential Fish Habitat (EFH) and federally managed fisheries. The MSFCMA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Habitat Areas of Particular Concern (HAPCs) comprise a more specific subset of EFH habitats that are considered to be especially critical due to factors such as rarity, susceptibility to human-induced degradation, and/or high ecological importance. Many of the estuarine and marine habitats that occur in the vicinity of the study area are designated as EFH and/or HAPCs in Fishery Management Plans (FMPs) developed by the SAFMC, Mid-Atlantic Fishery Management Council (MAFMC), and/or National Marine Fisheries Service (NMFS) (Table 3-7). This section describes the federally managed species and associated EFH/HAPC habitats that occur in the vicinity of the study area.

3.12.1 Penaeid Shrimp

Federally managed penaeid shrimp in North Carolina include the brown shrimp, pink shrimp (*F. duorarum*), and white shrimp. Adults spawn offshore in high salinity oceanic waters during the winter or spring (SAFMC 1981). Ocean-spawned planktonic larval and post-larval shrimp are transported by currents to inshore estuarine habitats where they maintain a benthic existence. Juveniles are most abundant in estuarine waters with intermediate salinities and mud-silt substrates, where they congregate at the highly productive marsh-water interface. As their size increases, shrimp move toward high-salinity oceanic waters, eventually migrating offshore in the fall. Essential Fish Habitat for penaeid shrimp includes important inshore estuarine nursery habitats, important offshore habitats for spawning and growth, and all interconnecting water bodies. Designated EFH and HPACs in the study area include estuarine tidal marshes, subtidal and intertidal non-vegetated flats (soft bottom), Cape Fear River inlet, and all state-designated Primary and Secondary Nursery Areas.

3.12.2 Red Drum

Red drum spawning areas include high salinity waters in the vicinity of major inlets and potentially high salinity waters inside estuaries. Eggs and larvae are transported throughout the inshore estuaries by tidal and wind driven currents, with the majority of the larvae being carried to the upper reaches of the estuaries where they settle in shallow, low-salinity nursery habitats. In North Carolina, juvenile one- and two-year-old red drums are distributed year-round over a wide range of salinities and habitats, but they generally prefer shallow shoreline waters in bays and rivers and shallow grass flats behind barrier islands (Ross and Stevens 1992). Some juveniles also migrate to the ocean after their first year, where they occur along beaches from late fall through early spring. Adult red drums spend less time in the estuaries and more time in the ocean; spending spring, early summer, and fall along the beaches and wintering offshore. In the fall and spring, red drums congregate around inlets, shoals, capes, and along ocean beaches from the surf zone to several miles offshore. Designated EFH and HAPCs for red drum in the study area include estuarine tidal marshes, subtidal and intertidal non-vegetated flats (soft

Table 3-7
EFH and HPAC in the Vicinity of the Study Area

<table>
<tr><th>EFH/HAPC</th><th colspan="2">Fisheries Management Plan</th><th>Management Authority</th></tr>
<tr><td colspan="4">EFH</td></tr>
<tr><td>Estuarine Emergent Wetlands (Intertidal Marshes)</td><td colspan="2">Shrimp, Red drum, Snapper-Grouper</td><td>SAFMC</td></tr>
<tr><td>Submerged Aquatic Vegetation (Seagrasses)</td><td colspan="2">Shrimp, Red drum, Snapper-Grouper, Cobia</td><td>SAFMC</td></tr>
<tr><td>Subtidal and Intertidal Non-Vegetated Flats</td><td colspan="2">Shrimp</td><td>SAFMC</td></tr>
<tr><td>Oyster Reefs and Shell Banks</td><td colspan="2">Red drum, Snapper-Grouper</td><td>SAFMC</td></tr>
<tr><td>Unconsolidated Bottom</td><td colspan="2">Red drum, Snapper-Grouper</td><td>SAFMC</td></tr>
<tr><td>Hardbottom</td><td colspan="2">Snapper-Grouper</td><td>SAFMC</td></tr>
<tr><td>Artificial Reefs</td><td colspan="2">Snapper-Grouper</td><td>SAFMC</td></tr>
<tr><td>Ocean High Salinity Surf Zone</td><td colspan="2">Red drum, Coastal migratory pelagics</td><td>SAFMC</td></tr>
<tr><td>Coastal Inlets</td><td colspan="2">Coastal migratory pelagics</td><td>SAFMC</td></tr>
<tr><td>NC Primary/Secondary Nursery Areas</td><td colspan="2">Coastal migratory pelagics</td><td>SAFMC</td></tr>
<tr><td>High Salinity Estuaries</td><td colspan="2">Cobia</td><td>SAFMC</td></tr>
<tr><td>Continental Shelf Waters, Estuaries</td><td colspan="2">Bluefish, Summer flounder</td><td>MAFMC</td></tr>
<tr><td rowspan="2">Continental Shelf Waters</td><td colspan="2">Highly Migratory Species (Sharks)</td><td rowspan="2">NMFS</td></tr>
<tr><td>Great hammerhead
Scalloped
White
Blacktip
Dusky
Sandbar
Spinner</td><td>Tiger
Sand tiger
Bonnethead
Atlantic sharpnose
Blacknose
Finetooth
Common thresher</td></tr>
<tr><td colspan="4">HAPC</td></tr>
<tr><td>Coastal Inlets</td><td colspan="2">Shrimp, Red drum, Snapper-Grouper, Coastal migratory pelagics</td><td>SAFMC</td></tr>
<tr><td>High Salinity Estuaries</td><td colspan="2">Spanish Mackerel</td><td>SAFMC</td></tr>
<tr><td>NC Primary/Secondary Nursery Areas</td><td colspan="2">Shrimp, Red drum, Snapper-Grouper, Coastal migratory pelagics</td><td>SAFMC</td></tr>
<tr><td rowspan="2">Submerged Aquatic Vegetation (Seagrasses)</td><td colspan="2">Red drum, Snapper-Grouper</td><td>SAFMC</td></tr>
<tr><td colspan="2">Summer flounder</td><td>MAFMC</td></tr>
<tr><td>Oyster Reefs and Shell Banks</td><td colspan="2">Snapper-Grouper</td><td>SAFMC</td></tr>
<tr><td>Hardbottom</td><td colspan="2">Snapper-Grouper</td><td>SAFMC</td></tr>
</table>

bottom), oyster reefs and shell banks, unconsolidated soft bottom habitats, the ocean high salinity surf zone, Cape Fear River Inlet, and all state-designated Primary and Secondary Nursery Areas.

3.12.3 Snapper-Grouper Complex

The snapper-grouper complex is an assemblage of 59 species that share a common association with hardbottom or reef habitats during part of their life cycle. Generally, snappers , groupers (Serranidae), porgies (Sparidae), and grunts inhabit offshore hardbottom habitats; whereas, nearshore ocean hardbottoms at depths of ~18 m along NC have cooler temperatures, less diverse invertebrate populations, and a fish community dominated primarily by black sea bass (*Centropristis striata*), scup, and associated temperate species (Sedberry and Van Dolah 1984). Most snapper-grouper species spawn in aggregations in the water column above offshore and shelf-edge reefs (Jaap 1984). Planktonic larval stages typically occur in the offshore water column, whereas juveniles and adults are typically demersal and associated with moderate to high relief hard structures on the outer continental shelf. However, the juveniles of some managed species such as black sea bass, gray snapper (*L. griseus*), and gag grouper reside in estuarine nursery areas where they typically inhabit SAV or oyster reef habitats (SAFMC 1998, NCDMF 2006). Juveniles of these estuarine-dependent species emigrate from the estuary to near shore hardbottom habitats in the fall, and eventually move to offshore hard/live bottom habitats. Designated EFH and HPACs for estuarine-dependent snapper-grouper species in the study area include attached estuarine tidal marshes, subtidal and intertidal non-vegetated flats (soft bottom), oyster reefs and shell banks, unconsolidated soft bottom habitats, hard bottom, artificial reefs, Cape Fear River Inlet, and all state-designated Primary and Secondary Nursery Areas.

3.12.4 Coastal Migratory Pelagics

The coastal migratory pelagics management unit includes king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculates*), and cobia (*Rachycentron canadum*). Adult coastal pelagics occur in coastal waters from shore out to the edge of the continental shelf. The distribution of coastal pelagics on the shelf is governed by temperature and salinity, with all species generally occurring in high salinity waters with temperatures above 20 degrees Centigrade (°C). Coastal migratory pelagics are fast swimming, schooling, and piscivorous predators. Spanish mackerel spawn in groups over the inner continental shelf, beginning in April off the Carolinas. Larvae grow quickly and are most commonly found in nearshore ocean waters at shallow depths less than 30 ft. Most juveniles remain in nearshore ocean waters, but some use high salinity estuaries as nursery areas. Adult Spanish mackerel spend most of their lives in the open ocean but are also found in tidal estuaries and coastal waters [Atlantic States Marine Fisheries Commission (ASMFC) 2011a and b, Mercer et al. 1990]. King mackerel are primarily a coastal species, with smaller individuals of similar size forming significant schools over areas of bottom relief and reefs; while larger solitary individuals prefer anthropogenic structures and/or wrecks. Cobia are abundant in warm waters along the United States coast from Chesapeake Bay south through the Gulf of Mexico. Cobia are found over the continental shelf and in high salinity estuarine waters, preferring waters in the vicinity of reefs and around structures such as pilings, buoys, platforms, anchored boats, and flotsam. Spawning off the North Carolina coast occurs during May and June, primarily in offshore ocean waters; however, spawning has also been observed in estuaries and shallow bays with the young moving offshore soon after hatching (SAFMC 1983 and 2011). Designated EFH and HAPCs for all coastal migratory pelagics in the study area include the sandy shoals of Cape Fear (Frying Pan Shoals), offshore bars and barrier island ocean-side waters, and the Cape Fear River Inlet complex.

3.12.5 Highly Migratory Species

The highly migratory species (HMS) complex encompasses tuna [albacore (*Thunnus alalunga*), bluefin (T. *thynnus*), bigeye (*T. obesus*), skipjack (*Katsuwonus pelamis*), and yellowfin (*T. albacres*)], swordfish (*Xiphias gladius*), billfish [blue marlin (*Mokaira nigricans*), white marlin (*Tetrapturus albidus*), sailfish (*Istiophorus platypterus*), and longbill spearfish (*T. pfluegeri*), and 39 species of sharks that are divided into three groups: large coastal sharks, small coastal sharks, and pelagic sharks. Of these species, 14 managed shark species have designated EFH consisting of nearshore continental shelf waters along the NC coast. Sharks are found in a wide variety of coastal and ocean habitats; including estuaries, nearshore and continental shelf waters, and the open ocean. Although managed sharks move primarily through the open ocean, several species move to shallow coastal waters and estuaries to pup. These nearshore/estuarine habitats also function as nursery areas for the developing young, with neonates typically remaining in these areas throughout their early life stages (NMFS 2009). Subtidal bottom in nearshore waters along the southern NC coast serve as pupping grounds for the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), bonnethead shark (*Sphyrna tiburo*), blacknose shark (*Carcharhinus acronotus*), spinner shark (*C. brevipinna*), dusky shark (*C. obscurus*), blacktip shark (*C. limbatus*), sandbar shark (*C. plumbeus*), and scalloped hammerhead shark (*S. lewini*). Neonates from southern NC waters are found primarily in June and July (Beresoff and Thorpe 1997, Thorpe et al. 2004).

3.12.6 Bluefish

Bluefish are a migratory, pelagic species found in temperate and semi-tropical continental shelf waters around the world with the exception of the north and central Pacific. In North America, bluefish range from Nova Scotia to Florida in the Atlantic Ocean and from Florida to Texas in the Gulf of Mexico (MAFMC 1990). Spawning in the South Atlantic Bight occurs near the shoreward edge of the Gulf Stream primarily during April and May (Kendall and Walford 1979). Larval development takes place in outer continental shelf waters within six meters of the surface. Transitional pelagic juveniles eventually move to estuarine and nearshore oceanic waters, which serve as the principal nursery habitats for juvenile development (Kendall and Walford 1979). Estuarine juveniles are most commonly associated with sandy soft bottom habitats; but also use mud and silt soft bottom habitats, SAV, marine macroalgae, oyster reefs, and tidal marsh grass (Shepherd and Packer 2006). Juvenile bluefish are common in high salinity estuaries along the southern NC coast during summer and fall and are common in the nearshore ocean from spring through mid-winter. Adults use both inshore estuarine and offshore oceanic habitats. Adults are common in the nearshore ocean along the NC coast from spring through mid-winter (MAFMC 1990). Adults undertake seasonal migrations, generally moving northward during spring and summer and southward during fall and winter. Designated EFH habitats for juvenile and adult bluefish in the study area include the Cape Fear River estuary and pelagic ocean waters overlying the inner continental shelf of Long Bay.

3.12.7 Summer Flounder

Summer flounder are found in shallow estuarine and outer continental shelf waters along the Atlantic coast from Nova Scotia to Florida and along the northern Gulf coast of Mexico

[Northeast Fisheries Science Center (NEFSC) 1999]. Summer flounder are concentrated in estuaries and sounds from late spring through early fall, before migrating to offshore wintering spawning habitats on the outer continental shelf (NEFSC 1999, ASFMC 2011c). Offshore spawning occurs during fall and early winter, and the larvae are transported by wind-driven currents to coastal waters. Post-larval and juvenile development occurs primarily in estuaries (NEFSC 2011). Larvae recruit to inshore waters from October to May where they bury into the sediment and develop into juveniles. Late larval and juvenile flounder actively prey on crustaceans, copepods, and polychaetes (NEFSC 1999). Juveniles prefer sandy shell substrates; but also inhabit marsh creeks, mud flats, and seagrass beds. Juveniles often remain in North Carolina estuaries for 18 to 20 months (NEFSC 1999, ASFMC 2011d). Adults primarily inhabit sandy substrates, but have been documented in seagrass beds, tidal marsh creeks, and sand flats (ASFMC 2011c and d, NEFSC 1999). Adults inhabit estuarine waters before moving to offshore wintering grounds on the outer continental shelf. Essential Fish Habitat for all life stages of summer flounder includes ocean waters overlying the continental shelf. Designated EFH and HPACs for juvenile and adult summer flounder in the study area include estuarine waters with salinities >0.5 ppt, marine macroalgae, and tidal/freshwater macrophytes.

3.13 Coastal Waterbirds

The Bald Head-Smith Island complex of natural and artificial dredged material islands in the lower Cape Fear River estuary is an important breeding area for numerous species of colonial nesting waterbirds and shorebirds (USFWS 2000). Dense maritime shrub thickets on Battery Island provide nesting habitat for the largest assemblage of colonial tree-nesting wading birds in the state. The Battery Island breeding colony encompasses a mixed-species assemblage of wading birds; including white ibis (*Eudocimus albus*), glossy ibis (*Plegadis falcinellus*), cattle egrets (*Bubulcus ibis*), little blue herons (*Egretta caeurlea*), tricolored herons (*E. tricolor*), snowy egrets (*E. thula*),, great egrets (*Ardea alba*), black-crowned night herons (*Nycticorax nycticorax*), and yellow-crowned night herons (*Nyctanassa violacea*). The white ibis breeding population is the largest in the state, with as many as 15,000+ pairs nesting annually on the island. At least ten pairs of American oystercatchers (*Haematopus palliatus*) nest on the Battery Island annually, along with willets (*Tringa semipalmata*), clapper rails (*Rallus crepitans*), seaside sparrows (*Ammospiza maritima*), and marsh wrens (*Cistothorus palustri*). South Pelican Island and Ferry Slip Island support the largest breeding colonies of brown pelicans (*Pelecanus occidentalis*), royal terns (*Sterna maxima*), and sandwich terns (*Thalasseus sandvicensis*) in southeastern NC. North Pelican Island provides nesting habitat for wading birds, brown pelicans, laughing gulls (*Leucophaeus atricilla*), clapper rails, willets, and American oystercatchers. Striking and Shellbed Islands are important breeding and wintering sites for American oystercatchers, and also support nesting by laughing gulls, willets, and clapper rails.

The expansive estuarine complex of tidal marshes and creeks, oyster reefs, and intertidal sand and mud flats provides highly productive foraging habitats that support breeding populations of coastal waterbirds, as well as thousands of migratory shorebirds and waterbirds that use the Cape Fear River estuary as a stopover refueling site during the spring and fall migration periods. The barrier island beaches of the study area also provide important foraging and roosting habitats for shorebirds and colonial waterbirds; including sanderlings (*Calidris alba*), willets, ruddy turnstones (*Arenaria interpres*), semipalmated plovers (*Charadrius semipalmatus*), laughing gulls, ring-billed gulls (*Larus delawarensis*), herring gulls (*L. argentatus*), and brown pelicans (Grippo et al. 2007) (Table 3-8).

Table 3-8
Ten Most Abundant Shorebird and Colonial Waterbird Species Observed in Oceanfront Beach Habitats.

Species		Abundance birds/km[1]/survey		
Common Name	**Scientific Name**	**Beach 1**	**Beach 2**	**Control**
	Colonial Waterbirds			
Laughing Gull	*Leucophaeus atricilla*	67.1	55.6	34.9
Ring-billed Gull	*Larus delawarensis*	50.4	49.6	25.4
Brown Pelican	*Pelecanus occidentalis*	7.3	7.0	4.0
Herring Gull	*Larus argentatus*	1.2	1.1	1.0
Forsters Tern	*Sterna forsteri*	0.3	1.0	0.9
Royal Tern	*Thalasseus maximus*	15.3	14.0	8.9
Great Black-backed Gull	*Larus marinus*	2.5	1.1	1.0
Bonapartes Gull	*Chroicocephalus philadelphia*	5.7	5.3	2.1
Double-crested Cormorant	*Phalacrocorax auritus*	0.5	0.6	0.4
Sandwich Tern	*Thalasseus sandvicensis*	0.6	0.5	0.7
	Shorebirds			
Sanderling	*Calidris alba*	5.8	9.0	10.1
Willet	*Tringa semipalmata*	0.4	0.1	0.0
Short-billed Dowitcher	*Limnodromus griseus*	1.8	2.5	4.5
Ruddy Turnstone	*Arenaria interpres*	0.25	0.6	1.2
Black-bellied Plover	*Pluvialis squatarola*	0.61	0.9	0.9
Semipalmated Plover	*Charadrius semipalmatus*	0.1	0.1	3.0
Semipalmated Sandpiper	*Calidris pusilla*	0.6	<0.1	0.2
Killdeer	*Charadrius vociferous*	0.1	0.1	0.1
Whimbrel	*Numenius phaeopus*	0.1	<0.1	0.1
American Oystercatcher	*Haematopus palliatus*	<0.1	<0.1	0.1

Beach 1 = Eastern Oak Island (1.6 km)
Beach 2 = Western Oak Island and Eastern Holden Beach (3.2 km)
Control = Western Holden Beach (1.6 km)

[1]km = kilometer
Source: Brunswick County Beaches Shorebird/Waterbird Monitoring Dec 2000-Nov 2002

3.14 Protected Species

A total of 13 ESA-listed threatened and endangered species are known from the vicinity of the study area (Table 3-9). Additionally, the study area encompasses a number of defined geographic areas that are designated under the ESA as critical habitats for threatened and endangered species (Table 3-10). Critical habitats are areas considered essential to the conservation of a species that may require special management or protection. Designated critical habitats have essential habitat features known as "primary constituent elements" that are considered requirements for survival and reproduction. In addition to ESA-listed species and their critical habitats, this section addresses other marine mammals that may occur in the study area. All marine mammal species are protected under the Marine Mammal Protection Act (MMPA).

Table 3-9
Endangered and Threatened Species That May Occur in Study Area

COMMON NAME	SCIENTIFIC NAME	ESA STATUS
North Atlantic right whale	*Eubalaena glacialis*	Endangered
West Indian manatee	*Trichechus manatus*	Endangered
Piping plover	*Charadrius melodus*	Threatened
Red knot	*Calidris canutus rufa*	Endangered
Wood stork	*Mycteria americana*	Threatened
Loggerhead sea turtle	*Caretta caretta*	Threatened
Green sea turtle	*Chelonia mydas*	Threatened
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
Seabeach amaranth	*Amaranthus pumilus*	Threatened

Table 3-10
Study Area Critical Habitats

Critical Habitat Type	Unit ID	Description	Length/Area
Piping Plover Wintering Critical Habitat	NC13 Masonboro	North end of Masonboro Island Masonboro Inlet	150 acres
Piping Plover Wintering Critical Habitat	NC14 Carolina Beach Inlet	South end of Masonboro Island Carolina Beach Inlet emergent shoals North end of Carolina Beach	924 acres
Piping Plover Wintering Critical Habitat	NC15 Fort Fisher	Fort Fisher Islands and ocean beach south of the ferry terminal	1,951 acres
Piping Plover Wintering Critical Habitat	NC16 Lockwoods Folly Inlet	West end of Oak Island Lockwoods Folly Inlet emergent shoals	90 acres
Piping Plover Wintering Critical Habitat	NC17 Shallotte Inlet	West end of Holden Beach Shallotte Inlet emergent shoals	296 acres
Piping Plover Wintering Critical Habitat	NC18 Mad Inlet	West end of Sunset Beach Marshes behind west end of Sunset Beach East end of Bird Island	278 acres
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-05	Pleasure Island/Ft Fisher	11.5 miles
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-06	Bald Head Island	9.4 miles
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-07	Oak Island	13.0 miles
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-08	Holden Beach	8.3 miles
Loggerhead Sea Turtle Nearshore Reproductive Critical Habitat	LOGG-N-05	Carolina Beach Inlet to Shallotte Inlet	
Loggerhead Sea Turtle Winter Critical Habitat	LOGG-N-02	Offshore waters between 20-m and 100-m depth contours from Cape Fear to Cape Hatteras	
Atlantic Sturgeon Critical Habitat	Carolina Unit 4	Cape Fear River from mouth(rkm 0) to Lock and Dam #2 Northeast Cape Fear River from mouth to Roans Chapel Rd Bridge at Mount Olive	
North Atlantic Right Whale Southeastern US Calving Critical Habitat	Unit 2	Nearshore waters from Cape Fear, NC to Cape Canaveral, FL	

3.14.1 North Atlantic Right Whale

Right whales (*Eubalaena glacialis*) in the North Atlantic and North Pacific were originally listed as a single endangered species in June 1970 [35 Federal Register (FR) 8495] under the Endangered Species Conservation Act (a predecessor to the ESA of 1973). In March 2008, right whales in the North Atlantic and North Pacific were listed as two separate endangered species under the Endangered Species Act (ESA) (73 FR 12024). The North Atlantic right whale population is divided into a western North Atlantic population, which numbers approximately 500 animals, and an eastern North Atlantic population that is nearly extinct. North Atlantic right whales in the western North Atlantic range from wintering and calving areas off the coast of the southeastern US to summer feeding and nursery areas that extend northward from New England to Nova Scotia. Important summer feeding and nursery areas are located in Massachusetts Bay and Cape Cod Bay, the Great South Channel (east of Cape Cod), the Bay of Fundy, and the Scotian Shelf in Canada. In the fall, a portion of the western North Atlantic population consisting primarily of pregnant females, females with young calves, and some juveniles migrate southward to nearshore continental shelf waters off the coast of southern Georgia and northern Florida. In some cases, adult males and non-pregnant females are also observed in the calving areas. Other members of the population spend the winter in Cape Cod Bay; however, a majority of the population is unaccounted for in winter (NMFS 2005). Calving takes place from December through March, and the peak migration periods are November/December and March/April.

Collision with ships is currently the most serious source of mortality threatening the right whale, followed closely by the threat of entanglement in commercial fishing gear. In order to reduce the risk of right whale deaths and injuries from ship collisions, the NMFS has established speed restrictions that limit vessels ≥65 ft in length to speeds of ten knots or less in designated Seasonal Management Areas (SMAs) along the US east coast (73 FR 60173). Seasonal Management Areas in the Mid-Atlantic migratory corridor encompass waters within 20 nautical miles (nm) of shore around the entrances to major ports, including the Port of Wilmington and the Port of Morehead City, along the NC coast. The waters off the Port of Wilmington are part of a continuous SMA that extends from Masonboro Inlet, NC, to Brunswick, Georgia (Figure 3-9). The Port of Morehead City SMA encompasses waters within a 20-nm radius of the port entrance. Speed restrictions for all Mid-Atlantic SMAs are effective from 1 November to 30 April.

The coastal waters of the Carolinas are part of the migratory corridor for the North Atlantic right whale (Winn et al. 1986, Knowlton et al. 2002). In an effort to better define the geographic and temporal extent of the right whale mid-Atlantic migratory corridor, Knowlton et al. (2002) analyzed 489 right whale sightings that occurred between 1974 and 2002. The largest number of sightings (34.4%) occurred within zero to five nm of land, and well over half of the sightings (63.8%) occurred within zero to ten nm of land. Nearly all of the sightings (94.1%) were within zero to 30 nm of land. Sightings within a 40 nm radius of the Wilmington Harbor entrance occurred from October through April, with peak sightings during February and March. A total of 18 sightings occurred within a 40 nm radius of the Wilmington Harbor entrance, and 14 of these sightings occurred within a 20 nm radius. Sightings in the vicinity of Morehead City Harbor followed the same spatial and temporal pattern. Surveys conducted off the coast of NC during the winters of 2001 and 2002 sighted eight calves, suggesting that calving grounds may extend as far north as Cape Fear (McLellan et al. 2004). Currently designated critical habitat for the right whale along the southeastern US coast includes nearshore ocean calving habitats from central Florida to Cape Fear, NC (81 FR 4838) (Figure 3-10). The essential features of the southeastern calving critical habitat include physical oceanographic conditions that support calving and nursing; including calm sea surface conditions, sea surface temperatures of 45° to 63°Fahrenheit (F), and water depths of 20 ft to 92 ft.

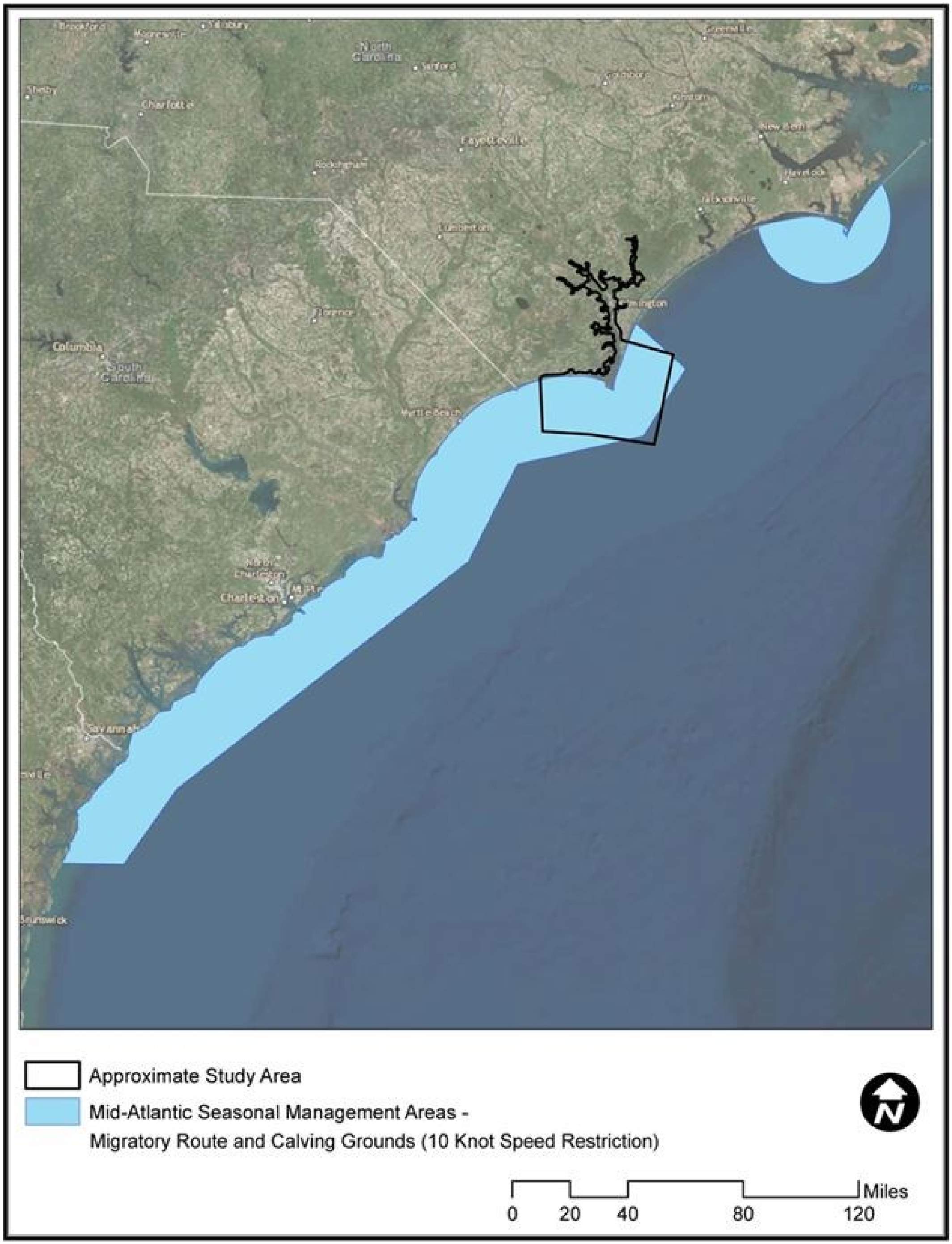

Figure 3-9
North Atlantic Right Whale Mid-Atlantic Seasonal Management Areas

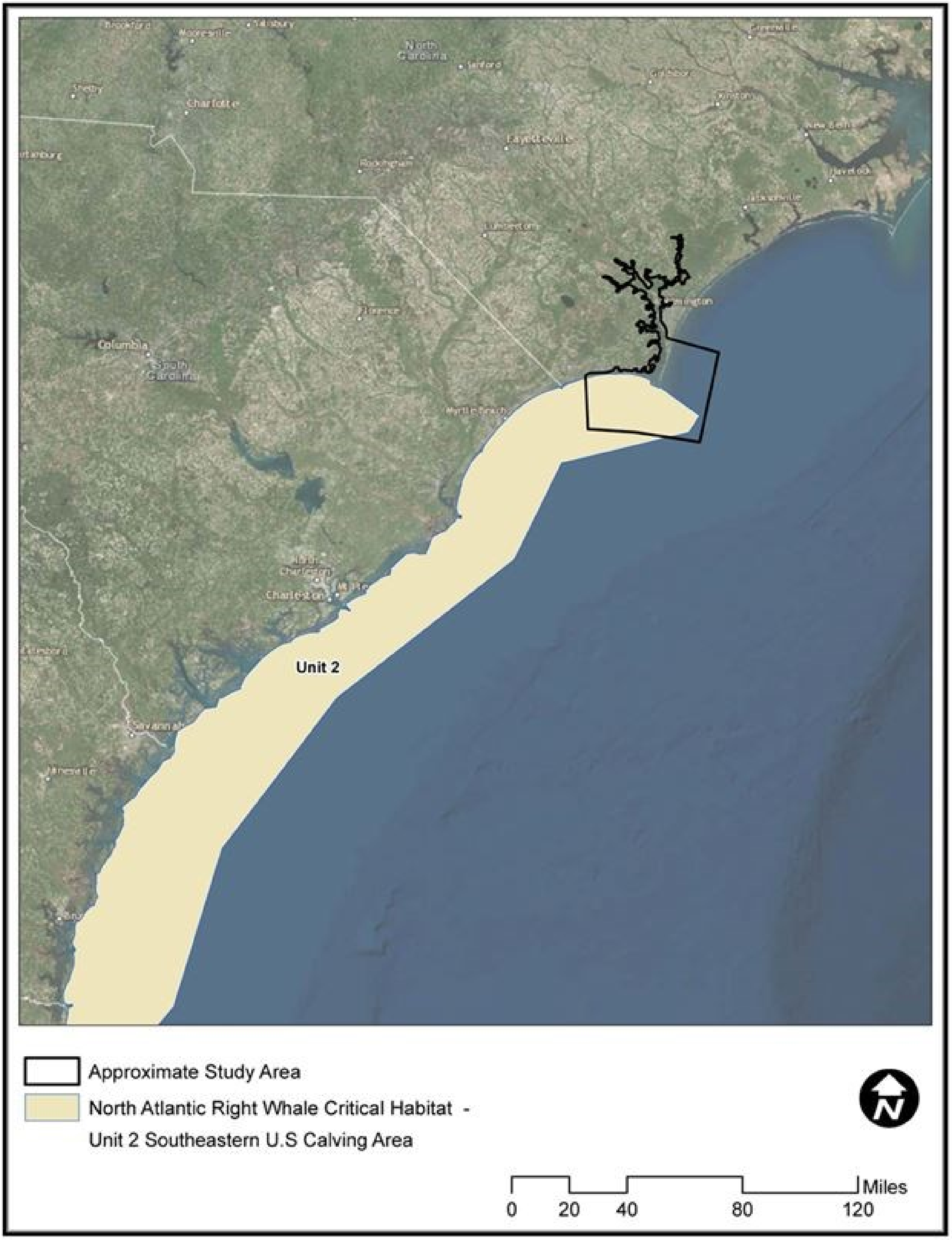

Figure 3-10
North Atlantic Right Whale Critical Habitat – Southeastern U.S. Calving Area

3.14.2 Florida Manatee

The Florida manatee (*Trichechus manatus latitostris*), a subspecies of the West Indian manatee, was originally listed as endangered in 1967 (32 FR 4001) under the Endangered Species Preservation Act of 1966. In 1969, the endangered listing was expanded to include the Antillean manatee (*T. manatus manatus*), a subspecies occurring in the Caribbean and South America. In 2017, both subspecies were reclassified as threatened throughout their ranges (82 FR 16668). Manatees are intolerant of cold water temperatures; and consequently, are generally restricted to warm water sites of peninsular Florida during the winter. In the spring as water temperatures reach 68°F, manatees disperse from winter sites and can undertake extensive movements along the coast and up rivers and canals (USFWS 2001). Manatees inhabit marine, brackish, and freshwater environments where they are found in seagrass beds, salt marshes, freshwater bottom areas, and many other habitat types. Manatees feed on a wide variety of submerged, floating, and emergent vegetation. Seagrasses are a staple in coastal habitats, and preferred foraging habitats consist of shallow seagrass beds with access to deep water. Manatees are also known to feed on salt marsh vegetation (i.e., smooth cordgrass), which they access at high tide. Although manatees tolerate a wide range of salinities, they prefer areas where osmotic stress is minimal or areas that have a natural or artificial source of fresh water (USFWS 2001). The principal anthropogenic threats to manatees include watercraft strikes, entrapment and/or crushing in water control structures, entanglement in fishing gear, and ingestion of marine debris. Of 1,877 deaths that were attributed to anthropogenic causes between 1978 and 2007; the majority (82%) were attributed to watercraft strikes. Water control structures accounted for ten percent of the deaths, and the remaining eight percent were attributed to a combination of entanglement, ingestion of marine debris, entrapment in pipes and culverts, and other human causes (USFWS 2009).

Cummings et al. (2014) described the temporal and spatial distribution of manatees in NC based on sighting and stranding records from 1991-2012. Although sightings were reported along the entire NC coast, most were concentrated around the densely populated areas of Wilmington and Beaufort, NC. Sightings were most common in the Atlantic Intracoastal Waterway (AIWW); however, manatees were also observed in sounds, bays, rivers, creeks, marinas, and the open ocean. Of 99 opportunistic sightings and nine strandings that were reported in NC between 1991 and 2012, nearly all (93%) occurred between June and October when water temperatures were above 68°F. Dramatic rapid declines in water temperature during the early fall can be hazardous to manatees that have not departed NC waters for Florida. Sightings reported from the mainstem Cape Fear River were confined to the lower estuary near the river mouth; however, two sightings were reported in the Northeast Cape Fear River ~20 to 30 river miles above Wilmington. A number of additional manatee sightings were reported from the AIWW behind Oak Island and Myrtle Grove Sound behind Carolina Beach.

3.14.3 Other Marine Mammals

Based on sightings, strandings, bycatch data, and habitat associations; a total of 38 marine mammal species may occur off the southern NC coast [Department of the Navy (DoN) 2008a and b]. Included among these species are 33 cetaceans (whales, dolphins, and porpoises), four pennipeds (seals, sea lions, and fur seals), and one sirenian (Florida manatee). The majority of these species are not expected to occur in the nearshore waters of the study area. Many are associated with offshore waters near the continental shelf break or beyond, while a number of others are known only from stranding records or rare sightings that are considered extralimital to their normal range. The species addressed in this section are limited to those that are resident, seasonally present, or migratory within the study area based on their documented ranges and habitat preferences; including the North Atlantic right whale, humpback whale (*Megaptera novaeangliae*), bottlenose dolphin (*Tursiops truncates*), Atlantic spotted dolphin (*Stenella frontalis*), and Florida Manatee. The North Atlantic right whale and Florida Manatee are listed under the ESA and were addressed in the previous section. The remaining three species are addressed below.

3.14.3.1 Humpback Whale

Humpback whales occurring in the US North Atlantic belong primarily to the Gulf of Maine feeding stock, although individuals from Canadian populations have also been sighted in US waters (Barco et al. 2002). Based on mark-recapture studies from 2008, the minimum population estimate for the Gulf of Maine stock is 823 individuals (Waring et al. 2014). In the western North Atlantic, humpbacks are widely distributed and their occurrence is strongly seasonal. During spring and summer, the largest numbers of humpback whales in US waters are found off the northeast and mid-Atlantic coasts [Cetacean and Turtle Assessment Program (CETAP) 1982, Whitehead 1982, Kenney and Winn 1986, Weinrich et al. 1997, Hamazaki 2002, and Stevick et al. 2008]. During the winter, many individuals migrate to calving grounds in the West Indies (Dawbin 1966, Whitehead and Moore 1982, Smith et al. 1999, and Stevick et al. 2003); however, significant numbers of humpbacks have been found at mid- and high latitudes during this time, suggesting that not all individuals undertake seasonal migrations (Dawbin 1966, Clapham et al. 1993, Swingle et al. 1993, Charif et al. 2001, and Clapham 2009). Humpbacks have been sighted in mid-Atlantic waters during all seasons and the waters from New Jersey to NC may be used as a supplemental winter feeding ground (Barco et al. 2002).

Although humpback whales typically travel over deep oceanic waters during migration, their feeding and breeding habitats are primarily located in shallow coastal waters (Clapham and Mead 1999). Females with calves in particular are associated with relatively shallow waters compared with breeding adults and other groups of humpbacks that use deeper offshore waters (Smultea 1994, Ersts and Rosenbaum 2003). The humpback whale is one of the most common baleen whales to strand along the NC coast (Byrd et al. 2014). Strandings recorded between 1997 and 2008 consisted entirely of immature humpback whales. According to Wiley et al. (1995), juveniles may spend time feeding at mid-latitudes instead of migrating as farther south with the adults. Most NC humpback whale sightings are concentrated off Cape Hatteras during winter and spring. A few sightings and strandings have been recorded off southeastern NC during these seasons (DoN 2008a and b).

3.14.3.2 Bottlenose and Atlantic Spotted Dolphins

Bottlenose dolphins may be present in both estuarine and nearshore marine waters throughout the year, although estuarine occurrences peak during summer and most winter sightings are from the nearshore ocean (DoN 2008a and b). Bottlenose dolphins along the South Atlantic coast include both resident and migratory populations. A resident population at Beaufort, NC is the northernmost documented site of year-round bottlenose dolphin residency in the western North Atlantic (Koster et al. 2000). Atlantic spotted dolphins occur regularly in inshore waters south of Chesapeake Bay (Mullin and Fulling 2003). In the Cape Fear River estuary, bottlenose dolphins have been observed at and upriver of Wilmington (USACE 2000). Nearshore sightings of

Atlantic spotted dolphins have been recorded along the NC coast during winter, spring, and summer (DoN 2008a and b).

3.14.4 Atlantic Sturgeon

Atlantic sturgeons are listed under the federal ESA as five Distinct Population Segments (DPSs); including four that are endangered (New York Bight, Chesapeake Bay, Carolina, and South Atlantic) and one that is threatened (Gulf of Maine). The Carolina DPS encompasses subpopulations from the Roanoke, Tar/Pamlico, Cape Fear, Waccamaw, Pee Dee, and Santee-Cooper Rivers in NC and South Carolina. The spawning population in each of the Carolina DPS river systems is thought to number less than 300 adults [Atlantic Sturgeon Status Review Team (ASSRT) 2007]. Atlantic sturgeons spawn in freshwater, but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in the spring/early summer (ASSRT 2007). Spawning is believed to occur in flowing water between the salt front and fall line of large rivers. Post-larval juveniles move downstream into brackish waters and eventually move to estuarine waters where they reside for a period of months or years (Moser and Ross 1995). Subadult and adult Atlantic sturgeons emigrate from rivers into coastal waters where they may undertake long range migrations; however, adults return to their natal river to spawn (ASSRT 2007). Atlantic sturgeon are benthic omnivores that filter quantities of mud along with their food. Adults consume mollusks, gastropods, amphipods, isopods, and fish; while juveniles feed on aquatic insects and other invertebrates (ASSRT 2007). According to the ASSRT (2007), projects that may adversely affect sturgeon include dredging; pollutant or thermal discharges; bridge construction/removal; dam construction, removal and relicensing; and power plant construction and operation. Other stressors on the populations are bycatch mortality, habitat impediments (e.g., Cape Fear and Santee-Cooper rivers), and apparent ship strikes (e.g., Delaware and James rivers).

Atlantic sturgeons were historically abundant in most NC coastal rivers and estuaries; however, at the time of its listing under the ESA, the Carolina DPS spawning population was estimated at less than 300 individuals (NMFS 2012a). Extant spawning populations in NC are currently known from the Roanoke, Tar-Pamlico, Cape Fear, and potentially the Neuse River systems (ASSRT 2007). Gill net surveys in the Cape Fear River system have captured substantial numbers of Atlantic sturgeon in the Cape Fear River mainstem, Brunswick River, and Northeast Cape Fear River (Moser and Ross 1995, ASSRT 2007). Subadult Atlantic sturgeons in the Cape Fear River system exhibit seasonal movements and distribution patterns; moving upriver during the summer and migrating out of the river to estuarine or ocean waters during the coldest time of the year (Post et al. 2014). High inter-annual return rates of tagged fish demonstrate fidelity to the Cape Fear River system; indicating that the Cape Fear River system may be the natal river system for these individuals (Post et al. 2014). Reports of Atlantic sturgeon above Lock and Dam #1 indicate that some fish are successful at passing Lock and Dam #1 via the recently constructed rock arch ramp. Although eggs have not been detected, the collective body of evidence suggests that both the Northeast Cape Fear River and Cape Fear River may be important spawning areas. Laney et al. (2007) analyzed Atlantic sturgeon incidental capture data from winter tagging cruises along the NC and Virginia coasts. Cruises conducted in nearshore ocean waters from Cape Lookout to Cape Charles, Virginia captured 146 Atlantic sturgeons between 1988 and 2006. Captures typically occurred over sand substrate in nearshore waters that were less than 60 ft deep. Laney et al. (2007) concluded that shallow nearshore ocean waters along the NC coast are an important winter (January-February) habitat and aggregation area for the Atlantic sturgeon.

In 2017, the NMFS designated critical habitat for the Carolina DPS in the large spawning river systems; including the Roanoke, Tar-Pamlico, Neuse, Cape Fear, and Pee Dee Rivers. Portions of both the Cape Fear River and Northeast Cape Fear River were designated as critical habitat for the Carolina DPS. Carolina Unit 4 encompasses the Cape Fear River main stem from river kilometer (rkm) 0 up to Lock and Dam #2 and the Northeast Cape Fear River from its confluence with the Cape Fear River to Rones Chapel Road Bridge at Mount Olive, NC (Figure 3-11). The physical or biological features (PBFs) of Atlantic sturgeon critical habitat that are essential to the conservation of the species include hardbottom substrate in low salinity waters for egg settlement and early life stage development; aquatic habitat encompassing a gradual salinity gradient (0.5-30 ppt) and softbottom (sand/mud) substrate for juvenile foraging and development; waters of sufficient depth and absent physical barriers to passage to support unimpeded movements of adults, subadults, and juveniles; and water quality conditions (temperature and oxygen) that support spawning, survival, development, and/or recruitment of the various life stages (82 FR 39160).

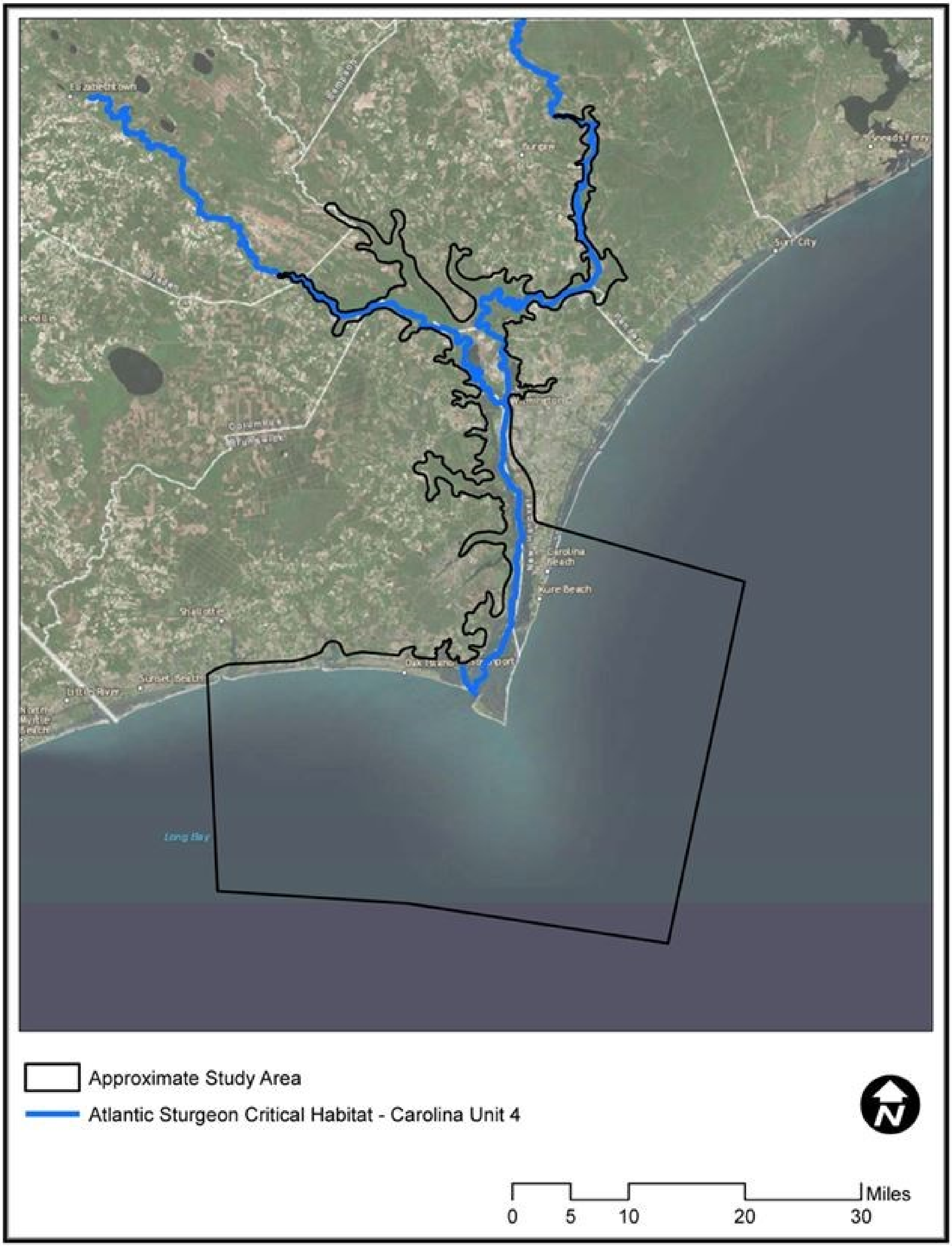

Figure 3-11
Atlantic Sturgeon Critical Habitat – Carolina Unit 4

3.14.5 Shortnose Sturgeon

The shortnose sturgeon was listed as endangered throughout its range on 11 March 1967 (32 FR 4001). The shortnose sturgeon inhabits large Atlantic coast rivers from the St. Johns River in northeastern Florida to the Saint Johns River in New Brunswick, Canada. Shortnose sturgeons occur primarily in slower moving rivers or nearshore estuaries associated with large river systems. Adults in southern rivers are estuarine anadromous, foraging at the saltwater-freshwater interface and moving upstream to spawn in the early spring. Shortnose sturgeons spend most of their life in their natal river systems and rarely migrate to marine environments. However, genetic studies indicate that some individuals move between the various spawning populations (Quattro et al. 2002, Wirgin et al. 2005). Spawning habitats include river channels with gravel, gravel/boulder, rubble/boulder, and gravel/sand/log substrates. Spawning in southern rivers begins in later winter or early spring and lasts from a few days to several weeks. Juveniles occupy the saltwater-freshwater interface, moving back and forth with the low salinity portion of the salt wedge during summer. Juveniles typically move upstream during the spring and summer and move downstream during the winter, with movements occurring above the saltwater-freshwater interface. In southern rivers, both adults and juveniles are known to congregate in cool, deep thermal refugia during the summer. Shortnose sturgeons are benthic omnivores feeding on crustaceans, insect larvae, worms, and mollusks. Juveniles randomly vacuum the bottom and consume mostly insect larvae and small crustaceans. Adults are more selective feeders, feeding primarily on small mollusks (NMFS 1998).

The shortnose sturgeon was thought to be extirpated from NC waters until an individual was captured in the Brunswick River in 1987 (Ross et al. 1988). Subsequent gill-net studies (1989-1993) confirmed the presence of a small shortnose sturgeon population in the lower Cape Fear River below Lock and Dam #1. Tagged shortnose sturgeons were found to move throughout the lower river from rkm 16 up to Lock and Dam #1 (rkm 96) (Moser and Ross 1995). Gravid females engaged in directed upstream migrations that suggested the possible existence of a reproducing population above Lock and Dam #1 (Moser and Ross 1995); however, the current distribution, abundance, and reproductive status of shortnose sturgeon in the Cape Fear River is unknown (Shortnose Sturgeon Status Review Team 2010). No critical habitat has been designated for the shortnose sturgeon.

3.14.6 Sea Turtles

3.14.6.1 Loggerhead Sea Turtle

The loggerhead sea turtle (*Caretta caretta*) was initially listed under the ESA as threatened throughout its range on 28 July 1978 (43 FR 32800). In 2011, the loggerhead's ESA status was revised to threatened and endangered based on the recognition of nine DPSs. Distinct population segments encompassing populations in the Northwest Atlantic Ocean, South Atlantic Ocean, Southwest Indian Ocean, and Southeast Indo-Pacific Ocean were reclassified as threatened; while the remaining five populations in the Northeast Atlantic Ocean, Mediterranean Sea, North Pacific Ocean, South Pacific Ocean, and North Indian Ocean were reclassified as endangered. Nesting in the US occurs along the Atlantic and Gulf coasts from southern Virginia to Texas, but is concentrated from NC through Alabama (NMFS and USFWS 2008). Nesting populations along the southeastern US coast from southern Virginia to the Florida-Georgia border comprise the Northern Recovery Unit, one of five designated recovery units within the Northwest Atlantic

DPS (USFWS 2009). Nesting in the Northern Recovery Unit had been declining at an annual rate of 1.3% through 2007; however, nesting has increased substantially since 2008, with the three highest annual nest totals on record occurring in 2012, 2013, and 2015. Similar nesting increases throughout the Northwest Atlantic DPS since 2007 indicate that the population may be stabilizing (USFWS 2015).

Adult female loggerheads return to their natal region to nest, and show a high degree of site fidelity to the nesting beach selected during their initial reproductive season, typically nesting during subsequent years within zero to three miles of the initial nesting site (Miller et al. 2003). A variety of different substrates and beach slopes are used for nesting, but loggerheads appear to prefer relatively narrow, steeply sloped, coarse-grained beaches (Provancha and Ehrhart 1987). Slope has been found to have more influence on nest-site selection than temperature, moisture, and salinity; and nest sites along a given beach are typically located on the steepest slopes, which generally correspond to the highest elevations on the beach (Wood and Bjorndal 2000). Loggerheads require deep, clean, relatively loose sand above the high-tide line for successful nest construction (Hendrickson 1982). Embryonic development requires a high-humidity substrate with sufficient gas exchange (Mortimer 1990, Miller 1997, and Miller et al. 2003). Hatchlings emerge from their nests en masse almost exclusively at night, and initial emergences are sometimes followed by secondary emergence events on subsequent nights (Carr and Ogren 1960, Witherington 1986, Ernest and Martin 1993, and Houghton and Hays 2001). Hatchlings use light cues to guide their movement from the nest to the surf zone, relying on the contrast between the relatively bright ocean horizon and the relatively dark dune line (Daniel and Smith 1947, Limpus 1971, Salmon et al. 1992, Witherington and Martin 2003, and Witherington 1997).

Loggerhead nesting occurs along the entire NC coast, but is concentrated along three sections of the coast; including the Cape Fear region from Holden Beach to Fort Fisher, Topsail Island, and Onslow Beach, and the barriers that comprise Cape Lookout National Seashore (CALO) and Cape Hatteras National Seashore (CAHA). Collectively, these three sections of the coast accounted for 83% of all loggerhead nesting in NC from 2000-2016. Nesting in NC is typically restricted to the period of 1 May to 15 September. Relatively few nests are recorded during the first three weeks of May, but nesting increases rapidly from late May onward, peaking from mid-June through the end of July. Nesting declines abruptly after July, and few nests are recorded after the third week of August. The Cape Fear region from Holden Beach to Fort Fisher supports the highest concentration of loggerhead nesting in NC, accounting for 30% of all loggerhead nests recorded in the state from 2000-2016. The average annual nest density for the region was 7.5 nests per mile from 2000-2016. A total of 1,196 loggerhead nests were recorded on Bald Head Island from 2000-2016, while 1,958 nests were recorded on Caswell Beach/Oak Island (Table 3-11). Annual nesting from 2000-2016 averaged 70 nests per year on Bald Head and 115 nests per year on Caswell Beach/Oak Island.

Table 3-11
Cape Fear Region Sea Turtle Nests 2000-2016

Shoreline Reach	Loggerhead	Green	Leatherback	Kemp's Ridley
Fort Fisher	516	4	0	1
Bald Head Island	1196	25	1	0
Caswell Beach	850	0	0	0
Oak Island	1108	3	0	0
Holden Beach	608	2	1	0
Total	**4278**	**34**	**2**	**1**

Source: NCWRC 2015, Seaturtle.org 2017

The USFWS and NMFS have designated terrestrial (79 FR 39756) and marine (79 FR 39855) critical habitat units for the loggerhead sea turtle along the US South Atlantic and Gulf Coasts from NC to Mississippi. In NC, eight loggerhead terrestrial critical habitat units encompassing approximately 96 miles of nesting beaches have been designated along the southern coast from Beaufort Inlet to the Shallotte River in Brunswick County (79 FR 39756). Designated marine critical habitat units along the NC coast include areas containing nearshore reproductive habitat, wintering habitat, breeding areas, and migratory corridors. Three designated nearshore reproductive critical habitat units encompass all nearshore waters along the 96 miles of designated nesting beaches from the MHW line to 1.6 kilometers (km) offshore. A single winter critical habitat unit encompasses offshore waters between the 20-m and 100-m bathymetric contours between Cape Hatteras and Cape Fear, and a single constricted winter habitat unit encompasses waters between the shoreline and the 200-m bathymetric contour from Cape Lookout north to Oregon Inlet. In the Cape Fear region, four terrestrial critical habitat units encompass all of ocean-facing beaches from Carolina Beach Inlet to Shallotte Inlet; including Pleasure Island/Fort Fisher, Bald Head Island, Oak Island, and Holden Beach (Figure 3-12). All waters from the MHW line out to 1.6 km along the designated terrestrial units are part of a single nearshore reproductive critical habitat unit that extends continuously from Carolina Beach Inlet to Shallotte Inlet (Figure 3-12). The inner boundary (20-m contour) of the winter critical habitat unit is located ~11 nm (13 m) seaward of the east-facing beaches to the north of Cape Fear northward (Figure 3-12).

Terrestrial critical habitat units encompass the dry ocean beach from the MHW line landward to the toe of the secondary dune or the first developed structure. The units represent beaches that are capable of supporting a high density of nests or those that are potential expansion areas for beaches with high nest densities. Critical nesting habitat primary constituent elements (PCEs) include unimpeded ocean-to-beach access for adult females and unimpeded nest-to-ocean access for hatchlings, substrates that are suitable for nest construction and embryonic development, a sufficiently dark nighttime environment to ensure that adult females are not deterred from nesting and that hatchlings are not disoriented and delayed or prevented from reaching the ocean,

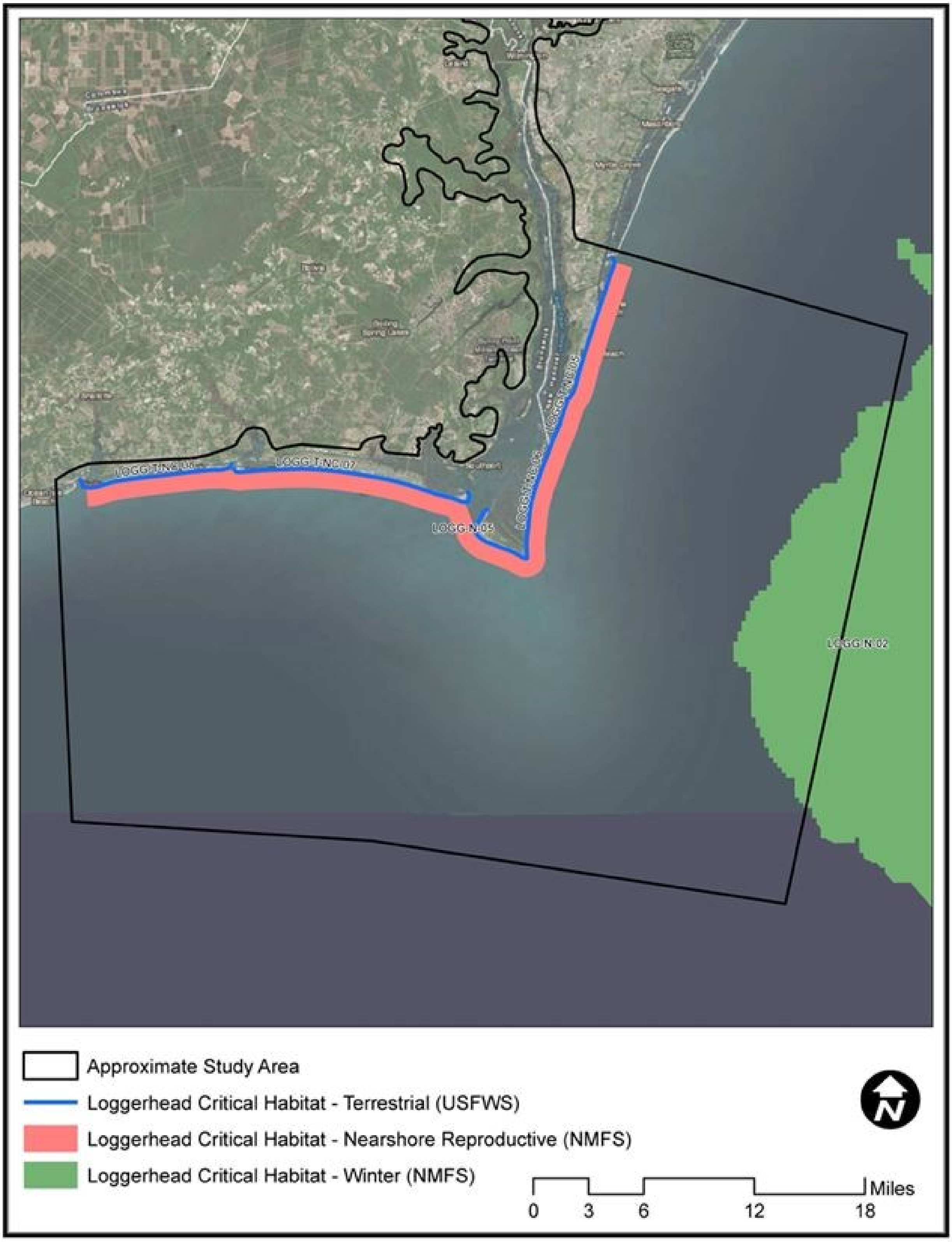

Figure 3-12
Loggerhead Critical Habitat

and natural coastal processes that maintain suitable nesting habitat or artificially maintained habitats that mimic those associated with natural processes (79 FR 39756). The corresponding nearshore marine critical habitat units represent reproductive habitat along nesting beaches that is used by hatchlings for egress to the open ocean and by nesting females for movements between beaches and the open ocean during the nesting season. Critical nearshore reproductive habitat PCEs include nearshore waters directly off the highest density nesting beaches and their adjacent beaches, waters sufficiently free of obstructions and artificial lighting to allow transit through the surf zone to open water, and waters with minimal manmade structures that could promote predators, disrupt wave patterns necessary for orientation, and/or create excessive longshore currents (79 FR 39855). Winter critical habitat encompasses warm waters south of near the western edge of the Gulf Stream that are used by a high concentration of juveniles and adults during the winter. Primary constituent elements include water temperatures above 10°C from November through April, continental shelf waters in proximity to the boundary of the Gulf Stream, and water depths between 20 and 100 m.

3.14.6.2 Green Sea Turtle

The green sea turtle (*Chelonia mydas*) was initially listed as endangered and threatened under the ESA on 28 July 1978 (43 FR 32800). Breeding populations in Florida and along the Mexican Pacific Coast were listed as endangered, while all other populations throughout the species' range were listed as threatened. In 2011, the green sea turtle's ESA status was revised to threatened and endangered based on the recognition of eight DPSs (81 FR 20057). All green sea turtles in the North Atlantic were listed as threatened under the North Atlantic Ocean DPS. Additional DPSs in the South Atlantic, Southwest Indian, North Indian, East Indian-West Pacific, Southwest Pacific, Central North Pacific, and East Pacific were listed as threatened; while DPSs in the Mediterranean, Central West Pacific, and Central South Pacific were listed as endangered. Nesting in the US is primarily limited to Florida, although nesting occurs in small numbers along the southeast coast from Georgia to NC and the Gulf Coast of Texas. Nesting turtles appear to prefer high wave energy barrier island beaches with coarse sands, steep slopes, and prominent foredunes; with the highest nesting densities occurring on sparsely developed beaches that have minimal levels of artificial lighting (Witherington et al. 2006). Nesting in Florida has increased exponentially over the last 20 years, with record highs of 36,195 and 37,341 nests recorded in 2013 and 2015, respectively [Florida Fish and Wildlife Conservation Commission (FWC)/Fish and Wildlife Research Institute (FWRI) 2016].

Green sea turtles nest in relatively small numbers along the NC coast, with reported nesting from 2000-2016 averaging 18 nests per year. Annual NC nest totals from 2000-2012 ranged from four to 26 nests. Nesting has increased since 2012, with the two highest nest totals on record occurring during 2013 (n=39) and 2015 (n=38). Annual average of 27 nests from 2013-2018. Green sea turtle nesting records span the entire NC coast, but are concentrated along the barrier islands of CALO and CAHA. Together, CALO and CAHA accounted for 63% of all reported nesting in NC from 2000 to 2016. Areas supporting consistent nesting in small numbers include Bald Head Island, Topsail Island, and Onslow Beach; which collectively account for 17% of all reported nesting in NC from 2000-2016. Nesting along the remainder of the NC coast has generally occurred sporadically in very small numbers. Nesting data show a peak in activity from the last week of June through the third week of August, with 79% of all nesting occurring during this period. A total of 25 green sea turtle nests were recorded on Bald Head Island from

2000-2016, while just three nests were recorded on Caswell Beach/Oak Island (Table 3-11 above).

In US waters, green sea turtles are distributed along the Atlantic and Gulf Coasts from Massachusetts to Texas (NMFS and USFWS 2007a). Post-hatchlings migrate to oceanic waters and begin an oceanic juvenile phase of development. Oceanic phase juveniles appear to move with the predominant ocean gyres for several years before returning to neritic waters where juvenile development continues to adulthood. Neritic phase juveniles inhabit shallow estuarine waters and nearshore continental shelf waters that are rich in seagrasses and/or marine macroalgae. Adults generally remain in relatively shallow foraging habitats with abundant seagrasses and macroalgae, but may enter the oceanic zone when migrating between foraging grounds and nesting beaches. No critical habitat has been designated in the continental US.

3.14.6.3 Leatherback Sea Turtle

The leatherback sea turtle (*Dermochelys coriacea*) was listed under the ESA as endangered throughout its range on 2 June 1970 (35 FR 8491). The leatherback has a circumglobal oceanic distribution that extends north and south into sub-polar regions. During the summer and fall, the highest densities of adult and subadult leatherbacks in the North Atlantic have been reported in Canadian waters (James et al. 2005). However, little is known of the distribution and developmental habitat requirements of leatherbacks from hatchling to adulthood (NMFS and USFWS 2013). Adults undertake extensive migrations between northern foraging grounds and nesting beaches that are distributed throughout the tropical and subtropical regions of the Atlantic, Pacific, and Indian Oceans. Nesting in the US is primarily restricted to Florida, Puerto Rico, and the US Virgin Islands; but nesting occurs in small numbers along the Gulf Coast of Texas and the southeastern US Atlantic Coast from Georgia to NC. Nesting in Florida has increased substantially over the last 20 years, with the two highest nest totals on record occurring during 2009 (n=1,747) and 2012 (n=1,712). Leatherback nesting is rare in NC, with just 33 nests reported from 2000-2016. Of the eight years that had reported nesting events, statewide annual totals ranged from one to nine nests. Leatherback nesting records are heavily concentrated along the barrier islands of CALO and CAHA, which accounted for 82% of all reported leatherback nesting in NC from 2000-2016. Leatherback nesting along the remainder of the NC coast from 2000-2016 was limited to two nests along Bogue Banks and one nest each along Carolina Beach, Bald Head Island, and Holden Beach. Reported nest establishment dates in NC range from 16 April to 30 July. The potential for leatherbacks to nest as early as late February (Meylan et al. 1995) suggests the possibility that some early nests in NC may be missed by monitoring efforts that generally begin in May.

3.14.6.4 Kemp’s Ridley Sea Turtle

The Kemp’s ridley sea turtle (*Lepidochelys kempii*) was listed as endangered throughout its range on 2 December 1970 (35 FR 18320). Kemp’s ridley sea turtles occur primarily in coastal waters of the Gulf of Mexico and the western North Atlantic Ocean. Data indicate that adults utilize coastal habitats of the Gulf of Mexico and the southeastern US. Adults inhabit nearshore waters and are commonly found over crab-rich sandy or muddy bottoms (NMFS and USFWS 2007b). Nesting is primarily restricted to coastal beaches along the Mexican states of Tamaulipas and Veracruz, nesting in small numbers occurs consistently along the Gulf Coast of Texas (Turtle Expert Working Group 1998). Rare nesting events occur along the Gulf Coast of

Alabama and the southeastern US Atlantic Coast from Florida to NC. A total of 80 Kemp's ridley nests were documented in Florida from 1979 to 2013 (FWC/FWRI 2016). Kemp's ridley nesting is extremely rare in NC, with just 12 nests reported from 2000-2016. Of the 12 nests, eight were reported north of Cape Lookout along the Outer Banks. Reported nest establishment dates range from 25 May to 23 June. Kemp's ridley nesting records for the Cape Fear region are limited to one nest at Fort Fisher in 2015. Hatchlings migrate to the oceanic zone where they are carried by currents into various areas of the Gulf of Mexico and the North Atlantic Ocean. At approximately two years of age, juveniles leave the oceanic zone and move to coastal benthic habitats in the Gulf of Mexico and the Atlantic Ocean along the eastern United States. During this stage, juveniles occupy protected coastal waters such as bays, estuaries, and nearshore waters that are less than 165 feet deep. Juveniles utilize a wide range of bottom substrates but apparently depend on an abundance of crabs and other invertebrates (NMFS and USFWS 2007b). No critical habitat has been designated for the Kemp's ridley sea turtle.

3.14.6.5 Hawksbill Sea Turtle

The hawksbill sea turtle (*Eretmochelys imbricata*) was listed as endangered throughout its range on 2 June 1970 (35 FR 8491). Hawksbill sea turtles are distributed circumglobally in tropical and to a lesser extent subtropical waters of the Atlantic, Indian, and Pacific Oceans. Nesting occurs on sandy beaches throughout the tropical and subtropical regions of the Atlantic, Pacific, and Indian Oceans. Nesting in the US is primarily limited to Florida, Puerto Rico, and the US Virgin Islands (NMFS and USFWS 1993). Marine and nesting critical habitats for the hawksbill sea turtle have been designated in Puerto Rico (63 FR 46693). Rare nesting events in the continental US are essentially restricted to the southeastern coast of Florida and the Florida Keys (Meylan 1992; Meylan et al. 1995). A total of 46 hawksbill nests were documented in Florida from 1979-2013 (FWC/FWRI 2016). Nesting records in NC are limited to two nests at CAHA that were identified through DNA testing in 2015 (National Park Service 2015). Although documented nesting in the continental US is extremely rare, the similarity of hawksbill tracks to those of the loggerhead suggests that some hawksbill nesting may go undetected along the southeastern US coast (USFWS 2015, Meylan et al. 1995). In US waters, hawksbills have been reported along the Atlantic and Gulf Coasts from Massachusetts through Texas; however, sightings north of Florida are rare. Hawksbills are commonly observed in the Florida Keys and on reefs off the coast of Palm Beach County, Florida. Texas is the only other state where sightings occur with any regularity. Hatchlings are carried by currents to the oceanic zone where they reside in major ocean gyres. Juveniles eventually depart the oceanic zone and move to nearshore habitats. Juveniles and adults are primarily associated with coral reef habitats; but may use other habitats such as hardbottoms, seagrass beds, algal beds, mangrove bays and creeks, and mud flats. Adults undertake extensive migrations between foraging grounds and nesting beaches (NMFS and USFWS 2007c).

3.14.6.6 Spatial and Temporal Distribution of Non-Breeding Sea Turtles

North Carolina's sounds and estuaries provide important developmental and foraging habitats for post-pelagic juvenile loggerhead, green, and Kemp's ridley sea turtles. Most of the information regarding the inshore distribution of sea turtles in NC has been generated by studies in the Pamlico-Albemarle estuarine complex, where large numbers of loggerhead, green, and Kemp's ridley sea turtles are incidentally captured annually by commercial fishing operations. All three species are represented primarily by juveniles, with few reported captures of older juveniles and adults (Epperly et al. 2007). All three species move inshore during the spring and disperse throughout the sounds during the summer. All three species leave the sounds and move offshore during the late fall and early winter. Epperly et al. (1995a) reported the presence of sea turtles in back-barrier estuaries along the NC coast from April through December. Goodman et al. (2007) reported the presence of sea turtles in Core and Pamlico Sounds and the nearshore (≤1 mile) ocean waters of Raleigh Bay from April through November. Juvenile loggerhead, green, and Kemp's ridley sea turtles utilize the lower Cape Fear River estuary during the warmer months. Sea turtles have been observed in the Cape Fear River estuary as far upstream as river mile 15 (NMFS 2012b). Although there are no published data on the distribution and movements of juvenile sea turtles in the Cape Fear River estuary, during a tracking study of 18 gill-netted green and Kemps ridley juveniles in the lower estuary, only one individual (a presumed mortality) moved north of Snows Cut (Snoddy and Williard 2010).

Several studies have reported a strong relationship between sea turtle distribution and sea surface temperature. Goodman et al. (2007) conducted aerial sea turtle surveys and sea surface temperature monitoring in Core Sound, Pamlico Sound, and adjacent nearshore ocean waters within one mile of shore from July 2004 to April 2006. All but one of the 92 sea turtle observations occurred in waters where sea surface temperatures were above 11°C. All sightings in the sounds occurred between 16 April and 20 November, and all sightings in the nearshore ocean occurred between 23 April and 27 November. The winter distribution of sea turtles offshore of Cape Hatteras was also correlated with sea surface temperatures above 11°C (Epperly et al. 1995c). In a similar study by Coles and Musick (2000), sea turtle distribution offshore of Cape Hatteras (from shore to edge of Gulf Stream) was restricted to sea surface temperatures ≥13.3°C.

The leatherback sea turtle is primarily a pelagic species preferring deep, offshore waters. Leatherbacks may be present in nearshore ocean waters during certain times of the year; however, they rarely enter estuarine waters. Epperly (1995b) reported the appearance of significant numbers of leatherback turtles in nearshore ocean waters during May, coincident with the appearance of jellyfish prey. Sightings declined sharply after four weeks and only a few sightings were reported after late June. Leatherbacks were infrequently observed in estuarine waters during this period. The surveys conducted by Goodman et al. (2007) recorded only one leatherback observation, during the summer in the nearshore ocean south of Cape Hatteras. Epperly et al. (1995a) reported the occurrence of three leatherbacks in Core and Pamlico Sounds during December 1989. Hawksbill sea turtles are rare in NC waters, and they rarely enter estuarine waters (Epperly et al. 1995a). A total of nine hawksbill stranding incidents were reported along NC beaches between 1998 and 2009 (Seaturtle.org 2011). Strandings were reported during the months of January, March, April, and November. Epperly et al. (1995b) reported the incidental capture of one hawksbill in Pamlico Sound.

3.14.7 Piping Plover

The piping plover (*Charadrius melodus*) was listed as endangered and threatened under the ESA on 10 January 1986 (50 FR 50726 – 50734). The final listing rule recognized three demographically independent populations that breed in three separate regions: the Atlantic Coast from NC to Canada, the Great Lakes watershed, and the Northern Great Plains region. Birds that breed along the Atlantic Coast are recognized as the subspecies *C. m. melodus*, while birds belonging to the interior Great Lakes and Northern Great Plains breeding populations are recognized as the subspecies *C. m. circumcinctus* (Miller et al. 2010). The piping plover is classified as endangered within the Great Lakes watershed and as threatened throughout the remainder of its breeding, migratory, and wintering range. The shared migratory and wintering range of the three breeding populations encompasses the Atlantic and Gulf Coasts from NC to northern Mexico, as well as the Bahamas and the West Indies. Outside of their breeding range, birds belonging to the endangered Great Lakes breeding population are indistinguishable from those belonging to the threatened Great Plains and Atlantic coast populations; and consequently, all piping plovers are classified as threatened within their shared migratory and wintering range (USFWS 2009). The 2009 status update identified the principal continuing threats to the recovery of the species as habitat loss attributable to beach stabilization and inlet management projects, human disturbance associated with vehicular and pedestrian recreational activities, and predation attributable to native wildlife and free-roaming and feral domestic animals (USFWS 2009).

Annual NC breeding pair estimates from 2000-2017 averaged 47 pairs. Annual estimates ranged from a low of 20 pairs in 2004 to a high of 70 pairs in 2012. Annual estimates since 2012 have ranged from 43 to 65 pairs. The vast majority of all breeding activity in NC occurs along the barrier islands of CALO and CAHA, which have accounted for 90% of all estimated breeding pairs in NC since 2000. Annual 2000-2017 estimates for the southern NC coast (south of CALO) ranged from two to nine breeding pairs (average = five pairs). Breeding activity along the southern NC coast is essentially restricted to the Lea-Hutaff Island/New Topsail Inlet complex and the north end of Bear Island. Collectively, these areas account for 89% of all southern NC coast breeding pair observations since 2000. Since 2000, 97% of all NC breeding pair observations and nest sites have occurred on undeveloped barrier islands. Furthermore, 79% of all breeding activity has occurred on undeveloped barriers that are also unstabilized; including North Core Banks (NCB), South Core Banks (SCB), Bear Island, Onslow Beach, and Lea-Hutaff Island. The accreting south end of Topsail Island along New Topsail Inlet is the only site associated with a developed island that supports any notable breeding activity in NC. Since 2000, all other developed islands in NC combined have accounted for just four breeding pair observations (Table 3-12). Breeding pair observations in the Cape Fear region from 2000-2017 include just two pairs at Fort Fisher; one each during 2002 and 2005.

Piping plovers from all three breeding populations use barrier island habitats along the NC coast as migratory stopover and/or wintering sites during the non-breeding season. The habitat use patterns of non-breeding plovers in NC are characterized by movements between different inlet complex habitats (Cameron 2006). Some sites are used exclusively for foraging while others are used for roosting.

Wintering plovers at Oregon Inlet primarily used back-barrier tidal flats and dredged material disposal islands for foraging; while the ocean beach within one mile of the inlet was the primary site used for roosting, preening, and being alert (Cohen et al. 2008). Foraging habitat use was influenced by tidal stage, with plovers exhibiting a preference for the dredged material disposal islands as the associated intertidal zones were exposed on the falling tide. The habitat preferences of wintering and migratory plovers are generally similar; however, there are some sites that are more important for migrating plovers (e.g., Ocracoke Inlet) and some that are more important for wintering plovers (e.g., Shackleford Banks and Bird Shoals) (Cameron 2006).

Comprehensive survey data for spring and fall migration periods along the southern NC coast are generally lacking; and consequently, patterns of migratory distribution and abundance along

Table 3-12
Annual NC piping plover breeding pair estimates 2000-2017

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
NORTHERN REGION																			
CAHA	4	3	2	3	3	3	5	6	11	9	12	15	15	9	14	12	12	7	**145**
PINWR	2	1	2	1	0	0	0	0	0	0	1	1	1	0	2	5	6	2	**24**
CALO NCB/SCB	16	16	15	14	13	26	33	46	46	37	42	41	51	45	47	43	30	27	**588**
CALO Shackleford	-	-	-	-	-	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Regional Subtotal	**22**	**20**	**19**	**18**	**16**	**30**	**38**	**52**	**57**	**46**	**55**	**57**	**67**	**54**	**63**	**60**	**48**	**36**	**758**
SOUTHERN REGION																			
Bear Island/Bogue Inlet	0	0	0	0	0	0	1	1	1	1	1	1	2	0	0	2	2	0	**12**
Onslow Beach	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	2	**6**
North Topsail/New River Inlet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**2**
South Topsail/New Topsail Inlet	0	1	1	1	1	2	2	2	2	1	0	1	0	1	0	0	1	1	**17**
Lea-Hutaff	2	2	2	5	3	4	5	5	4	4	5	2	0	1	1	0	0	0	**45**
Figure 8 Island	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	**5**
Fort Fisher	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Ocean Isle	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**
Sunset Beach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
Regional Subtotal	**2**	**3**	**4**	**6**	**4**	**7**	**8**	**9**	**7**	**7**	**6**	**5**	**3**	**2**	**2**	**4**	**5**	**7**	**91**
STATEWIDE TOTAL	**24**	**23**	**23**	**24**	**20**	**37**	**46**	**61**	**64**	**53**	**61**	**62**	**70**	**56**	**65**	**64**	**53**	**43**	**849**
Average Annual Breeding Pair Total																			**47**

some portions of the southern coast remain poorly understood. However, data compiled by the NCWRC show that piping plovers use stopover sites at nearly all of the southern region inlets during migration (Cameron 2006). Efforts to monitor wintering plovers along the southern NC coast have primarily been limited to the International Piping Plover Winter Census (IPPWC); a range-wide survey of all known wintering sites conducted every five years. The results of the IPPWC surveys indicate that the distribution of wintering plovers along the southern NC coast is highly similar to that of the breeding population. Wintering plovers are highly concentrated at the Lea-Hutaff/New Topsail Inlet/South Topsail complex and the Bear Island/Bogue Inlet complex. Small numbers of winter residents have been observed along Fort Fisher and on the east end of Ocean Isle Beach at Shallotte Inlet (Table 3-13).

Table 3-13
International Piping Plover Winter Census

Site Name	Year				Total
	2001	2006	2011	2016	
Fort Fisher to Bald Head	2	3	0	0	**5**
Oak Island	0	0	0	0	**0**
Holden Beach	0	0	0	0	**0**
Ocean Isle	0	4	1	0	**5**
Sunset Beach/Bird Island	0	0	0	0	**0**
Total	**2**	**7**	**1**	**0**	**10**

3.14.7.1 Piping Plover Habitat

The breeding and nesting habitat requirements of piping plovers in NC are highly restricted to wide, sparsely-vegetated sand flats along the most dynamic and unstable reaches of barrier islands. Although NCB and SCB encompass ~48 miles of unstabilized ocean beach habitat, breeding sites are restricted to the dynamic inlet-influenced ends of the islands, the similarly dynamic cape point, recently deposited overwash fans, and recently closed inlets. In the southern region, breeding sites are essentially restricted to the inlet-influenced ends of a few undeveloped barriers and natural overwash deposits on Lea-Hutaff Island. The highly restricted habitat use pattern in NC is consistent with the overall pattern of habitat use in the southern recovery unit, which is similarly restricted in comparison with the northern recovery units (USFWS 2009). During the breeding season, adults and broods forage primarily on low-energy inlet and back-barrier intertidal sand and mud flats. At CALO, pre-nesting adults spend less than ten percent of their foraging time along ocean beaches (National Park Service 2014); and a 1990 study reported that 96% of brood observations occurred on sound-side tidal flats, even though broods had access to both back-barrier and ocean beach habitats (McConnaughey et al. 1990).

A total of 18 wintering critical habitat units encompassing ~19,707 acres have been designated along the NC coast from Oregon Inlet south to Mad Inlet along the NC/South Carolina boundary. There are four designated units in the study area (Figure 3-13). The term “wintering” as used in the final rule refers to all non-breeding season piping plover occurrences; including both

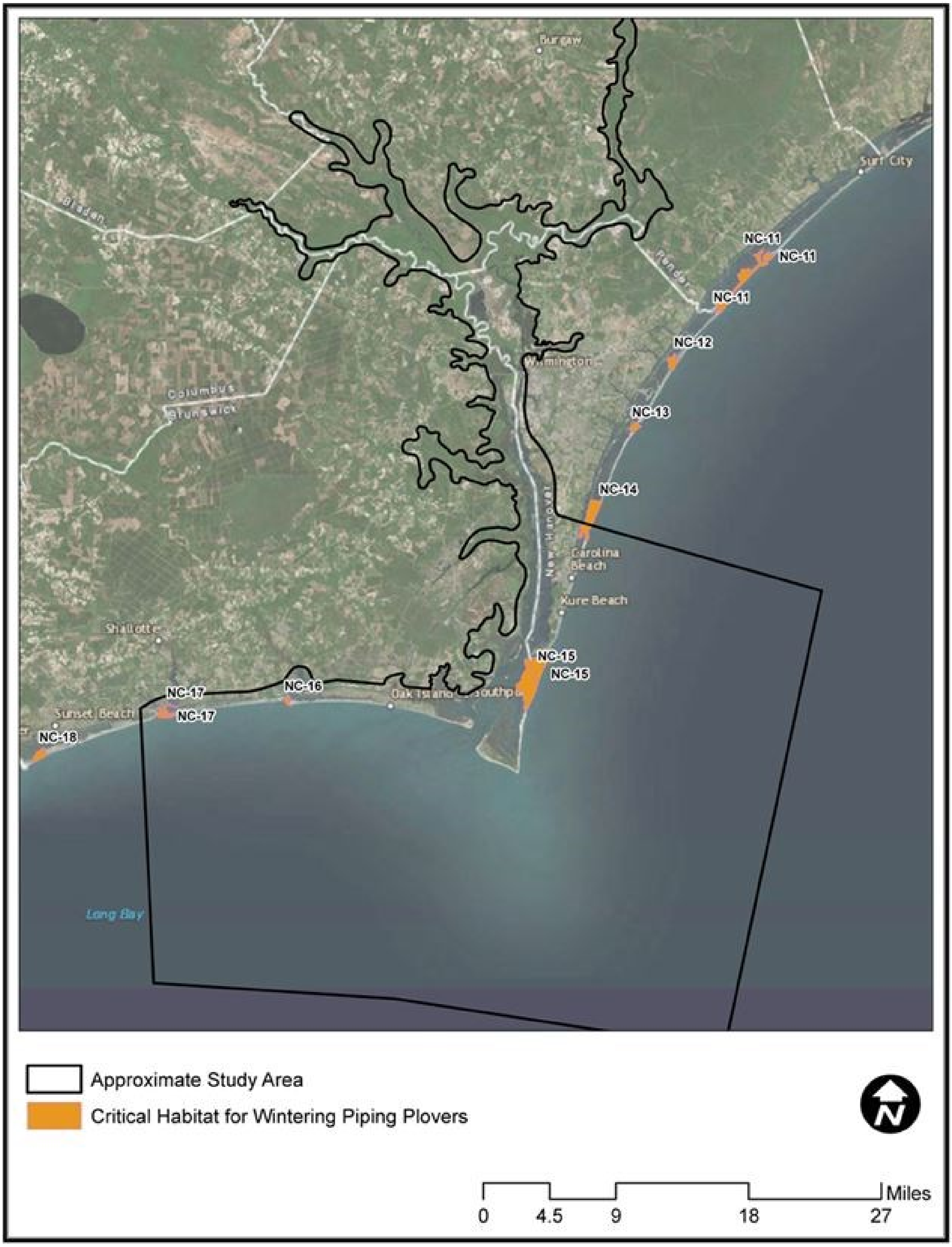

Figure 3-13
Critical Habitat for Wintering Piping Plover

migrating and wintering birds. Units have been designated at 15 of the state's 20 inlets. The PCEs of critical wintering habitat are those habitat components that are essential for the foraging, sheltering, and roosting requirements of piping plovers. Foraging habitat PCEs encompass elements of intertidal beaches and flats; including sand and mud flats, algal flats, and washover fans. Sheltering and roosting habitat PCEs include supratidal dune systems and flats that are associated with critical foraging habitat PCEs. High quality intertidal foraging habitats include sand and mudflats with little or no emergent vegetation. Adjacent exposed or sparsely vegetated sand, mud, and algal flats above high tide are also important, especially for roosting plovers. Other important habitat elements include sparsely vegetated sound-side habitats, salterns, sand spits, washover fans, and surf cast algae.

3.14.8 Red Knot

The rufa red knot (*Calidris canutus rufa*, hereinafter referred to as "red knot") was listed as threatened under the ESA on 12 January 2015 (79 FR 73705 73748). The USFWS has not approved a recovery plan for the red knot, and no critical habitat has been designated for the species. Red knots migrate between breeding grounds in the central Canadian High Arctic and wintering areas that are widely distributed from the southeastern US coast to the southern tip of South America. Migration occurs primarily along the Atlantic coast, where red knots use key stopover and staging areas for feeding and resting. Departure from the Arctic breeding grounds occurs from mid-July through August, and the first southbound birds arrive at stopover sites along the US Atlantic coast in July. Numbers of southbound birds peak along the US Atlantic coast in mid-August; and by late September, most birds have departed for their wintering grounds. Major fall stopover sites along the US Atlantic coast include the coasts of Massachusetts and New Jersey, and the mouth of the Altamaha River in Georgia. Principal wintering areas include the southeastern US Atlantic Coast from NC to Florida, the Gulf Coast from Florida to northern Mexico, the northern Atlantic coast of Brazil, and the island of Tierra del Fuego along the southern tip of South America. Smaller numbers of red knots also winter along the central and northeastern US Atlantic coast and in the Caribbean. The core southeastern US Atlantic wintering area is thought to shift from year to year between Florida, Georgia, and South Carolina (USFWS 2014a).

Red knots typically arrive at southeastern US and Caribbean wintering sites in November, but may arrive as early as September. Birds wintering along the US Atlantic coast and in the Caribbean typically remain on their wintering grounds through March, and in some cases as late as May. Northbound birds from both North and South American wintering areas use stopover sites along the US mid-Atlantic coast from late April through late May/early June (USFWS 2014a). Important spring stopover sites in the US include Delaware Bay and the Atlantic Coast from Georgia to Virginia; however, small to large groups of northbound red knots may occur in suitable habitats along all of the Atlantic and Gulf Coast states. Unknown numbers of non-breeding red knots, many consisting of one-year-old subadult birds, remain south of the breeding grounds throughout the year (USFWS 2014a).

The principal factors affecting red knots within the action area are the same as those affecting non-breeding piping plovers; including habitat loss and modification attributable to shoreline stabilization and inlet dredging and human disturbance associated with pedestrian and vehicular recreational activities.

Migrating and wintering red knots use similar habitats, generally expansive intertidal sand and mud flats for foraging and sparsely vegetated supratidal sand flats and beaches for roosting. The red knot is a specialized molluscivore, feeding on hard-shelled mollusks that are swallowed whole and crushed in the gizzard. The diet is sometimes supplemented with softer invertebrate prey such as shrimp- and crab-like organisms, marine worms, and horseshoe crab eggs. Both high-energy oceanfront intertidal beaches and sheltered estuarine intertidal flats are used for foraging. Preferred habitats include sand spits and emergent shoals associated with tidal inlets, and habitats associated with the mouths of bays and estuarine rivers. Access to quality high-tide roosting habitat in close proximity to foraging areas is an important constituent of high quality stopover and wintering sites (USFWS 2014a).

Systematic survey efforts have been relatively limited along the southern NC coast; and consequently, patterns of red knot distribution and abundance along some portions of the southern coast remain poorly understood. Systematic surveys along the southern NC coast have primarily been limited to the coordinated aerial surveys, which are conducted annually during the peak spring migration period of 20-24 May. The aerial survey data suggest that Emerald Isle, Lea Hutaff Island, Figure 8 Island, Masonboro Island, and Bald Head Island are important stopover sites for northbound red knots during the spring; however, the data also indicate that red knots make wide use of habitats along many of the southern region barriers, including habitats associated with both developed and undeveloped islands (Table 3-14). As indicated by the results of surveys at CALO and CAHA, peak annual spring migration numbers can occur from mid-April to late May; thus the short-window aerial surveys likely underestimate the distribution and abundance of red knots along the southern coast. Systematic survey coverage of the fall migration period along the southern coast has been limited to a few site specific studies. Systematic shorebird surveys conducted by the NCWRC at Bogue Inlet following the 2005 ebb channel relocation project recorded peak annual red knot counts ranging from 17 to 204 individuals (Rice and Cameron 2009). The three highest peak counts, ranging from 68 to 204 individuals, occurred during May. However, two of the five annual peak counts occurred in February and March, and were limited to relatively small numbers of individuals (43 birds in February and 17 in March). Consistent monitoring by Audubon NC has provided comprehensive information on red knot migration patterns at Rich Inlet (Addison and McIver 2015). Peak counts at Rich Inlet ranging from approximately 60 to 250 individuals have occurred during May, and few red knots have been observed during fall migration.

Table 3-14
Red Knot Aerial Survey Counts 2006-2012

	2006	2007	2008	2009	2010	2011	2012
Fort Fisher				81	4	20	8
Bald Head Island	78	67		21	5	26	40
Battery Island South			0		0		
Oak Island			0		0	22	0
Lockwood Folly Inlet		0	25	18			
Holden Beach					0	15	56
Ocean Isle Beach					0	23	112
Tubbs Inlet		0		11			
Sunset Beach				0	0	35	75

3.14.9 Wood Stork

In 2014, the ESA status of the US wood stork (*Mycteria americana*) breeding population was revised from endangered to threatened (79 FR 37078). The breeding population in Mississippi, Alabama, Florida, Georgia, South Carolina, and NC was also designated a DPS. The current breeding range encompasses peninsular Florida and the Coastal Plain of Georgia, South Carolina, and southeastern NC. The breeding population has been increasing and expanding northward. The three-year annual nesting averages for Florida, Georgia, South Carolina, and NC have exceeded 6,000 nests since 2003, and the average annual nest total for 2011-2013 was 9,692 nests (79 FR 37078). The first NC nesting colony consisting of 32 pairs was discovered at Lays Lake in Columbus County in 2005 (USFWS 2007). Three additional breeding colonies have since been discovered at Mill Branch Swamp in Columbus County, Steep Run along the Cape Fear River in Bladen County, and Warwick Mill Bay in Robeson County. The Steep Run colony is located along the southwest side of the Cape Fear River approximately four miles upriver of Lock and Dam #1. Annual nesting pair totals in NC increased from 32 pairs in 2005 to nearly 600 pairs in 2016 (Schweitzer 2016). Wood storks from northern Florida to southeastern NC lay eggs between March and late May, with fledging occurring in July and August (79 FR 37078). Post-breeding wood storks depart the colony sites and disperse widely throughout the Coastal Plain of the southeastern US, but many remain in NC through the early fall before migrating to Florida to spend the winter. Twin Lakes at Sunset Beach in Brunswick County is an important post-breeding site where numerous wood storks congregate each year.

Wood storks use a wide variety of freshwater and estuarine wetlands for nesting, foraging, and roosting. Nesting colonies are primarily established in cypress swamps, but other freshwater to estuarine forested habitats are also used; including mangroves, black gum, willow, and buttonbush (Coulter et al. 1999). Wood storks tend to use the same colony site over many years as long as the site remains undisturbed and there is sufficient feeding habitat in the surrounding area (USFWS 1997). Foraging habitat consists of natural and artificial wetlands with suitable prey and appropriate water depths (<50 cm) (Coulter et al. 1999). Wood storks also forage in man-made wetlands such as storm water treatment areas, golf course ponds, borrow pits, reservoirs, agricultural ditches, and dredge spoil sites (USFWS 2007). Roosting sites are generally in trees over water, but storks may also rest on the ground near feeding sites (Coulter et al.).

3.14.10 Seabeach Amaranth

Seabeach amaranth (*Amaranthus pumilus*) was listed as threatened throughout its range in 1993 (58 FR 18035 18042). Historically, this species occurred on coastal barrier island beaches from Massachusetts to South Carolina. Extant populations are currently known from South Carolina, NC, Virginia, Delaware, Maryland, New Jersey, and New York. Although the historical range included Rhode Island and Massachusetts, seabeach amaranth has not been found in these states for over a century. Range-wide population numbers increased substantially during the 1990s, reaching a record high population estimate of 244,608 plants in 2000. However, the range-wide trend since 2000 is characterized by a dramatic decline to just 1,308 plants in 2013. All of the state-specific populations have experienced similar declines, with record or near record lows recorded in all states by 2013.

Primary habitats include overwash flats on the accreting ends of islands, lower foredunes, and the upper strand on non-eroding beaches. Seabeach amaranth is an annual, meaning that the presence of plants in any given year is dependent on seed production and dispersal during previous years. Seeds germinate from April through July, flowering begins as early as June, and seed production begins in July or August. Seeds are dispersed by wind and water; flowering and seed production both continue until the end of the growing season. Seabeach amaranth is intolerant of competition; consequently, its survival depends on the continuous creation of newly disturbed habitats. Prolific seed production and dispersal enable the colonization of new habitats as they become available. A continuous supply of newly created habitats is dependent on dynamic and naturally functioning barrier island beaches and inlets.

Although variable from year to year, the distribution of seabeach amaranth encompasses the entire barrier island coast of NC. Annual state-wide surveys from 1995 to 2014 recorded an average of 6,726 plants per year. Long-term population trends in NC have been similar to those of the overall range-wide population. After a record high annual count of 39,933 plants in 1995, annual survey totals from 1996 through 2002 fluctuated between approximately 200 and 14,000 plants. Beginning in 2003, the NC population increased substantially over three consecutive years, reaching 25,885 plants in 2005. The NC population has since been in rapid decline, reaching a record low annual total of 154 plants in 2012. Numbers remained low in 2013 and 2014, with surveys recording just 166 and 526 plants, respectively. The largest numbers of plants have been found along the southern NC coast, with concentrations occurring along Topsail Island and Bogue Banks. However, smaller numbers of plants occur consistently along much of the NC coast. Since 2000, occurrences of seabeach amaranth in the study area have been heavily concentrated on the Brunswick County beaches to the west of Cape Fear, and primarily on the beaches of Oak Island and Holden Beach (Table 3-15). Annual numbers in the study area have varied considerably from a low of just 22 plants in 2000 to a high of 2,420 in 2006. Since 2010, the population trend within the study area has mirrored the statewide and range-wide trend of steadily declining plant numbers, with annual totals from 2011 to 2014 ranging from just 51 to 350 plants (Table 3-15).

Table 3-15
Cape Fear Region Seabeach Amaranth Counts 2000-2014

Survey Reach	**Survey Year**															**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
Fort Fisher	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
Bald Head Island	3	1	0	0	0	45	4	0	2	2	0	0			0	**226**
Oak Island East	9	63	413	302	4	92	291	105	51	40	1372	1	5	1	1	**15,341**
Oak Island West	0	3	129	965	7	82	171	11	14	24	204	15	0	0	0	**1,626**
Holden Beach East	1	12	0	18	4	8	9	0	0	0	0	0	0	0	26	**272**
Holden Beach West	9	211	702	825	75	792	1945	281	574	123	434	116	46	108	323	**6,829**
Total	**22**	**290**	**1244**	**2110**	**90**	**1020**	**2420**	**397**	**641**	**189**	**2010**	**132**	**51**	**109**	**350**	**24,295**

3.15 Invasive Species

Invasive species are organisms that have the potential to cause ecological and/or economic harm when introduced to an area outside of their historical native range. The state of NC has developed an Aquatic Nuisance Species Management Plan (ANSMP) to address the effects of aquatic invasive species (NC ANSMP Committee 2015). Aquatic invasive species that are present and currently causing ecological and/or economic harm in NC have been ranked and prioritized for action based on the potential for ecological and economic impacts, distribution and abundance trends, and management difficulty (Table 3-16). Many of the priority species have been reported from the study area, primarily from the tidal freshwater reaches of the upper estuary. Non-native blue catfish (*I. furcatus*) and flathead catfish (*Pylodictis olivaris*) are invasive species of particular concern in the freshwater reaches of the estuary. Both catfish species are apex predators that have come to dominate the freshwater fish community in terms of biomass. Common reed forms vast monospecific stands on dredged material deposits and other fill material throughout the high to low salinity reaches of the estuary. The 2017 tidal wetland classification identified 2,403 acres of common reed stands in the study area (Appendix F: Wetlands Impact Assessment). Lionfish (*Pterois volitans* and *P. miles*) are invasive species of particular concern in offshore marine habitats. Lionfish compete with native hardbottom and reef species in NC. Although not included on the NC priority list, the non-native red alga *Gracilaria vermiculophylla* is abundant in the Cape Fear River estuary. According to the NCDEQ (2016), *G. vermiculophylla* adds structure to tidal/subtidal mudflats that may improve habitat for some species; however, potential effects on native seagrasses are a concern.

Table 3-16
NC Priority Aquatic Invasive Species

			Priority	
			Higher Medium Lower	
Rank	**Scientific Name**	**Common Name**	**Group**	**Habitat**
1	*Hydrilla verticillata*	Hydrilla	Plant	Freshwater
2	*Pterois miles*	Lionfish	Fish	Marine
2	*Pterois volitans*	Red lionfish	Fish	Marine
4	*Nymphoides peltata*	Yellow floating-heart	Plant	Freshwater
4	*Phragmites australis australis*	Common reed	Plant	Fresh-Brackish
6	*Faxonius rusticus*	Rusty Crayfish	Crayfish	Freshwater
6	*Procambarus clarkii*	Red swamp crayfish	Crayfish	Freshwater
6	*Alternanthera philoxeroides*	Alligatorweed	Plant	Freshwater
9	*Faxonius virilis*	Virile crayfish	Crayfish	Freshwater
10	*Ictalurus furcatus*	Blue catfish	Fish	Freshwater
11	*Lynbya wollei*	Musty black mat algae	Cyanobacterium	Freshwater
12	*Cipangopaludina chinensis malleata*	Chinese mystery snail	Gastropod	Freshwater
12	*Anguillicoloides crassus*	Eel swim-bladder nematode	Nematode	NA
12	*Myriophyllum spicatum*	Eurasian water milfoil	Plant	Fresh-Brackish
16	*Myocastor coypus*	Nutria	Mammal	Freshwater
17	*Micropterus punctulatus*	Spotted bass	Fish	Freshwater
17	*Corbicula fluminea*	Asian clam	Bivalve	Freshwater
19	*Phyllorhiza punctata*	Australian spotted jellyfish	Coelenterate	Marine
19	*Lythrum salicaria*	Purple loosestrife	Plant	Freshwater
19	*Lythrum spp.*	Purple loosestrife	Plant	Freshwater
19	*Murdannia keisak*	Marsh dewflower	Plant	Freshwater
23	*Ludwigia hexapetala*	Uruguay water primrose	Plant	Freshwater
23	*Myriophyllum aquaticum*	Parrot feather	Plant	Freshwater
25	*Polysiphonia breviarticulata*	A red alga	Alga	Marine
25	*Egeria densa*	Brazilian elodea	Plant	Freshwater
25	*Najas minor*	Brittle naiad	Plant	Freshwater
25	*Triadica sebifera*	Chinese tallow tree	Plant	Freshwater
29	*Tilapia zillii*	Redbelly tilapia	Fish	Freshwater
29	*Ludwigia peploides peploides*	Creeping water primrose	Plant	Freshwater
31	*Codium fragile tomentosoides*	Green sea fingers	Alga	Marine
31	*Carcinus maenas*	European green crab	Crab	Marine
31	*Oreochromis aureus*	Blue tilapia	Fish	Freshwater
31	*Eichhornia crassipes*	Floating water-hyacinth	Plant	Freshwater
31	*Ludwigia peploides montevidensis*	Creeping water primrose	Plant	Freshwater
31	*Pistia stratiotes*	Water lettuce	Plant	Freshwater
37	*Potamogeton crispus*	Curly-leaf pondweed	Plant	Freshwater
38	*Nasturtium officinale*	Water-cress	Plant	Freshwater

Note: shaded rows indicate species reported from the Cape Fear River watershed below Lock and Dam #1

3.16 Managed and Protected Areas

The North Carolina Natural Heritage Program maintains a database of managed conservation areas in NC and serves as the state steward for the USGS Protected Areas Database of the United States. North Carolina Natural Heritage Program database records for the study area vicinity are shown in Table 3-17. The sites identified in Table 3-17 are those that encompass shorelines, waters, and/or wetlands that are influenced by tides and currents in the Cape Fear River estuary.

Table 3-17
Managed and Protected Conservation Areas in the Vicinity of the Study Area

Managed Area Name	Owner	Owner Type	Acres
Bald Head Island Conservancy Preserve	Bald Head Island Conservancy	Private	45
Bald Head Island State Natural Area	NC Division of Parks and Recreation	State	5,970
Bald Head Woods Coastal Reserve	NC Division of Coastal Management	State	189
Battery Island Audubon Sanctuary	National Audubon Society	Private	92
Black River Preserve	The Nature Conservancy	Private	5,398
Brunswick River/Cape Fear River Marshes	NC Division of Environmental Quality	State	92
Brunswick Town State Historic Site	NC Division of State Historic Sites and Properties	State	129
Cape Fear River Wetlands Game Land	NC Wildlife Resources Commission	State	7,250
Carolina Beach State Park	NC Division of Parks and Recreation	State	628
Eagle Island Natural Area	NC Div of Soil and Water Conservation	State	239
Ferry Slip Island Audubon Sanctuary	National Audubon Society	Private	7
Fort Fisher State Historic Site	NC Division of State Historic Sites and Properties	State	38
Fort Fisher State Recreation Area	NC Division of Parks and Recreation	State	475
Masonboro Island NCNERR	NC Division of Coastal Management	State	5,653
Military Ocean Terminal Sunny Point	US Department of Defense	Federal	10,887
No Name Island Audubon Sanctuary	National Audubon Society	Private	7
Orton Creek Preserve	The Nature Conservancy	Private	1,233
Snows Marsh Island	National Audubon Society	Private	118
South Pelican Island Audubon Sanctuary	National Audubon Society	Private	10
Striking Island Audubon Sanctuary	National Audubon Society	Private	43
USS North Carolina Battleship Memorial	NC Division of State Historic Sites and Properties	State	79
Zekes Island NCNERR	NC Division of Coastal Management	State	1,472
Total			**40,054**

NCNERR = North Carolina National Estuarine Research Reserve

3.17 Air Quality

Pursuant to the Clean Air Act (CAA) [42 United States Code (USC) 7401 et. seq.], the USEPA has set National Ambient Air Quality Standards (NAAQS) for commonly occurring "criteria pollutants" that may harm public health or the environment. National Ambient Air Quality Standards have been established for seven criteria pollutants: nitrogen dioxide (NO2), carbon monoxide (CO), particulate matter less than ten microns in diameter (PM10), particulate matter less than 2.5 microns in diameter (PM2.5), sulfur dioxide (SO2), lead (Pb), and ozone (O3). All US counties are assigned a designation of either "attainment," "maintenance," or "non-attainment" for each individual criteria pollutant. The individual states are responsible for achieving and maintaining the NAAQS through the development of State Implementation Plans (SIPs). Major stationary sources (i.e., industrial and commercial facilities) of criteria pollutants and other regulated Hazardous Air Pollutants (HAPs) require operating permits under the state-administered Title V Operating Permits program. Title V of the CAA defines major source facilities as those having the potential to emit ≥100 tons of any criteria pollutant, ≥10 tons of any single HAP, and/or ≥25 tons of any combination of HAPs on an annual basis. Mobile sources of emissions such as automobiles, aircraft, and other fuel-powered machinery are addressed in SIPs through vehicle emission budgets, transportation planning efforts, and enforcement of federal emissions standards through state-administered vehicle inspection programs. New Hanover and Brunswick Counties are currently designated as attainment areas for all criteria pollutants (USEPA 2018).

Sources of port-related air emissions at the Wilmington Terminal include ocean going vessels (OGVs), harbor craft, cargo handling equipment, rail locomotives, and heavy duty trucks. An air emissions inventory has not been conducted for the Port of Wilmington; however, an inventory for the Port of Charleston showed that OGVs were by far the largest contributor to air emissions, accounting for 45 to 99% of total port emissions, depending on the pollutant (Moffatt & Nichol 2013). Trucks were the second largest contributor of air emissions; followed in order of decreasing contribution by cargo handling equipment, harbor craft (i.e., tug boats), and rail locomotives. The USEPA has established domestic emissions standards for diesel engines installed on US vessels. Additionally, OGVs operating in foreign ports and waters are subject to international emissions standards established through the International Convention on the Prevention of Pollution from Ships (MARPOL) Annex VI.

3.18 Noise

The principal sources of anthropogenic underwater noise within the study area include commercial shipping operations associated with the Port of Wilmington, military shipping operations associated with MOTSU, recreational watercraft activity, and periodic maintenance dredging operations in the federally maintained Wilmington Harbor and AIWW navigation channels. Clarke et al. (2002) documented noise levels ranging from 120 to 140 decibels (dB) re: 1 micropascal (µPa) root mean square (rms) at a distance of 40 m during navigation dredging in Mobile Bay, Alabama. Peak spectral levels for individual commercial ships are in the frequency band of 10 to 50 Hertz (Hz) and range from 195 dB re: µPa 2/Hz a 1 m for fast-moving (>20 knots) supertankers to 140 dB re: µPa 2/Hz @ 1 m for small fishing vessels (NRC 2003). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency [1 to 5 kilohertz (kHz)] range and at moderate (150 to 180 dB re: 1 µPa @ 1 m) source levels (Erbe 2002, Kipple and Gabriele 2003 and 2004). For instance, small craft with outboard motors [14 to 18 ft (4.3 to 5.5 m) in length with 25 to 40 horsepower, 19 to 30 kilowatt (kW) outboard motors and operated at a speed of from 10 to 20 knots] had maximum source levels (one-third octave band) at 160 dB re: 1 µPa @ 1m with peak energy at 5 kHz (Kipple and

Gabriele 2003). On average, noise levels were found to be higher for the larger vessels, and increased vessel speeds resulted in higher noise levels (Hildebrand 2009).

Clarke et al. (2002) reported hopper dredge noise levels ranging from 120 to 140 dB re 1μPa rms at a distance of 40 m during navigation dredging in Mobile Bay, Alabama. A more recent study of the sounds produced by hopper dredges during sand mining at offshore borrow sites in Virginia reported noise levels ranging from 161 to 179 dB re 1μPa rms (Reine et al. 2014). Peak source levels did not exceed the NMFS Level A harassment threshold (≥180 dB re 1μPa rms) for injurious effects on marine mammals; however, noise levels generally exceeded the NMFS Level B harassment threshold (≥120 dB re 1μPa rms) within 1.2 km of the source and generally remained at or near 120 dB re 1μPa rms out to 2.1 km. According to a study by Clarke et al. (2002), cutterhead dredges produce peak sound levels in the range of 100 to 110 dB re 1μPa rms with rapid attenuation occurring at short distances from the dredge and sound levels becoming essentially inaudible at a distance of approximately 500 m.

Anthropogenic noise has the potential to cause behavioral disturbance and permanent injury to exposed marine mammals depending on the intensity level that individual animals experience (Southall et al. 2007). The NMFS defines two levels of acoustic "take" under the MMPA. Actions that may expose marine mammals to noise in excess of established values for various marine mammal hearing groups (Table 3-18) constitute Level A harassment with the potential to cause injury. Actions that may expose marine mammals to impulse (e.g., pile driving) noise levels ≥140 dB re 1μPa rms or continuous (e.g., dredging) noise levels ≥120 dB re 1μPa constitute Level B harassment with the potential to cause behavioral disruption.

Table 3-18
Level A Permanent Threshold Shift Onset Harassment Values for Marine Mammal Hearing Groups.

Hearing Group	PTS Onset (Received Level)	
	Impulsive	Non-Impulsive
Low-Frequency (LF) Cetaceans	PK: 219 dB SEL_{cum}: 183 dB	SEL_{cum}: 199 dB
Mid-Frequency (MF) Cetaceans	PK: 230 dB SEL_{cum}: 185 dB	SEL_{cum}: 198 dB
High-Frequency (HF) Cetaceans	PK: 202 dB SEL_{cum}: 155 dB	SEL_{cum}: 173 dB
Phocid Pinnipeds (PW)	PK: 218 dB SEL_{cum}: 185 dB	SEL_{cum}: 201 dB
Otariid Pinnipeds (OW)	PK: 232 dB SEL_{cum}: 203 dB	SEL_{cum}: 219 dB

PTS = Permanent Threshold Shift.
PK = Peak sound level
SEL_{cum} = Cumulative sound exposure level
Source: NMFS 2016

3.19 Hazardous, Toxic, and Radiological Waste (HTRW)

Based on investigations conducted for previous harbor projects, there is one Hazardous, Toxic, and Radiological Waste (HTRW) high priority site in the study area that could be affected by channel modifications. The high priority site is the former Southern Wood Piedmont treated-wood facility located along the Cape Fear River ~0.25 mile north of the Port of Wilmington. Investigations conducted for the Wilmington Harbor Improvement Project Turning Basin expansion project found that the sediment along the waterfront of the Southern Wood Piedmont facility was contaminated primarily with arsenic and polycyclic aromatic hydrocarbons (PAHs) (USACE 2018). The majority of the site had contamination that was slightly above USEPA regional preliminary remediation goals (PRGs); however, contamination levels in isolated areas were well above the PRGs for arsenic and PAHs, including several areas within 50 ft of the waterfront. Generally, soil arsenic and PAH levels within 50 to 150 ft of the waterfront were slightly above the PRGs. Additional contaminated areas with levels of dioxins and furans well above PRGs were detected within 200 ft of the waterfront. In 1999, Southern Wood Piedmont consented to voluntary remediation of the contamination, and responsibility for oversight and approval of remedial actions was deferred to the State under the Superfund State Deferral Memorandum of Agreement between the USEPA Region IV and the State of North Carolina. Oversight is provided by the NC Division of Waste Management under the Inactive Hazardous Sites Program. Remedial investigations have been ongoing since the late 1990s, but the site does not have an approved remedial action plan and no remedial actions have been undertaken.

3.20 Aesthetics and Recreation

Aesthetics addresses the physical, biological, and cultural landscape elements that contribute to perceptions of scenic beauty. The NC coast encompasses a broad range of natural landscape elements that are highly valued for their scenic beauty; including marine and estuarine water resources, tidal marshes, sandy beaches and dunes, maritime forests, and associated wildlife resources. Cultural elements such as lighthouses and historic waterfront districts contribute to a sense of place and the perception of the coast as a unique scenic resource. Surveys of visitors to NC's barrier islands indicate that natural beauty, wide sandy beaches, visible wildlife, and historical structures are considered important elements of a positive experience (Ellis and Vogelsong 2005). The study area encompasses a diverse assemblage of viewscapes, including natural forested tidal wetlands in the upper estuary; the historic downtown Wilmington waterfront; industrialized waterfront port facilities; expansive natural salt marshes in the lower estuary; and the sandy beaches, dunes, and maritime forests of Bald Head Island and Oak Island. Aesthetic value is not easily quantified, as perceptions of scenic beauty vary among different stakeholder groups. While many are likely to associate scenic beauty with natural and historically significant landscapes, others may place aesthetic value on industrialized port facilities to the extent that they are perceived as part of the maritime history and culture of the NC coast.

3.20.1 Recreation

The coastal waterways, ocean and beaches of New Hanover and Brunswick Counties provides a scenic and enjoyable setting for the general public, which also includes the numerous recreational vessels and commercial vessels commonly calling on the port. The estuarine and marine environment within the study area provides a wealth of opportunities for recreational fishing, diving, and boating, both by tourists and the public at large. The beaches present in the study area offer numerous recreational opportunities, including swimming, surfing, walking, diving, fishing, and other ecotourism activities. Public beaches within both counties have active shore protection programs to maintain their beaches for both shore protection of properties and to maintain public beaches for the general public.

Recreational and commercial fishermen have used the river/estuarine and marine waters within the study area extensively for many generations. Primary species sought include oysters, penaeid shrimp, blue crab, spot, flounder, trout, croaker, red drum, bluefish, Spanish mackerel, and king mackerel. Areas of primary importance to the local commercial fishing industry have included traditional fishing grounds off Bald Head and Oak Islands. Due to the presence of numerous offshore artificial reefs developed by the state and past actions of the USACE, where dredged rock was placed at the Wilmington Offshore Fisheries Enhancement Structure reef, located east of the new ODMDS (USACE 1996a, 2000).

3.21 Coastal Barrier Resources

The Coastal Barrier Resources Act (CBRA) of 1982 was enacted to discourage the development of hurricane prone, biologically sensitive coastal barrier islands. The CBRA prohibits most new federal expenditures that encourage or subsidize barrier island development. The CBRA established the John H. Chafee Coastal Barrier Resources System (CBRS) consisting of barrier islands that are either undeveloped or predominantly undeveloped. The CBRS includes two types of designated units; System Units and Otherwise Protected Areas (OPAs). In System Units, new development and projects that involve substantial improvements of existing structures are not eligible for most types of federal funding and assistance; including the National Flood Insurance Program (NFIP) and subsidies for road construction, channel dredging, and other coastal engineering projects. In the case of OPAs, NFIP is the only type of prohibited federal spending. The study area encompasses one System Unit (Masonboro Island Unit L09) and one OPA (Cape Fear Unit NC07P) (Figure 3-14). The Masonboro Island Unit encompasses the undeveloped ~2-mile north end of Carolina Beach, Carolina Beach Inlet, and Masonboro Island to the north of Carolina Beach Inlet. The Cape Fear Unit extends ~14 miles south from Snows Cut to the back-barrier shoreline of Baldhead Island; encompassing Carolina Beach State Park, the Fort Fisher State Historic Area, the Fort Fisher State Recreation Area, and the back-barrier marsh complex between Federal Point and Bald Head Island.

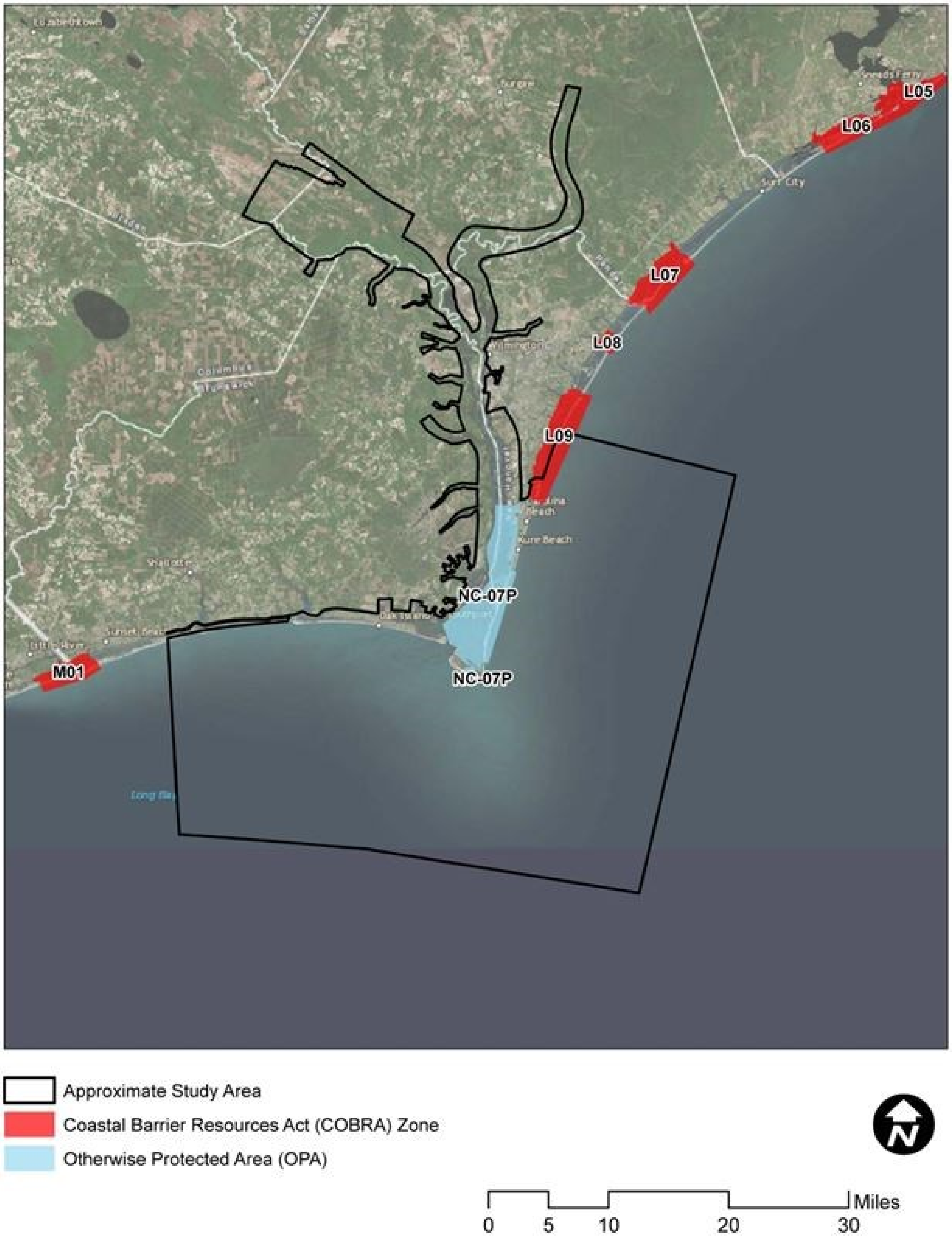

Figure 3-14
COBRA System Units and Otherwise Protected Areas

3.22 Cultural and Historic Resources

Panamerican (Appendix G: Cultural Resources) conducted cultural resource remote sensing surveys of areas potentially affected by harbor channel expansion; including a 250-ft-wide zone along either side of the ~26-mile inner harbor channel reach between the Cape Fear River mouth and Wilmington, a 500-ft-wide zone along either side of the existing Bald Head Shoals ocean entrance channel, and a 1,000-ft-wide by 8-mile zone encompassing the proposed ocean entrance channel extension reach (Appendix G: Cultural Resources). The remote sensing surveys identified seven potentially significant targets, all within the inner harbor survey areas. Subsequent diver investigations identified three of the seven targets as modern debris; one as an old wooden revetment; one as a natural ridge; one as the remains of a navigation buoy; and one as the paddlewheel of the shipwreck CSS *Kate*, a Confederate blockade runner previously identified by the NC Underwater Archaeological Branch (UAB). Of the investigated targets, only the paddlewheel of the CSS *Kate* was considered historically significant. Remote sensing surveys did not identify any potentially significant targets within the ocean channel survey areas. No subbottom paleofeatures potentially representing prehistoric sites were identified in either the inner or ocean survey areas. A number of historic sites that are listed in the National Register of Historic Places (NRHP) occur along the banks of the CFR; including the Wilmington Historic District, Brunswick Town/Fort Anderson State Historic Site, Orton Plantation, Fort Fisher State Historic Site, Southport Historic District, Fort Caswell Historic District, and the Bald Head Island Lighthouse. Additionally, the NRHP-listed USS North Carolina is berthed in the CFR opposite downtown Wilmington.

3.23 Socioeconomic Conditions

This section describes the demographic characteristics of the study area population pursuant to Executive Order (EO) 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations and EO 13045 Protection of Children from Environmental Health Risks and Safety Risks. Executive Order 13045 (Protection of Children from Environmental Health Risks and Safety Risks) requires federal agencies to identify and address environmental health and safety risks that may disproportionately affect children. Environmental health and safety risks are those attributable to products or substances that a child is likely to touch or ingest (e.g., air, food, drinking water, recreational waters, soil, or products they might use or to which they may be exposed).

3.23.1 Population

Table 3-19 shows decennial census data for North Carolina and the counties of Brunswick, New Hanover, and Pender from 1980 through 2010 and includes the 2017 Census Bureau population estimates. The Wilmington Metropolitan Statistical Area, defined as the combination of New Hanover and Pender Counties, is included as well, but is not a discrete area of summation for the Census Bureau.

In general, the population of the region surrounding Wilmington has more than doubled in the last 40 years. There have been dramatic increases in population in the New Hanover and Pender Counties and the population of Brunswick County has more than tripled since 1980, with particular population growth on the east side of the county, across the Cape Fear River from the City of Wilmington.

Table 3-19
MSA, County, and State Population 1980-2017

Locale	Designated Type	Population					
		1980	1990	2000	2010	2017	% change 1980-2017
North Carolina	State	5,881,766	6,628,637	8,049,313	9,535,483	10,052,564	70.9
Brunswick County	County	35,777	50,985	73,143	107,431	122,586	242.6
New Hanover County	County	103,471	120,284	160,307	202,667	219,866	112.5
Pender County	County	22,215	28,855	41,082	52,217	57,630	159.4
Wilmington MSA	Metropolitan Statistical Area	125,686	149,139	201,389	254,884	277,496	120.8

Source: U.S. Census Bureau

3.23.2 Employment & Income

With the exception of the national economic recession in the late 2000s, the economic conditions in the Wilmington region have remained relatively steady. As Table 3-20 indicates, the top ten employers within the City of Wilmington and New Hanover County are steady over the time period and represent about 20 percent of all employment within the county. Primary employment sectors include healthcare and social assistance, education, retail, accommodation and food services.[13]

Brunswick County had a total estimated civilian labor force of 32,771 in 2018. In that year, 27,925 people were employed in private non-farm jobs in the county; the highest proportion of those private sector jobs were in the trade, healthcare, and service industries (NCCommerce, 2018). In 2017, the county's unemployment rate was 5.7 percent, reflecting a continuing downward trend (i.e., a decline in unemployment and therefore an increase in employment) from 12.5 percent in 2010 after the recession of 2009 to 2012. Unemployment in 1990 and 2000 was 6.1 percent and 4.5 percent respectively.

New Hanover County had a total estimated civilian labor force of 114,449 in 2018. In that year, 95,159 people were employed in private non-farm jobs in the county; the highest proportion of those private sector jobs were in the trade, healthcare, and service industries (NCCommerce, 2018). In 2017, the county's unemployment rate was 4.2 percent, reflecting a continuing downward trend (i.e., a decline in unemployment and therefore an increase in employment) from 9.7 percent in 2010 after the recession of 2009 to 2012. Unemployment in 1990 and 2000 was 4.5 percent and 3.6 percent respectively.

Pender County had a total estimated civilian labor force of 12,142 in 2018. In that year, 9,756 people were employed in private non-farm jobs in the county; the highest proportion of those private sector jobs were in the trade, healthcare, and service industries (NCCommerce, 2018). In 2017, the county's unemployment rate was 4.7 percent, reflecting a continuing downward trend

13 https://accessnc.nccommerce.com/DemographicsReports/

(i.e., a decline in unemployment and therefore an increase in employment) from 11.4 percent in 2010 after the recession of 2009 to 2012. Unemployment in 1990 and 2000 was 4.5 percent and 4.1 percent respectively.

Table 3-20
Principal Employers in the City of Wilmington

Employer	2018		2009	
	Employees	Percentage of Total County Employment	Employees	Percentage of Total County Employment
New Hanover Health Network	6,880	5.91	4,887	4.61
New Hanover County Schools	3,831	3.29	4,129	3.90
University of North Carolina (Wilmington)	2,154	1.85	1,809	1.71
General Electric Nuclear Fuel/Aircraft	1,790	1.54	3,000	2.83
New Hanover County	1,756	1.51	1,673	1.58
Pharmaceutical Products Development	1,500	1.29	1,800	1.70
Cape Fear Community College	1,328	1.14	1,256	1.19
Verizon Wireless	1,278	1.10	1,200	1.13
Wal-mart	1,080	0.93	1,000	0.94
City of Wilmington	1,067	0.92	1,114	1.05
Total	22,664	19.45	21,868	20.64

Source: City of Wilmington (https://www.wilmingtonnc.gov/Home/ShowDocument?id=10007)

Median incomes in the area are slightly above state inflation-adjusted median income of $52,400 (Table 3-21). The income figures presented in Table 3-21 have been adjusted for inflation from their original values using the US Bureau of Labor Statistics' online inflation calculator[14] and rounded for ease of comparison across time. This comparison is valuable because, without adjustment for inflation, wages in the area appear have increased dramatically; however, when adjusted for inflation, real wages have slightly declined since 2000.

[14] https://www.bls.gov/data/inflation_calculator.htm

Poverty status is determined from various statistics gathered through the census and is measured on a family to family basis. The computation is based on a "poverty threshold" for an individual or family (based on family size), where earnings in a calendar year are compared to the threshold. The U.S. Census Bureau data on poverty for North Carolina and Brunswick, New Hanover, and Pender Counties shown in Table 3-21 indicate that the poverty rate increased as a result of the recession of 2009 to 2012, but recovery has not been even across the area, with Brunswick County at a poverty rate lower than it was in 2000, New Hanover County lower than in 2010, but not as low as 2000, and Pender County with the highest poverty rate over the last eighteen years.

Table 3-21
Employment, Income, and Poverty

North Carolina	1990	2000	2010	2017
Unemployment Rate[15]	3.4	3.3	11.4	4.9
Median Household Income[16]	N/A	58,700	50,500	52,400
Poverty Rate	N/A	12.3	17.5	14.7
Brunswick County	**1990**	**2000**	**2010**	**2017**
Unemployment Rate	6.1	4.5	12.5	5.7
Median Household Income	N/A	53,700	51,500	53,300
Poverty Rate	N/A	12.6	16.9	11.9
New Hanover County	**1990**	**2000**	**2010**	**2017**
Unemployment Rate	4.5	3.6	9.7	4.2
Median Household Income	N/A	60,200	53,800	53,600
Poverty Rate	N/A	13.1	18.1	15.5
Pender County	**1990**	**2000**	**2010**	**2017**
Unemployment Rate	4.5	4.1	11.4	4.7
Median Household Income	N/A	53,800	51,700	51,400
Poverty Rate	N/A	13.6	14.8	15.8

Source: U.S. Census Bureau, Decennial Census, 1990, 2000, 2010; American Community Survey, 2017

3.23.3 Minority and Low income Populations

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Population and Low-Income Populations, directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations[17] (Executive Order, 1994). When conducting NEPA evaluations, CEQ directs federal agencies to

[15] From Bureau of Labor Statistics (BLS, 2018).
[16] Figures have been inflation adjusted and rounded.
[17] Low income is defined as a person whose household income is at or below the current Department of Health and Human Services poverty guidelines.

incorporate Environmental Justice (EJ) considerations into both the technical analyses and the public involvement (CEQ, 1997).

The CEQ guidance defines "minority" as individual(s) who are members of the following population groups: American Indian or Alaskan native, Asian or Pacific Islander, Black, not of Hispanic origin, and Hispanic (CEQ, 1997). When defining areas for analysis, the Council defines a minority population when either the minority population of the affected area exceeds 50 percent of the total population, or the percentage of minority population in the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis. In addition, federal agencies have interpreted the CEQ EJ guidance to include identifiable minority communities with the potential to be disrupted, even when the population does not meet the threshold of 50 percent or meaningfully greater.

Low-income populations, as defined for the purposes of EJ analyses, are identified using statistical poverty thresholds from the Bureau of the Census Current Population Reports, Series P-60 on Income and Poverty (U.S. Census Bureau, 2010). In identifying low-income populations, a community may be considered either as a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect. The U.S. Census Bureau defines a poverty area as a census tract or other area where at least 20 percent of residents are below the poverty level (U.S. Census Bureau 2013). The poverty threshold[18] for a family of four for 2017 was an annual income of $24,858 (U.S. Census Bureau, 2019).

The Executive Order directs federal and state agencies to incorporate environmental justice as part of their mission by identifying and addressing the effects of all programs, policies and activities on minority and low-income populations. The fundamental principles of EJ are as follows:

> (i) Ensure the full and fair participation by all potentially affected communities in the decision-making process;
>
> (ii) Prevent the denial of, reduction in or significant delay in the receipt of benefits by minority and low-income populations; and
>
> (iii) Avoid, minimize or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.

Table 3-22 shows the 2017 U.S. Census population and the racial mix (as a percentage) for the State of North Carolina and the counties of Brunswick, New Hanover, and Pender (U.S. Census Bureau, 2017). As stated above, minority populations are identified when either the minority population of the affected area exceeds 50 percent of the total population, or the percentage of minority population in the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis.

[18] Poverty status is determined from various statistics gathered through the census and is measured on a family to family basis with the computation based on a "poverty threshold" for an individual or family (based on family size), where earnings in a calendar year are compared to the threshold.

According to the Council's guidance on EJ populations, the conditions necessary to define a minority population is present in the Brunswick County.

Table 3-22
2017 Population, Race, and Percent Below Poverty Threshold

Geographic Area	2017 Population	Race Percent of Total					Percent Below Poverty Threshold
		White	Black	American Indian	Hispanic*	Asian	
North Carolina	10,052,564	71.1	22.9	1.9	9.1	3.2	16.1
Brunswick County	16,435	43.4	55.8	1.0	2.1	0.7	20.9
New Hanover County	219,866	82.7	15.1	0.8	5.4	2.0	18.0
Pender County	57,630	79.1	16.8	1.3	6.8	0.8	15.8

* Hispanics may be of any race, so also are included in applicable race categories.

The identification of minority and low income populations for Environmental Justice purposes is based on US Census data. Analysis of Census data for the study area was accomplished using the USEPA EJSCREEN Environmental Justice Screening and Mapping Tool. Based on the CEQ guidelines, minority and low income populations occur in the vicinity of downtown Wilmington, the Port of Wilmington, and in rural areas to the north and west of Wilmington (Figures 3-15 and 3-16).

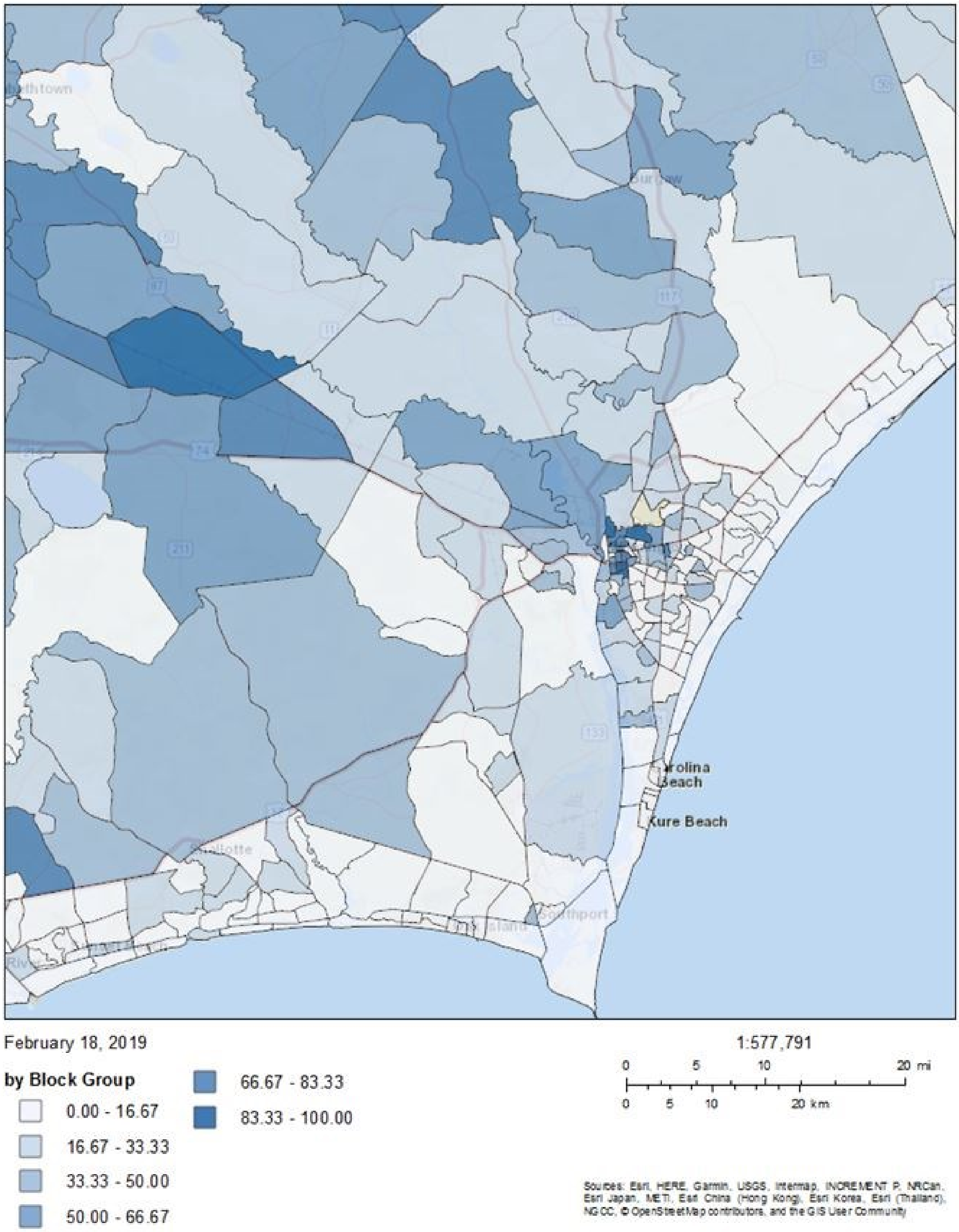

Figure 3-15
Percent Minority Population

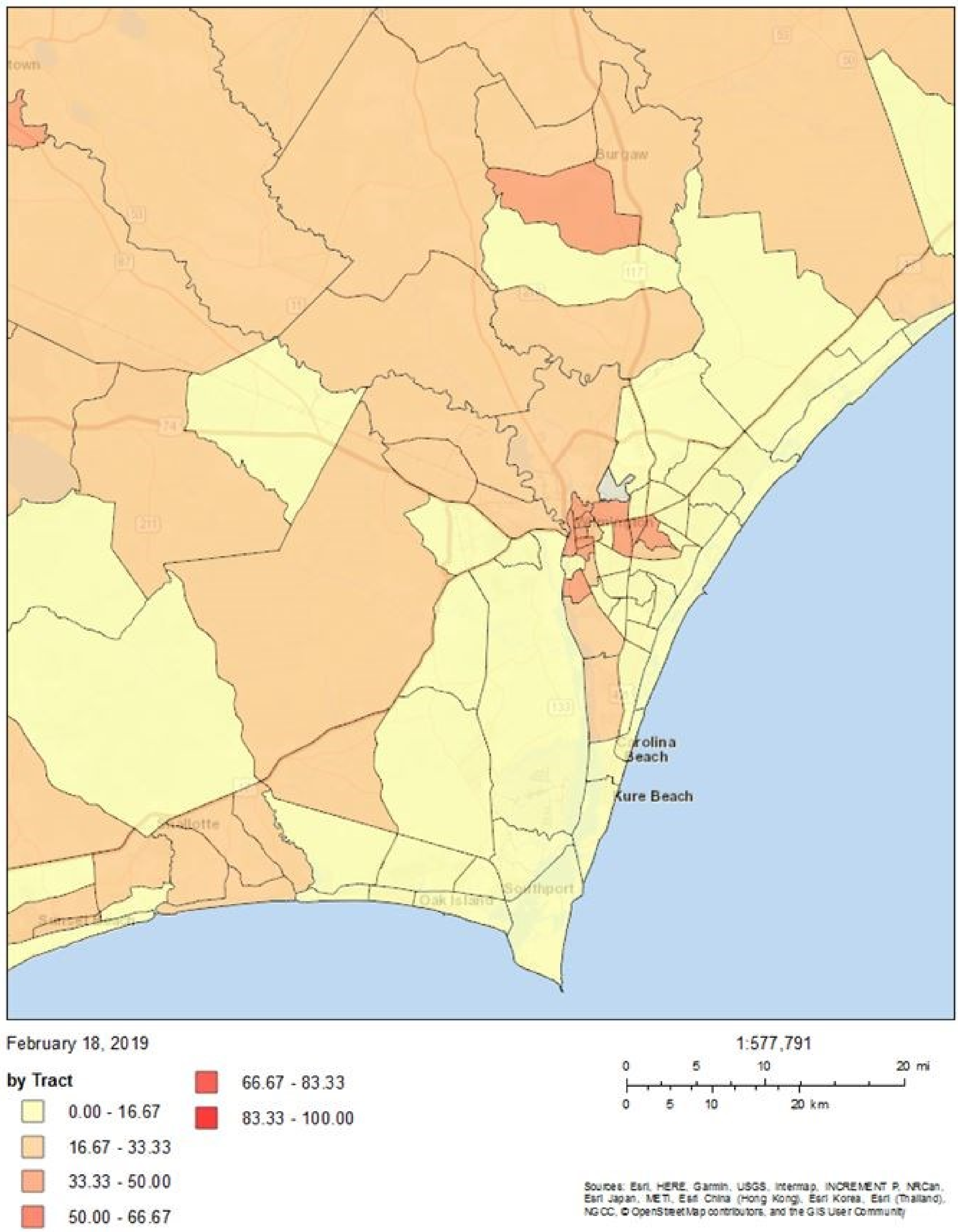

Figure 3-16
Percent of Population Below Poverty Level

4 WITHOUT-PROJECT CONDITIONS

Without-project future conditions are based on the following assumptions that are discussed in the sections identified below and further substantiated in the Economics Appendix:

- Without-project future conditions include completion of the ongoing navigation and marine transport improvements that are occurring at the Port of Wilmington (Sections 4.1 and 4.2);
- Without-project future conditions include completion of the ongoing navigation and marine transport improvements that are occurring at other USEC ports (Section 4.3);
- Continuing increases in the amount and proportion of fleet capacity in PPX3Max and PPX4 containership classes, the cascade effect of larger vessels displacing smaller vessels on the USEC-Asia services, and the efficiencies provided by larger vessels will further increase the size of vessels calling at USEC ports resulting in PPX3Max vessels being deployed on the ZCP and EC2 services(Section 4.5); and
- Under without-project condition channel depth constraints and draft restrictions at the Port of Wilmington, the resulting light loading of the design vessel for the ZCP and EC2 services will cause the two Asia services to drop Wilmington as a port-of-call (Section 4.6).

The combination of completed navigation improvements at other USEC ports and the continuing introduction of PPX3Max vessels into the USEC-Asia services will make the Port of Wilmington unable to successfully compete as a port-of-call on USEC-Asia services under without-project conditions. If the disparity in channel depths between the Port of Wilmington and other USEC ports continues, then these services will cease calling at the Port of Wilmington and the containers on these services will be required to use alternative ports to reach their final destinations, as discussed below.

4.1 Wilmington Harbor Navigation Features

Under without-project conditions, NCSPA improvements to the turning basin at the Lower Anchorage and the raising of the dikes for increased dredged material placement capacity at the Eagle island CDF are projected to be completed.

4.1.1 Channels and Turning Basins

The Lower Anchorage Basin, immediately upstream of the container terminal at the Port of Wilmington, is used as the turning basin for vessels calling at the Port of Wilmington. The turning basin is currently undergoing improvements designed to allow a containership with a length overall (LOA) of 1,200 feet to turn in the basin. A length overall of 1,200 feet is consistent with the design vessel for this project, which has a LOA of 1,200 feet, a beam of 159 feet, and a maximum draft of 51 feet. Construction is scheduled to be complete in 2020 (see Section 5: Formulation and Preliminary Evaluation of Alternatives).

The without-project future condition Federal navigation channel at Wilmington Harbor, exclusive of the turning basin expansion, was designed for a Panamax vessel with a length overall of 965 feet, a beam of 106 feet, and a maximum draft of 40 feet (USACE 1996). The design vessel for this project has a length overall of 1,200 feet, a beam of 159 feet, and a maximum draft of 51 feet. At a sailing draft of 40 feet, the design vessel would have nearly 48 feet of freeboard (excluding superstructure), which would make navigating the without-project condition channel tenuous under all but the most benign conditions. The design vessel, although it may be capable of periodically transiting the without-project condition Federal navigation channel under perfect wind, current, and tide conditions with additional tug assistance, cannot use the without-project condition Federal navigation channel as standard operating procedures with the Port of Wilmington as a regular port-of-call.

4.1.2 Dredged Material Disposal

The Eagle Island Confined Disposal Facility is situated on a 1,473-acre tract of land that forms a peninsula between the Cape Fear and Brunswick Rivers. Eagle Island CDF is operated in a three-cell configuration. Cell 1 consists of 230 acres, Cells 2 is approximately 260 acres, and Cell 3 is approximately 265 acres, for a total of 755 acres of diked uplands. Maximum dike height is currently 40 feet above mean sea level for Cell 1 and 42 feet for Cells 2 and 3 (USACE 2017). The dikes for all three cells are proposed to be raised to 50 feet above mean sea level, which will extend the useful life of Eagle Island CDF to 2032 (USACE 2017).

4.2 Wilmington Harbor Terminal Facilities

This section focuses on the container terminal at the Port of Wilmington. There are no major improvements projected for the bulk terminals at Wilmington Harbor, which would influence plan selection, and therefore they are not discussed further other than being included in HarborSym model runs as origins and destinations for channel traffic.

4.2.1 Port of Wilmington Container Terminal

The NCSPA is currently engaged in a $200 million terminal improvement program to increase the efficiency and throughput capacity of the Port of Wilmington container terminal (Figure 4-1). The intent of the improvement program is to increase throughput capacity to 750,000 TEUs by 2022 and to 1.1 million TEUs by 2025. Scheduled improvements include:

- Repaving and warehouse demolition to increase container storage capacity;
- Build out of the reefer yard;
- South Gate upgrade; and
- Construct intermodal rail yard.

Figure 4-1
Port of Wilmington Container Terminal Improvement Plan

4.3 USEC Federal Navigation Projects

Historically, containerships calling at the USEC have not been the largest vessels in the world fleet. Although the USEC has the cargo demand and terminal capacity to service larger containerships than they do currently, channel constraints have limited vessel loading and draft at many USEC ports, resulting in the slower deployment of these newer, larger vessels. At some USEC ports vessel length and beam are also limited. All the major international trade partner ports in Europe and in Asia are capable of servicing vessels with a 48-foot draft and most are capable of servicing vessels with a 52-foot draft. Recently, most major ports along the USEC have been authorized deepening projects to allow the new generation of containerships to achieve operating drafts similar to major international trade partner ports. A number of these projects have been, or are being, constructed and the majority will be completed over the next 10 years. Table 4-1 presents the current and future depths for the major USEC container ports. As these projects come on-line, the improved channel dimensions are allowing larger vessels to call efficiently loaded and as a result, the USEC container fleet is dramatically increasing in vessel size.

Table 4-1
Current and Future USEC Port Depths – Major Container Ports

Port	Current Depth	Future Depth & Status	Projected Completion
Boston*	40 feet	48 feet - under construction	2024
New York*	50 feet	50 feet - constructed	Complete
Philadelphia	45 feet	45 feet - constructed	Complete
Baltimore	50 feet	50 feet - constructed	Complete
Norfolk	50 feet	55 feet – under construction	2025
Wilmington, NC	**42 feet**	**42 feet – constructed**	**N/A**
Charleston*	45 feet	52 feet – under construction	2021
Savannah*	42 feet	47 feet – under construction	2020
Jacksonville*	40 feet	47 feet – under construction	2025
Port Everglades	42 feet	48 feet – in design	2024
Miami	50 feet	50 feet - constructed	Complete

* USEC-Asia service loop partners with Port of Wilmington, NC

At the present time, before the improvements shown in Table 4-1 are complete, the Federal navigation channel at Wilmington Harbor is deeper than Boston and Jacksonville, has the same depth as Savannah and Port Everglades, and is only three feet shallower than Charleston and Philadelphia. This relative parity has allowed the Port of Wilmington to be competitive as a port of call for the USEC container services. However, under future without-project conditions, the depth at the Port of Wilmington relative to other major USEC container ports will decline substantially, making the Port of Wilmington far less competitive.

By 2025, when construction of the projects listed in Table 4-1 will be completed, the Federal navigation channel at Wilmington Harbor will have substantially less depth than the other major USEC container ports. For the ports that are service loop partners with the Port of Wilmington on the USEC-Asia services, the relative lack of depth at the Port of Wilmington will range from a 5-foot deficit with Jacksonville and Savannah (which also has a six-foot tide) to a 10-foot deficit with Charleston. As these projects near completion, USEC container services will complete the transition to larger, more deeply drafting containerships to take advantage of the economies of scale provided by the newer, larger vessels, as described in Section 2.28.2 Existing Containership Fleet. This will place Wilmington at a further disadvantage since the vessels on the service will need to substantially light load to call at Wilmington, but not at the other ports on the EC2 and ZCP services (Table 4-2).

Table 4-2
Existing and Future Without-Project Condition Channel Depths for USEC Port Rotations on the Two USEC-Asia Services (Feet below MLLW)

ZCP Service			EC2 Service		
	2019	2025		2019	2025
Savannah	42	47	New York	50	50
Charleston	45	52	Boston	40	48
Wilmington	**42**	**42**	**Wilmington**	**42**	**42**
Jacksonville	40	47	Savannah	42	47
Kingston, JM	50	50	Charleston	45	52

4.4 Commodity Projections

Without-project commodity projections for the Federal navigation channel at Wilmington Harbor are focused on containerized cargo at the Port of Wilmington. Commodity projections for bulk and break-bulk commodities are projected to remain at existing condition levels throughout the planning horizon. Potential commodity growth for bulk commodities is not projected to influence plan formulation or effect plan selection because only a small number of vessel calls would likely be able to take advantage of the deeper channel.

4.4.1 Containerized Commodities

The future without-project containerized commodity forecast includes:

- non-Aisa containerized cargo that is projected to use the Port of Wilmington under without-project conditions; and
- Asia containerized cargo that is projected to use alternative USEC ports under without-project conditions.

The without-project condition containerized commodity forecast for the Port of Wilmington excludes USEC-Asia services based on without-project channel restrictions on vessel size and loading and the resulting increase in transportation costs that would be incurred by the carriers. Under without-project conditions USEC-Asia services will not call at the Port of Wilmington and USEC-Asia cargo will use alternative USEC ports capable of providing the economies of scale associated with larger vessels carrying larger loads and operating at deeper drafts, which cannot be accommodated at the Port of Wilmington. Only non-Asia containerized cargo, which is not constrained by without-project channel conditions is projected to call at the Port of Wilmington under without project conditions.

The USEC cargo growth rates are the same growth rates identified for Norfolk Harbor Navigation Improvements General Reevaluation Report/Environmental Assessment, Appendix B: Economics, May 2018. The growth rates used for this analysis compare favorably with the harbor-specific growth rates used for the Charleston Post-45 Feasibility Study and the Norfolk

Harbor GRR (Table 4-3). Note that all forecasts are based on work performed by MSI, Inc., a third-party contractor engaged by USACE to forecast future TEU traffic.

Table 4-3
Forecast Growth Rate Comparisons

USEC (2018)[1]			Norfolk (2018)[2]			Charleston (2015)[3]		
Years	IMP	EXP	Years	IMP	EXP	Years	IMP	EXP
2018 - 2023	3.70%	5.40%	2015-2023	3.96%	3.96%			
2023 - 2028	4.40%	5.50%	2023-2030	3.65%	3.66%	2022-2027	5.1%	6.7%
2028 - 2030	3.50%	3.50%	2030-2035	3.48%	3.49%	2027-2032	3.5%	4.2%
2030 - 2045	2.50%	2.50%	2035-2040	3.30%	3.31%	2032-2037	2.8%	2.8%
			2040-2043	3.11%	3.12%			

[1] Norfolk Harbor Navigation Improvements General Reevaluation Report/Environmental Assessment, Appendix B Economics Appendix, May 2018, supporting documentation

[2] Norfolk Harbor Navigation Improvements General Reevaluation Report/Environmental Assessment, Appendix B Economics Appendix, May 2018, Tables 22 & 23

[3]Charleston Harbor Post 45 Integrated Feasibility Study and Environmental Impact Statement, Economics Appendix, June 2015 Table 21

The Port of Wilmington without-project containerized commodity forecast (non-Asia cargo) is presented in 5-year increments from 2025 through 2045 and is held constant at 2045 levels throughout the remainder of the analysis. Asia cargo that would divert from the Port of Wilmington to alternative USEC ports under without-project conditions is presented (Table 4-4).

Table 4-4
Port of Wilmington Hinterland Containerized Cargo Forecast (loaded TEUs only)

Region	Port	2025	2030	2035	2040	2045
Non-Asia	Wilmington, NC	107,203	132,875	150,336	170,091	192,443
Asia	USEC Alternate	162,621	201,564	228,052	258,019	291,925

4.4.2 Bulk Commodity and Fleet Forecast

Bulk and breakbulk commodities include fuel and chemicals (liquid bulk), wood chips and potash (dry bulk), and lumber (break bulk). Historical tonnages (Tables 2-7 and 2-8) show no persistent growth trends and no projected future growth in bulk commodity tonnages were identified. Therefore, future without-project bulk commodity tonnages are projected to be consistent with recent historical tonnages. The transport of bulk commodities is not constrained by without-project channel dimensions and will not benefit from the proposed project. Therefore, bulk commodity transport has no effect on plan formulation or plan selection and is included in the detailed economic analysis only to account for the impact of bulk vessel transits on potential channel congestion.

The fleet forecast for bulk and break bulk commodities was developed using the HarborSym vessel loading tool. The number of vessel calls does not change from year to year under future without-project conditions (Table 4-5) because the commodity forecast is held constant.

Table 4-5
Bulk, Breakbulk, and Non-Asia Container Vessel Fleet Forecast
(Annual Vessel Calls)

Vessel Type	Annual Calls
Sub-Panamax Containership	66
Bulk Carrier	48
General Cargo	110
Oil Tanker	151
Chemical Tanker	92
Ro-Ro	15
Total	**482**

4.5 Containership Fleet Forecast

The Wilmington Harbor Asia services fleet forecast is based on historical trends, observed vessel operations, and projected conditions at other domestic ports of call sharing the relevant USEC-Asia services, as well as trade partner international ports. The containership fleet forecast is the focus of this analysis. Bulk vessels are forecasted for inclusion in HarborSym modeling, but do not benefit or otherwise influence plan formulation or selection.

The without-project condition fleet forecast for non-Asia containerized cargo is based on the existing fleet calling at the Port of Wilmington. There are three weekly containership services and one bi-weekly service, all using sub-Panamax vessels (Table 4-6). Over time, the vessels on these services may load more fully or Panamax vessels may rotate into the services as the number of TEUs increase with projected growth in trade. However, in the foreseeable future, vessels on these services are not projected to be constrained by without-project channel conditions.

Table 4-6
Non-Asia Cargo Without-project Containership Fleet Forecast
for Port of Wilmington

Frequency	Route	Carrier	Average Vessel TEU Capacity
Weekly	Central & South America	Sealand/Maersk	1,720
Weekly	Europe	International Container lines	3,100
Weekly	Central America & Carib	Crowley	960
Bi-weekly	Europe & Mid-East	Bahri	364 with RoRo

The future without-project fleet for vessels on USEC-Asia services is projected to consist mainly, if not exclusively, of Neo-Panamax vessels (PPX3 and PPX3Max) for services that transit the Panama Canal. For USEC-Asia services transiting the Suez Canal, the future without-project fleet will consist of Neo-Panamax vessels and Post-Neo-Panamax vessels (PPX4). The two USEC-Asia services calling at the Port of Wilmington that are projected to shift to alternative USEC ports under without-project conditions transit the Panama Canal and therefore are the focus of the without-project fleet forecast. Note that USEC-Asia services, which use the Suez Canal, would also be constrained at the Port of Wilmington, but because there are no services using the Suez Canal currently calling at the Port of Wilmington Suez services are not included in the forecast.

Prior to the Panama Canal expansion, all the USEC-Asia services using the Panama Canal consisted exclusively of Panamax-sized vessels. These vessels all had a beam of 106 feet and were no longer than 965 feet, with TEU capacities ranging from 4,300 for older vessels to 5,100 for newer vessels. Panamax vessels became dominant on these services because they were the most efficient vessels (lowest transportation cost per TEU) that could be deployed through the Panama Canal. The maximum vessel size for the new Panama Canal locks[19] is 160 feet beam, 1,200 feet LOA, and maximum operating draft through the canal of 50 feet. These dimensions define the size of the Neo-Panamax class of containerships, which include PPX3 and PPX3Max vessels (see Table 4-7).

The future without-project condition fleet forecast for vessels on the USEC-Asia services transiting the Panama Canal will consist of PPX3 and PPX3Max vessels. Tables 2-15 through 2-18 demonstrate the transition from a Panamax dominated fleet in 2009 (prior to the Panama Canal expansion) to a Neo-Panamax dominated fleet. In 2018, only two years after the opening of the new Panama Canal locks, Neo-Panamax vessels increased from 0% to 58% - 72% of the fleet for the example routes presented in the tables. This transition is projected to continue until USEC-Asia services transiting the Panama Canal are dominated by Neo-Panamax vessels in the same manner that Panamax vessels dominated under the historical lock constraints.

The annual number of vessel calls (Table 4-7) for the USEC-Asia without-project condition commodity forecast (Table 4-4) was developed using the HarborSym vessel loading tool.

Table 4-7
Port of Wilmington Hinterland Asia Cargo Without-project Containership Fleet Forecast

Vessel Class	Port	2023	2028	2030	2040	2045-2076
PPX3 & PPX3Max	USEC Alternate	64	83	89	126	126

4.6 Without-project Transportation Costs

Without-project transportation costs are calculated for the USEC-Asia cargo, which is using alternative ports and PPX3 and PPX3Max vessels under without-project conditions. Without-

[19] OP Notice to Shipping No. N-1-2018 Vessel Requirements, 01Jan18, Panama Canal Authority

project transportation costs for the USEC-Asia cargo includes waterborne and landside transportation costs. Transportation costs are not calculated for non-Asia cargo or bulk cargo using the Port of Wilmington because these transportation costs are projected to remain the same under without and with-project conditions.

4.6.1 Without-project Waterborne Transportation Costs

Without-project waterborne transportation costs are based on the Port of Savannah as the alternative port for Wilmington's hinterland containerized Asia cargo identified in the commodity forecast. Savannah was selected as the most likely alternative port because Savannah's position in the without-project condition port rotation is ahead of Charleston (Table 4-8), which is reasonable considering that Savannah has the largest share of cargo on the vessel. Calling at Savannah before calling at Charleston, which is consistent with the existing condition (Table 2-19) creates a 2-day time advantage for Wilmington-hinterland cargo being offloaded at Savannah as compared to Charleston. Base-case without-project waterborne transportation costs are calculated for Wilmington's hinterland containerized Asia cargo using Savannah as the alternative port. The risk and uncertainty associated with this without-project condition assumption is addressed in a sensitivity analyses that uses Savannah as the alternative port for Wilmington's hinterland Asia imports (maintaining the time advantage) and using Charleston as the alternative port for Wilmington's hinterland Asia exports.

Table 4-8
Without-project ZCP and EC2 Services Ports-of-Call (Loop)

ZCP Service (Zim/2M)	EC2 Service (ONE)
Tianjing Xingang	Qingdao
Qingdao	Ningbo
Ningbo	Shanghai
Shanghai	Busan
Pusan	Panama Canal
Panama Canal	Manzanillo (PA)
Kingston, JA	New York, NY
Savannah, GA	Boston, MA
Charleston, SC	Savannah, GA
Jacksonville, FL	Charleston, SC
Kingston, JA	Panama Canal
Panama Canal	Qingdao
Slavyanka	
Pusan	
Tianjing Xingang	

Without-project waterborne transportation costs (Table 4-9) were calculated by the USACE Deep Draft Navigation Planning Center of Expertise, using the HarborSym model. The average annual equivalent value waterborne transportation costs, under Base-case without-project conditions (Savannah as alternate port), are $119,361,000 calculated at the FY 2020 Federal discount rate (2.75%) over 50 years. Waterborne transportation costs are marginally lower for the sensitivity analysis because export cargo, which uses Charleston in the sensitivity analysis, has a 100-nautical mile shorter distance to travel to Asia.

Table 4-9
Wilmington Hinterland Containerized Asia Cargo Without-project Waterborne Transportation Costs: Alternate Ports for Selected Years (thousands $FY20)

	2025	2030	2035	2040	2045	AAEQ
Savannah	$84,687	$101,667	$114,209	$126,749	$139,291	$119,361
Savannah/Charleston	$84,247	$101,138	$113,616	$126,092	$138,568	$118,742

4.6.2 Without-project Landside Transportation Costs

Without-project landside transportation costs are calculated based on the trucking costs from the cargo's origin or destination in the Port of Wilmington's hinterland to the Port of Savannah. Trucking costs associated with transporting a 40-ft shipping container from the port of entry to the landside hinterland were estimated by surveying regional trucking companies. Costs, including fuel service rates, were obtained from five trucking companies for transporting a container from the ports of Wilmington, Norfolk, Charleston, and Savannah to a selection of cities in the region and further into the hinterland. Surveyed trucking quotes were aggregated and analyzed in Excel to calculate distribution functions for total costs, including fuel service costs. The quotes were assessed for round trips from all ports to all destinations.

A linear regression equation was developed from the survey information, which is used in this analysis to determine the trucking cost based on mileage traveled. Route optimization was set to preserve total travel time rather than total travel distance. Output values for travel distance, time, and route path GIS line geometry were generated. It is assumed that the return trip distance from the destination city to the port is the same as the distance traveled from the port to the city.

Graphical analysis of trucking quotes as depicted in Figures 4-2 and 4-3 reveals an initial cost of $70.13 (FY 2017 dollars) to initiate a trip and an expected decrease in trip rate with increased distance traveled. The FY 2017 costs are updated to FY 2020 costs using the Producer Price Index for General Freight Trucking, Long-Distance Truckload generated the Federal Reserve Bank of St. Louis.[20]

[20] Average PPI for FY17 = 124.6; Average PPI for FY19 = 140.9; Update factor = 1.131

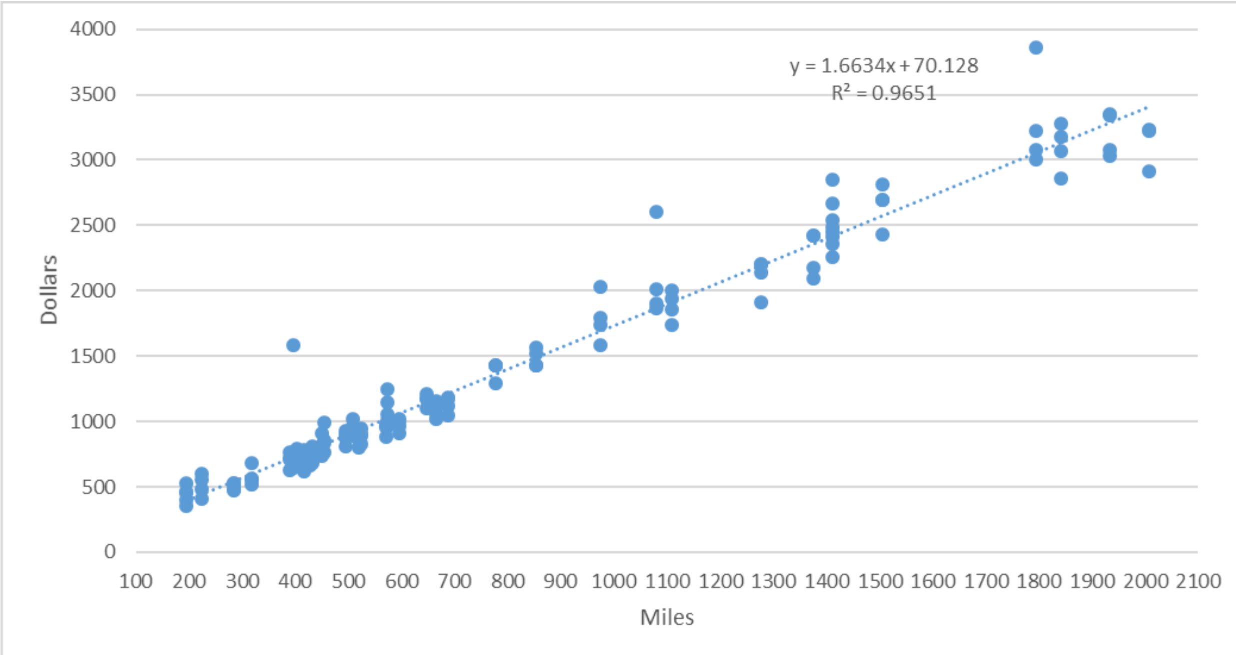

Figure 4-2
Trucking Costs by Miles Driven

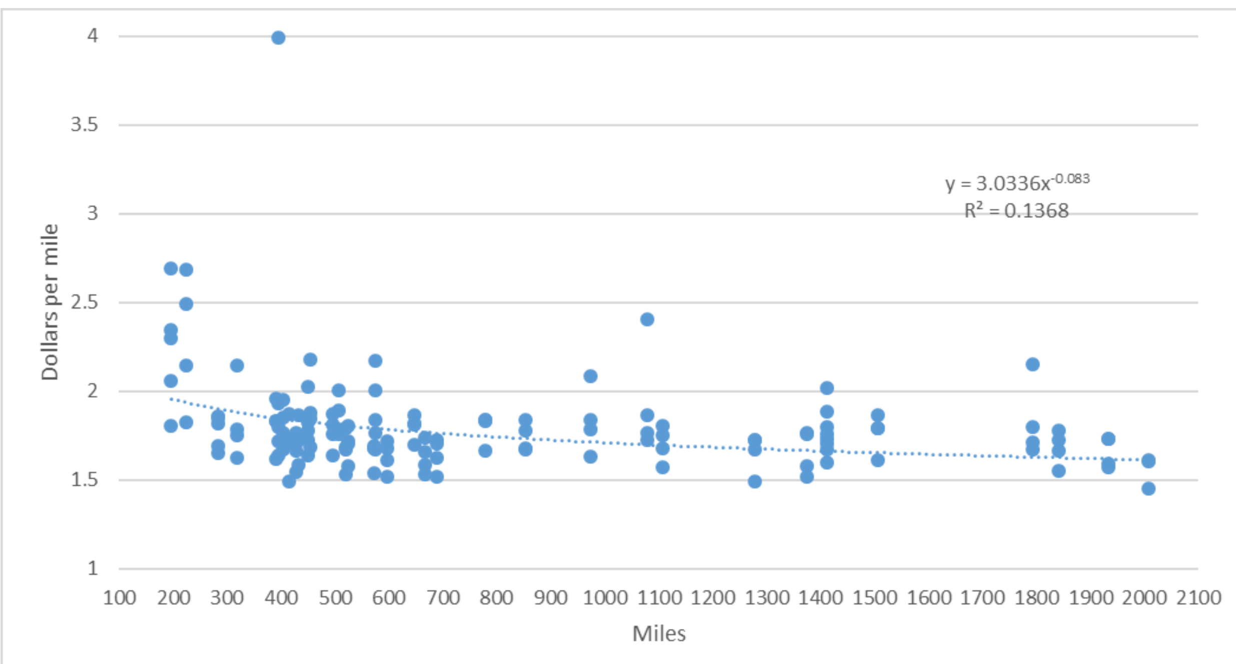

Figure 4-3
Trucking Rates (dollars per mile) by Miles Driven

Without-project landside costs for Wilmington's hinterland containerized Asia cargo are calculated for Savannah as the alternative port in the base-case. Calculation are also performed for a sensitivity analysis using Savannah as the alternative port for imports and Charleston as the alternative port for exports. Weighted average trucking costs per TEU and weighted average trucking costs per truck haul are presented in Table 4-10. The values in Table 4-10 are weighted by the number of TEUs and number of trips from each origin and destination for cargo in the Wilmington hinterland Asia containerized cargo forecast. Trucking costs are calculated for each year of the 50-year planning period and are held constant at 2045 levels from 2045 – 2076 because the commodity forecast is held constant during the same time period, although discounting continues for the full 50 years. Table 4-11 presents trucking costs for selected years.

Table 4-10
Round Trip Trucking Costs

Cost Metric	Savannah	Savannah/Charleston
Weighted Average $/TEU	$ 683.91	$ 600.03
Weighted Average $/Truck Haul	$ 1,265.23	$ 1,110.06

Table 4-11
Port of Wilmington's Hinterland Containerized Asia Cargo Total Trucking Costs (Thousands of FY20 Dollars)

	2025	2030	2035	2040	2045	AAEQ
Savannah	$105,323	$130,546	$147,701	$167,110	$189,069	$172,030
Savannah/Charleston	$91,750	$113,471	$128,382	$145,253	$164,340	$155,260

Total origin to destination transportation costs for Wilmington's hinterland containerized Asia cargo includes water borne costs (Table 4-9) and landside costs (Table 4-11). Total transportation costs are presented in Table 4-12 for the base-case (Savannah as alternate port for all cargo) and in Table 4-13 for the sensitivity analysis (Savannah as alternative port for imports and Charleston as the alternative port for exports).

Table 4-12
Port of Wilmington's Hinterland Containerized Asia Cargo Total Transportation Costs: Savannah as Alternate Port (Thousands of FY20 Dollars)

	2025	2030	2035	2040	2045	AAEQ
Waterborne	$84,687	$101,667	$114,209	$126,749	$139,291	$119,361
Landside	$105,323	$130,546	$147,701	$167,110	$189,069	$172,030
Total	$190,010	$232,213	$261,910	$293,859	$328,360	$291,391

Table 4-13
Port of Wilmington's Hinterland Containerized Asia Cargo Total Transportation Costs: Savannah as Alternate Port for Imports and Charleston as Alternate Port for Exports (Thousands of FY20 Dollars)

	2025	2030	2035	2040	2045	AAEQ
Waterborne	$84,247	$101,138	$113,616	$126,092	$138,568	$118,742
Landside	$91,750	$113,471	$128,382	$145,253	$164,340	$155,260
Total	$175,997	$214,609	$241,998	$271,345	$302,908	$247,002

4.7 Without-Project Environmental Conditions

4.7.1 Geology, Soils, and Sediments

Under without-project conditions, continuing maintenance of the currently authorized Wilmington Harbor Project would not be expected to affect geologic, soil, or sediment conditions within the study area.

4.7.2 Shoreline Erosion

Under without-project conditions, maintenance of the currently authorized federal navigation channel and associated beach disposal practices would continue in accordance with current practices. Therefore, it is expected that erosional conditions along the shorelines of Bald Head Island and Oak Island would remain similar to existing conditions. Depending on the rate of sea level rise, background erosion rates along the shorelines of both islands would be expected to gradually increase. Shipping activity in the harbor would be expected to remain the same or decrease due to the inability to accommodate larger vessels; therefore, no significant changes in estuarine shoreline erosional conditions would be expected.

4.7.3 Hydrogeology

As described in the Groundwater Modeling section of Appendix A: Engineering, the USGS's MODFLOW hydrologic model was used to evaluate the potential effects of sea level rise and harbor deepening on local groundwater flow and the regional freshwater aquifer system. Baseline modeling results indicate that the Cape Fear River serves primarily as a discharge area for the surficial, Castle Hayne, and Peedee aquifers; thus indicating limited potential for lateral movements of saline river water into the aquifer system. However, baseline modeling identified localized areas near the Cape Fear River channel where pumping has lowered groundwater heads below sea level, indicating the potential for salinity intrusion via downward migration of surface water into the groundwater system. The identified areas are associated with industrial and municipal water supply well fields; including those operated by the Capital Power Corporation in Southport, the Carolina Beach and Kure Beach, Bald Head Island, and the Invista Corporation near Lake Sutton. The principal focus of the modeling effort was to investigate any changes in the aquifer to river discharge relationship and/or groundwater pumping patterns that could increase the potential for salinity intrusion. Groundwater simulations for both the No Action

Alternative and Tentatively Selected Plan (TSP) were run under the high (RSLR3) sea level change scenario.

Under without-project conditions, the model results indicate that the effects of RSLR on groundwater flow and discharge patterns would be negligible. Furthermore, the model results indicate that the increase in river surface water levels under the RSLR3 scenario would not increase the potential for salinity intrusion into groundwater via downward surface water migration.

4.7.4 Surface Water Hydrology - Water Levels, Tides, and Currents

The Delft 3-D hydrodynamic model was used to evaluate the effects of without and with-project conditions on water levels and current speeds under various flow conditions (low, typical, and high) and RSLR scenarios (low, intermediate, and high). Water level and current velocity data were extracted from the model results for a series of data point locations along the longitudinal axis of the estuary (Figure 4-4).

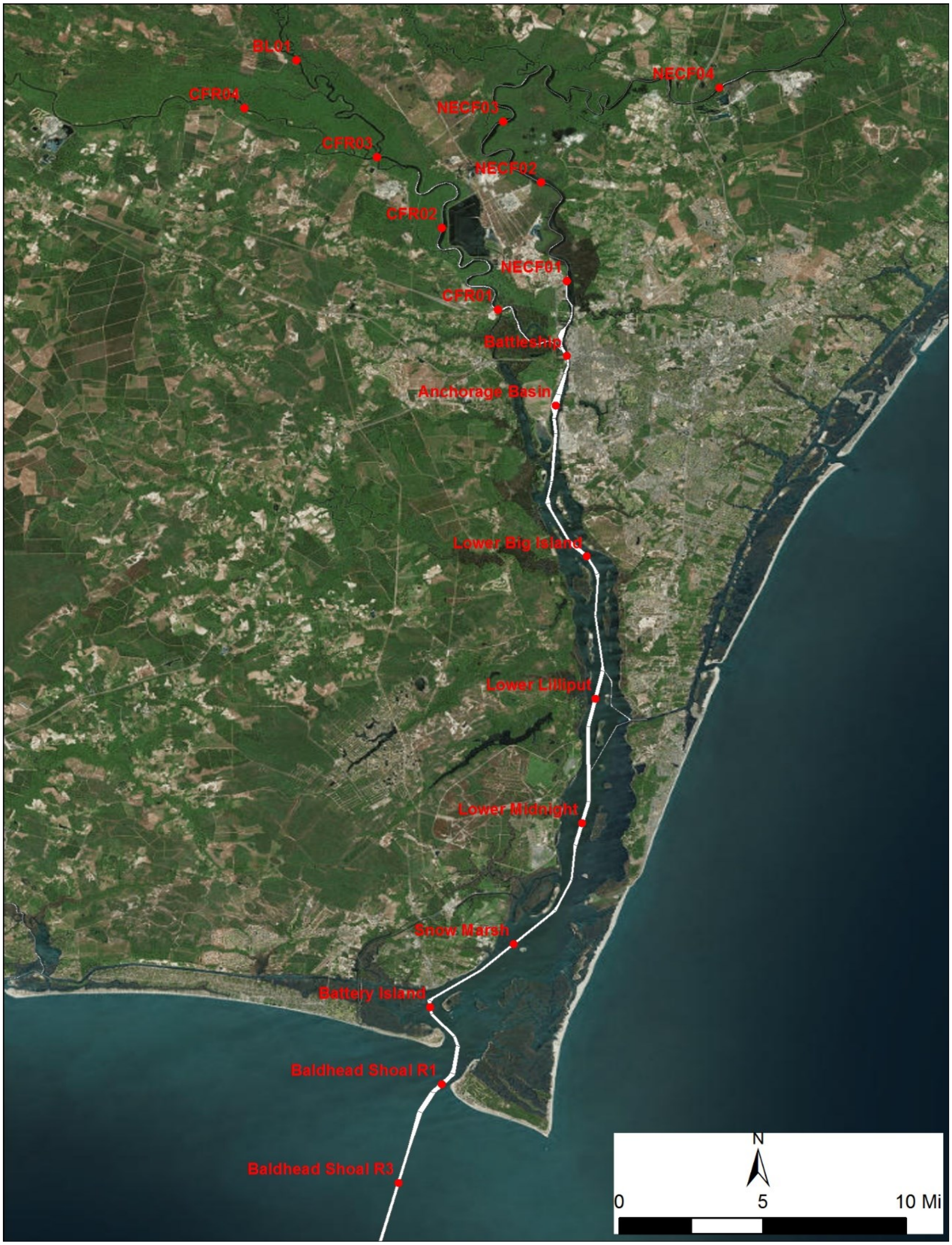

Figure 4-4
Hydrodynamic Model Data Extraction Points

4.7.4.1 Water Levels/Tides

Under without-project conditions, the modeling results indicate that RSLR will cause both MHW and MLW to rise throughout the Cape Fear River estuary. Under the RSLR1 scenario and typical flow conditions, the largest projected MHW increase is 0.34 ft (4.1 inches) in the lowermost estuary at Battery Island (Table 4-14). The magnitude of projected MHW increase declines steadily through the estuary above Battery Island, with an increase of 0.28 ft (3.4 inches) projected in the mid-estuary at Wilmington and an increase of 0.19 ft (2.3 inches) projected at data point CFR04 near the upper end of the estuary. The projected MLW rise at Battery Island is also 0.34 ft; however, the magnitude of MLW rise increases steadily through the estuary above Battery Island, with a rise of 0.38 ft (4.6 inches) projected at Wilmington and a maximum rise of 0.46 ft (5.5 inches) projected at data point CFR03 in the uppermost estuary near the mouth of the Black River (Table 4-14).

Table 4-14
Projected Water Level Changes Under Without-project Conditions on MHW, MLW, and Tidal Range Using RSLR1 Scenario

Reach	MHW (ft)			MLW (ft)			Tidal Range (ft)		
	Low Flow	Med Flow	High Flow	Low Flow	Med Flow	High Flow	Low Flow	Med Flow	High Flow
BL01	0.22	0.19	0.21	0.32	0.18	0.16	-0.11	0.02	0.05
NECF01	0.28	0.28	0.28	0.39	0.39	0.4	-0.11	-0.12	-0.12
NECF02	0.26	0.25	0.25	0.41	0.41	0.41	-0.15	-0.16	-0.15
NECF03	0.25	0.25	0.25	0.42	0.43	0.43	-0.18	-0.18	-0.18
NECF04	0.28	0.26	0.25	0.36	0.33	0.29	-0.08	-0.08	-0.04
CFR04	0.19	0.18	0.18	0.4	0.4	0.23	-0.2	-0.22	-0.05
CFR03	0.22	0.21	0.22	0.46	0.47	0.36	-0.24	-0.27	-0.14
CFR02	0.24	0.25	0.26	0.45	0.43	0.43	-0.21	-0.19	-0.17
CFR01	0.27	0.27	0.28	0.39	0.39	0.39	-0.12	-0.12	-0.11
Battleship	0.28	0.28	0.28	0.38	0.38	0.39	-0.1	-0.11	-0.11
Lower Anchorage	0.28	0.28	0.28	0.38	0.38	0.39	-0.1	-0.1	-0.11
Lower Big Island	0.28	0.28	0.27	0.37	0.37	0.38	-0.09	-0.09	-0.1
Lower Lilliput	0.3	0.3	0.29	0.37	0.37	0.37	-0.06	-0.07	-0.08
Lower Midnight	0.32	0.32	0.31	0.36	0.36	0.37	-0.04	-0.05	-0.05
Snows Marsh	0.33	0.33	0.33	0.36	0.36	0.36	-0.03	-0.03	-0.03
Battery Island	0.34	0.34	0.34	0.34	0.34	0.34	0.00	0.00	0.00

Although the model results show increases in both MHW and MLW, the projected rise in MLW is larger than the projected MHW rise. The resulting net effect of the disproportionate MHW and MLW changes under the without-project conditions is a decrease in tidal range. In the lowermost estuary, where the projected increases in MHW and MLW are similar (Battery Island to Lower Lilliput), the net decreases in tidal range are relatively small (0.0 to -0.06 ft) (Table 4-14). However, in the reaches above Lower Lilliput where the projected rise in MLW becomes substantially larger than the rise in MHW, reductions in tidal range are greater, with a projected decrease of -0.11 at Wilmington and a maximum projected decrease of -0.27 ft in the upper estuary at data point CFR03. In relation to typical flow conditions, the model results for low and high flow conditions under RSLR1 show only negligible differences in water levels of ≤0.03 ft.

4.7.4.2 Currents

Under without-project conditions, the model results indicate that the effects of RSLR on currents would be negligible. Under the RSLR1 scenario, projected maximum current speed changes in the surface layer are +/- 0.2 ft/second (s) under all flow conditions. The largest projected current speed increase is 0.17 ft/s in the Anchorage Basin under high flow conditions. Maximum increases throughout the remainder of the study area are <0.1 ft/s under all flow conditions. The largest projected current speed decrease is -0.14 ft/s at CFR04 in the uppermost reach of the estuary. Maximum projected decreases throughout the remainder of the study area are ≤0.1 ft/s under all flow conditions.

4.7.5 Wind and Wave Climate

The DELFT 3D WAVE module was used to investigate the effects of RSLR and channel deepening on the nearshore ocean wave climate (Appendix A: Engineering). The WAVE module was developed to simulate wave transformation from deepwater to the oceanfront shoreline. Wave data were extracted from the model results for a series of nearshore data points along the shorelines of Bald Head Island and Oak Island.

Under without-project conditions, the model results indicate that RSLR would have negligible effects on the nearshore wave climate and significant wave heights. No adverse wave climate effects would be expected under the No Action Alternative.

4.7.6 Sea Level Rise

Although sea level rise is a critical factor in the analyses of potential impacts, the rate of RSLR within the study area would be unaffected by any actions that may occur under without-project conditions.

4.7.7 Salinity

The Delft 3-D hydrodynamic model was used to simulate salinity changes under tidal flows, vertical salinity gradient dynamics, and the propagation of salinity into the upper reaches of the estuary. As in the case of the main hydrodynamic modeling effort, salinity was modeled under low, medium, and high flow conditions and three sea level rise scenarios. Salinity data for surface, mid-depth and bottom layers were extracted from the model results for a series of point locations along the longitudinal axis of the estuary. Projected salinity changes under all flow and RSLR scenarios generally follow a similar longitudinal pattern, with the largest projected increases occurring in the bottom to mid-depth layers in the vicinity of Anchorage Basin and maximum surface salinity increases of reduced magnitude occurring in the down-estuary Lower Lilliput to Lower Midnight reaches. Projected salinity increases in all three layers are steadily reduced in the up-estuary and down-estuary reaches above and below the projected maximum increase locations. This general pattern reflects both longitudinal tidal range variability and vertical stratification within the estuary. Stratification sets up density currents that drive saline ocean water upstream along the channel bottom, while concurrently freshwater river discharge flows downstream on the surface, thus lowering surface salinities and shifting the surface layer salinity gradient downstream in relation to the bottom and mid-depth layers.

Under without-project conditions, the modeling results indicate that RSLR and resulting increases in the tidal prism will increase surface, mid-depth, and bottom salinities. Projected increases in average annual salinity under the typical flow year, low RSLR scenario are relatively small, with a maximum increase of 0.7 ppt occurring in the bottom layer in the vicinity of the Anchorage Basin (Table 4-15). The maximum increase at mid-depth of 0.6 ppt also occurs in the vicinity of the Anchorage Basin, while the maximum surface layer increase of 0.5 ppt occurs downstream in the Lower Lilliput to Lower Midnight channel reaches. In the case of all three depth layers, projected salinity increases are steadily reduced in the reaches above and below the maxima. The up-estuary limit of salinity change occurs at CFR01 and NECFR02, where projected increases in all three layers are reduced to 0.1 ppt. Projected salinity changes under the remaining flow and RSLR scenarios follow the same general longitudinal pattern, with the largest projected increases occurring in the bottom to mid-depth layers in the vicinity of Anchorage Basin and relatively small maximum surface layer increases occurring in the down-estuary Lower Lilliput to Lower Midnight reaches. Under the RSLR2 scenario and typical flow conditions, the maximum average annual salinity increases in the mid-depth and bottom layers are 1.5 and 3.8 ppt in the vicinity of Anchorage Basin, while the maximum surface salinity increase is 1.2 ppt in the Lower Midnight reach. Salinities at stations along the declining up-estuary and down-estuary gradients under the RSLR2 scenario are similarly increased in proportion to the corresponding station salinities under the RSLR1 scenario. However, the RSLR2 scenario has little additional effect on the up-estuary extent of salinity intrusion, with the upper limit of effects remaining at CFR01 and NECFR02.

Table 4-15
Without-project Conditions - Projected Average Annual Salinity Changes (ppt) Under RSLR1 and Typical Flow Conditions

Station	Surface			Mid-Depth			Bottom		
	Exist	FWOP	FWOP Δ	Exist	FWOP	FWOP Δ	Exist	FWOP	FWOP Δ
NECFR02	0.1	0.1	**0.1**	0.1	0.1	**0.1**	0.1	0.1	**0.1**
CFR01	0.2	0.3	**0.1**	1.1	1.3	**0.2**	1.6	1.8	**0.2**
NECFR01	1.9	2.1	**0.2**	3.6	4.0	**0.4**	4.0	4.3	**0.4**
Battleship	2.7	3.0	**0.2**	6.8	7.3	**0.5**	9.6	10.2	**0.6**
Lower Anchorage	3.3	3.6	**0.3**	9.6	10.2	**0.6**	13.5	14.2	**0.7**
Lower Big Island	6.3	6.7	**0.4**	14.0	14.7	**0.6**	17.6	18.1	**0.6**
Lower Lilliput	10.1	10.5	**0.5**	20.1	20.6	**0.5**	22.5	22.9	**0.4**
Lower Midnight	14.2	14.7	**0.5**	24.3	24.7	**0.5**	26.8	27.2	**0.3**
Snows Marsh	21.2	21.6	**0.4**	28.7	29.0	**0.3**	30.6	30.7	**0.2**
Battery Island	24.6	25.0	**0.4**	29.8	30.0	**0.2**	31.5	31.6	**0.1**
Bald HeadR1	28.2	28.6	**0.3**	32.8	32.8	**0.1**	33.5	33.5	**0.0**
Bald HeadR3	31.7	31.8	**0.1**	35.0	35.0	**0.0**	35.0	35.0	**0.0**

4.7.8 Surface Water Quality

The D-Water Quality (D-WAQ) module for DELFT 3D was used to evaluate potential effects on dissolved oxygen (DO) concentrations in the Cape Fear River estuary. Although Total Maximum Daily Loads (TMDLs) have not been established for the lower Cape Fear River, the ~15-mile mainstem Cape Fear River reach from the lower end of Keg Island upriver to Navassa is listed as an impaired water body on the NC 303d list; in part due to exceedances of the state water quality standard for DO (>5.0 mg/L). Dissolved oxygen concentrations are strongly and negatively correlated with water temperature. Oxygen solubility (i.e., water capacity to accept new oxygen) decreases with increasing temperature, while oxygen removal via biological (microbial) consumption increases with increasing temperature. As a result, minimum DO concentrations and exceedances of the state water quality standard typically occur during the summer when water temperatures are the highest. According to Mallin (2013), other factors that contribute to summer exceedances of the DO standard include the discharge of organic industrial effluent at Riegelwood, organic-rich blackwater inputs from the Black River and Northeast Cape Fear River, and algal blooms that form in the summer behind Lock and Dam #1. Low flow conditions and associated increases in salinity and stratification can also contribute to low DO concentrations, as oxygen solubility decreases with increasing salinity, and stratification typically reduces the delivery of oxygen to the bottom layer via mixing.

Under without-project conditions, the typical flow RSLR1 model results indicate that RSLR would cause surface, middle, and bottom layer DO concentrations in the middle to upper estuary to decrease by 0.3 mg/L or less. The largest decreases of 0.3 mg/L are projected in the mainstem Cape Fear River above Eagle Island from station CFR01 to CFR03. Maximum decreases are reduced to 0.2 mg/L in the Battleship and Anchorage Basin channel reaches below, and projected decreases throughout the remainder of the estuary are ≤0.1 mg/L. The maximum decreases occur during the winter months when DO concentrations are typically the highest of the year.

4.8 Tidal Wetlands

The composition of tidal wetland communities in the Cape Fear River estuary is determined by tidal flood water salinities and resulting soil biochemical conditions (methanogenic vs sulfate reducing) (Hackney and Avery 2015). Accordingly, any increases in estuarine salinity could potentially alter the composition, distribution, and relative extent of saltwater, brackish, and freshwater tidal wetlands within the Cape Fear River system. The potential effects of salinity on tidal wetlands were a principal issue of concern and a major focus area of the environmental analyses conducted for this study. An updated tidal wetland classification was developed for the study area to provide an accurate baseline for the analysis of wetland effects. ENVI 5.4 image analysis software and satellite imagery (Landsat 8) were used to perform a GIS-based supervised classification of tidal wetlands within the Cape Fear River estuary. The ENVI program uses a maximum likelihood analysis to group pixels into spectral classes based on user defined training data. Field surveys conducted during the late summer and fall of 2017 provided training data that were used to refine the classification. Surface salinity data were extracted from the year-long model simulation results and averaged for each grid cell to produce average annual surface salinity GIS layers for the various Existing Condition, No Action, and TSP flow and RSLR scenarios. Based on the grid cell average salinity values, salinity isopleths were added to define the boundaries or thresholds between the polyhaline, mesohaline, oligohaline, and tidal freshwater salinity zones in the various river and tidal creek channels. The model-projected Existing Condition salinity isopleths [polyhaline-mesohaline (18 ppt), mesohaline-oligohaline (5 ppt), and oligohaline-tidal freshwater (0.5 ppt)] and the projected changes in the isopleths under the various No Action and with-project scenarios, in combination with the baseline wetland classification, comprise the basis for the analysis of wetland effects. The methods employed and results of the assessment are detailed in the Wetland Impact Assessment Appendix (Appendix F).

Under without-project conditions, the salinity modeling results indicate that RSLR will cause upstream shifts in the oligohaline-freshwater (0.5 ppt) salinity isopleths ranging from ~0.08 to 0.75 mile. Wetlands potentially affected by the projected upstream shifts in the 0.5 ppt isopleths under without-project conditions include ~278 acres of tidal freshwater wetlands and ~11 acres of tidal brackish wetlands (Table 4-16). The potentially affected freshwater wetlands include ~180 acres of tidal swamp forest and ~98 acres of tidal freshwater marsh. The potentially affected tidal brackish wetlands include approximately six acres of cattail marsh, approximately three acres of brackish marsh mix, and approximately two acres of Phragmites marsh. Projected shifts in the mesohaline-oligohaline (5.0 ppt) isopleths under without-project conditions are confined to the existing brackish marsh-dominated reaches of the estuary. The delineated tidal floodplain areas that are affected by the mesohaline-oligohaline isopleth shifts encompass ~267 acres of brackish cattail marsh, approximately two acres of Phragmites marsh, and approximately one acre of smooth cordgrass marsh.

Table 4-16
Wetlands Potentially Affected by Projected Upstream Salinity Isopleth Shifts Under Without-project Conditions

Water Body	Model Scenario (Flow/RSLR)	Isopleth Shift (river miles)	Wetland Class[1]						
			SWF	FWM	CAT	BRM	PHR	SPA	Total
Oligohaline-Freshwater Isopleth Shifts (acres)									
Cape Fear River Mainstem	DY – RSLR1	0.08	6.0	3.6	2.4				**12.0**
Northeast Cape Fear River	DY – RSLR1	0.74	52.8	75.4					**128.2**
Smith Creek	TY – RSLR1	0.22	19.5	0.3		0.5	0.3		**20.6**
Sturgeon Creek	TY – RSLR1	0.11	1.2	0.5	3.6		2.1		**7.4**
Jackeys Creek[2]	TY – RSLR1	0.27	39.6	0					**39.6**
Town Creek[2]	TY – RSLR1	0.44	35.8	1.8					**37.6**
Lilliput Creek[2]	TY – RSLR1	0.75	25.4	16.0		2.4			**43.8**
Total Oligohaline-Freshwater (acres)			**180.3**	**97.6**	**6.0**	**2.9**	**2.4**	**0.0**	**289.2**
Mesohaline-Oligohaline Isopleth Shifts (acres)									
Cape Fear River Mainstem	DY – RSLR1	0.42			142.3		0.6		**142.9**
Northeast Cape Fear River	DY – RSLR1	0.06			15.0		0.7		**15.7**
Barnards Creek	TY – RSLR1	0.05			1.5			1.1	**2.6**
Lilliput Creek[3]	TY – RSLR1	0.67			42.7				**42.7**
Town Creek	TY – RSLR1	0.73			65.2		1.1		**66.3**
Total Mesohaline-Oligohaline (acres)			**0.0**	**0.0**	**266.7**	**0.0**	**2.4**	**1.1**	**270.2**

[1] SWF = Tidal Freshwater Swamp Forest; FWM = Tidal Freshwater Marsh; CAT = Cattail; BRM = Brackish Mix; PHR = Phragmites australis; SPA = Spartina alterniflora

[2] The model-projected series of Existing Condition, No Action, and TSP salinity isopleths was manually shifted downstream until the Existing Condition isopleth was positioned at the upper end of the active tidal swamp forest to freshwater marsh conversion zone. The model-projected distances between the isopleths were maintained.

[3] The model-projected series of Existing Condition, No Action, and TSP salinity isopleths was manually shifted downstream until the Existing Condition isopleth was positioned at the approximate threshold between the cattail dominant and Spartina alterniflora dominant tidal wetland zones. The model-projected distances between the isopleths were maintained.

4.9 Benthic Communities

4.9.1.1 Soft Bottom

Under without-project conditions, ~2,226 acres of soft bottom habitat in the currently authorized navigation channel, inclusive of the channel slopes, would experience recurring maintenance dredging disturbance. Depending on reach-specific maintenance intervals, benthic infaunal communities in the various channel reaches would experience recurring cycles of depletion and recovery every one to four years. Reported rates of benthic infaunal recovery in the Wilmington Harbor channel (Ray 1997) and other navigation channels (Van Dolah et al. 1984, Van Dolah et al. 1979, Stickney and Perlmutter 1975, and Stickney 1972) indicate that the effects of individual dredging events on benthic infaunal communities in silty channel reaches would be short-term (<6 months), whereas benthic communities in the coarse sand channel reaches of the lower estuary and nearshore ocean would experience longer term effects lasting one to two years. Although the impacts of individual dredging events would be temporary, recurring periods of infaunal depression would cause a reduction in total benthic community productivity over the 50-year assessment period.

4.9.1.2 Hardbottom

Remote sensing investigations conducted for previous harbor projects indicate that the nearest naturally occurring hardbottom areas are located approximately two to three miles west of the ocean entrance channel and the new ODMDS. Several deposits of dredged rubble material along the west side of the existing channel within the old ODMDS have relief and have been colonized by hardbottom benthic assemblages (Appendix H: Hardbottom Resources). Under without-project conditions, continuing maintenance of the currently authorized navigation channel and associated disposal operations would not be expected to have any direct mechanical impacts on the naturalized hardbottom features in the old ODMDS. Maintenance dredging would potentially affect these hardbottom features through sediment suspension and redeposition effects. However, due to their proximity to the navigation channel, these features are subject to continual sedimentation from ship prop wash, strong tidal currents, and frequent ongoing maintenance dredging. Therefore, continuing maintenance dredging would not be expected to alter the condition of these habitats.

4.9.1.3 Shell bottom

Analyses of remote sensing survey data did not identify any structural shell bottom habitats within the existing channel. Therefore, continuing maintenance of the currently authorized navigation channel would not have any direct mechanical impacts on shell bottom resources. Heavy sediment redeposition can impact oysters by inhibiting larval attachment to hard substrates and reducing the respiration and feeding rates of juveniles and adults (Wilber and Clarke 2010). However, the results of sediment plume monitoring during hydraulic barge overflow loading at Wilmington Harbor indicate that suspended sediment plumes are narrow and confined to the navigation channel in the immediate vicinity of the barge (Reine et al. 2002). Monitoring detected no evidence of plume migration or elevated TSS concentrations over the adjacent flats during either the ebb or flood tide surveys. Furthermore, according to Colden and Lipcius (2015), eastern oysters that were subjected to experimental sediment deposition did not exhibit significant mortality or sublethal effects until at least 70% of the shell height was buried.

Therefore, it is expected that any sediment suspension and redeposition effects on shell bottom habitats would be temporary and minor.

4.9.2 Submerged Aquatic Vegetation

NCDMF benthic habitat maps show small scattered patches of SAV throughout the lower Cape Fear River estuary; however, NCDMF has determined that the mapped occurrences are aerial imagery-based misidentifications of marine macroalgae (Personal communication, Ann Deaton, NCDMF Habitat Protection and Enhancement Section, 19 Feb 2019). NCDMF has concluded that SAV beds are absent from the lower estuary. The only confirmed SAV beds in the Cape Fear River estuary, consisting of slender naiad (*Najas gracillima*), are located in the Brunswick River near the US HWY 74/76 Bridge. Therefore, continuing maintenance of the currently authorized navigation channel would not be expected to have any effect on SAV.

4.9.3 Fisheries

Under without-project conditions, continuing maintenance dredging of the currently authorized federal navigation channel would affect marine and estuarine fisheries through soft bottom habitat disturbance, losses of benthic infaunal prey, sediment suspension, and larval entrainment. Maintenance dredging would have direct recurring impacts on soft bottom benthic infaunal invertebrate communities that comprise the prey base for most marine and estuarine soft bottom demersal fishes. Approximately 2,226 acres of previously disturbed soft bottom habitat in the currently authorized channel would experience recurring maintenance dredging disturbance every one to four years. Corresponding cycles of benthic infaunal prey depletion and recovery would impact the foraging activities of soft bottom foraging demersal fishes (e.g., flounders, rays, spots, and croakers), inducing fishes to expend additional energy seeking out alternative soft bottom foraging habitats (Byrnes et al. 2003). As previously described, reported recovery rates in the Wilmington Harbor channel indicate that infaunal recovery in the silty channel reaches would be relatively rapid (<6 months), whereas full recovery in sandy channel reaches would require longer periods of one to two years. Although the effects of individual dredging events would be temporary, recurring periods of infaunal depression would reduce total benthic infaunal productivity over the 50-year assessment period.

Continuing beach disposal operations on Bald Head Island and Oak Island would have recurring direct temporary impacts on intertidal benthic infaunal invertebrate communities that comprise the prey base for many surf zone fishes. The continuing six-year disposal cycle would impact ~3 to 5 linear miles of intertidal beach foraging habitat every two years. Losses of the associated benthic infauna to direct burial would temporarily reduce the availability of prey resources for surf zone fishes. Most benthic infaunal recovery studies have reported recovery within one year of the initial impact when highly compatible beach fill sediments were used and peak infaunal recruitment periods were avoided (Jutte et al. 1999a, Burlas et al. 2001, Van Dolah et al. 1994, Van Dolah et al. 1992, Gorzelany and Nelson 1987, Salomon and Naughton 1984, Parr et al. 1978, and Hayden and Dolan 1974). It is expected that the Wilmington District would continue to conduct beach disposal in accordance with the established sea turtle nesting environmental work window (16 November – 31 April) and beach fill compatibility standards; thereby increasing the likelihood of relatively rapid infaunal recovery.

Dredging-induced sediment suspension and associated increases in turbidity can affect the behaviors (e.g., feeding, predator avoidance, habitat selection) and physiological functions (e.g., gill-breathing) of estuarine fishes and invertebrates. In response to fisheries concerns, a study was undertaken at Wilmington Harbor to monitor the sediment plumes produced by overflow barge loading in the Keg Island and Lower Big Island reaches of the navigation channel (Reine et al. 2002). The principal objective of the study was to determine the spatial extent of plumes and their potential to affect fish utilization of undisturbed nursery habitats that are adjacent to the maintained navigation channel. The study found that overflow plumes and elevated suspended sediment concentrations were narrowly confined to the navigation channel under both ebb and flood tidal conditions, with significant settling of the plumes to the lower portion of the water column occurring within ~300 meters of the barges. A maximum TSS concentration of 191 mg/L was recorded within the plume at the sampling point nearest the barge, whereas maximum TSS concentrations of 60 to 80 mg/L were recorded in the plume at a distance of 300 m. During active dredging, TSS concentrations over the adjacent flats remained similar to ambient conditions, with measured concentrations ranging from 19 to 33 mg/L. No evidence of plume migration or elevated TSS concentrations was detected over the adjacent flats during either the ebb or flood tide surveys. It is expected that the Wilmington District would continue to conduct maintenance dredging within the established fisheries environmental work window (1 August – 31 January), thereby minimizing the potential for adverse sediment suspension effects on estuarine-dependent and anadromous fisheries.

4.10 Managed Fisheries and Essential Fish Habitat

Under without-project conditions, continuing maintenance dredging and disposal activities would affect EFH and federally managed fisheries primarily through sediment suspension and soft bottom habitat disturbance. The water column and soft bottom habitats are components of multiple EFH and/or HPAC habitats within the study area; including unconsolidated bottom, subtidal and intertidal non-vegetated flats, PNA, coastal inlets, and the ocean high salinity surf zone. As previously described, continuing maintenance operations would have recurring temporary direct impacts on soft bottom habitats and benthic infaunal prey communities in the existing navigation channel. Temporary losses of benthic invertebrate infauna would reduce the availability of benthic prey for federally managed species such as red drum, summer flounder, and estuarine-dependent snapper-grouper species. Recurring periods of infaunal depression would reduce total benthic infaunal productivity over the 50-year assessment period. Maintenance dredging events would temporarily affect the water column through sediment suspension and increases in turbidity. Increases in suspended sediment concentrations and turbidity can affect the behavior (e.g., feeding, predator avoidance, habitat selection) and physiological functions (e.g., gill-breathing) of federally managed fisheries such as red drum, summer flounder, estuarine-dependent snapper-grouper species, bluefish, coastal migratory pelagics, and shrimp. Additionally suspended sediments that are dispersed and redeposited outside of the existing channel can impact adjacent soft bottom EFH habitats and associated benthic invertebrate prey communities. However, as previously described, Wilmington Harbor monitoring studies indicate that suspended sediments are narrow and confined to the navigation channel, with significant settlement to the bottom layer occurring with 300 meters of the source (Reine et al., 2002). Therefore, it is expected that the effects of dredging-induced sediment suspension and redeposition on EFH and federally managed species would be localized and short-term.

Continuing beach disposal operations would have recurring direct impacts on intertidal and subtidal soft bottom habitats along Bald Head Island and Oak Island. Temporary losses of soft bottom benthic infauna would reduce the availability of benthic prey for federally managed species that utilize nearshore unconsolidated bottom EFH habitats; including red drum, summer flounder, and bluefish. It is expected that the Wilmington District would continue to conduct beach disposal in accordance with the established sea turtle nesting environmental work window (16 November – 31 April) and beach fill compatibility standards; thereby increasing the likelihood of relatively rapid benthic infaunal recovery. Temporary increases in suspended sediment concentrations and turbidity along the beach disposal areas would have short-term and localized effects on managed species that utilize nearshore unconsolidated bottom and ocean high salinity surf zone EFH habitats; including coastal migratory pelagic species, bluefish, red drum, and summer flounder.

4.11 Coastal Waterbirds

Under without-project conditions, continuing beach disposal operations on Bald Head Island and Oak Island would affect coastal waterbirds through disturbance and impacts on intertidal beach foraging habitats. Beach disposal is conducted every two years in conjunction with maintenance dredging of the Smith Island and Baldhead Shoal 1 entrance channel reaches. Maintenance events have generally placed ~1.1 mcy of material along either a three-mile reach of Bald Head Island or a five-mile reach of Oak Island. Beach construction activities would temporarily disrupt the foraging and/or roosting activities of shorebirds and colonial waterbirds. Beach disposal would result in the burial and temporary loss of intertidal benthic invertebrate infauna within the beach fill templates; thereby, reducing the availability of benthic infaunal prey for shorebirds. Most benthic infaunal recovery studies have reported recovery within one year of the initial impact when highly compatible beach fill sediments were used and larval recruitment periods were avoided (Jutte et al. 1999a, Burlas et al. 2001, Van Dolah et al. 1994, Van Dolah et al. 1992, Gorzelany and Nelson 1987, Salomon and Naughton 1984, Parr et al. 1978, and Hayden and Dolan 1974). It is anticipated that the Wilmington District USACE would continue to conduct maintenance dredging and beach placement on Bald Head Island and Oak Island in accordance with current conservation measures to minimize effects on coastal waterbirds; including adherence to a 16 November - 31 April beach placement environmental work window, beach fill compatibility standards, and the use of onshore delivery pipeline routes that avoid high value inlet habitats for shorebirds.

4.12 Protected Species

4.12.1 North Atlantic Right Whale

Under without-project conditions, continuing maintenance of the currently authorized Wilmington Harbor project would not be expected to have any adverse effects on North Atlantic right whales. It is anticipated that the Wilmington District USACE would continue to conduct maintenance dredging operations in accordance with the terms and conditions of the South Atlantic Regional Biological Opinion (SARBO) (NMFS 1997), thereby effectively mitigating the potential for adverse effects.

4.12.2 Florida Manatee

Under without-project conditions, continuing maintenance of the currently authorized Wilmington Harbor project would not be expected to have any adverse effects on the Florida manatee. It is anticipated that the Wilmington District USACE would continue to conduct maintenance dredging operations in accordance with the USFWS Guidelines for Avoiding Impacts to the West Indian Manatee: Precautionary Measures for Construction Activities in North Carolina Waters.

4.12.3 Other Marine Mammals

Additional MMPA-protected marine mammals that may occur in the project area include the humpback whale and bottlenose dolphin. Under without-project conditions, it is anticipated that the Wilmington District would continue to conduct maintenance dredging and disposal operations in accordance with the terms and conditions of the SARBO (NMFS 1997); thereby, effectively mitigating the potential for adverse effects on both right whales and humpback whales. Due to their mobility, it is expected that the effects of dredging on dolphins would be limited to short-term avoidance behaviors.

4.12.4 Atlantic and Shortnose Sturgeon

Dredging operations can potentially impact Atlantic and shortnose sturgeons directly through entrainment in the dredge intake pipe and/or indirectly through sediment suspension and soft bottom habitat modification. Although shortnose sturgeons have been taken by both hopper and cutterhead dredges in rivers along the North Atlantic Coast, no takes have occurred along the South Atlantic Coast. The shortnose sturgeon is typically found in the upper portions of rivers above the freshwater-saltwater interface, which reduces the potential for dredge interactions. Based on the absence of reported dredge interactions along the South Atlantic Coast and its restriction primarily to the upper portions of rivers, it is expected that the risk of shortnose sturgeon entrainment would be negligible. Cutterhead dredges have not been implicated in Atlantic sturgeon takes along the South Atlantic Coast. However, a total of 18 Atlantic sturgeons were taken by hopper dredges during federal navigation dredging operations along the South Atlantic Coast from October 1990 to March 2012 (USACE 2014). Takes occurred at Wilmington Harbor, NC (n=2), Winyah Bay, South Carolina (n=1), Charleston Harbor, South Carolina (n=4), Savannah Harbor, Georgia (n=5) and Brunswick Harbor, Georgia (n=6). The two takes at Wilmington Harbor included one in the upper Cape Fear River near the state port in 1998, and one in the lower river near Horse Shoe Shoals in 2010. The small number of takes at Wilmington Harbor indicates that the potential hopper dredge entrainment risk to Atlantic sturgeon is very low. It is assumed that the Wilmington District USACE would continue to conduct maintenance dredging operations in accordance with current practices, including adherence to the established fisheries environmental work window (1 August to 31 January). Therefore, it is expected that the potential for Atlantic sturgeon entrainment would remain very low under without-project conditions.

Continuing maintenance dredging of the currently authorized navigation channel would have direct recurring temporary impacts on soft bottom foraging habitats and associated benthic infaunal invertebrate communities. Approximately 2,226 acres of previously disturbed soft bottom habitat would experience recurring dredging disturbance every one to four years. Temporary losses of benthic infauna would reduce the availability of prey resources for shortnose and Atlantic sturgeon. As previously described, reported recovery rates in the Wilmington Harbor channel indicate that infaunal recovery in the silty channel reaches would be relatively rapid (<6 months), whereas full recovery in sandy channel reaches would require longer periods of one to two years. Recurring periods of infaunal depression would reduce total benthic infaunal productivity in the existing channel over the 50-year assessment period.

4.12.5 Sea turtles

Under without-project conditions, it is anticipated that the Wilmington District would continue to conduct maintenance dredging operations in accordance with the terms and conditions of the SARBO (NMFS 1997); thereby, effectively mitigating the risk of sea turtle entrainment during hopper dredging operations. Continuing beach disposal may have minor, short-term effects on the dry beach nesting habitat for sea turtles. However, it is anticipated that habitat effects would be minimized through continued adherence to the terms and conditions of the SMP BO (NMFS 2010), including adherence to the to the NC sea turtle nesting environmental work window (16 November – 31 April), beach fill compatibility standards, and compaction and escarpment monitoring.

4.12.6 Piping Plover and Red Knot

Under without-project conditions, maintenance of the currently authorized federal navigation channel and associated beach disposal of navigation dredged material would continue in accordance with existing practices. Piping plover breeding activity has not been documented at Cape Fear Inlet, and the red knot is a non-breeding species in NC. Therefore, no effects on breeding activity would be expected. Beach placement operations may disrupt the foraging and/or roosting activities of migratory and wintering plovers and red knots. However, construction-related disturbance would be temporary and confined to a relatively short section of the beach at any given point during beach placement operations. Beach placement would result in the temporary loss of intertidal benthic invertebrate infauna within the beach fill templates; thereby, reducing the availability of benthic prey for piping plovers and red knots. However, most benthic recovery studies have reported rapid recovery within one year of the initial impact when highly compatible beach fill sediments were used and larval recruitment periods were avoided (Jutte et al. 1999a, Burlas et al. 2001, Van Dolah et al. 1994, Van Dolah et al. 1992, Gorzelany and Nelson 1987, Salomon and Naughton 1984, Parr et al. 1978, and Hayden and Dolan 1974). It is anticipated that the Wilmington District USACE would continue to conduct maintenance dredging and beach placement on Bald Head Island and Oak Island in accordance with the terms and conditions of the SMP BO (USFWS 2000); including adherence to a 16 November - 30 April beach placement environmental work window, beach fill compatibility standards, and the use of onshore delivery pipeline routes that avoid high value inlet habitats for shorebirds. Adherence to a 16 November - 30 April beach placement environmental work window would avoid peak benthic invertebrate recruitment periods (May – September) in NC (Hackney et al. 1996, Diaz 1980, and Reilly and Bellis 1978). Therefore, it is expected that effects on the piping plover and red knot would be short-term and localized. There is no designated piping plover critical wintering habitat at Cape Fear River Inlet. Therefore, the without-project condition would not be expected to have any effect on critical habitat.

4.12.7 Wood Stork

The nearest documented wood stork nesting colony is located approximately four miles above the study area in Bladen County, and no potential nesting habitat in the study area would be directly impacted under the without-project condition. No potential wetland foraging habitat would be directly impacted under without-project conditions, and the effects of the existing project on salinity intrusion and potential tidal wetland foraging habitats are anticipated to be minor.

4.12.8 Seabeach Amaranth

Under without-project conditions, it is anticipated that the Wilmington District USACE would continue to conduct beach disposal on Bald Head Island and Oak Island in accordance with the terms and conditions of the SMP BO (USFWS 2000); including adherence to a 16 November - 30 April beach placement environmental work window and beach fill compatibility standards. These measures would minimize the potential for adverse effects by avoiding the seabeach amaranth growing season and minimizing the potential for adverse substrate changes. Some seeds that are redistributed by sand placement and grading operations may be redeposited in unsuitable habitats; thereby, preventing successful germination or growth. Conversely, some seeds that are banked in unsuitable habitats may be redistributed to suitable dry beach habitats. Beach disposal would contribute to the maintenance of wider vegetation-free dry beach habitats, thereby enhancing habitat conditions for seabeach amaranth along the erosional shorelines that adjoin the inlet. It is expected that any adverse effects on seed germination would be minor and localized.

4.13 Invasive Species

Under without-project conditions, a fleet of container vessels would continue to call on the Port of Wilmington. Projections indicate that the number of vessel-calls and the total volume of cargo moving through the port would decrease due to the inability to accommodate larger vessels. Therefore, it is expected that the potential for invasive species introductions via foreign vessels would remain the same or decrease under the No Action Alternative.

4.14 Managed and Protected Areas

Under without-project conditions, maintenance of the currently authorized federal navigation channel and associated disposal operations would continue in accordance with current practices. No effects on managed or protected areas would be expected.

4.15 Air Quality

4.15.1 No Action Alternative

Under without-project conditions, a fleet of container vessels would continue to call on the Port of Wilmington. Projections indicate that the number of vessel-calls and the total volume of cargo moving through the port would decrease due to the inability to accommodate larger vessels. Therefore, it is expected that air emissions would remain the same or decrease under the No Action Alternative.

4.16 Noise

Under without-project conditions, anthropogenic underwater noise would continue to include commercial shipping operations associated with the Port of Wilmington, military shipping operations associated with MOTSU, recreational watercraft activity, and periodic maintenance dredging operations in the federally maintained Wilmington Harbor and AIWW navigation channels.

4.17 Hazardous, Toxic, and Radioactive Waste (HTRW)

Under without-project conditions, maintenance of the currently authorized federal navigation channel would continue in accordance with current dredging practices. The continued removal of alluvial material from the existing channel prism would not be expected to encounter or have any effect on HTRW.

4.18 Aesthetics and Recreation

Under without-project conditions, continuing maintenance dredging and beach disposal activities would short term and localized effects on aesthetics and recreation. During beach disposal events, the presence of pipelines and construction equipment on the beach and associated noise emissions and artificial nighttime lighting would temporarily diminish the aesthetic quality of the beach. Construction safety zones would restrict public beach access and recreational activities in the immediate vicinity of the active beach fill discharge point; however, effects on recreation would be short-term and limited to a relatively small segment of the beach at any given point during the construction process. Public exposure to aesthetic and recreational impacts would be limited, as adherence to the sea turtle nesting environmental work window for beach placement (16 November - 30 April) would limit operations to the colder months when recreational beach use is at its lowest point. Maintenance dredging would not restrict recreation vessel traffic in the Cape Fear River and any effects on recreational fishing would be short-term and localized to a small portion of the estuary.

4.19 Coastal Barrier Resources

The CBRS Cape Fear Unit OPA (NC-07P) encompasses the majority of the undeveloped Cape Fear peninsula from Snows Cut to the southern boundary of the Bald Head State Natural Area; including most of the east-facing oceanfront beach between Fort Fisher and Cape Fear and the estuarine marsh and dredged material islands that lie between the peninsula and the federal navigation channel. However, the developed south-facing ocean beaches of Bald Head Island and Oak Island that comprise beach disposal areas are not part of the CBRS. Furthermore, the NFIP is the only type of prohibited federal spending that is applicable to OPAs; and federal navigation maintenance and improvement activities, including beach placement of dredged materials, are exempt from CBRA spending restrictions.[21] Therefore, the without-project condition would not result in any federal spending that would affect the CBRS.

4.20 Cultural and Historic Resources

Under without-project conditions, continuing maintenance dredging operations would be limited to the removal of alluvial material from the existing disturbed channel prism. Therefore, no adverse effects on cultural resources would be expected.

4.21 Socioeconomics

Under without-project conditions, maintenance of the currently authorized federal channel would continue in accordance with existing practices. Projections indicate that the number of vessel calls and the total volume of cargo moving through the port would decrease due to the inability to accommodate larger vessels. Therefore, the without-project condition would reduce local revenues, employment, and wages as described in Section 5.5.3 Regional Economic Development.

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[21] See: http://www.fws.gov/CBRA/Consultations/Limitations-and-Exceptions.html

5 PROBLEMS, OPPORTUNITIES, AND CONSTRAINTS

This section describes the problems to be addressed by the alternative plans developed for this study and the opportunities that may be realized by the alternative plans. Problems are identified as the negative conditions that would be reduced or removed by the alternative plans. Opportunities are beneficial outcomes that are projected to result from the alternative plans. This section also describes the planning constraints, which limit or pose restrictions on the alternative plans developed for this study.

5.1 Problems

The width and depth of the Federal channel at Wilmington Harbor cause transportation inefficiencies for the existing and projected future containership fleet. In general, the problem at Wilmington Harbor is that containerized trade has outgrown the Federal navigation channel that accesses the Port of Wilmington. The existing and projected future volume of trade and size of vessels using the Port of Wilmington are constrained by channel dimensions. The projected future fleet includes vessels with dimensions of 138,000 dead weight tons, 1,200 feet length overall, 158 feet beam, and 50 feet draft[22]. The existing channel was designed for a vessel with 65,000 dead weight tons, 965 feet length overall, 106 feet beam and 40 feet draft.

The insufficient dimensions of the Federal channel limits vessel size, limits vessel loading, and increases the cost of trade through the Port. The limits on vessel size and operating drafts at Wilmington Harbor make it infeasible for the newer and more efficient vessels projected for the USEC-Asia services to call at the Port of Wilmington. Without the Port of Wilmington as a port-of-call on USEC-Asia services, cargo currently using the Port of Wilmington will be required to use other USEC ports where channel conditions can accommodate the newer more efficient vessels.

5.2 Opportunities

From 2016 to 2019, the NCSPA has spent $140 million on improvements to port infrastructure, including three 22-box wide cranes, wharf improvements, and equipment upgrades. The NCSPA is currently investing $20 million in turning basin expansion to ensure that the largest possible vessels can call at the Port under without-project conditions. The ongoing implementation of the Port's Master Plan includes a total of more than $240 million in container yard, reefer yard, truck gate, and intermodal yard improvements. These improvements enable the container terminal the Port of Wilmington to handle the projected containership fleet on the USEC-Asia services, which are the largest vessels projected to call at the USEC.

There are opportunities for the NCSPA to more effectively and efficiently meet the demand for the cargo services now and in the future. Opportunities for improvement include:

- Allow existing and projected future cargo vessels to have less restricted access to berths and terminals, reducing delays and increasing the efficiency of port operations;
- Allow existing and projected future cargo vessels to be loaded more efficiently;
- Allow larger cargo vessels to be used that can deliver more cargo at lower unit costs; and

[22] These are the design vessel dimensions.

- Achieve the full capability and efficiency of terminal and infrastructure improvements at the Port of Wilmington.

Improvements to the Federal navigation channel would increase the efficiency of cargo vessels currently using the Port, as well as allow the use of larger, more efficient vessels in the future. This increase in efficiency will result in substantial transportation cost savings compared to the expected future without-project conditions, especially as the realization of opportunities for increased vessel efficiency allows the Port of Wilmington to remain a port-of-call on USEC-Asia services. Section 9, Detailed Economic Evaluation of Final Alternative Plans, presents a detailed quantitative assessment of the benefits resulting from alternative plans that support the realization of these opportunities.

5.3 Federal Objective

The Federal objective is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. Water resources project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to the Federal objective. Contributions to NED are increases in the net value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net economic benefits that accrue in the planning area and in the rest of the nation. NED benefits for deep draft navigation projects are calculated as the transportation cost savings that typically result from improvements to general navigation features, such as channels, dredged material disposal facilities, turning basins, etc. Transportation cost savings are calculated as reductions in the cost of transporting goods from their ultimate origin to their ultimate destination. The conceptual basis for NED benefits resulting from improvements to the Federal navigation channel at Wilmington Harbor is that the improved channel will reduce vessel inefficiencies, which allow the Port of Wilmington to continue to be a port-of-call on USEC-Asia services. Under without-project conditions, cargo from the Port of Wilmington's hinterland must travel to the alternative deep-water port (Savannah, GA), which is a substantially farther distance and more costly truck haul.

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 10 May 1983) identifies this category of principal direct effects as cost reduction benefits, which apply as follows:

> *(2) Same commodity and origin and destination, different harbor*. This situation occurs where commodities that are now moving or are expected to move via alternative harbors without the proposed improvement would, with the proposed plan, be diverted through the subject harbor. Cost reduction benefits from a proposed plan apply to both new and existing harbors and channels (p.58 section 2.7.2).

5.3.1 Planning Objectives

Consistent with the Federal objective identified in Section 4.3 Federal Objective, project-specific planning objectives have been identified, and these objectives guided the plan formulation process in this study. Planning objectives must be clearly defined and provide information on:

- the effect desired (quantified, if possible);
- what will be changed by accomplishing the objective;
- the location where the expected result will occur; and
- the timing of the effect (when would the effect occur) and the duration of the effect.

Based on the problems posed by channel dimensions and the opportunities available through channel improvements (as detailed in Sections 4.1 and 4.2), the following planning objectives have been established to assist in the development of management measures and evaluation of alternative plans:

> **Planning Objective 1:** Contribute to NED by reducing origin to destination transportation costs, at the Port of Wilmington from 2027 to 2076;
>
> **Planning Objective 2:** Contribute to NED by reducing trucking miles and trucking costs for the Port of Wilmington's hinterland cargo, from 2027 to 2076; and
>
> **Planning Objective 3:** Contribute to NED by reducing waterborne transportation costs at the Wilmington Harbor Federal navigation project by accommodating the transit of larger and more efficient vessels, from 2027 to 2076.

5.4 Constraints

Plans must be formulated within planning constraints, to solve the problems and realize the opportunities. Constraints are conditions to be avoided or things that cannot be changed, which limit the development and selection of alternative plans. Constraints on the formulation of alternatives include:

- Avoid impacts to groundwater resources;
- Avoid induced flooding:
- Avoid impacts to existing waterfront infrastructure;
- Avoid impacts to marine facilities at MOTSU;
- Avoid or minimize impacts to recreational boaters and commercial fishing vessels using the channel; and
- Avoid or minimize impacts to natural and historic resources within the study area.

5.5 Study Assumptions

There are five assumptions that are integral to the problems and opportunities identified in this study:

1. Container terminal improvements currently under construction or in the design phase, including the turning basin expansion, will be completed to allow the design vessel and future cargo to use the terminal;

2. Federal channel deepening projects currently under construction at Savannah, Charleston, Boston, and Jacksonville will be completed and maintained to project depth, which will allow vessels to operate at the drafts required to realize the transportation cost savings calculated for those projects;
3. The future fleet for the two Asia services currently calling at the Port of Wilmington is represented by the design vessel;
4. Under without-project conditions, channel depth constraints, draft restrictions, and the resulting light loading of the design vessel for the two Asia services will cause the two Asia services to drop Wilmington as a port-of-call prior to the base-year of the project (2027); and
5. Under with-project conditions, deeper channel depths at Wilmington will increase vessel operating drafts, reduce light loading, and increase vessel operating efficiency inducing the two Asia services to include Wilmington as a port-of-call.

Assumption 1 is substantiated by the ongoing construction and continuous funding for the terminal improvements as described in Section 2.26.1 Existing Conditions: Container Terminal and section 3.2.1 Future Without-project Conditions: Container Terminal. These without-project condition terminal improvements enhance terminal operations and efficiency regardless of improvements to the federal channel. The NCSPA is currently realizing benefits of larger and faster cranes, improved mooring facilities, and yard configuration. Planned future improvements will further increase the efficiency of cargo flow at the terminal.

Assumption 2 is substantiated by work plan construction funding that has been allocated to each of these authorized projects over the years. It is highly unlikely that projects with a history of work plan construction funding would not be completed and maintained as authorized.

Assumption 3 is substantiated by historical trends in the size of vessels transiting the Panama Canal (Section 2.5.2 Existing Containership Fleet and Tables 2-15 through 2-18) which indicates that prior to the expansion of the Panama Canal, 99% of containerships on the major Asia-USEC routes were Panamax vessels and after the expansion in 2015, vessels on these services are trending towards the neo-Panamax vessels (PPX3Max). This assumption is further substantiated by the 01Jan20 announcement by the THE Alliance that the vessels on the EC2 service will begin transitioning to 13,100 TEU vessels, which are equivalent in size to the design vessel, commencing in April 2020.

The shift towards PPX3 Max vessels on the two Asia services in question is also supported by the historical trend in carriers reducing the transportation cost per TEU by shifting to larger more efficient vessels. The Economics Appendix Section 2.5 Without-project Condition Status of Wilmington as a Port of Call on the EC2 and ZCP Services provides a detailed discussion of the relative efficiency of PPX3 Max vessels. Note that THE Alliance has announced the transition to 13,000 TEU vessels on the EC2 service, beginning in April 2020.

Assumption 4 is substantiated by the enormity of the inefficiency of having vessels light-loaded on 82% of calls and light-loaded by as much as seven feet. Sections 2.3 and 2.5 of the Economics Appendix provides the calculations displaying the relative inefficiency of calling at Wilmington under without-project conditions. The draft restrictions imposed by the without-project condition channel depth at Wilmington increases the waterborne cost by 40% per TEU per 1,000 miles. The weighted average number of TEUs on board at Wilmington under without-project conditions is 2,605 TEUs fewer than the weighted average number of TEUs for the same vessel at Charleston or Savannah. Over the course of a single year, the two services would leave at combined 271,000 TEUs at the docks due to draft restrictions at Wilmington, which also affects the departure draft at the prior port and the arrival draft at the next port. It would take an additional 38 trips per year (under without-project draft restrictions), just to get this cargo to its destinations. It is economically infeasible for the design vessel to regularly call at Wilmington under without-project conditions. Six carriers on the EC2 and ZCP services have provided letters supporting this assumption (see Economics Appendix: Letters of Support).

The future without-project assumption that the EC2 and the ZCP services will transition to the design vessel by the project base year of 2027 is developed in Economics Appendix Section 1.8.2 Existing Containership Fleet and Economics Appendix Sections 2.3 through 2.4:

- Section 1.8.2 Existing Containership Fleet
- Section 2.3 Without-project Conditions at other USEC Federal Navigation Projects
- Section 2.4 Without-project Condition Containership Fleet for the EC2 and ZCP Services

Assumption 5, PPX3Max vessels on the two services in question will call at Wilmington under with-project conditions, is substantiated by historical precedent and economic rationality. Under existing conditions, channel depths at other USEC ports are very similar to Wilmington's depth (Table 4-1 Existing and Future USEC Port Depths) and vessel draft restrictions at these same ports are very similar to draft restrictions at Wilmington. Under existing conditions, the USEC ports-of-call for the two services in question can service the existing fleet with similar vessel loads and operating costs per TEU (Economics Appendix Table 2-4 Operating Costs for Selected Vessel Drafts). Over many years under these historical conditions, Wilmington has developed a longstanding relationship with the carriers on these two services and managed to substantially increase the amount of cargo handled for these two services. Under with-project conditions, channel depth and draft restrictions at the other USEC ports would again be similar to those at Wilmington. Vessel loading and operating costs per TEU at the other USEC ports would also be similar to those at Wilmington (Table 4-1 of the Economics Appendix). If future with-project operating and economic conditions are comparable to existing operating and economic conditions, then it is reasonable to assume that the two services would continue to call at Wilmington.

6 FORMULATION AND EVALUATION OF ALTERNATIVES

This section of the report presents the preliminary planning process that was used to identify a TSP and the NED Plan. It describes the development of alternative plans and provides an overview of the preliminary screening of alternative plans, including the development of the preliminary alternative plans (Focused Array of Alternatives).

Based on the problems, opportunities, and constraints identified in the analysis, the development of alternative plans followed the standard planning model, which includes:

- Establishment of plan formulation rationale (Section 6.1);
- Identification and screening of potential solutions, including nonstructural measures (Section 6-2);
- Identification of the Focused Array of Alternatives (Sections 6-3 and 6-4);
- Evaluation of the Alternative Plans (Section 6-5); and
- Selection of the TSP and identification of the NED Plan (Section 6-6).

USACE project planning follows the six-step process described in the Principles and Guidelines (1983), which is the basis for Federal agency water resources planning, and further elaborated in the Planning Guidance Notebook, ER 1105-2-100 (April 2000). Although presented in series, these steps are applied in an iterative process that puts emphasis on succeeding steps.

6.1 Plan Formulation Rationale

The Planning Guidance Notebook (ER 1105-2-100, dated April 22, 2000) states that "water and related land resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study planning objectives and, consequently, to the Federal objective" (page 2-1). Plan formulation has been conducted for this study with a focus on achieving the Federal objective of water and related land resources project planning, which is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net economic benefits that accrue in the planning area and in the rest of the Nation[23]. The NED benefits that typically result from improvements to general navigation features, such as channels, dredged material disposal facilities, turning basins, etc. are transportation cost savings. Transportation cost savings are calculated as reductions in the cost of transporting goods from their ultimate origin to their ultimate destination.

6.1.1 System of Accounts Framework

Plan formulation also considers all effects, beneficial or adverse, to each of the four evaluation accounts identified in the Principles and Guidelines (1983), which are National Economic Development, Environmental Quality, Regional Economic Development, and Other Social Effects. The four evaluation accounts were established by the Principles and Guidelines to facilitate evaluation and display of effects of alternative plans. To be consistent with USACE

[23] USACE, National Economic Development Procedures Manual Overview, 2009

planning and environmental operating principles, and to ensure maximum participation in the planning process, this approach was also employed for this study.

Briefly, the effects considered under each of the four accounts include the following:

- The National Economic Development (NED) account displays changes in the economic value of the national output of goods and services.
- The Environmental Quality (EQ) account displays nonmonetary effects on significant natural and cultural resources.
- The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan.
- The Other Social Effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, such as: urban and community impacts; life, health, and safety factors; displacement; long-term productivity; and energy requirements and energy conservation.

6.2 Management Measures

Management measures were developed with information gathered during discussions and interviews with Port of Wilmington operations and management personnel, Cape Fear River Pilots Association, terminal operators, shipping agents, and tugboat operators that work in Wilmington Harbor.

Non-structural measures identified as potential improvements to navigation at Wilmington Harbor include:

- Reduce vessel speed in the channel;
- Increase the use of tugboat assistance to improve vessel maneuverability;
- Relocate aids to navigation to take advantage of naturally deep areas;
- Use tidal advantage; and
- Use lightering.

Structural measures identified as potential improvements to navigation at Wilmington Harbor include:

- Channel deepening;
- Turning basin deepening;
- Stepped channel;
- Improve existing turning areas and/or create new turning areas;
- Improve existing anchorages and/or create new anchorages;
- Channel widening to reduce navigation restrictions; and
- Channel widening to accommodate vessel meeting.

Local service facility improvements include measures that may be taken by the non-Federal sponsor or local operators to support achievement of the planning objectives. These measures include:

- Berth deepening;
- Container terminal improvements;
- Bulk terminal improvements;
- Breakbulk/general cargo terminal improvements; and
- Relocate cargo terminals.

6.2.1 Management Measures Screening

Management measures were evaluated with respect to their ability to meet the planning objectives based on the four general criteria for plan formulation that are identified in the Principles and Guidelines (1983):

- Completeness: does the alternative provide and account for all necessary investments or actions to ensure the realization of the planning objectives;
- Effectiveness: does the alternative contribute to achieving the planning objectives;
- Efficiency: is the alternative the most cost-effective means of addressing the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment; and
- Acceptability: is the alternative plan acceptable in terms of applicable laws, regulations, and policies.

<u>Effectiveness Metrics</u>

- Potential to meet planning objectives
    - 1 indicates the measure is very unlikely to support meeting the planning objectives
    - 3 indicates the measure is very likely to support meeting the planning objectives
- Magnitude of transportation cost savings
    - 1 indicates the measure is very unlikely to generate transportation cost savings
    - 3 indicates the measure is very likely to generate transportation cost savings

<u>Efficiency Metrics</u>

- Preliminary costs
    - 1 indicates that the costs of implementing the measure are likely to be very high compared to other measures
    - 3 indicates that the costs of implementing the measure are likely to be very low compared to other measures
- Preliminary benefits
    - 1 indicates that the preliminary benefits of the measure are likely to be very low
    - 3 indicates that the preliminary benefits of the measure are likely to be very high

- Preliminary net benefits
    - 1 indicates that the preliminary net benefits of the measure are likely to be very low
    - 3 indicates that the preliminary net benefits of the measure are likely to be very high

<u>Technical Feasibility Metrics</u>

- Technically feasible
    - 1 indicates that the technical requirements of the measure would make it very difficult to implement
    - 3 indicates that the technical requirements of the measure are commonly implemented in the industry and there are no foreseen difficulties with implementation at Wilmington Harbor

<u>Acceptability Metrics</u>

- Environmental impact
    - 1 indicates that the measure will likely have an environmental impact that will require extreme mitigation measures
    - 3 indicates that the measure will likely have an environmental impact that can be mitigated using common mitigation practices
- Meets applicable laws and regulations
    - 1 indicates that the measure will very likely not meet applicable laws and regulations
    - 3 indicates that the measure will very likely meet applicable laws and regulations

Measures retained for further evaluation must have a greater than minimum score (1) for three of the four criteria. Measures that have a minimum score (1) for two of the four criteria are not advanced for further evaluation (Table 6-1).

Table 6-1 Preliminary Screening

Non-Structural Measures	Effectiveness	Efficiency	Technical Feasibility	Acceptability	Total	Retained
Reduce vessel speed	1	1	2	3	7	No
Additional tug assistance	1	1	2	3	7	No
Relocate aids to navigation	1	1	3	2	7	No
Tidal advantage	2	3	3	3	11	Yes
Lightering	1	1	1	1	4	No
Structural Measures	**Effectiveness**	**Efficiency**	**Technical Feasibility**	**Acceptability**	**Total**	**Retained**
Channel deepening	3	3	3	2	11	Yes
Stepped channel	1	1	3	2	7	No
Turning basin expansion	1	1	3	1	6	No
Turning basin deepening	3	3	3	2	11	Yes
Anchorage basin	1	1	3	2	7	No
Channel widening to reduce navigation restrictions	3	3	3	2	11	Yes
Channel widening to accommodate vessel meeting	1	1	3	2	7	No
Local Service Facility Improvements	**Effectiveness**	**Efficiency**	**Technical Feasibility**	**Acceptability**	**Total**	**Retained**
Container terminal improvements	1	1	3	2	7	No
Relocate cargo terminals	1	1	3	1	6	No
Berth deepening	3	3	3	3	12	Yes
Bulk terminal improvements	1	1	3	2	7	No
Breakbulk/General cargo improvements	1	1	3	2	7	No

6.2.2 Non-Structural Measures

Reduce vessel speed in the channel: Reducing vessel speed while transiting the channel will reduce the amount of squat affecting the vessel. Reducing vessel squat would allow the vessel to ride higher in the water, thereby reducing the vessel's draft while transiting the channel.

Implementation of vessel speed reduction is constrained by the need to maintain speed sufficient for maneuverability and the need to reduce crab angle when transiting the channel under windy conditions. The amount of squat reduction potentially gained by slowing to a minimum safe speed would be inconsequential because vessels typically operate at or very near this speed under existing conditions. This measure would not be effective and the cost of additional tug assistance needed for very slow speeds make this measure inefficient. Therefore, reducing vessel speed in the channel is not carried forward.

Increase tugboat assistance: Tugboats are used to improve the maneuverability of vessels that have slowed during channel transits, to turn vessels, and to dock vessels. The standard operating practices for tug assistance are sufficient for vessels currently using the channel. Additional tug assistance would not improve the efficiency of vessels transiting the channel because additional use of tugs would not improve vessel loading, increase the size of vessels using the channel on a regular basis, or appreciably increase vessel speed. Additional use of tugs is not carried forward.

Relocate aids to navigation to take advantage of naturally deep areas: Some areas adjacent to the Federal channel at Wilmington Harbor are naturally deeper than Federally maintained channel depths. However, there are not sufficient areas of existing deep water where simply moving the aids to navigation would substantially improve navigation. However, existing deep-water areas may be incorporated into channel widening in limited areas to support safe navigation of the design vessel. This measure is not forwarded for additional analysis as a planning measure, but relocation of aids to navigation may be required for some alternative plans to maintain navigational safety.

Tidal advantage: The use of high tide when deep draft vessels transit the channel provides additional underkeel clearance to depth constrained vessels. Use of tidal advantage is a common practice within the study area that is projected to continue in the future, independent of channel improvements. The use of tidal advantage is therefore included as a standard operating procedure in the evaluation of all alternative plans. This measure is carried forward.

Use lightering: During a lightering operation, a vessel is loaded or unloaded to an operable draft in order to transit the channel. Container ships are not capable of lightering. Most of the deeper draft channel transits are outbound bulk transits. Lightering exports requires that the cargo on the vessel making the ocean transit be initially placed onto two light loaded vessels so that the cargo can exit the harbor. The cargo would be consolidated onto one vessel by a cargo transfer operation that would occur in deep water. Lightering for bulk exports is an inefficient operation which is not currently practiced at Wilmington Harbor. Therefore, this measure is not carried forward.

6.2.3 Structural Measures

Channel deepening: Deepening the existing channel would allow for deeper and more efficient loading of the existing fleet; and also allow for the efficient use of larger vessels which may not call on the Port under without project conditions. The evaluation of deepening alternatives will include the non-Federal associated costs of deepening any berthing areas that would be necessary to reap the benefits of a deeper main ship channel. This measure is carried forward.

Stepped channel: In a stepped channel configuration, the outbound lane would be dredged more deeply than the inbound lane to accommodate more deeply laden outbound traffic. The inbound lane would be shallower than the outbound lane under the presumption that inbound vessels would have less cargo and thus be operating at shallower drafts. This configuration was used historically at other harbors, such as Norfolk Harbor prior to the 2007 deepening of the inbound channel. The stepped channel configuration would be ineffective for projected future with project conditions at Wilmington Harbor, however, because inbound container traffic currently is loaded nearly as deeply as outbound traffic. Wilmington Harbor is an intermediate port of call on U.S. east coast container services, and vessels transiting inbound are expected to arrive at the Port at even greater depths as deepening projects at other U.S. east coast container ports are completed. Therefore, a stepped channel configuration is not carried forward.

Turning Basin Expansion (increase turning radius): The NCSPA is currently making improvements to the Federal navigation channel under 33 United States Code (USC) 408 (Section 408), at the Lower Anchorage Basin, which is used as the turning basin for vessels calling at the Port of Wilmington. These improvements are designed to allow a containership with a length overall of up to 1,200 feet to turn in the basin. A length overall of 1,200 feet is consistent with the dimensions of the design vessel for this project. The ongoing turning basin expansion is a part of the without-project condition however, the expanded basin will be at the without-project channel depth. Expanding turning areas (increased radius) are not carried forward for further evaluation because the design vessel can operate in the existing turning basin.

Turning Basin Deepening: Deepening the turning area would allow the design vessel to turn with drafts that cannot be accommodated under the without-project condition. In combination with a deeper channel and berth, a deepened turning basin would allow the realization of the transportation efficiencies associated with a deeper channel. This measure is forwarded for more detailed analysis.

Improve existing/create additional anchorages: The existing Anchorage Basin serves as a turning basin for vessels using the Port of Wilmington. The existing Anchorage Basin is not typically used for lay vessels or to hold vessels for extended lengths of time. There are no vessel delays or constraints on vessel operations due to anchorage unavailability or unsuitability. Therefore, expanding existing or creating new anchorages are not carried forward however, deepening the existing Anchorage Basin would be included in all channel deepening alternatives.

Channel widening to reduce navigation restrictions: Channel widening is required for the design vessel to regularly navigate the federal channel at Wilmington Harbor. Widening allows larger vessels to navigate the channel thereby potentially reducing transportation costs. Vessel would remain depth constrained, if the channel were only widened. Desktop ship simulation analyses were performed to evaluate where and to what extent widening would be necessary for safe navigation of the design vessel (Engineering Sub-appendices B-1 through B-5). Full bridge simulation modeling will be performed during Preconstruction Engineering and Design (PED) to define the details of channel widening. The widening resulting from the desktop simulation is considered a “maximum” widening, which will be refined during PED. The decision to use “maximum” widening during the feasibility phase results in conservative cost and impact estimates, which would likely be reduced after the full bridge simulation analysis to be performed in PED. This measure is forwarded for more detailed analysis.

Channel widening to accommodate vessel meeting: The existing Federal navigation channel has a six-mile reach that is 600 feet wide that is used for vessel meeting. Containerships up to 8,500 TEU may meet an old-Panamax-size vessel (maximum beam of 106 feet) within the passing lane. Old-Panamax-size vessels may pass outside of the six-mile passing lane under favorable conditions and at pilot discretion. Vessel delays due to meeting restrictions occur infrequently[24]. The largest vessels, which are restricted from meeting, are the vessels on the USEC-Asia services. Under with-project conditions, these vessels are projected to call as frequently as twice a week. At this frequency of large vessel transits, there would be few delays due to meeting restrictions, which indicates that widening the channel to accommodate vessel meeting would not generate sufficient benefits for economic justification. Therefore, channel widening to accommodate vessel meeting is not carried forward. Note however, that channel widening to support safe navigation of the design vessel is carried forward.

6.2.4 Local Service Facility Improvements

Container Terminal Improvements: The use of more and/or larger ship-to-shore cranes could reduce the vessel's time at the dock and/or allow for larger vessels to be loaded and unloaded more efficiently. The impact of this measure is expected to be limited because the Port of Wilmington has already upgraded its cranes and is in the middle of a terminal improvement project. Additional upgrades, beyond those already included in without-project conditions, would make only marginal improvements to efficiency. The number of cranes assigned to a vessel is a balance of physical ability of a ship to accommodate the cranes and the availability of crane and container handling resources. A minimum number is typically stipulated in the contract established between the terminal operator and ship line. In general, terminal operations are designed to prioritize vessel service over landside operations to minimize time in berth. Container terminal improvements are not carried forward, however; planned improvements will be included in the without and with-project conditions.

Relocate Cargo Terminals: There is no relocation of cargo terminals that would reduce channel constraints or improve navigation in the Federal channel at Wilmington Harbor. In 2006, the NCSPA initiated a feasibility level investigation into the development of a container terminal at a 600-acre parcel at Southport, NC adjacent to the federal navigation channel to Wilmington, but closer to the ocean entrance. Based on the results of the feasibility study, the NCSPA decided not to continue development of the Southport container terminal. Relocation of the Port of Wilmington container terminal to Southport, or construction of a new container terminal at Southport, does not substantially reduce channel improvement costs, such as channel deepening, because existing water depths are shallow. The overall cost for container terminal development at Southport was estimated to be $2.5 billion in 2008. In addition, the environmental impact of dredging a deepwater access channel to Southport could be substantially larger than the impact of deepening the existing channel to Wilmington. The large construction expense of a new container terminal at Southport, the anticipated environmental impact, and the low level of public and institutional support for a new terminal at Southport make this measure infeasible. This measure is not carried forward.

Berth Deepening: Increasing water depths at cargo berths would allow vessels to be loaded more deeply and would be required as a locally funded component of any alternative plan that includes channel deepening. Any berth deepening required for the realization of project benefits would be included as a part of project costs for the purpose of evaluating project net benefits. Although a necessary component of a channel deepening plan, berth deepening alone is not a viable solution to channel depth constraints, since it would not allow deeper or more fully laden

[24] Meeting restrictions are based on personal communication with Captains Wes Kirby and Scott Aldridge, Cape fear River Pilots (19 April 2017).

vessels to navigate the Federal channel. Berth deepening is carried forward as a component of channel deepening alternatives.

Bulk Terminal Improvements: Bulk operations have a low-margin/high-volume model where operational efficiency is a critical focus during initial design and during ongoing process improvements. The existing bulk facilities are sufficient for the amount and types of cargo handled. Any marginal improvements to terminal facilities are not projected to have a substantial effect on reducing channel congestion. This measure is not carried forward.

Breakbulk/General Cargo Terminal Improvements: General cargo terminals typically have transfer operations that preclude substantial streamlining due to the variability of their cargo. Volume is also likely too low to justify any gains that could be made with substantial investment in automation or other capital investments. This measure is not carried forward.

6.3 Array of Alternatives

The measures identified for further evaluation may be implemented individually or in combination. All three elements of deepening the existing project (channel deepening, turning basin deepening, and berth deepening) are required for deepening to be effective. Channel widening may be implemented individually or in combination with project deepening. Channel widening implemented as an individual alternative would allow the design vessel to use the channel on a regular basis, but the design vessel's operating draft would be constrained. The combination of deepening and widening allows the design vessel to operate in the channel and load more fully based on the depth of the alternative. The no action alternative does not allow regular use of the channel by the design vessel and constrains vessel operating drafts. Use of tidal advantage is assumed to be implemented in combination with all alternatives.

Channel widening and channel deepening are evaluated individually and in combination (Table 6-2) in an intermediate screening based on potential transportation cost savings. Channel widening allows the design vessel (PPX3Max) to navigate the channel on a regular basis, which even without channel deepening, would allow more cargo to be carried on each vessel call thereby reducing the transportation cost per TEU. Channel deepening also reduces transportation costs per TEU by allowing vessels to load more deeply and carry more cargo per trip, but without channel widening vessel size is restricted to no larger than the existing fleet (PPX3). Note that in order to realize the transportation cost savings associated with channel deepening berths and the turning basin at the Port of Wilmington must also be deepened to the depth of the channel. The combination of channel widening and deepening, with the necessary berth and turning basin deepening, allows the design vessel to regularly navigate the channel and allows the vessel to load more deeply.

Table 6-2 presents the economic evaluation of channel widening and channel deepening individually and in combination. The waterborne cost per TEU per $1,000 miles is weighted by the historical tonnage for imports and exports at the Port of Wilmington (see the Economics Appendix for detailed discussion). The combination of widening and deepening reduces transportation costs per TEU more than either widening or deepening reduces transportation costs individually. Therefore, the combination of widening and deepening is forwarded for more detailed evaluation.

Table 6-2
Weighted $/TEU/1,000 Miles for the Structural Measures at Wilmington Harbor

Row	Measures (Vessel Class)	Channel Depth					
		42	44	45	46	47	48
1	W/out Project (PPX3)	$51.51	-	-	-	-	-
2	Widening Only (PPX3Max)	$47.45	-	-	-	-	-
3	Deepening Only (PPX3)	-	$46.49	$44.25	$42.20	$39.37	$37.95
4	Widening & Deepening (PPX3Max)	-	$43.06	$41.10	$39.27	$36.62	$35.23

The following describes the information presented in Table 6-2:

- Row 1 presents the waterborne transportation cost per TEU per 1,000 miles for the largest vessel that could call at Wilmington under without-project conditions, which a PPX3 vessel. Section 2.5 Without-project Condition Status of Wilmington as a Port of Call on the EC2 and ZCP Services (above), shows that the relative inefficiency associated the PPX3 size vessel would cause the two services to bypass Wilmington and Wilmington's hinterland Asia cargo would shift to Savannah as a lower cost alternative port.
- Row 2 shows that implementing the widening measure allows the PPX3Max vessel to call at Wilmington and cost per TEU is lower than without-project conditions, but the vessel would not be able to load any deeper than allowed by the without-project condition depth, thereby restricting any additional cost savings.
- Row 3 indicates that implementing the deepening measures allows additional efficiency for the PPX3 vessel but does not allow for an increase in vessel size. Deepening includes channel, turning basin, and berth deepening. Deepening of all three elements is required for this measure to be effective. Throughout the remainder of the analysis all three elements are considered deepened to the same incremental project depth.
- Row 4 shows that implementing the widening and deepening measures in combination allow for the increase in vessel size and additional efficiency for each incremental increase in depth. Turning basin and berth deepening would also need to be implemented for this measure to be effective. These structural measures, implemented in combination, provide the greatest potential for transportation costs savings and are forwarded for more detailed analysis.

6.4 Final Array of Alternatives

The final array of alternatives is based on the preliminary economic evaluation presented in Table 6-2. The alternatives that are the most effective in reducing unit transportation costs are alternatives that combine channel widening to allow regular transit of the design vessel and channel, turning basin, and berth deepening to allow greater vessel operating drafts. Note that berth deepening is a local service facility improvement that is the responsibility of the NCSPA and not a component of the federal General Navigation Features. The amount of channel widening was determined by ship simulation modeling of the design vessel and does not change appreciably for any of the action alternatives, therefore the action alternatives are identified by their incremental project depth:

- No Action Alternative – no improvements are made to the federal channel and economic conditions are described by the without-project condition;
- 44-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -44 feet, the entrance channel is deepened to -46 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling;
- 45-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -45 feet, the entrance channel is deepened to -47 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling;
- 46-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -46 feet, the entrance channel is deepened to -48 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling;
- 47-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -47 feet, the entrance channel is deepened to -49 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling; and
- 48-foot Alternative – The channel, turning basin, and container terminal berths are deepened to -48 feet, the entrance channel is deepened to -50 feet and extended to meet project depth, the channel is widened to accommodate the design vessel based on requirements identified in ship simulation modeling.

Alternative project depth increments start at -44 feet because there is no non-federal interest in a one-foot deepening resulting in a -43-foot channel. Alternative project depth increments are truncated at -48 feet because at this depth vessel operating drafts at Wilmington would be constrained at the same level as vessel operating drafts at the prior and next US ports on the two services. A channel deeper than -48 feet would not be expected to provide appreciable additional benefits because vessel operating drafts would be constrained by depths at the prior and next US ports on the two services (Boston -48 feet, Savannah and Jacksonville -47 feet).

The final array of action alternatives consists of the following elements:

- Deepening and widening the Federal navigation channel;
- Dredged material placement;
- Oil pipeline relocation; and
- Relocation of aids to navigation

6.4.1 Deepening and Widening the Federal Navigation Channel

Deepening the Federal navigation channel includes deepening from its currently authorized and maintained depth of -42 ft MLLW in the river and -44 ft MLLW beginning at the Battery Island Reach and extending offshore to new depths incrementally increasing from -44 feet in the river and -46 feet at the Battery Island Reach to -48 ft MLLW in the river and -50 ft MLLW beginning at the Battery Island Reach and extending offshore, as generally described in section 6.4 above.

The incremental depths in the Cape Fear River apply to the Federal navigation channel at the Lower Swash range and all ranges up to and including the Lower Anchorage. The additional depth at the Battery Island Reach and extending offshore will be two feet deeper than the depth in the river to allow for adequate under keel clearance in areas affected by ocean waves. The range offshore of the current pilot boarding station (Sta 490+00) will have a heading of approximately 30° (inbound), which, is approximately 16° shifted from Bald Head Shoal Reach 3 (14°). The purpose of this heading change is to reach deeper water in the most direct path and reduce dredging costs. The Cape Fear River Pilots have been consulted and approve of this realignment.

In addition, the existing Lower Anchorage Basin, a portion of which is used to turn vessels, will be dredged to match the incremental increase in channel depth in the river.

Widening of channel reaches (Table 6-3) is based on Ship Simulation modeling for design vessel maneuvering during vessel transits. The Federal navigation channel is not being widened for the purpose of creating meeting areas, which were evaluated during Preliminary Screening and not advanced for more detailed analysis.

Table 6-3
Existing and Proposed Channel Widths by Range

ID	Range Name	Channel Widths [ft]		Widening Details
		Existing Channel	Proposed	
0	Entrance	N/A	600	New
1	Bald Head Shoal Reach 3	500 - 900	600 - 900	Symmetric
2	Bald Head Shoal Reach 2	900	900	No Change
3	Bald Head Shoal Reach 1	700	900	Green Side Only
4	Smith Island	650	900	Red Side Only
5	Bald Head - Caswell	500	800	Red Side Only
6	Southport	500	800	Re-orientation Red Side then Green Side
7	Battery	500	800 - 1300	Replaced with 4000-ft Radius Curve And Green Side at Apex
8	Lower Swash	400	800 - 500	Green Side to Symmetric
9	Snows Marsh	400	500	Symmetric
10	Horseshoe Shoal	400	500	Symmetric
11	Reaves Point	400	500	Symmetric
12	Lower Midnight	600	600	No Change
13	Upper Midnight	600	600	No Change
14	Lower Lilliput	600	600	No Change
15	Upper Lilliput	400	500	Symmetric
16	Keg Island	400	500	Symmetric
17	Lower Big Island	400	500	Symmetric
18	Upper Big Island	660	660	No Change
19	Lower Brunswick	400	500	Symmetric
20	Upper Brunswick	400	500	Symmetric
21	Fourth East Jetty	500	550	Green Side Only
22	Between Channel	550	625	Green Side Only
22	Anchorage Basin	625	625 - 1509	No Change

6.4.2 Dredged Material Characteristics

Characterization of materials likely to be encountered during dredging was developed using grain size curves and data plots showing fines content and unconfined compressive strength (UCS) versus elevation for channel reaches which contained historical data. Transverse cross sections were also performed approximately every 1,500 feet beginning at Anchorage Basin to the end of Baldhead Shoal Reach 3 to aid with the interpretation and characterization. Seismic survey data acquired for this project provided additional interpretation for the location of potential shallow rock outcrops, especially on the channel flanks, to further aid in both the inner and outer channel subsurface conditions. Seismic data was correlated with the historical geotechnical and previous mapping to show which formation is likely to be encountered (if any) if deepening were to occur. A previously unmapped area 8.7 miles long, southwest of the end of Baldhead Reach 3, was surveyed and geologic formations were interpreted.

6.4.2.1 Physical Characteristics

Table 6-4 provides a summary of the interpreted subsurface conditions for each channel reach, with the material being categorized based on its potential beneficial use:

- Category A = Potentially Suitable for Engineering Structural Fill or Beach Nourishment; Fines content typically less than 10% and low calcium carbonate content;
- Category B = Potentially Suitable for Non-Engineered Fill; Fines content typically between 10 and 20%; may include thin lenses of fine-grained deposits;
- Category C = Potentially Suitable for Low-Quality Fills (e.g. habitat restoration and development, offshore berms, parks and recreation, etc.); Fines content 20 to 25%; and
- Category D = Disposal Area (Upland or Offshore).

The geotechnical analysis evaluated potential opportunities for beneficial use of dredged materials. Several areas were identified as containing material that potentially be used for fill or beach nourishment projects. Interpretation of geotechnical and geophysical data suggest that channel flanks in Keg Island through Lower Lilliput and Horseshoe Shoal reaches likely contain material with low fines content, which may be desirable for use as fills. Lower Midnight, Reaves Point, Lower Swash reaches and north of the Anchorage Basin reach appear to have materials with a low fines content and may be desirable for repurposing as Category A and B materials. The other channel reaches appear to contain material with high fines content or substantial interbeds of fines (clay and silt) and do not appear to desirable for fills and beach nourishment projects, which are considered Category C and/or D materials.

Table 6-4
Summary of Subsurface Conditions

Channel Reach	Beneficial Use Widening	Beneficial Use Deepening	Deepening Interval (ft)	Rock Encountered	Estimated Top of Rock Elevation (ft below MLLW)
Anchorage Basin	D	D	0 to 5	Likely (Peedee)	-41 to -52*
		D	5 to 10	Likely (Peedee)	
Between Channel	D	D	0 to 5	Likely (Peedee)	-41 to -54*
		D	5 to 10	Likely (Peedee)	
Fourth East Jetty	D	D	0 to 5	Likely (Peedee)	-47 to -54*
		D	5 to 10	Likely (Peedee)	
Upper Brunswick	C, D	C, D	0 to 5	Likely (Peedee)	-47 to -57*
		C, D	5 to 10	Likely (Peedee)	
Lower Brunswick	C, D	C, D	0 to 5	Likely (Peedee)	-47 to -57*
		C, D	5 to 10	Likely (Peedee)	
Upper Big Island	C, D	C, D	0 to 5	Likely (Castle Hayne B/A)	-45 to -50*
		C, D	5 to 10	Likely (Castle Hayne B/A)	
Lower Big Island	C, D	C, D	0 to 5	Likely (Castle Hayne B/A)	-47 to -52*
		C, D	5 to 10	Likely (Castle Hayne B/A)	
Keg Island	A, B, C, D	B, C, D	0 to 5	Likely (Peedee) (Castle Hayne A)	-47 to -67*
		C, D	5 to 10	Likely (Peedee) (Castle Hayne A)	
Upper Lilliput	A, B, C, D	B, C, D	0 to 5	Likely (Peedee) (Castle Hayne A)	-47 to -57*
		B, C, D	5 to 10	Likely (Peedee) (Castle Hayne A)	
Lower Lilliput	A, B, C, D	A, B, C, D	0 to 5	Likely (Peedee) (Castle Hayne A)	-47 to -62*
		A, B, C, D	5 to 10	Likely (Peedee) (Castle Hayne A)	
Upper Midnight	C, D	C, D	0 to 5	Not Likely	-56 to -65
		C, D	5 to 10	Not Likely	
Lower Midnight	B, C, D	B, C, D	0 to 5	Not Likely	-56 to -65
		B, C, D	5 to 10	Not Likely	
Reaves Point	B, C, D	B, C, D	0 to 5	Not Likely	-57 to-62
		B, C, D	5 to 10	Not Likely	
Horseshoe Shoal	A, B, C, D	A, B, C, D	0 to 5	Not Likely	-58 to -66
		A, B, C, D	5 to 10	Not Likely	
Snows Marsh	C, D	C, D	0 to 5	Likely (Peedee) (Castle Hayne A)	-47 to -59*
		C, D	5 to 10	Likely (Peedee) (Castle Hayne A)	
Lower Swash	B, C, D	B, C, D	0 to 5	Likely (Castle Hayne B)	-47 to -52*
		C, D	5 to 10	Likely (Castle Hayne B)	
Battery Island	A, B, C, D	C, D	0 to 5	Likely (Castle Hayne B)	-47 to -52*
		C, D	5 to 10	Likely (Castle Hayne B)	
Southport	A, B, C, D	A, B, C, D	0 to 5	Likely (Castle Hayne B)	-47 to -72*
		A, B, C, D	5 to 10	Likely (Castle Hayne B)	
Baldhead-Caswell	A, B, C, D	A, B, C, D	0 to 5	Not Likely	-70 to -75
		A, B, C, D	5 to 10	Not Likely	
Smith Island	A, B, C, D	B, C, D	0 to 5	Not Likely	-70 to -80
		B, C, D	5 to 10	Not Likely	
Baldhead Shoal Reach 1	A, B, C, D	B, C, D	0 to 5	Not Likely	-65 to -72
		B, C, D	5 to 10	Not Likely	
Baldhead Shoal Reach 2	A, B, C, D	B, C, D	0 to 5	Not Likely	-62 to -75
		B, C, D	5 to 10	Not Likely	
Baldhead Shoal Reach 3	C, D	C, D	0 to 5	Likely (Castle Hayne)	-46 to -58
		C, D	5 to 10	Likely (Castle Hayne)	

*Channel widening or excavation of the cut slope may encounter rock shallower than indicated by this range

6.4.2.2 Underlying Channel Rock

Geotechnical analyses were performed to map the top of rock and confirm mapping of top of rock performed previously by others. “Rock” implies that the materials have undergone lithification (deposits have been subjected to pressure, heat, and/or cementation and lithified as a rock) and exhibit physical properties (e.g. strength) of rock. “Formation” refers to materials that have been assigned to a geologic formation and been given a formation name (e.g. Castle Hayne). Formation materials may exhibit properties similar to rock or soil (e.g. dense to very dense sand or hard clay). The geotechnical analysis interpreted seismic horizons (or reflectors) and interpreted their association with formations. In the inner harbor, the interpreted seismic horizons generally correlate well with rock intervals described on exploration logs and top of rock mapping presented by others. However, in the offshore channel reaches there appear to be differences between top of rock mapping by others and the seismic horizons presented in this study due to limited data in this area.

As show in Table 6-4, in general, from the Turning Basin through Upper Lilliput any type of deepening from the current channel bottom is likely to encounter rock. In addition, based on the average UCS data and presumed rock thickness, deepening in the Lower Brunswick, Upper and Lower Big Island and Keg Island reaches may require blasting to remove the encountered rock (Table 6-5). From Lower Lilliput through Horseshoe Shoal, deepening of the channel is not likely to encounter rock. From Snows Marsh to approximately the end of Battery Island, it is likely to encounter rock if any deepening were to occur, although due to a lack of strength data it is uncertain if blasting will be required to excavate the material. Southport, Baldhead-Caswell, Smith Island and Baldhead Reaches 1 & 2 are not likely to encounter rock. Deepening in Baldhead Reach 3 is interpreted to likely encounter Castle Hayne Unit B materials.

Table 6-5
Rock Summary

Channel Reach	Rock Quality Designation (RQD)			Rock Layer Thickness (ft)			UCS (psi)		
	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Anchorage Basin	26	0	100	4.2	0.1	20	624	257	2,286
Between Channel	50	7	98	2.8	0.2	6	1,025	776	1,269
Fourth East Jetty	7	0	34	0.5	0.1	2.5	4,880[a]	4,835[a]	4,924[a]
Upper Brunswick	11	0	24	0.4	0.1	0.9	n/a	n/a	n/a
Lower Brunswick	13	0	34	0.6	0.2	1.2	1,666	319	4,346
Upper Big Island	43	0	99	3.3	0.1	9.7	4,258	461	12,273
Lower Big Island	69	10	99	2	0.4	14.4	4,077	252	7,462
Keg Island	26	0	46	1.9	0.2	12.2	4,956	1,384	10,167
Upper Lilliput Lower Lilliput	26	26	26	2.5	0.4	9.4	1,939	1,682	2,177
Upper Midnight Lower Midnight Reeves Point Horseshoe Shoal	--	--	--	3.45	1.3	5.6	--	--	--
Snows Marsh	15	0	63	4.6	1.3	10	2,636	2,636	2,636
Lower Swash	36	0	76	5	4	6	1,473	1,473	1,473
Battery Island	54	54	54	9	4	14.1	--	--	--
Southport Baldhead-Caswell Smith Island Baldhead Shoal Reaches 1 and 2	--	--	--	--	--	--	--	--	--
Baldhead Shoal Reach 3	41	0	100	4.3	0.2	8.5	1,239	969	1,473

[a] Only two test results are reported for this reach

6.4.2.3 Chemical Characteristics

Materials dredged from the Federal navigation channel historically have been suitable for ocean placement at the New Wilmington ODMDS (USACE and EPA, 2013) and beneficial use in accordance with the Sand Management Plan (USACE 2000):

- as beach replenishment material at Bald Head Island and Oak Island; and
- as bird nesting island restoration at South Pelican Island and Ferry Slip Island.

Prior to placement at the New Wilmington ODMDS, material must be determined suitable for ocean placement by the Wilmington District USACE in a MPRSA Section 103 evaluation and independently concurred by EPA Region 4 prior to disposal. Modeling (LTFATE and MTFATE) to evaluate potential mounding and dispersion may be required prior to material disposal.

6.4.3 Dredging Methods

The dredging equipment and methods presented in this section of the report are considered the most likely dredging methods for the Project (Table 6-6). However, market forces at the time of contract, equipment and labor resources available to different Contractor(s), together with their experience, will affect the selected Contractor(s)' final means and methods and ultimately the schedule and contract prices.

It is anticipated that the surface sediments (sand and silt) overlying the rock will be dredged by a hopper dredge. Several methods are anticipated for rock removal. Some rock areas will be dredged, without pre-treatment, by a mechanical dredge placing material in material transport scows. Other rock areas will be dredged by a cutter suction dredge pumping directly to material transport scows via a spider barge. The scows will discharge the material through the split-hull and then return to the dredge site. Other rock will be pre-treated in place by a cutter suction dredge or by confined underwater (CU) blasting and removed via mechanical dredges. Utilizing a cutter suction dredge to cut and fragment the underlying rock area will allow for more precise identification of the hardest rock that cannot be cut by this method and would require another form of pre-treatment, such as CU blasting or chiseling.

Table 6-6
Summary of Dredging Equipment and Dredged Material Type

Range Name	Dredge Equipment	Dredged Material Type
Entrance	Hopper	Sand / Silt
Bald Head Shoal Reach 3	Hopper and Cutterhead	Sand / Silt / Soft Rock
Bald Head Shoal Reach 2	Hopper	Sand / Silt
Bald Head Shoal Reach 1	Cutterhead with Beach Disposal	Sand
Smith Island	Cutterhead with Beach Disposal	Sand
Bald Head - Caswell	Cutterhead with Beach Disposal	Sand
Southport	Cutterhead with Beach Disposal	Sand
Battery Island	Cutterhead with Spider Barge	Sand / Silt / Soft Rock
Lower Swash	Cutterhead with Spider Barge	Sand / Silt / Soft Rock
Snows Marsh	Cutterhead with Spider Barge	Sand / Silt / Soft Rock
Horseshoe Shoal	Cutterhead with Spider Barge	Sand
Reaves Point	Cutterhead with Spider Barge	Sand
Lower Midnight	Cutterhead with Spider Barge	Sand
Upper Midnight	Cutterhead with Spider Barge	Sand
Lower Lilliput	Cutterhead with Spider Barge	Sand / Silt / Soft Rock
Upper Lilliput	Cutterhead with Spider Barge	Sand / Silt / Soft Rock
Keg Island	Blasting Rig with Mechanical Dredge for Rock, Cutterhead with Spider Barge	Sand / Silt / Hard Rock
Lower Big Island	Blasting Rig with Mechanical Dredge for Rock, Cutterhead with Spider Barge	Sand / Silt / Hard Rock
Upper Big Island	Blasting Rig with Mechanical Dredge for Rock, Cutterhead with Spider Barge	Sand / Silt / Hard Rock
Lower Brunswick	Blasting Rig with Mechanical Dredge for Rock, Cutterhead with Spider Barge	Sand / Silt / Hard Rock
Upper Brunswick	Cutterhead with Spider Barge	Sand / Silt / Soft Rock*
Fourth East Jetty	Cutterhead with Spider Barge	Sand / Silt / Soft Rock*
Between Channel	Cutterhead with Spider Barge	Sand / Silt / Soft Rock*
Anchorage Basin	Cutterhead with Spider Barge	Sand / Silt / Soft Rock*

*These reaches may contain thin layers of hard rock which can be dredged with a cutterhead.

6.4.3.1 Pre-treatment Methods

Based on the available RQD and hardness characteristics of the channel, it is expected that some rock areas within the channel will need pre-treatment prior to excavation. There are several methods by which this can be accomplished, and the final means and methods will depend on the equipment available to the winning Contractor(s) and the Contractor(s)' experience. Pre-treatment can be performed using a cutterhead suction dredge, CU blasting, or hydraulic hammer.

A cutter suction dredge can be used for both dredging and rock pre-treatment. A cutter section dredge used for rock pre-treatment would be followed by excavation via mechanical dredging. Generally, it is more efficient to use hydraulic dredging with a cutter suction dredge, without pre-treatment, to avoid double-handling material. However, pre-treatment with a cutter suction dredge followed by mechanical excavation may be necessary in siltstone so that overflow from the dump scow does not exceed turbidity limits.

The use of CU blasting as a pretreatment technique is anticipated to be required for some of areas of the channel where standard construction methods are unsuccessful due to the hardness of the rock. The areas requiring blasting will be determined by core boring logs and the performance of a cutter suction dredge on rock areas.

In confined blasting, each charge is placed in a hole drilled in the rock approximately 5 to 10 ft below the desired excavation depth, depending on how much rock needs to be broken and the intended project depth. The hole is then loaded with an explosive charge, a detonation device, a delay-timing device, and ultimately capped with an inert material, such as crushed rock, to confine the energy within the rock. This process is referred to as “stemming the hole” and is a key feature to “confined” underwater blasting. Stemming requirements will be detailed in the Project specifications. The blasting charge is set and the chain of explosives within the rock is detonated.

A hydraulic hammer can fracture rock up to 11,600 psi, which is likely harder than any of the rock within the Project area. This method consists of hydraulically driving a hammer and chisel into rock at any desired angle. The hydraulic hammer can be mounted on an excavator, backhoe, or cutter suction dredge and extraction occurs with the use of an extracting cat (spring buffer) placed on the leader profile in between the pulling line. The operation is generally limited to a depth of approximately 40 ft, but could be modified to accomplish the depths associated with the Project. This method is extremely effective in very small areas of hard rock and is generally used on pinnacles or very small outcroppings.

6.4.3.2 Viable Methods for Different Rock Characteristics

The determination of which equipment to use for different rock characteristics is described in this section. Prior to rock dredging in the offshore reaches, it is anticipated that the Contractor will remove sand and loose material to top of rock using a hopper dredge. Different equipment is anticipated for the various rock characteristics and the Contractor(s)’ available equipment. Dredging methods have been estimated for three categories of material, labeled “No Pre-Treat” for areas that are not anticipated to require pre-treatment, soft rock for areas that would require a cutterhead dredge, and hard rock, which requires CU blasting.

For “No Pre-Treat” category materials offshore, a hopper dredge will be used for sands and silts. For sands that will be used for beneficial placement, a cutterhead dredge and pipeline would be used. In areas with known soft rock and areas where soft rock may be present a cutter head dredge with spider barge will be used to load dump scows. The assumption that all hard rock (hardness above 4,000 psi) will require CU blasting is conservative and is based on a relative lack of data that will be augmented during Preconstruction Engineering and Design. Hard rock will be drilled and blasted as pre-treatment, then dredged with a mechanical dredge and loaded onto dump scows.

6.4.3.3 Construction Assumptions

Prior to all dredging, sediment sampling will be performed to ensure that materials are suitable for their proposed placement locations and the appropriate permits will be obtained. All dredging will be performed within the currently established USACE environmental work windows (USACE 2017).

Overall, the construction is projected to take three years. Dredging (and blasting when necessary) will be performed by crews working 12-hour shifts 24 hours per day and seven days per week. Although dredging crews are projected to be on-site and working as described above, dredging production will likely be limited to 25 days per month due to necessary set up, break down, and maintenance operations.

Dredging will be performed by a 7,600 cy capacity hopper dredge in the Entrance, Baldhead Shoal Reach 3 and Baldhead Shoal Reach 2. Excess water will be decanted on-site. The dredged material will be hauled to the placement area at the New Wilmington ODMDS and dumped from the split-hull vessel.

The hopper dredge would be assumed to operate 24/7, with personnel shifts assumed to be eight hrs/day, seven days a week, with a monthly average of 621 production hours per month. A total of 16 personnel would be assumed to operate the hopper dredge including personnel for three shifts.

The cutterhead dredge with beach placement will dredge in the following reaches:

- Baldhead Shoal Reach 1;
- Smith Island Reach;
- Baldhead-Caswell Reach; and
- Southport Reach.

The 30-inch cutterhead dredge would be assumed to operate 24/7, with personnel shifts assumed to be eight hrs/day, seven days a week with a capacity of 2,800 cy/hour. A total of 43 personnel would be assumed to operate the cutterhead dredge including personnel for three shifts, support staff, and all of the required shore crews. The cutterhead dredge would be assumed to be actively dredging for 475 hrs/month.

The 30-inch cutterhead dredge with spider barge will work in rock and non-rock channel reaches, including:

- Battery Island Reach
- Lower Swash Reach;
- Snows Marsh Reach;
- Horseshoe Shoal Reach;
- Reaves Point Reach;
- Lower Midnight Reach;
- Upper Midnight Reach;
- Lower Lilliput Reach;
- Upper Lilliput Reach;

- Upper Brunswick Reach;
- Forth East Jetty Reach and Berths;
- Between Reach; and
- Turning Basin.

Cutterhead production rates will vary from 2,000 cy/hr in sand to 500 cy/hour in hard material.

Areas where CU blasting will occur will use the 30-inch cutterhead dredge with spider barge to remove any sand overlay. Blasted material will be removed by a 26 cubic yard clamshell dredge outfitted with a 14 cubic yard bucket. Production is estimated to be 200 cy of blasted material per hour. CU blasting with cutterhead sand overlay removal will occur in the following reaches:

- Keg Island Reach;
- Lower Big Island Reach;
- Upper Big island Reach; and
- Lower Brunswick Reach.

6.4.4 Dredged Material Placement

New work and incremental maintenance dredging volumes resulting from the proposed improvements to the Federal Navigation channel fit within the Wilmington District's existing dredged material management practices and there are no substantial modifications to existing placement sites required. Existing dredged material management practices include the least cost method of dredge material disposal from the existing Wilmington Harbor project, which is the same method recommended in this report for material dredged for the alternative action plans.

Construction dredging material will be disposed within the New Wilmington ODMDS. Dredged sediment is expected to primarily include fine- to medium-grained sand with silts from the upper channel reaches and the anchorage basin. Dredged rock is expected to be limestone, siltstone and sandstone (sedimentary rock). Beneficial use of dredged material is being evaluated for:

- Beach placement on Bald Head Island and Oak Island;
- Battery Island shore placement (potential mitigation opportunity);
- South Pelican and Ferry Slip Island restoration (potential mitigation opportunity);
- Island creation adjacent to South Pelican and Ferry Slip Islands (potential mitigation opportunity); and
- Wetland restoration on Battery, Shellbed, and Striking Islands using thin-layer placement.

6.4.5 Dredged Material Quantities and Costs

Dredging quantities (Table 6-7) were calculated based on the channel configurations detailed in Section 6.1.1 Deepening the Federal Channel. Dredging in-situ volumes are based on the required dredge depth, which consists of the proposed channel dimensions and a one-foot rock buffer in areas where rock is encountered. Two feet of allowable overdepth has been included in the project volume estimates. Dredging quantities and costs in Table 6-7 include local service facility berth dredging to project depth. Dredging costs include mobilization and de-mobilization costs.

Table 6-7
Dredge Material Construction Volumes (cy) and Costs ($FY20)

Project Depth	Dredging Quantities			Total Cost
	Rock	Non-Rock	Total Quantity	
-44	1,315,653	12,156,737	13,472,390	$285,626,229
-45	2,266,484	15,665,991	17,932,475	$373,528,298
-46	3,217,315	19,175,245	22,392,560	$461,430,367
-47	4,168,146	22,684,499	26,852,645	$549,332,436
-48	5,826,091	26,550,219	32,376,311	$670,853,654

6.4.6 Advanced Maintenance

The Wilmington District does not perform advanced maintenance of the channel and no advanced maintenance is proposed in the TSP. An additional rock buffer is proposed in areas where rock is present, which includes dredging an additional depth of 1 ft to ensure future maintenance capability.

6.4.7 Pipeline Relocation

There are no utility relocations required for the project. As-built drawings for the Carolina Power and Light company and for the Brunswick County, NC display an 8” HDPE waterline and cable in a joint bore at -63 feet MLLW. The waterline and cable diverge outside of the channel. The existing overhead cable crossing has a vertical clearance of 210 feet, which does not interfere with projected future navigation.

There are four pipelines crossing the channel in the Fourth East Jetty Reach just south of Eagle Island that are owned by Exxon Mobile with the operation and maintenance of the pipelines contracted to Kinder Morgan. Two pipelines are active but currently have no commercial flow. These two pipelines are six-inch nominal diameter and are currently pressurized with nitrogen awaiting future business opportunities. Two pipelines are not active. These two pipelines are four-inch nominal diameter, filled with sea water and capped. One of the active six-inch lines is directionally drilled to a depth in excess of 68 feet MLLW and does not need to be relocated. The second active six-inch line is at a depth of ~49 feet MLLW and needs to be relocated. The two inactive four-inch lines are at a depth of ~47 feet MLLW and need to be removed. Table 6-8 provides the disposition of each pipeline.

Table 6-8
Pipeline Disposition

Size	Status	Depth (MLLW)	Action Needed
4-inch	Inactive	~47 feet	Remove
4-inch	Inactive	~47 feet	Remove
6-inch	Active	~49 feet	Relocate
6-inch	Active	>68 feet	No Action

Pursuant to Section 101(a) of the Water Resources Development Act of 1986 (WRDA 86), as amended, the non-Federal Sponsor is responsible for performing, or assuring the performance, of all relocations, including utility relocations, which are necessary for the navigation improvement project. All relocations, including utility relocations, are to be accomplished at no cost to the Federal Government. The estimated cost of one six-inch pipeline relocation is $2,000,000. This cost is included in the project cost as a 100% non-federal expense and the non-Federal Sponsor will receive equivalent credit toward its additional 10 percent cash payment required by Section 101(a)(4) of WRDA 86.

The two four-inch pipelines do not need to be relocated because they are no longer active. The non-Federal Sponsor has contacted the owner to reach a determination as to whether the owner has an interest in the existing line for which compensation is owed by the non-Federal Sponsor. If the owner has a compensable interest, the non-Federal Sponsor, as part of its requirement to provide lands, easements, and rights-of-way required for the navigation improvement project, will be responsible for acquiring this interest, at no cost to the Federal Government. At this time, it appears that there is no compensable interest in these pipelines.

If there is a compensable interest, the non-Federal Sponsor will receive credit toward its additional 10 percent cash payment required by Section 101(a)(2) of WRDA 86 for the value of the interest acquired, and the Corps will revoke any existing Section 10 permit and remove the line as part of construction of the navigation improvement project, with the costs of the removal shared by the Corps and Sponsor as part of the costs of the general navigation features.

If no compensation is owed to the owner of the line, then the Corps will revoke any existing Section 10 permit and remove the line as part of construction of the navigation project, with the costs of the removal shared by the Corps and non-Federal Sponsor as part of the costs of the general navigation features. The estimated removal cost for the two four-inch pipelines is $300,000.

The non-Federal Sponsor will receive credit toward its additional 10 percent cash payment required by Section 101(a)(2) for the value of relocations provided under Section 101(a)(3) and for the costs of utility relocations borne by the Sponsor under Section 101(a)(4). Such credit will include any payment made by the Sponsor to the Corps associated with the Corps' exercise of the navigation servitude. At this time there is no indication that the exercise of navigation servitude will be required.

6.4.8 Relocation of aids to navigation (ATON)

A total of 56 ATONS are included in the alternative action plans, which includes new offshore range markers, new and relocated Lateral Buoys, and relocated inshore range markers, including:

- Range Markers (steel multi-pile jacket structures, varying height steel skeleton towers with ranger markers attached):
    - Two (2) new range markers
    - Relocate ten (10) range markers
    - Buoys (floating aids with anchors and attached lights):
- Thirteen (13) new lateral marker buoys (this number could go up or down a couple depending on whether bend wideners are installed at each bend).
    - Relocate up to thirty-eight (38) lateral marker buoys.
    - Relocate the sea buoy.

The action alternatives will require temporary relocation of buoys during construction and the permanent relocation of buoys and range markers after construction. Existing ATON within 50 ft of the channel will be temporarily relocated during dredging and re-installed in their existing locations after the localized dredging is complete. The contractor will remove the buoys and sinker one day prior to dredging and replace it in its original location no more than one day after dredging is complete. Final buoy relocation will occur during the final year of construction dredging. Permanent ATON relocation and will take place during the final year of construction and will be coordinated with the USCG, the NCSPA, and the Cape Fear River Pilots Association. The federally-operated ATON may be installed by the NCSPA based on specifications provided by USCG. The installed ATON could then be transferred to the USCG at a mutually agreeable time, likely during year 3 of construction (Sub-Appendix 1, Aids to Navigation). All ATON relocation will be conducted with a crane barge and supporting plant.

Table 6-9 identifies the ATONs to be relocated or constructed.

Table 6-9
Aids to Navigation Relocation and Construction

Reach (Channel Location)	ID Nos	Type	Qty.	New or Relocation
New Sea Range	1	Front Range Marker	1	New
New Sea Range	2	Rear Range Marker	1	New
New Sea Range	3, 4	Lateral Marker Buoy	10	New
New Sea Range	5	Lateral Marker Buoy	1	Relocation
New Sea Range	6	Sea Buoy	1	New
Bald Head Shoal 3	7 to 13	Lateral Marker Buoy	7	Relocation
Bald Head Shoal 1	14	Front Range Marker	1	Relocation
Bald Head Shoal 1	15	Rear Range Marker	1	Relocation
Bald Head Shoal 1	16, 17	Lateral Marker Buoy	2	Relocation
Smith Island	18	Front Range Marker	1	Relocation
Smith Island	19	Rear Range Marker	1	Relocation
Southport/Battery Continuous Turn	20	Front Range Marker	1	Relocation
Southport/Battery Continuous Turn	21	Rear Range Marker	1	Relocation
Southport/Battery Continuous Turn	22, 23	Lateral Marker Buoy	2	Relocation
Southport/Battery Continuous Turn	24	Lateral Marker Buoy	1	New
Lower Swash	25	Front Range Marker	1	Relocation
Lower Swash	26	Rear Range Marker	1	Relocation
Lower Swash	27	Lateral Marker Buoy	1	Relocation
Snows Marsh	28 to 31	Lateral Marker Buoy	4	Relocation
Horseshoe Shoal	32 to 34	Lateral Marker Buoy	3	Relocation
Horseshoe Shoal	35	Lateral Marker Buoy	1	New
Reaves Point	36	Lateral Marker Buoy	1	Relocation
Upper Lilliput	37 to 40	Lateral Marker Buoy	4	Relocation
Keg Island	41, 42	Lateral Marker Buoy	2	Relocation
Keg Island	43	Lateral Marker Buoy	1	New
Lower Big Island	44 to 46	Lateral Marker Buoy	3	Relocation
Lower Brunswick	47 to 51	Lateral Marker Buoy	5	Relocation
Upper Brunswick	52	Lateral Marker Buoy	1	Relocation
Fourth East Jetty Range	53	Front Range Marker	1	Relocation
Fourth East Jetty Range	54	Rear Range Marker	1	Relocation
Fourth East Jetty Range	55, 56	Lateral Marker Buoy	2	Relocation

6.5 Comparison of Final Array of Alternatives

Consistent with the plan formulation rationale outlined in section 5.1, the final alternatives are evaluated with respect to their effects on the four accounts (NED, RED, OSE, and EQ). Effects to the NED account identify the alternative plan's ability to meet the Federal objective to contribute to NED consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. The following presentation of alternative plan costs, benefits, and net benefits addresses effect on the NED account.

6.5.1 Alternative Plan Costs

Construction of the alternative plans would consist of dredging, confined underwater blasting, dredged material placement at the New Wilmington ODMDS, and placement of suitable beneficial use material for beach nourishment and/or island restoration. Two four-inch inactive pipelines need to be removed and one six-inch active pipeline needs to be relocated. Navigation buoys will be relocated to accommodate the new channel dimensions. New ranges are required because the project relocates the existing channel centerline in a number of reaches. Alternative plan costs are presented in Table 6-10.

Dredging costs were developed using a cost estimating worksheet that accounts for the efficiency of the dredges for each reach based upon the areas, volume, amount of pay amount not dug on average, and the amount dug in excess of the allowable pay amount, and many other factors associated with dredging operations. All costs associated for the contractor including overhead, profit, and bonds are included in the unit price calculated. The cost estimating worksheet also calculates costs for mobilization and demobilization, which are provided separately from the unit costs. It was assumed that the USACE would provide the post construction survey, so no cost was estimated with regards to surveys (note: the contractor is assumed to have a surveyor of their own, but no surveys were included for the owner).

Local service facility construction costs, which consist entirely of berth dredging, were estimated in a manner similar to channel dredging costs.

Pipeline removal and relocation costs were developed in collaboration with pipeline owners and operators. ATON relocation and construction costs were developed in collaboration with the USCG.

Pre-construction, engineering and design (PED) costs are estimated for input into the total project costs. The estimate for PED includes a breakdown of field work including Cultural Resources, sediment sampling and testing, engineering and surveys to assemble bid documents, as well construction management and support through construction.

A Cost and Schedule Risk Analysis (Appendix D: Cost, Sub-Appendices D and E) was performed to evaluate uncertainties associated with each major construction cost item or feature in coordination with input with other members of the project development team. The Cost and Schedule Risk Analysis was developed with technical assistance from the USACE Wilmington District. The resulting contingency at the 80% confidence level is 21.4%.

Interest during construction (IDC) was calculated using the FY20 federal discount rate (2.75%). The construction schedule was used to identify a schedule of costs incurred during PED and construction. Costs were escalated by month up to the base year to calculate the investment costs of the project.

Table 6-10
Alternative Plan Costs with Contingency at 21.4% (FY2020 Dollars)

Cost Item	-44 feet	-45 feet	-46 feet	-47 feet	-48 feet
Land	$14,568,000	$25,470,000	$25,470,000	$25,470,000	$34,575,000
Relocations	$2,792,000	$2,792,000	$2,792,000	$2,792,000	$2,792,000
Dredging	$346,046,000	$452,055,000	$558,768,000	$665,129,000	$812,304,000
ATON	$10,531,000	$10,531,000	$10,531,000	$10,531,000	$10,531,000
LSF Berths	$704,000	$1,056,000	$1,408,000	$1,760,000	$2,112,000
Const. Mgt.	$13,111,000	$13,111,000	$13,111,000	$13,111,000	$16,389,000
PED	$25,615,000	$25,615,000	$25,615,000	$25,615,000	$25,615,000
Mitigation	$40,426,000	$44,918,000	$71,869,000	$89,836,000	$112,295,000
Monitoring	$12,140,000	$12,140,000	$12,140,000	$12,140,000	$12,140,000
IDC	$19,228,000	$26,059,000	$31,810,000	$37,287,000	$54,290,000
Total	**$485,161,000**	**$613,747,000**	**$753,514,000**	**$883,671,000**	**$1,083,043,000**

6.5.2 National Economic Development

The projected future commodity tonnage and the projected future fleet are the same under without- and with-project conditions. Under with-project conditions, at incrementally increasing project depths, unit costs to carriers would be reduced, however, reductions in unit costs to the carriers do not fully explain the shift of TEUs from Savannah in the without-project condition to Wilmington under with-project conditions.

The port shift projected to occur under with-project conditions is based on the demand for transportation services at the Port of Wilmington. This demand is represented by a willingness-to-pay schedule for the Port of Wilmington's hinterland Asia TEUs importers and exporters that use Savannah under without-project conditions. The willingness-to-pay (demand) schedule identifies the potential landside transportation cost savings for each Port of Wilmington's hinterland Asia import or export TEU that would have used Savannah under without-project conditions. TEUs from each Port of Wilmington hinterland origin or destination were ranked by total potential savings from greatest savings to no savings (indifferent to using Wilmington or Savannah) and shifted from Savannah to Wilmington in order of potential savings. In this manner, TEUs with the highest potential savings (highest willingness-to-pay) were the first boxes to shift to Wilmington followed by boxes with the next highest potential savings and so on until the potential for savings had been exhausted.[25] The demand schedule was developed from PIERS data for Asia imports and exports for calendar years 2017 and 2018 (loaded TEUs only).

[25] Independent Reviewer Larry Prather provided significant input by pointing out the importance of and the method used to develop the demand schedule.

The resulting demand schedule (Table 6-11 and Figure 6-1) identifies the incremental value of shifting to Wilmington for Wilmington's hinterland importers and exporters that necessarily use Savannah as an alternative port under without-project conditions.

Table 6-11
Demand Schedule for Asia Import and Export Cargo at the Port of Wilmington

Project Depth (feet below MLLW)	Cumulative TEUs	Cumulative Savings	Incremental Savings	Proportion of Total Savings
43	20,020	$5,202,000	$5,202,000	24.21%
44	40,040	$10,049,000	$4,847,000	22.56%
45	60,060	$13,988,000	$3,938,000	18.33%
46	80,080	$17,025,000	$3,037,000	14.13%
47	100,100	$19,354,000	$2,329,000	10.84%
48	120,120	$21,488,000	$2,134,000	9.93%

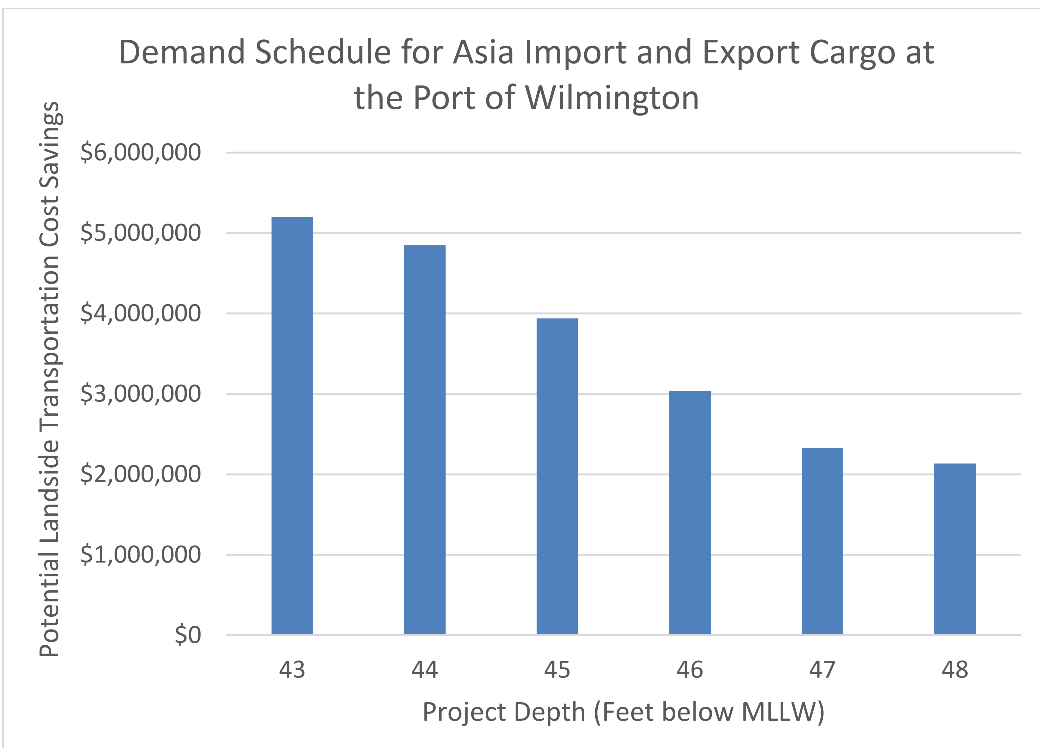

Figure 6-1
Demand Schedule for Asia Import and Export Cargo at the Port of Wilmington

The demand schedule presented in Table 6-11 and Figure 6-1 is a snapshot of potential willingness-to-pay based on historical data (2017 and 2018). The incremental increase in project depth is truncated at -48 feet because the depth constraints at the prior and next ports (-48 feet Boston, -47 feet Savannah and Jacksonville) indicate that there would be very limited cost savings at project depths deeper than -48 feet. Although the incremental increase in the number of TEUs is consistent from foot to foot, i.e., each incremental foot of project depth is capable of accommodating the same number of TEUs, there is a difference in the value (willingness-to-pay) for each incremental foot, with the first increment of depth being the most valuable and the last increment being the least valuable as indicated by the demand schedule. The boxes with the highest potential savings (potential consumer surplus) would be the first boxes to shift to the vessel capacity made available by the additional project depth, based on the standard economic assumption of resource allocation to the highest value.

The incremental shift in cargo (Table 6-12) results in fewer truck hauls from the Port of Wilmington's hinterland to Savannah, which reduces truck miles traveled. Note that each truck haul carries 1.85 TEUs on average. Table 6-13 presents the number of truck-miles avoided for each increment of project depth. At each project depth increment, the reduction in truck miles also reduces total landside transportation costs (Table 6-14) because at each project depth increment more of the Port of Wilmington's hinterland containerized Asia cargo is using the Port of Wilmington and less of that cargo is using Savannah. Tables describing interim tabulations for total truck hauls, total truck miles, and trucking costs by project depth, port, and year are presented in the Economics Appendix Section 4: Alternative Plans Economic Evaluation.

Table 6-12
Port of Wilmington's Hinterland Containerized Asia Cargo Loaded TEUs: With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	0	0	0	0	0
-44	Wilmington	51,334	63,627	71,989	81,448	92,151
-45	Wilmington	77,001	95,441	107,983	122,173	138,227
-46	Wilmington	102,668	127,255	143,977	162,897	184,303
-47	Wilmington	128,335	159,068	179,971	203,621	230,379
-48	Wilmington	154,002	190,882	215,966	244,345	276,454
-42	Savannah	154,002	190,882	215,966	244,345	276,454
-44	Savannah	102,668	127,255	143,977	162,897	184,303
-45	Savannah	77,001	95,441	107,983	122,173	138,227
-46	Savannah	51,334	63,627	71,989	81,448	92,151
-47	Savannah	25,667	31,814	35,994	40,724	46,076
-48	Savannah	0	0	0	0	0

Table 6-13
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Miles Avoided: With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Savannah	0	0	0	0	0
-44	Sav & Wilm	11,041,000	13,686,000	15,484,000	17,519,000	19,821,000
-45	Sav & Wilm	16,562,000	20,529,000	23,227,000	26,278,000	29,732,000
-46	Sav & Wilm	22,083,000	27,371,000	30,969,000	35,038,000	39,642,000
-47	Sav & Wilm	27,603,000	34,214,000	38,710,000	43,797,000	49,553,000
-48	Wilmington	33,125,000	41,057,000	46,452,000	52,557,000	59,463,000

Table 6-14
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Cost Savings: With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Savannah	$0	$0	$0	$0	$0
-44	Sav & Wilm	$14,431,000	$17,889,000	$20,239,000	$22,899,000	$25,907,000
-45	Sav & Wilm	$23,882,000	$29,602,000	$33,493,000	$37,894,000	$42,872,000
-46	Sav & Wilm	$35,187,000	$43,615,000	$49,346,000	$55,831,000	$63,167,000
-47	Sav & Wilm	$47,950,000	$59,434,000	$67,244,000	$76,081,000	$86,078,000
-48	Wilmington	$61,113,000	$75,749,000	$85,703,000	$96,965,000	$109,707,000

Table 6-15 presents an annual average equivalent (AAEQ) summation of trucking costs at each depth increment using FY20 prices calculated over 50 years at the FY20 Federal discount rate of 2.75%. Average annual equivalent waterborne costs for the Port of Wilmington's hinterland containerized Asia cargo are calculated for each depth increment based on the amount of cargo using Wilmington and Savannah at each increment (Table 6-16). Waterborne transportation costs were calculated by the DDNPCX using the HarborSym model based data provided by the NCSPA. Note that waterborne transportation costs increase as more cargo shifts to Wilmington because there is a slight increase in the distance traveled by ships adding Wilmington to the port rotation as described in Section 2.9.1 Without-Project Condition Waterborne Transportation Costs. Figure 6-2 presents a summary of transportation costs at incremental project depths.

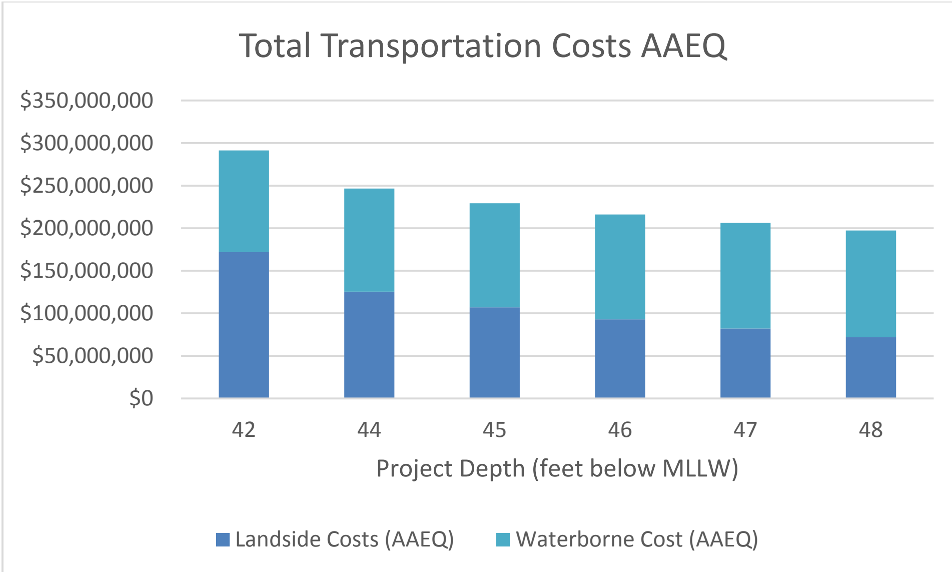

Figure 6-2
Total Transportation Costs at Incremental Project Depths

Table 6-15
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Cost AAEQ: With-Project Conditions

Depth	Wilmington	Savannah	Total
-42	$0	$172,030,000	$172,030,000
-44	$33,770,000	$91,580,000	$125,350,000
-45	$47,010,000	$60,050,000	$107,060,000
-46	$57,210,000	$35,730,000	$92,940,000
-47	$65,040,000	$17,090,000	$82,130,000
-48	$72,210,000	$0	$72,210,000

Table 6-16
Port of Wilmington's Hinterland Containerized Asia Cargo Waterborne Cost AAEQ: With-Project Conditions

Depth	Wilmington	Savannah	Total
-42	$0	$119,361,000	$119,361,000
-44	$41,680,000	$79,570,000	$121,250,000
-45	$62,530,000	$59,680,000	$122,210,000
-46	$83,370,000	$39,790,000	$123,160,000
-47	$104,210,000	$19,890,000	$124,100,000
-48	$125,050,000	$0	$125,050,000

6.5.2.1 Transportation Cost Savings at Incremental Project Depths

Table 6-17 summarizes Tables 6-15 and 6-16 to present the average annual equivalent total transportation costs and cost savings (project benefits) at each increment of project depth. Average annual equivalent project costs (developed in the Engineering Appendix) are presented in Table 6-18. Project costs are developed using FY20 prices. Incremental net benefits and benefit-to-cost ratios are presented in Table 6-19. Figure 6-3 presents a summary of project costs, benefits, and net benefits.

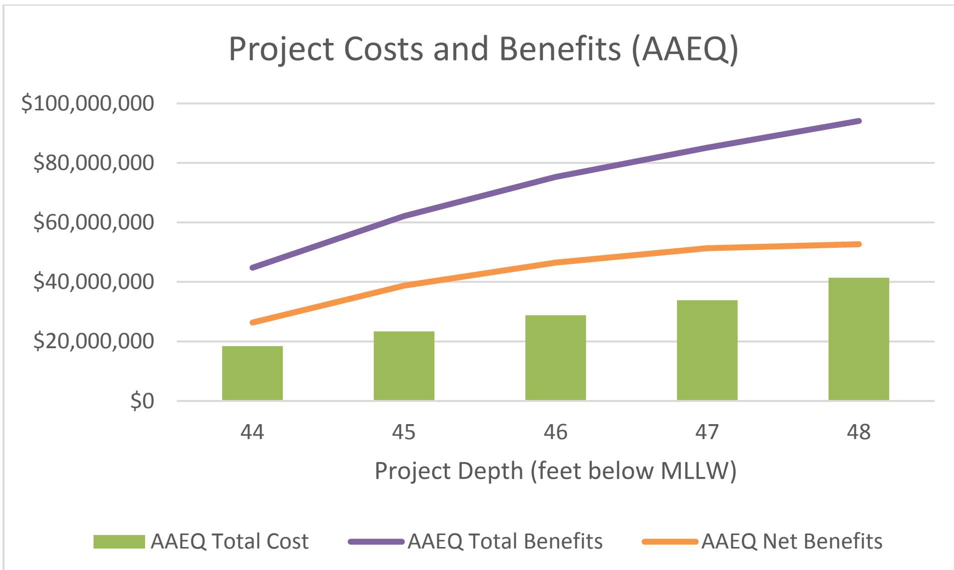

Figure 6-3
Project Costs, Benefits, and Net Benefits at Incremental Project Depths

Table 6-17
Port of Wilmington's Hinterland Containerized Asia Cargo Total Transportation Cost AAEQ: With-Project Conditions

Depth	Total	Savings (Benefits)	Incremental Savings
-42	$291,391,000		
-44	$246,600,000	$44,791,000	$44,791,000
-45	$229,270,000	$62,121,000	$17,330,000
-46	$216,100,000	$75,291,000	$13,170,000
-47	$206,230,000	$85,161,000	$9,870,000
-48	$197,260,000	$94,131,000	$8,970,000

Table 6-18 Project Costs

Depth	Project Cost	AAEQ Cost	Maintenance Increase	AAEQ Total Cost
-44	$485,161,000	$17,970,000	$464,000	$18,434,000
-45	$613,747,000	$22,730,000	$696,000	$23,426,000
-46	$753,514,000	$27,910,000	$928,000	$28,838,000
-47	$883,671,000	$32,730,000	$1,160,000	$33,890,000
-48	$1,083,043,000	$40,120,000	$1,392,000	$41,512,000

Table 6-19 Project Net Benefits

Depth	AAEQ Total Cost	AAEQ Total Benefits	AAEQ Net Benefits	Benefit/Cost Ratio
-44	$18,434,000	$44,791,000	$26,357,000	2.43
-45	$23,426,000	$62,121,000	$38,695,000	2.65
-46	$28,838,000	$75,291,000	$46,453,000	2.61
-47	$33,890,000	$85,161,000	$51,271,000	2.51
-48	$41,512,000	$94,131,000	$52,619,000	2.27

6.5.3 Regional Economic Development

The flow of containerized cargo through the Port of Wilmington affects multiple industries and local economies throughout North Carolina and the extended Port hinterland. The movement of containerized cargo through the Port generates revenues, jobs, employee compensation, state and local tax revenues, and value added to the region. An analysis of the economic impact of North Carolina Ports in 2018, including itemization of the impact of containerized trade through the Port of Wilmington, was preformed by the Institute for Transportation Research and Education at the North Carolina State University (ITRE, 2019).

The economic impact analysis used the IMPLAN input-output model to estimate direct effects, indirect effects, and induced effects of Port of Wilmington operations. International trade facilitated through the Port, port operations and related employment and employee compensation were identified as direct impacts in the analysis. Indirect effects include the economic activity of businesses that facilitate trade through the Port, including third party logistics providers, custom house brokers, freight forwarders, rail lines, truck lines, and tug operators. The induced effects are the economic activities of these businesses and employees based on the revenue and compensation derived from port operations.

Under without-project conditions, the Port of Wilmington would lose 48.3% of its containerized cargo to the Port of Savannah. A simplified estimate of the RED impact under without-project conditions would be to reduce the amount of regional economic activity by the proportionate reduction in containerized trade. Table 6-20 presents the estimated economic impact with-project conditions by comparing without-project to with-project economic impacts generated by containerized trade at the Port of Wilmington at 2018 price levels and volume of trade. Revenues, full-time jobs, and wages are presented as the total of direct, indirect, and induced effects. Overall, revenues, employment, and wages are projected to increase under with-project conditions.

Table 6-20: RED Project Impacts

Project Depth	Revenues	Full-time Jobs	Wages
-42	$4,426,060,000	28,600	$1,309,260,000
-44	$6,003,200,000	38,800	$1,775,790,000
-45	$7,580,340,000	49,000	$2,242,320,000
-46	$8,631,760,000	55,800	$2,553,330,000
-47	$9,069,850,000	58,600	$2,682,920,000
-48	$9,157,470,000	59,200	$2,708,840,000

6.5.4 Environmental Quality

The environmental quality account displays non-monetary effects on significant natural and cultural resources (USACE, 2000). Effects on natural and cultural resources are evaluated for each of the alternative plans in Table 6-21 Environmental Quality – Direct and Indirect Effects of the Alternative Plans. A detailed analysis of the environmental consequences of the TSP is presented in Section 7: Environmental Consequences. A summary of impacts to significant natural resources and a preliminary mitigation plan to address those impacts is presented in Section 8: Tentatively Selected Plan.

Following Table 6-21, truck haul greenhouse gas emissions are presented for Carbon Dioxide (Table 6-22), Methane (Table 6-23) and Nitrous Oxide (Table 6-24) for each alternative plan for selected years. Under with-project conditions, truck mileage decreases (Table 6-13 above) which results in decreased greenhouse gas emissions.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Geology, Soils, and Sediments	Continuing maintenance dredging operations would not affect geologic, soil, or sediment resources.	Channel deepening would not breach or thin the upper Pee Dee confining unit, and thus would not increase the potential for salinity intrusion in the Upper Pee Dee aquifer.	Channel deepening would not breach or thin the upper Pee Dee confining unit, and thus would not increase the potential for salinity intrusion in the Upper Pee Dee aquifer.	Channel deepening would not breach or thin the upper Pee Dee confining unit, and thus would not increase the potential for salinity intrusion in the Upper Pee Dee aquifer.	Channel deepening would not breach or thin the upper Pee Dee confining unit, and thus would not increase the potential for salinity intrusion in the Upper Pee Dee aquifer.	Channel deepening would not breach or thin the upper Pee Dee confining unit, and thus would not increase the potential for salinity intrusion in the Upper Pee Dee aquifer.
Groundwater	Modeling results indicate negligible RSLR effects on groundwater flow and discharge patterns, and no increase in potential for salinity intrusion via downward surface water migration.	Interpolated modeling results indicate no measurable effects on groundwater flow and discharge patterns, and no increase in potential for salinity intrusion via downward surface water migration.	Interpolated modeling results indicate no measurable effects on groundwater flow and discharge patterns, and no increase in potential for salinity intrusion via downward surface water migration.	Interpolated modeling results indicate no measurable effects on groundwater flow and discharge patterns, and no increase in potential for salinity intrusion via downward surface water migration.	Modeling results indicate no measurable effects on groundwater flow and discharge patterns, and no increase in potential for salinity intrusion via downward surface water migration.	Interpolated modeling results indicate no measurable effects on groundwater flow and discharge patterns, and no increase in potential for salinity intrusion via downward surface water migration.
Water Levels and Tides	Modeling results indicate a maximum MHW increase of 4.1 inches in the lower estuary at Battery Island due to RSLR. Projected increases are progressively smaller through the estuary above.	Interpolated modeling results indicate a maximum relative MHW increase of 0.3 inch in the Anchorage Basin. Projected increases are progressively smaller through the up-estuary and down-estuary reaches above and below.	Interpolated modeling results indicate a maximum relative MHW increase of 0.7 inch in the Anchorage Basin. Projected increases are progressively smaller through the up-estuary and down-estuary reaches above and below.	Interpolated modeling results indicate a maximum relative MHW increase of 1.0 inch in the Anchorage Basin. Projected increases are progressively smaller through the up-estuary and down-estuary reaches above and below.	Modeling results indicate a maximum relative MHW increase of 1.3 inches in the Anchorage Basin. Projected increases are progressively smaller through the up-estuary and down-estuary reaches above and below.	Interpolated modeling results indicate a maximum relative MHW increase of 1.6 inches in the Anchorage Basin. Projected increases are progressively smaller through the up-estuary and down-estuary reaches above and below.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Currents	Modeling results indicate negligible RSLR effects on current speeds. Maximum projected changes are +/- 0.2 ft/s.	Interpolated modeling results indicate that channel deepening would have minor relative effects on current speeds. Projected maximum relative increases and decreases are +0.2 ft/s and -0.1 ft/s.	Interpolated modeling results indicate that channel deepening would have minor relative effects on current speeds. Projected maximum relative increases and decreases are +0.3 ft/s and -0.2 ft/s.	Interpolated modeling results indicate that channel deepening would have minor relative effects on current speeds. Projected maximum relative increases and decreases are +0.5 ft/s and -0.3 ft/s.	Modeling results indicate that channel deepening would have minor relative effects on current speeds. Projected maximum relative increases and decreases are +0.6 ft/s and -0.4 ft/s.	Interpolated modeling results indicate that channel deepening would have minor relative effects on current speeds. Projected maximum relative increases and decreases are +0.8 ft/s and -0.5 ft/s.
Wind and Wave Climate	Modeling results indicate that RSLR would have negligible effects on the nearshore wave climate and significant wave heights.	Interpolated modeling results indicate that channel deepening would have negligible effects on the nearshore wave climate.	Interpolated modeling results indicate that channel deepening would have negligible effects on the nearshore wave climate.	Interpolated modeling results indicate that channel deepening would have negligible effects on the nearshore wave climate.	Modeling results indicate that deepening would have negligible effects on the nearshore wave climate. Projected relative increases in significant wave heights are <0.1 ft.	Interpolated modeling results indicate that channel deepening would have negligible effects on the nearshore wave climate.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Beach Erosion	RSLR would generally cause background erosion rates to increase.	Interpolated modeling results for indicate negligible increases in erosion rates of <0.2 ft/yr along Bald Head Island, Caswell Beach, and Oak Island.	Interpolated modeling results for indicate minor to negligible increases in erosion rates of ≤0.3 ft/yr along Bald Head Island Caswell Beach, and Oak Island.	Interpolated modeling results for indicate minor to negligible increases in erosion rates of <0.5 ft/yr along Bald Head Island Caswell Beach, and Oak Island.	Modeling results for Bald Head Island indicate minor relative increases in erosion rates of ≤0.6 ft/yr along central South Beach and minor relative decreases in erosion rates along western South Beach. Negligible relative increases in erosion rates of ≤0.2 ft/yr are projected along Caswell Beach and Oak Island.	Interpolated modeling results for indicate minor relative increases in erosion rates ≤0.8 ft/yr along Bald Head Island, and negligible increases along Caswell Beach and Oak Island.
Estuarine Shoreline Erosion	Potential increase in estuarine shoreline erosion rates due to RSLR.	Ship wake modeling results indicate potential increases in shoreline erosion to the north of Southport, along the northern portion of Battery Island, and in the vicinity of Orton Point.	Ship wake modeling results indicate potential increases in shoreline erosion to the north of Southport, along the northern portion of Battery Island, and in the vicinity of Orton Point.	Ship wake modeling results indicate potential increases in shoreline erosion to the north of Southport, along the northern portion of Battery Island, and in the vicinity of Orton Point.	Ship wake modeling results indicate potential increases in shoreline erosion to the north of Southport, along the northern portion of Battery Island, and in the vicinity of Orton Point.	Ship wake modeling results indicate potential increases in shoreline erosion to the north of Southport, along the northern portion of Battery Island, and in the vicinity of Orton Point.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Salinity	Modeling results indicate that RSLR will cause maximum bottom and surface layer salinity increases of 0.7 and 0.5 ppt, respectively.	Interpolated modeling results indicate maximum bottom and surface layer relative salinity increases of 1.0 and 0.3 ppt, respectively.	Interpolated modeling results indicate maximum bottom and surface layer relative salinity increases of 2.1 and 0.6 ppt, respectively.	Interpolated modeling results indicate maximum bottom and surface layer relative salinity increases of 3.1 and 0.9 ppt, respectively.	Modeling results indicate that channel deepening would cause maximum bottom and surface layer salinity increases of 4.1 and 1.2 ppt, respectively.	Interpolated modeling results indicate maximum bottom and surface layer relative salinity increases of 5.1 and 1.5 ppt, respectively.
Dissolved Oxygen (DO)	Modeling results indicate that RSLR would cause negligible decreases in DO concentrations of ≤0.3 mg/L at all depths. The increases are projected to occur during the winter when DO concentrations are at annual peak levels.	Interpolated modeling results indicate that channel deepening would cause negligible decreases in DO concentrations of ≤0.3 mg/L at all depths. The decreases are projected to occur during the winter when concentrations are at annual peak levels.	Interpolated modeling results indicate that channel deepening would cause negligible decreases in DO concentrations of ≤0.3 mg/L at all depths. The decreases are projected to occur during the winter when concentrations are at annual peak levels.	Interpolated modeling results indicate that channel deepening would cause negligible decreases in DO concentrations of ≤0.3 mg/L at all depths. The decreases are projected to occur during the winter when concentrations are at annual peak levels.	Modeling results indicate that channel deepening would cause negligible decreases in DO concentrations of ≤0.3 mg/L at all depths. The decreases are projected to occur during the winter when concentrations are at annual peak levels.	Interpolated modeling results indicate that channel deepening would cause negligible decreases in DO concentrations at all depths. The decreases are projected to occur during the winter when concentrations are at annual peak levels.
Turbidity	Temporary and localized increases in turbidity during maintenance dredging and disposal operations.	Relative increase in turbidity during channel construction. Temporary and localized increases in turbidity during maintenance dredging and disposal operations.	Relative increase in turbidity during channel construction. Temporary and localized increases in turbidity during maintenance dredging and disposal operations.	Relative increase in turbidity during channel construction. Temporary and localized increases in turbidity during maintenance dredging and disposal operations.	Relative increase in turbidity during channel construction. Temporary and localized increases in turbidity during maintenance dredging and disposal operations.	Relative increase in turbidity during channel construction. Temporary and localized increases in turbidity during maintenance dredging and disposal operations.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Wetlands	Model-projected upstream shifts in the 0.5 ppt salinity isopleth would affect ~278 acres of tidal freshwater wetlands. Projected surface salinity increases of ≤0.2 ppt in the isopleth shift zones would have negligible to minor effects on the composition of freshwater tidal wetlands.	Interpolated upstream shifts in the 0.5 ppt salinity isopleth would affect ~63 acres of tidal freshwater wetlands, including ~46 acres of tidal swamp forest and ~17 acres of tidal freshwater marsh. Projected surface salinity increases of ≤0.3 ppt in the isopleth shift zones would have negligible to minor effects on the composition of freshwater tidal wetlands.	Interpolated upstream shifts in the 0.5 ppt salinity isopleth would affect ~127 acres of tidal freshwater wetlands, including ~91 acres of tidal swamp forest and ~36 acres of tidal freshwater marsh. Projected surface salinity increases of ≤0.3 ppt in the isopleth shift zones would have negligible to minor effects on the composition of freshwater tidal wetlands.	Interpolated upstream shifts in the 0.5 ppt salinity isopleth would affect ~205 acres of tidal freshwater wetlands, including ~154 acres of tidal swamp forest and ~51 acres of tidal freshwater marsh. Projected surface salinity increases of ≤0.3 ppt in the isopleth shift zones would have negligible to minor effects on the composition of freshwater tidal wetlands.	Model-projected upstream shifts in the 0.5 ppt salinity isopleth would affect ~341 acres of tidal freshwater wetlands, including ~242 acres of tidal swamp forest and ~99 acres of tidal freshwater marsh. Projected surface salinity increases of ≤0.3 ppt in the isopleth shift zones would have negligible to minor effects on the composition of freshwater tidal wetlands.	Interpolated upstream shifts in the 0.5 ppt salinity isopleth would affect ~427 acres of tidal freshwater wetlands, including ~313 acres of tidal swamp forest and ~114 acres of tidal freshwater marsh. Projected surface salinity increases of ≤0.3 ppt in the isopleth shift zones would have negligible to minor effects on the composition of freshwater tidal wetlands.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	-44 ft	-45 ft	-46 ft	-47 ft	-48 ft
Softbottom	Maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed estuarine and marine soft bottom habitat every one to four years.	In relation to the No Action alternative, construction and maintenance of the -44 ft channel would impact an additional 866 acres of previously undisturbed soft bottom habitat in channel widening and extension areas. Benthic infaunal communities in the new dredging areas would experience recurring cycles of depletion and recovery every one to four years for the duration of the 50-year project. Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal marine soft bottom habitat every two years. A minor relative increase in the extent of impacts would occur during the initial construction beach disposal event.	Under the -45 ft alternative, new dredging impacts would increase slightly in relation to the -44 ft alternative. Construction and maintenance of the -45 ft channel would impact 886 acres of previously undisturbed soft bottom habitat in channel widening and extension areas. Benthic infaunal communities in the new dredging areas would experience recurring cycles of depletion and recovery every one to four years for the duration of the 50-year project. Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal marine soft bottom habitat every two years. A minor relative increase in the extent of impacts would occur during the initial construction beach disposal event.	Under the -46 ft alternative, new dredging impacts would increase slightly in relation to the -45 ft alternative. Construction and maintenance of the -46 ft channel would impact 905 acres of previously undisturbed soft bottom habitat in channel widening and extension areas. Benthic infaunal communities in the new dredging areas would experience recurring cycles of depletion and recovery every one to four years for the duration of the 50-year project. Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal marine soft bottom habitat every two years. A minor relative increase in the extent of impacts would occur during the initial construction beach disposal event.	Under the -47 ft alternative, new dredging impacts would increase slightly in relation to the -46 ft alternative. Construction and maintenance of the -47 ft channel would impact 925 acres of previously undisturbed soft bottom habitat in channel widening and extension areas. Benthic infaunal communities in the new dredging areas would experience recurring cycles of depletion and recovery every one to four years for the duration of the 50-year project. Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal marine soft bottom habitat every two years. A minor relative increase in the extent of impacts would occur during the initial construction beach disposal event.	Under the -48 ft alternative, new dredging impacts would increase slightly in relation to the -47 ft alternative. Construction and maintenance of the -48 ft channel would impact 945 acres of previously undisturbed soft bottom habitat in channel widening and extension areas. Benthic infaunal communities in the new dredging areas would experience recurring cycles of depletion and recovery every one to four years for the duration of the 50-year project. Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal marine soft bottom habitat every two years. A minor relative increase in the extent of impacts would occur during the initial construction beach disposal event.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	-44 ft	-45 ft	-46 ft	-47 ft	-48 ft
Hardbottom	Continuing maintenance of the currently authorized channel would not affect hardbottom communities.	Widening of the Baldhead Shoal entrance channel would have minor direct impacts on naturalized hardbottom rubble mounds in the old ODMDS.	Widening of the Baldhead Shoal entrance channel would have minor direct impacts on naturalized hardbottom rubble mounds in the old ODMDS.	Widening of the Baldhead Shoal entrance channel would have minor direct impacts on naturalized hardbottom rubble mounds in the old ODMDS.	Widening of the Baldhead Shoal entrance channel would have minor direct impacts on naturalized hardbottom rubble mounds in the old ODMDS.	Widening of the Baldhead Shoal entrance channel would have minor direct impacts on naturalized hardbottom rubble mounds in the old ODMDS.
Submerged Aquatic Vegetation (SAV)	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.
Shell Bottom	No direct mechanical impacts on shell bottom. Short term and localized effects from sediment suspension and redeposition during maintenance dredging operations.	No direct mechanical impacts on shell bottom. Short-term localized effects from sediment suspension and redeposition during channel construction and maintenance dredging operations.	No direct mechanical impacts on shell bottom. Short-term localized effects from sediment suspension and redeposition during channel construction and maintenance dredging operations.	No direct mechanical impacts on shell bottom. Short-term localized effects from sediment suspension and redeposition during channel construction and maintenance dredging operations.	No direct mechanical impacts on shell bottom. Short-term localized effects from sediment suspension and redeposition during channel construction and maintenance dredging operations.	No direct mechanical impacts on shell bottom. Short-term localized effects from sediment suspension and redeposition during channel construction and maintenance dredging operations.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	-44 ft	-45 ft	-46 ft	-47 ft	-48 ft
Fisheries	Maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed estuarine and marine soft bottom foraging habitat every one to four years.	Channel construction and maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed soft bottom foraging habitat and 866 acres of previously undisturbed soft bottom foraging habitat every one to four years.	Channel construction and maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed soft bottom foraging habitat and 886 acres of previously undisturbed soft bottom foraging habitat every one to four years.	Channel construction and maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed soft bottom foraging habitat and 905 acres of previously undisturbed soft bottom foraging habitat every one to four years.	Channel construction and maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed soft bottom foraging habitat and 925 acres of previously undisturbed soft bottom foraging habitat every one to four years.	Channel construction and maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed soft bottom foraging habitat and 945 acres of previously undisturbed soft bottom foraging habitat every one to four years.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	-44 ft	-45 ft	-46 ft	-47 ft	-48 ft
Essential Fish Habitat	Maintenance dredging would have recurring direct impacts on 2,226 acres of previously disturbed estuarine and marine soft bottom EFH every one to four years. Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal marine soft bottom EFH every two years. Temporary sediment suspension effects on estuarine and marine water column EFH during maintenance dredging and beach disposal operations.	Direct impacts on 3.0 acres of shallow (<6) PNA habitat and 26.6 acres of deep (>6 ft) PNA habitat. Maintenance dredging would have recurring temporary direct impacts on 2,226 acres of previously disturbed soft bottom EFH and 866 acres of previously undisturbed soft bottom EFH every one to four years. Temporary sediment suspension effects on estuarine and marine water column EFH during maintenance dredging and beach disposal operations. Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal marine soft bottom EFH every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event.	Direct impacts on 3.1 acres of shallow (<6) PNA habitat and 27.3 acres of deep (>6 ft) PNA habitat. Maintenance dredging would have recurring temporary direct impacts on 2,226 acres of previously disturbed soft bottom EFH and 886 acres of previously undisturbed soft bottom EFH every one to four years. Temporary sediment suspension effects on estuarine and marine water column EFH during maintenance dredging and beach disposal operations. Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal marine soft bottom EFH every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event.	Direct impacts on 3.3 acres of shallow (<6) PNA habitat and 28.0 acres of deep (>6 ft) PNA habitat. Maintenance dredging would have recurring temporary direct impacts on 2,226 acres of previously disturbed soft bottom EFH and 905 acres of previously undisturbed soft bottom EFH every one to four years. Temporary sediment suspension effects on estuarine and marine water column EFH during maintenance dredging and beach disposal operations. Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal marine soft bottom EFH every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event.	Direct impacts on 3.5 acres of shallow (<6) PNA habitat and 28.8 acres of deep (>6 ft) PNA habitat. Maintenance dredging would have recurring temporary direct impacts on 2,226 acres of previously disturbed soft bottom EFH and 925 acres of previously undisturbed soft bottom EFH every one to four years. Temporary sediment suspension effects on estuarine and marine water column EFH during maintenance dredging and beach disposal operations. Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal marine soft bottom EFH every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event.	Direct impacts on 3.7 acres of shallow (<6) PNA habitat and 29.7 acres of deep (>6 ft) PNA habitat. Maintenance dredging would have recurring temporary direct impacts on 2,226 acres of previously disturbed soft bottom EFH and 945 acres of previously undisturbed soft bottom EFH every one to four years. Temporary sediment suspension effects on estuarine and marine water column EFH during maintenance dredging and beach disposal operations. Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal marine soft bottom EFH every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Coastal Waterbirds	Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Potential indirect impacts on Battery Island waterbird nesting habitat due to RSLR and continuing shoreline erosion.	Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event. Potential indirect impacts on Battery Island waterbird nesting habitat due to ship wakes and increased shoreline erosion. Beneficial use options to enhance waterbird nesting habitat on bird nesting islands in the lower estuary are being evaluated.	Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event. Potential indirect impacts on Battery Island waterbird nesting habitat due to ship wakes and increased shoreline erosion. Beneficial use options to enhance waterbird nesting habitat on bird nesting islands in the lower estuary are being evaluated.	Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event. Potential indirect impacts on Battery Island waterbird nesting habitat due to ship wakes and increased shoreline erosion. Beneficial use options to enhance waterbird nesting habitat on bird nesting islands in the lower estuary are being evaluated.	Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event. Potential indirect impacts on Battery Island waterbird nesting habitat due to ship wakes and increased shoreline erosion. Beneficial use options to enhance waterbird nesting habitat on bird nesting islands in the lower estuary are being evaluated.	Beach disposal would have recurring direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of impacts during the initial construction beach disposal event. Potential indirect impacts on Battery Island waterbird nesting habitat due to ship wakes and increased shoreline erosion. Beneficial use options to enhance waterbird nesting habitat on bird nesting islands in the lower estuary are being evaluated.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
North Atlantic Right Whale	Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through adherence to Seasonal Management Area speed restrictions. No adverse effect on critical habitat.	Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through adherence to Seasonal Management Area speed restrictions. No adverse effect on critical habitat.	Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through adherence to Seasonal Management Area speed restrictions. No adverse effect on critical habitat.	Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through adherence to Seasonal Management Area speed restrictions. No adverse effect on critical habitat.	Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through adherence to Seasonal Management Area speed restrictions. No adverse effect on critical habitat.	Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through adherence to Seasonal Management Area speed restrictions. No adverse effect on critical habitat.
Florida Manatee	Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through implementation of USFWS guidelines for avoiding impacts to manatees in NC waters.	Risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through implementation of USFWS guidelines for avoiding impacts to manatees in NC waters.	Risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through implementation of USFWS guidelines for avoiding impacts to manatees in NC waters.	Risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through implementation of USFWS guidelines for avoiding impacts to manatees in NC waters.	Risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through implementation of USFWS guidelines for avoiding impacts to manatees in NC waters.	Risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Low risk of vessel collisions during dredged material transport to ODMDS. Risk would be minimized through implementation of USFWS guidelines for avoiding impacts to manatees in NC waters.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Sea Turtles	Beach disposal would have recurring temporary impacts on 3 to 5 miles of dry beach nesting habitat every two years. Risk of entrainment by hopper dredges during channel maintenance operations. Risk would be minimized through adherence to established hopper dredge environmental work window.	Beach disposal would have recurring temporary impacts on 3 to 5 miles of dry beach nesting habitat every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event. Low risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel. Risk would be minimized through adherence to established hopper dredge environmental work window.	Beach disposal would have recurring temporary impacts on 3 to 5 miles of dry beach nesting habitat every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event. Low risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel. Risk would be minimized through adherence to established hopper dredge environmental work window.	Beach disposal would have recurring temporary impacts on 3 to 5 miles of dry beach nesting habitat every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event. Low risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel. Risk would be minimized through adherence to established hopper dredge environmental work window.	Beach disposal would have recurring temporary impacts on 3 to 5 miles of dry beach nesting habitat every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event. Low risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel. Risk would be minimized through adherence to established hopper dredge environmental work window.	Beach disposal would have recurring temporary impacts on 3 to 5 miles of dry beach nesting habitat every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event. Low risk of injury and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel. Risk would be minimized through adherence to established hopper dredge environmental work window.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Piping Plover and Red Knot	Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years.	Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event.	Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event.	Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event.	Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event.	Beach disposal would have recurring temporary direct impacts on 3 to 5 miles of intertidal beach foraging habitat and associated benthic infaunal prey resources every two years. Minor relative increase in extent of habitat impact during the initial construction beach disposal event.
Wood Stork	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Atlantic and Shortnose Sturgeon	Risk of entrainment by hopper dredges during channel maintenance operations.	Risk of injurious and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel.	Risk of injurious and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel.	Risk of injurious and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel.	Risk of injurious and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel.	Risk of injurious and/or behavioral effects from confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Risk of entrainment by hopper dredges during construction and maintenance of outer entrance channel.
Seabeach Amaranth	Recurring beach disposal every two years would have the potential for adverse effects on seabeach amaranth through seed redistribution and burial.	Recurring beach disposal every two years would have the potential for adverse effects on seabeach amaranth through seed redistribution and burial.	Recurring beach disposal every two years would have the potential for adverse effects on seabeach amaranth through seed redistribution and burial.	Recurring beach disposal every two years would have the potential for adverse effects on seabeach amaranth through seed redistribution and burial.	Recurring beach disposal every two years would have the potential for adverse effects on seabeach amaranth through seed redistribution and burial.	Recurring beach disposal every two years would have the potential for adverse effects on seabeach amaranth through seed redistribution and burial.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
MMPA Marine Mammals	Negligible risk of humpback whale vessel collisions during dredged material transport to ODMDS.	Risk of injurious and/or behavioral effects on bottlenose dolphins from confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Negligible risk of humpback whale vessel collisions during offshore dredged material transport to ODMDS.	Risk of injurious and/or behavioral effects on bottlenose dolphins during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Negligible risk of humpback whale vessel collisions during offshore dredged material transport to ODMDS.	Risk of injurious and/or behavioral effects on bottlenose dolphins during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Negligible risk of humpback whale vessel collisions during offshore dredged material transport to ODMDS.	Risk of injurious and/or behavioral effects on bottlenose dolphins during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Negligible risk of humpback whale vessel collisions during offshore dredged material transport to ODMDS.	Risk of injurious and/or behavioral effects on bottlenose dolphins during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program. Negligible risk of humpback whale vessel collisions during offshore dredged material transport to ODMDS.
Invasive Species	Continuing potential for new invasive species introductions via ship ballast water.	No increase in potential for new invasive species introductions.	No increase in potential for new invasive species introductions.	No increase in potential for new invasive species introductions.	No increase in potential for new invasive species introductions.	No increase in potential for new invasive species introductions.
Managed and Protected Areas	Potential indirect impacts on historic properties in the vicinity of Orton Point due to RSLR and continuing shoreline erosion.	Potential effects on historic properties in the vicinity of Orton Point and the Audubon Battery Island Bird Sanctuary due to increased ship wake erosion.	Potential effects on historic properties in the vicinity of Orton Point and the Audubon Battery Island Bird Sanctuary due to increased ship wake erosion.	Potential effects on historic properties in the vicinity of Orton Point and the Audubon Battery Island Bird Sanctuary due to increased ship wake erosion.	Potential effects on historic properties in the vicinity of Orton Point and the Audubon Battery Island Bird Sanctuary due to increased ship wake erosion.	Potential effects on historic properties in the vicinity of Orton Point and the Audubon Battery Sanctuary due to RSLR and increased ship wake erosion.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Air Quality	Vessel calls would decrease as the shipping alliances continue to transition to larger cargo vessels. Port-related air emissions would remain the same or decrease under the No Action alternative.	Temporary relative increase in dredging operations and associated exhaust emissions during channel construction. Larger container ships would consist of newer vessels that emit less air pollutants per unit weight of cargo when fully loaded. Vessel calls and associated emissions would increase over the 50-year project, but would not be expected to significantly affect air quality.	Temporary relative increase in dredging operations and associated exhaust emissions during channel construction. Larger container ships would consist of newer vessels that emit less air pollutants per unit weight of cargo when fully loaded. Vessel calls and associated emissions would increase over the 50-year project, but would not be expected to significantly affect air quality.	Temporary relative increase in dredging operations and associated exhaust emissions during channel construction. Larger container ships would consist of newer vessels that emit less air pollutants per unit weight of cargo when fully loaded. Vessel calls and associated emissions would increase over the 50-year project, but would not be expected to significantly affect air quality.	Temporary relative increase in dredging operations and associated exhaust emissions during channel construction. Larger container ships would consist of newer vessels that emit less air pollutants per unit weight of cargo when fully loaded. Vessel calls and associated emissions would increase over the 50-year project, but would not be expected to significantly affect air quality.	Temporary relative increase in dredging operations and associated exhaust emissions during channel construction. Larger container ships would consist of newer vessels that emit less air pollutants per unit weight of cargo when fully loaded. Vessel calls and associated emissions would increase over the 50-year project, but would not be expected to significantly affect air quality.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Noise	Underwater noise conditions would remain approximately the same under the No Action alternative. Vessel calls would decrease as the shipping alliances continue to transition to larger cargo vessels. Thus, ship transit noise events would occur less frequently.	Temporary relative increase in dredging operations and associated underwater noise emissions during channel construction. Risk of injurious and/or behavioral effects on marine mammals, sea turtles, and fisheries during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program.	Temporary relative increase in dredging operations and associated underwater noise emissions during channel construction. Risk of injurious and/or behavioral effects on marine mammals, sea turtles, and fisheries during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program.	Temporary relative increase in dredging operations and associated underwater noise emissions during channel construction. Risk of injurious and/or behavioral effects on marine mammals, sea turtles, and fisheries during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program.	Temporary relative increase in dredging operations and associated underwater noise emissions during channel construction. Risk of injurious and/or behavioral effects on marine mammals, sea turtles, and fisheries during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program.	Temporary relative increase in dredging operations and associated underwater noise emissions during channel construction. Risk of injurious and/or behavioral effects on marine mammals, sea turtles, and fisheries during confined blasting operations. Risk would be minimized through implementation of a blast mitigation protection program.
HTRW	Continuing maintenance dredging would not be expected to encounter any HTRW.	Channel deepening would not be expected to encounter any HTRW.	Channel deepening would not be expected to encounter any HTRW.	Channel deepening would not be expected to encounter any HTRW.	Channel deepening would not be expected to encounter any HTRW.	Channel deepening would not be expected to encounter any HTRW.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Aesthetics and Recreation	Beach disposal operations would have temporary impacts on aesthetics and beach recreational opportunities.	Beach disposal operations would have temporary impacts on aesthetics and beach recreational opportunities. Restrictions on vessel traffic in the immediate vicinity of confined blasting operations would have short term impacts on water recreational activities. Blasting would not restrict recreational vessel passage through the Cape Fear River estuary.	Beach disposal operations would have temporary impacts on aesthetics and beach recreational opportunities. Restrictions on vessel traffic in the immediate vicinity of confined blasting operations would have short term impacts on water recreational activities. Blasting would not restrict recreational vessel passage through the Cape Fear River estuary.	Beach disposal operations would have temporary impacts on aesthetics and beach recreational opportunities. Restrictions on vessel traffic in the immediate vicinity of confined blasting operations would have short term impacts on water recreational activities. Blasting would not restrict recreational vessel passage through the Cape Fear River estuary.	Beach disposal operations would have temporary impacts on aesthetics and beach recreational opportunities. Restrictions on vessel traffic in the immediate vicinity of confined blasting operations would have short term impacts on water recreational activities. Blasting would not restrict recreational vessel passage through the Cape Fear River estuary.	Beach disposal operations would have temporary impacts on aesthetics and beach recreational opportunities. Restrictions on vessel traffic in the immediate vicinity of confined blasting operations would have short term impacts on water recreational activities. Blasting would not restrict recreational vessel passage through the Cape Fear River estuary.

Table 6-21: Environmental Quality – Direct and Indirect Effects of the Alternative Plans

Resource	Alternatives					
	No Action	**-44 ft**	**-45 ft**	**-46 ft**	**-47 ft**	**-48 ft**
Cultural Resources	Continuing maintenance dredging would not be expected to affect underwater archaeological resources. Potential indirect impacts on historic properties in the vicinity of Orton Point due to RSLR and continuing shoreline erosion.	The paddlewheel spindle from the CSS *Kate* is located on the existing west channel slope in the lower river. Potential impacts would be mitigated through implementation of a relocation or recovery plan in coordination with the SHPO. Potential effects on historic properties in the vicinity of Orton Point due to RSLR and increased ship wake erosion.	The paddlewheel spindle from the CSS *Kate* is located on the existing west channel slope in the lower river. Potential impacts would be mitigated through implementation of a relocation or recovery plan in coordination with the SHPO. Potential effects on historic properties in the vicinity of Orton Point due to RSLR and increased ship wake erosion.	The paddlewheel spindle from the CSS *Kate* is located on the existing west channel slope in the lower river. Potential impacts would be mitigated through implementation of a relocation or recovery plan in coordination with the SHPO. Potential effects on historic properties in the vicinity of Orton Point due to RSLR and increased ship wake erosion.	The paddlewheel spindle from the CSS *Kate* is located on the existing west channel slope in the lower river. Potential impacts would be mitigated through implementation of a relocation or recovery plan in coordination with the SHPO. Potential effects on historic properties in the vicinity of Orton Point due to RSLR and increased ship wake erosion.	The paddlewheel spindle from the CSS *Kate* is located on the existing west channel slope in the lower river. Potential impacts would be mitigated through implementation of a relocation or recovery plan in coordination with the SHPO. Potential effects on historic properties in the vicinity of Orton Point due to RSLR and increased ship wake erosion.
Socioeconomics	No disproportionate adverse effects on minority or low income populations.	No disproportionate adverse effects on minority or low income populations.	No disproportionate adverse effects on minority or low income populations.	No disproportionate adverse effects on minority or low income populations.	No disproportionate adverse effects on minority or low income populations.	No disproportionate adverse effects on minority or low income populations.

Table 6-22: Truck Emission Metric Tons of Carbon Dioxide per Year

Project Depth	Truck Emissions			
	2030	2035	2040	2045
-42	97,479	110,288	124,782	141,179
-44	75,981	85,967	97,264	110,045
-45	65,232	73,804	83,505	94,477
-46	54,485	61,643	69,745	78,911
-47	43,736	49,484	55,987	63,343
-48	32,988	37,323	42,227	47,777
Project Depth	**Truck Emissions Reductions**			
	2030	**2035**	**2040**	**2045**
-42	-	-	-	-
-44	21,498	24,322	27,518	31,134
-45	32,246	36,484	41,277	46,702
-46	42,994	48,645	55,037	62,268
-47	53,742	60,804	68,795	77,836
-48	64,491	72,965	82,555	93,403

Table 6-23: Truck Emission Metric Tons of Methane per Year

Project Depth	Truck Emissions			
	2030	2035	2040	2045
-42	0.32	0.36	0.41	0.46
-44	0.25	0.28	0.32	0.36
-45	0.21	0.24	0.27	0.31
-46	0.18	0.20	0.23	0.26
-47	0.14	0.16	0.18	0.21
-48	0.11	0.12	0.14	0.16
Project Depth	**Truck Emissions Reductions**			
	2030	**2035**	**2040**	**2045**
-42	-	-	-	-
-44	0.07	0.08	0.09	0.10
-45	0.10	0.12	0.13	0.15
-46	0.14	0.16	0.18	0.20
-47	0.17	0.20	0.22	0.25
-48	0.21	0.24	0.27	0.30

Table 6-24: Truck Emission Metric Tons of Nitrous Oxide per Year

Project Depth	Truck Emissions			
	2030	2035	2040	2045
-42	0.30	0.34	0.38	0.43
-44	0.23	0.26	0.30	0.34
-45	0.20	0.23	0.26	0.29
-46	0.17	0.19	0.21	0.24
-47	0.13	0.15	0.17	0.19
-48	0.10	0.11	0.13	0.15
Project Depth	**Truck Emissions Reductions**			
	2030	**2035**	**2040**	**2045**
-42	-	-	-	-
-44	0.07	0.07	0.08	0.10
-45	0.10	0.11	0.13	0.14
-46	0.13	0.15	0.17	0.19
-47	0.16	0.19	0.21	0.24
-48	0.20	0.22	0.25	0.29

6.5.5 Other Social Effects

The Other Social Effects account displays plan effects from perspectives that are relevant to the planning process but are not reflected in the other three accounts (USACE, 2000). With-project condition effects to the Other Social Effects account are projected to be minor and will be assessed during the development of the EIS with the benefit of additional public involvement

6.6 Plan Selection

The Planning Guidance Notebook (PGN) states that:

- for all project purposes, except ecosystem restoration, the NED Plan shall be the recommended plan, and
- the NED Plan is defined as "the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment" (USACE, 2000 page 2-7).

Although the largest net benefits accrue to the -48-foot plan (Table 6-25), it requires $199.4 million more in construction costs than the -47-foot plan (Table 6-18) to generate $1.3 million more in average annual equivalent net benefits. The -47-foot plan by comparison, requires $130.2 million more in construction costs than the -46-foot plan to generate $4.8 million more in average annual equivalent benefits. The relatively small and costly incremental increase in net benefits provided by -48-foot plan indicates that the next smallest plan, the -47-foot plan, is the plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment. The TSP is the -47-foot plan, the NED Plan.

Table 6-25
Project Net Benefits

Depth	AAEQ Total Cost	AAEQ Total Benefits	AAEQ Net Benefits	Benefit/Cost Ratio
-44	$18,434,000	$44,791,000	$26,357,000	2.43
-45	$23,426,000	$62,121,000	$38,695,000	2.65
-46	$28,838,000	$75,291,000	$46,453,000	2.61
-47	$33,890,000	$85,161,000	$51,271,000	2.51
-48	$41,512,000	$94,131,000	$52,619,000	2.27

7 EFFECTS OF TENTATIVELY SELECTED PLAN ON EXISTING NAVIGATION INFRASTRUCTURE

Analyses performed for this report include evaluations of alternative plan effects on:

- federal and non-federal infrastructure;
- performance of the federal navigation project; and
- operation and maintenance of the federal navigation project

Investigations into the effects of plan alternatives on operation and maintenance of the federal navigation project include investigations into:

- Maintenance quantities; and
- dredged material management.

Investigations into the effects of plan alternatives on performance of the federal navigation project include investigations into effects on:

- Navigation during construction;
- Aids to navigation;
- Dredged material disposal capacity; and
- Routine maintenance capability.

7.1 Effects on Federal and non-Federal Infrastructure

Investigations into the effects of plan alternatives on federal and non-federal infrastructure include investigations into effects on:

- New Wilmington ODMDS; and
- Eagle Island Confined Disposal Facility.

7.1.1 New Wilmington ODMDS

The Site Management and Monitoring Plan for the New Wilmington ODMDS originally finalized in July 2002 and the SMMP update was approved in January 2013. The 2013 updated SMMP remains in effect. Dredged material from the ocean bar channel of the Wilmington Harbor Federal navigation project and from the access channel and berths at the Military Ocean terminal at Sunny Point (MOTSU) are placed at the New Wilmington ODMDS on a mostly annual basis. The updated SMMP indicates that 2 to 3 million cubic yards of dredged material is anticipated to be placed at the ODMDS annually (USACE and USEPA, 2013).

The New Wilmington ODMDS has an area of approximately 9.4 square nautical miles. Existing depths range from -35 feet MLLW to -52 feet MLLW. The disposal depth limitation is -30 feet MLLW (USACE and USEPA, 2013). Based on bathymetry taken in 2017, the existing static dredged material disposal capacity at the New Wilmington ODMDS is 386 million cubic yards.

Table 7-1 shows the total amount of construction material to be dredged is 26.8 million cubic yards, which would be placed during three years of construction. Placement of construction material into the New Wilmington ODMDS will not reduce the disposal area's capacity during the 50-year life of the project. Placement of additional maintenance material at the ODMDS is projected to increase by less than 57,000 cubic yards per year due to increased shoaling in the entrance channel reaches; however, this material it is very likely that this material would be suitable for beach placement as a beneficial use alternative. With project construction material and all future maintenance material (estimated at the largest historical annual volume) placed at the ODMDS for 50 years, the New Wilmington ODMDS will have 40% of its capacity (156 million cubic yards) available at the end of 50 years.

Table 7-1
New Wilmington ODMDS Capacity (cy)

Dredging	Volume	50-Year Total
Construction	26,800,000	26,800,000
Anchorage Annual Increase (HRSLR)[1]	121,500	6,080,000
Entrance Annual Increase[2]	57,000	2,840,000
Total Project		35,720,000
Maximum Annual Historical Placement	3,887,000	194,350,000
Maximum 50-year Placement		230,070,000
ODMDS Capacity		386,000,000
Remaining Capacity after 50 Years		155,930,000

[1]This material alternatively may be placed at Eagle Island
[2]This material alternatively may be used beneficially as beach placement material

7.1.2 Eagle Island Confined Disposal Facility

The Eagle Island Confined Disposal Facility is situated on a 1,473-acre tract of land that forms a peninsula between the Cape Fear and Brunswick Rivers. Eagle Island CDF is operated in a three-cell configuration. Cell 1 consists of 230 acres, Cells 2 is approximately 260 acres, and Cell 3 is approximately 265 acres, for a total of 755 acres of diked uplands. Maximum dike height is currently 40 feet above mean sea level for Cell 1 and 42 feet for Cells 2 and 3 (USACE 2017).

Eagle Island CDF historically receives silty material from the upper reaches of the channel (from the Lower Brunswick channel reach to the upstream limits of the federal navigation project). Dredged material from the upper channel reaches is placed into the Eagle Island CDF with varying frequency (USACE 2007). The dikes for all three cells are proposed to be raised to 50 feet above mean sea level, which will extend the useful life of Eagle Island CDF to 2032 (USACE 2017).

Placement of additional maintenance material from the channel improvement project would increase the 5-year placement cycle volume by 9.4% (Table 7-2). Note that the maintenance material dredged at a frequency of every five years and every two years is dredged from outside of the -47-foot plan boundaries (upriver). Annual maintenance material is projected to be placed at the Eagle Island CDF until it achieves capacity in 2032. Creating additional capacity at the Eagle Island CDF by raising the dikes to 62 feet above mean sea level was evaluated by USACE (USACE 2017) but was determined to economically infeasible. If the Eagle Island CDF is not available for placement of maintenance material after 2032, the material would likely be placed at the New Wilmington ODMDS, which has more than sufficient capacity for inner harbor maintenance material.

Table 7-2
Eagle Island CDF 5-Year Placement Cycle Volumes (cy)

Frequency	Without-Project	With-Project
One time each year	6,261,500	6,869,020
One time every 2 years	95,900	95,900
One time every 5 years	97,300	97,300
Total	6,454,700	7,062,220
5-Year Volume Difference		607,520
5-Year Percentage Difference		9.4%

7.2 Effects on Performance of the Federal Navigation Project

Investigations into the effects of plan alternatives on performance of the federal navigation project include investigations into effects on:

- Vessel transits during construction;
- Aids to navigation;
- Dredged material disposal capacity and availability; and
- Routine maintenance capability.

7.2.1 Effects on Vessel Transits During Construction

The current proposed construction schedule assumes that all dredging and disposal will be performed during the established dredging and beach placement environmental work windows (see Section 6.7). CU blasting will be limited to August 1 through January 31. During construction, the federal channel will remain an active navigation channel, with approximately 300 to 400 deep draft commercial vessel calls per year, which is an average of 12 to 16 transits through the navigation channel per week. In addition, during construction USACE will perform annual maintenance on channel reaches that have not been dredged as a part of the construction project.

There are four mechanisms through which navigation and navigational safety will be maintained during channel construction:

- Communication protocols;

- USCG Notice to Mariners;
- Safety zones; and
- Equipment relocation.

Communication will be maintained among the pilots, USCG, dredging and blasting contractors, and safety patrol boats. The commercial and recreational fleet using the navigation channel will be notified of the radio channel to monitor for current construction information.

Daily Local Notice to Mariners will be issued by the USCG to convey temporary information of short duration that may have an impact on navigation. Data, such as dredge type, name, location, duration and likely movements, will be provided and published so marine traffic is aware of potential hazards.

Safety zones will be established and the contractor will have a COMMS plan in place to contact local or federal law enforcement (i.e. USCG, etc.) to provide safety zone enforcement when necessary. A safety zone for recreational vessels will be established around hopper dredges, cutter suction dredges, and mechanical dredges whenever they are operating. A continuous safety zone will be established around drill barges, including when actively working and when idle. When actively working there will be patrol boat(s) in the vicinity of the drill barge to restrict both commercial and recreational traffic to outside of the safety zone. Immediately prior to the blast the patrol boat(s) will close off the channel and the closure will be communicated over UHF/VHF radio. Immediately after the blast, once the "all clear" has been given after it is verified all holes successfully detonated, the channel will be re-open to normal vessel movement.

Hopper dredges are the only self-propelled and most mobile pieces of dredging equipment to be deployed during construction. A hopper dredge can clear the channel by sailing outside of the channel limits if there is sufficient water depth or move into the anchorage and allow large vessels to pass. The hopper dredge may time its trip offshore to the ODMDS to deposit its load of material, such that the navigation channel is clear for the deep draft vessel to pass. Because the hopper dredge sails up and down the channel to collect material, it needs to constantly mind recreational traffic. However, the notice to mariners should communicate to recreational users to steer clear of the channel when near a working vessel.

The other types of equipment (mechanical dredges, cutter suction dredges and drill barges) are not self-propelled and are stationary when working. This means they may require some type of assistance by a tug in order to clear out of the channel for large commercial vessels. The cutter suction dredge can work on the side of the channel and swing into the channel to dredge/cut the material; it is capable of swinging to the side of the channel without tug assistance to allow for vessel passage. The cutter suction dredge will also have a swing wire that will lay across the channel that will need to be "slacked off" when deep draft vessels pass. This process can happen within minutes.

Mechanical dredges will need the assistance of a tug to move out of the channel. They will have a scow alongside during dredging operations and will have a tending tug present. The mechanical dredges generally require 1 to 2 hours of notice to clear the channel. Given notice, they can clear the channel to allow channel access for deep draft vessels.

The drill barge is stationary when working and needs to remain in place after a drill hole is loaded with explosives until a blast is detonated. Maintaining navigation has been successfully managed in active channels around the world by limiting CU blasting to one side (toe to centerline) of the channel for navigation of smaller vessels that can safely navigate the channel with only half the channel width available. The side where the contractor is blasting would be closed through the Notice to Mariners, communication with the pilots, and patrolled by safety boats to keep vessels out of the vicinity of CU blasting. The other half of the channel would remain open for vessel transits except for immediately prior to and after the detonation of the blast, when the entire channel near the blast zone would be closed.

The dredging contractor can work with the Port of Wilmington and Pilots to reduce CU blasting related navigation restrictions during times of planned arrival or departure of larger vessels. There are two primary components to ensure safe passage of the larger vessels:

- Immediately after blasting there is a “heave”, or bulking, of the rock broken by the blast event. This heave may push broken rock above the maintained channel depth. One way to potentially avoid heaving above the maintained channel depth is for the contractor to remove the softer materials (overburden) that overlie the harder rock that requires blasting. Removal of the overburden may create vertical space for the heave to occur without effecting the maintained channel. The contractor will be required, immediately (within one hour) after the blast, to perform a post-blast multi-beam hydrographic survey to verify that the resultant heave did not cause material to lie above the maintained channel depth. If post-blast material does remain above the maintained channel depth, a draft restriction would be placed on the channel until the material above depth is removed. This removal action can be specified to occur within 24 hours of the blast.
- If there are areas that require blasting outside of the channel area, it may be possible to allow the blasting operation to continue when the channel is open. The contractor can work with the Pilots to continue drilling in these areas during the transit times or work with the Pilots and Port of Wilmington to coordinate transits immediately after blasts when the drill barge is clear of the channel and the post-blast survey have been completed. If the Pilots do not feel there is an adequate level of safety the CU blasting can be restricted to outside a certain window around the anticipated transit times.

7.2.2 Effects on Aids to Navigation

During construction, existing ATON within 50 ft of the improved channel limits will be temporarily relocated during dredging and re-installed in their existing locations. The dredging contractor will remove the buoy(s) one day prior to dredging within 50 feet of the sinker and replace the buoy(s) back into its original location no more than one day after the localized dredging is complete. Final buoy relocation will occur during year 3 of construction dredging.

A total of 56 ATONS have been addressed, which includes new offshore range markers, new and relocated Lateral Buoys, and relocated inshore range markers. This includes:

- Range Markers (steel multi-pile jacket structures, varying height steel skeleton towers with ranger markers attached):
  - Two (2) new range markers
  - Relocate ten (10) range markers

- Buoys (floating aids with anchors and attached lights):
  - Thirteen (13) new lateral marker buoys (this number could go up or down a couple depending on whether bend wideners are installed at each bend).
  - Relocate up to thirty-eight (38) lateral marker buoys.
  - Relocate the sea buoy.

Section 6: Formulation and Evaluation of Alternative Plans Table 6-9 identifies the ATONS to be relocated or constructed.

7.2.3 Effects on Dredged Material Disposal Capacity and Availability

Section 7.1.1 discusses the effects on dredged material disposal capacity at the New Wilmington ODMDS. The channel improvement project will have no effect on the ability of the ODMDS to provide sufficient dredged material disposal capacity for 50 years after completion of the project. The Eagle Island CDF is estimated to have capacity for routine maintenance material through 2032. The annual addition of 64,000 to 122,000 cubic yards of maintenance material during the last few years[26] of the CDF's useful life would have limited, if any, impact on use of the facility. After 2032, the additional maintenance material would continue to be dredged and placed along with other maintenance material and disposed of in either a further improved Eagle Island CDF or at the New Wilmington ODMDS.

7.2.4 Effects on USACE Routine Maintenance Capability

The largest estimates of increased annual maintenance dredging due to the channel improvement project (121,500 cubic yards in the Anchorage and 57,000 cubic yards in the entrance) represent a 9.6% increase in annual maintenance dredging. The estimated additional annual maintenance dredging cost is $1.155 million in FY19 dollars. The additional dredging volumes require no additional equipment or placement location. The USACE Wilmington District typically uses dredging contractors to perform annual maintenance dredging. Maintenance dredging typically takes place during three to four months in the fall or winter. Different contractors may be used to dredge the anchorage and the outer bar. Historically there is variability in the total quantity dredged and the number of working days for the dredging contractor.

The estimated additional annual maintenance dredging cost is $1.155 million in FY19 dollars. Wilmington Harbor received an average of $17.3 million (FY2019 dollars) for maintenance dredging in fiscal years 2017 – 2019 (USACE Operations and Maintenance Work Plans 2017 – 2019). The annual increase in maintenance costs is a 6.7% increase over the three-year average.

There is no indication that the additional maintenance dredging volume for the anchorage and entrance channel reaches would cause any constraints on the USACE Wilmington District's ability to carry out its annual maintenance program.

[26] The projected first year of post-channel improvement maintenance is 2028.

8 ENVIRONMENTAL CONSEQUENCES

This section describes the environmental consequences of the TSP in accordance with NEPA and the CEQ regulations for implementing NEPA (40 CFR 1500 et. seq.). Section 5.6 Plan Selection identified the -47-foot plan as both the NED Plan and the TSP. The NCSPA did not pursue the -48-foot plan as a Locally Preferred Plan in order to minimize environmental impacts and to avoid other environmental impacts, which may be associated with project depths greater than -47 feet.

Under the without-project condition, which is also the No Action Alternative, the Wilmington District would continue to maintain and operate the currently authorized Wilmington Harbor federal navigation project in the same manner as it has in the past. The existing dimensions of the federal navigation channel would be maintained through the continuation of current dredging and dredged material management practices. The effects of the No Action Alternative are the environmental changes that are projected to occur in the future without any modifications of the federal navigation channel. Pursuant to NEPA, the projected No Action effects comprise the future without project condition and the baseline against which the effects of the TSP are measured. Under the TSP, the existing navigation channel from the Anchorage Basin to the seaward limit of the ocean bar channel would be deepened and widened to accommodate larger container vessels. In addition to modifications of the existing channel, the ocean bar channel would be extended an additional nine miles offshore. The effects of the TSP are the environmental changes that are projected to occur in the future as a result of channel deepening and any related changes in harbor operations and vessel traffic.

The timeframe of the effects analysis encompasses the projected three-year project construction period and the subsequent 50-year project life through 2077. The timing, location, and duration of various construction activities over the course of the three-year construction period would vary according to the construction sequence and annual environmental work windows that were previously described in Section 6.7. Post-construction maintenance of the federal navigation channel for the duration of the 50-year project would involve the continuation of current dredging and disposal practices and maintenance intervals for the existing channel reaches, with the addition of periodic maintenance dredging of the nine-mile offshore entrance channel extension reach.

8.1 Geology, Soils, and Sediments

Groundwater investigations (Appendix A: Engineering – sub-appendices E-1 and E-2) indicate the following:

- The proposed channel improvement project does <u>not</u> significantly influence groundwater flow patterns. In fact, groundwater flow patterns for all four modeled aquifers (the Surficial, the Castle Hayne, the Upper Peedee, and the Lower Peedee) were virtually identical under the proposed channel modification simulations.
- The proposed channel deepening adjacent to Southport does not breach or thin the Upper Peedee Confining Layer, and therefore the proposed channel does not increase the potential for saltwater intrusion into the Upper Peedee Aquifer in that area. Model simulations reveal no effect on the groundwater flow patterns near Southport in response to proposed channel modifications.

The potential effects of the project on groundwater resources are detailed below in Section 8.3.

8.2 Shoreline Erosion

The GenCade shoreline change and sand transport model was used to investigate the potential effects of the TSP on longshore sediment transport and erosional shoreline conditions along Bald Head Island and Oak Island (Appendix A: Engineering). GenCade was used to simulate shoreline changes over a 14-year period using input wave conditions from the DELFT 3D wave transformation model results. On Bald Head Island, the GenCade model results indicate that channel deepening would have minor adverse effects on the central South Beach shoreline and minor beneficial effects on the western South Beach shoreline in relation to the No Action Alternative. The model results indicate that erosion rates would increase slightly along the central South Beach shoreline from Stations 92+15 to 170+02, with the largest relative increase of ~0.6 ft/yr occurring between Stations 118+2 and 129+98. The model results indicate that erosion rates would decrease by an average of ~1.3 ft/yr along the westernmost ~1,200-ft shoreline reach adjacent to Cape Fear River Inlet. Westerly longshore sediment transport rates along the western half of the South Beach shoreline are projected to increase by as much as 3,800 cy/yr in relation to the No Action Alternative. The model results indicate that the relative effects of channel deepening on the Oak Island shoreline would be negligible, with relative erosion rate increases of <0.1 ft/yr projected along most of the island and a relative increase of ~0.2 ft/yr projected along the east end of Caswell Beach. Model-projected changes in sediment transport along Oak Island are negligible.

Under the TSP, the 8,000 TEU container vessels that currently call on the Port of Wilmington would be replaced by larger 12,400 TEU container vessels. The XBeach hydrodynamic model was used to assess the effects of larger vessels and their associated ship wakes on historically erosional shoreline reaches in the vicinity of Southport, Battery Island, and Orton Point. The results of ship wave model simulations were used to calculate wave-induced bed shear stress, which was used as an indicator of shoreline erosion potential. The modeling results indicate that the wave-induced bed shear stress produced by a 12,400 TEU vessel would increase significantly in relation to an 8,000 TEU vessel traveling at the same speed. In regard to the shoreline reaches of interest, the modeling results indicate that larger ships would have minimal effects on the Southport shoreline, whereas increases in bed shear stress are projected along shorelines to the northeast of Southport and in the vicinity of Orton Point. A decrease in bed shear stress is projected along the northernmost Battery Island shoreline during inbound transits due to the new channel alignment being farther from the shoreline. Conversely, bed shear stress is projected to increase along the southern shoreline of Battery Island during outbound transits.

Additional XBeach ship wake simulations were conducted to assess the effects of smaller 2,500 TEU vessels transiting closer to the shorelines of Southport and Battery Island in the widened and realigned Battery Island channel reach. The small vessel simulations showed an increase bed shear stress along the northeastern coast of Southport, whereas minimal to no increase in bed shear stress occurred along the southern coast of Southport. A minimal increase in bed shear stress occurred along the western coast of Battery Island, whereas bed shear stress decreased along the northern shoreline of Battery Island. Increases in bed shear indicate the potential for increased erosion; however, the XBeach model results do not address the extent of any additional erosion that might occur. The potentially affected shoreline areas, as indicated by projected increases in bed shear stress, would be evaluated further during development of the DEIS and the

Pre-Construction Engineering and Design (PED) phase of project development. Based on input from agencies and stakeholders, ship wake modeling analyses would also be expanded to include additional shoreline reaches and potential effects on waterfront infrastructure and historic sites.

8.3 Hydrogeology

As described in the Groundwater Modeling section of Appendix A: Engineering, the USGS's MODFLOW hydrologic model was used to evaluate the potential effects of sea level rise and harbor deepening on local groundwater flow and the regional freshwater aquifer system. Baseline modeling results indicate that the Cape Fear River serves primarily as a discharge area for the surficial, Castle Hayne, and Peedee aquifers; thus indicating limited potential for lateral movements of saline river water into the aquifer system. However, baseline modeling identified localized areas near the Cape Fear River channel where pumping has lowered groundwater heads below sea level, indicating the potential for salinity intrusion via downward migration of surface water into the groundwater system. The identified areas are associated with industrial and municipal water supply well fields; including those operated by the Capital Power Corporation in Southport, the Carolina Beach and Kure Beach, Bald Head Island, and the Invista Corporation near Lake Sutton. The principal focus of the modeling effort was to investigate any changes in the aquifer to river discharge relationship and/or groundwater pumping patterns that could increase the potential for salinity intrusion. Groundwater simulations for both the No Action Alternative and TSP were run under the high (RSLR3) sea level change scenario.

The modeling results indicate that channel deepening would not have any measurable effects on groundwater flow and discharge patterns. Simulated groundwater flow patterns in all four modeled aquifers (Surficial, Castle Hayne, Upper Pee Dee, and Lower Pee Dee) were essentially identical to those projected under the baseline simulations. Although the Capital Power well field cone of depression in the Upper Pee Dee aquifer extends beneath the Cape Fear River, the upper surface of the aquifer lies 50 ft below the bottom of the proposed channel, and monitoring well data indicate that the aquifer is well-confined and not directly connected to surface water in the river. The cone of depression associated with the Carolina Beach/Kure Beach well fields impinges on the Cape Fear River; however, the depression does not extend beneath the river to the navigation channel, and the modeling results indicate that the proposed channel is too far removed from the pumping areas to affect the potential for salinity intrusion. The results of the groundwater investigation indicate that the TSP would not have any adverse effects on groundwater resources.

8.4 Surface Water Hydrology - Water Levels, Tides, and Currents

The Delft 3-D hydrodynamic model was used to evaluate the effects of the No Action Alternative and TSP on water levels and current speeds under various flow conditions (low, medium, and high) and RSLR scenarios (low, intermediate, and high). Water level and current velocity data were extracted from the model results for a series of data point locations along the longitudinal axis of the estuary (see Figure 4-4 presented in Section 4.7.4 Surface Water Hydrology).

8.4.1 Water Levels/Tides

Under the TSP, the model results show increases in MHW and MLW that are similar to the No Action Alternative in terms of their longitudinal pattern through the estuary (Figure 8-1). However, as a result of channel deepening, friction is reduced and the hydraulic efficiency of the channel is increased. The model results indicate that increased hydraulic efficiency will cause additional small increases in tidal range in relation to the No Action Alternative. Under the RSLR1 scenario and medium flow conditions, the largest projected relative MHW increase is 0.11 ft (1.3 in) in the Anchorage Basin and adjoining Battleship reach (Table 8-1, Figure 8-1). The magnitude of relative MHW increase declines rapidly in the estuary above the Battleship reach, with relative increases of 0.04 ft (0.5 inches) and 0.0 ft projected in the uppermost estuary at data points CFR02 and CFR03, respectively. Relative MHW increases are also steadily reduced through the down-estuary reaches below the Anchorage Basin, with a projected increase of just 0.02 ft in the lower end of the estuary at Battery Island. Although MLW levels are projected to rise under the TSP, the increases are smaller than those projected under the No Action Alternative. Thus, MLW levels under the TSP are projected to decrease in relation to the No Action Alternative. Under the RSLR1 scenario and medium flow conditions, the largest relative MLW decrease is -0.17 ft (-2.0 inches) in the Anchorage Basin (Table 8-1, Figure 8-1).

Relative MLW decreases are steadily reduced in the up-estuary and down-estuary reaches above and below the Anchorage Basin. The resulting net effect of the combined MHW and MLW changes under the TSP is a relative increase in tidal range. The largest relative increases of 0.28 ft and 0.26 ft are projected to occur in the Anchorage Basin and Battleship channel reaches, respectively. Relative tidal range increases are rapidly reduced through the up-estuary and down-estuary reaches above and below the Anchorage Basin and Battleship reaches. Under the RSRL2 and RSRL3 scenarios, the relative effects of the TSP on water levels are minimally increased by by ~0.01 ft. The small projected MHW increases of 1.4 inches or less under the TSP would not significantly affect the frequency of tidal nuisance flooding events or the potential for related adverse effects on waterfront infrastructure along the CFR.

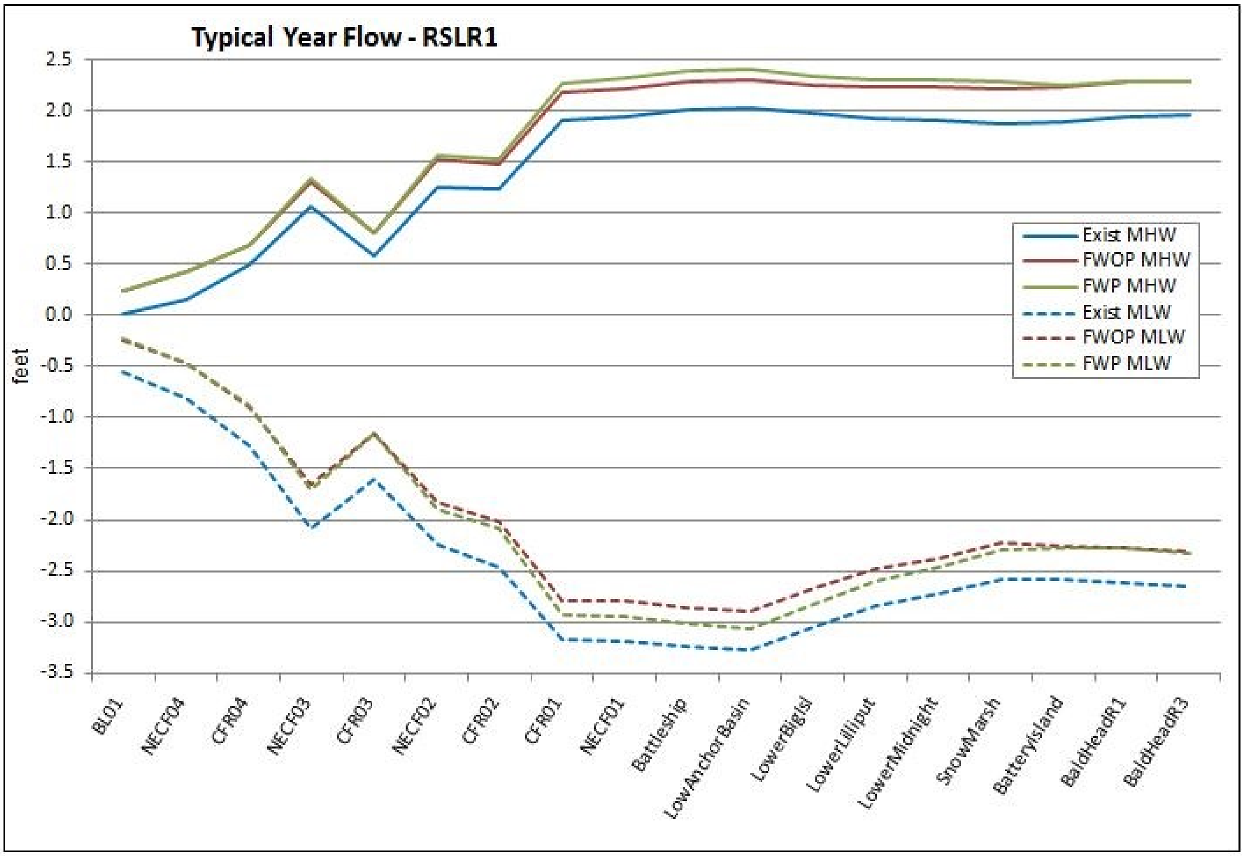

Figure 8-1
Projected MHW and MLW Levels under the No Action Alternative and TSP: Medium Year Flow / RSLR1

Table 8-1
Projected Water Level Changes Under the TSP on
MHW, MLW, and Tidal Range Using RSLR1 Scenario

Reach	Low Flow	Med Flow	High Flow	Low Flow	Med Flow	High Flow	Low Flow	Med Flow	High Flow
	MHW (ft)			MLW (ft)			Tidal Range (ft)		
BL01	0.00	0.01	0.01	0.00	-0.01	-0.01	0.00	0.01	0.02
NECF04	0.09	0.09	0.09	-0.15	-0.14	-0.14	0.24	0.23	0.23
NECF03	0.04	0.04	0.04	-0.06	-0.05	-0.05	0.10	0.10	0.08
NECF02	0.03	0.03	0.03	-0.04	-0.04	-0.03	0.07	0.07	0.06
NECF01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01
CFR04	0.00	0.00	0.01	0.00	0.01	-0.01	-0.01	-0.02	0.01
CFR03	0.00	0.00	0.01	0.00	0.01	0.00	0.00	-0.01	0.01
CFR02	0.04	0.04	0.03	-0.06	-0.06	-0.05	0.11	0.10	0.09
CFR01	0.09	0.09	0.08	-0.14	-0.14	-0.14	0.23	0.23	0.23
Battleship	0.10	0.11	0.10	-0.16	-0.16	-0.16	0.26	0.26	0.26
Lower Anchorage	0.11	0.11	0.12	-0.17	-0.17	-0.18	0.28	0.28	0.29
Lower Big Island	0.09	0.09	0.08	-0.15	-0.15	-0.14	0.24	0.24	0.23
Lower Lilliput	0.07	0.07	0.07	-0.12	-0.11	-0.12	0.19	0.19	0.18
Lower Midnight	0.07	0.07	0.06	-0.09	-0.09	-0.09	0.16	0.15	0.15
Snows Marsh	0.07	0.07	0.07	-0.07	-0.07	-0.07	0.14	0.14	0.14
Battery Island	0.02	0.02	0.02	-0.02	-0.02	-0.04	0.04	0.04	0.05

8.4.2 Currents

Under the TSP, the model results indicate that channel deepening would result in additional small changes in current speeds in relation to the No Action Alternative. Under the RSLR1 scenario, the maximum projected relative increase in surface layer current speed is 0.55 ft/s in the Anchorage Basin under high flow conditions, while the maximum relative increase in the bottom layer is 0.60 ft/s in the Snows Marsh channel reach under medium flow conditions (Table 8-2). The maximum relative decrease in surface layer current speed is -0.43 ft/s in the Battery Island reach under high flow conditions. The decrease in the Battery Island reach is primarily the result of a significant increase in channel width through the turn. The maximum relative decrease in the bottom layer is -0.14 ft/s in the Anchorage Basin under high flow conditions. Under the RSLR2 and RSLR3 scenarios, the projected effects of the TSP on current speeds are slightly reduced.

Table 8-2
Projected Relative Effects on Current Speeds Under the TSP
Using RSLR1 Scenario

Station	Surface			Bottom		
	Low Flow	Medium Flow	High Flow	Low Flow	Medium Flow	High Flow
BL01	-0.01	0	0	-0.01	0.00	0.00
NECF04	0.02	0.01	0.02	0.02	0.01	0.01
CFR04	0.01	0.00	-0.01	0.00	0.00	0.00
NECF03	0.04	0.05	0.04	0.04	0.03	0.04
CFR03	0.05	0.02	0.00	0.04	0.01	0.00
NECF02	0.07	0.05	0.05	0.03	0.03	0.03
CFR02	0.09	0.10	0.07	0.06	0.05	0.05
CFR01	0.18	0.22	0.26	0.04	0.06	0.06
NECF01	0.20	0.26	0.15	0.04	0.01	0.02
Battleship	0.21	0.21	0.32	0.15	0.17	0.19
Lower Anchorage Basin	0.20	0.26	0.55	-0.09	-0.13	-0.14
Lower Big Island	-0.21	-0.30	-0.37	0.12	0.12	0.17
Lower Lilliput	-0.08	-0.15	-0.12	0.32	0.32	0.31
Lower Midnight	0.030	0.00	0.02	0.29	0.23	0.25
Snow Marsh	0.04	0.03	0.06	0.52	0.59	0.6
Battery Island	-0.30	-0.35	-0.43	-0.12	0.03	0.11
Baldhead ShoalR1	0.21	0.12	0.11	0.51	0.35	0.42
Baldhead ShoalR3	0.05	0.00	0.04	0.06	0.03	0.01

8.5 Wind and Wave Climate

The DELFT 3D WAVE module was used to investigate the effects of channel deepening on the nearshore ocean wave climate (Appendix A: Engineering). The WAVE module was developed to simulate wave transformation from deepwater to the oceanfront shoreline. Wave data were extracted from the model results for a series of nearshore data points along the shorelines of Bald Head Island and Oak Island.

Under the TSP, the model results indicate that channel deepening would have negligible effects on the nearshore wave climate and significant wave heights. Projected increases in significant wave heights at all of the nearshore data extraction points are <0.1 ft, with the vast majority of the increases being <0.02 ft. The model results indicate that the TSP would not have any significant effects on the nearshore wave climate.

8.6 Sea Level Rise

Although sea level rise is a critical factor in the analyses of potential impacts, the rate of RSLR within the study area would be unaffected by any actions that may occur under the No Action Alternative or under the TSP.

8.7 Salinity

The Delft 3-D hydrodynamic model was used to simulate salinity changes under tidal flows, vertical salinity gradient dynamics, and the propagation of salinity into the upper reaches of the estuary. As in the case of the main hydrodynamic modeling effort, salinity was modeled under low, medium, and high flow conditions and three sea level rise scenarios. Salinity data for surface, mid-depth and bottom layers were extracted from the model results for a series of point locations along the longitudinal axis of the estuary. Projected salinity changes under all flow and RSLR scenarios generally follow a similar longitudinal pattern, with the largest projected increases occurring in the bottom to mid-depth layers in the vicinity of Anchorage Basin and maximum surface salinity increases of reduced magnitude occurring in the down-estuary Lower Lilliput to Lower Midnight reaches. Projected salinity increases in all three layers are steadily reduced in the up-estuary and down-estuary reaches above and below the projected maximum increase locations. This general pattern reflects both longitudinal tidal range variability and vertical stratification within the estuary. Stratification sets up density currents that drive saline ocean water upstream along the channel bottom, while concurrently freshwater river discharge flows downstream on the surface, thus lowering surface salinities and shifting the surface layer salinity gradient downstream in relation to the bottom and mid-depth layers.

Projected estuarine salinity increases under the TSP follow the same longitudinal pattern described above, however, the model simulated deepening project increases the hydraulic efficiency of the channel, allowing saline ocean water to penetrate farther into the estuary. The modeling results indicate that channel deepening under the TSP will increase surface, mid-depth, and bottom salinities in relation to the No Action Alternative. Under the typical flow year RSLR1 scenario, the maximum relative increases in average annual salinity occur in the mid-depth (3.9 ppt) and bottom (4.1 ppt) layers in the vicinity of the Anchorage Basin (Table 8-3, Figures 8-2 to 8-4). A maximum relative increase in surface salinity of 1.2 ppt is also projected in the Anchorage Basin. Projected increases in all three layers are rapidly reduced in the reaches above and below the Anchorage Basin. Under the RSLR2 scenario, the relative salinity impacts under the TSP are very slightly reduced by 0.1 to 0.3 ppt at all depths throughout the estuary. Under the RSLR3 scenario, the relative salinity impacts under the TSP are reduced by 0.5 to 0.9 ppt at all depths throughout the estuary.

Table 8-3
Projected Relative Effects of the TSP on Average Annual Salinities (ppt) under RSLR1 and Typical Flow Conditions.

Station	Surface			Mid-Depth			Bottom		
	FWOP	TSP	TSP Δ	FWOP	TSP	TSP Δ	FWOP	TSP	TSP Δ
NECFR02	0.1	0.2	**0.1**	0.1	0.2	**0.1**	0.1	0.2	**0.1**
CFR01	0.3	0.4	**0.1**	1.3	2.0	**0.7**	1.8	2.6	**0.9**
NECFR01	2.1	2.9	**0.8**	4.0	5.8	**1.8**	4.3	6.3	**2.0**
Battleship	3.0	3.9	**1.0**	7.3	10.2	**2.9**	10.2	14.1	**3.9**
Lower Anchorage	3.6	4.7	**1.2**	10.2	14.1	**3.9**	14.2	18.3	**4.1**
Lower Big Island	6.7	7.5	**0.9**	14.7	17.0	**2.3**	18.1	21.1	**3.0**
Lower Lilliput	10.5	11.4	**0.9**	20.6	22.3	**1.7**	22.9	24.8	**1.9**
Lower Midnight	14.7	15.4	**0.7**	24.7	25.7	**0.9**	27.2	28.3	**1.2**
Snows Marsh	21.6	22.2	**0.6**	29.0	29.3	**0.3**	30.7	31.4	**0.7**
Battery Island	25.0	25.2	**0.3**	30.0	30.2	**0.2**	31.6	32.2	**0.5**
Bald HeadR1	28.6	28.6	**0.1**	32.8	32.8	**0.0**	33.5	33.7	**0.2**
Bald HeadR3	31.8	31.9	**0.1**	35.0	34.9	**0.0**	35.0	35.0	**0.0**

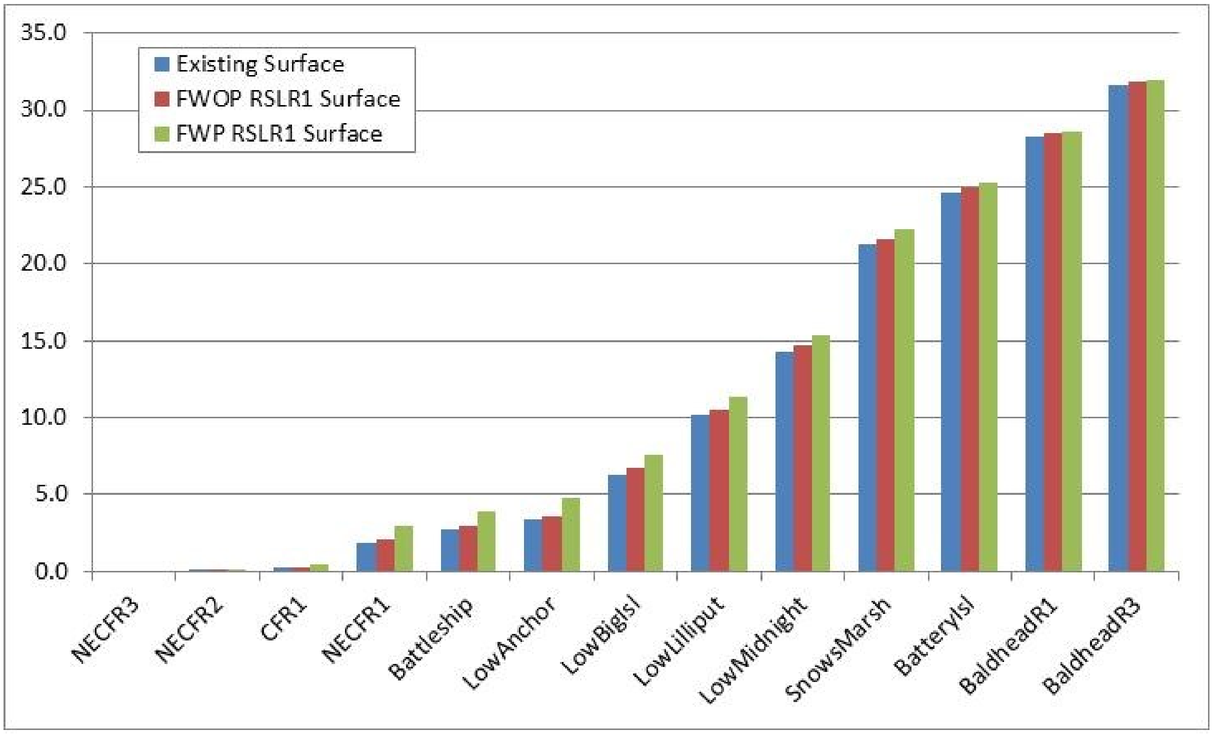

Figure 8-2
Projected Average Annual Surface Salinities under the No Action Alternative and TSP – RSLR1/Typical Flow Conditions

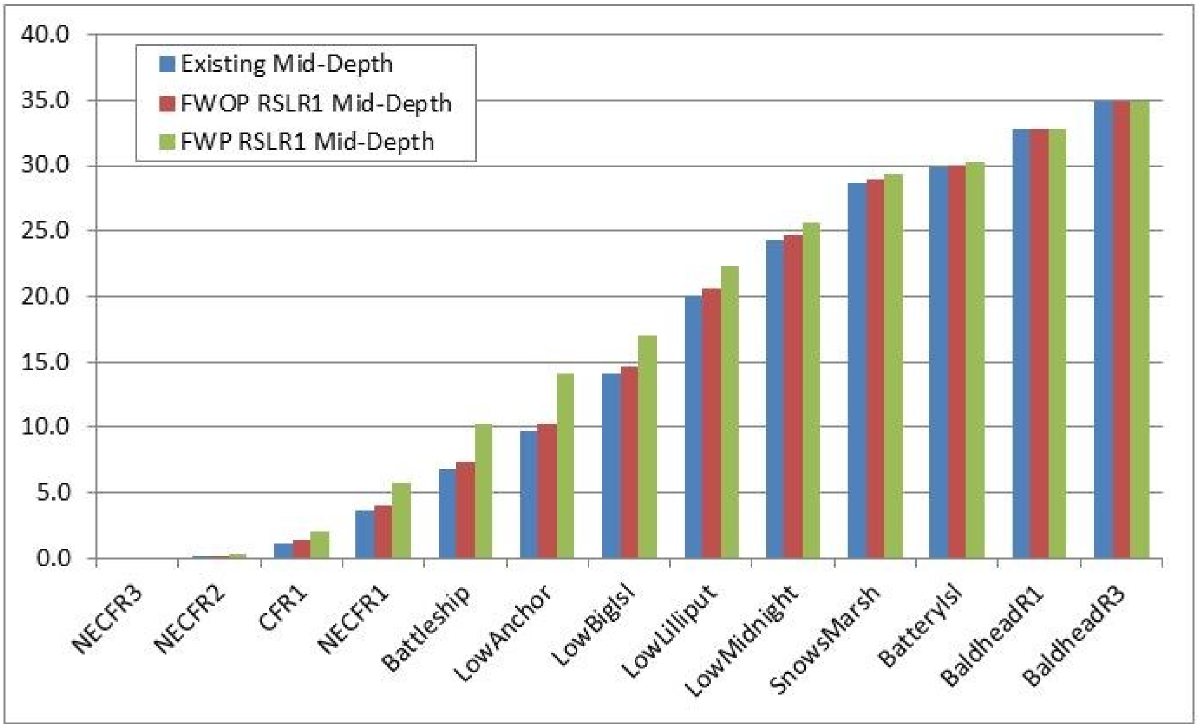

Figure 8-3
Projected Average Annual Mid-Depth Salinities under the No Action Alternative and TSP – RSLR1/Typical Flow Conditions

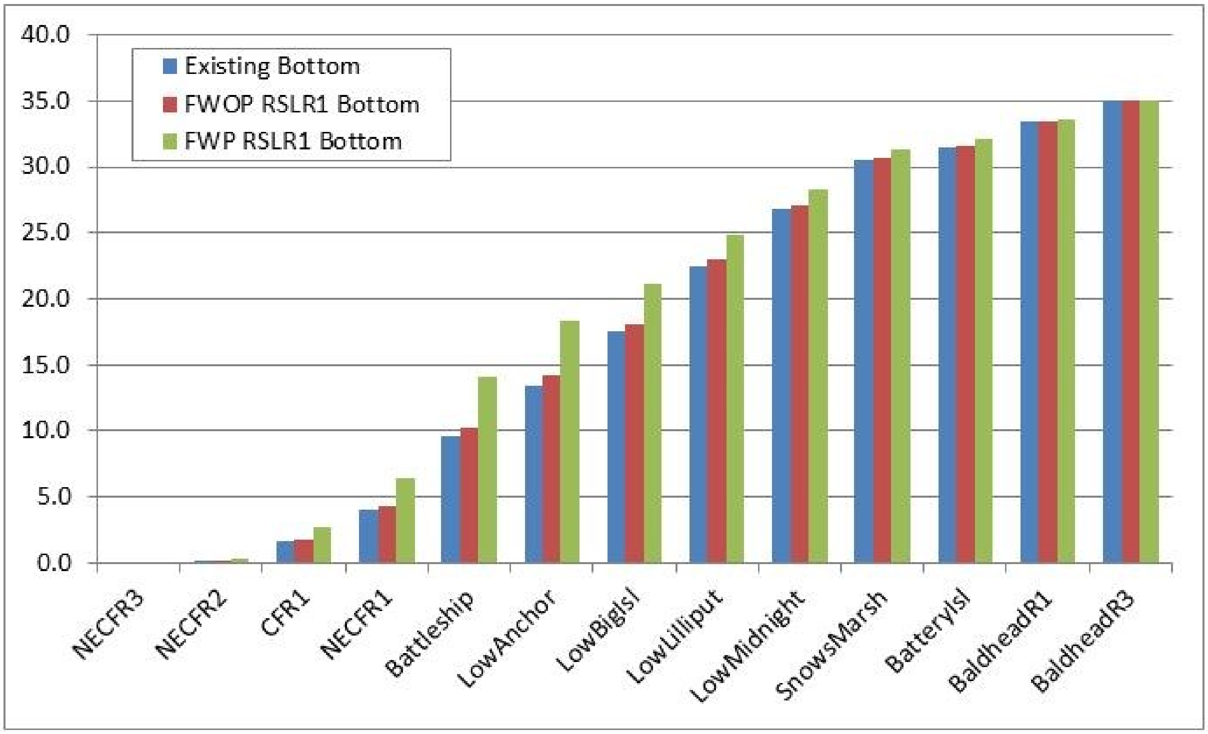

Figure 8-4
Projected Average Annual Bottom Salinities under the No Action Alternative and TSP – RSLR1/Typical Flow Conditions

8.8 Surface Water Quality

The D-Water Quality (D-WAQ) module for DELFT 3D was used to evaluate potential effects on dissolved oxygen (DO) concentrations in the Cape Fear River estuary. Under the TSP, the typical flow RSLR1 model results indicate that middle and bottom layer DO concentrations would decrease by 0.3 mg/L or less in relation to the No Action Alternative. The largest relative decreases of 0.3 mg/L are projected at stations in the Battleship, Anchorage Basin, and Lower Big Island channel reaches in the vicinity of downtown Wilmington. Maximum relative decreases are reduced to 0.2 mg/L in the Lilliput and Lower Midnight reaches below, and projected decreases throughout the remainder of the estuary are ≤0.1 mg/L. Projected relative decreases in surface layer DO concentrations are ≤0.1 mg/L throughout the study area. The maximum decreases occur during the winter months when DO concentrations are typically the highest of the year. Model-projected absolute DO concentrations under the typical flow RSLR1 scenario are on the order of 8 to 10 mg/L during these months; thus indicating that the TSP would not contribute to exceedances of the state DO standard (5.0 mg/L). Model results for the dry year RSLR1 scenario show slightly smaller DO decreases of ≤0.2 mg/L, thus the relative effects of the TSP are slightly reduced. The relative effects of the TSP are also slightly reduced under the RSLR2 and RSLR3 scenarios. Given the small decreases in DO that are projected, and the timing of maximum decreases during the winter, the TSP would not be expected to adversely affect water quality.

8.9 Tidal Wetlands

The composition of tidal wetland communities in the Cape Fear River estuary is determined by tidal flood water salinities and resulting soil biochemical conditions (methanogenic vs sulfate reducing) (Hackney and Avery 2015). Accordingly, any increases in estuarine salinity could potentially alter the composition, distribution, and relative extent of saltwater, brackish, and freshwater tidal wetlands within the Cape Fear River system. The potential effects of salinity on tidal wetlands were a principal issue of concern and a major focus area of the environmental analyses conducted for this study. An updated tidal wetland classification was developed for the study area to provide an accurate baseline for the analysis of wetland effects. ENVI 5.4 image analysis software and satellite imagery (Landsat 8) were used to perform a GIS-based supervised classification of tidal wetlands within the Cape Fear River estuary. The ENVI program uses a maximum likelihood analysis to group pixels into spectral classes based on user defined training data. Field surveys conducted during the late summer and fall of 2017 provided training data that were used to refine the classification. Surface salinity data were extracted from the year-long model simulation results and averaged for each grid cell to produce average annual surface salinity GIS layers for the various Existing Condition, No Action, and TSP flow and RSLR scenarios. Based on the grid cell average salinity values, salinity isopleths were added to define the boundaries or thresholds between the polyhaline, mesohaline, oligohaline, and tidal freshwater salinity zones in the various river and tidal creek channels. The model-projected Existing Condition salinity isopleths [polyhaline-mesohaline (18 ppt), mesohaline-oligohaline (5 ppt), and oligohaline-tidal freshwater (0.5 ppt)] and the projected changes in the isopleths under the various No Action and with-project scenarios, in combination with the baseline wetland classification, comprise the basis for the analysis of wetland effects. The methods employed and results of the assessment are detailed in the Wetland Impact Assessment Appendix (Appendix F).

8.9.1 Effects of the Tentatively Selected Plan

Under the TSP, the salinity modeling results indicate that harbor deepening will cause additional relative upstream shifts in the oligohaline-freshwater 0.5 ppt salinity isopleths ranging from ~0.18 to 0.83 mile. Wetlands potentially affected by the projected upstream shifts in the 0.5 ppt isopleths under the TSP include ~242 acres of tidal freshwater swamp forest, ~98 acres of tidal freshwater marsh, and ~62 acres of brackish cattail marsh (Table 8-4). Projected shifts in the mesohaline-oligohaline 5.0 ppt isopleths under the TSP are confined to the existing brackish marsh-dominated reaches of the estuary, with the exception of the Lilliput Creek isopleth, which extends ~200 ft into the transition zone where small patches of tidal freshwater marsh first begin to occur. The potentially affected freshwater marsh areas along Lilliput Creek total less than one acre. The remaining delineated tidal floodplain areas that are affected by the various mesohaline-oligohaline isopleth shifts under the TSP encompass ~470 acres of brackish cattail marsh, ~20 acres of Phragmites marsh, and approximately five acres of brackish marsh mix.

Projected surface salinity changes within the mesohaline-oligohaline isopleth shift zones are limited to relatively small increases of ≤1.5 ppt. The potentially affected brackish wetlands consist almost entirely of cattail marsh under both the No Action Alternative (97%) and TSP (96%), with the majority (~3.5%) of the remaining brackish wetlands consisting of marshes dominated by the non-native invasive species *Phragmites australis australis*. Cattail marshes dominate the estuarine tidal floodplain from approximately two miles below Eagle Island to the upper ends of the oligohaline reaches in the Cape Fear River and Northeast Cape Fear River, and thus are well adapted to a broad range of salinities. Therefore, the relatively small increases in salinity that are projected under the No Action Alternative and TSP would not be expected to have any significant effect on cattail marshes. In the case of Phragmites marshes, any changes in community composition would be considered a beneficial effect. Therefore, the anticipated effects of the TSP on existing brackish marshes are considered to be insignificant and will not be considered in determining any wetland mitigation requirements for the TSP.

The remaining tidal freshwater wetlands that were identified as potentially affected by oligohaline-freshwater isopleth shifts under the TSP include 241.8 acres of tidal freshwater swamp forest and 103.4 acres of tidal freshwater marsh (Table 8-5). Although in many cases the projected oligohaline-freshwater isopleth shifts cover substantial distances, the projected surface salinity changes within the isopleth shift zones are limited to very small increases of ≤0.3 ppt. Although tidal freshwater swamp forest communities are capable of tolerating or recovering from occasional pulses of saline water, they are generally not able to tolerate regular flooding by saline waters. Based on studies conducted in the Cape Fear River estuary, Hackney and Avery (2015) indicate that the location along the river salinity gradient where 12% to 25% of the high tide events flood the adjacent tidal wetlands with >1 ppt saline water is the active zone of tidal swamp to tidal marsh conversion. Tidal freshwater marshes as defined by the baseline classification are slightly more tolerant of very low oligohaline salinities; however, the restriction of freshwater marshes to relatively short reaches of the estuary in the immediate vicinity of the oligohaline-freshwater boundary indicates that overall salinity tolerance is very limited. Thus, tidal swamp forest and tidal freshwater marsh communities are potentially vulnerable to relatively small increases in salinity. However, given the very small projected increases in salinity, the exact nature and extent of effects are difficult to predict. Generally, it is anticipated that the projected salinity increases would have some effects on community

Table 8-4
Wetlands Potentially Affected by Projected Upstream Salinity Isopleth Shifts Under the TSP

Water Body	Model Scenario (Flow/RSLR)	Isopleth Shift (river miles)	Wetland Class[1]						
			SWF	FWM	CAT	BRM	PHR	SPA	Total
Oligohaline-Freshwater Isopleth Shifts (acres)									
Cape Fear River Mainstem	DY – RSLR1	0.32	29.9	16.2					**46.1**
Northeast Cape Fear River	DY – RSLR1	0.44	75.8	16.7	8.0				**100.5**
Smith Creek	TY – RSLR1	0.32	27.4						**27.4**
Sturgeon Creek	TY – RSLR1	0.83	19.4	55.2	54.0				**128.6**
Jackeys Creek[2]	TY – RSLR1	0.66	58.0						**58.0**
Town Creek[2]	TY – RSLR1	0.18	13.9						**13.9**
Lilliput Creek[2]	TY – RSLR1	0.29	17.4	9.7					**27.1**
Total Oligohaline-Freshwater (acres)			**241.8**	**97.8**	**62.2**	**0.0**	**0.0**	**0.0**	**401.6**
Mesohaline-Oligohaline Isopleth Shifts (acres)									
Cape Fear River Mainstem	DY – RSLR1	0.32			69.3		9.7		**79.1**
Northeast Cape Fear River	DY – RSLR1	0.54			103.0		3.9		**106.9**
Barnards Creek	TY – RSLR1	0.69			66.2				**66.2**
Lilliput Creek[3]	TY – RSLR1	1.83			225.6	3.7	6.0		**235.3**
Town Creek	TY – RSLR1	0.15		0.9	6.0	1.2			**8.1**
Total Mesohaline-Oligohaline (acres)			**0.0**	**0.9**	**470.1**	**4.9**	**19.6**	**0.0**	**495.6**

[1] SWF = Tidal Freshwater Swamp Forest; FWM = Tidal Freshwater Marsh; CAT = Cattail; BRM = Brackish Mix; PHR = Phragmites australis; SPA = Spartina alterniflora

[2] The model-projected series of Existing Condition, No Action, and TSP salinity isopleths was manually shifted downstream until the Existing Condition isopleth was positioned at the upper end of the active tidal swamp forest to freshwater marsh conversion zone. The model-projected distances between the isopleths were maintained.

[3] The model-projected series of Existing Condition, No Action, and TSP salinity isopleths was manually shifted downstream until the Existing Condition isopleth was positioned at the approximate threshold between the cattail dominant and Spartina alterniflora dominant tidal wetland zones. The model-projected distances between the isopleths were maintained.

composition, and that shifts in freshwater community composition towards the brackish marsh spectrum would reduce community diversity. However, it is considered unlikely that the projected increases would result in large-scale swamp forest to marsh conversions.

Table 8-5
Freshwater Tidal Wetlands Potentially Affected under the TSP

			Wetland Class (acres)		
Water Body	**Isopleth Shift**	**Model Scenario**	**Tidal Swamp Forest**	**Tidal Freshwater Marsh**	**Total Freshwater Wetlands**
Cape Fear Mainstem	Oligohaline-Freshwater	Dry Yr RSLR1	29.9	16.2	**46.1**
Cape Fear Mainstem	Mesohaline-Oligohaline	Dry Yr RSLR1	0.0	0.0	**0.0**
Northeast Cape Fear	Oligohaline-Freshwater	Dry Yr RSLR1	75.8	16.7	**92.5**
Northeast Cape Fear	Mesohaline-Oligohaline	Dry Yr RSLR1	0.0	0.0	**0.0**
Smith Creek	Oligohaline-Freshwater	Typical Yr RSLR1	27.4	0.0	**27.4**
Sturgeon Creek	Oligohaline-Freshwater	Typical Yr RSLR1	19.4	55.2	**74.6**
Jackeys Creek	Oligohaline-Freshwater	Typical Yr RSLR1	58.0	0.0	**58.0**
Barnards Creek	Mesohaline-Oligohaline	Typical Yr RSLR1	0.0	0.0	**0.0**
Town Creek	Oligohaline-Freshwater	Typical Yr RSLR1	13.9	0.0	**13.9**
Town Creek	Mesohaline-Oligohaline	Typical Yr RSLR1	0.0	0.0	**0.0**
Lilliput Creek	Oligohaline-Freshwater	Typical Yr RSLR1	17.4	9.7	**27.1**
Lilliput Creek	Mesohaline-Oligohaline	Typical Yr RSLR1	0.0	0.9	**0.9**
		Total (acres)	**241.8**	**98.7**	**340.5**

8.10 Benthic Communities

8.10.1 Soft Bottom

Construction of the proposed Wilmington Harbor navigation channel improvements, inclusive of the channel slopes, would directly impact ~3,151 acres of soft bottom habitat over a three-year period; including ~2,226 acres of previously disturbed (dredged) habitat within the existing channel and ~925 acres of undisturbed (new dredging) habitat in the proposed channel widening and extension areas (Table 8-6). The new dredging acreages in Table 8-6 represent areas between the existing channel top-of-slope and proposed channel top-of-slope, along with the channel bottom and side slopes of the offshore entrance channel extension reach. In relation to the No Action alternative, long-term maintenance of the new dredging areas would increase the area of soft bottom habitat that is subject to recurring dredging disturbance by ~925 acres, including 557 acres of estuarine soft bottom and 368 acres of marine softbottom (Table 8-6). Depending on reach-specific maintenance intervals, estuarine soft bottom habitats in the new dredging areas would experience recurring maintenance dredging disturbance every one to four years for the duration of the 50-year project. The majority of the marine soft bottom new dredging areas are associated with the proposed offshore entrance channel extension reach (207 acres) and the adjoining Baldhead Shoal 3 outer ocean entrance channel reach (132 acres). The remaining 29 acres of new marine soft bottom dredging impact would occur in the Baldhead Shoal 1 and 2 nearshore entrance channel reaches. New dredging marine soft bottom habitats along the existing Baldhead Shoal reaches would experience recurring maintenance dredging disturbance every one to two years, whereas marine soft bottom habitats in the proposed entrance channel extension reach would experience recurring maintenance disturbance approximately every 10 years.

The effects of deepening on estuarine soft bottom habitats and benthic infaunal communities in the existing disturbed channel would be similar to the effects of continuing maintenance dredging under the No Action alternative. The TSP would not affect the frequency of recurring dredging impacts in relation to the No Action alternative. Deepening would have some physical bottom habitat modifying effects similar to those described above, especially in the case of existing channel habitats that are currently positioned on the upper channel slope; however, as described above, there is no indication that habitat modification would lead to permanent changes in community composition or structure.

The existing deep (>6 ft) estuarine soft bottom habitats within the new dredging areas are predominantly located in waters >12 ft deep (542 acres), with the remainder (9 acres) occurring at depths of 6 to 12 ft.

The effects of dredging on soft bottom benthic infaunal communities in the Wilmington Harbor navigation channel were investigated by Ray (1997) in a study conducted for the Wilmington Harbor 96 Act Deepening Project. Sampling of the navigation channel bottom, side slopes, adjacent undisturbed flats, and control sites was conducted during March and October along 14 transects representing channel reaches at 1, 2, and 3-year post-dredging durations. Species composition differed primarily along longitudinal sediment and salinity gradients, whereas the only significant compositional difference between vertical station positions (channel/slope/flat) was related to salinity intrusion along the channel bottom during the low flow October sampling period. Benthic community structure (taxa richness, abundance, and biomass) differed among the sampling sites according to sediment type, vertical station position, and post-dredging duration**.** In the sandy sediment reaches of the lower estuary; taxa richness, abundance, and biomass at stations in the channel were depressed for one to two years post-dredging, especially on the channel bottom and western channel slope. However, there were no differences among stations in the sandy reaches at 3-year post-dredging sites. In the silty sediment reaches of the middle to upper estuary, there were no differences in benthic community structure among stations. Taxa richness, abundance, and biomass at silty stations were always higher than corresponding control station values; regardless of station position (channel/slope/flat) and post-dredging duration. The absence of detected dredging effects at silty sites is consistent with short-term recovery periods of <6 months that have been reported in other silty sediment estuarine navigation channels (Van Dolah et al. 1984, Van Dolah et al. 1979, Stickney and Perlmutter 1975, and Stickney 1972). The benthic study results indicate that post-maintenance dredging infaunal recovery processes in the navigation channel eventually lead to the reestablishment of infaunal communities that are equivalent to those of adjacent undisturbed flats and control sites in terms of taxa richness, abundance, biomass, and species composition.

8.10.1.1 Estuarine Soft Bottom Effects

Construction and long term maintenance of the improved channel would have recurring direct impacts on all estuarine soft bottom habitats and benthic infaunal communities in the new dredging areas. Benthic infaunal communities would experience regular recurring cycles of removal and recovery for the duration of the 50-year project. Based on reported rates of benthic infaunal recovery in the Wilmington Harbor channel and other estuarine navigation channels (described above), the effects of individual dredging events on benthic infaunal communities in silty channel reaches would be relatively short-term (<6 months), whereas infaunal communities in sandy channel reaches of the lower estuary would experience longer term effects lasting one to two years. Although the impacts of individual dredging events would be temporary, recurring periods of infaunal depression would cause a reduction in total benthic community productivity over the 50-year project life. The magnitude of productivity loss would vary among channel reaches according to reach-specific dredging frequencies and infaunal recovery rates.

The initial channel deepening process would permanently modify the vertical position of soft bottom habitats within the water column, lowering their positions along vertical water column gradients of light, DO, and salinity. Depth increases would generally be accompanied by reduced light availability and DO and increased salinity. Light availability at the bottom is an important component of shallow (<6 ft) estuarine soft bottom habitats that supports significant primary productivity by benthic microalgae. Benthic microalgal productivity in turn supports high secondary productivity by soft bottom benthic infaunal invertebrate communities that comprise the prey base for most soft bottom fishes. Channel construction would convert 5.9 acres of shallow (<6 ft) estuarine soft bottom habitat to deepwater (>6 ft) bottom habitat. Light is strongly attenuated in the CFR estuarine water column by both turbidity and dark organic stained waters from the major blackwater river tributaries (Mallin 2013). Consequently, bottom light availability and benthic microalgal primary productivity in the shallow to deepwater conversion areas would be lost or reduced to insignificant levels. Losses of primary productivity would in turn reduce secondary productivity by benthic infaunal invertebrate communities in the conversion areas. Given the strong light attenuating properties of the CFR estuarine water column, reduced light availability at the bottom is not expected to be a factor affecting soft bottom communities that are currently positioned at depths greater than 6 ft.

As previously described (Section 8.8.2), model-projected decreases in DO concentrations in the deepened channel are ≤0.3 mg/L and occur during the winter when DO concentrations are the highest of the year. Thus DO is not expected to be a factor affecting benthic communities under the TSP. Average annual bottom salinities are projected to increase by ~4 to 5 ppt in the Anchorage Basin and Battleship channel reaches in the vicinity of downtown Wilmington. The distributions of mesohaline and oligohaline benthic assemblages would be expected to shift upstream accordingly. The dominant salinity-based benthic assemblages in the CFR estuary are continually shifting their relative positions along the longitudinal estuarine axis in response to seasonal fluctuations in salinity (Ray 1997), thus it is expected that benthic assemblages would respond rapidly to the projected salinity changes under the TSP. As described above, statistical analysis of infaunal community differences indicate that post-dredging infaunal recovery processes on the channel bottom and slopes eventually lead to the reestablishment of infaunal communities that are equivalent to those of adjacent undisturbed flats in terms of taxa richness, abundance, biomass, and species composition. The Wilmington Harbor study provides no indication that a vertical shift in habitat position from adjacent flat to channel slope or bottom would lead to permanent benthic community changes.

8.10.1.2 Marine Soft Bottom Effects

As described above, the majority of the marine soft bottom new dredging areas are associated with the proposed offshore entrance channel extension reach and the existing Baldhead Shoal 3 outer entrance channel reach. Existing bottom elevations in the extension reach and along the outermost section of the Baldhead Shoal 3 reach are within one to two feet of (and in some cases below) the proposed overdredge channel depth of -51 ft. Thus, depth increases and associated modifications of the soft bottom physical environment in these areas, which comprise ~65 percent (240 acres) of the total marine soft bottom new dredging area, would be minimal. Existing bottom depths in the remaining new dredging areas (~128 acres) range from approximately -45 ft near the mid-point of the Baldhead Shoal 3 reach to approximately -20 ft in the Baldhead Shoal 1 reach near the estuary mouth. Accordingly, the magnitude of depth change and physical habitat modification in the remaining areas would vary along an offshore to onshore gradient. As in the case of the estuary, statistical analysis of nearshore marine benthic infaunal community differences at channel bottom, slope, and adjacent undisturbed flat stations indicate that recovery processes in the channel eventually lead to the reestablishment of infaunal communities that are equivalent to those of adjacent undisturbed flats in terms of taxa richness, abundance, biomass, and species composition. The previously described Wilmington Harbor benthic study provides no indication that modification of the ocean physical bottom environment would lead to permanent changes in community composition or structure within the nearshore ocean new dredging areas.

Construction and long-term maintenance of the improved channel would have recurring impacts on marine soft bottom habitats and benthic infaunal communities in the new dredging areas. Reported rates of benthic infaunal recovery in the Wilmington Harbor channel indicate that infaunal communities in the sandy nearshore ocean channel reaches would experience effects lasting one to two years after each dredging event. The Wilmington Harbor benthic study did not investigate infaunal recovery in the offshore silty channel reaches. However, soft bottom habitats in deep offshore waters are relatively stable in relation to those of nearshore and estuarine environments. Consequently, the associated benthic infaunal communities are generally comprised of larger, longer-lived species that recover relatively slowly from disturbance. In the case of the entrance channel extension reach, infrequent dredging every 10 or more years would allow for full recovery during the interim periods between maintenance events. However, it is expected that dredging frequencies of one to two years in the Baldhead Shoal 3 and outer Baldhead Shoal 2 reaches would maintain the affected communities in a continual state of recovery, thereby permanently shifting composition towards that of a more opportunistic assemblage. Regardless of recovery rates, recurring periods of infaunal depression would reduce total benthic community productivity over the 50-year project life.

Table 8-6
Soft Bottom Dredging Impacts under the TSP

Channel Reach	Existing Width[1]	Proposed Width[1]	Dredging Frequency (Yrs)	Dredging Area (acres)		
				New[2]	Existing Channel[3]	Total
Anchorage Basin	625	625-1509	1	2	95	97
Between Channel	550	625	1	8	37	45
Fourth East Jetty	500	550	2	30	111	141
Upper Brunswick	400	500	2	21	48	69
Lower Brunswick	400	500	2	40	87	127
Upper Big Island	660	660	2	11	59	70
Lower Big Island	400	500	2	16	43	59
Keg Island	400	500	2	37	81	118
Upper Lilliput	400	500	2	41	102	143
Lower Lilliput	600	600	2	15	160	175
Upper Midnight	600	600	2	19	205	224
Lower Midnight	600	600	2	9	122	131
Reaves Point	400	500	9	22	67	89
Horseshoe Shoal	400	500	3	23	59	82
Snows Marsh	400	500	3	59	143	202
Lower Swash	400	800-500	2	48	62	110
Battery Island	500	800-1300	2	111	80	191
Southport	500	800	4	13	10	23
Baldhead-Caswell	500	800	4	10	21	31
Smith Island	650	900	2	22	62	84
Total Inner Harbor				**557**	**1,656**	**2,213**
Baldhead Shoal Reach 1	700	900	2	207	0	207
Baldhead Shoal Reach 2	900	900	2	132	398	530
Baldhead Shoal Reach 3	500-900	600-900	1	5	99	104
Entrance Extension	N/A	600	10	24	73	97
Total Ocean Entrance				**368**	**570**	**938**
Total Ocean + Inner Harbor				**925.0**	**2,226.0**	**3,151.0**
Total Dredging < 12 ft				14.8	4.6	19.4
Total Dredging > 12 ft				910.2	2,221.4	3,131.6
Total Dredging < 6 ft				5.9	2.3	8.2
Dredging PNA < 6 ft				3.5	0.0	3.5
Dredging PNA > 6 ft				28.8	0.0	28.8
Dredging AFSA < 6 ft				0.5	0.0	0.5
Dredging AFSA > 6 ft				99.9	478.1	578.0

[1]Channel bottom width, excluding side slopes
[2]New dredging encompasses the area between the existing channel top-of-slope and the proposed channel top-of-slope, along with the bottom and slopes of the proposed entrance channel extension reach.
[3]Existing channel dredging encompasses the existing channel bottom and side slopes.

8.10.2 Hardbottom

Remote sensing surveys did not identify any naturally occurring hardbottom resources within the proposed channel modification areas. As indicated above, previous investigations indicate that the nearest naturally occurring hardbottoms are located approximately two to three miles west of the entrance channel and the new ODMDS. One of the naturalized hardbottom rubble features that were identified in the old ODMDS is located along and just inside the proposed entrance channel top of slope (Appendix H: Hardbottom Resources). The TSP would widen the old ODMDS reach by 50 ft along either side of the channel; however, efforts would be made to avoid or minimize impacts to this hardbottom feature during the final channel design process. A slight shift in the channel alignment at this location would be sufficient to avoid the feature. Sediment suspension and redeposition effects during channel construction would be comparable to those of continuing maintenance dredging events under the No Action Alternative. Previous remote sensing surveys conducted by the USACE did not identify any hardbottom habitats within the new ODMDS or a surrounding 500-meter buffer zone. Therefore, proposed ocean disposal at the new ODMDS would not be expected to have any effect on hardbottom resources.

8.10.3 Shell bottom

Analyses of remote sensing survey data did not identify any structural shell bottom habitats within the existing channel or the proposed channel expansion areas. Therefore, construction of the proposed channel improvements would not have any direct mechanical impacts on shell bottom. The distribution of oyster reefs in the estuary is limited by salinity to the lowermost ~10-mile reach of the CFR (Rodriguez 2009). Therefore, oyster reefs would not be affected by confined blasting at locations 18 miles or more above the estuary mouth. The effects of dredging-induced sediment suspension and redeposition on oyster reefs outside of the navigation channel would be similar to the effects of maintenance dredging under the No Action alternative. As described above, the results of dredge plume monitoring at Wilmington Harbor indicate that significant sediment redeposition outside of the navigation channel would be unlikely. Therefore, it is expected that any sediment suspension and redeposition effects on shell bottom habitats would be temporary and minor.

8.10.4 Submerged Aquatic Vegetation

Based on the above described distribution of SAV in the estuary, construction of the proposed navigation channel improvements would not be expected to have any direct mechanical or sediment resuspension effects on SAV. Although SAV beds in the Brunswick River are removed from the proposed construction areas, slender naiad is a species of tidal freshwater to oligohaline habitats that is potentially vulnerable to indirect salinity intrusion effects. The identified occurrences are located on shallow subtidal flats adjacent to the shoreline, thus model-projected surface layer salinity data were used to evaluate potential salinity effects under the TSP. Model-projected average annual surface salinity increases in the vicinity of the Brunswick River SAV beds are ~0.2 ppt under typical year flow conditions and ~1.0 ppt under dry year flow conditions. The effects of these relatively small projected increases in salinity on slender naiad are difficult to predict; however, ten years of continuous salinity monitoring data from the Cape Fear River at the upper end of Eagle Island show that the area experiences intrusions of relatively high salinity water on a regular basis (Leonard 2011). The apparent tolerance of slender naiad to periodic high salinity pulses suggests that significant adverse effects would be unlikely under the TSP.

8.11 Fisheries

8.11.1 Impacts on Soft Bottom Nursery and Foraging Habitats

Construction of the proposed Wilmington Harbor navigation channel improvements, inclusive of the channel slopes, would directly impact ~925 acres of previously undisturbed (new dredging) soft bottom habitat in the proposed channel widening and extension areas; including ~557 acres of estuarine soft bottom habitat and ~368 acres of marine soft bottom habitat (Table 8-6, shown previously). New dredging estuarine soft bottom impacts would include ~32.3 acres of state-designated PNA habitat in the uppermost Anchorage Basin, Between Channel, and Fourth East Jetty project reaches. The vast majority (536 ac) of the existing estuarine soft bottom habitats in the proposed new dredging areas are currently positioned at depths >12 ft MLLW. Of the remaining estuarine soft bottom habitats in the new dredging areas, 15 acres are currently positioned at depths of 6 to 12 ft, and 5.9 acres are positioned at depths <6 ft. Construction and maintenance of the improved channel would impact soft bottom foraging and nursery habitat functions in the new dredging areas through permanent modification of the physical soft bottom environment and temporary recurring impacts on soft bottom habitats and associated benthic infaunal prey communities. The initial channel deepening process would lower the position of soft bottom habitats along vertical water column gradients. Increases in bottom depth would generally be accompanied by reductions in light availability and DO and increases in salinity. Long-term maintenance dredging of the improved channel would have recurring direct impacts on estuarine soft bottom habitats and benthic infaunal prey communities every one to four years for the duration of the 50-year project.

New dredging soft bottom impacts would include ~5.9 acres of shallow (<6 ft) estuarine soft bottom habitat and ~551 acres of deep (>6 ft) estuarine soft bottom habitat, as defined by the NCCHPP (NCDEQ 2016). Shallow (<6 ft) soft bottom habitats are especially important as foraging and nursery areas for the early juveniles of estuarine and estuarine-dependent fish and invertebrate species. High light availability at the bottom allows for substantial benthic microalgal primary productivity in shallow habitats, which in turn promotes high secondary productivity by benthic infaunal invertebrates that comprise the prey base for most soft bottom demersal fishes (NCDEQ 2016). Shallow soft bottom flats that are inaccessible to large predatory fishes provide critical refuge habitat for the early life stages of estuarine and estuarine-dependent fishes and invertebrates. Channel construction would permanently convert 5.9 acres of shallow (<6 ft) soft bottom habitat to deep (>6 ft) soft bottom habitat. Conversion would eliminate the shallow water refuge functions of these habitats, which in turn would render the affected soft bottom areas unsuitable as foraging habitat for the early juveniles of most estuarine dependent species. Bottom light availability and benthic microalgal primary productivity would be lost or reduced to insignificant levels in the shallow to deepwater conversion areas. Losses of primary productivity would in turn reduce secondary benthic infaunal productivity and the overall productivity of the affected bottom areas as foraging and nursery habitats for estuarine fisheries.

As indicated above, the vast majority (542 ac) of the existing deepwater estuarine soft bottom habitats in the new dredging areas are currently positioned at depths >12 ft, with the remaining 9 acres currently occupying depths of 6 to 12 ft. Although refuge and significant benthic primary productivity are lacking at these depths, deepwater soft bottom benthic infaunal communities are an important food source for the later life stages of estuarine and estuarine-dependent fisheries. As described in Section 8.8.2, the DELFT 3D model results indicate that the TSP would have negligible effects on temperature and DO concentrations. Dissolved oxygen concentrations in the estuary are projected to decrease by 0.3 mg/L or less in relation to the No Action Alternative; with the maximum decreases occurring during the winter months when DO concentrations are typically the highest (8 - 10 mg/L) of the year. The modeling results indicate that DO changes would not be a factor significantly affecting the productivity of soft bottom foraging habitats. As previously described (Section 8.10.1.2), statistical analysis of infaunal community differences between channel bottom, channel slope, and adjacent undisturbed flat sampling stations in the CFR estuary indicate that post-dredging infaunal recovery processes in the channel (bottom and slope) eventually lead to the reestablishment of infaunal communities that are equivalent to those of adjacent undisturbed flats in terms of taxa richness, abundance, biomass, and species composition (Ray 1997). The results of this study provide no indication that direct modification of the physical bottom environment would lead to permanent changes in community composition or structure within the new dredging areas. Benthic infaunal assemblages would be indirectly affected by projected bottom salinity increases along the longitudinal estuarine axis. Average annual bottom salinities are projected to increase by ~4 ppt in the Anchorage Basin and Battleship channel reaches in the vicinity of downtown Wilmington. Mesohaline and oligohaline benthic assemblages would be expected to shift upstream accordingly. However, as described by Ray (1997), the dominant salinity zone benthic assemblages are continually shifting their relative positions along the longitudinal estuarine axis in response to seasonal fluctuations in salinity. Thus, project–related prey shifts would not be expected to impact the foraging activities of predatory demersal fishes.

Long-term maintenance dredging of the improved channel would have recurring temporary impacts on estuarine soft bottom habitats in the new dredging areas every one to four years for the duration of the 50-year project. As previously described, reported rates of recovery in the Wilmington Harbor channel and other navigation channels indicate that the effects of individual dredging events on benthic infaunal communities in silty channel reaches would be relatively short-term (<6 months), whereas infaunal communities in coarse sand reaches would experience longer term effects lasting one to two years. Benthic infaunal prey availability in the new dredging areas would fluctuate in accordance with recurring cycles of removal and recovery. Although the effects of individual maintenance events would be temporary, recurring periods of infaunal depression would reduce total benthic infaunal productivity over the 50-year project life.

In summary, estuarine fisheries would be negatively affected by the permanent conversion of 5.9 acres of shallow soft bottom nursery and foraging habitat to deep bottom habitat and reductions in benthic infaunal productivity associated with recurring direct impacts on 551 acres of deep soft bottom foraging habitat. The magnitude of impact on fisheries productivity over the 50-year project life would depend on the availability of equivalent undisturbed foraging habitats and the capacity of those habitats to support additional fish and invertebrate productivity. In regard to availability, the lower mainstem portion of the estuary below Wilmington alone contains ~25,000 acres of soft bottom habitat (NOAA 1999). Studies of habitat utilization in the CFR estuary (Ross 2003, Rozas and Hackney 1984) have found that densities of many estuarine-dependent juveniles are high in nursery habitats throughout the majority of estuary from the lower high salinity salt marsh zone through the uppermost oligohaline reaches of the CFR and NECFR many miles above Wilmington, thus indicating that equivalent habitats are widespread within the estuary. Ross (2003) also found that density was not a factor affecting the growth rates of estuarine-dependent juveniles in nursery habitats of the CFR estuary, thus indicating that the habitats are below carrying capacity.

8.11.2 Entrainment

Hopper and cutterhead dredges have the potential to entrain fishes and invertebrates during all life cycle phases; including adults, juveniles, larvae, and eggs. Among adult and juvenile fishes, demersal species that inhabit the near-bottom water column environment are most likely to be entrained (Reine and Clarke 1998); however, studies have also reported the entrainment of pelagic fishes in small numbers (McGraw and Armstrong 1990). Entrainment studies indicate that dredging elicits an avoidance response by demersal and pelagic species and that most juvenile and adult fishes are successful at avoiding entrainment (Larson and Moehl 1990, McGraw and Armstrong 1990). The planktonic larvae of marine fishes and invertebrates lack effective swimming capabilities; and therefore, are vulnerable to entrainment by dredges operating in both offshore and inshore waters. Tidal inlets are a critical conduit for the larvae of ocean-spawning/estuarine-dependent fishes and invertebrates that spawn offshore on the continental shelf and use estuarine habitats for juvenile development. Successful larval recruitment to estuarine nursery areas is dependent on transport through a relatively small number of narrow tidal inlets. Larval ingress studies indicate that larvae accumulate in the nearshore ocean zone where they are picked up by along-shore currents and transported to the inlet (Churchill et al. 1999). The results of a long-term sampling program at Beaufort Inlet indicate that larval densities within the inlet are highest from late May to early June and lowest in November (Hettler and Chester 1990).

Larvae are concentrated in inlets during ingress periods, and thus are potentially more vulnerable to entrainment by dredges. However, model-projected larval entrainment studies at Beaufort Inlet indicate that entrainment rates are very low regardless of larval concentrations and the distribution of larvae within the water column (Settle 2003). Even under worst case conditions when the dredge is operating 24 hours/day and all larvae are assumed to be concentrated in the bottom of the navigation channel, the model-projected entrainment rate barely exceeds 0.1% of the daily (24-hour) larval flux through the inlet. Channel construction would temporarily increase the intensity of dredging operations in the Cape Fear River estuary; however, it is expected that the use of cutterhead dredges for all hydraulic dredging in the inlet and estuarine reaches would minimize the extent of larval entrainment, as the cutterhead mechanism is typically buried in the sediment during active dredging. Estuarine dredging operations under the TSP would adhere to the established fisheries environmental work window (1 August – 31 January), thereby avoiding peak larval ingress periods. Based on the low projected entrainment rates and avoidance of peak ingress periods, it is anticipated that the loss of larvae due to entrainment would have negligible effects on marine and estuarine-dependent fish and invertebrate populations. The studies described above indicate that most juvenile and adult demersal and pelagic fishes would be successful at avoiding entrainment.

8.11.3 Sediment Suspension and Redeposition

The extent and duration of dredging-induced sediment suspension are influenced by sediment composition at the dredge site, the type of dredge employed, and hydrodynamic conditions at the dredge site (Wilber et al. 2005). Prolonged sediment suspension and extensive turbidity plumes are primarily associated with the suspension of fine silt/clay particles that have relatively slow settling velocities, whereas sands and gravels that make up the coarse-grained sediment fraction resettle rapidly in the immediate vicinity of the dredge (Schroeder 2009). Construction of the proposed Wilmington Harbor navigation improvements would employ hydraulic pipeline (cutterhead), hopper, and mechanical (bucket) dredges. Associated disposal operations would include hydraulic (cutterhead) loading of barges for offshore transport to the ODMDS, mechanical (bucket dredge) scow loading for offshore transport to the ODMDS, direct transport to the ODMDS via self-propelled hopper dredges, and direct hydraulic (cutterhead) pipeline disposal to the beaches of Bald Head Island and Oak Island. Refer to Table 6-6 (previously shown) for a breakdown of dredging and disposal operations by equipment type, channel reach, and dates of operation (i.e., environmental work windows).

Sediment suspension by cutterhead dredges is generally confined to the near bottom water column in the immediate vicinity of the rotating cutterhead assembly (LaSalle et al. 1991).Based on sediment resuspension data collected during navigation dredging projects, Hayes et al. (2000) and Hayes and Wu (2001) reported average cutterhead dredge sediment resuspension rates ranging from 0.003 to 0.135% of the fine silt/clay fraction. Although cutterhead suspension rates at the sea floor are relatively low, hydraulic barge loading operations are typically associated with high suspension rates, primarily due to the surface discharge associated with overflow loading. Overflow loading is employed to achieve economically efficient loads for long-distance transport to offshore disposal sites. Similarly, hopper dredges are associated with high suspension rates due to the surface discharge associated with overflow loading of the hoppers. Mechanical dredges (bucket and clamshell) generally have the highest sediment suspension rates. Sediment suspension by mechanical dredges occurs through the impact of the bucket on the bottom, the washing of material out of the bucket as it is withdrawn from the bottom and moved through and above the water column, and losses of material during barge or scow loading via inadvertent spillage and/or intentional overflow loading to achieve economic loads (LaSalle 1990).

Dredging activities would directly affect marine and estuarine fishes through temporary sediment suspension and associated increases in turbidity. Dredging-induced increases in suspended sediment concentrations and turbidity can affect the behavior (e.g., feeding, predator avoidance, habitat selection) and physiological functions (e.g., gill-breathing) of marine and estuarine fishes. Additionally, the redeposition of suspended sediments can impact benthic invertebrate prey through direct burial and/or adverse effects on gill-breathing and filter-feeding functions (Michel et al. 2013). In response to fisheries concerns, a study was undertaken at Wilmington Harbor to monitor the sediment plumes produced by overflow barge loading in the Keg Island and Lower Big Island reaches of the navigation channel (Reine et al. 2002). The principal objective of the study was to determine the spatial extent of plumes and their potential to affect fish utilization of undisturbed nursery habitats that are adjacent to the maintained navigation channel. The study found that overflow plumes and elevated suspended sediment concentrations were narrowly confined to the navigation channel under both ebb and flood tidal conditions, with significant settling of the plumes to the lower portion of the water column occurring within ~300 meters of the barges. A maximum TSS concentration of 191 mg/L was recorded within the plume at the sampling point nearest the barge, whereas maximum TSS concentrations of 60 to 80 mg/L were recorded in the plume at a distance of 300 m. During active dredging, TSS concentrations over the adjacent flats remained similar to ambient conditions, with measured concentrations ranging from 19 to 33 mg/L. No evidence of plume migration or elevated TSS concentrations was detected over the adjacent flats during either the ebb or flood tide surveys.

Under the TSP, the intensity of dredging operations would temporarily increase during the initial three-year channel construction process; however, the results of the overflow plume study indicate that construction-related sediment suspension effects would primarily be confined to the navigation channel in the immediate vicinity of the barges. Dredging operations would adhere to the established fisheries environmental work window (1 August to 31 January), thus limiting the exposure of estuarine-dependent and anadromous species to potential sediment suspension effects. Pursuant to EPA's ocean dumping criteria established under the authority of the Marine Protection, Research, and Sanctuaries Act (MPRSA); water and dredged material would not be permitted to overflow or spill out of scows, barges, or hoppers during transport to the ODMDS. Post-construction channel maintenance would be accomplished through the continuation of current dredging practices. Relatively small increases in shoaling rates in the Anchorage Basin and lowermost inner harbor reaches would not require any modifications of the current maintenance dredging regime. Thus, the effects of maintenance dredging under the TSP would not differ significantly from the effects of maintenance dredging under the No Action alternative.

8.11.4 Confined Blasting

Confined blasting would be used as a pretreatment measure to break up hardened rock for subsequent removal by cutterhead and mechanical (bucket) dredges. Areas potentially requiring confined blasting encompass ~188 acres of rock surface area within the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches. These four reaches comprise a continuous ~4.4-mile section of the navigation channel from a point ~18 miles above the estuary mouth to a point approximately two miles below Eagle Island. Confined blasting involves the detonation of charges in drill holes that have been plugged with rock or other material (stemming) to prevent gas from escaping. A typical blast consists of an array of charges that are detonated on a delay to prevent cumulative blast pressure effects. Confined blasting greatly reduces blast pressure, which is the principal cause of injury to aquatic organisms.

The effects of confined blasting on fishes in the Cape Fear River estuary were investigated through a series of test blasts conducted during the fall and winter of 1998/1999 (Rickman 2000; Moser 1998, 1999). Test blasts consisting of 32 or 33 stemmed 52 to 62 pound charges on a 25 millisecond delay were conducted in a portion of the Big Island channel reach where blasting was to occur as part of the 96 Harbor Act Project. Hatchery reared shortnose sturgeon and striped bass along with locally captured white mullet and killifish were held in cages at distances of 35, 70, 140, 280, and 560 ft from the blast locations. Fish were evaluated and assigned an index of injury score immediately after the blasts and again after a holding period of 24 hours. Subsamples of the surviving sturgeon and striped bass that appeared to be uninjured based on external examination were subsequently necropsied to document internal injuries and assess the likelihood that fish would have recovered from any injuries that were identified. Additional subsamples of surviving fish were held in tanks for a period of two months to evaluate long-term survival. Blasts were also conducted with and without the use of air bubble curtains that were intended to reduce blast pressure impacts; however, bubble curtains were determined to have had little or no effect on fish survival, and were ultimately abandoned as a mitigative measure (Moser 1999, USACE 2000).

Survival rates at distances of 140 ft and beyond were similar to survival rates at control stations located 0.5 mile from the blast locations, thus indicating that effects were confined to the area within a 140-ft radius of the blast location (Moser 1999). At the 35-ft and 70-ft locations, shortnose sturgeon mortality and injury rates were much lower than those for all other species. Immediate post-blast survival rates for sturgeon at distances of 35 ft and 70 ft ranged from 82.2% to 99.8%. Sturgeon survival rates did not change over the 24 hour post-blasting holding period, and the long-term (two months) survival rates of sturgeons from the 35 ft and 70 ft locations were similar to those from the control station. Necropsies indicated that 88% and 100% of the surviving fish from the 35-ft and 70-ft locations would have recovered and survived long-term. Immediate post-blast survival rates for striped bass were approximately 65% at 35 ft and 90% at 70 ft; while the average combined survival rates for white mullet and killifish were approximately 50% at 35 ft and 90% at 70 ft. Necropsies of surviving striped bass from the 35-ft location indicated that 34% would have recovered and survived long-term. Most of the injuries to striped bass consisted of swim bladder damage; including ruptures and hemorrhaging. In contrast, sturgeon injuries consisted primarily of distended intestines and hemorrhaging of the interior body wall, with very few swim bladder injuries. Moser (1999) attributed the low incidence of swim bladder injuries and relatively high survival rates of sturgeon to a direct connection between the swim bladder and the esophagus that allows gas to escape rapidly.

Under the TSP, blasting methods and measures to mitigate blast pressure impacts on fisheries would be similar to those developed by the Wilmington District USACE for blasting in the northern Anchorage Basin as part of the last completed phase of the Wilmington Harbor 96 Act Project (USACE 2012). Although never employed, the effects of the planned blasting were evaluated in coordination with regulatory agencies through an Environmental Assessment (USACE 2012) and Section 7 formal consultation with the NMFS that resulted in a Biological Opinion (BO) for blasting effects on Atlantic and shortnose sturgeon (NMFS 2012b). The development of a site specific blasting plan for the TSP would be coordinated with federal and state resource agencies to ensure that the potential effects of blasting on fisheries are mitigated to the maximum extent practicable. Although some impacts on fisheries in the form of mortality and injury would be unavoidable, the blast mitigation test results indicate that impacts would be limited to a relatively small area. Therefore, with the implementation of an effective mitigation plan, blasting would not be expected to have significant adverse effects on the productivity of fisheries in the Cape Fear River estuary.

8.11.5 Water Quality and Salinity Effects

As described in Section 8.8.2, the DELFT 3D model results indicate that the TSP would have negligible effects on temperature and DO concentrations. DO concentrations in the estuary are projected to decrease by 0.3 mg/L or less in relation to the No Action Alternative; and the maximum decreases are projected to occur during the winter months when DO concentrations are typically the highest (8 - 10 mg/L) of the year. Therefore, changes in DO under the TSP would not be expected to have any significant adverse effects on fisheries. As described in Section 8.7.2, the model results indicate that channel deepening under the TSP would increase surface, mid-depth, and bottom salinities in relation to the No Action Alternative. Maximum increases in average annual salinity of ~4 to 5 ppt are projected in the bottom layer of the Anchorage Basin and Battleship channel reaches in the vicinity of downtown Wilmington. The distributions of mesohaline and oligohaline fish and benthic infaunal prey assemblages would be expected to shift upstream accordingly. Fish and benthic infaunal assemblages in the estuary are continually shifting their relative positions along the longitudinal estuarine axis in response to seasonal fluctuations in salinity, thus it is expected that fish and benthic assemblages would respond rapidly to salinity changes. Habitat Suitability Index (HSI) models were used to assess the effects of water quality and other on estuarine habitat quality for five representative species; including red drum, Atlantic menhaden, white shrimp, striped bass, and Atlantic sturgeon (Appendix J: Fish Habitat Assessment). The five species-specific estuarine models were selected by the Fisheries Technical Working Group (TWG) to represent a range of habitat-based estuarine-dependent and anadromous fish guilds. The models evaluate key life requisite habitat components for specific life stages; ultimately producing an overall index of habitat suitability between 0.0 (unsuitable habitat) and 1.0 (optimal habitat). The selected models rely primarily on physical habitat variables; including water quality, water depth, and hydrological characteristics. The majority of the model input data; including salinity, temperature, DO, and current velocities; were derived from the DELFT 3D hydrodynamic model results. The estuary was divided into six discrete modeling compartments; including the lower estuary, middle estuary, upper estuary, Cape Fear River, Northeast Cape Fear River, and Black River. The HSI models were run in GIS utilizing the DELFT 3D model grid to produce color-coded habitat suitability GIS layers for existing, FWOP, and FWP conditions. HSI values were averaged and multiplied by the total habitat area to produce an estimate of available Habitat Units (HUs) within each compartment.

Salinity change was the principal driver of all significant model-projected changes in habitat suitability. Accordingly, projected changes in habitat suitability for the representative species are primarily functions of their optimal salinity tolerance ranges and the model-projected increases in estuarine salinity. The modeling results for red drum, which is a highly euryhaline species that tolerates a wide range of salinities, the modeling results show no change in estuarine habitat suitability. Habitat suitability for the white shrimp, which is less tolerant of very high salinities, habitat suitability was reduced in the lower estuary compartment due to increased salinity. The model results for Atlantic menhaden, which is limited by both high and low salinities, show reduced habitat suitability in the lower estuary and increased suitability in the upper CFR and NECFR reaches. Overall, the compartmentalized model results for white shrimp and Atlantic menhaden resulted in small net reductions in HUs of one and three percent, respectively. Optimal salinity ranges and projected changes in habitat suitability for the anadromous species (striped bass and Atlantic Sturgeon) vary widely among specific life stages and spawning versus non-spawning adults. Spawning habitats are located far above the uppermost limit of project-related effects, and thus would not be affected under the TSP. HSI model results for non-spawning Atlantic sturgeon show salinity-driven decreases in foraging habitat suitability in the CFR near Navassa and in the NECFR immediately above Smith Creek. For striped bass, the suitability of existing poor quality foraging habitat between the Port of Wilmington and the mouth of NECFR is rendered unsuitable by increased salinity. Suitability of striped bass foraging habitat in the upper Brunswick River is also reduced due to increased salinity. Habitat suitability for striped bass larvae is reduced along the eastern bank of the CFR from Snows Cut up to Masonboro Country Club due to increased salinity.

8.12 Managed Fisheries and Essential Fish Habitat

The effects of the No Action Alternative and the TSP on fisheries and estuarine and marine habitats that comprise EFH and HPAC in the study area have been described in detail in the preceding sections. Additionally, pursuant to the MSFCMA, the EFH Assessment report in Appendix I: Essential Fish Habitat Assessment provides an in-depth evaluation of effects specific to EFH/HPAC and federally managed species. The sections below provide a brief summary of the anticipated effects of the alternatives on EFH, HPAC, and federally managed fisheries.

Under the TSP, dredging and disposal operations would have direct effects on EFH/HPAC and federally managed species that are similar to those described above for the No Action alternative. However, the extent of dredging and disposal operations and the magnitude of resulting effects would increase. As previously described, new dredging would increase the area of soft bottom habitat that is subject to recurring dredging disturbance by ~925 acres, including 32.3 acres of softbottom PNA habitat. Temporary losses of benthic invertebrate infauna would reduce the availability of benthic prey for federally managed species such as red drum, summer flounder, and estuarine-dependent snapper-grouper species. Deepening would convert 3.5 acres of shallow (<6 ft) PNA habitat to deepwater habitat, resulting in the loss of shallow refuge function. The loss of refuge function would render the areas unsuitable as foraging habitat for the early juvenile life stages of federally managed estuarine-dependent species; including summer flounder, estuarine-dependent snapper-grouper species, and coastal migratory pelagics.

Preliminary estimates indicate that the beach disposal volume during construction Year 2 would be approximately 1.5 times the typical maintenance disposal volume. An additional 1.5 to 2.5 linear miles of beach placement would occur during Year 2, resulting in additional impacts on intertidal and subtidal soft bottom EFH habitats along Bald Head Island and Oak Island. Additional temporary losses of soft bottom benthic infauna would reduce the availability of benthic prey for federally managed species that utilize nearshore unconsolidated bottom and ocean high salinity surf zone EFH habitats; including bluefish, red drum, and summer flounder. Beach disposal operations would adhere to the established sea turtle nesting environmental work window (16 November – 31 April) and beach fill compatibility standards; thereby avoiding peak infaunal recruitment periods and increasing the likelihood of relatively rapid benthic infaunal recovery. Based on projected channel shoaling rate increases under the TSP, post-construction maintenance dredging beach disposal volumes would increase by five percent in relation to the No Action alternative. A five percent increase would equate to an additional 0.14 mile of beach disposal on Bald Head Island or an additional 0.25 mile of disposal on Oak Island, thus indicating that the effects of recurring maintenance beach disposal would not differ significantly from the No Action alternative.

The use of confined blasting as a pretreatment measure to break up areas of hard rock would not have any additional direct impacts on softbottom habitats beyond those already described for dredging; however, confined blasting would have additional direct impacts on federally managed species in the form of mortality, injury, and/or behavioral disruption. As described in Section 8.11, the results of caged fish experiments conducted during mitigation blast tests for the Wilmington Harbor 96 Act Project found that mortality and injury were confined to the area within a 140-ft radius of the blast locations. Under the TSP, blasting methods and measures to mitigate blast pressure impacts on fisheries would be similar to those that were developed by the Wilmington District USACE for blasting in the northern Anchorage Basin as part of the last completed phase of the Wilmington Harbor 96 Act Project (USACE 2012). Although never employed, the effects of the planned blasting were evaluated in coordination with regulatory agencies through an Environmental Assessment (USACE 2012) and Section 7 formal consultation with the NMFS that resulted in a BO for blasting effects on Atlantic and shortnose sturgeon (NMFS 2012b). The development of a site specific blasting plan for the TSP would be coordinated with federal and state resource agencies to ensure that the potential effects of blasting on fisheries are mitigated to the maximum extent practicable.

As described in Section 8.8.2, hydrodynamic model results indicate that the TSP would have negligible effects on temperature and DO concentrations. Dissolved oxygen concentrations in the estuary are projected to decrease by 0.3 mg/L or less in relation to the No Action Alternative; and the maximum decreases are projected to occur during the winter months when DO concentrations are typically the highest (8 - 10 mg/L) of the year. As described in Section 8.7.2, the model results indicate that channel deepening under the TSP would increase surface, mid-depth, and bottom salinities in relation to the No Action Alternative. Under typical flow conditions, the maximum relative increases in average annual salinity occur in the mid-depth (3.9 ppt) and bottom (4.1 ppt) layers in the vicinity of the Anchorage Basin and the Battleship channel reach. Projected increases at all depths are rapidly reduced in the reaches above and below Wilmington. As described in Section 8.11, the potential indirect effects of water level, salinity, and water quality changes on fisheries were evaluated through the application of HSI models to a group of representative species, including two federally managed species (red drum and white shrimp). Salinity change was the principal driver of all significant model-projected changes in habitat suitability. The modeling results for red drum, which is a highly euryhaline species that tolerates a wide range of salinities, show no change in estuarine habitat suitability. Habitat suitability for the white shrimp, which is less tolerant of high salinities, was reduced in the lower estuary compartment due to increased salinity. The HSI model results for all species presented in Appendix J: Fish Habitat Assessment.

8.13 Coastal Waterbirds

Channel deepening would not have any direct impacts on intertidal or supratidal waterbird habitats. As described in Section 8.2.2, the XBeach hydrodynamic model was used to assess the effects of larger vessels and their associated ship wakes on historically erosional shoreline reaches in the vicinity of Southport, Battery Island, and Orton Point. In addition to Battery Island, a number of natural and man-made islands in the lower estuary are important nesting sites for colonial waterbirds. Although the additional islands were not specifically modeled, the ~1.0-mile-long disposal island immediately below Orton Point was included as representative of waterbird nesting islands that are adjacent to the navigation channel and thus potentially vulnerable to erosional effects. The modeling results show a decrease in bed shear stress along the northernmost Battery Island shoreline during inbound transits due to the new channel alignment being farther from the shoreline. Conversely, bed shear stress is projected to increase along the southern shoreline of Battery Island during outbound transits. Results for the disposal island below Orton Point show a general increase in bed shear stress along the channel adjacent shoreline that is somewhat reduced from south to north. Due to the proposed realignment and widening of the Battery Island channel reach, additional ship wake simulations were conducted to assess the effects of smaller 2,500 TEU vessels transiting closer to the shoreline. The small vessel simulations show a minimal increase in bed shear stress along the western coast of Battery Island and a decrease in bed shear stress along the northern shoreline of Battery Island.

Although increases in bed shear stress are an indicator of increased erosion potential, the model results do not address the extent of any additional erosion that might occur. However, the projected increases in bed shear stress indicate that additional modeling of Battery Island and the other channel-adjacent waterbird nesting islands is warranted. These islands would be included in expanded modeling analyses to be conducted during development of the DEIS and the PED phase of project development. Beneficial use and mitigation options that are currently under evaluation include the restoration of eroded waterbird nesting islands in the lower estuary and measures to mitigate ongoing erosion of the Battery Island shoreline. As described in Section 8.7.2, small projected increases in average annual surface salinity (≤0.3 ppt) may cause minor changes in tidal wetland community composition at the upper ends of salinity gradients in the estuary; however, these changes would not be expected to affect the availability or quality of coastal waterbird habitats.

As described in Section 8.2.2, the model results indicate that channel deepening would have minimal effects on sediment transport and shoreline erosion rates along the beaches of Bald Head Island and Oak Island. The effects of beach disposal on coastal waterbirds would be similar to the effects of continuing beach disposal of dredged material under the No Action alternative. Beach disposal of dredged material would occur during Year 2 of the three-year channel construction project and subsequently every two years in accordance with the existing sand management plan maintenance cycle. Expanded beach placement during construction Year 2 would impact an additional 1.5 to 2.5 linear miles of intertidal beach foraging habitat, resulting in additional temporary losses of benthic infaunal prey resources. Beach disposal operations would adhere to the established sea turtle nesting environmental work window (16 November – 31 April) and beach fill compatibility standards; thereby avoiding peak infaunal recruitment periods and increasing the likelihood of relatively rapid benthic infaunal recovery. Based on projected channel shoaling rate increases, post-construction maintenance beach disposal volumes would increase by five percent in relation to continuing beach disposal under the No Action alternative. A five percent volumetric increase would equate to an additional 0.14 mile of beach disposal on Bald Head Island or an additional 0.25 mile of disposal on Oak Island, thus indicating that the effects of maintenance beach disposal under the TSP would not differ significantly from those of disposal events under the No Action alternative.

8.14 Protected Species

8.14.1 North Atlantic Right Whale

8.14.1.1 Vessel Strikes

Hopper dredging operations in the offshore entrance channel reaches would coincide with right whale migration periods along the central NC coast. Although instances of lethal whale-dredge interactions (i.e., vessel collisions) have not been documented, a non-lethal interaction was reported in 2005 when a hopper dredge collided with an apparent right whale along the Georgia coast near the Brunswick Harbor entrance channel (NMFS 2012c). The risk of collisions between dredges and whales during channel construction would be very low, as hopper dredges travel at slow speeds (approximately three knots) during the active dredging process. The potential for vessel strikes would primarily be associated with transit between the channel dredging areas and the ODMDS offshore disposal site (unloaded hopper dredges are capable of speeds up to ~17 knots during transit) (USACE 2008). Hopper dredging operations would employ conservation measures to reduce the risk of vessel collisions; including the presence of protected species observers during transit, avoidance of right whales in accordance with 50 Code of Federal Regulations (CFR) 224.103(c), and adherence to Mid-Atlantic SMA speed restrictions for the Port of Wilmington (73 FR 60173). It is expected that these conservation measures would reduce the risk of collisions to negligible levels.

8.14.1.2 Underwater Noise

The NMFS defines two levels of acoustic "take" under the MMPA. Actions that may expose marine mammals to noise in excess of the values shown in Table 8-7 constitute Level A harassment with the potential to cause injury. Actions that may expose marine mammals to impulse (e.g., pile driving) noise levels ≥140 dB re 1µPa rms or continuous (e.g., dredging) noise levels ≥120 dB re 1µPa constitute Level B harassment with the potential to cause behavioral disruption. Clarke et al. (2002) reported hopper dredge noise levels ranging from 120 to 140 dB re 1µPa rms at a distance of 40m during navigation dredging in Mobile Bay, Alabama. A more recent study of the sounds produced by hopper dredges during sand mining at offshore borrow sites in Virginia reported noise levels ranging from 161 to 179 dB re 1µPa rms (Reine et al. 2014). Peak source levels did not exceed the NMFS Level A harassment threshold (≥180 dB re 1µPa rms) for injurious effects on marine mammals; however, noise levels generally exceeded the NMFS Level B harassment threshold (≥120 dB re 1µPa rms) within 1.2 km of the source and generally remained at or near 120 dB re 1µPa rms out to 2.1 km. According to a study by Clarke et al. (2002), cutterhead dredges produce peak sound levels in the range of 100 to 110 dB re 1µPa rms with rapid attenuation occurring at short distances from the dredge and sound levels becoming essentially inaudible at a distance of approximately 500m.

Table 8-7
Level A Permanent Threshold Shift Onset Harassment Values for Marine Mammal Hearing Groups

Hearing Group	PTS Onset (Received Level)	
	Impulsive	Non-Impulsive
Low-Frequency (LF) Cetaceans	PK: 219 dB SEL_{cum}: 183 dB	SEL_{cum}: 199 dB
Mid-Frequency (MF) Cetaceans	PK: 230 dB SEL_{cum}: 185 dB	SEL_{cum}: 198 dB
High-Frequency (HF) Cetaceans	PK: 202 dB SEL_{cum}: 155 dB	SEL_{cum}: 173 dB
Phocid Pinnipeds (PW)	PK: 218 dB SEL_{cum}: 185 dB	SEL_{cum}: 201 dB
Otariid Pinnipeds (OW)	PK: 232 dB SEL_{cum}: 203 dB	SEL_{cum}: 219 dB

PTS = Permanent Threshold Shift. PK = Peak sound level, SEL_{cum} = Cumulative sound exposure level
Source: NMFS (2016)

Based on the noise studies described above, the sound levels produced by cutterhead dredges would not be expected to exceed the NMFS thresholds for behavioral or injurious effects on marine mammals. In the case of hopper dredging, the previously described studies indicate that sound levels would not be expected to exceed the NMFS thresholds for injurious effects on marine mammals, but may exceed the thresholds for behavioral effects on marine mammals within 2.1 km of the dredge. Although shipping and industrial noise may represent a threat to large whales, the severity of this potential threat is unknown (NMFS 2010a). Most observations of marine mammal responses to anthropogenic noise have been limited to short-term responses involving cessation of feeding, resting, or social interactions. Therefore, it is expected that any behavioral effects on the North Atlantic right whales would be short-term and minor.

8.14.1.3 Confined Blasting

The proposed confined blasting areas encompass ~188 acres of rock surface area within the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches. The proposed confined blasting areas are located in the mid-estuary at a distance of 18 miles or more from the ocean. Based on sound pressure and dB levels produced by test blasting conducted in the Cape Fear River for the Wilmington Harbor 96 Act project, the Wilmington District determined that the NMFS thresholds for injurious and behavioral marine mammal effects would not be exceeded within ~560 ft and 3,500 ft of the blast locations, respectively (USACE 2000). Therefore, blasting would not be expected to have any adverse effects on North Atlantic right whales.

8.14.1.4 Critical Habitat

The essential features of right whale critical habitat within the study area are those associated with optimal calving habitat; including calm sea surface conditions, sea surface temperatures of 45°F to 63°F, and water depths of 20 ft to 92 ft. The TSP would not be expected to affect any of these essential features.

8.14.2 Florida Manatee

Hopper dredging operations in the outer harbor entrance channel would adhere to a dredging window of 1 December to 15 April; thus limiting operations to periods of relatively cold water temperatures when manatees are unlikely to be present in NC waters. Nearly all manatee sightings in NC waters have occurred between June and October when water temperatures were above 20^{o}C (Cummings et al. 2014). The use of hopper dredges would be limited to the outermost Baldhead Shoal 2 and 3 ocean entrance channel reaches where manatees would be unlikely to occur. Cutterhead dredging would occur year-round in the channel reaches below Snows Cut and from 1 July to 31 January in the above Snows Cut, thus coinciding with warmer periods when manatees could be present. Bucket dredge operations in the Keg Island to Lower Brunswick reaches would also occur year-round. Cutterhead and bucket dredges operate from anchored barges and would present only a minimal collision risk during brief periods of barge repositioning. The potential for vessel strikes would primarily be associated with support vessel operations and scow transits between the dredge sites and the ODMDS. As a measure to reduce the risk of collisions, all TSP dredging and disposal operations would implement Guidelines for Avoiding Impacts to the West Indian Manatee: Precautionary Measures for Construction Activities in North Carolina Waters (USFWS 2003).

Confined blasting operations in the ~4.4-mile Keg Island to Lower Brunswick channel reach would occur from 1 July to 31 January; thus coinciding with warmer periods when manatees could be present. Blasting operations under the proposed action would employ stemmed charges and charge delays to reduce the magnitude of potentially injurious blast shock waves. Drill holes containing the individual charges would be stemmed (capped) with angular rock or other suitable material for the purpose of containing blast energy within the rock. Studies indicate that the use of stemmed charges with confined blasting can reduce shock wave peak pressure by 60 to 90% in relation to unconfined open water blasts (Nedwell and Thandavamoorthy 1992, Hempen et. al. 2005). The use of delays between individual charge detonations limits the development of cumulative blast pressure. Blasting operations would implement protective measures for marine mammals similar to those previously approved by NMFS (2000, 2012) for proposed blasting operations under the Wilmington Harbor 96 Act Project. Protective measures would include the establishment of blast zones of influence and the development of a Watch Program in accordance with NMFS Southeast Region guidance for mitigating the effects of marine blasting on protected species; including marine mammals and sea turtles (Baker 2008). The development and implementation of a site-specific blast protection mitigation program would be coordinated with the USFWS, NMFS, and other resource agencies to ensure that the potential for adverse impacts on manatees and other protected species are effectively mitigated.

8.14.3 Other Marine Mammals

Under the TSP, the potential effects of dredging on humpback whales and bottlenose dolphins would be similar to those of the No Action Alternative. It is expected that the proposed conservation measures for the North Atlantic right whale would also effectively mitigate the potential for adverse dredging effects on humpback whales. As in the case of the right whale, the location of proposed blasting and the results of mitigation blast tests indicate that humpback whales would not be affected. Bottlenose dolphins may be present in the vicinity of the outer and inner harbor channel reaches during dredging and confined blasting operations. Due to their mobility, it is expected that the effects of dredging on dolphins would be limited to short-term avoidance behaviors. As described above, based on the results of test blasting conducted in the Cape Fear River for the Wilmington Harbor 96 Act project, the Wilmington District USACE determined that the NMFS thresholds for injurious and behavioral marine mammal effects would not be exceeded within ~560 ft and 3,500 ft of the blast locations, respectively (USACE 2000). Under the TSP, pre-blasting surveys and other conservation measures would be implemented to minimize the risk to dolphins. The development and implementation of a site-specific blast protection mitigation program would be coordinated with NMFS and other resource agencies to ensure that the potential for adverse impacts on bottlenose dolphins and other protected species are effectively mitigated.

8.14.4 Atlantic and Shortnose Sturgeon

8.14.4.1 Entrainment

Under the TSP, the potential dredge entrainment risk to shortnose and Atlantic sturgeon would be similar to that of the No Action Alternative. Analysis of historical take along the South Atlantic Coast indicates that the risk of dredge entrainment is primarily limited to hopper dredging within riverine channels (USACE 2014). Hopper dredges would be used only in the outer ocean entrance channel where any occurrences of Atlantic sturgeon would likely consist of subadults and adults that would be able to avoid the dredge. As a conservation measure to reduce the risk of entrainment, all hopper dredges would employ rigid draghead deflectors. The potential risk of entrainment to adult sturgeon is presumed to be low, and the use of rigid deflecting dragheads and associated operating requirements likely reduces the risk of entrainment (Dickerson et al. 2004). Analyses of cutterhead dredge intake velocities and sturgeon swimming capabilities indicate that the risk of entrainment is limited to juveniles within 1.0 meter of the dredge pipe intake (NMFS 2012). The only confirmed sturgeon takes by cutterhead dredges have occurred in the upper Delaware River, with all five entrainments occurring during the winter months in an area that is known to contain dense aggregations of sturgeon that are resting on the bottom and exhibiting little movement. NMFS has previously determined in dredging consultations that mechanical dredges are extremely unlikely to overtake or adversely affect sturgeon (NMFS 2019). Based on all of the above considerations, it is anticipated that the risk of direct injury to Atlantic sturgeon from dredging operations would be negligible under the TSP.

8.14.4.2 Confined Blasting

As previously described, the effects of confined blasting on shortnose sturgeon in the Cape Fear River estuary were investigated through a series of test blasts conducted during the fall and winter of 1998/1999 (Rickman 2000, Moser 1998, 1999). Hatchery reared shortnose sturgeon were held in cages at distances of 35, 70, 140, 280, and 560 ft from the blast locations. Fish were evaluated and assigned an index of injury score immediately after the blasts and again after a holding period of 24 hours. Subsamples of the surviving sturgeon that appeared to be uninjured based on external examination were subsequently necropsied to document internal injuries and assess the likelihood that fish would have recovered from any injuries that were identified. Additional subsamples of surviving fish were held in tanks for a period of two months to evaluate long-term survival.

Shortnose sturgeon survival rates at distances of 140 ft and beyond were similar to survival rates at control stations located 0.5 mile from the blast locations, thus indicating that injurious effects were confined to the area within a 140-ft radius of the blast location (Moser 1999). Immediate post-blast survival rates for sturgeon at distances of 35 ft and 70 ft ranged from 82.2% to 99.8%. Sturgeon survival rates did not change over the 24 hour post-blasting holding period, and long-term (two months) survival rates were similar to those from the control station. Necropsies indicated that 88% and 100% of the surviving sturgeon from the 35-ft and 70-ft locations would have recovered from any injuries and survived long-term. Injuries consisted primarily of distended intestines and hemorrhaging of the interior body wall; however, sturgeon experienced very few swim bladder injuries in relation to other species. Sturgeon mortality and injury rates were also much lower than those for other species that were utilized in the study. Moser (1999) attributed the low incidence of swim bladder injuries and relatively high survival rates of sturgeon to a direct connection between the swim bladder and the esophagus that allows gas to escape rapidly.

Under the TSP, confined blasting methods and measures to mitigate blast pressure impacts on sturgeon would be similar to those that were developed by the Wilmington District USACE for proposed blasting in the northern Anchorage Basin as part of the last completed phase of the Wilmington Harbor 96 Act Project (USACE 2012). Although never employed, the effects of blasting on Atlantic and shortnose sturgeon were addressed through Section 7 formal consultation with NMFS (NMFS 2012b). The development of a site specific blasting plan for the TSP would be coordinated with NMFS to ensure that the potential effects of blasting on sturgeon are mitigated to the maximum extent practicable. Although some risk to sturgeon would be unavoidable, the blast mitigation test results indicate that the potential for mortality and injury would be limited to a relatively small area. Therefore, with the implementation of an effective blast mitigation protection program, it is expected that the risk to sturgeon would be very low.

8.14.4.3 Effects on Foraging Habitat

As previously described, new dredging would increase the area of soft bottom habitat that is subject to recurring dredging disturbance by ~925 acres; including ~557 acres of estuarine soft bottom habitat and ~368 acres of marine soft bottom habitat (Table 8-6, shown previously). Depending on reach-specific maintenance intervals, soft bottom habitats in the new dredging areas would experience recurring dredging disturbance every one to four years for the duration of the 50-year project. Temporary losses of benthic invertebrate infauna would reduce benthic prey availability for Atlantic and shortnose sturgeon. As previously described, reported rates of recovery in the Wilmington Harbor channel indicate that the effects of individual dredging events on benthic infaunal communities in silty channel reaches would be relatively short-term (<6 months), whereas infaunal communities in coarse sand reaches of the lower estuary and nearshore ocean would experience longer term effects lasting one to two years. Recurring periods of infaunal depression would reduce total benthic infaunal productivity over the 50-year project life. Total losses of benthic productivity over the 50-year project life would vary among channel reaches in accordance with reach-specific maintenance intervals and recovery rates.

8.14.4.4 Salinity and Water Quality

As described in Section 8.8.2, the DELFT 3D model results indicate that the TSP would have negligible effects on temperature and DO concentrations. Dissolved oxygen concentrations in the estuary are projected to decrease by 0.3 mg/L or less in relation to the No Action Alternative; with the maximum decreases occurring during the winter months when DO concentrations are typically the highest (8 - 10 mg/L) of the year. The modeling results indicate that DO changes would not be a factor significantly affecting sturgeon or the productivity of soft bottom benthic infaunal prey communities.

As described in Section 8.7.2, the model results indicate that channel deepening under the TSP would increase surface, mid-depth, and bottom salinities in relation to the No Action Alternative. Under typical flow conditions, the maximum relative increases in average annual salinity occur in the mid-depth (3.9 ppt) and bottom (4.1 ppt) layers in the vicinity of the Anchorage Basin and the Battleship channel reach. Projected increases at all depths are rapidly reduced in the reaches above and below Wilmington. Mesohaline and oligohaline benthic assemblages in the vicinity of Wilmington would be expected to shift upstream accordingly; however, as described by Ray (1997), the dominant salinity zone benthic assemblages are continually shifting their relative positions along the longitudinal estuarine axis in response to seasonal fluctuations in salinity.

The juveniles of both species and, to lesser extent the adults, are known to follow and congregate at the salt front during certain times of the year. The largest salinity increases are projected in the vicinity of Wilmington where there are known concentration areas for sturgeon such as the Brunswick River. Although the position of the salt front varies widely throughout the year, an increase in average annual salinity would shift the average position of the salt front upstream, potentially affecting habitat use patterns. As described in Section 8.11.2.5, HSI model results for non-spawning Atlantic sturgeon show salinity-driven decreases in foraging habitat suitability in the CFR near Navassa and in the NECFR immediately above Smith Creek. A detailed discussion of the HIS modeling results is provided in Appendix J Fish Habitat Assessment.

8.14.4.5 Atlantic Sturgeon Critical Habitat

Designated critical habitat (Carolina Unit 4) for the Atlantic sturgeon encompasses the mainstem Cape Fear River from rkm 0 up to Lock and Dam #2 and the Northeast Cape Fear River from its confluence with the Cape Fear River to Rones Chapel Road Bridge at Mount Olive, NC. The PBFs of Atlantic sturgeon critical habitat that are essential to the conservation of the species include hardbottom substrate in low salinity waters for egg settlement and early life stage development; aquatic habitat encompassing a gradual salinity gradient (0.5-30 ppt) and softbottom (sand/mud) substrate for juvenile foraging and development; waters free of physical barriers and of sufficient depth to support passage and unimpeded movements of adults, subadults, and juveniles; and water quality conditions (temperature and oxygen) that support spawning, survival, development, and/or recruitment of the various life stages (82 FR 39160).

The proposed deepening project would affect Atlantic sturgeon critical habitat PBFs through direct recurring impacts on estuarine soft bottom foraging habitats and modification of the estuarine salinity gradient. The effects of the TSP on soft bottom foraging areas within designated critical habitat would be the same as those described above for Atlantic sturgeon. The projected salinity increases described above would alter the estuarine salinity gradient in the vicinity of known concentration areas, potentially reducing habitat suitability and/or shifting the distribution of suitable habitats within the estuary.

8.14.5 Sea turtles

8.14.5.1 Dredging

Loggerhead, green, Kemp's ridley, and hawksbill sea turtles are vulnerable to direct injury by hopper dredges as a result of being entrained in the dredge intake pipe during the sand extraction process. The Wilmington District USACE reported 37 sea turtle takes by hopper dredges in the vicinity of Wilmington Harbor between 1992 and 2013; including 30 loggerhead, four Kemp's ridley, and three green sea turtles. All of the takes occurred outside of the proposed 1 December – 15 April hopper dredging environmental work window for the TSP, with the exception of one Kemp's ridley that was taken during mid-December. Hawksbill sea turtles are rare in NC waters (Epperly et al. 1995a) and are primarily associated with coral reef habitats (NMFS and USFWS 2007c) that are restricted to deep offshore waters (>20 miles from shore) along the NC coast (MacIntyre and Pilkey 1969, MacIntyre 2003). Furthermore, there are no records of hawksbill incidental takes during dredging operations along the US South Atlantic or Gulf Coasts. Although the leatherback sea turtle has been documented in nearshore ocean waters during the warmer months, it is primarily a pelagic species of deep, oceanic waters. The pelagic feeding habit of the leatherback reduces its vulnerability to entrainment, and there are no records of incidental take by dredges along the South Atlantic or Gulf Coasts. Therefore, hopper dredging under the TSP would not be expected to have any direct impacts on hawksbill or leatherback sea turtles.

Hopper dredging operations in the ocean entrance channel reaches would adhere to a 1 December – 15 April environmental work window, thus limiting operations to the colder months when most loggerhead, green, and Kemp's ridley sea turtles have moved to warmer offshore waters beyond the proposed dredging areas. The distribution of sea turtles along the NC coast is characterized by a seasonal pattern of inshore migration during the spring and offshore migration during the fall. Aerial surveys indicate that sea turtle occurrences in estuaries and nearshore ocean waters along the NC coast are strongly correlated with sea surface temperatures ≥11°C (Goodman et al. 2007, Epperly et al. 1995c). As an additional conservation measure to reduce the risk of sea turtle entrainment, all hopper dredges would employ rigid draghead deflectors. Sea turtle entrainment rates are dramatically reduced when rigid deflector dragheads are used and deployed correctly (Dickerson et al. 2004). Cutterhead and mechanical dredges are not known to take sea turtles; and therefore, dredging activities in the inner harbor channel reaches would not be expected to have any direct impact on sea turtles.

8.14.5.2 Confined Blasting

The proposed confined blasting areas are located in the mid-estuary at a distance of 18 miles or more from the ocean. Sea turtles reportedly prefer higher salinity waters of the lower estuary (NMFS 2000, 2012). During a tracking study of 18 gill netted green and Kemp's ridley juveniles in the lower estuary, only one individual (a presumed mortality) moved north of Snows Cut (Snoddy and Williard 2010). Therefore, it is unlikely that sea turtles would be affected by blasting. However, the development of a site specific blast mitigation protection program for the TSP would be coordinated with NMFS to ensure that any potential blasting effects on sea turtles and other protected species are mitigated to the maximum extent practicable.

8.14.5.3 Beach Placement

Beach placement of navigation dredged material would occur within nesting habitat or potential nesting habitat for all five species of sea turtles. Beach placement operations would adhere to the established sea turtle nesting environmental work window (16 November – 31 April); thereby, avoiding direct impacts on nesting adult females, nests, and hatchlings. Sand placement can potentially modify beach nesting habitats in ways that reduce nesting attempts and/or nesting success. Observed declines in nesting on nourished beaches have been attributed to modification of the natural beach profile, substrate compaction, and escarpment formation (Crain et al. 1995, Steinitz et al. 1998, Ernest and Martin 1999, Herren 1999, Rumbold et al. 2001, Byrd 2004, and Brock et al. 2009). By design, sand placement projects construct a flat berm that gradually steepens to the natural equilibrium profile over time through natural sediment transport processes. The initial post-construction reduction in slope can deter nesting females from emerging onto the beach or increase the proportion of false crawls on the affected beaches. Furthermore, the beach profile equilibration process can induce the formation of escarpments that prevent adult females from accessing upper dry beach nesting habitats, and the compaction of sediments by construction activities can impede the ability of adult females to excavate nests.

Holloman and Godfrey (2008) studied the effects of multiple beach nourishment events on sea turtle nesting and hatching success on Bogue Banks, NC. The five-year study included monitoring of nesting activity, hatching success, substrate compaction, and nest temperature. No significant beach nourishment effects on nesting success (i.e., nest/false crawl ratios), egg development, or hatching success were detected; with the exception of one nest that apparently failed due to poor gas exchange. Nourishment had no significant effect on compaction; however, nests in nourished areas were on average 1.9°C warmer than nests laid at the same time on undisturbed beaches. Other studies that have documented declines in nesting on nourished beaches have generally reported a return to normal nesting activity by the second or third post-project nesting season (Crain et al. 1995, Steinitz et al. 1998, Ernest and Martin 1999, Herren 1999, Rumbold et al. 2001, Byrd 2004, and Brock et al. 2009). In the case of severely eroded beaches, the restoration of a wider and higher dry beach may enhance the quality of sea turtle nesting habitat. Studies have reported immediate increases in nesting success following sand placement on chronically eroded beaches (Davis et al. 1999, Byrd 2004).

Beach disposal of dredged material under the TSP would occur during Year 2 of the three-year channel construction project and subsequently every two years in accordance with the existing sand management plan maintenance cycle. Expanded beach placement during construction Year 2 would impact an additional 1.5 to 2.5 linear miles of sea turtle beach nesting habitat, resulting in additional temporary reductions in nesting habitat suitability. Based on projected channel shoaling rate increases, post-construction maintenance beach disposal volumes would increase by five percent in relation to continuing beach disposal under the No Action alternative. A five percent volumetric increase would equate to an additional 0.14 mile of beach disposal on Bald Head Island or an additional 0.25 mile of disposal on Oak Island, thus indicating that the effects of maintenance beach disposal under the TSP would not differ significantly from those of disposal events under the No Action alternative. Measures to minimize beach disposal effects on sea turtle nesting habitat would include adherence to beach fill compatibility standards and the implementation of escarpment and compaction monitoring in accordance with established Wilmington District practices. Only compatible material that is similar in grain-size composition and color to native beach sediments would be placed on the beach.

8.14.5.4 Loggerhead Critical habitat

Hopper dredging in the nearshore ocean Baldhead Shoal Reach 1 entrance channel reach would occur within designated marine nearshore reproductive critical habitat for the loggerhead sea turtle. The delivery of dredged material from cutterhead dredges in the Baldhead Shoal Reach 1 channel to beach disposal sites on Baldhead Island and Oak Island would require the placement of pipelines in nearshore critical habitat. The presence of dredges and pipelines in the nearshore zone could potentially affect the habitat conditions that allow for unimpeded hatchling egress and/or the unimpeded passage of adults to and from the nesting beach. However, based on avoidance of the sea turtle nesting and hatching season in NC, it is unlikely that any loggerhead turtles would experience a loss of these habitat functions.

Beach disposal would occur within designated terrestrial critical habitat for the loggerhead sea turtle. As described above, projected shoaling rate increases indicate that channel maintenance beach disposal events under the TSP would not differ significantly from continuing disposal events under the No Action alternative. The additional 1.5 to 2.5 linear miles of beach disposal during construction Year 2 would not be expected to have any significant relative effects on loggerhead critical habitat. Measures to minimize potential effects on beach nesting habitat would include adherence to the established sea turtle nesting environmental work window (16 Nov – 30 April), the placement of only compatible material that is similar in grain-size composition and color to native beach sediments, and the implementation of escarpment and compaction monitoring.

8.14.6 Piping Plover and Red Knot

Under the TSP, the potential effects of beach disposal on piping plovers and red knots and wintering critical habitat for the piping plover would be similar to those of continuing beach disposal oprations under the No Action Alternative. Beach disposal of dredged material under the TSP would occur during Year 2 of the three-year channel construction project and subsequently every two years in accordance with the existing sand management plan maintenance cycle. Expanded beach placement during construction Year 2 would impact an additional 1.5 to 2.5 linear miles of intertidal beach foraging habitat, resulting in additional temporary losses of benthic infaunal prey resources. Based on projected channel shoaling rate increases, post-construction maintenance beach disposal volumes would increase by five percent in relation to continuing beach disposal under the No Action alternative. A five percent volumetric increase would equate to an additional 0.14 mile of beach disposal on Bald Head Island or an additional 0.25 mile of disposal on Oak Island, thus indicating that the effects of maintenance beach disposal under the TSP would not differ significantly from those of disposal events under the No Action alternative. Potential effects on piping plovers and red knots would be minimized through adherence to all terms and conditions of the SMP BO (USFWS 2000). As described in Section 8.2.2, the XBeach model results indicate that deepening would have minimal effects on sediment transport and shoreline erosion rates along the beaches adjacent to Cape Fear River Inlet. Back barrier intertidal flats that comprise critical wintering habitat for the piping plover at Fort Fisher are located ~1 mile east of the navigation channel; therefore, no effects on critical habitat would be expected under the TSP.

8.14.7 Wood Stork

The nearest documented wood stork nesting colony is located approximately four miles above the study area in Bladen County, and no potential nesting habitat in the study area would be directly impacted under the TSP. No potential wetland foraging habitat would be directly impacted, and the effects of the project on salinity intrusion and potential tidal wetland foraging habitats are anticipated to be minor. Therefore, the TSP would not be expected to have any adverse effects on the wood stork.

8.14.8 Seabeach Amaranth

Under the TSP, the potential effects of beach disposal operations on seabeach amaranth would be similar to those of the No Action Alternative. Beach disposal would be conducted in accordance with all terms and conditions of the SMP BO (USFWS 2000). The frequency and extent of beach disposal on Bald Head Island and Oak Island under the TSP would not differ significantly from the No Action alternative.

8.15 Invasive Species

Under the TSP, the fleet of 10,000 to 11,000 TEU container vessels that currently call on the Port of Wilmington would be replaced by newer, larger 12,400 TEU container vessels. Landside origins and destinations would not change in relation to the No Action Alternative, as export and import volumes moving through the Port of Wilmington's hinterland would remain the same. Therefore, it is expected that the potential for invasive species introductions via foreign trade would be similar to that of the No Action Alternative.

8.16 Managed and Protected Areas

There are no marine or estuarine protected areas that would directly affected by channel deepening. There are several managed and protected areas in the lower estuary that encompass estuarine waters, islands and marshes to the east of the navigation channel; including the Bald Head Island State Natural Area, Zekes Island NCNERR, and Carolina Beach State Park. The hydrodynamic and ship wake modeling results do not show any changes in current velocities or erosional conditions that would affect these areas, with the exception of Battery Island component of the Bald Head Island State Natural Area. As described in Section 8.2.2, the ship wake model results indicate that bed shear stress along the southern shoreline of Battery Island would increase during outbound transits. Increases in bed shear indicate the potential for increased erosion; however, the XBeach model results do not address the extent of any additional erosion that might occur. Potential effects on the Battery Island shoreline and the need for mitigation would be evaluated further during development of the DESI and the PED phase of project development.

8.17 Air Quality

Under the TSP, dredges and other heavy machinery would produce exhaust emissions similar in composition to those of continuing maintenance dredging operations under the No Action Alternative. During periods of active construction, temporary increases in dredging activity and exhaust emissions would be expected; however, Brunswick and New Hanover Counties are in attainment for all criteria pollutants, and it is anticipated that emissions would be rapidly dispersed. The 10,000 to 11,000 TEU container vessels that currently call on the Port of Wilmington would be replaced by larger 12,400 TEU container vessels under the TSP. The 12,400 TEU fleet of would consist of newer vessels that emit less air pollutants per unit weight of cargo when fully loaded. In addition, truck miles traveled moving cargo to and from the Port of Wilmington's hinterland would be substantially reduced under the TSP, thereby reducing greenhouse gas emissions (Tables 6-22 through 6-24). Therefore, it is expected that air emissions under the TSP would be reduced in relation to the No Action Alternative.

8.18 Noise

Noise impacts on marine mammals associated with implementation of the TSP is discussed above in Section 8.14.1. As stated in that section, the sound levels produced by cutterhead dredges would not be expected to exceed the NMFS thresholds for behavioral or injurious effects on marine mammals. In the case of hopper dredging, the previously described studies indicate that sound levels would not be expected to exceed the NMFS thresholds for injurious effects on marine mammals but may exceed the thresholds for behavioral effects on marine mammals within 2.1 km of the dredge. Most observations of marine mammal responses to anthropogenic noise have been limited to short-term responses involving cessation of feeding, resting, or social interactions. Therefore, it is expected that any behavioral effects on the marine mammals would be short-term and minor.

Past geotechnical investigations and recent geophysical surveys (Appendix B: Geotechnical) involving rock strength analysis indicates that rock over 4,000 psi would require blasting, while rock under this strength can be removed with either a cutterhead dredge or a rock bucket clamshell dredge and would not require blasting. As a result of this analysis and the fact that the USACE did not require blasting for the 2000-2002 project, further geotechnical analysis will be performed during PED to reduce the footprint of rock over 4,000 psi, therefore minimizing potential effects resulting from noise impacts to marine mammals and fish that blasting may cause.

8.19 Hazardous, Toxic, and Radioactive Waste (HTRW)

There are no known HTRW sites in the Cape Fear River that would be encountered during channel construction. Channel deepening in the Anchorage Basin would not encounter contaminated soils on the North Terminal Property (i.e., former Southern Wood Piedmont site), as the channel would not be widened at this location. Therefore, no adverse effects related to HTRW would be expected under the TSP.

8.20 Aesthetics and Recreation

Under the TSP, it is expected that channel deepening and beach disposal operations would have short term and localized effects on aesthetics and recreation that are similar to those of the No Action Alternative. Confined blasting would result in additional restrictions on vessel traffic and recreational activities such as fishing; however, these restrictions would be short-term would not restrict recreational vessel passage through the Cape Fear River estuary.

8.21 Coastal Barrier Resources

The effects of the TSP on Cape Fear Unit NC-07P would be the same as those of the No Action Alternative. The TSP would not result in any federal spending that would affect the CBRS.

8.22 Cultural and Historic Resources

Of the investigated underwater targets, only the paddlewheel of the CSS *Kate* was considered historically significant. This Confederate blockade runner was previously identified by the NC UAB. Remote sensing surveys did not identify any potentially significant targets within the ocean channel survey areas. No subbottom paleofeatures potentially representing prehistoric sites were identified in either the inner or ocean survey areas. Construction of the TSP could result in damage to the spindle of the paddlewheel of the CSS *Kate*, located on the west channel slope in the lower river (Figures 8-5 and 8-6). As described in the report (Appendix G: Cultural Resources), removal of the remains of the vessel from this existing slope and proposed widening area should be performed. A relocation and or recovery plan will be prepared and coordinated with the State Historic Preservation Office and NC UAB in accordance with Section 106 during the formal NEPA coordination by the Wilmington District USACE.

A number of NRHP-listed historic sites are located along the banks of the CFR; including the USS North Carolina, Wilmington Historic District, Brunswick Town/Fort Anderson State Historic Site, Orton Plantation, Fort Fisher State Historic Site, Southport Historic District, Fort Caswell Historic District, and the Bald Head Island Lighthouse. Shoreline erosion has been an issue of concern in the vicinity of Southport Historic District, Orton Plantation, and Brunswick Town/Fort Anderson. Accordingly, modeling analyses were used to evaluate the potential effects of channel deepening and ship wakes on these areas. The model results indicate that the TSP would have negligible effects on the Southport shoreline. Along the shoreline of Orton Plantation and Brunswick Town/Fort Anderson, ship wave water levels and bed shear stress are generally projected to decrease; however, increases in bed shear stress are projected to occur at isolated locations along the shoreline. Increases in bed shear indicate the potential for increased erosion; however, the model results do not address the extent of any additional erosion that might occur. The potentially affected shoreline areas would be evaluated further during the Pre-Construction Engineering and Design (PED) phase of project development. Tidal nuisance flooding has been an ongoing issue of concern for the downtown Wilmington waterfront and Battleship Park. Under the TSP, the DELFT 3D hydrodynamic modeling results show a maximum relative MHW increase of 1.4 inches in the vicinity of downtown Wilmington and the Anchorage Basin, with progressively smaller increases through the up-estuary and down-estuary reaches above and below. MHW increases of 1.4 inches or less would not have any significant effect on the frequency of nuisance flooding events, and thus would not be expected to adversely affect historic sites along the CFR.

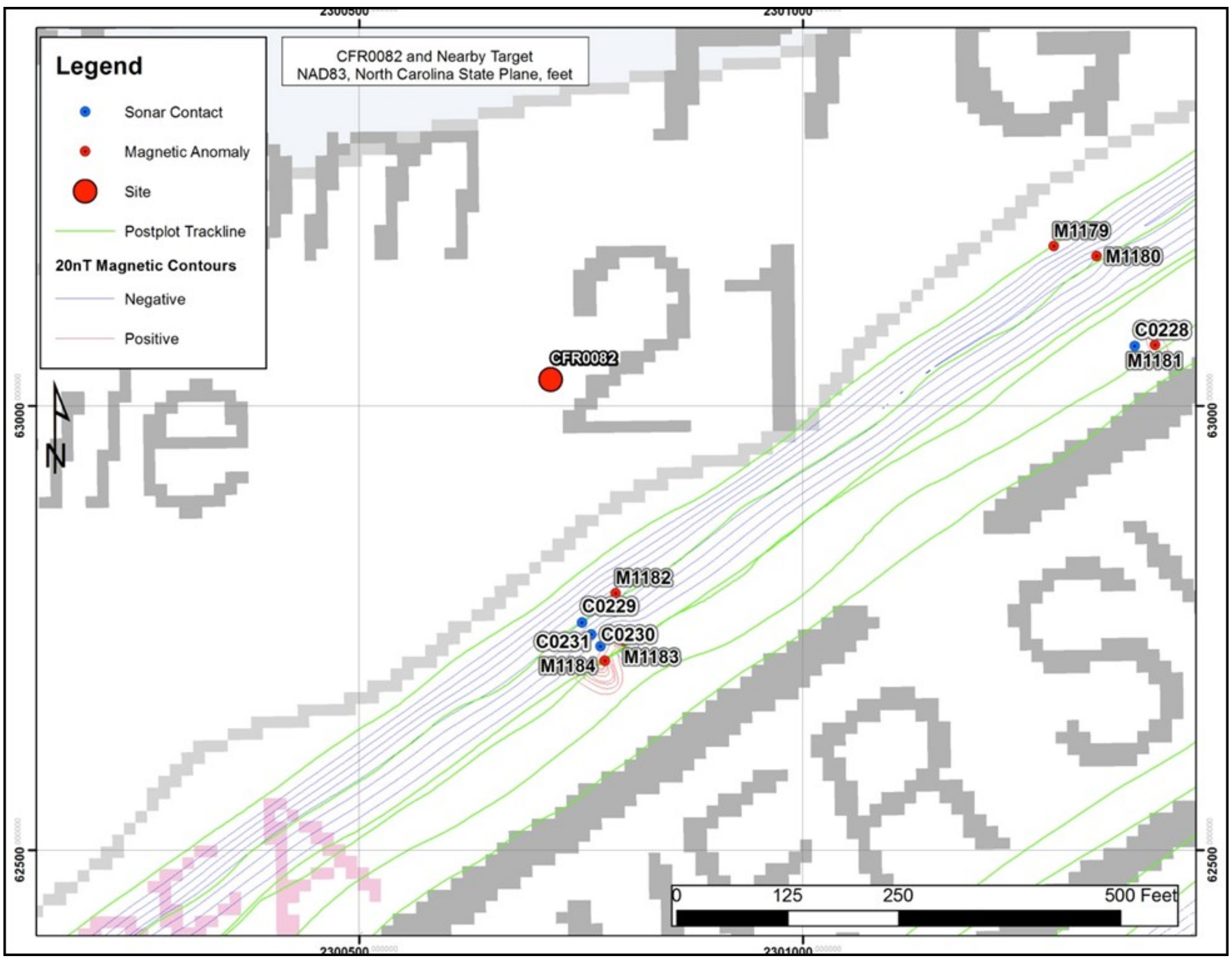

Figure 8-5
Cluster map of Target 6; note proximity to Site CFR0082, the wreck site of the Confederate blockade-runner *Kate*

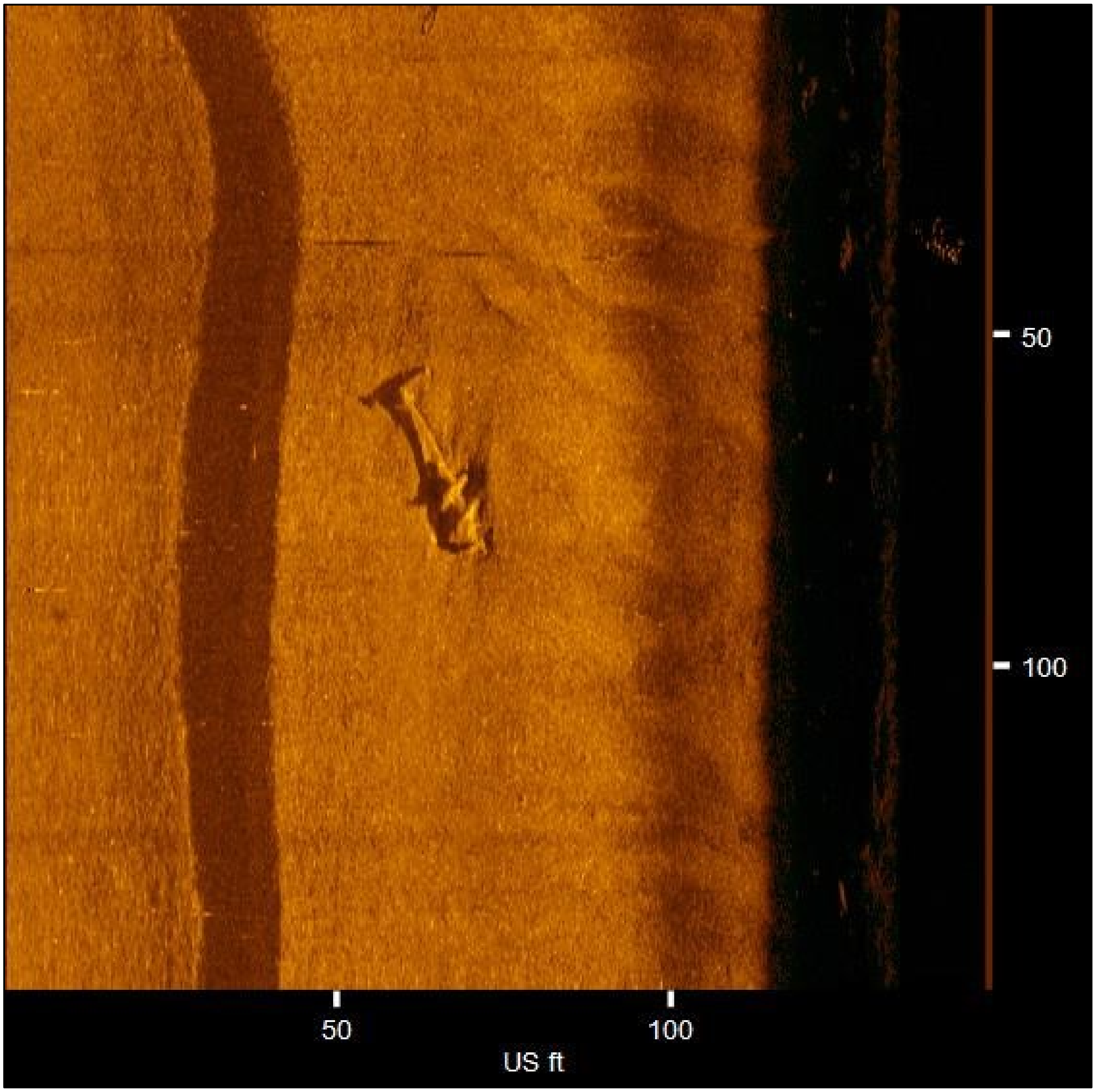

Figure 8-6
Acoustic image of Target 6, Contact C0230, believed to represent a paddlewheel shaft from the Confederate blockade-runner *Kate*

8.23 Socioeconomics

Under the TSP, the fleet of 10,000 to 11,000 TEU container vessels that currently call on the Port of Wilmington would be replaced by larger 12,400 TEU container vessels. However, projections indicate that the total volume of import and export moving through the Port of Wilmington's hinterland would remain the same, however under the TSP more cargo would use the Port of Wilmington. The increased cargo moving through the Port of Wilmington would increase local revenue, employment, and wages a identified in Section 5.5.2 Regional Economic Development. Therefore, the TSP would likely have beneficial effects on low income and minority populations as compared to the effects of the No Action Alternative.

8.24 Cumulative Effects

The NEPA, as implemented by CEQ regulations (40 CFR §§ 1500 -1508) requires federal agencies, including the USACE, to consider cumulative impacts in rendering a decision on a federal action under its jurisdiction. According to 40 CFR § 1508.7, a *cumulative impact* is the impact on the environment that results from the incremental impact of the proposed project when added to other past, present, and reasonably foreseeable future actions regardless of the agency (federal or non-federal) or person that undertakes such other actions; cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Cumulative effects include, but are broader than, the direct and indirect effects described in other sections of the EIS. According to 40 CFR 1508.8, "direct effects" are caused by the action and occur at the same time and place, while "indirect effects" are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. A cumulative impact analysis assesses the total impact of the direct and indirect effects of the proposed action in combination and interaction with the effects of all other activities impacting the same resources.

An inherent part of the cumulative effects analysis is the uncertainty surrounding future actions that have not yet been fully developed. The regulations provide for the inclusion of uncertainties in the impact assessment analysis, and state that "when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an EIS and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking" (40 CFR Part 1502.22). However, the CEQ has also recognized that "the complexities of cumulative effects problems ensures that even rigorous analyses will contain substantial uncertainties about predicted environmental consequences" (*Considering Cumulative Effects Under the National Environmental Policy Act*, CEQ 1997).

The cumulative impact analysis presented in this EIS is consistent with guidance documents issued by the CEQ, *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ 1997), and USEPA, *Consideration Of Cumulative Impacts In USEPA Review of NEPA Documents*, (USEPA 1999) as well as CEQ's additional *Guidance on the Consideration of Past Actions in Cumulative Effects Analysis* (CEQ 2005). The analysis used the following approach:

- For each resource area addressed in Sections 2 and 8 of this document, the potential for cumulative effects on these resources from the action alternatives in combination with other past, present, or reasonably foreseeable future actions was considered.
- For those resource areas that were determined to have potential for cumulative effects, an appropriate geographic scope (or geographic study area) for the cumulative impacts analysis for those resources was identified.
- Within the geographic study area for each resource, past, present, or future actions having the potential for additive and/or interactive effects were identified.
- The cumulative impacts of the past, present, and future actions in combination with the impacts assessed for the alternative sets was then assessed. This assessment considered synergistic and countervailing impacts and identified whether the cumulative impacts on resources was adverse or beneficial and minor, moderate, or significant.

8.24.1 General Project Area

The general project area considered in this study includes the Cape Fear River estuary and surrounding areas, the barrier island beaches of Bald Head Island and Oak Island, and offshore areas encompassing the ocean entrance channel and Wilmington ODMDS (Figure 2-1, shown previously in Section 2) The Cape Fear River estuary encompasses the tidally affected river basin systems and wetlands of the lower Cape Fear River basin including the mainstem Cape Fear River and small tributaries from the Atlantic Ocean up to Lock and Dam #1 at Kelly, NC (~60 river miles), the Northeast Cape Fear River from its confluence with the Cape Fear River up to NC HWY 53 (~48 river miles), and the Black River from its confluence with the Cape Fear River up to NC HWY 53 (~24 river miles).

8.24.2 Past, Present, and Future Actions

Cumulative effects analysis for the proposed project includes a review of the impacts of past, present, and reasonably anticipated future dredging actions on water quality, tidal wetlands and unvegetated benthic habitat. Past dredging projects (2000-present) for new construction and maintenance of the harbor and berths at the port includes the harbor deepening to -42 ft. in 2000-2002, expansion of the turning basin at the port in 2015, and other maintenance operations of the federal channel and port and private berths (i.e., agitation dredging, maintenance dredging). Present projects include recent permits issued in the past year for agitation and water injection dredging. Relevant future projects will include continued maintenance dredging, the proposed multi-use terminal, and the expansion to the Turning Basin, and construction of the TSP once authorized by Congress. Table 8-8 includes a list of all dredging related projects and specific information associated with each action. The table does not include reoccurring shore protection projects at Oak Island or Bald Head Island, nor does it include annual maintenance of the federal channel, which would occur under both the No Action Alternative and the TSP.

It is not likely that Wilmington Harbor will undergo additional deepening in the foreseeable future. Although the fleet will get larger from a TEU capacity, which is accomplished by making longer and wider vessels, while vessel maximum drafts have leveled off in the 51 to 53 foot range. Wilmington at -47 feet is within the normal operating range for vessels in the foreseeable future. Not all ports need to be at the deepest end of the range such as New York, Norfolk, Boston, Charleston, and Miami, which are capable of accepting very deeply loaded vessels. As long as Savannah stays at -47 feet, Wilmington has no reason to dredge beyond -47 feet. The frequency of vessels calls will actually be less, but serviced by larger vessels.

Table 8-8
Past, Present and Foreseeable Future Projects

Project	Dates	Purpose	Tidal Wetland	Benthic Habitat (PNA)	Water Quality
Past Projects (2000-2016)					
Wilmington Harbor Deepening	2000-2002	Dredging to -42 ft MLLW	No direct or indirect wetland impacts	None impacted	Moderate
Turning Basin Expansion	2015	Expansion of basin for larger vessels	No	8.53 acres	Minimal, short-term
Present (2017-2018)					
Water Injection Dredging	2017	Maintenance of berths	No	Minimal and short-term	Minimal
Future (2019-2022) Proposed					
Multi-purpose Terminal	2020	Berthing and storage for break bulk	No direct impact to tidal wetlands, 0.06 ac of indirect effect	4.94 acres	Minimal and short-term
Turning Basin Expansion	2019	Expand basin to accommodate larger vessels	1.4 ac of tidal wetland and Section 404 wetlands	17.76 ac (3.8 acres < 4 meters)	Minimal and short-term

8.24.3 Cumulative Impacts Analysis on Selected Resources

The potential cumulative impacts resulting from the combination of past, present, and foreseeable future actions within the general project area include direct and indirect effects on tidal wetlands, water quality, and benthic communities.

8.24.3.1 Tidal Wetlands

Human activities and sea level rise over the last two centuries have dramatically altered the composition and distribution of tidal wetland communities in the Cape Fear River estuary (Hackney and Yelverton 1990). The past 150 years of dredging and harbor improvements, as well as the conversion of wetlands to rice plantations, watershed development, and sea level rise, have greatly reduced the extent and altered the composition and distribution of tidal wetlands in the lower Cape Fear River estuary. Incremental channel deepening and sea level rise since the late 1800s have increased the tidal range in the Cape Fear River, resulting in salinity intrusion and the conversion of tidal freshwater swamp forests to brackish marsh along the middle to upper reaches of the estuary. Hackney and Yelverton (1990) suggest that the distribution of former rice fields is a reliable indicator of the pre-settlement extent of tidal freshwater wetlands along the river, as rice is incapable of growing in fields that are flooded by saline water >1 ppt. Based on this indicator, tidal freshwater wetlands would have been present at least as far downriver as Orton Plantation, ~12 miles above the river mouth.

Tidal marshes and wetlands are especially vulnerable with respect to changes brought on by climate change and sea level rise, and potentially due to dredging. Two of the main effects include tidal marsh submergence and habitat migration, which will occur as wetlands move landward and replace tidal freshwater and brackish wetlands (Moorhead and Brinson 2005; Park et. al. 1991). Conversion of tidal swamps to tidal marshes occurs not only due to increased salinity, but by the sulfate constituent in seawater. Once the sulfate concentration increases to an adequate amount in soil, sulfate-reducing bacteria activate and begin converting sulfate to hydrogen sulfide; thus killing plant life not adapted to this chemical and beginning the habitat transition from swamp to marsh. Species of herbaceous vascular plants with salinity tolerance begin to dominate (Hackney and Avery 2015).

The decrease in wetland areas and conversion of other habitats would result in a reduction of the ecosystem services provided by these wetlands, which include reduced productivity and waste treatment. Fresh and saltwater wetlands (i.e. those at the upper and lower ranges of salinity) would be most affected by sea level rise. Freshwater wetlands will be overtaken by brackish marshes migrating inland while saltwater wetlands will likely be submerged due to their low rate of vertical accretion that would be unlikely to keep up with the projected rate of sea level rise (Craft 2007). Declines in wetlands and marsh habitats may also result in cascading effects on important animal species such as the American alligator, wood stork, and other species that rely on wetland habitats.

There have been no direct impacts to tidal wetlands within the Cape Fear River associated with NCSPA port and federal harbor actions that have occurred over the past 20 years. The last federal channel deepening project in the early 2000s did not directly impact any wetlands; and did not result in any adverse indirect effects on tidal wetlands, based on model-projected salinity changes and ten years of post-construction salinity and vegetation monitoring (USACE 2012). Maintenance dredging and agitation/water injection dredging of the federal channel and/or berths has not and will not impact wetlands in the future. No tidal wetlands were impacted by the 2015 turning basin expansion. Potential impacts associated with future dredging projects by the port include impacts to 0.06 acres of tidal marsh due to shading and 8.64 acres of impacts to Section 404 non-tidal freshwater wetlands for the proposed future multi-use terminal, and 1.4 acres of coastal and Section 404 wetland impacts for the proposed turning basin expansion. This includes 1.01 acres coastal wetlands (smooth cordgrass marsh) and 0.39 acres of invasive dominated wetlands (common reed marsh). The 1.4 acres of wetlands would be excavated and permanently converted to shallow subtidal soft bottom. Mitigation has been proposed to compensate for unavoidable impacts to wetlands for all known present and future projects.

Section 8.9 and Appendix F: Wetland Impact Assessment, provide a thorough assessment of the present wetlands in the study area and the salinity shift effects of the No Action Alternative (with sea level rise) and with implementation of the TSP on tidal wetlands. Based on the updated mapping and classification there are 66,671 acres of tidal wetlands, representing six tidal wetland classes present in the study area.

Under the No Action Alternative, the salinity modeling results indicate that RSLR will cause upstream shifts in the oligohaline-freshwater (0.5 ppt) salinity isopleths ranging from ~0.08 to 0.75 mile. Wetlands potentially affected by the projected upstream shifts in the 0.5 ppt isopleth under the No Action Alternative include ~278 acres of tidal freshwater wetlands and ~11 acres of tidal brackish wetlands. The potentially affected freshwater wetlands include ~180 acres of tidal swamp forest and ~98 acres of tidal freshwater marsh. The potentially affected tidal brackish wetlands include approximately six acres of cattail marsh, approximately three acres of brackish marsh mix, and approximately two acres of Phragmites marsh. Projected shifts in the mesohaline-oligohaline (5.0 ppt) isopleths under the No Action Alternative are confined to the existing brackish marsh-dominated reaches of the estuary. The delineated tidal floodplain areas that are affected by the mesohaline-oligohaline isopleth shifts encompass ~267 acres of brackish cattail marsh, approximately two acres of Phragmites marsh, and approximately one acre of smooth cordgrass marsh

Under the TSP, the salinity modeling results indicate that harbor deepening will cause additional upstream shifts in the oligohaline-freshwater 0.5 ppt salinity isopleths ranging from ~0.18 to 0.83 mile. Wetlands potentially affected by the projected upstream shifts in the 0.5 ppt isopleths under the TSP include ~242 acres of tidal freshwater swamp forest, ~98 acres of tidal freshwater marsh, and ~62 acres of brackish cattail marsh. Projected shifts in the mesohaline-oligohaline 5.0 ppt isopleths under the TSP are confined to the existing brackish marsh-dominated reaches of the estuary, with the exception of the Lilliput Creek isopleth, which extends ~200 ft into the transition zone where small patches of tidal freshwater marsh first begin to occur. The potentially affected freshwater marsh areas along Lilliput Creek total less than one acre. The remaining delineated tidal floodplain areas that are affected by the various mesohaline-oligohaline isopleth shifts under the TSP encompass ~470 acres of brackish cattail marsh, ~20 acres of Phragmites marsh, and approximately five acres of brackish marsh mix.

The potentially affected brackish wetlands consist almost entirely of cattail marsh under both the No Action Alternative (97%) and TSP (96%), with the majority (~3.5%) of the remaining brackish wetlands consisting of marshes dominated by the non-native invasive species *Phragmites australis australis*. Cattail marshes dominate the estuarine tidal floodplain from approximately two miles below Eagle Island to the upper ends of the oligohaline reaches in the Cape Fear River and Northeast Cape Fear River, and thus are well adapted to a broad range of salinities.

Projected surface salinity changes within the mesohaline-oligohaline isopleth shift zones are limited to relatively small increases of ≤1.5 ppt. The potentially affected brackish wetlands consist almost entirely of cattail marsh under both the No Action Alternative (97%) and TSP (96%), with the majority (~3.5%) of the remaining brackish wetlands consisting of marshes dominated by the non-native invasive species *Phragmites australis australis*. Cattail marshes dominate the estuarine tidal floodplain from approximately two miles below Eagle Island to the upper ends of the oligohaline reaches in the Cape Fear River and Northeast Cape Fear River, and thus are well adapted to a broad range of salinities. Therefore, the relatively small increases in salinity that are projected under the No Action Alternative and TSP would not be expected to have any significant effect on cattail marshes. In the case of Phragmites marshes, any changes in community composition would be considered a beneficial effect. Therefore, the anticipated effects of the TSP on existing brackish marshes are considered to be insignificant and will not be considered in determining any wetland mitigation requirements for the TSP.

Projected surface salinity changes within the oligohaline-freshwater isopleth shift zones are limited to very small increases of ≤0.3 ppt. Freshwater tidal wetland communities at the oligohaline-freshwater boundary, including tidal freshwater marsh and tidal swamp forest, are most likely to be significantly affected by small increases in salinity. Conversely, the brackish marshes that occur below are dominated by a relatively small number of species that are adapted to a much broader range of salinities. Consequently, the brackish communities are not expected to be significantly affected by the relatively small increases in salinity (≤1.5 ppt) that are projected to occur within the isopleth shift zones. Although brackish wetlands potentially affected by the mesohaline-oligohaline isopleth shifts are quantified in this assessment, the potential effects of small salinity increases on brackish wetlands within the existing mesohaline and oligohaline zones are not considered to be significant.

Based on the analysis, the anticipated salinity shift effects of the TSP on existing brackish marshes are considered to be insignificant and will not be considered in determining any wetland mitigation requirements for the TSP. Due to the dominance of cattail marshes, which are tolerant of increases in salinity, the relatively small increases in salinity that are projected under the No Action Alternative and TSP would not be expected to have any significant effect on cattail marshes. In the case of Phragmites marshes, any changes in community composition would be considered a beneficial effect.

The remaining tidal freshwater wetlands that were identified as potentially affected by oligohaline-freshwater isopleth shifts under the TSP include 241.8 acres of tidal freshwater swamp forest and 103.4 acres of tidal freshwater marsh. Although in many cases the projected oligohaline-freshwater isopleth shifts cover substantial distances, the projected surface salinity changes within the isopleth shift zones are limited to very small increases of ≤0.3 ppt. Although tidal freshwater swamp forest communities are capable of tolerating or recovering from occasional pulses of saline water, they are generally not able to tolerate regular flooding by saline waters. Tidal freshwater marshes, as defined by the baseline classification, are slightly more tolerant of very low oligohaline salinities; however, the restriction of freshwater marshes to relatively short reaches of the estuary in the immediate vicinity of the oligohaline-freshwater boundary indicates that overall salinity tolerance is very limited. Thus, tidal swamp forest and tidal freshwater marsh communities are potentially vulnerable to relatively small increases in salinity.

Given the very small projected increases in salinity, the exact nature and extent of effects are difficult to predict. It is anticipated that the projected salinity increases may have some effects on community composition, and that shifts in freshwater community composition towards the brackish marsh spectrum could reduce community diversity. However, it is considered unlikely that the projected increases would result in large-scale swamp forest to marsh conversions. A functional assessment would be performed in coordination with the Tidal Wetlands TWG to assess potential effects on wetland functions.

In summary, based on a review of readily available information on dredging related actions in the study area, tidal wetlands have not been directly or indirectly affected by dredging actions over the past 20 years, are likely to affect 1.07 acres of tidal wetlands and 9.03 acres of Section 404 freshwater wetlands over the next few years, and based on the modeled wetland effects analysis presented for the TSP, could result in a shift of significant freshwater tidal marsh and swamp forest acreage to brackish marsh, as a result of small increases in predicted salinity. Therefore, based on this review, the proposed TSP is not likely to result in a cumulative effect on tidal wetlands, predominately due to the lack of any significant past or recent wetland effects and to the low probability of the TSP resulting in any significant wetland changes.

Tidal marshes and wetlands are especially vulnerable with respect to changes brought on by climate change and sea level rise, and potentially due to dredging. Two of the main effects include tidal marsh submergence and habitat migration, which will occur as wetlands move landward and replace tidal freshwater and brackish wetlands (Moorhead and Brinson 2005; Park et. al. 1991). Conversion of tidal swamps to tidal marshes occurs not only due to increased salinity but by the sulfate constituent in seawater. Once the sulfate concentration increases to an adequate amount in soil, sulfate-reducing bacteria activate and begin converting sulfate to hydrogen sulfide, thus killing plant life not adapted to this chemical and beginning the habitat transition from swamp to marsh. Species of herbaceous vascular plants with salinity tolerance begin to dominate (Hackney and Avery 2015).

The decrease in wetland areas and conversion of other habitats would result in a reduction of the ecosystem services provided by these wetlands, which include reduced productivity and waste treatment. Fresh and saltwater wetlands (i.e. those at the upper and lower ranges of salinity) would be most affected by sea level rise. Freshwater wetlands will be overtaken by brackish marshes migrating inland while saltwater wetlands will likely be submerged due to their low rate of vertical accretion that would be unlikely to keep up with the projected rate of sea level rise (Craft 2007). Declines in wetlands and marsh habitats may also result in cascading effects on important animal species such as the American alligator, wood stork, and other species that rely on wetland habitats.

8.24.3.2 Water Quality

All water bodies in NC are assigned a surface water classification that defines the best uses to be protected (e.g., water supply, swimming, fishing). Each classification is subject to a specific set of water quality standards that are designed to protect the designated uses. The waters of the mainstem Cape Fear River immediately upstream and downstream of Lock and Dam #1 are classified as WS-IV. This WS-IV classification is assigned to waters that are used as a water source for drinking, culinary use, and/or for food processing where a more protective classification (WS-I, II, or III) is not feasible due to watershed development. The waters immediately above Lock and Dam #1 are also classified as a CA because they are proximal to a water supply intake or reservoir where the risk of pollution has greater consequences. The impounded Cape Fear River reach above Lock and Dam #1 serves as the principal water supply for New Hanover, Brunswick, and Pender Counties. Both the CFPUA and the Lower Cape Fear Water and Sewer Authority have water intakes above Lock and Dam #1. These entities service approximately 250,000 residents in southeastern NC and pull approximately 20 million gallons of raw, untreated water each day through 36 miles of raw water mains (CFPUA 2017).

The WS-IV waters below Lock and Dam #1 to the Federal Paperboard water supply intake at Riegelwood have been assigned a supplemental classification of Swamp Waters (Sw). This classification is associated with slow moving reaches that are flatter in topography than adjacent waters (NCDEQ 2018). The Cape Fear River mainstem waters from Riegelwood to Navassa are Class C waters with a supplemental classification of Sw. Class C waters are protected for secondary recreation, fishing, wildlife, fish consumption, and aquatic life propagation and survival. The mainstem waters from Navassa to Federal Point are Class SC tidal saltwaters protected for secondary recreation, fish and non-commercial shellfish consumption, wildlife, and aquatic life propagation and survival. The remaining mainstem Cape Fear River waters below from Federal Point to the ocean are classified as SA waters. SA waters are protected for commercial shellfishing along with all designated SC uses. SA waters are assigned a supplemental classification of HQW that is intended to protect waters that are rated excellent based on biological and physical/chemical characteristics.

Present water quality conditions within the project area are described in Section 2.8 of this document, which is indicative of the effects of past actions. Moderate effects on water quality within the river likely occurred during the Wilmington Harbor Deepening Project of the early 2000s, simply due to the duration of the dredging events over a two-year period. However, use of a hydraulic cutterhead dredge has minimized suspended sediment loading, as compared to other dredge types. Water quality degradation due to annual maintenance dredging and recent use of agitation and water injection dredging over the 20 year review period has and will likely continue to be short-term and minimal. Water quality effects due to dredging projects over the 20 year review period show periodic elevations in suspended sediments and turbidity during active dredging; however, there is no information to indicate that the effects of the proposed actions would contribute to significant cumulative impacts when added to the effects of separate past, present, and future actions. The port has chosen to use water injection dredging as a means to reduce environmental effects and costs typically associated with use of hydraulic pipeline or hopper dredges for maintenance dredging

Implementing the TSP will likely result in greater increases in turbidity given the larger size and scale of this project compared to the turning basin expansion and maintenance dredging events. However, these turbidity effects are also expected to be minor when using a hydraulic cutterhead dredge inshore as compared to a moderate effect on turbidity when using a hopper dredge offshore. Turbidity impacts from dredged material disposal at the ODMDS would also be temporary. For the TSP, there are currently several beneficial use projects being considered for alternative placement options for some dredged material. Turbidity effects could result from the implementation of some of these beneficial use projects depending on which projects, if any, are approved.

Sea level rise will have the effect of forcing brackish waters farther upstream from their current locations. This effect will be magnified with the deepening of the channel, as proposed by the TSP. Climate change is also likely to increase the frequency of storm activity in the area which, when combined with projected levels of sea level rise, can also have detrimental effects on water quality. The passage of storms can cause severe impacts to water quality via flooding and runoff of raw and partially treated human waste into waterways, which can result in decreases in DO leading to massive fish kills. Previous hurricanes have resulted in significant declines in benthic abundances (Mallin et al. 1999).

The Cape Fear River covers 17% of the total state land area and is the largest and most industrialized river in the state. Receiving discharges from tributaries in 25 of the state’s 100 counties, pollutants entering the river upstream have a high probability of deteriorating water quality in the lower river-estuary. Recent and ongoing investigations and actions regarding the presence of GENX in surface water and groundwater within the lower Cape Fear River basin, serve to demonstrate the difficulties associated with improving surface water quality in the lower Cape Fear River.

Salinity levels in the Cape Fear River are continually changing in response to variability in tidal conditions and freshwater inflow. Past periods of drought-induced low flow and extreme flood events have led to impacts on water levels, tidal conditions, and salinity in the Cape Fear River (Leonard et. al. 2011). Sea level rise would increase the level of saltwater intrusion and reduce the force needed by other external factors.

Based on a review of water quality related effects of past, recent, and likely foreseeable future dredging related projects, the proposed TSP is not likely to result in a cumulative effect on water quality. The effects of dredging on water quality are exceedingly small compared to the effects that past and present pollutant discharges and natural weather related events have on the surface water in the lower Cape Fear River.

8.24.3.3 Benthic Communities

Estuarine soft bottom consisting of unvegetated, unconsolidated sediments comprises the vast majority of the subtidal benthic habitat in the Cape Fear River estuary. The estuary is estimated to contain ~37,800 acres of soft bottom habitat in waters less than six feet deep and ~188,549 acres in waters greater than six feet (NCDEQ 2018a). Estuarine intertidal flats and shallow subtidal soft bottom habitats support a highly productive benthic microalgal community. Benthic microalgae, along with imported primary production in the form of phytoplankton and detritus, support a diverse community of benthic infaunal and epifaunal invertebrates; including nematodes, copepods, polychaetes, amphipods, decapods, bivalves, gastropods, and echinoderms (SAFMC 1998, Peterson and Peterson 1979). Large mobile invertebrates such as blue crabs and penaeid shrimp move between intertidal and subtidal habitats with the changing tides. Mobile predatory gastropods (e.g., whelks and moon snails) occur along the lower margins of submerged tidal flats, and fiddler crabs are common on exposed flats during low tide (Peterson and Peterson 1979). Benthic invertebrates are an important food source for numerous predatory fishes that move between intertidal and subtidal habitats; including spot, Atlantic croaker, flounders, inshore lizardfish, pinfish, red drum, and southern kingfish. Shallow unvegetated flats provide an abundant food source and are relatively inaccessible to large predators (SAFMC 1998). Intertidal and subtidal flats function as an important nursery area for numerous benthic oriented estuarine-dependent species, especially Atlantic croaker, flounder, spot, and penaeid shrimp. Salinity and sediment composition are major factors in soft-bottom benthic assemblages. A study of North Carolina estuaries showed species diversity of soft-bottom benthic infaunal assemblages generally decreased with decreasing salinity and increasing mud content (Hyland et al. 2004).

The annual maintenance dredging of the federal channel and berths has been maintained by the USACE for well over 70 years, and continues as a present and future action that directly removes and impacts the soft bottom habitat within the dredge footprint. The soft bottom habitat within the project area has been affected by dredging many times in the past; however, much of this has been associated with habitat in the federal channel.

Past and recent dredging for navigational improvements to the federal channel and turning basin impacted an unknown total acreage for the Wilmington Harbor 96 Act Project (2000-2002) and 8.53 acres for the 2015 Turning Basin project. For future proposed projects, temporary impacts to benthic habitat may include dredging 17.76 acres (3.8 acres <4 m) of soft bottom for the turning basin, 4.94 acres for the multi-use terminal, and up to 925 acres (557 inner harbor and 368 ocean entrance) of sand and mud bottom benthic habitat for the proposed TSP. Of the total area of past, recent, and future proposed dredging actions, impacts to shallow bottom habitat less than four meters included 3.83 acres from 2019 project, 4.94 acres for the proposed multi-use terminal, and 19.5 acres projected for the TSP. This cumulatively represents new dredging of 956 total acres of benthic habitat temporarily affected when considering past, present, and foreseeable future projects (note this does not include dredging acreage from the Wilmington Harbor 96 Act Project dredging in 2000-2002). Since shore protection and maintenance dredging will occur on an as need basis in the future, benthic habitat effected from dredging and beach placement are considered part of the No Action Alternative and will continue irrespective of the proposed TSP.

Benthic habitat designated as Primary Nursery Area (PNA) was not dredged during the deepening project in 2000-2002. For recent and near future actions dredging has and will likely result in the deepening of 30.73 acres of PNA for turning basin and terminal improvement projects. For the TSP, a total of 33.80 acres of PNA habitat would be dredged for channel and basin improvements.

New dredging in the channel expansion areas would remove the majority of the associated soft bottom benthic invertebrate infauna and epifauna, resulting in an initial sharp reduction in community levels of abundance, diversity, biomass, and availability of prey for predatory demersal fishes within the dredged areas. Dredging involves direct, short term impacts to softbottom communities in the dredge footprint during construction; however the communities are not expected to be negatively affected over the long term. Stickney (1974) reported minor, short-term impacts on benthic communities in a dredged AIWW channel in Georgia with full recovery occurring in one to two months. In a subsequent study, Stickney and Perlmutter (1975) reported complete removal of the benthic community in a dredged Georgia AIWW channel; however, full recovery was observed in only two months. Van Dolah et al. (1979) observed minor, isolated effects on the benthic community in a dredged estuarine channel in South Carolina; recovery occurred within two months. In another South Carolina study of benthic community response in a dredged AIWW channel, recovery occurred within six months (Van Dolah et al. 1984). In both the Georgia and South Carolina channels, the rapid rates of recovery were attributed in part to recolonization via slumping of adjacent undisturbed sediments into the dredged channel. Van Dolah et al. (1984) also attributed rapid recovery to infilling by sediments that were similar in composition to the extracted sediment and avoidance of spring benthic invertebrate recruitment periods. A review showed recovery of soft bottom habitats from dredging within two to five years across multiple projects; and while the short-lived and high-turnover biological components should recover within five years (Borja 2010). The soft bottom habitat adjacent to the dredging footprint may incur thin layers of sediment, but impacts would be expected to be short term as benthic communities return to baseline conditions within three to ten months and benthic organisms are adapted to some level of sediment movement and periodic exposures to high rates of sedimentation (Wilber et al. 2007). This project area has experienced physical disturbances in the past due to dredging, which should lend the soft bottom community to having a higher resilience; and therefore, impacts may be reduced compared to undisturbed areas because of the higher resilience of the community that has become established in conditions of frequent disturbances (Hiddink 2006).

The soft bottom benthic infaunal communities are dominated by opportunistic species that are adapted to frequent disturbance and recover quickly following dredging, especially in the upper river reaches near the port where high energy conditions prevail. The communities within the areas affected will fairly rapidly reflect shifts in species abundance and composition. The changes in water quality and human predation of those species pursued for commercial and recreational fishing may be the most important effect on the long-term dynamics of those populations. Although the impacts of agitation and/or water injection dredging on benthic invertebrates would reduce the availability of benthic prey for estuarine fishes, it is expected that benthic community recovery would occur rapidly. Therefore, it is expected that the majority of the effects on soft bottom habitat function would be short term and localized.

Potential indirect prey-loss effects on demersal fishes could include reduced foraging efficiency within the dredging footprint and/or displacement to adjacent undisturbed soft bottom foraging habitats. However, based on the anticipated rapid rates of benthic community recovery, it is anticipated that the indirect effects of prey loss on demersal fishes would be localized and short term. Short-term impacts also indirectly affect shorebird, crustacean, and fish foraging along with impacting recreational fishing through a reduction in bait species.

The potential for temporally-crowded cumulative effects on soft bottom communities would be considered likely if the intervals between the repeated maintenance dredging of the deferral channel and berths, the Turning Basin Expansion, and the Wilmington Harbor Navigation Improvement events were insufficient to allow for full recovery of benthic communities. The overall frequency of combined project-related and separate dredging events could potentially result in repeated impacts on soft bottom benthic communities prior to full recovery from previous events. As a result, benthic invertebrate communities in the channel could be held in an early successional stage and/or could experience long-term reductions in levels of infaunal/epifaunal abundance and biomass. While the soft bottom communities may fully recover their ecosystem structure with the presence of appropriate organisms, this does not necessarily indicate complete ecosystem functionality has been regained. Depending on the intensity and scale of perturbations, the soft bottom habitat may become resilient to normal periodic stress instead of recovering completely to a pre-dredge state (Borja 2010).

The potential for spatially-crowded cumulative effects on soft bottom communities is high based on the proximity of the dredging actions for the Turning Basin Expansion, construction of the Multi-purpose Terminal, annual maintenance dredging of federal channel and berths, and the extent of overlap between the project-related and separate action impacts locations. Concurrent reductions in benthic invertebrate prey densities within the PNA could potentially have cumulative effects on predatory demersal fishes. However, the cumulative area of temporary habitat/prey loss would be approximately 23 acres within the PNA, which constitutes a small fraction of the available soft bottom habitat in the vicinity of the Wilmington Harbor.

Local species loss can result in a cumulative impact of regional reductions in species richness and body size (Hiddink 2006). In general, after a disturbance, the species composition shifts to an increased proportion of fast-growing species, which may have a long term impact on soft bottom species composition in the area. There is a negative relationship between increasing turbidity and species composition and cover, and the cumulative impacts of reduced water quality and increased sedimentation in combination with the physical disturbances of the dredging may lead to increased cumulative effects (Hansen and Snickars 2014). Sea level rise, which can affect water depth, flow velocities, and tidal fluctuation, may cause cumulative effects that alter the soft bottom communities over time. Specifically, brackish waters will move farther upstream and soft bottom habitat may migrate due to sea level rise.

8.24.3.4 Summary of Cumulative Effects

In summary, an analysis of dredging activities over the +/- 20 year review period (2000-2020), inclusive of those associated with the proposed action, shows no cumulative loss of wetlands due to past and/or present port related activities. Assuming the proposed actions are permitted and constructed, a total of 1.07 acres of tidal marsh within PNA and a total of 9.03 acres of additional Section 404 wetlands could be affected. It is important to note that wetland impacts associated with these two proposed projects will be mitigated in accordance with state and federal mitigation rules and regulations. Following completion of the turning basin expansion and the deepening associated with the Wilmington Harbor Navigation Improvement Project, future construction will be limited solely to maintenance dredging events to maintain existing channel depth. For the TSP, the predicted indirect effects on freshwater marsh and swamp forest are tough to assess the full extent or probability of their conversion to brackish marsh over time. Due to minimal change in predicted salinity, it is more likely that smaller incremental changes or shifts in vegetation may occur, or not at all. While the combined impacts of the proposed actions could potentially have minor cumulative effects on wetlands, the impacts of the proposed TSP will be effectively mitigated through proposed wetland mitigation as described in the mitigation plan (Section 8.25, below). However, the projected impacts of sea level rise and climate change have the potential to cause permanent and lasting effects (i.e. shifting distribution of wetland communities) if efforts are not taken to reduce or mitigate these impacts.

Short term water quality degradation has and will continue to occur periodically, typically in association with larger federal harbor deepening projects like the deepening associated with the Wilmington Harbor Navigation Improvement Project, as opposed to dredging activities associated with maintenance, turning basin expansion, or small terminal expansion projects. While the combined impacts of the proposed actions could potentially have minor cumulative effects on water quality (primarily turbidity), the impacts of the proposed action would be effectively mitigated through best management practices. Therefore, it is expected that any cumulative water quality effects from the proposed action would be minor and temporary. However, the projected impacts of sea level rise and climate change have the potential to cause permanent and lasting effects (i.e. degradation of water quality through increased flooding/storm activity, increased salinity) if efforts are not taken to reduce or mitigate these impacts.

Given that the functional benefits associated with much of the affected benthic and PNA habitat has or will recover naturally from dredging, and considering that effective mitigation is proposed to offset the impacts to shallow PNA functions of the proposed Wilmington Harbor Navigation Improvement Project, it is concluded that the effects of the proposed action, when added to the effects of separate past, present, and future actions, will not result in significant cumulative effects.

8.25 Mitigation, Monitoring, and Adaptive Management Plan

Mitigation planning is a critical element of the overall planning process, which began early in feasibility study development. The mitigation, monitoring, and adaptive management plan developed in this report is a preliminary plan that presents a set of mitigation and monitoring measures that would sufficiently provide compensatory mitigation for the environmental impacts of the navigation improvements included in the TSP. The preliminary mitigation, monitoring, and adaptive management plan is technically feasible, can be implemented at a reasonable cost, and has been developed with technical input from local agency subject matter experts.

Over the past year numerous meetings have been held with the Wetland and Fish and Fish Habitat Technical Working Groups (TWG) to work through the impact assessment process, develop functional assessments for tidal wetland and fish habitat impacts, and to assess mitigation options.. The USACE initiated development of the Interagency Review Team (IRT) in December 2019 and will continue coordination through the NEPA process. Continuing technical coordination with the TWGs will support completion of the DEIS, which will include the final mitigation, monitoring, and adaptive management plan. The preliminary draft plan identified herein provides the elements of a plan that will continue to be modified and or refined during completion of the DEIS. The full development of the preliminary draft Mitigation, Monitoring and Adaptive Management Plan is provided in Appendix N.

Mitigation and monitoring costs are included in total project costs and were developed to ensure that costs for the preliminary plan sufficiently approximate final plan costs. Estimated costs for mitigation elements (see Appendix N: Mitigation and Monitoring Plan for details) described in the Mitigation, Monitoring and Adaptive Management Plan were developed adhering to the USACE planning guidance principles for cost estimating. Real estate costs were developed through consultation with landowners and with the aid of USFWS for a proposed conservation easement. Construction costs for mitigation measures described in the plan were prepared using standard engineering and construction cost estimating protocols at a feasibility study level of design. Estimates for wetland plant installation were obtained through consultation with local wetland plant nurseries. Monitoring costs were developed using comparable budgets associated with other recent deep draft navigation projects (eg. Charleston Post 45 deepening project) and based on past budgeting for the Wilmington Harbor deepening project initiated in 2000 for project monitoring. While the overall budget is robust and not expected to change substantially, recognize that aspects of the mitigation plan are subject to change during development of the DEIS and agency coordination process.

This section provides a summary of the preliminary draft plan, including a review of avoidance and minimization measures considered during the design process for ecological resources, mitigation measures for those resources which may be significantly impacted, functional assessments to determine mitigation requirements, and selected mitigation measures based on agency review and engagement. In addition, conceptual monitoring protocols for assessing project effects, mitigation success and adaptive management measures are provided. During early 2020 additional technical meetings will be held with local subject experts and agencies to develop specific monitoring protocols for project effects.

Direct and indirect effects of the TSP that may require compensatory mitigation includes:

- Indirect effects of salinity shifts on tidal palustrine freshwater forested (swamp forest) and herbaceous wetlands;
- Direct effects of conversion of shallow water benthic habitat, including Primary Nursery Areas (PNAs) and non-PNA, to deeper benthic habitat;
- Indirect changes in fish habitat suitability due to salinity changes for selected managed and protected fish species;
- Erosional effects on three managed bird islands in the Lower Cape Fear River (LCFR) including Battery Island, Ferry Slip, and South Pelican Island; and

- Effects of vessel wakes on selected shoreline reaches of the river from the mouth of the Cape Fear to below the Military Ocean Terminal at Sunny Point (MOTSU).

8.25.1 Avoidance and Minimization Measures

The first step in mitigation planning involves efforts to avoid and/or minimize impacts. Because the alternative action plans included similar levels of channel widening and incremental levels of channel deepening, there were few opportunities to formulate approaches to avoiding and or minimizing effects on ecological resources. Impact assessment methods and results of the analysis for wetlands, fish, and fish habitat effects were reviewed with interagency TWGs during the development of the study report. These meetings centered on the primary environmental concerns of the project (DO, salinity increase, wetlands, fish habitat, and endangered fish species) as identified during early public and agency involvement. Further refinements to avoidance and minimization measures may occur during development of the DEIS. The following measures were taken to avoid and minimize project related effects.

8.25.1.1 Evaluation during pre-construction engineering and design of minimizing slope of channel where widening is proposed

During the Pre-Construction Engineering and Design (PED) phase, detailed ship simulation results will be used to optimize the widening measures to the size necessary to safely maneuver vessels. For purposes of the effects analysis in the feasibility phase, these channel widening measures have been assumed to be at maximum size. The optimization of those measures could reduce environmental effects on fish habitat, salinity intrusion, wetlands, and shallow subtidal habitat; as well as the projected increase in channel shoaling. Any substantial changes or reductions in significant effects will be reviewed during the PED phase of the project

8.25.1.2 Excluding the addition of passing lanes within the river portion of the project

Initial design considerations included assessing the addition of passing lanes in the wider reaches of the channel within the river; however, further analysis discounted this measure due to the extent of dredging required, potential increases in salt water intrusion upriver, and potential conversion of shallower more productive subtidal habitat to deeper less productive soft bottom habitat. Avoiding widening for passing lanes also reduced potential significant effects on fish habitat and brackish and freshwater wetlands.

8.25.1.3 Widening within the inlet on the west side to minimize erosional effects to the east

To minimize erosional effects of widening the inlet entrance channel on the Bald Head Island shoreline, channel widening is proposed only on the west side of the channel. Baldhead Shoal Reach 1 is proposed to be widened up to 200 ft on the west side to allow vessels to better align themselves entering the turn at the Smith Island and Baldhead-Caswell Reaches. These latter two reaches would then be widened on the east side, where there is naturally deep water already existing, to provide an acceptable radius of curvature to allow the design vessel to safely make this turn.

8.25.1.4 Minimize the loss of sand from the estuarine system through beneficial use of dredged material in the lower river

The loss of sediment from the river-estuary through placement offshore in the ODMDS is not beneficial to the overall estuarine sediment processes and potentially reduces material available for tidal marshes to capture and deposit, thus naturally keeping up with sea level rise. Restoring existing bird islands and potentially building new ones serves to keep sediment in the system; can yield ecological benefits, such as observed for South Pelican and Ferry Slip islands; and, if sited and designed appropriately, can serve as least cost options to disposal offshore. Engagement with the interagency Beneficial Use TWG demonstrated the desire on the part of both state and federal agencies to maximize use of dredged material, as shown in the beneficial use plan (see Appendix R: Dredged Material Management). Further refinement during PED can serve to demonstrate the ecological and cost benefits of these measures.

8.25.1.5 Reducing rock blasting effects by further geotechnical analysis during PED

Past geotechnical investigations and recent geophysical surveys (Appendix B: Geotechnical) involving rock strength analysis indicates that rock over 4,000 psi would require blasting, while rock under this strength can be removed without blasting using either a cutterhead dredge or a rock bucket clamshell dredge. As a result of improved dredging technologies and the fact that the USACE did not require blasting for the -42-foot project, further geotechnical analysis will be performed during PED to reduce the footprint of rock over 4,000 psi, therefore minimizing potential effects resulting from noise impacts to marine mammals and fish that blasting may cause.

8.25.1.6 Cultural resource impact avoidance or minimization

Most of the anomalies identified during the surevys performed for this study consisted of modern debris and did not represent significant historic or cultural items; however, due to the sheer number of anomalies detected and mapped, it is recommended that an archaeologist be on board to monitor for cultural resources when dredging occurs in these areas. If any additional resources are discovered during construction, the dredge will be shut down and coordination will be conducted to comply with the National Historic Preservation Act.

8.25.2 Guidance and Framework for Mitigation Planning

Present USACE policy, under Section 2036(a) of WRDA 2007, requires that mitigation plans comply with applicable mitigation guidance and policies of the regulatory programs administered by the Secretary of the Army. The USACE and the United States Environmental Protection Agency published regulations (33 CFR Parts 332, as amended, 33 CFR Part 325, and 40 CFR Part 230) entitled, "Compensatory Mitigation for Losses of Aquatic Resources," ("Mitigation Rule") on 10 April 2008. The purpose of these regulations is to improve the quality and success of compensatory mitigation plans authorized by Department of the Army regulatory permits. Subsequent guidance (CECW-PC Memorandum, Implementation Guidance for Section 2036 (a) of the Water Resources Development Act of 2007 (WRDA 07) - Mitigation for Fish and Wildlife and Wetlands Losses, 31 August 2009), published by the USACE, determined that civil works guidance for mitigation planning is consistent with the policies and standards of the USACE Regulatory wetlands mitigation program.

In accordance with civil works guidance and the Mitigation Rule, the USACE is responsible for determining ecological preferences for each project. The Mitigation Rule emphasizes the selection of compensatory mitigation sites on a watershed basis. Equivalent standards are also provided under the rule for all three types of compensatory mitigation: mitigation banks, in-lieu fee programs, and permittee-responsible mitigation plans. The preferential hierarchy for types of wetland mitigation, include the four basic methods for providing compensatory mitigation: restoration, enhancement, establishment, and preservation. Under civil works guidance and the Mitigation Rule, restoration should be the first method considered.

It is important to acknowledge that this study considered the effects resulting from the proposed project's maximum dimensions. As discussed above, during the PED phase of the project, ship simulation will be used to potentially reduce effects associated with wideners and overall widening of the channel due to increases in depth. Therefore, since all mitigation alternatives are evaluated based on an assumption of maximum impacts, it is the intent that additional avoidance and minimization may be realized during PED.

8.25.3 Mitigation for Indirect Effects on Tidal Wetlands

Based upon the comprehensive analysis of the predicted spatial changes in salinity associated with dredging for the TSP, wetlands affected are fully discussed in the Main Report Appendix F: Wetlands Impact Assessment. These predicted changes are based upon a comparison of FWOP and Future with Project (FWP) conditions. The FWOP conditions were based upon a dry year and low SLR scenario for the mainstem of the river, and a typical year and low SLR for the tidal creek. The tidal freshwater wetlands that were identified as potentially affected by oligohaline-freshwater isopleth shifts under the TSP include 241.8 acres of tidal freshwater swamp forest and 98.7 acres of tidal freshwater marsh.

Although in many cases the projected oligohaline-freshwater isopleth shifts cover substantial distances, the projected surface salinity changes within the isopleth shift zones are limited to very small increases of $\leq$0.3 parts per thousand. Although tidal freshwater swamp forest communities are capable of tolerating or recovering from occasional pulses of saline water, they are generally not able to tolerate regular flooding by saline waters. Tidal freshwater marshes, as defined by the baseline classification, are slightly more tolerant of very low oligohaline salinities; however, the restriction of freshwater marshes to relatively short reaches of the estuary in the immediate vicinity of the oligohaline-freshwater boundary indicates that overall salinity tolerance is very limited. Thus, tidal swamp forest and tidal freshwater marsh communities are potentially vulnerable to relatively small increases in salinity.

Given the very small projected increases in salinity, the exact nature and extent of effects are difficult to predict. It is anticipated that the projected salinity increases may have some effects on community composition, and that shifts in freshwater community composition towards the brackish marsh spectrum could reduce community diversity. However, it is considered unlikely that the projected increases would result in large-scale swamp forest to marsh conversions.

8.25.3.1 Determination of Mitigation Requirements

Mitigation planning was performed with the incorporation of risk and uncertainty into the mitigation planning process. The most important risk factor identified in the mitigation planning process was identified as the uncertainty associated with salinity modeling and salinity model results. This uncertainty is based on knowledge uncertainty, the imperfectness of modeling and data inputs, and the inherent variability of natural systems such as wetlands. The salinity model results indicate virtually no impact to salinity that can be distinguished from projected future impacts due to SLR. The uncertainty associated with this result directly affects the design objective, which is to appropriately mitigate for tidal forest and freshwater marsh impacts. The unacceptable level of uncertainty associated with the salinity model's no-impact result caused the Wetland TWG to remove the "no mitigation" option from further consideration.

Mitigation plan design was used to reduce the risks associated with knowledge uncertainty and inherent variability. Although mitigation planning for this project is constrained by existing land uses and ownership, multiple mitigation options to manage the risk associated with the uncertainty of the salinity model results were assessed. An array of alternative treatments and measures, including passive measures such as property acquisition for ecosystem preservation and active restoration and enhancement measures have been identified for development of alternative mitigation plans.

The alternative mitigation treatments and measures will be evaluated for completeness, effectiveness, efficiency and acceptability according to the Planning Guidance Notebook (USACE 2000). A final mitigation, monitoring, and adaptive management plan will be selected during development of the DEIS in coordination with the USACE, the local sponsor, and stakeholders. A draft wetland mitigation plan has been developed to indicate that appropriate mitigation can be developed for this project and to ensure that sufficient mitigation cost is included in the project's total cost.

The mitigation needed to compensate for wetland impacts, based on risk and uncertainty and to be in compliance with the USACE mitigation policies, includes preservation of tidal forested wetlands in accordance with the USACE accepted ratios for preservation, restoration, and enhancement. Should restoration and/or enhancement measures be selected as part of the final plan, this ratio can be lower than the required 10:1 ratio. Therefore, if only preservation is selected, a minimum of 3,410 acres would be required to mitigate for the impacts of the salinity shift on 340.5 acres of tidal forest and freshwater marsh. In addition, due to the use of risk and uncertainty and modeling results, no functional assessment modeling is deemed practicable.

8.25.3.2 Alternative Mitigation Site Selection Review

Many options were identified and assessed prior to completion of the wetland effects analysis and reflected opportunities throughout the salinity range in the river-estuary, including for saltmarsh, brackish marsh, and tidal freshwater marsh/swamp forest mitigation. Following completion of the wetland assessment and coordination with the Wetland TWG, options in the lower estuary were eliminated from further consideration and inclusion in this plan. Only feasible options available for mitigating effects on tidal swamp forest and freshwater marsh were further evaluated.

Mitigation options reviewed included potential tidal forested wetland preservation parcels within the Cape Fear River, including the Black River, where restoration and/or enhancement of wetland functional values could also be included (Figure 8-7). Evaluation of suitable properties to consider also involved working with stakeholders in the basin to leverage the benefits of cooperative efforts towards regional acquisition goals.

The Black River and Northeast Cape Fear River wetland mitigation properties (Figure 8-8) were assessed as mitigation options through coordination with TNC, USFWS, NCWRC and other entities. Based on the wetland effects analysis presented earlier in this plan, these mitigation options are acceptable for mitigating impacts to freshwater marsh and tidal swamp forest. The preferred preservation approach is fee simple acquisition of tidal wetlands or headwater stream wetlands. While a conservation easement may suffice if the property offers higher resource protection value than others, fee simple purchase is the preferred transaction. In addition, where practicable, restoration and/or enhancement measures were also assessed for both tracts.

Attributes for both properties are listed in Table 8-9. Through purchase, conservation and conveyance of title to a willing non-governmental organization or the North Carolina Wildlife Resources Commission (NCWRC), either of these two tracts can be protected in perpetuity and would serve to benefit the watershed by increasing the extent of contiguous preserved tidal wetlands and to some degree the adjacent transitional habitats and uplands.

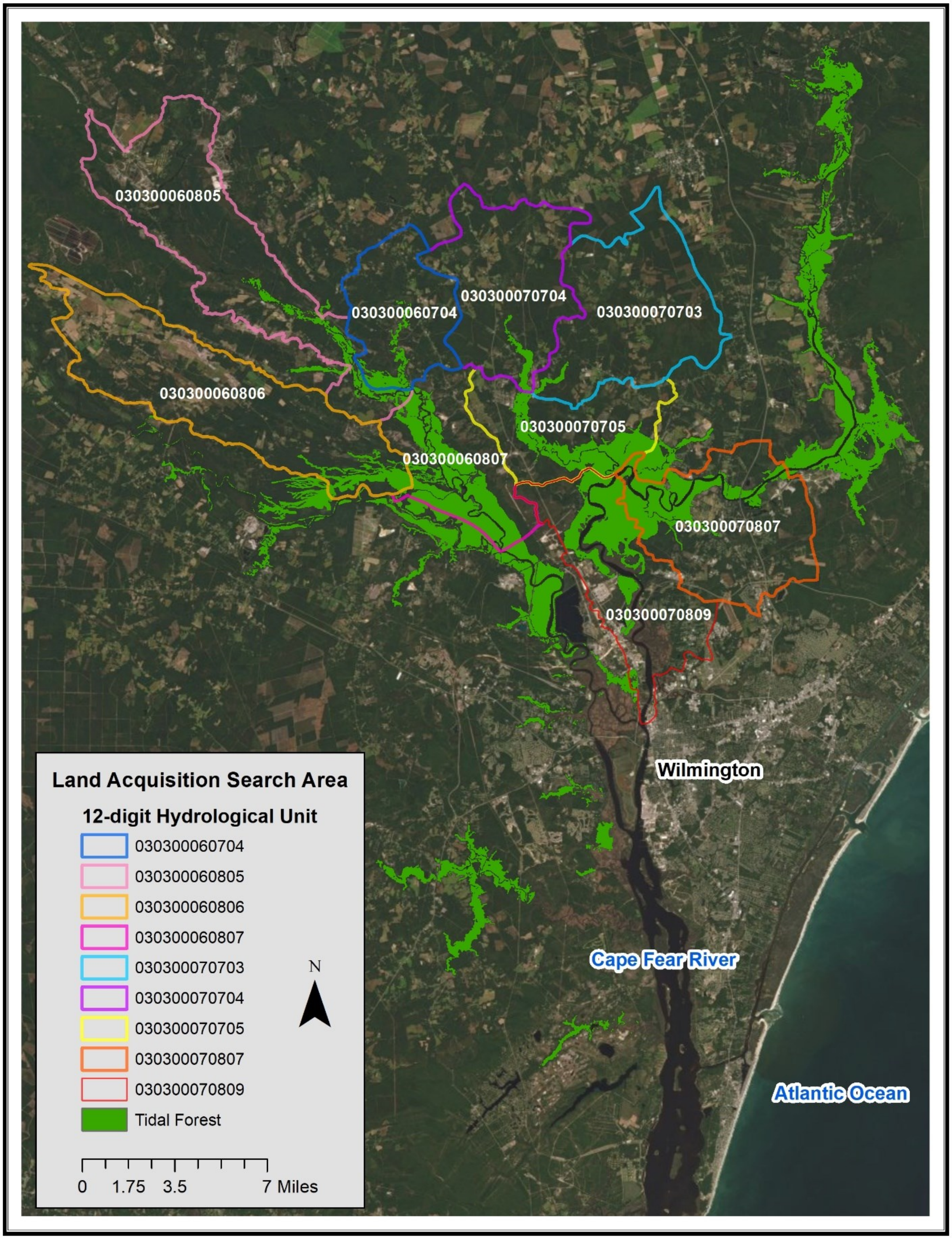

Figure 8-7
Tidal Wetland Forest Preservation Land Acquisition Search Area

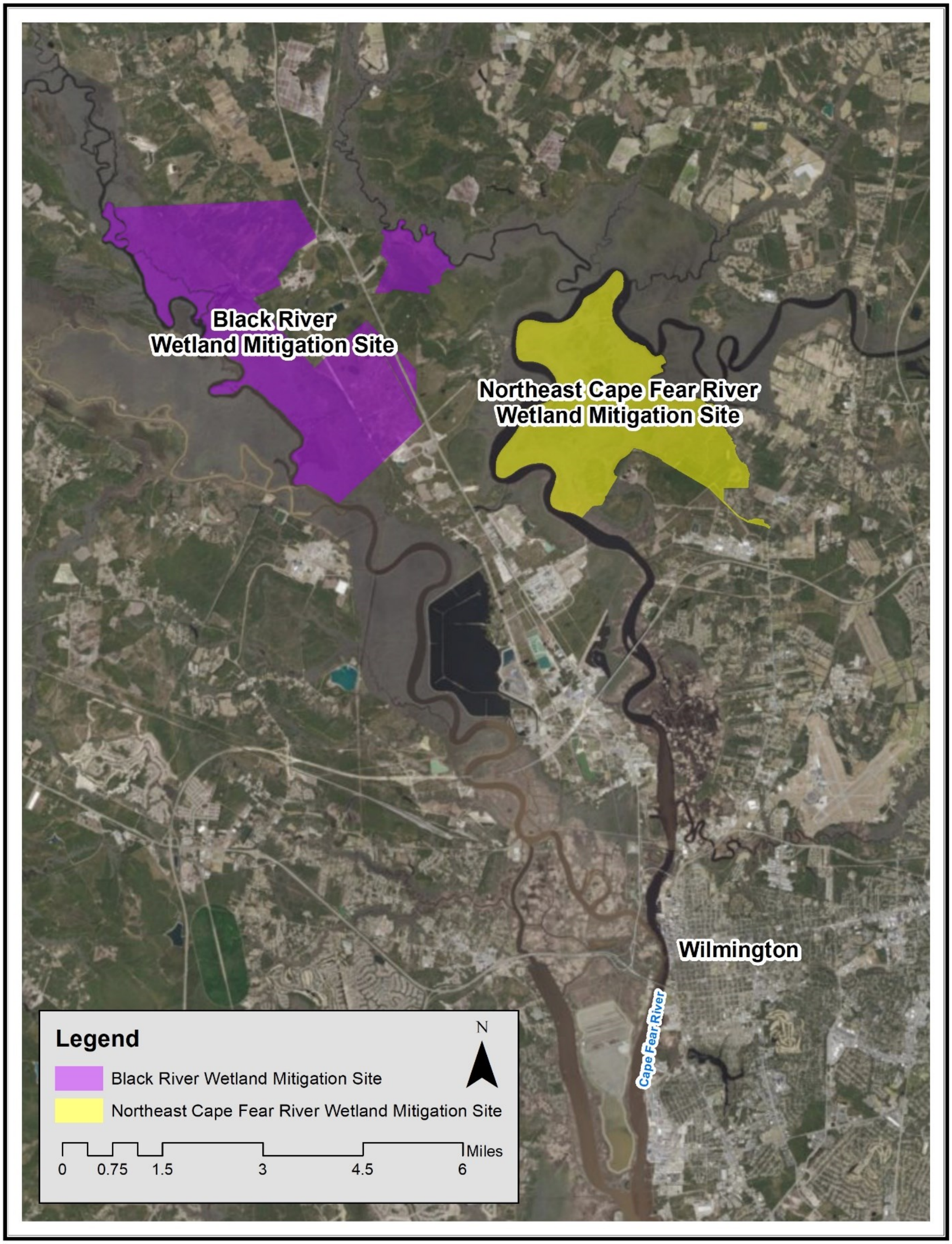

Figure 8-8
Wetland Mitigation Properties Selected Following Screening Analysis

Table 8-9
Resource Information for the Northeast Cape Fear River and Black River Wetland Mitigation Sites

	Northeast Cape Fear River Wetland Mitigation Site	Black River Wetland Mitigation Site
Total Area (ac)	3,900	4,485
Tidal Swamp Area (ac)	900	2,350
Non-tidal Wetland Area (ac)	1,925	1,335
Uplands Area (ac)	1,075	800
Conservation Priority	Medium	High
Restoration and Enhancement Potential	Low	High
Preservation Type	Fee Simple	Fee Simple /Easement
Collaborative Interest by Stakeholders	Medium	Medium

8.25.3.3 Selected Mitigation Site

Based upon the mitigation requirements for civil works planning, the preservation of land and eventual conveyance to a non-profit organization or the NCWRC is an environmentally-preferred mitigation alternative. Sufficient mitigation bank credits for the wetland type effected or in-lieu fee program credits are presently not available. While this may change over the next few years, with several mitigation banks being considered, this at present does not represent a viable option.

Wetland creation options were assessed as a type of mitigation option available for meeting compensatory requirements associated with this project. Accomplishing this type of mitigation typically involves excavating uplands to the elevation of the adjacent wetlands and planting the area with native wetland vegetation. Potential upland areas of adequate size located in the targeted region for selecting mitigation sites were limited or not available for purchase. In addition, creating large areas of tidal swamp forest is very expensive and the degree of risk to achieve success very high. For these reasons, no effective options were available to consider wetland creation as a viable choice to compensate for functional wetland losses associated with the TSP.

While restoration is typically preferred over preservation for mitigation, available opportunities for in-kind tidal swamp restoration are limited in scale and can only partially fulfill the mitigation needed. Due to the type of wetland being restored (e.g. tidal swamp) and difficulty associated with achieving restoration success, the risk and long-term cost of monitoring and management are greater. Restoration measures considered on the two parcels included removal of timber roads and ditches through forested wetlands. Enhancement opportunities are available on both tracts, including planting of cypress or other hardwood species within prior cut over areas.

Preservation of land and future conveyance to the NCWRC as the principal mitigation element for wetland effects associated with a shift in salinity is the preferred plan. Preservation of high quality tidal swamp forests provides significant benefits within the watershed and ensures the perpetual ability of these wetlands to provide important physical, chemical, and biological benefits to the LCFR Basin. While it is likely that silvicultural activities will continue to occur on the planted pine portions of adjacent tracts of land and eventually developed; preserving upland buffers adjacent to the swamp forest serves to provide a critical buffer for minimizing future soil erosion, water quality degradation, and serves to protect the intrinsic functional values of the swamp forest. Due to the high degree of focus by the TNC, Coastal Land Trust, NCWRC, National Fish and Wildlife Foundation, National Oceanic and Atmospheric Administration (NOAA), Cape Fear Partnership, Cape Fear River Watch (CFRW), and mitigation bankers within the lower Cape Fear watershed; the proposed acquisition will make a significant contribution to the sustainability of the watershed. As proposed, preservation as the selected type of mitigation serves as a low risk and practicable option. The proposed mitigation would protect and sustain these at-risk riparian resources for perpetuity. The inclusion of adjacent uplands as buffers would also help protect and sustain the aquatic resources and, through removal from future development, aid in reducing stressors on the watershed for the long-term.

The Black River Wetland Mitigation Site is best suited to provide the compensatory mitigation requirements in accordance with applicable wetland policies and regulations and in accordance with risk and uncertainty analysis. Given that a portion of the Northeast Cape Fear River Wetland Mitigation Site is within the area of the river where salinity shifts may occur, the viability of the property is reduced. With a stated goal of maximizing the preservation of swamp forest, the Black River property has over two times the acreage of swamp forest compared to the NECFR property. Finally, restoration and enhancement opportunities and the conservation priority ranking are higher for the Black River property.

8.25.3.4 Black River Wetland Mitigation Site

The purpose of this property is to provide mitigation that will offset the effects of projected salinity increases on 341 acres of tidal freshwater wetlands under the TSP. Mitigation sufficient to offset these effects will be provided through wetland preservation and restoration. The proposed mitigation treatments are shown in Figure 8-9 and summarized below in Table 8-10.

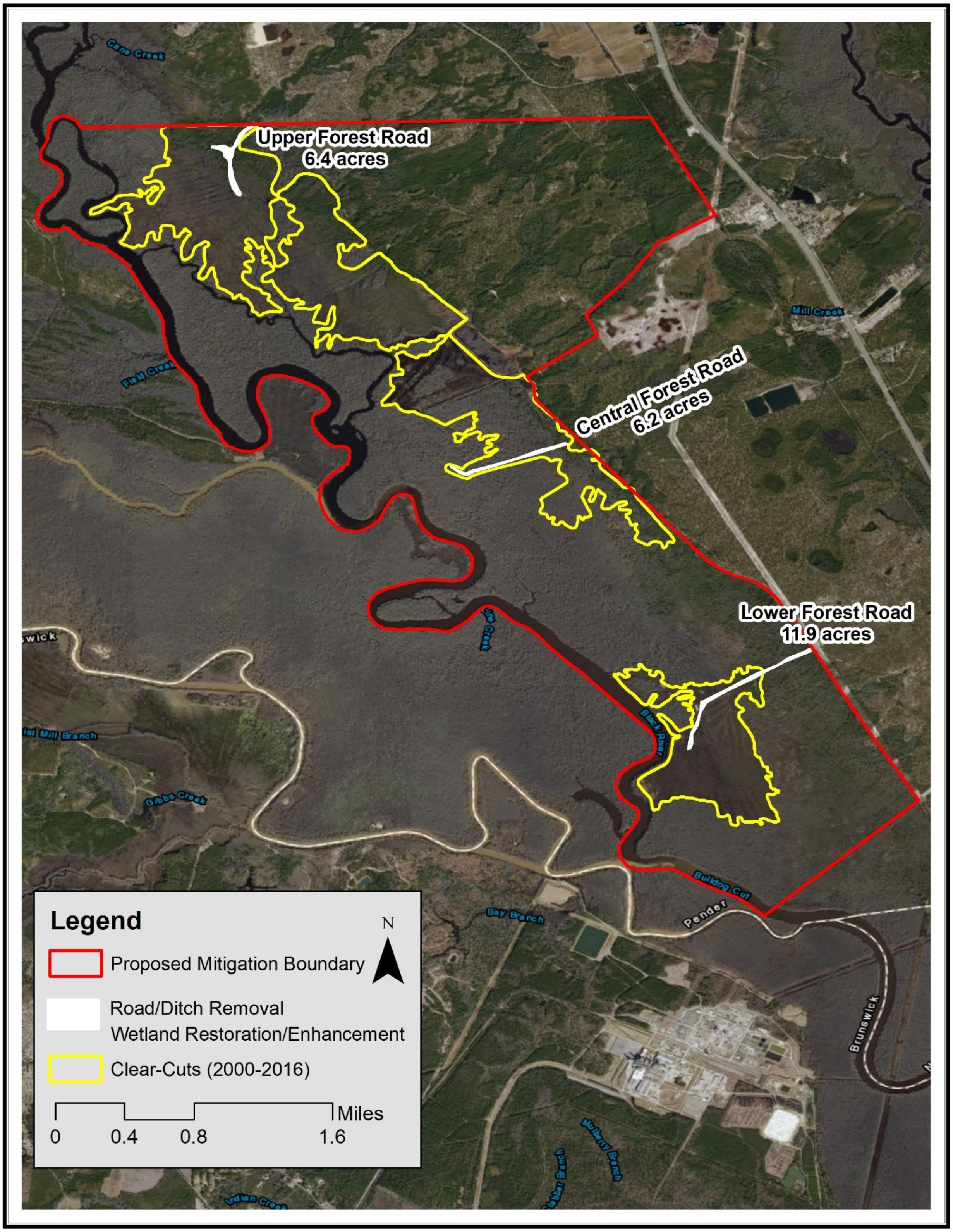

Figure 8-9
Black River Wetland Mitigation Site Conceptual Mitigation Plan

Table 8-10
Black River Wetland Mitigation Site Summary

Wetland Type	Preservation (acres)	Restoration (acres)		
		Lower Forest Road	Central Forest Road	Upper Forest Road
Tidal Cypress-Gum Swamp	2,350	6.1	6.2	1.4
Pocosin - Pond Pine Woodland	865	5.8		5.0
Streamhead Pocosin	470			
Long leaf pine upland buffer	800			
Total	**4,485**	**11.9**	**6.2**	**6.4**

Wetland Preservation

Wetland preservation would be the principal mitigation mechanism employed on this tract. Protection of the ~4,485-acre mitigation site would provide an estimated 3,685 acres of wetland preservation; including ~2,350 acres of tidal cypress-gum swamp, ~865 acres of pocosin pond pine woodland wetlands, and ~470 acres of streamhead pocosin wetlands. Protection of the site would also conserve ~800 acres of natural longleaf pine xeric sandhill scrub uplands that provide nesting and foraging habitat for the endangered RCW. Property is proposed to be protected through fee simple purchase of 3,220 acres of wetlands and through a conservation easement for the streamhead pocosin wetlands and adjoining 800 acres of long leaf pine uplands. Contingent on the confirmation of wetland acreages through the completion of a Section 404 wetland jurisdictional determination, the estimated 3,600 acres of wetland preservation would provide mitigation for the 341 acres of affected tidal wetlands at a ratio of 10.8 to 1.0. The overall 10.8 to 1.0 ratio represents tidal cypress-gum swamp wetland preservation at a ratio of 6.9 to 1.0 and pocosin wetland preservation at a ratio of 3.9 to 1.0.

Forest Road Removal - Wetland Restoration and Enhancement

The three forest access roads and their associated borrow ditches will be restored to tidal cypress-gum swamp and pond pine woodland pocosin wetlands through the removal of upland road fill and the return of the material to the roadside borrow ditches to reestablish the original pre-impact grade of the road/ditch corridors. Upon reestablishment of the natural grade, the corridors will be planted with bald cypress and/or pond cypress along with other wetland tree species that are constituents of the existing on-site wetland communities. A total of ~25 acres of wetlands will be restored within the three road/ditch corridors; including ~14 acres of tidal cypress-gum swamp and ~11 acres of pond pine woodland pocosin. Removal of the roads will provide additional hydrological enhancement within the existing adjoining wetlands through the restoration of natural lateral flow across the floodplain.

More specific information on this property and compliance with the USACE mitigation rule are provided within plan details (see Appendix N: Mitigation and Monitoring) and in Appendix E:

Real Estate. It is important to note that to date no formal real estate actions have occurred and until which time that the IRT provides full concurrence with the selected alternative, and the project is federally authorized, no formal actions will be taken.

8.25.4 Mitigation for Direct Effects on Shallow Water Estuarine Habitat and indirect Effects on Fish Habitat Suitability

The preliminary plan includes a description of impacts, mitigation options, functional assessments (mitigation requirements), and the selected mitigation plans for direct impacts to shallow water benthic habitat (PNA and non-PNA) and indirect effects of salinity on selected estuarine and anadromous fish species. Direct impacts on shallow water habitat functional loss and mitigation proposed were functionally assessed using the Unified Mitigation Assessment Method (UMAM). Indirect effects on fish habitat suitability were quantitatively assessed using the USFWS Habitat Suitability Index (HIS) for selected managed and/or protected fish species. Mitigation requirements were assessed using the USWFS Habitat Evaluation Procedures (HEP). Direct and indirect effects of construction of the TSP on fish and fish habitat were evaluated in detail in Appendix J: Fish Habitat Assessment. Additional agency consultation will occur during development of the DEIS with regards to the draft functional assessments and recommended mitigation measures. The sites tentatively selected for mitigation have been acceptable to the TWG members to date.

8.25.4.1 Mitigation for Direct Effects on Shallow Water Estuarine Habitat

Direct impacts were characterized and assessed for PNA and non- PNA shallow water estuarine habitat above 6 ft, from 6-12ft and below 12 ft (Table 8-11).

Table 8-11
Impact Summary for UMAM Assessment (Acres)

	Impact Site #1	Impact Site #2	Impact Site #3	Impact Site #4	Impact Site #5	Impact Site #6	Foraging >12 feet
PNA <6 ft		4.14					
Non-PNA <6 ft			0.3	1.0		0.4	
PNA 6 to 12 ft	0.1	1.63					
Non-PNA 6 to 12 ft			1.5	3.4	0.3	0.6	
Foraging >12 ft							27.0

To evaluate direct functional impacts to fisheries habitat resulting from construction of the alternative plans, the UMAM was used. The UMAM was developed in Florida in response to a request by the Florida State legislature to evaluate mitigation options to offset adverse effects to wetlands and wetland functions. According to the UMAM training manual, “The UMAM is designed to assess any type of impact and mitigation, including the preservation, enhancement, restoration, and creation of wetlands, as well as the evaluation and use of mitigation banks….” Moreover, the UMAM is a flexible tool that is appropriate for evaluating impacts to surface waters and benthic and sessile communities. For this reason, it was determined to be the most applicable method for evaluating the direct effects to fisheries habitat associated with the Wilmington Harbor Navigation Improvements Project. Recommended by the USACE Ecosystem Planning Center of Expertise, the UMAM was successfully applied to calculate wetland mitigation needs for the Jacksonville Harbor project and the Charleston Harbor Post 45 Study.

Preliminary results were based on hydrodynamic modeling, aerial imagery interpretation, and local expert knowledge. It is anticipated, however, that during the NEPA process the IRT may participate in UMAM training and conduct site visits to further refine scoring. Preliminary UMAM results indicate 40 acres of habitat (PNA/Foraging) would be directly impacted by new dredging for the TSP within the inner harbor and would require 18.9 acres of mitigation to offset lost functions. It is important to note that the UMAM evaluates functional losses and gains based on the quality of the existing habitat at the impact sites and the quality of habitat at the proposed mitigation site. Since habitat quality at the selected mitigation site (e.g. Alligator Creek) is expected to be near optimal upon completion of the restoration effort and habitat quality at the impact sites is lower, less acreage is needed to offset the functional loss

Alligator Creek Restoration and Enhancement Mitigation Site

Proposed mitigation includes ecological restoration of 18.9 acres of restored stream channel, tributaries, and shallow tidal pools in the location of historic Alligator Creek (Figures 8-10 and 8-11). The mitigation site, located on Eagle Island, is dominated by the invasive common reed (*Phragmites australis*) and old dredged spoil. The restored stream channel would be 75 ft wide and would be flanked by 50 ft of created tidal marsh on each side. The stream channel restoration would reestablish 12.1 acres of shallow PNA fisheries habitat. In addition, two tributaries and shallow tidal pools totaling 6.8 acres would be connected to the stream channel. Conceptually, restoration would restore 7,000 linear feet of tidal creek channel at a depth of three feet below MLLW.

Construction would entail removal of vegetation and excavation of old spoil material to establish the original creek channel, tidal pools, creeks, and tidal marsh. In addition, construction would include placement of a bridge at the access road and shoreline stabilization at the channel access on the river (Figure 8-10). Restoration of the creek would have similar meanders as the old creek based on historical aerial photography. This restoration would also allow regular tidal flushing to the interior marshes that has not occurred since the 1950s. The northern end of Alligator Creek is presently proposed for restoration as part of the Kerr -McGee settlement program approved by state and federal stakeholders (Figure 8-10). Coordination with the stakeholders for this action is ongoing to ensure consistency in modeling and channel design. More detailed analysis is needed to confirm elevations on site and to accurately estimate the volume of material to excavate to achieve good tidal flushing through the restored channel. It is anticipated that excavated spoil material would be pumped and/or hauled by truck to the Eagle Island CDF.

Restoration of the historic Alligator Creek will provide habitat for a myriad of both freshwater and estuarine dependent invertebrates and fish fauna, foraging habitat for juvenile fish, and other nektonic species, and enhance water quality from both the Brunswick River and Cape Fear River, through tidal exchanges. This restored creek channel will quickly be used by anadromous fish species including stripers and sturgeon for foraging during their annual runs upriver and annually by stripers living in this region of the river year -round.

Hydrological restoration by fill removal and the lowering of elevations to those of the adjacent natural brackish marshes would restore juvenile nekton access to areas that are currently tidally restricted; thereby, restoring or enhancing the functions of the areas as estuarine nursery habitats. The restoration of native vegetation and tidal hydrology would restore or enhance the foraging and refuge habitat functions of these wetlands for estuarine dependent juveniles. Additional ecological uplift would occur through the provision of enhanced foraging habitat for colonial nesting wading birds. The Cape Fear River estuary supports the largest nesting assemblage of colonial wading birds in the state, including up to 15,000 nesting pairs of white ibis annually. The tidal marshes of the Cape Fear River estuary are important foraging habitats for breeding and non-breeding wading birds. Hydrological restoration via fill removal would increase tidal floodwater volumetric capacity and residency time, thereby enhancing water quality functions in terms of pollutant, sediment, and nutrient removal.

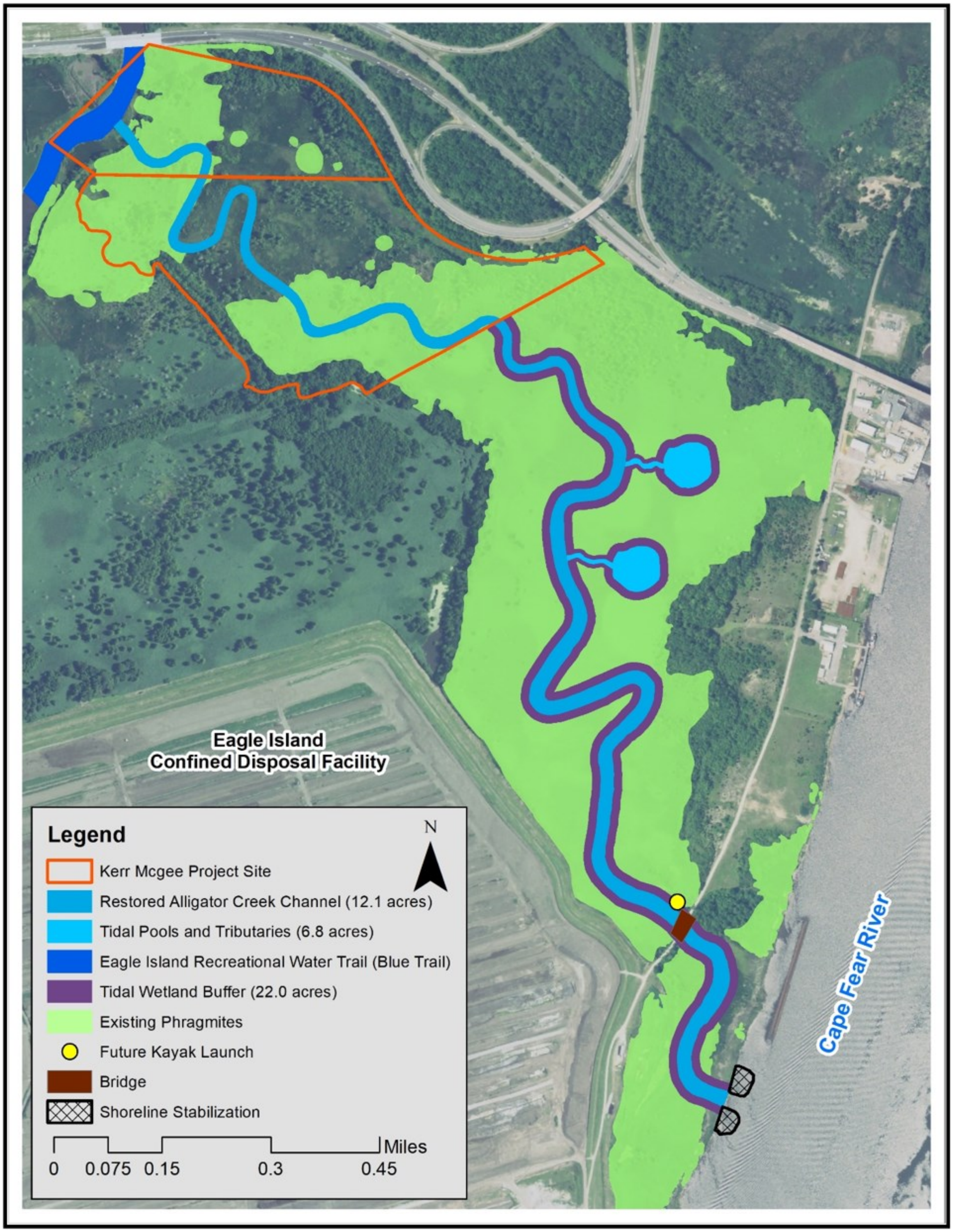

Figure 8-10
Alligator Creek Restoration Plan

Figure 8-11
Alligator Creek Concept Restoration Master Plan

8.25.4.2 Mitigation for Indirect Effects on Fish Habitat Suitability

To quantify potential indirect impacts to fish habitat suitability resulting from the alternative plans, a fish HSI analysis was completed (Main Report Appendix J: Fish Habitat Assessment). Six species were selected for the assessment, including Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), Atlantic menhaden (*Brevoortia tyrannus*), white shrimp (*Litopenaeus setiferus*), southern flounder (*Paralichthys lethostigma*), red drum (*Sciaenops ocellatus*), and striped bass (*Morone saxatilis*). The assessment utilized a coupled modeling approach, combining a three-dimensional hydrodynamic and water quality model with USFWS HSI models. These models use a numerical index to score areas on a 0.0-1.0 scale and provide a way to quantify habitat value through species-habitat relationships. Changes in habitat value were quantified using the USFWS HEP and reported as losses or gains in Habitat Units (HUs). Habitat units were determined by multiplying the HSI score for a given area by the total available acreage (USFWS 1980). Examining the difference in HUs between the FWOP and the TSP revealed losses of 123.08 and 226.12 HUs for Atlantic sturgeon and striped bass, respectively. These losses occurred near Wilmington, NC, and were classified as indirect impacts to Atlantic sturgeon and striped bass foraging habitat.

To identify gains that benefit the target species (Atlantic sturgeon and striped bass) and offset the impacts, a HEP Compensation Analysis was performed (USFWS 1980). The compensation goal is to offset the HU losses (349.2) with an equal or greater number of HU gains. The compensation area comprises the Cape Fear River mainstem from the USACE Lock and Dam #2 to the historic spawning grounds at Smiley Falls near Lillington, NC (Figure 8-12). The proposed mitigation includes the removal of Lock and Dam #2 as well as the construction of a fish passage at the USACE William O'Huske Dam (Lock and Dam #3) near Fayetteville, NC. Alternatively, an analysis was performed to evaluate changes in HUs gained if a fish passage was implemented at Lock and Dam #2 instead of dam removal. Removing and/or modifying these barriers restores access to historic spawning grounds for Atlantic sturgeon, striped bass, and American shad; however, proceeding with removal or fish passage construction at Lock and Dam #2 without modifying Lock and Dam #3 does not provide the HUs necessary to reach the compensation goal. Likewise, implementing a fish passage at Lock and Dam #3 does not provide the same benefits to the target species if Lock and Dam #2 is not removed or modified to support access to upstream habitat.

To calculate the HUs gained from implementing the proposed mitigation, the compensation area was classified into three habitat classes (Figure 8-12): migratory/foraging habitat, artificial spawning habitat (fish passage), and natural spawning habitat (Smiley Falls). Habitat Suitability Index scores were assigned to each class, and HUs gained were determined by multiplying the HSI scores by available acreage. Natural spawning habitat was given the highest HSI score (1.00) followed by artificial spawning habitat (0.50) and migratory/foraging habitat (0.25).

Results for two treatment scenarios are described below, the difference being removal of Lock and Dam #2 for the first scenario and a fish passage at Lock and Dam #2 for the second.

Scenario 1 (Removal of Lock and Dam #2 and Fish Passage at Lock and Dam #3)

Removing Lock and Dam #2 would allow target species to access 997.94 acres of upstream migratory/foraging habitat between Lock and Dam #2 and Lock and Dam #3, resulting in 249.49 HUs gained. However, an additional 99.71 HUs would be needed to offset losses associated with the TSP (349.20). A fish passage at Lock and Dam #3 would create novel spawning habitat below the dam and reconnect the target species with natural spawning grounds at Smiley Falls. This scenario results in an additional 770.81 HUs gained and satisfies the compensation goal

Scenario 2 (Fish Passages at Lock and Dam #2 and Lock and Dam #3)

Implementing a fish passage at Lock and Dam #2 would create novel spawning habitat below the dam and offer another option should removal be deemed inappropriate. Regardless, it would be necessary to modify Lock and Dam #3 to reach the compensation goal (349.20) because constructing a fish passage at Lock and Dam #2 would only result in 256.56 HUs.

In conclusion, either scenario above will achieve the required compensation goal and offset losses to foraging habitat associated with the TSP; however, Scenario 2 provides 7.07 additional HUs by creating artificial spawning habitat below Lock and Dam #2. Under both scenarios, overcompensation is provided, and the additional HUs gained can mitigate for unquantifiable impacts to the target species as described in the Biological Assessment (Appendix F), including entrainment and vessel strikes, blasting and associated activities, sediment suspension and turbidity, and artificial nighttime lighting. Moreover, dredging activities are expected to occur for approximately three to four years and overcompensation can address concerns related to prolonged project activities

Restoration of Fish Passages for Lock and Dams #2 and #3

Restoring access to historic migratory fish habitat in the Cape Fear River Basin above all three lock and dam's serves as a comprehensive watershed- based strategy to improve the resilience of anadromous fish populations in the river system (Figure 8-13). The Cape Fear River Action Plan, developed by the Cape Fear River Partnership, identified the action of constructing fish passage structures at Lock and Dams #2 and #3 on the Cape Fear River as a high priority and critical for the recovery of endangered and federally-managed species and the Cape Fear ecosystem. Construction of the rock rapids fish passages would provide for greater free flowing access to historic spawning grounds utilized by federally listed and federally-managed fish species, without compromising congressionally authorized purposes of navigation or affecting water supply users with intakes upstream of each the dams, such as the Lower Cape Fear Public Utility Authority and Fayetteville Public Works Commission.

Prior to the advent of dam construction, the Cape Fear Watershed generally provided a largely unimpeded river network. Anadromous species could cross the coastal plains to spawn in the riffles and rapids along the steeper gradient fall line where the coastal plains of NC meet the Piedmont region. These rapids provided critical spawning habitat for American shad, Atlantic and shortnose sturgeon, striped bass, and other species sustaining populations - not only in the Cape Fear River, but in coastal waters of the Atlantic Ocean.

Dam construction fragmented the Cape Fear Watershed and blocked these historic migrations. The role of the Lower Cape Fear dams in the decline of anadromous species of the Cape Fear River have been well documented. American shad, Atlantic sturgeon, shortnose sturgeon, striped bass, and river herring are all known to have been significantly more abundant upstream of dams prior to their construction.

Lock and Dams #2 and #3 continue to impede free flowing spawning runs to Smiley Falls, a historical spawning habitat. Restoring greater fish passage beyond these two barriers is critical to rebuilding resilient migratory fish populations and functional coastal ecosystems in the Cape

Fear River and a top priority of the Cape Fear River Partnership and NOAA. Constructing fish passages at Lock and Dams #2 and #3 will increase the availability of spawning habitat to a greater number of anadromous fish species and ensure resilient populations during extreme weather events. By increasing the proportion of a watershed that is available to migrating fish, we increase the likelihood that they will successfully reproduce in the less affected areas of the watershed; thereby, increasing population resilience as the impacts of climate change become more pronounced. Converting these dams to fishways and connecting an additional 84 free-flowing river miles of mainstem habitat and 995 tributary miles to the Atlantic Ocean will provide coastal plain river ecosystems in general, and the anadromous fish species of the Cape Fear River basin in particular, with greater resilience to extreme weather events. Since the conversion of Lock and Dam #1 to rock arch rapids in 2012 (Figure 8-14), American shad reproduction appears to have increased upstream of the dam and an Atlantic sturgeon has been observed below Lock and Dam #2. Proposed modifications to the Lock and Dam #1 fish passage should serve to benefit striped bass and Atlantic sturgeon and will be completed in 2020.

The planning and design effort for the nature-like fishways at Lock and Dams #2 and #3 were based on evaluating the performance of the completed fishway at Lock and Dam #1 and modifying the design to reflect updated guidelines by NOAA and the United States Geological Survey in natural fishway design, as well as the physical conditions and operational considerations at these two locations (NOAA 2016).

Bladen County, with support from the Cape Fear River Partnership, various federal and state stakeholders and Bladen County's consultants, has undertaken the planning and preliminary design of fish passages at Lock and Dams #2 and #3 based on the effort completed by the USACE Wilmington District for Lock and Dam #1. The construction of the rock arch rapid fish way at Lock and Dam #1 and the success of passing species such as American shad on the LCFR after fish passage construction at Lock and Dam #1, has accelerated the planning and design of similar structures at Lock and Dams #2 and #3.

The planning stage for development of fish passages at Lock and Dams #2 and #3 started in fall 2016 with collection of data including conducting field investigations (bathymetric and topographic surveys). During this period, a basis of design for the fish passage structure was developed, which included the core design rationale for selection of natural-like fish passage structure at Lock and Dams #2 and #3 in addition to the fundamental design criteria for the structures.

Preliminary hydrologic analyses were performed to assess and identify the range of discharges in the Cape Fear River for the design of the fish passages. Alternative concepts were developed at each lock and dam based on physical and environmental conditions, constructability and regulatory considerations, construction cost, and projected passing efficiencies of target species. Five to six alternatives were developed for each lock and dam. Refinements to each alternative fishway were performed using the results of preliminary hydraulic analyses to determine the flow paths, weir heights, and pool configurations that produced velocities suitable for fish to swim upstream.

An alternative analysis is underway to identify the preferred alternative at each lock and dam based on set of selection criteria and the need to maintain the mandated authorization of these federally installations that are managed by the USACE. A preliminary preferred fish passage structure has been selected for Lock and Dam #3, but additional evaluation of a preferred fish passage at Lock and Dam #2 is still underway in light of the Section 216 disposition study undertaken by the USACE Wilmington District to deauthorize all three lock and dams on the Cape Fear River.

More detailed hydrologic and hydraulic analyses are underway to refine the design of the preferred alternative for Lock and Dam #3 in preparation for submitting environmental and Section 408 applications to the USACE for review and approval of construction in fall 2020.

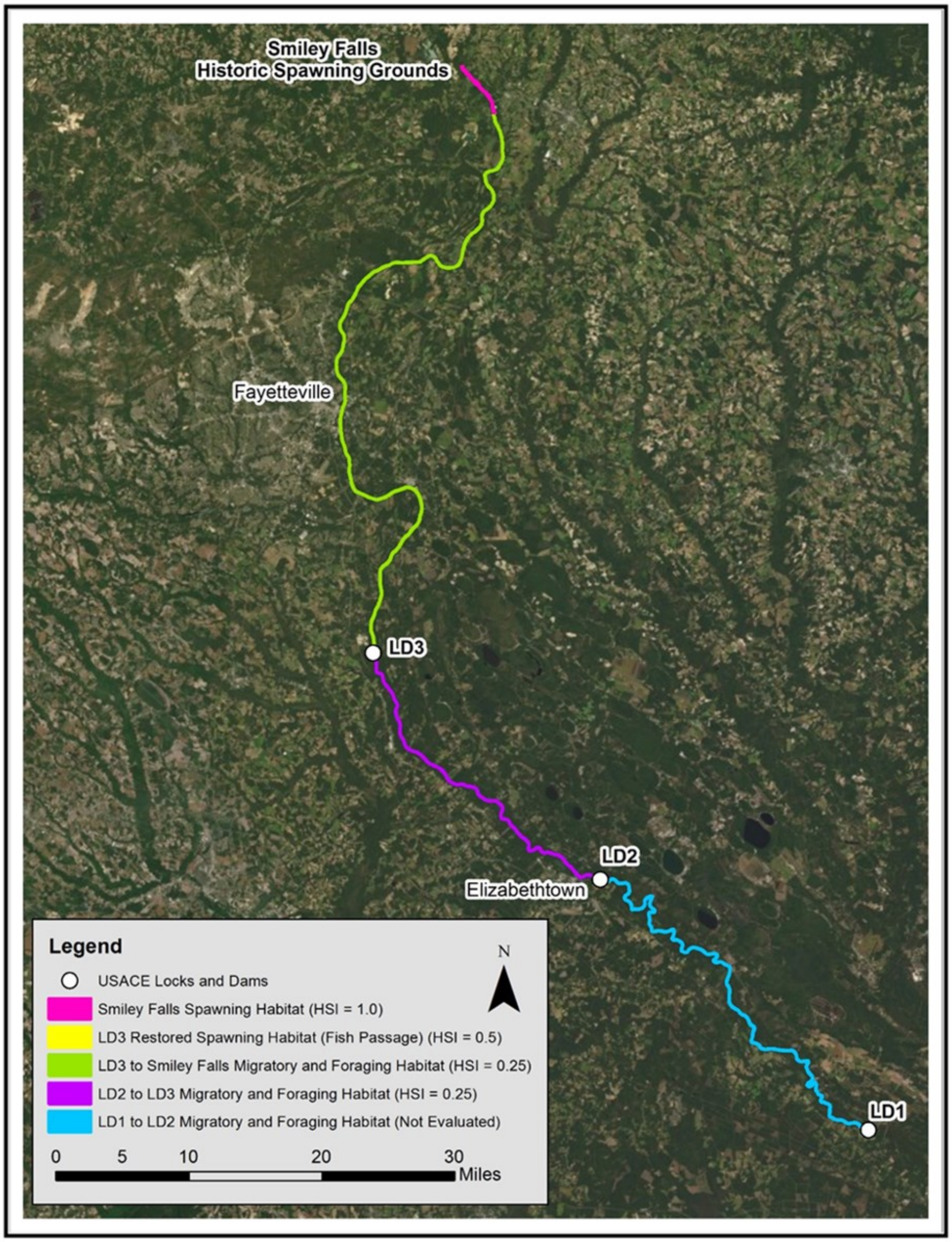

Figure 8-12
Lock and Dam #2 and #3 Locations and HEP Analysis Habitat Designations

Figure 8-13
Location of Lock and Dams #1, #2, and #3 in the Cape Fear River Watershed

Figure 8-14
Existing Rock Arch Rapids Fish Ramp at Lock and Dam #1

8.25.5 Mitigation for Erosion of Bird Islands in the Lower Cape Fear River

This section includes a summary of the past and present use of three islands in the LCFR by coastal waterbirds (Figure 8-15), a review of potential threats imposed by erosive losses of the islands on these bird populations, and a mitigation plan for improving bird habitat and prolonging the lifespan of the islands. While some modeling and analysis of the effects of vessel wakes has been performed for specific locations along the shoreline from Southport to Brunswick Town and Battery Island, no modeling has been performed for Ferry Slip and South Pelican**.** During development of the DEIS, additional modeling analysis will be performed on these islands to determine the extent of effect of ship generated waves on erosive processes.

8.25.5.1 Background

The Lower Cape Fear River (LCFR) provides habitat for approximately 25% of nesting coastal waterbirds in North Carolina. These bird populations utilize LCFR islands and marsh complexes on an annual basis. However, these areas are subjected to SLR and wave energy within the Cape Fear River, which are exacerbated due to increased shipping traffic in addition to the widening and deepening of the navigational channel that most recently occurred almost 20 years prior. Impacts from the last deepening and widening were not mitigated for, and the relatively rapid loss of shorelines from the river, marsh, and islands has become visibly apparent. It is expected that similar impacts would result from the planned deepening and widening, which, when combined with current stressors and projected levels of SLR, would shorten the lifespan of these islands and decrease their utility to the avian populations that utilize them for nesting and roosting activities. As such, naturalistic protection of these island shorelines and the addition of new material will be required in order to protect and sustain these islands over the coming decades.

Figure 8-15
Lower Cape Fear River Bird Islands Restoration Location Map

8.25.5.2 Mitigation Measures

For Ferry Slip and South Pelican Islands, approximately 250,000 cubic yards (cy) would be placed on each island, which would expand them to approximately 15 acres each. This would increase the longevity and promote use by current and future avian communities. Since "beach quality" sand (less than 10% fines) is required for this mitigation, it is assumed that the material for both islands would originate from the Horseshoe Shoal Reach. Depending upon future geotechnical investigations, material from the Reeves Point and/or Snows Marsh Reaches may be deemed suitable and could decrease the proposed cost. The amount of dredged material that would be available for use may vary in quality and location within the project area. Although a significant amount of historical data has been collected on the type of dredged material that is available, further analysis would be required to thoroughly evaluate the amount, quality, and location of sediments in the project area. Overall, there is a large quantity of beach compatible material spanning from the start of the entrance channel offshore and extending up through the mouth of the Cape Fear River. The proximity of this good and intermediate quality material to the proposed mitigation sites in the southern area of the project area would be an advantage in reducing the costs of transport and disposal. Further analysis will be required to assess the cost-effectiveness of the remaining material north of the three islands.

Both Ferry Slip Island and South Pelican Island are currently permitted for an area of seven acres each. It is proposed that the permitted size for each island be increased to 15 acres to accommodate the project's expected volume of dredged material, which would otherwise be disposed in the Offshore Dredged Material Disposal Site. It is recommended that the island footprints be reshaped to include more curvature, as this would increase linear shoreline available to birds. Incorporating more variation in elevation and slope might also attract additional avian species that have lost traditional beach habitat. The increase in each island's permitted footprint would require approval from all federal and state agencies as part of the federally authorized project. Modeling of the coastal processes and geotechnical analysis would be required to assess the most effective way of placing sediment on these islands to maximize lifespan and minimize erosion over time factoring in the increased wave action and flow resulting from the deepened and widened channel.

For Battery Island, proposed mitigation measures include the placement of dredged material along the southern and western shorelines of Battery Island to restore the previously existing berm and protect the existing trees from saltwater intrusion. Approximately 250,000 cy of material dredged from nearby reaches would be used to re-nourish the beach along the south and west sides of Battery Island. Width and height should be commensurate with the berm that was lost, which was approximately one meter above Mean High Water and approximately 10-20 meters in width.

To ensure the long-term viability of each island and the benefits provided to shorebirds, establishing physical targets (*e.g.* minimum allowable size and elevation) that would trigger dredging or other restoration projects with an appropriate funding source would ensure that these islands do not degrade beyond their functional utility for nesting birds in the LCFR ecosystem. Development of a management plan for the islands within the framework of the mitigation program for the TSP will be assessed during development of the DEIS and through agency coordination.

8.25.6 Mitigation for Vessel Wake Effects on Shorelines in Lower Cape Fear River

An evaluation was made of the effect of ship generated waves as a result of the deepened and widened channel and the new 12,400 Twenty-foot Equivalent (TEU) container ship design vessel. To evaluate the primary ship generated wave, the XBeach model was used and three areas of concern were identified where an increase in vessel wakes due to the project may negatively impact the shoreline. These include Orton Point, Brunswick Town/MOTSU, and a northern section of Southport. More details on the modeling effort can be found in Main Report Appendix A: Engineering.

8.25.6.1 Shoreline Vessel Wake Attenuation Mitigation Measures

Orton Point

Much of this shoreline is already protected by a rock revetment and no mitigation efforts are proposed in these locations. However, there are two sections of shoreline (650 ft and 1,500 ft) with a marsh platform in front which are currently unprotected and may be impacted. A rock sill (Figures 8-16 and 8-17) is proposed in these areas to provide protection from increased vessel wakes to the existing marsh. The rock sill would extend up to Elevation +3.0 North American Vertical Datum. A rock revetment along the shoreline was considered in these areas, but it was not deemed feasible as its construction would be detrimental to the existing marsh platform in front and would not provide protection to these marshes from ship wake induced erosion.

Figure 8-16
Orton Point – Brunswick Town Conceptual Plan

Figure 8-17
Example of Rock Sill Used with a Living Marine Shoreline

Brunswick Town/MOTSU

Various sections of this shoreline are already protected by a rock revetment and the proprietary pile supported “Reefmaker” system with additional sections currently in the bidding process. In areas where an unprotected marsh platform still exists and may be impacted, a rock sill is proposed to provide protection from increased vessel wakes. The rock sill would extend up to Elevation +3.0 North American Vertical Datum and extend along approximately 2,600 ft of shoreline. Similarly to Orton Point, a rock revetment along the shoreline was considered in these areas, but was not deemed feasible as its construction would be detrimental to the existing marsh platform in front and would not provide protection to these marshes from ship wake induced erosion.

In an area extending about 700 ft along the shoreline where the bottom profile is rather steep and the remnants of a historically significant wharf exists, a rock sill is not a viable approach as it would require a significant amount of material and its cost would be comparable to that of a pile supported system, although in some areas the bottom profile may drop off too quickly for a rock sill to even be constructed in a stable position. Hence, the proprietary “Reefmaker” system (or similar system) is proposed for this area (see Figure 8-18).

Figure 8-18
Example of Reef Maker Wave Attenuation Structure

Southport

About 1,700 ft of shoreline at the north end may be negatively impacted by the proposed project. The coastal marsh in the area has been heavily eroded or no longer exists, and the shoreline consists of rock revetments and bulkheads in various conditions. Additionally, private piers extend out into the river at this location. A “living shoreline” is proposed in this area. It would consist of a rock sill similar to those proposed in the other locations above (Figure 8-19). However, the beneficial use of material dredged from the adjacent Lower Swash Reach would then be placed behind the sill and planted.

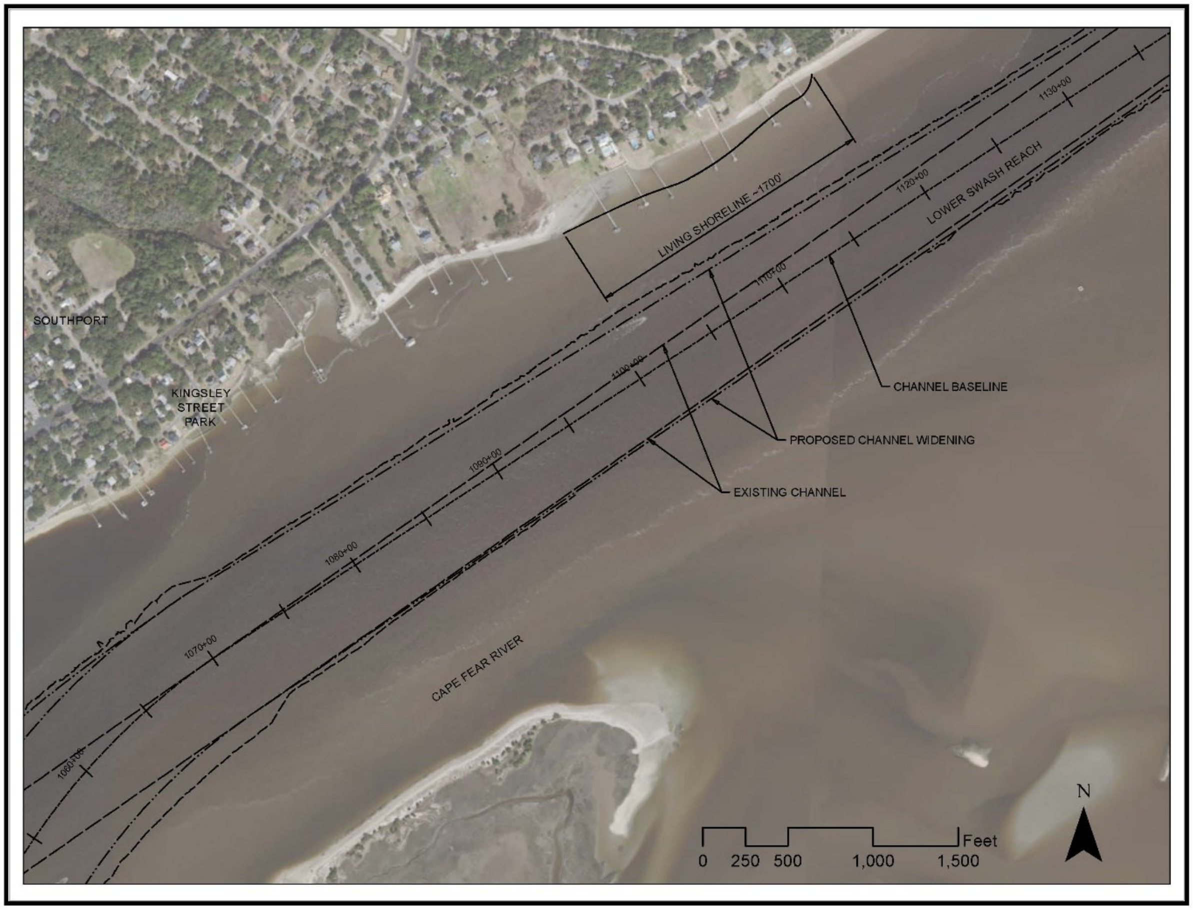

Figure 8-19
Upper Southport Shoreline Conceptual Mitigation Plan

Additional Shoreline Potentially Impacted by Vessel Wakes

During development of the Draft EIS, additional areas may be analyzed, as identified by concerned stakeholders to determine if they may be negatively impacted by ship generated waves as a result of the deepened and widened channel and the new 12,400 TEU container ship design vessel. If such impacted areas are found, similar mitigative measures as those discussed previously would be considered such as rock sills, pile supported "reef" systems, living shorelines and /or placement of dredged material for habitat creation.

8.25.7 Monitoring Program and Adaptive Management Measures

A comprehensive monitoring program, corrective action plan, and adaptive management measures will be developed thorough formal coordination with the IRT recently assembled by the USACE for development of the DEIS, as well as through the Wetland and Fish and Fish Habitat TWGs, which have been meeting for over a year. Anticipated components of the monitoring program and schedule are included in Table 8-12. Development of the monitoring program will include collaborative efforts with the University of North Carolina at Wilmington

Center for Marine Science, and federal and state agencies with specific knowledge and experience within the river. Due to the knowledge gained from the ten years of post-construction monitoring by the University of North Carolina at Wilmington for the last Wilmington Harbor deepening project started in 2000, their guidance will be beneficial. An estimated budget for the monitoring efforts defined below was prepared based in part on review of monitoring protocols for recently approved deep draft navigation projects along the southeast coast, and by establishing a reasonable level of effort for project related monitoring and mitigation- based monitoring (see Appendix N: Mitigation and Monitoring).

Table 8-12
Monitoring and Adaptive Management Program Components and Schedule

Tidal Wetlands

- Conceptual framework
- Preconstruction - multispectral imagery of tidal wetlands (1 year)
- Post-construction - multispectral imagery of tidal wetlands (Years 1, 3, and 7)
- Mitigation site trend analysis using multispectral imagery (Years 1, 3, and 7)
- Mitigation plan baseline and post- restoration monitoring (7 years)
- Corrective action plan and adaptive management measures

Fish and Fish Habitat

- Conceptual framework
- Preconstruction baseline benthic and fish resource monitoring (1 year)
- Construction concurrent pre-treatment monitoring (1-3 years)
- Post-construction benthic and fish resource monitoring (Years 1,3,5, and 7)
- Mitigation plan(s) baseline and post-construction monitoring (7 years)
- As-built surveys of all constructed mitigation measures (1 year)
- Corrective action plan and adaptive management measures

Water Column Modelling Post-Construction Calibration Monitoring

- Conceptual framework
- Preconstruction calibration and data collection platform constructed
- Construction concurrent data collection (3-4 years)
- Post-construction data collection (6-7 years)
- Post- construction model calibration and report (1 year)
- Corrective action and adaptive management measure

Shoreline Change Monitoring

- Conceptual framework
- Preconstruction shoreline survey and mapping (1 year)
- Post- construction surveys and mapping (Years 1,5, and 7)
- Mitigation plan(s) baseline and post-construction monitoring (7 years)
- As-built surveys of all constructed mitigation measures (1 year)
- Corrective action plan and adaptive management measures

Table 8-12
Monitoring and Adaptive Management Program Components and Schedule

Lower Cape Fear Bird Islands Erosion Monitoring

- Conceptual framework
- Preconstruction shoreline survey and mapping (1 year)
- Post- construction surveys and mapping (Years 1,5, and 7)
- Mitigation plan(s) baseline and post-construction monitoring (7 years)
- As-built surveys of all constructed mitigation measures
- Corrective action plan and adaptive management measures

Threatened and Endangered Species Monitoring

- Construction dredge monitoring using PSOs
- Construction - blast monitoring per Biological Opinion and monitoring plan
- Construction - sea turtle and nest monitoring for beach placement
- Construction – Atlantic sturgeon monitoring during dredging
- Mitigation baseline and post-construction monitoring for lock and dam fish passages

Beneficial Use of Dredged Material Project(s) Monitoring

- Conceptual framework
- Preconstruction surveys for island treatment sites and beach disposal areas
- Post- construction beach disposal areas surveys
- Post-construction island treatment monitoring
- As-built surveys for island treatment sites
- Corrective action plan and adaptive management measures

8.25.8 Future Environmental Considerations

The following actions will be considered during the preparation of a NEPA document.

1. Salinity impacts to wetlands and fish/fisheries habitat induced by the proposed deepening will be mitigated. Mitigation planning will continue to be coordinated with regulatory agencies (see Appendix N: Mitigation, Monitoring, and Adaptive Management Plan).
2. As part of any Corrective Action Plan, results of any related data collection or analyses will be coordinated with the regulatory agencies and other stakeholders and modification to the mitigation plan, if necessary, will be implemented (see Appendix N: Mitigation, Monitoring, and Adaptive Management Plan).
3. Protective measures for threatened and endangered species will be implemented pursuant to Endangered Species Act-Section 7 consultation (Appendix K: Biological Assessment of Threatened and Endangered Species).
4. A Pre-treatment (Blasting) Plan, which includes protection measures for marine animals, will be prepared and coordinated with regulatory agencies.

5. The proposed deepening will be performed in compliance with NC state water quality statutes.
6. Migratory birds will be protected in accordance with the Migratory Bird Treaty Act.
7. During the construction phase, equipment emissions and noise will be controlled in compliance with applicable laws.
8. During the construction phase, the USACE contracting officer will notify the contractor in writing of any observed noncompliance with federal, state, or local laws or regulations, permits and the contractor's Environmental Protection Plan.

9 TENTATIVELY SELECTED PLAN

The TSP is a single purpose project that will contribute to the economic efficiency of commercial navigation. The TSP is the National Economic Development (NED) Plan. Based on Fiscal Year (FY) 2020 price levels, the FY 2020 discount rate (2.75%), and a 50-year period of analysis, the total project first cost of the NED Plan is $834,093,000 with average annual benefits of $85,161,000; average annual costs of $33,890,000, and a benefits-to-costs ratio of 2.5 to 1. At a discount rate of 7%, the benefits-to-costs ratio is 1.2 to 1.

9.1 Tentatively Selected Plan General Navigation Features

The TSP is the NED Plan, which consists of the following general navigation feature improvements:

- Deepening the Federal navigation channel; and
- Widening the Federal navigation channel.

9.1.1 Deepening the Federal Navigation Channel

The 47-ft MLLW depth evaluated for this study applies to the Federal navigation channel from the Lower Swash range and all ranges up to and including the Lower Anchorage. From the Battery Island Range to the pilot station, the depth will be increased to -49 ft MLLW to allow for adequate under keel clearance in areas affected by ocean waves. The improved channel will extend 48,000 ft, (~9.1 miles) out to sea from the junction with Baldhead Reach 3 to reach water that is consistently deeper than the maintained channel depth of -49 ft MLLW. The range offshore of the current pilot boarding station (Sta 490+00) will have a heading of approximately 30° (inbound), which, is approximately 16° shifted from Bald Head Shoal Reach 3 (14°). The purpose of this heading change is to reach deeper water in the most direct path and reduce dredging costs (Figure 9-1). The Cape Fear River Pilots have been consulted and approve of this realignment.

In addition, the existing Lower Anchorage Basin, a portion of which is used to turn vessels, will be dredged from the existing authorized depth of -42 ft MLLW to -47 ft MLLW. The total volume of material to be dredged under the -47-foot plan is projected to be 26.9 million cubic yards (mcy) in situ, of which 22.7 mcy is sand and silt and 4.2 mcy is rock.

9.1.2 Widening the Federal Navigation Channel

Widening of channel reaches (Table 9-1) is based on Ship Simulation modeling for design vessel maneuvering during vessel transits. The Federal navigation channel is not being widened for the purpose of creating meeting areas, which were evaluated during Preliminary Screening and not advanced for more detailed analysis.

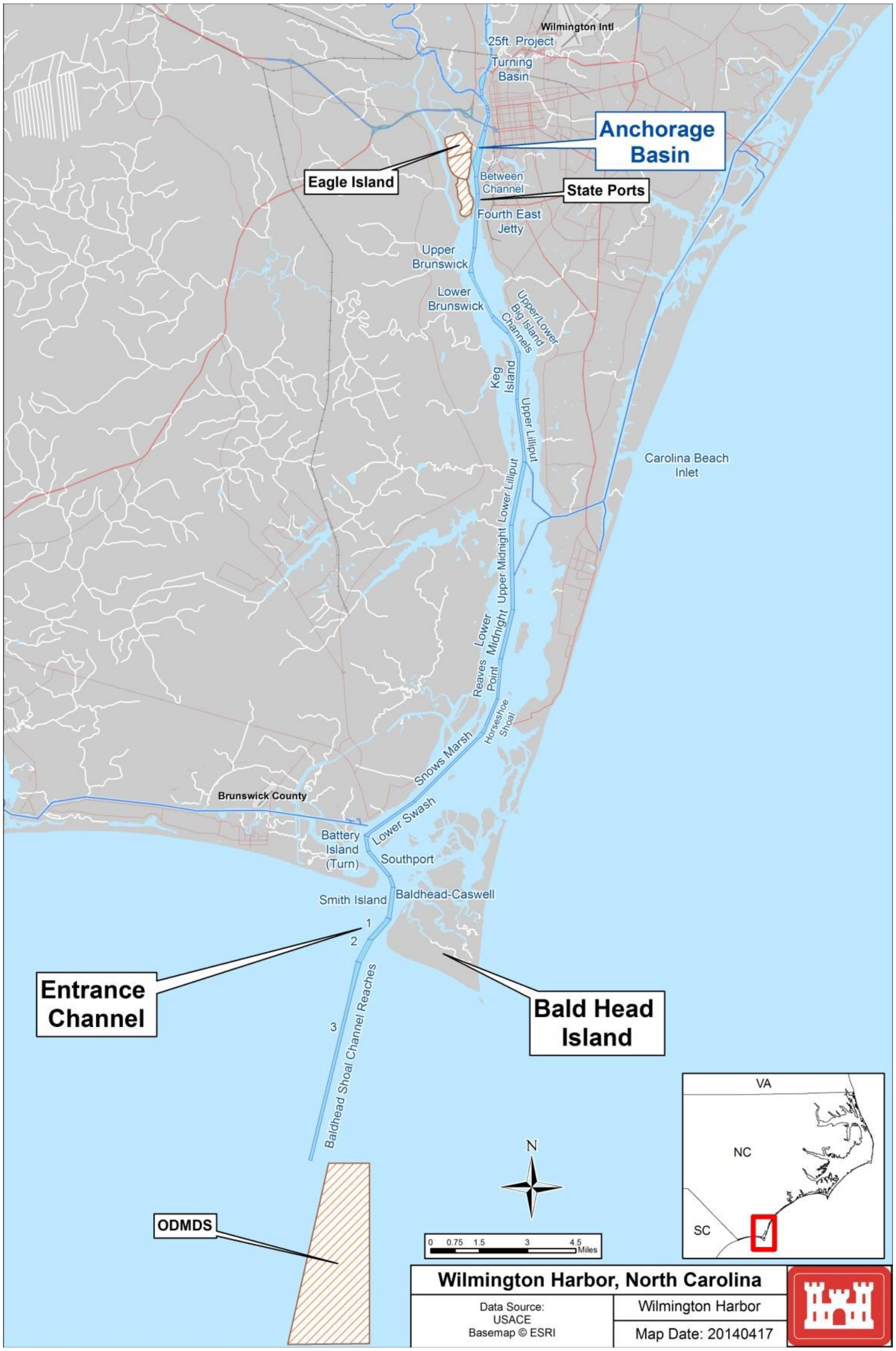

Figure 9-1
Wilmington Harbor Federal Navigation Project

Table 9-1
Existing and Proposed Channel Widths by Range

Range Name	Channel Widths [ft]		Widening Details
	Existing Channel	Proposed	
Entrance	N/A	600	New
Bald Head Shoal Reach 3	500 - 900	600 - 900	Symmetric
Bald Head Shoal Reach 2	900	900	No Change
Bald Head Shoal Reach 1	700	900	Green Side Only
Smith Island	650	900	Red Side Only
Bald Head - Caswell	500	800	Red Side Only
Southport	500	800	Re-orientation Red Side then Green Side
Battery	500	800 - 1300	Replaced with 4000-ft Radius Curve And Green Side at Apex
Lower Swash	400	800 - 500	Green Side to Symmetric
Snows Marsh	400	500	Symmetric
Horseshoe Shoal	400	500	Symmetric
Reaves Point	400	500	Symmetric
Lower Midnight	600	600	No Change
Upper Midnight	600	600	No Change
Lower Lilliput	600	600	No Change
Upper Lilliput	400	500	Symmetric
Keg Island	400	500	Symmetric
Lower Big Island	400	500	Symmetric
Upper Big Island	660	660	No Change
Lower Brunswick	400	500	Symmetric
Upper Brunswick	400	500	Symmetric
Fourth East Jetty	500	550	Green Side Only
Between Channel	550	625	Green Side Only
Anchorage Basin	625	625 - 1509	No Change

9.2 Dredged Material Placement

Construction dredging material will be placed within the New Wilmington ODMDS, which is consistent with the existing dredged material management practices and is the least cost disposal option. Dredged sediment is expected to primarily include fine- to medium-grained sand with silts from the upper channel reaches and the anchorage basin. Dredged rock is expected to be limestone, siltstone and sandstone (sedimentary rock). Beneficial use of dredged material is being evaluated for:

- Beach placement on Bald Head Island and Oak Island;
- Battery Island shore placement;
- South Pelican and Ferry Slip Island restoration;
- Island creation adjacent to South Pelican and Ferry Slip Islands; and
- Wetland restoration on Battery, Shellbed, and Striking Islands using thin-layer placement.

New work and future maintenance dredging volumes resulting from the proposed improvements to the Federal Navigation channel fit within the Wilmington District's existing dredged material management practices and there are no substantial modifications to existing placement sites required. Existing dredged material management practices, which are least cost method of dredge material disposal for the existing Wilmington Harbor project, are the same dredged material management practices recommended the -47-foot Plan's new work material and future maintenance material.

All construction material will be either disposed at the New Wilmington ODMDS or placed at one or multiple beneficial use sites being evaluated for this project. All post-construction maintenance material will be placed at the existing sites currently in use.

9.3 Relocation of aids to navigation (ATON)

A total of 56 ATONS are included in the -47-foot plan, which includes new offshore range markers, new and relocated Lateral Buoys, and relocated inshore range markers, including:

- Range Markers (steel multi-pile jacket structures, varying height steel skeleton towers with ranger markers attached):
  - Two (2) new range markers
  - Relocate ten (10) range markers
  - Buoys (floating aids with anchors and attached lights):
- Thirteen (13) new lateral marker buoys (this number could go up or down a couple depending on whether bend wideners are installed at each bend).
  - Relocate up to thirty-eight (38) lateral marker buoys.
  - Relocate the sea buoy.

Table 6-3 in Section 6.2.2 Effects on Aids to Navigation identifies the ATONS to be relocated or constructed.

9.4 Tentatively Selected Plan Construction Schedule

The construction schedule (Table 9-2) has been developed based on equipment types, production rates, and environmental work windows (Table 9-3) for dredging and beach placement (USACE, 2019). The construction schedules provide one means of accomplishing the Project within 3 years. CU blasting is assumed to be restricted to the same environmental work window that applies to dredging operations in the same locations. This schedule is representative of a typical plan in that uses the most likely equipment and maximizes dredge efficiency. It should be noted that this schedule will not be a requirement of the Contract (i.e., it represents one possible plan, but is not necessarily the plan that will be implemented).

Table 9-2
47-foot Plan Construction Schedule

Equipment Type	Year 1	Year 2	Year 3
Hopper Dredges	Entrance	Baldhead Shoal 2	Baldhead Shoal 3
Cutterhead Suction Dredge 1	Baldhead Shoal 3 Battery Island Lower Swash Snows marsh	Beach Placement Baldhead Shoal 1 Smith Island Baldhead-Casewell Southport	Lower Lilliput Upper Lilliput
Cutterhead Suction Dredge 2	Horseshoe Reaves Lower Midnight Upper Midnight	Keg Island Lower Big Island Upper Big Island Lower Brunswick	Upper Brunswick Fourth East Jetty Between Reach Anchorage Basin
Drill Barges and Mechanical Dredge	---	Keg Island Lower Big Island Upper Big Island Lower Brunswick	---

Table 9-3: WHNIP Environmental Work Windows

Construction Activity	Channel Reaches	Environmental Work Window	Reason for Window
Hopper dredging with ODMDS disposal	Baldhead Shoal 2 Baldhead Shoal 3 Entrance channel extension reach	1 Dec – 15 April	Minimization of sea turtle entrainment risk
Cutterhead dredging with ODMDS disposal	Baldhead Shoal 3 Battery Island Lower Swash Snows marsh Horseshoe Shoal	Year round	NA
Cutterhead dredging with ODMDS disposal	Reaves point Lower Midnight Upper Midnight Lower Lilliput Upper Lilliput Keg Island Lower Big Island Upper Big Island Lower Brunswick Upper Brunswick Fourth East Jetty Between Reach Anchorage Basin	1 Aug – 31 Jan	Avoidance of anadromous fish spawning period
Cutterhead dredging with beach placement	Baldhead Shoal 1 Smith Island Baldhead-Caswell Southport	16 Nov - 30 April	Avoidance of sea turtle nesting season
CU blasting with drill barge and ODMDS disposal	Keg Island Lower Big Island Upper Big Island Lower Brunswick	1 Aug – 31 Jan	Avoidance of anadromous fish spawning period
Bucket dredging with ODMDS disposal	Keg Island Lower Big Island Upper Big Island Lower Brunswick	Year round	NA

9.4.1 Cost Sharing

Project cost sharing is detailed in Table 9-4.

Table 9-4
Project Cost Shares

Cost Item	Total Cost	75% Federal	25% Non-Federal
Dredging Cost	$547,882,000	$410,912,000	$136,971,000
Mitigation & Monitor	$84,000,000	$63,000,000	$21,000,000
Construction S&A	$10,800,000	$8,100,000	$2,700,000
PED	$21,100,000	$15,825,000	$5,275,000
Contingency (21.4%)	$142,049,000	$106,537,000	$35,512,000
Total Construction of GNF	**$805,831,000**	**$604,373,000**	**$201,458,000**
Lands & Damages	$28,262,000	$0	$28,262,000
Total project First Costs	**$834,093,000**	**$604,373,000**	**$229,720,000**
Berthing Area Dredging Costs	$1,760,000	$0	$1,760,000
Aids to Navigation	$10,531,000	$10,531,000	$0
10% GNF Non-Federal		-$52,321,000	$52,321,000
Total Cost	**$846,384,000**	**$562,583,000**	**$283,801,000**

The estimated Federal and non-Federal shares of the project first cost are $604,373,000 and $229,720,000, respectively, as apportioned in accordance with the cost sharing provisions of Section 101 of WRDA 1986, as amended (33 U.S.C. 2211): the cost for dredging greater than 20 feet and less than 50 feet will be shared at a rate of 75 percent by the Federal Government and 25 percent by the non-Federal sponsor.

In addition to the non-Federal sponsor's estimated share of the total first cost of constructing the project in the amount of $229,720,000, pursuant to Section 101(a)(2) of WRDA 1986, as amended, the non-Federal sponsor must pay an additional 10% of the costs of general navigation features of the project in cash over a period not to exceed 30 years, with interest. The value of the costs for lands, easements, rights-of-way and relocations provided by the non-Federal sponsor under Section 101(a)(3) of WRDA 1986 as amended will be credited toward this payment. The costs for lands, easements, rights-of-way or relocations provided by the non-Federal sponsor for this project total $28,262,000 and 10% of the GNF cost is $80,583,000, which results in a net 10% General Navigation Features (GNF) requirement of $52,321,000.

Additional costs of operation and maintenance for this TSP, over and above the costs to operate and maintain the existing Federal project, are estimated to be $1,160,000 annually. In accordance with Section 101(b)(1) of WRDA 1986, as amended (33 U.S.C. 2211(b)(1))), the Federal

Government will be responsible for an amount equal to 100 percent of the excess of the cost of operation and maintenance of the project over the cost of which would be incurred for operation and maintenance for project depths up to 50 feet. Therefore, the Federal share of the incremental annual maintenance cost is estimated to be $1,160,000.

Estimated associated costs of $1,760,000 are 100% non-federal costs associated with development of local service facilities (including dredging of berthing areas). The projected additional costs for aids to navigation, $10,531,000 are a 100% Federal responsibility.

9.4.2 Section 203 Study Costs

Should the project that is recommended in this feasibility study be authorized by Congress, the North Carolina State Ports Authority, who has fully funded this Section 203 feasibility study, intends to seek credit under the provisions of Public Law 99-662, 99th Congress, November 17, 1986, (WRDA 1986), Section 203.(d) Credit and Reimbursement.

> Section 203(d) states *"If a project for which a study has been submitted under subsection (a) is authorized by any provision of Federal law enacted after the date of such submission, the Secretary shall credit toward the non-Federal share of the cost of construction of such project an amount equal to the portion of the cost of developing such study that would be the responsibility of the United States if such study were developed by the Secretary."*

9.4.3 Financial Analysis of Non-Federal Sponsor's Capabilities

A financial analysis is required for any plan being considered for USACE implementation that involves non-Federal cost sharing. The purpose of the financial analysis is to ensure that the non-Federal sponsor understands the financial commitment involved and has reasonable plans for meeting that commitment. The financial analysis includes the non-Federal sponsor's statement of financial capability, the non-Federal sponsor's financing plan, and an assessment of the sponsor's financial capability.

The North Carolina State Ports Authority has expressed support for a potential project. Their funding of this Section 203 study is proof of their willingness to proceed with the proposed solution to the channel constraint problems identified at Wilmington Harbor. The North Carolina State Ports Authority has the capability to fund the non-Federal share of project design and construction costs. Furthermore, their capability as a non-Federal sponsor has been evidenced by their performance as the non-Federal sponsor on all previous Federal projects at Wilmington Harbor.

The non-Federal sponsor will provide a Self-Certification of Financial Capability for Agreements prior to submission of the Project Partnership Agreement. Included with the self-certification, the financial analysis shall include the non-Federal sponsor's statement of financial capability, the non-federal sponsor's financing plan, and an assessment of the non-federal sponsor's financial capability.

9.5 Tentatively Selected Plan Operations and Maintenance

The incremental increase in annual maintenance dredging due to the NED Plan is 122,000 cubic yards per year, which would increase annual maintenance costs by $1,160,000.

9.6 Tentatively Selected Plan Environmental Impacts and Mitigation

Environmental impacts of the TSP are evaluated in Section 8: Environmental Consequences and are summarized below. The preliminary mitigation, monitoring, and adaptive management plan is presented in section 8.25 and developed in Appendix N: Mitigation and Monitoring. The preliminary mitigation, monitoring, and adaptive management plan indicates that the appropriate level of mitigation is available for the TSP at a reasonable cost. Final mitigation planning will be performed in coordination with USACE, during development of the DEIS.

The environmental impacts of the TSP include:

- **Tidal amplitude** – Hydrodynamic modeling results indicate that channel deepening and associated increases in hydraulic efficiency will cause small changes in MHW, MLW, and tidal range. The largest projected MHW increase is ~1.3 inches in the vicinity of downtown Wilmington. MLW is projected to decrease, with a maximum decrease of ~2.0 inches projected to occur in the vicinity of Wilmington. The net effect of the projected MHW and MLW changes is a maximum increase in tidal range of 3.4 inches at Wilmington. Projected effects on MHW, MLW, and tidal range are reduced through the up-estuary and down-estuary reaches above and below Wilmington;
- **Salinity** - Hydrodynamic modeling results indicate that channel deepening would increase surface, mid-depth, and bottom salinities; with the largest increases occurring at mid to bottom depths in the vicinity of downtown Wilmington. Under typical river flow conditions; average annual surface, mid-depth, and bottom salinities are projected to increase by 1.2 ppt, 3.9 ppt, and 4.1 ppt at Wilmington, respectively. Projected effects on salinity are reduced through the up-estuary and down-estuary reaches above and below Wilmington;
- **Dissolved oxygen** – Hydrodynamic modeling results indicate that channel deepening would have negligible effects on dissolved oxygen (DO) concentrations, with projected decreases of 0.3 mg/L or less throughout the estuary. Maximum decreases are projected to occur during the winter months when estuarine DO concentrations are typically the highest; providing further indication that projected decreases would not have any significant effect on estuarine biological resources;
- **Tidal wetlands** – Channel deepening would not have any direct impacts on wetlands. Hydrodynamic modeling results indicate that channel deepening would cause small increases in average annual surface salinity of 0.3 ppt or less at the upper ends of existing salinity gradients in the estuary. Projected salinity increases of 0.3 ppt or less may have minor effects on the composition of tidal freshwater marsh and swamp forest communities in the upper estuary; but would not be expected to convert tidal swamp forests to tidal marsh communities;
- **Estuarine shoreline erosion** - Modeling results indicate that transits by larger container vessels would result in increased bed shear stress along the shoreline northeast of Southport, the southern shoreline of Battery Island, and at isolated shoreline locations in the vicinity of Orton Point. Projected increases in bed shear stress indicate the potential for increased shoreline erosion. Potential erosional effects will be investigated further during development of the DEIS and the PED project phase;

- **Beach erosion** - Wave transformation and shoreline change modeling results indicate that channel deepening would have minor to negligible effects on the shorelines of Bald Head Island and Oak Island. On Bald Head Island, channel deepening is projected to have minor adverse effects on the central South Beach shoreline and minor beneficial effects on the western South Beach shoreline. Erosion rates (net of any beach nourishment activity) along the central South Beach shoreline are projected to increase by 0.6 ft/yr or less, while erosion rates along the western South Beach shoreline are projected to decrease by ~1.3 ft/yr. Erosion rate increases (net of any beach nourishment activity) of 0.1 ft/yr or less are projected along most of Oak Island, with an increase of ~0.2 ft/yr projected along the east end of Caswell Beach;

- **Benthic softbottom habitat** - New dredging would impact ~925 acres of relatively undisturbed softbottom habitat in the channel widening areas and the new entrance channel extension reach; including ~368 ac of offshore marine softbottom habitat and ~557 acres of inshore estuarine softbottom habitat. The vast majority of the impacts would consist of temporary effects on existing deepwater habitats that are presently subject to frequent disturbance and depth limitations on productivity. New dredging would affect just 5.9 acres of highly productive shallow (<6 ft) softbottom habitat, including just 3.5 acres of softbottom PNA habitat;

- **Fisheries and Essential Fish Habitat** - New dredging impacts on softbottom habitats and associated benthic invertebrate communities would have primarily short-term effects on benthic prey base for predatory demersal fishes. New dredging impacts on 5.9 acres of highly productive shallow (<6 ft) softbottom habitat, including 3.5 acres of softbottom PNA habitat may have longer term effects on nursery habitat functions and estuarine dependent juveniles. However, the project would impact a small fraction of the estimated 37,800 acres of <6 ft shallow softbottom habitat in the CFR estuary. The effects of blasting on fisheries may include direct injury and mortality; however these impacts would be minimized through the development and implementation of an effective blast mitigation protection program;

- **Coastal waterbirds** - Beach placement of dredged material would affect coastal waterbirds through disturbance and temporary losses of intertidal benthic invertebrate prey resources; and

- **Protected species** - Dredging may have short-term effects on Atlantic and shortnose sturgeon through softbottom foraging habitat disturbance and temporary losses of benthic prey resources. The effects of blasting on Atlantic and shortnose sturgeon may include direct injury and mortality; however, these impacts would be minimized through the development and implementation of an effective blast mitigation protection program. Projected increases in salinity would shift the average position of the salt front upstream, potentially affecting habitat suitability in the vicinity of Wilmington where known concentration areas for sturgeon are located. Atlantic and shortnose sturgeons could experience a loss of habitat or a reduction in habitat suitability. The projected salinity increases may adversely affect critical habitat for the Atlantic sturgeon.

Preliminary mitigation measures developed as compensation for direct and indirect effects of the TSP are summarized below:

- **Tidal Wetland Mitigation** - Preservation and restoration of the Black River Wetland Mitigation Site would provide protection of 3,685 acres of tidal swamp and pocosin pond pine woodlands contiguous with the tidal floodplain/bottomland area, conservation of an additional 470 acres of pocosin wetlands and 800 acres of upland buffers, and restoration of 25 acres of wetlands from existing timber roads and ditches.
- **Shallow Water Estuarine Habitat Mitigation** - Mitigation includes restoring 12.1 acres of subtidal shallow water estuarine habitat (7,000 linear ft and less than 6 ft deep) of the historic the Alligator Creek channel, enhancing 22 ac of fringing tidal marshes (currently Phragmites) along both sides of the restored channel reach, and enhancing 6.8 acres of tidal pools and creeks for juvenile fish refugia from Phragmites habitat,
- **Fish Habitat Suitability Mitigation** - Mitigation for salinity effects on anadromous species would include construction of fish passages at Lock and Dam 2 and Lock and Dam 3 on the Cape Fear River, thus allowing anadromous fish species access to natal spawning grounds for the first time in almost a century. The balance of credits also provide compensation for other indirect effects such blasting, interruption of migration during construction, and due to the long construction period.
- **Bird Island Enhancement** - Mitigation for erosional effects on three significant managed bird islands in the LCFR would include expanding the subaerial footprint of Ferry Slip and South Pelican Islands to 15 acres each through placement of 250,000 CY of dredged material and sand placement on the western shoreline of Battery Island to protect waterbird nesting habitat against ongoing and future erosion.
- **Vessel Wake Attenuation and Mitigation** - Mitigation measures to reduce the effects of vessel wakes on areas along the western shoreline of the LCFR include construction of a rock sill along 2,150 linear ft of shoreline at Orton Point, construction of a 2,600 linear ft rock sill and 700 ft Reef maker section along the Brunswick Town shoreline area and construction of 1,700 linear ft of living marine shoreline adjacent to the north end of Southport. Additional areas may be added following additional modelling and analysis.

9.7 Tentatively Selected Plan Lands, Easements, Rights-of-Way, and Relocation Considerations

It is the responsibility of the non-Federal sponsor to acquire real estate interests required for the project. Real estate acquisition is a component of the preliminary mitigation plan. Detailed information pertaining to potential real estate acquisition is provided in the Real Estate Appendix. No real estate acquisition is required for deepening or widening of the Federal channel, nor is real estate acquisition required for the placement and disposal of dredged material.

One active pipeline requires relocation and two inactive pipelines require removal. The active six-inch pipeline is at a depth of ~49 feet MLLW and needs to be relocated. The two inactive four-inch lines are at a depth of ~47 feet MLLW and need to be removed. All relocations, including utility relocations, are to be accomplished at no cost to the Federal Government. Relocation costs are included in the project cost as a 100% non-federal expense and the non-

Federal Sponsor will receive equivalent credit toward its additional 10 percent cash payment required by Section 101(a)(4) of WRDA 86.

The two four-inch pipelines do not need to be relocated because they are no longer active. The non-Federal Sponsor has contacted the owner to reach a determination as to whether the owner has an interest in the existing line for which compensation is owed by the non-Federal Sponsor. If the owner has a compensable interest, the non-Federal Sponsor, as part of its requirement to provide lands, easements, and rights-of-way required for the navigation improvement project, will be responsible for acquiring this interest, at no cost to the Federal Government. At this time, it appears that there is no compensable interest in these pipelines.

9.8 Risk and Uncertainty

A Cost and Schedule Risk Analysis was performed with technical assistance from the USACE Wilmington District (see the Cost Appendix). The resulting contingency at the 80% confidence level is 21.4% of construction costs, which have been included in all cost estimates.

A sensitivity analysis was performed to identify potential effects on NED Plan selection for a split between Charleston as the alternative port for export cargo and Savannah as the alternate ports for import cargo (see the Economics Appendix). The results of the sensitivity analysis confirm the -47-foot plan as the NED Plan.

In addition, a risk pointed out by a reviewer indicated that the increase in landside transportation costs for Port of Wilmington hinterland exports under without-project conditions could force some exporters to reduce export quantities or leave the export market altogether. The loss of export value would be an impact to the NED account. Under with-project conditions, the reduction of landside transportation costs to levels equivalent to exiting conditions would presumably restore export values and thereby generate additional NED benefits not calculated in this analysis.

The effects of relative sea level rise have been included in all analyses performed for this feasibility study and environmental report as indicated throughout.

9.8.1 Climate Change

The USACE's Engineering and Construction Bulletin (ECB) 2018-14, issued in September 2018, requires a qualitative climate hydrology analysis that discusses the relationships between climate, streamflows, and the USACE project, to ensure that changes in climate with the potential to significantly affect the project with respect to hydrology are identified, and the potential impacts are assessed with respect to the project over its life cycle. The USACE recommends that projects be evaluated for potential vulnerabilities to planning, engineering and operational activities affected by climate change. Navigation and associated dredging projects like the TSP may be impacted.

ECB 2018-14 was developed by the USACE as an update to ECB 2016-25, *Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects*. The ECB provides guidance for incorporating climate change into the USACE planning process for long term projects. The analysis was performed for this project based on literature review and two USACE tools in accordance with this guidance. The full analysis is presented in the Engineering Appendix Section 1.6: Climate Change Impacts. The conclusions of the analysis are presented below.

The project itself is not expected to have a significant effect on climate change per se. Furthermore, potential climate change impacts do not impact the decision regarding the selection of the TSP. However, the project will be affected by the results of climate change. Increases in extreme precipitation events and resulting increases in streamflow have the potential to move more nutrients and sediment into the navigation channel. This combined with increases in air temperatures has the potential to impact water quality and dissolved oxygen (DO) levels through increases in oxygen demanding materials and nuisance algal blooms. Furthermore, increases in sediment transport may increase the need for channel maintenance in the future.

Review of the model results presented in Appendix A, though, indicates that the project impacts on water quality (DO) are most pronounced during the winter months when DO is at its highest levels (and temperature is lowest). Therefore, the potential impacts from increased temperatures and nutrients will likewise have the largest relative changes during the winter months when these impacts will not further adversely affect fishery resources under the with-project conditions as compared to without-project conditions.

With respect to the increase of salinity intrusion into the estuary due to the project (as well as future RSLR), increases in streamflow will actually be a mitigating factor reducing the potential impacts of the project on wetland vegetation composition and fishery resources.

Increases in streamflow and suspended sediment will likely increase potential maintenance dredging activities. If any changes in predicted future dredging volumes are observed, these will ultimately have to be incorporated into future dredge material management practices. However, given the project itself is expected to only increase these volumes by about 10%, climate change impacts should also be relatively minor and adaptive responses can be undertaken.

9.8.2 Tidal Datum Instability

Tidal range instability has been identified as a potential risk factor concerning future project performance. Historically, the river channel has been modified numerous times, and quite substantially, which has led to the observed changes in tidal datums (MHW, MLW) and mean tidal range. Previous analysis of tidal range at the Cape Fear River (Zervas, 2013) recognize this important point, and previous modeling efforts have shown that the prior deepening and widening of the river channel has increased the tidal range over time. It is this increase in tidal range due to previous channel modifications that has then been manifested in the apparently higher historical rate of increase of MHW over MSL (which encompasses these periods of channel modifications) referenced anecdotally and in prior studies.

Going forward in time, though, it is expected that MHW should generally increase at the same rate as MSL increases absent any alterations to the river channel, which would reduce risks to project performance. To support this assumption, analyses of the water levels at Wilmington over the past four decades were performed. These analyses consisted of investigating two distinct time periods:

1. From April 2004 to December 2019 which represents the time since the most recent channel deepening / widening project; and

2. From January 1983 to July 2000 which represents the time between the most recent two channel deepening / widening projects.

It is noted that the most recent project was performed in phases between August 2000 and March 2004, so this time interval was not included in the two analysis periods. The prior deepening / widening project was completed in October 1982.

9.8.2.1 Tidal Analyses

The present tidal analysis was performed using hourly observations at the NOAA CO-OPS Station 8658120 Wilmington, NC. Continuous data was available from 1936 until the present. The analysis of tidal constituents and tidal datums was performed based on monthly and annual (January to December) intervals. The tidal datums values (MHW and MLW) were referenced to the local MSL. MSL values was computed as the arithmetic mean of observations over each interval. Mean tidal range was computed as the difference between MHW and MLW.

As shown in Table 9-5 and Figure 9-2 the rate of increase during the aforementioned time periods for MHW and MLW is similar to the rate of increase of MSL. Specifically, it was observed that MHW is increasing at a slower rate (by 15–20%) than MSL during the periods when no major alterations were made to the river channel.

Table 9-5: Tidal Datum Rate of Change

Tidal Datum	1983-2000 (ft/yr)	2004-2019 (ft/yr)
MHW	0.006	0.033
MSL	0.008	0.039
MLW	0.008	0.043
Mean Range	-0.002	-0.010

Table 9-6 shows a notable change in the mean tide range as a result of the channel improvements that occurred between 2000 and 2004. This is especially clear in Figure 9-2 based on yearly data. Figure 9-2 shows a significant but gradual increase in the tidal range which occurred between 2000 and 2004 due to the most recent channel deepening / widening project.

Table 9-6: Tidal Datum Absolute Changes

Tidal Datum	1983-2000 (ft-MSL)	2004-2019 (ft-MSL)	Change (ft)	Change Relative to MSL (ft)
MHW	1.958	2.251	+0.293	+0.081
MSL	-0.017	0.195	+0.212	0.000
MLW	-2.242	-2.177	+0.065	-0.147
Mean Range	4.200	4.429	+0.228	n/a

Additionally, with respect to the modeling performed for the proposed project, a comparison can be made between the changes that occurred previously and the model predictions for the current project. One can expect similar in magnitude changes given the similar scopes of each project. In fact, Table 9-6 shows an increase in MHW of 0.081 feet compared to the model prediction of 0.12 feet; a decrease in MLW of 0.147 feet compared to the model prediction of -0.18 feet, and an increase in the tidal range of 0.228 feet compared to the model prediction of 0.31 feet. This provides a validation that the model is predicting similar tendencies and changes in magnitudes that are comparable to those measured previously for a similar magnitude of modifications to the river channel.

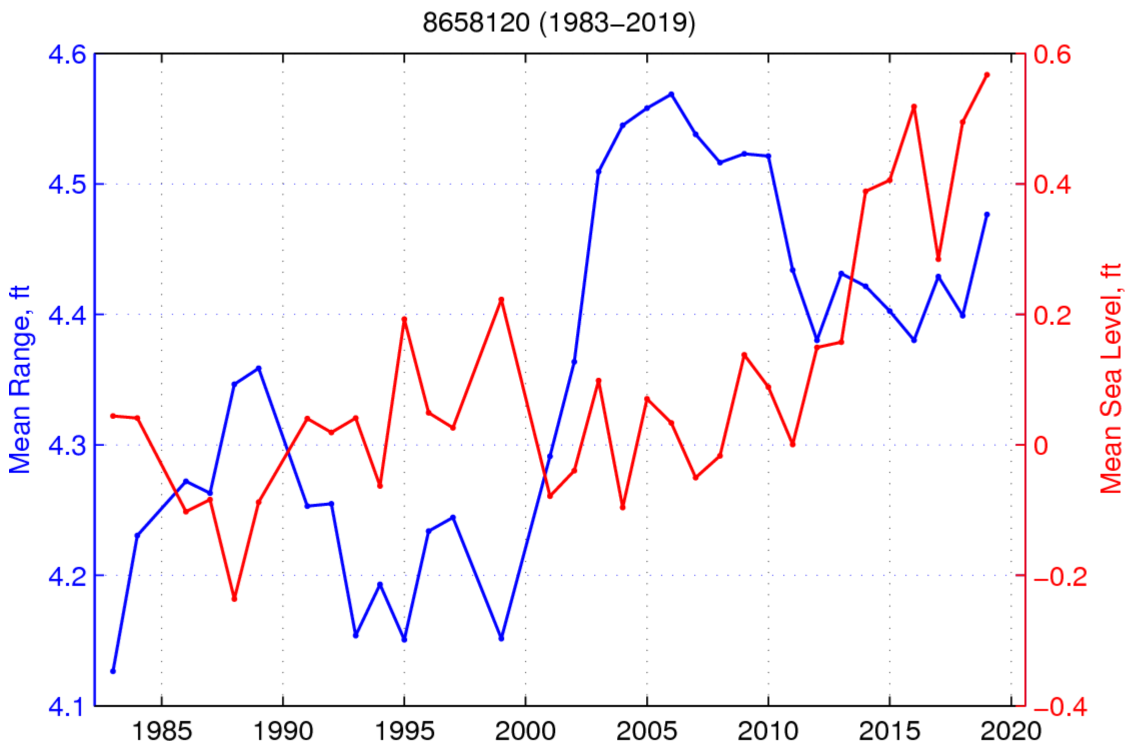

Figure 9-2
Variability of Mean Tidal Range Based on Annual Data

10 COMPLIANCE WITH ENVIRONMENTAL COMMITMENTS

In addition to NEPA, the actions that are proposed under the TSP are subject to additional regulatory consultation and compliance requirements under a number of other federal environmental laws and EOs. The following sections summarize the relevant laws and policies and the steps that have been or will be undertaken to ensure that the TSP fully satisfies all compliance requirements

10.1 Sections 404 and 401 of the Clean Water Act of 1977

Section 404 of the Clean Water Act (33 USC 1344) authorizes the USACE to regulate the discharge of dredged or fill material into waters of the US, including wetlands. Section 401 of the Clean Water Act (33 USC 1341) delegates federal authority to the state to issue 401 Water Quality Certifications for the discharge of dredged and fill material into Waters of the State. Extensive efforts have been undertaken to quantify and address the potential effects of the TSP on wetlands; including the indirect effects of potential salinity increases in the CFR estuary. The analyses of wetland effects and potential mitigation measures have been coordinated with federal and state resource agencies through the formation of a Tidal Wetlands TWG. The results of the wetland impact analysis are provided in Appendix F: Wetlands Impact Assessment.

10.2 Magnuson-Stevens Fishery Conservation and Management Act

The MSFCMA (16 USC 1801 et seq.) requires federal agencies to consult with the NMFS to ensure that actions they undertake, fund, or authorize incorporate EFH conservation into the planning process. Essential Fish Habitats are defined as those "necessary to fish for spawning, breeding, feeding, or growth to maturity." Analyses of potential effects on EFH have been coordinated with the NMFS through the formation of a Fish and Fish Habitat TWG. An EFH Assessment report has been prepared that evaluates the effects of the TSP on EFH and federally managed fisheries (Appendix I: Essential Fish Habitat Assessment). The EFH assessment will be submitted to the NMFS to initiate formal consultation pursuant to the MSFCMA.

10.3 Fish and Wildlife Coordination Act of 1958

The Fish and Wildlife Coordination Act (FWCA) (16 USC 661 et seq.), as amended, requires federal agencies to incorporate fish and wildlife resource conservation into the planning process for water resources development projects that they undertake, fund, or authorize. Section 2(b) of the FWCA requires the federal action agencies for water resource projects to consult with the USFWS and the state fish and wildlife agency (i.e., the NCWRC) to ensure that conservation is fully incorporated. The USFWS and NCWRC are responsible for identifying adverse impacts on fish and wildlife resources and developing recommendations to avoid, minimize, and/or compensate for impacts; which are provided to the action agencies in FWCA reports. The USFWS and NCWRC have participated in the analyses of potential fish and wildlife impacts and the evaluation of potential mitigation measures through the Fish and Fish Habitat, Tidal Wetlands, and Beneficial Use of Dredged Material TWGs.

10.4 Endangered Species Act of 1973

Pursuant to Section 7 of the ESA (16 USC 1536), federal agencies are required to consult with the USFWS and NMFS to ensure that actions they undertake, fund, or authorize are not likely to jeopardize the continued existence of any threatened or endangered species; or result in the destruction or adverse modification of designated critical habitat. The USFWS and NMFS have participated in the analyses of potential TSP impacts on aquatic and terrestrial biological resources through the Fish and Fish Habitat and Tidal Wetlands TWGs. A Biological Assessment has been prepared that evaluates the potential effects of the TSP on federally listed threatened and endangered species that may occur within the action area (Appendix K: Biological Assessment of Threatened and Endangered Species). The Biological Assessment will be submitted to the USFWS and NMFS to initiate formal consultation pursuant to Section 7 of the ESA.

10.5 Marine Mammal Protection Act of 1972

The MMPA (16 USC 1361 et seq.) prohibits the take of marine mammals in US waters and authorizes programs to conserve, protect, and recover declining marine mammal populations. Although take is generally prohibited, the MMPA makes allowances for limited take through permits and incidental harassment authorizations. The responsibilities for implementing the MMPA are divided between the NMFS (cetaceans and pinnipeds) and the USFWS (manatees, sea otters, walruses). Channel deepening under the TSP will require the use of confined blasting as a pretreatment measure to prepare hard rock for removal by dredges. The areas of rock that will require confined blasting are located within an approximately 4-mile reach of the channel that extends from a point approximately 18 miles above the estuary mouth up to a point approximately two miles below Eagle Island. Due to the potential for manatees and bottlenose dolphins to occur in the vicinity of the blasting areas, an incidental harassment authorization may be required. The development of a site-specific blasting plan will be coordinated with the NMFS and the USFWS to ensure that the potential effects of blasting on marine mammals are minimized to the maximum extent possible.

10.6 Migratory Bird Treaty Act of 1918

The Migratory Bird Treaty Act (MBTA) (16 USC 703 et seq.) prohibits the take of migratory birds and authorizes the USFWS to implement programs to conserve, protect, and recover declining migratory bird populations. The MBTA does not impose any specific consultation requirements on the federal action agencies; however, compliance with the MBTA will be coordinated with the USFWS through the FWCA consultation process.

10.7 Marine Protection, Research, and Sanctuaries Act

Under Section 103 of the MPRSA, dredged material that is proposed for ocean placement at the ODMDS would require testing and concurrence from the USEPA prior to transport for disposal. All dredged material placement within the USEPA designated ODMDS would be conducted in accordance with the Wilmington Harbor ODMDS SMMP (USEPA and USACE 2012).

10.8 National Historic Preservation Act of 1966

Pursuant to Section 106 of the National Historic Preservation Act (16 USC 470 et seq.), federal agencies are required to consider the effects of actions they undertake, fund, or authorize on historic properties that are listed or may be eligible for listing in the National Register of Historic Places. Federal action agencies are required to consult with the Advisory Council on Historic Preservation, either directly or through State Historic Preservation Offices for the purpose of identifying historic properties potentially affected by the action, assessing the effects, and mitigating adverse impacts. Remote sensing surveys for underwater cultural resources were conducted in all areas potentially affected by harbor channel expansion; including a 250-ft-wide zone along either side of the ~26-mile inner harbor channel reach between the Cape Fear River mouth and Wilmington, a 500-ft-wide zone along either side of the existing Bald Head Shoals ocean entrance channel, and a 1,000-ft-wide x 8-mile zone encompassing the proposed ocean entrance channel extension reach (Appendix G: Cultural Resources). The remote sensing surveys and subsequent diver investigations identified one historically significant resource in the proposed channel; the paddlewheel of the shipwreck CSS *Kate*, which is a Confederate blockade runner previously identified by the NC UAB. Based on preliminary coordination with the NC UAB, it is anticipated that the paddlewheel will be relocated to an area just outside proposed dredging area.

10.9 Coastal Zone Management Act of 1972

The Coastal Zone Management Act (CZMA) (16 USC 1451 et seq.) established a cooperative program between the federal government and the coastal states for the management and protection of coastal resources. The CZMA is carried out primarily by the coastal states through the implementation of federally approved coastal management programs. North Carolina's coastal management program was established by the NC Coastal Area Management Act (CAMA) of 1974. Federal actions must demonstrate consistency with the key elements of the state's coastal management program; including state coastal management rules and policies established in Chapter 7 of Title 15A of the NCAC, the policies set forth in approved local Land Use Plans, and the NC Dredge and Fill Law. The North Carolina Division of Coastal Management is the lead state agency responsible for implementing CAMA and conducting federal action consistency reviews. Compliance with the federal consistency requirements will be achieved through consultation with the North Carolina Division of Coastal Management.

10.10 Coastal Barrier Resources Act

The CBRA of 1982 was enacted to discourage the development of hurricane prone, biologically sensitive coastal barrier islands. The CBRA prohibits most new federal expenditures that encourage or subsidize barrier island development. The CBRA established the John H. Chafee CBRS consisting of barrier islands that are either undeveloped or predominantly undeveloped. The CBRS includes two types of designated units; System Units and OPAs. The CBRS Cape Fear Unit OPA (NC-07P) encompasses the majority of the undeveloped Cape Fear peninsula from Snows Cut to the southern boundary of the Bald Head State Natural Area; including most of the east-facing oceanfront beach between Fort Fisher and Cape Fear and the estuarine marsh and dredged material islands that lie between the peninsula and the federal navigation channel. However, the developed south-facing ocean beaches of Bald Head Island and Oak Island that comprise beach disposal areas are not part of the CBRS. Furthermore, the NFIP is the only type of prohibited federal spending that is applicable to OPAs. Therefore, the TSP would not result in any federal spending that would affect the CBRS.

10.11 Estuary Protection Act of 1968

The Estuary Protection Act provides a means to protect, conserve, and restore estuaries in a manner that maintains balance between the need for natural resource protection and conservation and the need to develop estuarine areas to promote national growth. The act authorizes the

Secretary of the Interior to work with the states and other federal agencies in undertaking studies and inventories of estuaries of the United States.

10.12 Submerged Lands Act of 1953

The Submerged Lands Act recognizes the title of the states to submerged lands in navigable waters within their boundaries. Pursuant to North Carolina General Statute 146-12 (Easements in Lands Covered by Water), projects that place certain structures on state-owned submerged lands or place fill in navigable waters to raise state-owned submerged lands above the MHW line require an easement from the NC Department of Administration. The TSP would not encompass any actions that would require an easement from the NC Department of Administration.

10.13 Rivers and Harbors Act of 1899

Section 10 of the Rivers and Harbors Act (33 USC 403) authorizes the USACE to regulate work in navigable waters; including construction, excavation, and the deposition of material. The TSP would not obstruct navigable waters of the US.

10.14 Executive Order 11988 (Floodplain Management)

Executive Order 11988 requires federal agencies to avoid, to the extent possible, the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Pursuant to FEMA implementing regulations (44 CFR Part 9), the proposed project has been evaluated for EO 11988 compliance through an 8-Step planning process (Table 10-1). The TSP is not expected to have any effects on floodplain development or management.

Table 10-1
WHNIP 8-Step Floodplain Planning Process

Step	Project Analysis
Step 1: Determine whether the Proposed Action is located in a wetland and/or the 100-year floodplain, or whether it has the potential to affect or be affected by a floodplain or wetland.	The project is located in the 100-year floodplain (FIRM Zones AE and VE). The project is not located in wetlands.
Step 2: Notify public at earliest possible time of the intent to carry out an action in a floodplain or wetland, and involve the affected and interested public in the decision-making process.	The USACE published a Notice of Intent (NOI) informing the public of the proposed project and the intent to develop a Draft Environmental Impact Statement (DEIS). An initial public scoping meeting was held on 26 September 2019.
Step 3: Identify and evaluate practicable alternatives to locating the Proposed Action in a floodplain or wetland.	The Wilmington Harbor navigation channel is a functionally dependent water resource project. There are no alternatives to locating the project in a floodplain.
Step 4: Identify the full range of potential direct or indirect impacts associated with the occupancy or modification of floodplains and wetlands, and the potential direct and indirect support of floodplain and wetland development that could result from the Proposed Action.	The project would be confined to the subtidal river channel. Navigation channel deepening would not obstruct the floodway or affect its capacity to discharge floodwater. Modeling results indicate that the project would produce small increases in MHW (≤1.3 inches), but no significant effects on 100-yr flood elevation are expected. Small increases in salinity (≤0.3 ppt) in the upper estuary would cause minor changes in tidal freshwater wetland community composition. The project would not induce development in floodplains or wetlands.
Step 5: Minimize the potential adverse impacts from work within floodplains and wetlands (identified under Step 4), restore and preserve the natural and beneficial values served by wetlands.	The project would not have any adverse impacts on floodplains. A mitigation plan is currently being developed that will address the effects of salinity increases on tidal freshwater wetlands. Wetland impacts will be fully mitigated through the NEPA process.
Step 6: Re-evaluate the Proposed Action to determine: 1) if it is still practicable in light of its exposure to flood hazards; 2) the extent to which it will aggravate the hazards to others; and 3) its potential to disrupt floodplain and wetland values.	The proposed action would not be subject to flood hazards and would not aggravate flood hazards or disrupt floodplain or wetland values.
Step 7: If the agency decides to take an action in a floodplain or wetland, prepare and provide the public with a finding and explanation of any final decision that the floodplain or wetland is the only practicable alternative. The explanation should include any relevant factors considered in the decision-making process.	The public will be involved in decision making through the NEPA process.
Step 8: Review the implementation and post-implementation phases of the Proposed Action to ensure that the requirements of the EOs are fully implemented. Oversight responsibility shall be integrated into existing processes.	Full compliance with EO requirements will be achieved through the NEPA process.

10.15 Executive Order 11990 (Protection of Wetlands)

Executive Order 11990 directs all federal agencies to issue or amend existing procedures to ensure consideration of wetlands protection in decision making and to ensure the evaluation of the potential effects of any new construction proposed in a wetland. As described above, the potential effects of the TSP on wetlands have been evaluated extensively in coordination with federal and state resource agencies.

10.16 Executive Order 13112 (Invasive Species)

Executive Order 13112 directs federal agencies to use their authorities to prevent the introduction, establishment, and spread of invasive species. The effects of the TSP on invasive species have been evaluated in this document. The principal mechanism that could potentially contribute to the introduction and spread of invasive species would be new introductions via ship ballast water. However, although the TSP would result in larger vessels calling on the Port of Wilmington, the number of vessel calls would decrease. Therefore, the TSP would not increase the potential for introductions and would be compliant with EO 13112

10.17 Farmland Protection Policy Act of 1981

The TSP would not contribute to the conversion of any important farmland to nonagricultural uses.

10.18 Executive Order 12898 (Environmental Justice)

Executive Order 12898 directs federal agencies to identify and address disproportionately high and adverse environmental and human health effects of their actions on minority and low-income populations. Pursuant to EO 12898, federal agencies must develop environmental justice strategies to ensure that their programs, policies, and activities are conducted in a manner that does not exclude persons (including populations) from participation in, deny persons the benefits of, or subject persons to discrimination under their programs, policies, and activities because of their race, color, or national origin. The effects of the TSP on minority and low income populations have been evaluated in this document. The TSP is not expected to have any disproportionate effects on minority or low income populations.

11 PUBLIC/AGENCY PARTICIPATION AND COMMENTS

Public involvement in development of the Section 203 Feasibility Study and Environmental Report is divided into two phases. The first phase consists of early public involvement activities performed by the NCSPA prior to federal participation in public involvement. The second phase of public involvement began when USACE published a Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) pursuant to the National Environmental Policy Act (NEPA) on 13 September 2019 Although this Section 203 Feasibility Study and Environmental Report is a non-federal study, the NCSPA has developed this Report in accordance with USACE planning and environmental compliance guidelines to facilitate the USACE ongoing development of a Draft EIS for the 203 Study. The NCSPA believes that its first phase public and agency involvement activities meet the spirit of NEPA in regard to the inclusion of public input in the plan formulation and selection process.

Public and agency involvement activities performed by the NCSPA include:

- Public notification of the study;
- Public notification of the stakeholder information meeting;
- Public information meeting;
- Agency engagement meeting; and
- Technical working group meetings.

Technical working groups were developed for wetlands, fish and fisheries habitat, and beneficial use of dredged material. Technical working group membership included representatives from USFWS, NMFS, USEPA, NCDEQ, NCWRC, and NC Audubon. The purpose of the technical working groups (TWGs) is to assemble the applicable experts from the agencies who can offer technical guidance towards assessing the effects of the proposed project on tidal freshwater wetlands, fish and fisheries habitat, and to provide concepts for the beneficial use of dredging material. The overall framework of the TWG's is to 1) review available data sources for baseline conditions, 2) concur on assessment methods to be used, 3) provide technical review and input on the existing conditions and effects analysis for wetland and fish/fisheries habitat, and 4) discuss applicable options for mitigating any adverse effects. For the Beneficial Use TWG, the overall goal is to identify potential uses for future dredged material, including beach placement, bird islands, marine resource restoration/enhancement etc. that can be further assessed for suitability and cost. The working group meetings are informal, held locally in the Wilmington area, and last about two-hours. Each committee is chaired by a member of the port consultant team and other team members brought in as needed for review of modeling results, alternatives, engineering analysis etc. The overall goal is preparation of a technical report which describes the effected resources, methods used, effects analysis comments and consensus, ranked mitigation options for each resource (wetland and fish/fisheries habitat). For the Beneficial Use TWG, a summary of recommendations has been prepared for further use by the consultant team in developing the overall beneficial use study report (see Appendix R: Dredged Material Management Plan).

12 RECOMMENDATIONS

The North Carolina State Ports Authority recommends that the Assistant Secretary of the Army (Civil Works) transmit a favorable recommendation to Congress that the existing project for deep draft navigation at Wilmington Harbor, authorized by the Water Resources Development Acts of 1986 (WRDA 86) Public Law 99-662[27] and 1996 (WRDA 96) Public Law 104-303[1] and combined into a single project by Public Law 105-62 (Energy and Water Development Appropriations Act of 1998) be modified as described herein to provide for implementation of a Federal project to deepen and widen the existing Federal channels and turning basins with such modifications as in the discretion of the Secretary may be deemed advisable; at a first cost to the United States presently estimated at $604,373,000; with an annual incremental operations and maintenance cost to the United States presently estimated at $1,160,000.

The TSP, which is the most economical plan analyzed, consists of deepening the main ship channel from the ocean entrance inland to the turning basin at the Lower Anchorage, from its current authorized depth of -42 feet in river reaches and -44 feet in the ocean entrance reaches to -47 feet in river reaches and -49 feet in the ocean entrance reaches. In addition to deepening, widening of the existing Federal project to provide for passage of the project design vessel is recommended (Table 12-1) in the following reaches:

[27] Section 201 - WILMINGTON HARBOR-NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA - The project for navigation, Wilmington Harbor-Northeast Cape Fear River, North Carolina: Report of the Chief of Engineers, dated September 16, 1980, at a total cost of $10,000,000, with an estimated first Federal cost of $8,300,000 and an estimated first non-Federal cost of $1,700,000.

Table 12-1
Existing and Proposed Channel Widths by Range

Range Name	Channel Widths [ft]		Widening Details
	Existing Channel	Proposed	
Entrance	N/A	600	New
Bald Head Shoal Reach 3	500 - 900	600 - 900	Symmetric
Bald Head Shoal Reach 2	900	900	No Change
Bald Head Shoal Reach 1	700	900	Green Side Only
Smith Island	650	900	Red Side Only
Bald Head - Caswell	500	800	Red Side Only
Southport	500	800	Re-orientation Red Side then Green Side
Battery	500	800 - 1300	Replaced with 4000-ft Radius Curve And Green Side at Apex
Lower Swash	400	800 - 500	Green Side to Symmetric
Snows Marsh	400	500	Symmetric
Horseshoe Shoal	400	500	Symmetric
Reaves Point	400	500	Symmetric
Lower Midnight	600	600	No Change
Upper Midnight	600	600	No Change
Lower Lilliput	600	600	No Change
Upper Lilliput	400	500	Symmetric
Keg Island	400	500	Symmetric
Lower Big Island	400	500	Symmetric
Upper Big Island	660	660	No Change
Lower Brunswick	400	500	Symmetric
Upper Brunswick	400	500	Symmetric
Fourth East Jetty	500	550	Green Side Only
Between Channel	550	625	Green Side Only
Anchorage Basin	625	625 - 1509	No Change

A preliminary mitigation, monitoring, and adaptive management plan has been developed for this report. The mitigation, monitoring and adaptive management plan will be finalized during development of the DEIS.

The North Carolina State Ports Authority will:

a. Provide 25 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

b. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs;

c. Provide, during the period of construction, a cash contribution equal to the following percentages of the total cost of construction of the general navigation features:

i. Twenty-five percent of the costs attributable to dredging to a depth in excess of 20 feet, but not in excess of 50 feet; plus

ii. Fifty percent of the costs attributable to dredging to a depth in excess of 50 feet;

d. Provide 50 percent of the excess cost of operation and maintenance of the project over that cost which the Federal Government determines would be incurred for operation and maintenance for depths deeper than 50 feet;

e. Pay with interest, over a period not to exceed 30 years following completion of the period of construction of the project, up to an additional 10 percent of the total cost of construction of general navigation features. The value of LERRs and deep-draft utility relocations provided by the Sponsor for the general navigation features, described below, may be credited toward this required payment. The value of deep-draft utility relocations for which credit may be afforded shall be that portion borne by the Sponsor, but not to exceed 50 percent, of deep-draft utility relocation costs;

If the amount of credit equals or exceeds 10 percent of the total cost of construction of the general navigation features, the Sponsor shall not be required to make any contribution under this paragraph, nor shall it be entitled to any refund for the value of LERRs and deep-draft utility relocations in excess of 10 percent of the total cost of construction of the general navigation features;

f. Provide all LERRs and perform or ensure the performance of all relocations and deep-draft utility relocations determined by the Federal Government to be necessary for the construction, operation, maintenance, repair, replacement, and rehabilitation of the general navigation features (including all lands, easements, and rights of way, relocations, and deep-draft utility relocations necessary for the dredged material disposal facilities);

g. Provide, operate, maintain, repair, replace, and rehabilitate, at its own expense, the local service facilities in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

h. Accomplish all removals determined necessary by the Federal Government other than those removals specifically assigned to the Federal Government;

i. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the Sponsor owns or controls for access to the project for the purpose of operating, maintaining, repairing, replacing, and rehabilitating the general navigation features;

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

k. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as will properly reflect total cost of construction of the general navigation features, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

l. Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights of way that the Federal Government determines to be necessary for construction, operation, maintenance, repair, replacement, or rehabilitation of the general navigation features. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Federal Government provides the Sponsor with prior specific written direction, in which case, the Sponsor shall perform such investigations in accordance with such written direction;

m. Assume complete financial responsibility, as between the Federal Government and the Sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights of way that the Federal Government determines to be necessary for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project;

n. To the maximum extent practicable, perform its obligations in a manner that will not cause liability to arise under CERCLA;

o. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the Sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

p. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights of way, required for construction, operation, maintenance, repair, replacement, and rehabilitation of the general navigation features, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

q. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army.” The State is also required to comply with all applicable Federal labor standards requirements including, but not limited to, the Davis-Bacon Act (40 USC 3144 *et seq*.), the Contract Work Hours and Safety Standards Act (40 USC 3701 *et seq*.), and the Copeland Anti-Kickback Act (40 USC 3145 *et seq*.);

r. Provide the non-Federal share that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement;

s. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might reduce the ecosystem restoration, hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities which would degrade the benefits of the project;

t. Do not use Federal funds to meet the Sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds in authorized;

u. Provide a cash contribution equal to the non-Federal cost share of the project's total historic preservation mitigation and data recovery costs attributable to commercial navigation that are in excess of 1 percent of the total amount authorized to be appropriated for commercial navigation; and

v. In the case of a deep-draft harbor, provide 50 percent of the excess cost of operation and maintenance of the project over that cost which the Secretary determines would be incurred for operation and maintenance if the project had a depth of 50 feet."

The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the North Carolina State Ports Authority (the non-federal sponsor), interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

13 LIST OF PREPARERS AND REVIEWERS

Table 13-1
Preparers

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Table 13-1
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Table 13-2
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