Wilmington Harbor, North Carolina Navigation Improvement Project

Integrated Section 203 Study & Environmental Report

APPENDIX C

ECONOMICS

June 2019

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1 INTRODUCTION

This Integrated Section 203 Feasibility and Environmental Study 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 is publicly acceptable.

1.1 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.

1.2 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[1] 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).

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

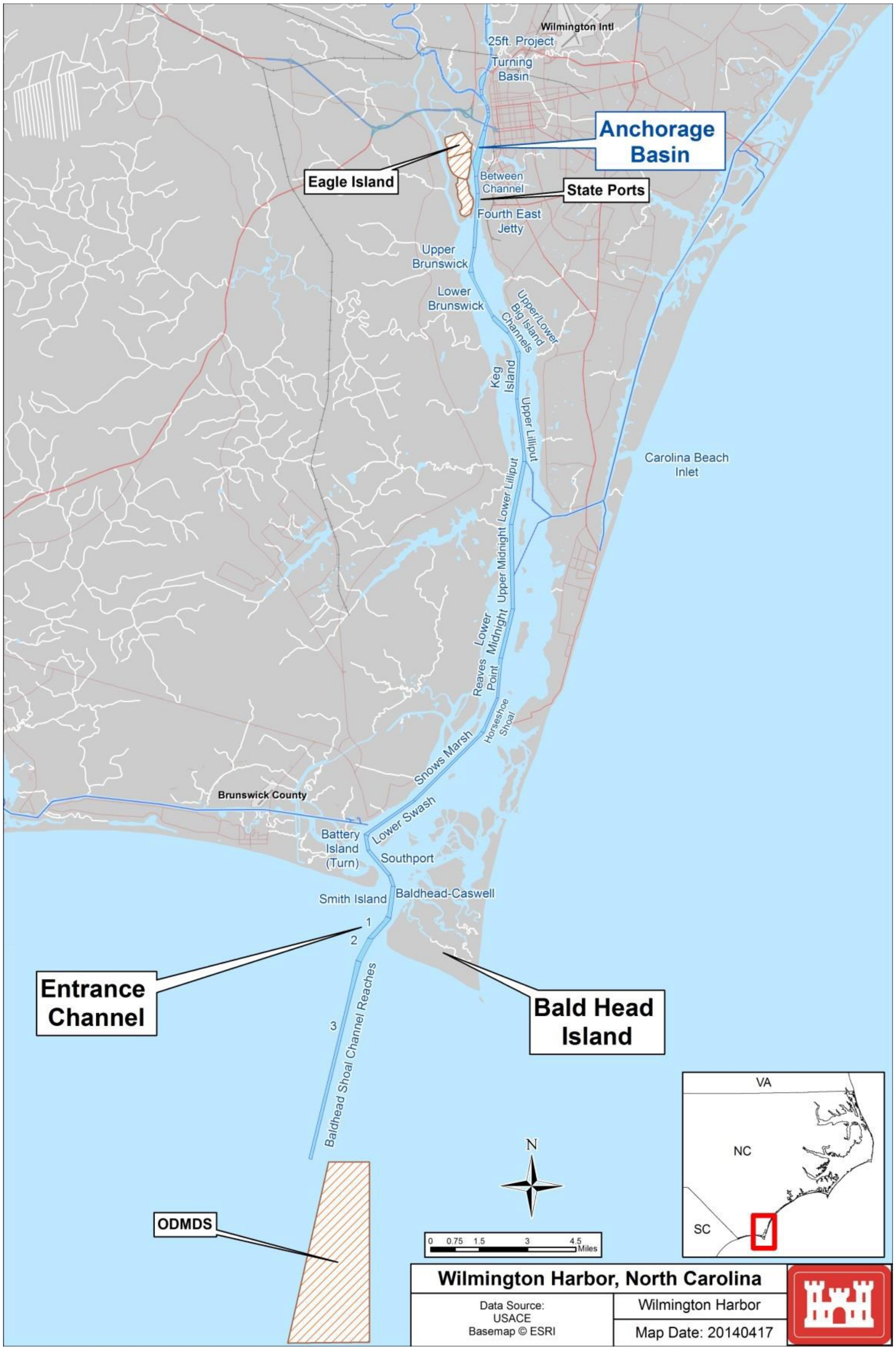

Figure 1-1
Wilmington Harbor Federal Navigation Project

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 Midnight4	8,241	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 2016 Turning Basin Expansion

1.3 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 U S 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, North Carolina. The CSX Carolina Connector hub will connect the Port of Wilmington with the entire CSX network.

1.4 Navigation Features

1.4.1 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 ranges to the Port of Wilmington facilities. The existing channel geometry is published in the current nautical charts for the Cape Fear River. Nautical charts published by the National Oceanic and Atmospheric Administration (NOAA) relevant to this area include the following:

- NOAA Nautical Chart number 11537 (Figures 1-2 and 1-3); and
- NOAA Electronic Nautical Chart (ENC) tile US5NC12M.

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 ranges, 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 Range to Lower Lilliput Range.
- Upper Big Island range, which is 660 ft wide.
- Fourth East Jetty Range, and the channel adjacent to the Wilmington terminal facilities, which are 500 ft wide.

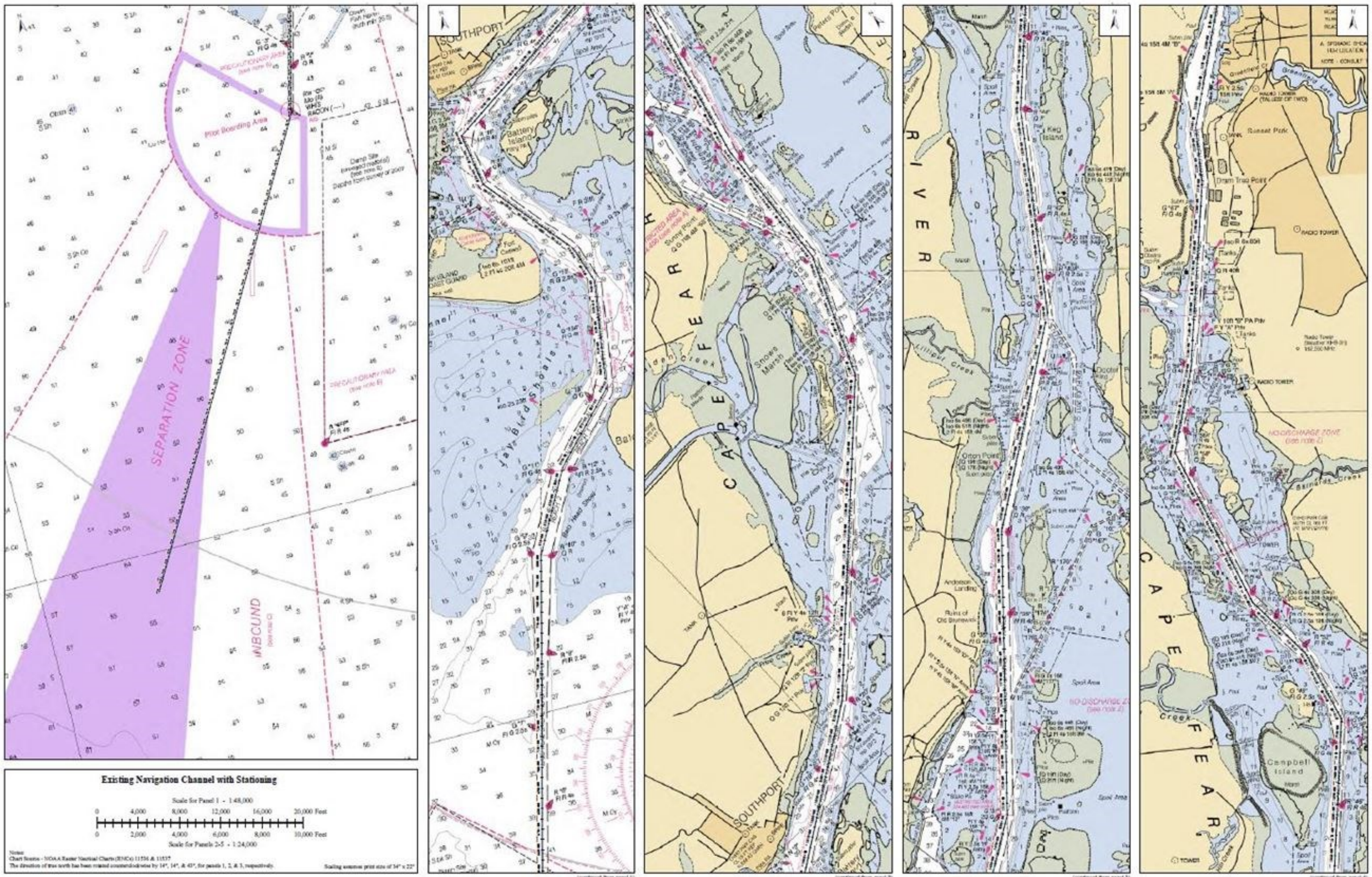

Figure 1-2
NOAA Nautical Chart number 11537

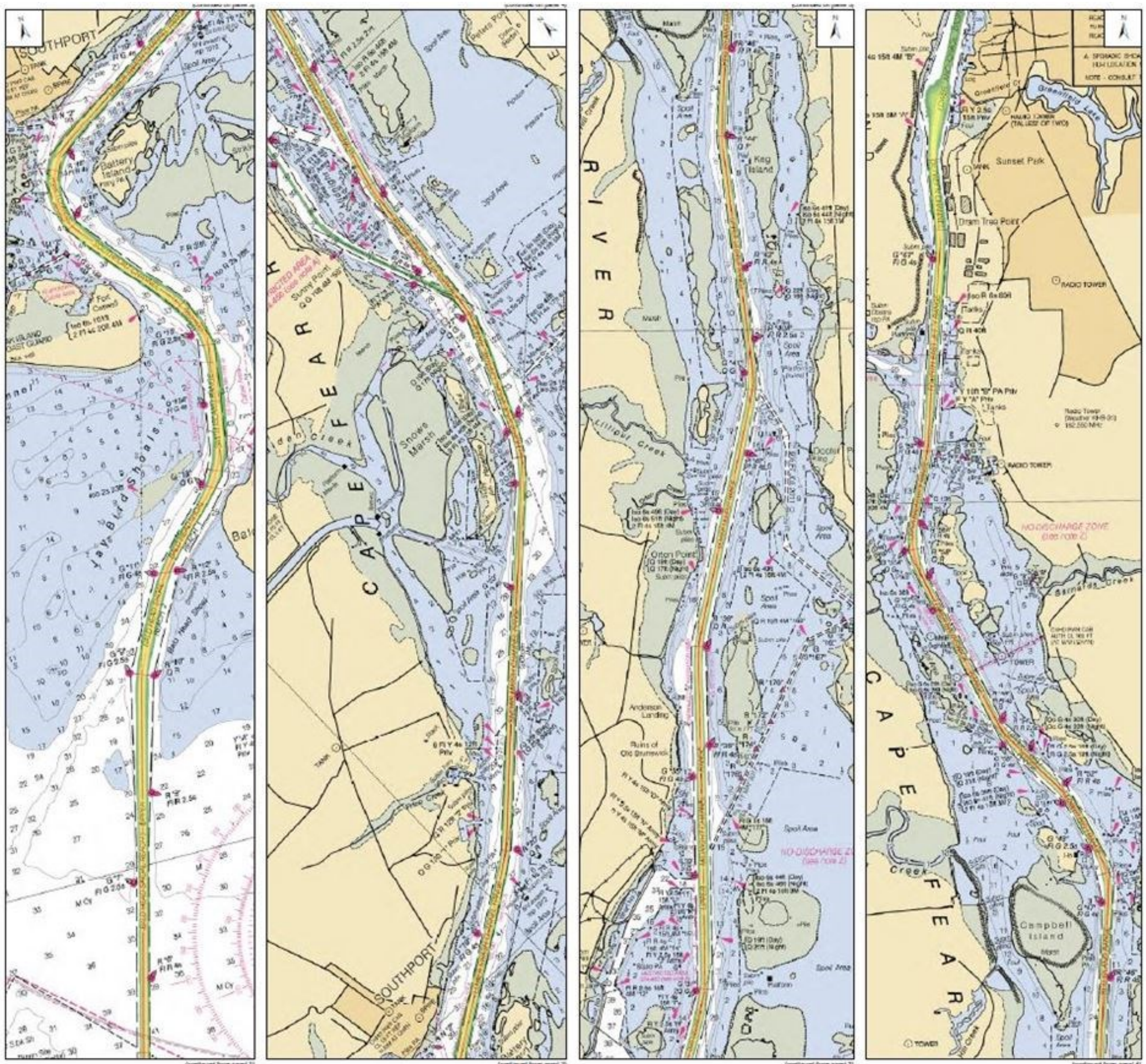

Figure 1-3
Continuation of NOAA Nautical Chart number 11537

1.5 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 is the focus of this report. Other vessel traffic and terminals are presented for reference.

1.5.1 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 feet of wharf frontage with on-dock rail. Depth at the Berths 1 and 2 is -38 feet MLLW, with permits in place to increase to -42 feet MLLW, and depth at Berths 3 – 9 is -42 feet MLLW. Maximum air draft along the approaching channel is restricted to 171 feet above MHHW due to electric cable crossing (vertical clearance of 187 feet at channel centerline with a 16-foot arc limit).

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 two super post-Panamax ship-to-shore cranes (22-box wide). A third super post-Panamax crane is scheduled for delivery in 2019.

Current TEU 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 a five-year program (FY2016 – FY2021) of improvements at an overall cost of more than $240 million. Master Plan recommendations for yard, gate, and operations improvements will increase annual throughput capacity to 1 million TEUs per year (see Section 3.2 Without-Project Conditions: Terminal Facilities).

1.5.2 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 1-4) 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.

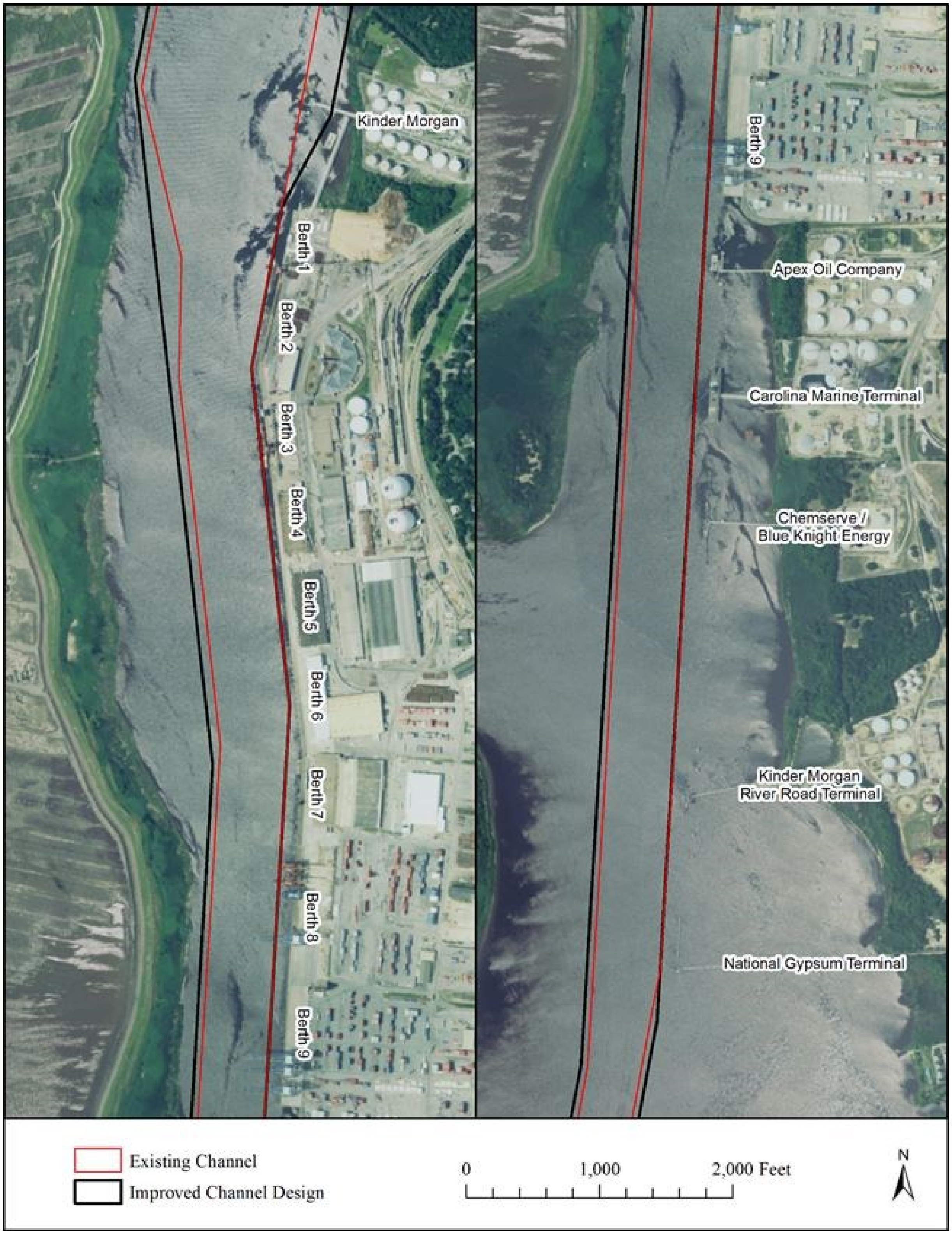

Figure 1-4
Identification of Terminals

1.6 Existing Economic Conditions

1.6.1 Population

Table 1-2 shows decennial census data for North Carolina and the counties of Brunswick, New Hanover, and Pender (Figure 1-5) 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 (Figure 1-6).

Table 1-2
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

Figure 1-5
Counties Surrounding Wilmington, NC

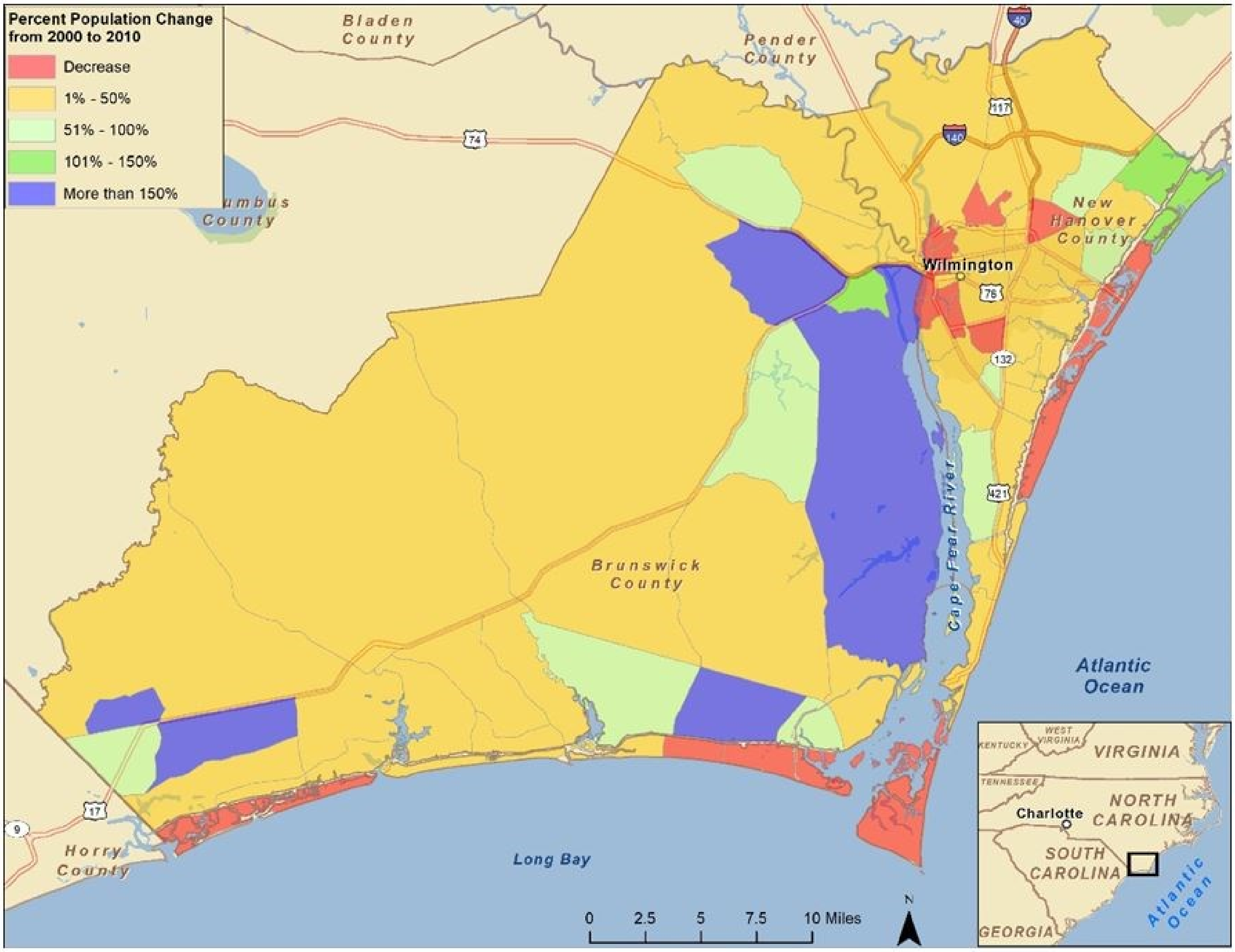

Figure 1-6
Percent Population Change from 2000 to 2010
in Brunswick and New Hanover Counties by Census Tract

1.6.2 Employment

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 1-3 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.[2]

[2] https://accessnc.nccommerce.com/DemographicsReports/

Table 1-3
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 1-4).

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 (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.

The income figures presented in Table 1-4 have been adjusted for inflation from their original values using the US Bureau of Labor Statistics' online inflation calculator[3] 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.

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 1-4 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.

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

Table 1-4
Employment, Income, and Poverty

North Carolina	1990	2000	2010	2017
Unemployment Rate[4]	3.4	3.3	11.4	4.9
Median Household Income[5]	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

1.6.3 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[6] (Executive Order, 1994). When conducting NEPA evaluations, CEQ directs federal agencies to 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

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

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[7] 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 1-5 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. According to the Council's guidance on EJ populations, the conditions necessary to define a minority population is present in the Brunswick County.

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[7] 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.

Table 1-5
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.

1.7 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[8], 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 1-6, 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

[8] Additional detail concerning the PIERS data is provided in Attachment A to this Appendix (Attachment A: PIERS Data Analysis).

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 1-6
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 1-7). 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 1-7
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. 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 1-7). Table 1-8 shows the geographic distribution of TEUs within these regions and those outside of North Carolina.

Table 1-8
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%**

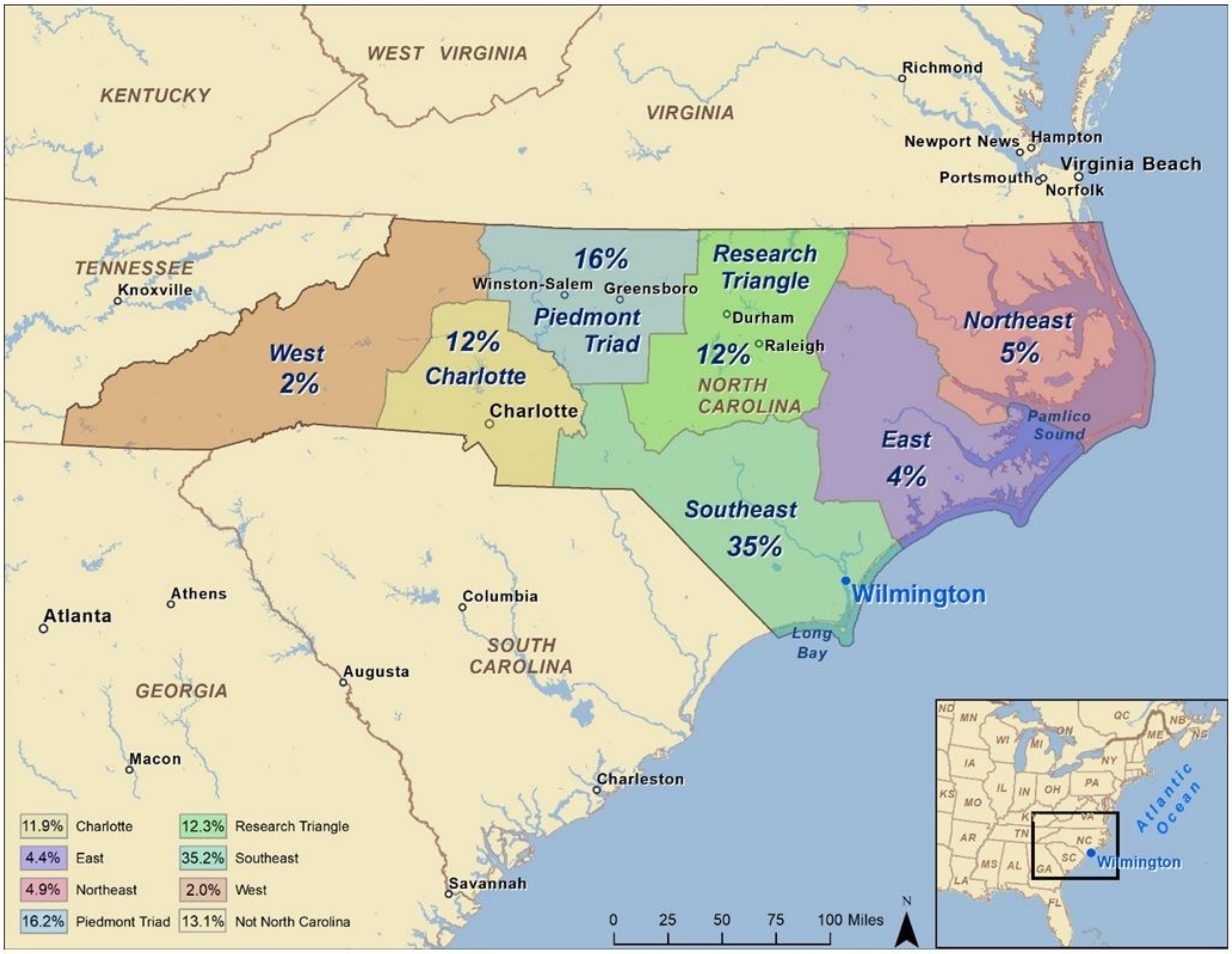

Figure 1-7
Geographic Distribution of TEUs Transiting the Port of Wilmington

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.

1.8 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[9] because of the infrequency of such a high tide.

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

The majority of the deepest draft vessels calling at Wilmington Harbor are containerships on U. S. East Coast to Asia (USEC-Asia) services (Table 1-9). All of the deeply loaded vessels included in Table 1-9 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 1-9
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, all the bulk vessels calling at the Port of Wilmington at Panamax vessels or smaller. The small number of annual vessel calls that might take advantage of deeper depths would have only a marginal influence on economic justification and would not influence plan selection (see section 5: Formulation and Preliminary Evaluation of Alternatives).

1.8.1 Existing Cargo Characterization

Commodity types moved through Wilmington Harbor (Tables 1-10 through 1-13) 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 2-32) due to the increased capacity of vessels calling at the port (see next Section 2.34.2 Table 2-41).

Table 1-10
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 1-11
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 1-12
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 1-13
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

1.8.2 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[10].

The benchmark for container ship size used in this analysis is the vessel size classification system (Table 1-14) used by the DDNPCX in the Norfolk Harbor Channel Deepening Study

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

(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 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[11]. 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 1-14
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.

1.8.2.1 Existing Conditions: World Fleet

The characteristics of the world container ship fleet (Table 1-15) indicate that the larger vessels in the fleet are also the newest vessels. The progression of increase in vessel size since 1995 (Table 1-16) 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 1-17). When these new build vessels are added to the world fleet (2 to 3 years), and assuming no scrapping of older vessels, the two

[11] 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)

largest vessel classes will account for 46% of the fleet's TEU capacity (Table 1-18). Currently, the average age of vessels in the PPX3Max and PPX4 classes are 6 year and 3 years, respectively.

Table 1-15
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 1-16
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 1-17
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 1-18
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

1.8.2.2 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 1-19 through 1-21). The three international ports shown in Tables 2-38 through 2-40 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 1-19
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 1-20
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 1-21
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 2-38 through 2-40.

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[12] and the Port of Jacksonville's planned improvements to service two post-Panamax vessels simultaneously[13]. The combination of ongoing terminal and navigation channel improvements described in the without project condition will ensure continuance of the trends exhibited in Tables 1-19 through 1-21.

1.8.2.3 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[14] 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 1-22). However, these larger vessels cannot operate to their full efficiency at Wilmington, due to existing channel constraints.

Table 1-22
Vessel Class Distribution for Container Ships Asia Services Calling at the Port of Wilmington

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

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

The Port of Wilmington data for 2018 reflect the transitions in Asia services, which occurred 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 and Hapag-Lloyd 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 and MSC). 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 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.

[12] Port Technology International 06Feb19
[13] Port Technology International 05Mar19
[14] 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.

The result of the changes that occurred in 2018 can be seen in the vessel size distribution for the Port of Wilmington in 2019. The 2019 data is based on vessel schedules published on the Zim and ONE websites. The schedules include vessels from all members of the two alliances (THE and 2M). The Zim schedule extends through May 2019 and the ONE schedule extends through October 2019. The two PPX3Max vessels scheduled to call at the Port of Wilmington are in the smaller size range for vessels in that size class, but will nevertheless push existing channel capacity to its limit. The ports-of-call for the two USEC-Asia services calling at the Port of Wilmington are presented in Table 1-23.

Table 1-23
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**
Jacksonville	Savannah, GA
Wilmington, NC	Charleston, SC
Kingston	Panama Canal
Panama Canal	Qingdao
Slavyanka	
Pusan	
Tianjing Xingang	

2 WITHOUT-PROJECT CONDITIONS

The major difference between existing conditions and without-project conditions is the completion of many navigation and marine transport improvements which are occurring at other USEC ports and at the Port of Wilmington. Continuing increases in size of containerships in the world fleet and the cascade effect of larger vessels displacing smaller vessels on the USEC-Asia services will further increase the size of vessels calling at USEC ports, including Wilmington. 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 unless the Federal navigation channel is deepened commensurate with other USEC ports. If this 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.

2.1 Wilmington Harbor Navigation Features

The major differences between existing conditions and without-project conditions at the Wilmington Harbor Federal navigation project are 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.

2.1.1 Channels and Turning Basins

The NCSPA is currently applying to the Corps of Engineers under 33 United States Code (USC) 408 (Section 408) to make improvements to the Federal navigation channel at the Lower Anchorage Basin. The Lower Anchorage Basin is used as the turning basin for vessels calling at the Port of Wilmington. These proposed improvements are 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 (see Section 5: Formulation and Preliminary Evaluation of Alternatives).

The existing and 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.

2.1.2 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).

2.2 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.

2.2.1 Port of Wilmington Container Terminal

The NCSPA is engaged in a terminal improvement program to increase the efficiency and throughput capacity of the Port of Wilmington container terminal (Figure 2-1). 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 2-1
Port of Wilmington Container Terminal Improvement Plan

2.3 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 2-1 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 2-1
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 – in design	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 2-1 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 2-1 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 2.34.2 Existing Containership Fleet.

This depth deficit will make it economically unsustainable for the Port of Wilmington to remain as a port-of-call the USEC-Asia services. Currently, there are two USEC-Asia services that call at the Port of Wilmington, which combined also call at Jacksonville, Savannah, Charleston, New York, and Boston. The vessels on these services are in the 8,000 to 10,000 TEU range. These are the largest vessels that can currently call at the Port of Wilmington on a regular basis. In the future, when all the ports-of-call on these services - except the Port of Wilmington - have substantially deeper depths, carriers will shift to larger vessels to take advantage of the economies of scale of using larger more deeply loaded vessels. As an example of the size of the incentive for carriers to switch to larger more deeply loaded vessels, consider that it costs 26% less per TEU to transport a TEU on a 12,500 TEU vessel loaded to 85% capacity (47-foot draft) than it costs to transport that same TEU on a 10,000 TEU vessel loaded to a draft of 41-feet (the maximum draft for this vessel at the port of Wilmington)[15].

It will be economically unsustainable for the future USEC-Asia containership fleet to call at the Port of Wilmington under without-project conditions. Table 2-2 compares the waterborne transportation cost[16] per TEU per 1,000-mile transit for a 10,000 TEU vessel with a 40-foot draft (Port of Wilmington without-project condition) with vessels with unrestricted draft at 85% capacity utilization (alternative USEC port without-project condition). The percentage increase shows the increase in waterborne transportation costs that the carrier would incur by loading vessels to a 40-foot draft in order to access the Port of Wilmington, which includes leaving the prior port with a 40-foot draft and arriving at the next port with a 40-foot draft. For example, it would be 42% more expensive per TEU for a 10,000 TEU vessel to call at the Port of Wilmington with a 41-foot draft restriction than it would be for the same vessel to call at another USEC port without the draft restriction. There is no economic justification for a carrier to include the Port of Wilmington in a USEC-Asia service port rotation that also includes other USEC ports with the future depths listed in Table 2-1. The economically rational conclusion is that USEC-Asia services will not call at the Port of Wilmington under future without-project conditions.

An alternative way to conceptualize USEC-Asia services is to look at each service as a system of ports, as opposed to looking at each service as a collection of unrelated ports. As a system, the depth at any one port in the system directly affects the departure drafts from the previous port in the system and the arrival draft at the next port. The system of ports that comprise the USEC-Asia services is being upgraded (Table 2-1) from a system of ports in the -40-foot to -45-foot project depth range to a system of ports in the -47 to -52-foot range. Although each port being improved has been evaluated individually to economically justify the project depth improvement, the effect is an improvement to the performance of the system. However, the presence of a single unimproved port within the system restricts the overall performance of that system. In the

[15] Based on FY 2017 VOCs: $33.51/TEU/1,000 miles for 10,000 TEU vessel loaded to 41 feet draft vs. $24.71/TEU/1,000 miles for a 12,500 TEU vessel loaded to 47 feet draft, which is a cost savings of $8.80/TEU.
[16] Based on FY 2017 USACE VOCs

case of USEC-Asia services, the lack of improvement at Wilmington Harbor in the without-project condition poses a severe restriction on the system's overall performance.

Table 2-2
Waterborne Transportation Cost per TEU Comparisons

Vessel Size (TEUs)	Vessel Draft	$/TEU/1000 miles	Cost Savings per TEU ($)	Cost Savings per TEU (%)
10,000	41	$33.51	-	-
10,000	46	$27.90	$5.61	17%
12,500	47	$24.71	$8.80	26%
14,000	48	$22.22	$11.29	34%
16,000	49	$18.98	$14.53	43%
18,000	50	$16.42	$17.09	51%

2.4 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.

2.4.1 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 Appendix, 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 2-3). 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 2-3
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 2-4).

Table 2-4
Port of Wilmington Containerized Cargo Forecast (TEUs)

Region	Port	2025	2030	2035	2040	2045
Non-Asia	Wilmington, NC	179,713	223,554	252,930	286,168	323,772
Asia	USEC Alternate	272,615	339,119	383,682	434,101	491,145

2.4.2 Bulk Commodities

Bulk commodities include fuel and chemicals (liquid bulk), wood chips and potash (dry bulk), and lumber (break bulk). Future without-project 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, they have no effect on plan formulation or plan selection.

2.5 Fleet Forecast

The Wilmington Harbor 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.

2.5.1 Containership Fleet Forecast

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 2-5). 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 2-5
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[17] is 160 feet beam, 1,200 feet LOA, and maximum operating draft through the canal of 50 feet. These dimensions

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

define the size of the Neo-Panamax class of containerships, which include PPX3 and PPX3Max vessels (see Table 2-6).

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 1-19 through 1-21 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 2-6) for the USEC-Asia without-project condition commodity forecast (Table 2-4) was developed using the HarborSym vessel loading tool.

Table 2-6
USEC-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

2.6 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-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.

2.6.1 Without-project Waterborne Transportation Costs

Without-project waterborne transportation costs are based on the Port of Savannah as the alternative port for the USEC-Asia cargo identified in the commodity forecast (Table 2-4). The Port of Charleston is typically closer to the Port of Wilmington's hinterland than other alternative ports including Norfolk Harbor and Savannah (see the Distance Tables in the Economics Appendix). However, Savannah's slot in the port rotation is ahead of Charleston (Table 2-7), creating a time advantage for Wilmington-hinterland cargo to be offloaded at Savannah. Base-case without-project waterborne transportation costs are calculated for the two USEC-Asia services using Savannah as the alternative port. Sensitivity analyses are performed with 50% of Wilmington-hinterland cargo using Charleston and 50% using Savannah and with 100% of Wilmington-hinterland cargo using Charleston.

Table 2-7
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 2-8) 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 without-project conditions, are $117,098,000, which is calculated at the FY 2019 Federal discount rate (2.875%) over 50 years.

Table 2-8
USEC-Asia Cargo Without-project Waterborne Transportation Costs-Savannah as Alternate Port (thousands $FY19)

	2027	2030	2035	2040	2045	AAEQ
Waterborne Cost	$90,857	$100,341	$112,463	$124.589	$136,705	$117,098

2.6.2 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 Charleston. 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[18]. 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 2-2 and 2-3 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. Typical trucking costs were calculated using the linear interpolation depicted in Figure 2-2 and are shown in Table 2-9. Anticipated costs to any city in the hinterland are similarly calculated. The FY 2017 costs are updated to FY 2019 costs using the Producer Price Index for General Freight Trucking, Long-Distance Truckload generated the Federal Reserve Bank of St. Louis.[19]

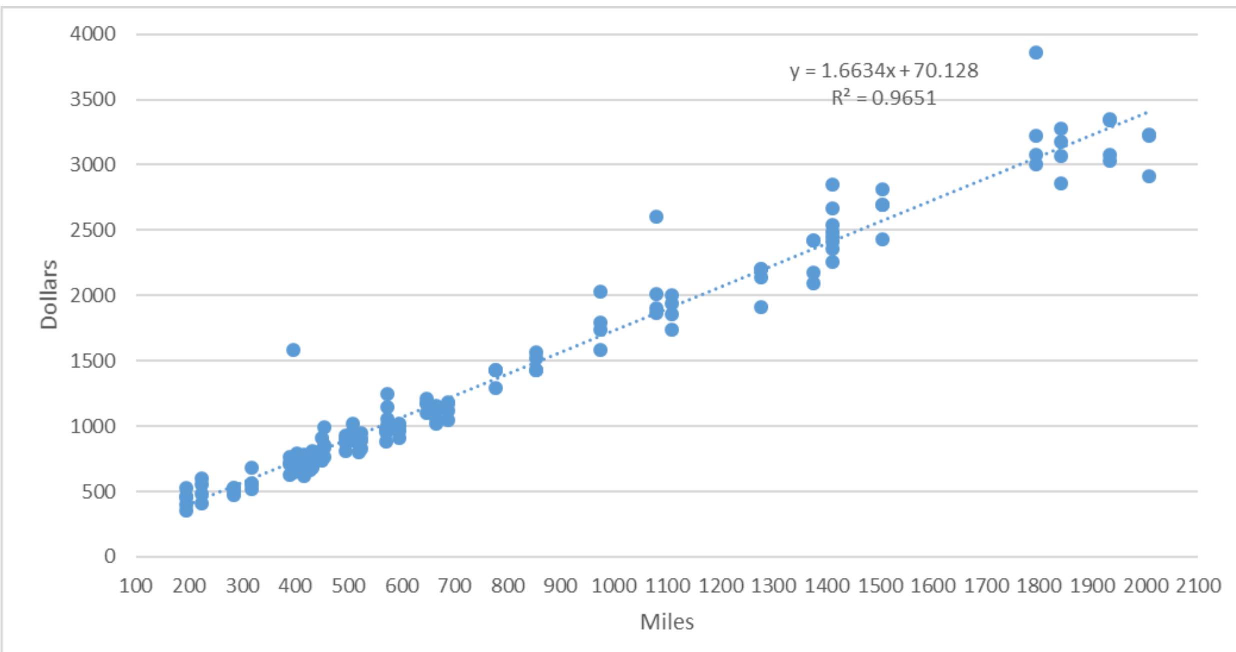

Figure 2-2
Trucking Costs by Miles Driven

[18] Additional detail concerning the trucking cost model is provided in an Attachment to this Appendix (Attachment B: Trucking Cost Model)
[19] Average PPI for FY17 = 124.6; Average PPI for FY19 = 140.9; Update factor = 1.131

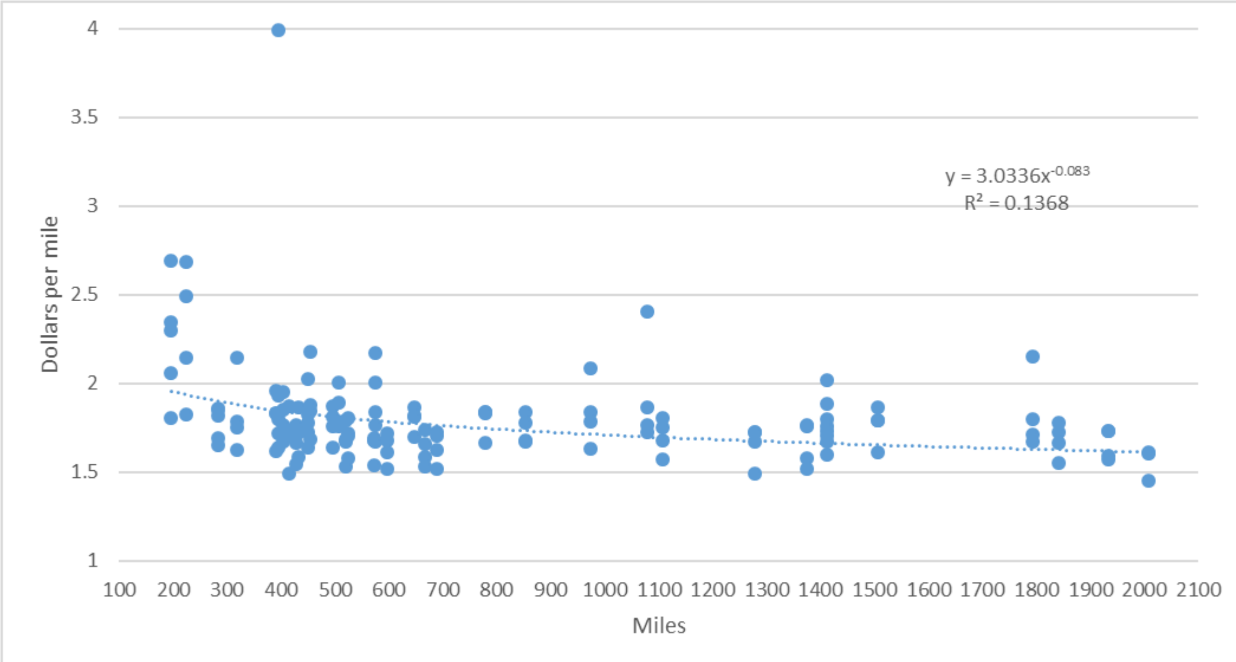

Figure 2-3
Trucking Rates (dollars per mile) by Miles Driven

Table 2-9
Linear Interpolation of Truck Quotes (FY17$)

City	Linear Interpolated Costs (dollars)			
	Wilmington	Norfolk	Charleston	Savannah
Fayetteville, NC	396	825	789	942
Raleigh, NC	543	719	1022	1178
Columbia, SC	729	1364	443	599
Charlotte, NC	762	1148	782	935
Winston-Salem, NC	819	915	1062	1215
Greenville, SC	1025	1491	742	895
Nashville, TN	2196	2419	1913	1690
Cleveland, OH	2359	1867	2419	2575
Chicago, IL	3410	3054	3134	3287

Without-project landside costs for cargo on the ZCP and EC2 services that shift to alternative ports under without-project conditions are calculated for each year (Table 2-10) from 2027 (the base year) to 2076 (50-year planning period). Landside trucking costs 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. The average annual equivalent value landside transportation costs are $339,100,000, which is calculated at the FY 2019 Federal discount rate (2.875%) over 50 years.

Table 2-10
USEC-Asia Cargo Without-project Landside Transportation Costs-Savannah as Alternate Port (thousands $FY19)

	2027	2030	2035	2040	2045	AAEQ
Landside Cost	$228,756	$257,576	$291,423	$329,719	$373,047	$339,100

3 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.

3.1 Problems

A general description of the problems at Wilmington Harbor is that containerized trade, in terms of volume and size of vessels, 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 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 in 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 US east coast ports where channel conditions can accommodate the newer more efficient vessels.

3.2 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
- 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 significant 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 10: Economic Evaluation of Alternative Plans presents a detailed quantitative assessment of the benefits resulting from alternative plans that support the realization of these opportunities.

3.3 Federal Objective

The Federal objective in formulating alternative plans is based largely on contributions to National Economic Development (NED). 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 nearest alternative port (Charleston, SC), 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).

3.3.1 Planning Objectives

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 (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:

Objective 1: Reduce access restrictions for containerships on USEC-Asia services at the Port of Wilmington to accommodate use by larger vessels from 2027 to 2076.

Objective 2: Accommodate efficient loading of containerships on USEC-Asia services at the Port of Wilmington from 2027 to 2076.

Objective 3: Maintain the Port of Wilmington as a port-of-call for USEC-Asia services from 2027 to 2076.

3.4 Constraints

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 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.

4 FORMULATION AND PRELIMINARY EVALUATION OF ALTERNATIVES

This section of the report presents the preliminary planning process that was used to identify a Tentatively Selected Plan 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;
- Identification and screening of potential solutions, including nonstructural measures;
- Identification of the Focused Array of Alternatives;
- Evaluation of the Preliminary Alternative Plans; and
- Selection of the TSP and identification of the NED Plan.

Based on the results of the preliminary analysis presented in this section, a more detailed set of analyses were performed on the No Action Alternative and the TSP, which is the NED plan. The description of these detailed analyses and their results follow this section. Detailed descriptions of the No Action Alternative and TSP are presented in Section 6: Detailed Description of the Final Alternative Plans. Detailed evaluations of the TSP, which is the NED Plan, are presented in Section 7: Economic Evaluation of the Final Alternative Plans, Section 8: Physical Effects of the Final Alternative Plans, and Section 9: Environmental Effects of the Final Alternative Plans.

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.

4.1 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[20]. 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.

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

Transportation cost savings are calculated as reductions in the cost of transporting goods from their ultimate origin to their ultimate destination.

4.1.1 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 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.

4.2 Plan Formulation and Screening Criteria

Management measures and alternative plans were developed to address the problems of constrained cargo vessel size and limited efficiency at the Port of Wilmington. Management measures were evaluated with respect to their ability to meet the planning objectives. Each alternative plan was formulated in consideration of meeting the planning objectives and in consideration of the following formulation and evaluation criteria: technical, economic, institutional, environmental, and social. They are further defined below based on the four general criteria for plan formulation that are identified in the Principles and Guidelines (1983): completeness, efficiency, effectiveness, and acceptability.

Technical Criteria

- Channel improvement plans must be realistic and reflect state-of-the-art measures and analysis techniques;
- The optimal scale of project development should be identified by analyzing economic, engineering, and environmental feasibility;
- The plan should accommodate vessels projected to call at the port during the planning period, based on observed industry operations and reasonable fleet forecasts;

- The plan should maintain vessel operability under various weather conditions and should withstand projected weather and sea conditions, such as storms, floods, and waves;
- The selected plan should be consistent with local, regional, and state goals for water resources development;
- Required actions and costs to ensure entrance channel and shoreline stability should be clearly outlined and explained;
- The plan should ensure that federal navigation structures are stable and maintainable; and
- The plan should clearly demonstrate potential impacts to the O&M of the navigation channel as well as to other project features.

Economic Criteria

- Each separable unit of improvement should be optimized to ensure that each independent element of the selected plan is economically justified; and
- The scope of the proposed development should be scaled to allow identification of the plan that provides maximum net NED benefits.

Institutional Criteria

- Plans must be consistent with existing Federal, state, and local laws;
- The ASA(CW) will review this study to determine whether the study, and the process under which it was developed, complies with Federal laws and regulations applicable to feasibility studies of navigation projects for deep draft harbors. Following that review, the Secretary will transmit to Congress, in writing, the results of his review and any recommendations the Secretary may have concerning the project.

Environmental Criteria

- Plans should minimize the commitment of natural resources, whether they are marine bottom-lands, wetlands, other coastal zones, inland environments, or Federally-listed species according to the Endangered Species Act;
- Plans should avoid or minimize environmental impacts and maximize environmental quality in the project area to the extent practicable considering environmental, economic, and engineering criteria;
- Available sources of expertise should be used to identify environmental resources that might be endangered, damaged, or impacted by plan implementation. These would include the United States Fish and Wildlife Service (USFWS), USEPA, NMFS, and appropriate state agencies, such as the North Carolina Department of Environmental Quality; and
- Measures should be incorporated into plans to protect, preserve, or restore environmental quality in the project area.

Social Criteria

- Plans should be capable of being integrated into local or regional planning for water and air pollution abatement, transportation, recreation, and land use;
- As much as possible, plans should minimize noise, dust, odor, unsightliness, and potential health risks;
- Plans should meet existing public health and environmental control standards;
- Plans should not displace, devalue, or destroy important historical and cultural landmarks or sites; and
- Adverse impacts on area recreation resources should be avoided or minimized.

4.3 Management Measures

The management measures identified 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.

4.3.1 Non-structural Measures

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.

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. 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. Therefore, this measure is not carried forward. However, existing deep-water areas may be incorporated into channel widening in some areas to support safe navigation of the design vessel.

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.

4.3.2 Structural Measures

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

- Channel deepening
- Stepped channel
- Improve existing turning areas and/or create new turning areas
- Improve existing anchorages and/or create new anchorages
- Channel widening to accommodate vessel meeting.

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.

Improve existing/create additional turning areas: The NCSPA is currently applying to make 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 expanded turning basin 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 however, deepening the turning area would be included in all channel deepening alternatives.

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 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[21]. 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 a component of all alternative plans.

4.3.3 Local Service Facility Improvements

Increasing terminal efficiency by using more and/or larger cranes and other equipment enhancements could potentially reduce the vessel's time at the dock and/or allow for larger vessels to be loaded and unloaded efficiently. Enhancement options discussed with the users include:

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

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

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 general, relocating a cargo facility along the channel closer to the ocean could potentially reduce channel improvement costs, if it allowed the channel improvements to be limited to a shorter reach from the ocean to the relocated terminal. Relocation of the Port of Wilmington container terminal to Southport, or construction of a new container terminal at Southport, would reduce with-project improvement costs, such as channel deepening. Currently, the expense of constructing a new container terminal at Southport and the 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 vessels to navigate the Federal channel.

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.

The study constraints and planning objectives were used to screen the range of measures as discussed in Section 3. Table 4-1 shows the measures considered for this study and the results of initial measures screening.

Table 4-1
Objectives – Measures Matrix

Measure		Meets Objectives			Carried Forward
		1	2	3	
Structural Modification Measures					
1	Channel Deepening	Yes	Yes	Yes	**Yes**
2	Stepped Channel	Yes	Yes	Yes	No
3	Turning Basin	No	No	No	No
4	Anchorage Basin	No	No	No	No
5	Channel Widening	No	No	No	No
Operational Measures					
6	Reduce vessel speed	No	No	No	No
7	Additional tug assistance	No	No	No	No
8	Additional aids to navigation	No	No	No	No
9	Tidal advantage	Yes	Yes	No	**Yes**
10	Lightering	No	No	No	No
Locally Implementable Measures					
11	Terminal improvements	No	No	No	No
12	Relocate cargo terminals	No	No	No	No
13	Berth deepening	Yes	Yes	Yes	**Yes**
14	Bulk Terminal improvements	No	No	No	No
15	BreakBulk Terminal improvements	No	No	No	No

4.4 No Action Alternative

The no action alternative is the expected future without-project condition, which is used as the basis of comparison for all other alternative plans. Under the no action alternative, none of the operational measures (other than the existing practice of using tidal advantage), locally implementable measures, or the structural modifications to the Federal channel would be implemented. The result of the no action alternative plan would be constrained vessel operations at the Port of Wilmington (as described in Section 3, Without-Project Conditions), which would continue throughout the period of analysis. Under the No Action Alternative, vessels on the ZCP and EC2 USEC-Asia services would not include the Port of Wilmington as a port-of-call due to the high cost of light-loading at Wilmington (see Table 2-2). Smaller vessels, which would not be restricted at the port of Wilmington under without-project conditions, would not replace larger vessels on Asia Services because it is economically infeasible.

Asia cargo (imports and exports) on the ZCP and EC2 USEC-Asia services with origins and destinations in the Port of Wilmington hinterland would use alternative ports under the No Action Alternative. Without the Port of Wilmington in the port rotation for these two services, the most likely alternative ports are Savannah and Charleston, which are nearer to the Port of Wilmington hinterland than other USEC ports in the port rotation of these two services (see Without-Project Conditions: Table 2-7). Savannah is the most likely alternative port for both services because it comes before Charleston in the port rotation for both services and because carriers would reduce delivery times by offloading or picking up cargo at the first reasonable opportunity, which is a competitive advantage for carriers.[22] In addition, the Port of Savannah has substantially larger container handling capacity, which can absorb the additional cargo from the Port of Wilmington Hinterland, than is available at the Port of Charleston.

4.5 Preliminary Alternative Plans

None of the three measures carried forward to more detailed analysis meets all the planning objectives as a stand-alone alternative plan. As described in the previous section, berth deepening by itself does not fully address the navigational constraints and associated problems at the port. Each of the structural measures applied to the Federal channel requires berth deepening to fully address the navigational constraints and problems. Channel deepening requires associated berth deepening, so that the benefits of channel deepening can be realized. Use of tidal advantage is projected to continue as a standard practice under each alternative.

The three measures combined (channel deepening, berth deepening, and use of tide) directly address Objectives 1 and 2, which allow use of larger vessels and allow more efficient vessel loading. The three measures combined do not necessarily meet Objective 3, which is to maintain the Port of Wilmington as a port-of-call for USEC-Asia services.

To meet Objective 3, the Port of Wilmington must be able to support the carrier's profit-making objective by ensuring that the decision to call at the Port of Wilmington is an economically rational decision. Existing conditions and projected future without-project conditions indicate that the Port of Wilmington has the TEU volume, terminal capacity, and vessel service capability to be a port-of-call on the ZCP and EC2 USEC-Asia services. However, with a maximum operating draft of 41 feet, it would not be economically rational for the carrier to extensively

[22] Sensitivity analyses are conducted for Charleston as the alternative port and for a 50%/50% split between Savannah and Charleston.

light-load on a regular basis in order to call at the Port of Wilmington when Wilmington's hinterland cargo can be handled at alternative ports such as Savannah and Charleston, which are existing ports-of-call on the EC2 and ZCP services. Therefore, channel deepening and berth deepening are used to develop alternative plans that meet Objective 3.

4.5.1 Preliminary Alternative Plan Development

Under existing conditions, with USEC ports on the ZCP and EC2 services not at their improved depths, carrier operations indicate that it is economically rational to call at the Port of Wilmington. The Port of Wilmington maintains its position as a port-of-call on these services because its project depth is similar to the project depths of the ports that come before and after Wilmington in the port rotation for these services (Table 4-2). Savannah and Wilmington have the same project depth of -42 feet under existing conditions. Based on pilot's data, the typical maximum operating draft at Savannah under existing conditions is -42 feet and -41 feet at Wilmington, both using tidal advantage. Currently, based on analyses performed for their respective channel deepening feasibility studies, the maximum operating drafts at Boston and Jacksonville are -40 feet. Having project depths, and therefore operating drafts, that are similar to the project depths and operating drafts of other ports on the rotation (Table 4-2) allows vessels to operate with similar transportation costs. Existing carrier operations, which include the Port of Wilmington as a port-of -call after Boston and before Savannah, indicate that the one-foot vessel operational range differential between the Ports of Savannah and Wilmington is not so restrictive as to preclude Wilmington from being a port-of-call.

Table 4-2
USEC-Asia Services USEC Ports-of-Call: Existing Conditions Depths

Ports	Project Depth (MLLW)	Typical Maximum Operating Draft (feet)	Vessel Operational Range (feet)*
Boston	-40	-40	30 to 40
Charleston	-45	-45	33 to 45
Savannah	-42	-42	30 to 42
Jacksonville	-42	-40	30 to 40
Wilmington	-42	-41	30 to 41

*Assumes 12-foot range with 30 feet being a minimum draft

For the Port of Wilmington to be a port-of-call under future conditions, the transportation cost per TEU incurred by calling at the Port of Wilmington must be similar to other ports-of-call on the same services. Under future without-project conditions project depths at the USEC ports-of-call on the two USEC-Asia services range from -47 feet MLLW to -52 feet MLLW (Table 4-3). In addition, those ports have differing opportunities for tidal advantage. It is assumed that the use of tides, which is standard practice under existing conditions, would continue under future conditions. Under without-project conditions, the ZCP and EC2 USEC-Asia services using PPX3 vessels will not call at the Port of Wilmington because it will not be economically feasible to do so. The restriction on the range of vessel operating drafts at Wilmington under without-project conditions would result in extreme light loading to the carriers, which would be cost prohibitive as explained further below.

Table 4-3
USEC-Asia Services USEC Ports-of-Call: Without-Project Condition Depths

Ports	Project Depth (MLLW)	Typical Maximum Operating Draft (feet)	Vessel Operational Range (feet)*
Boston	-47	-47	35 to 47
Charleston	-52	-52	40 to 52
Savannah	-47	-47	35 to 47
Jacksonville	-47	-45	33 to 45
Wilmington	-42	-41	30 to 41

*Assumes 12-foot range with 30 feet being a minimum draft

Alternative plans, each including channel deepening, berth deepening, and use of tidal advantage (Table 4-4), were developed in one-foot increments for preliminary evaluation. Each plan is identified by its project depth and includes the necessary additional depth in the ocean channel and channel widening where necessary to accommodate the design vessel. Note that channel widening to accommodate passing of the design vessel was not advanced for more detailed analysis (Table 4-1).

Table 4-4
Preliminary Alternative Plans – Incremental Channel Depth

Plan	Project Depth (feet MLLW)	Typical Maximum Operating Draft (feet)	Vessel Operational Range (feet)*
44-foot	-44	-43	31 to 43
45-foot	-45	-44	32 to 44
46-foot	-46	-45	33 to 45
47-foot	-47	-46	34 to 46
48-foot	-48	-47	35 to 47
49-foot	-49	-48	36 to 48
50-foot	-50	-49	37 to 49

*Assumes 12-foot range with 30 feet being a minimum draft

4.5.2 Preliminary Alternative Plan Evaluation

A preliminary alternative plan evaluation was performed to identify the set of plans to be advanced for more detailed evaluation and selection. The preliminary evaluation focuses on alternative plan net benefits to ensure that only economically viable plans are advanced for more rigorous analysis, which includes detailed environmental and economic analyses.

Alternative plan benefits are based on full origin to destination transportation cost savings as described in the Principles and Guidelines[23], the Planners Guidance Notebook[24], and the NED Manual for Deep Draft Navigation[25]. Transportation cost savings are identified for two categories: waterborne and landside. Waterborne transportation cost savings are generated when alternative plans allow for commodities to be transported by ship at a lower unit cost, which typically result from the use of larger, more efficient vessels or vessels being loaded more efficiently under with-project conditions. Landside transportation cost savings are generated when with-project conditions allow for cargo to take a shorter, less costly route from the commodity's domestic origin or destination to the port. For this study, landside transportation cost savings may be generated if Wilmington's hinterland cargo were to switch from an alternative USEC port to the Port of Wilmington.

Under without-project conditions, two USEC-Asia services (ZCP and EC2) carrying Port of Wilmington hinterland cargo will call at Charleston or Savannah but will not call at Wilmington due to without-project draft restrictions (Table 4-3). The without-project fleet forecast for the Port of Wilmington (Table 2-5) includes Panamax and sub-Panamax vessels, which would not load more efficiently or switch to large vessels under alternative plans. Therefore, there are no waterborne transportation cost savings for the without-project fleet under the alternative plans. The benefits of a deeper channel can only accrue for vessels that are large enough to take advantage of a deeper channel.

Vessels on the ZCP and EC2 services are currently transitioning to PPX3 vessels, which includes the design vessel, as identified in table 1-22. These vessels are large enough to take advantage of a deeper channel at the Port of Wilmington but will not call at Wilmington under the draft restrictions of a 42-foot channel under without-project conditions, with ongoing improvements at other USEC ports in the port rotation having been completed (Table 3-1). Incremental channel deepening plans reduce draft restrictions at the Port of Wilmington and reduce the difference in operating drafts between Wilmington and the other ports-of-call on the ZCP and EC2 services.

Under existing conditions, the Wilmington Harbor project and the Savannah Harbor Project have a similar project depth of -42 feet MLLW. The two USEC-Asia services, which call at the port of Wilmington, also call at the Port of Savannah. Large vessels calling at both ports use tidal advantage. Savannah has a greater tidal advantage that Wilmington. The deepest observed operating draft for containerships at Savannah is 42 feet. The deepest observed operating draft for containerships at Wilmington is -41 feet.

4.5.2.1 Incremental Channel Depth Waterborne Unit Cost Analysis

Vessel operating characteristics, which display vessel deployment and loading decisions made by vessel operators, have been explored in previous USACE deep draft navigation studies. The Savannah Harbor Expansion Project Feasibility Study (USACE 2012) identified the waterborne transportation cost per TEU per 1,000 miles as a decision point for vessel operators to switch to

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[23] Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, Section 7, 10 March 1983
[24] ER 1105-2-100, Chapter 3-2, 22 April 2000
[25] IWR Report 10-R-4 April 2010

larger vessels with lower operating costs. Table 38 of the Savannah Economics Appendix (presented below) shows that at deeper channel depths carriers switch to larger vessels, which are able to load more deeply and take advantage of economies of scale, thereby lowering unit costs. This concept of switching vessel size based on unit costs can also be applied to the operator's decision to include a port as a port-of-call.

available for cargo at each sailing draft. Table 38 shows the estimated unit cost by vessel class by channel depth. Entries shaded in yellow identify the breakpoints or depth where it makes economic sense for a shipper to deploy a larger vessel to the route.

Table 38: Unit Cost in Tonnes per Thousand Miles

World Region Route	Vessel Classes	Channel Depths (feet)					
		42	44	45	46	47	48
FE (Suez) ECUS	PX MPD	$ 2.31	$ 2.31	$ 2.31	$ 2.31	$ 2.31	$ 2.31
	PPX1 MPD	$ 2.02	$ 1.85	$ 1.81	$ 1.81	$ 1.81	$ 1.81
	PPX2 MPD	$ 2.04	$ 1.87	$ 1.80	$ 1.73	$ 1.72	$ 1.72
ECUS MED	PX MPD	$ 2.07	$ 1.99	$ 1.99	$ 1.99	$ 1.99	$ 1.99
	PPX1 MPD	$ 2.02	$ 1.85	$ 1.78	$ 1.76	$ 1.76	$ 1.76
	PPX2 MPD	$ 2.04	$ 1.87	$ 1.80	$ 1.73	$ 1.67	$ 1.67
FE (Panama) ECUS	PX MPD	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46
	PPX1 MPD	$ 2.02	$ 1.92	$ 1.92	$ 1.92	$ 1.92	$ 1.92
	PPX2 MPD	$ 2.04	$ 1.87	$ 1.82	$ 1.82	$ 1.82	$ 1.82
FE ECUS EU PEN	PX MPD	$ 2.38	$ 2.38	$ 2.38	$ 2.38	$ 2.38	$ 2.38
	PPX1 MPD	$ 2.02	$ 1.86	$ 1.86	$1.86	$ 1.86	$ 1.86
	PPX2 MPD	$ 2.04	$ 1.87	$ 1.80	$ 1.76	$ 1.76	$ 1.76
FE ECUS MED PEN	PX MPD	$ 2.27	$ 2.27	$ 2.27	$ 2.27	$ 2.27	$ 2.27
	PPX1 MPD	$ 2.02	$ 1.85	$ 1.78	$ 1.78	$ 1.78	$ 1.78
	PPX2 MPD	$ 2.04	$ 1.87	$ 1.80	$ 1.73	$ 1.69	$ 1.69
RTW	PX MPD	$ 2.07	$ 2.00	$ 2.00	$ 2.00	$ 2.00	$ 2.00
	PPX1 MPD	$ 2.02	$ 1.85	$ 1.78	$ 1.76	$ 1.76	$ 1.76
	PPX2 MPD	$ 2.04	$ 1.87	$ 1.80	$ 1.73	$ 1.67	$ 1.67
ECUS EU GULF PEN	PX MPD	$ 2.07	$ 2.06	$ 2.06	$ 2.06	$ 2.06	$ 2.06
	PPX1 MPD	$ 2.02	$ 1.85	$ 1.78	$ 1.76	$ 1.76	$ 1.76
	PPX2 MPD	$ 2.04	$ 1.87	$ 1.80	$ 1.73	$ 1.67	$ 1.67

Figure 4-1
Table 38 of the Savannah Harbor Expansion Project Feasibility Study Economics Appendix

The Charleston Post-45 Feasibility Study (USACE, 2015) projected operating draft distributions for the design vessel (PPX3) at various project depths at Charleston. Figure 26 from the Charleston Economics Appendix displays the cumulative distribution functions for operations drafts for the design vessel at project depths of 45 ft, 48 ft, 50 ft, and 52 feet (presented below). Note that the design vessel for the Charleston Post-45 Study is the same vessel as the Wilmington Harbor Design Vessel. Combining the vessel operator's deployment and loading decisions, as developed in the Savannah and Charleston studies, can be used to evaluate vessel deployment decisions under alternative project conditions at Wilmington Harbor.

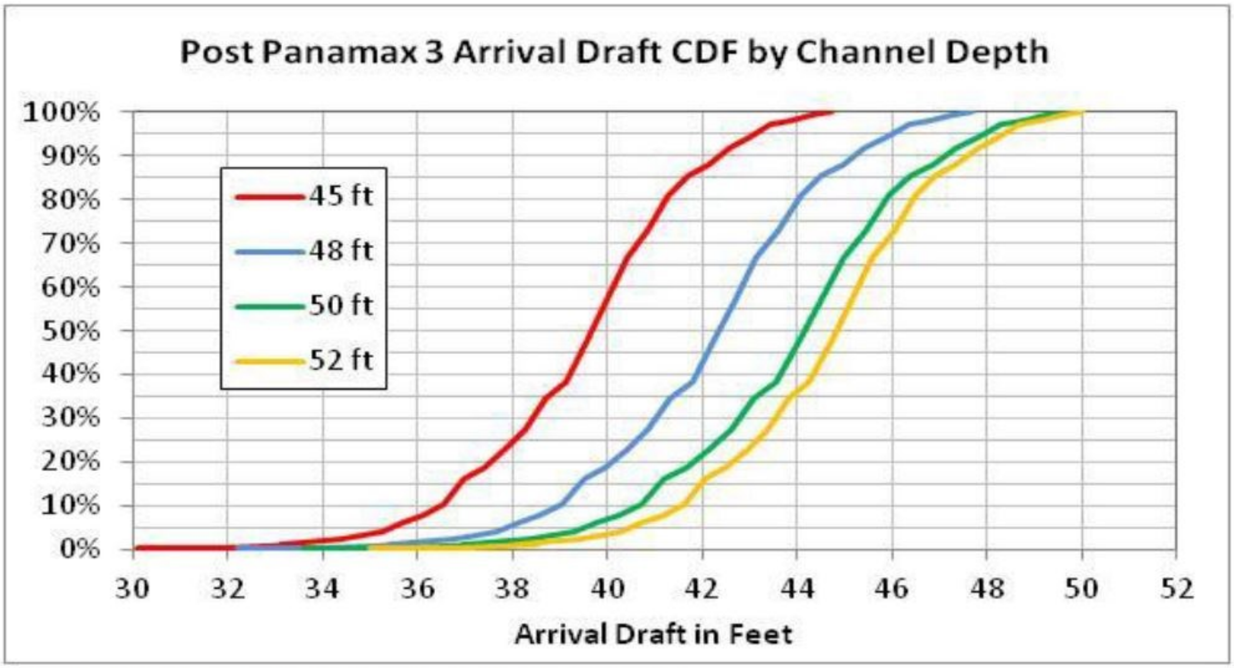

Figure 26: Post Panamax Gen III Arrival Draft by Channel Depth

Figure 4-2
Figure 26 of the Charleston Post-45 Feasibility Study Economics Appendix

Weighted average unit costs per TEU per 1,000 miles were developed for the Wilmington Harbor design vessel using observed TEU weights, calculated immersion rates, and 2017 USACE vessel operating costs approximated from the 2013 costs. Under existing conditions, with Ports of Savannah and Wilmington at the same project depth (-42 feet MLLW) unit costs are very similar among the two ports. The weighted average cost is slightly lower at Savannah due to the greater tidal advantage available at Savannah. The 6.3% cost differential for existing conditions – the weighted average unit cost is 6.3% higher at Wilmington -, is obviously acceptable to the carriers, as they call at both Wilmington and Savannah under existing conditions.

Under without-project conditions, in which Savannah Harbor is deepened to a project depth of -47 ft MLLW and Wilmington Harbor remains at -42 ft MLLW, the cost differential increases to 43.7% – the weighted average unit waterborne transportation cost is 43.7% higher at Wilmington. Based on the cumulative distribution functions developed for the design vessel at Charleston Harbor, the five-foot difference in channel depth would restrict vessel calls from Savannah to Wilmington to a maximum draft of 41 feet, which would affect 70% of calls. This is the economic rationale for dropping the Port of Wilmington from the port rotation under without-project conditions.

The following table displays the weighted average unit costs for Savannah and Wilmington under alternative project conditions. The cost differential between Savannah and Wilmington decreases as the project depth at Wilmington Harbor increases. Weighted average unit costs are equivalent for a project depth of -47 feet MLLW at Savannah and -48 feet MMLW at Wilmington. Savanah accommodates deeper operating drafts and lower unit costs at any depth than Wilmington due to the greater tidal advantage at Savannah. The unit cost differential for a -47-foot channel at Wilmington Harbor is similar to, but somewhat lower than, the cost differential under existing conditions. Vessel operators have shown through existing operations that they are willing to incur a small cost differential and call at the Port of Wilmington.

Table 4-5
Weighted Average Unit Costs for PPX3 at Alternative Depths

Port	Project depth (ft)	$/TEU/1,000 miles	Differential
Existing Condition			
Savannah	-42	$39.79	
Wilmington	-42	$42.30	6.3%
Without-Project Condition			
Savannah	-47	$29.43	
Wilmington	-42	$42.30	43.7%
With-Project Alternative Depths			
Wilmington	-44	$37.52	27.5%
Wilmington	-45	$35.44	20.4%
Wilmington	-46	$33.53	13.9%
Wilmington	-47	$30.85	4.8%
Wilmington	-48	$29.43	0%

The North Carolina State Ports Authority is satisfied with the -47-foot alternative, which is the smallest alternative that provides comparable unit costs to Savannah and will not pursue -48 feet as a Locally Preferred Plan because of the cost and additional environmental impacts that would result from the additional depth.

4.5.2.2 Incremental Channel Depth Total Transportation Cost Analysis

The 47-foot plan is the smallest plan that reduces unit costs down to differences experienced under existing conditions (Table 4-5). Carriers on these two services are projected to call at the Port of Wilmington when the unit cost difference between the ports-of-call are equivalent to the differences experienced under existing conditions, which first occurs with the -47-foot increment.

The -47-foot plan is the smallest plan that reduces unit cost differentials, between the Port of Wilmington and other USEC ports-of-call on the ZCP and EC2 services, down to differences exhibited under existing conditions. If the Federal navigation channel at the Port of Wilmington were 47 feet deep, Wilmington would be able to accommodate vessels in a transportation cost range similar to Savannah, Jacksonville, and Boston. This analysis indicates -47 feet as a tipping point for Wilmington’s inclusion as a port-of-call on these services. The NED benefits of this alternative would include reductions in landside origin to destination costs as identified in the Principles and Guidelines under the category of “same commodity and origin and destination, different harbor" for Port of Wilmington hinterland cargo shifting from alternative ports to the Port of Wilmington.

Note that there is a slight offsetting increase in waterborne transportation costs due to the additional distance required to add the Port of Wilmington as a port of call. Reinstating the Port of Wilmington as a port-of-call on the ZCP service increase the distance traveled on that service by 403 nautical miles, for the EC2 service the distance increase is 77 nautical miles. This additional distance is included in the waterborne costs presented in Table 4-6.

Under the 48-foot plan, transportation costs at the Port of Wilmington would be further reduced due to the increased efficiency of vessels being able to load more deeply. The waterborne transportation costs for this depth increment include the waterborne transportation cost savings afforded by the one-foot increase in channel depth. The Port of Wilmington would be a port-of-call on the two USEC-Asia services and increased efficiencies on these two services would provide the waterborne transportation cost savings. The total waterborne transportation costs would include any offsetting additional transportation costs due to the additional nautical miles traveled.

A 49-foot plan was also evaluated to identify whether a trend in successive incremental net benefits could be identified and used to determine whether additional depths should be evaluated.

Table 4-6
AAEQ Transportation Costs ($FY2019 thousands)

Scenario	Waterborne Costs	Landside Costs	Total Costs
Without-project	$118,718	$339,100	$457,818
-44-foot Plan	$118,070	$339,100	$457.170
-45-foot Plan	$117,746	$339,100	$456,846
-46-foot Plan	$117,422	$339,100	$456.522
-47-foot Plan	$125,046	$172,660	$297,706
-48-foot Plan	$124,722	$172,660	$297,382
-49-foot Plan	$124,398	$172,660	$297,058

AAEQ values calculated over 50 years at the federal FY19 discount rate (2.875%)

Alternative plan costs used in the preliminary evaluation are based on the construction elements described in detail in Section 6: Detailed Description of Final Alternative Plans and construction costs described in detail in Section 9: Detailed Economic Evaluation of Final Alternative Plans. The net benefits of preliminary alternative plans (Table 4-7) indicate that although benefits increase at project depths deeper than -47 feet, project costs increase at a faster rate than benefits. The 47-foot plan is the NED plan, which is the plan that maximizes net benefits, because smaller plans (44-foot through 46-foot) provide negative net benefits and larger plans (48-foot and 49-foot) provide decreasing net benefits.

Table 4-7
Preliminary Alternative Plan Evaluation: Average Annual Equivalent Net Benefits

	44-foot Plan	45-foot Plan	46-foot Plan	47-foot Plan	48-foot Plan	49-foot Plan
Landside Benefits	$0	$0	$0	$166,440	$166,440	$166,440
Waterborne Benefits	$0	$0	$0	($7,948)	($7,624)	($7,313)
Total Benefits	$0	$0	$0	$158,492	$158,816	$159,127
Total Costs	$11,780	$17,670	$23,560	$29,630	$35,810	$43,279
Net Benefits	($11,780)	($17,670)	($23,560)	$128,862	$123,006	$115,848

Note: Values in thousands of FY19 dollars discounted over 50 years at the FY19 Federal discount rate (2.875%)

5 DETAILED DESCRIPTION OF FINAL ALTERNATIVE PLANS

This section describes final alternative plan to improve the Federal navigation channel from the Atlantic Ocean to Wilmington Harbor, which will be compared to the No Action Alternative (equivalent to the without-project condition). The Final Alternative Plan is the -47-foot Plan, which was the only alternative plan advanced through Preliminary Screening for more detailed analysis. Project elements for the -47-foot Plan are described below. The without-project condition (WOP) is the No Action Alternative. The evaluation of final alternative plans includes the WOP and the -47-foot Plan.

5.1 Elements of the Final Alternative Plans

The -47-foot Plan consists of the following elements:

- Dredging the Federal navigation channel;
- Dredged Material Placement; and
- Relocation of Aids to Navigation

5.1.1 Dredging the Federal Navigation Channel

Dredging the Federal navigation channel 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 of -47 ft MLLW in the river and -49 ft MLLW beginning at the Battery Island Reach and extending offshore.

The 47-ft MLLW depth evaluated for this study applies to the Federal navigation channel at 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 feet 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. 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.

Widening of channel reaches (Table 5-1) 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.

Table 5-1
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

5.1.2 Dredged Material Placement

Construction dredging material will be placed within the New Wilmington ODMDS. Dredged sediment is expected to primarily include fine- to medium-grained sand with fines from the upper channel reaches and the anchorage basin. Dredged rock is expected to be 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.

5.1.3 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.

5.1.4 Advanced Maintenance

The Wilmington District does not perform advanced maintenance of the channel and no advanced maintenance is proposed in the -47-foot plan. 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 DETAILED ECONOMIC EVALUATION OF FINAL ALTERNATIVE PLANS

The economic evaluation of alternative plans includes assessments of plan costs, benefits, and net benefits. The NED Plan I also identified as the plan that maximizes net benefits.

6.1 Alternative Plan Costs

Construction of the -47-foot plan will 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. 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.

6.1.1 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 voluntary environmental windows established by the USACE (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-Casewell 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-inh 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.

6.1.2 Construction and Investment Costs

Dredging quantities were developed based on the latest condition surveys provided by the USACE. Dates of the surveys are noted in the Engineering Appendix. Quantities include 1 Vertical to 3 Horizontal (1:3) side slopes, to match existing channel width for depths to -47 feet MLLW. Depths from -47 to -49 feet MLLW will be dredged to a 1:5 slope. Volume calculations were completed for each channel reach at 1-foot increments to inform plan formulation. AutoCAD® Civil 3D® software was used to perform the volume calculations.

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, any 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.

There are submerged utilities (water and electric cables), which cross under the channel at Baldhead Island, but they are deep enough to not require relocation. The Duke Energy overhead power lines are being raised as a part of the without-project condition to provide sufficient overhead clearance for the projected fleet (current height is 171 feet above MHHW). There have been no costs identified for inclusion in the Lands, Easements, Rights-of-way, Relocations, and Damages (LERRs) category.

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 (Engineering Sub-appendix F) 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 the equivalent of 23.7% of the dredging cost.

The project cost for the purpose of evaluating net benefits (Table 6-1) is $750,342,000. The incremental increase in annual maintenance costs is $1,155,000. The average annual equivalent cost calculated over 50 years at the 2019 Federal discount rate (2.875%) is $29,630,000. The average annual equivalent cost calculated over 50 years at a 7% discount rate is $58,330,000.

Table 6-1
47-foot and 48-foot Plan Costs (FY2019 Dollars)

Cost Item	-47-foot Plan	-48-foot Plan
Dredging	$531,120,000	$639,010,000
Aids to Navigation	$8,675,000	$8,675,000
Associated Costs (berths)	$1,450,000	$1,745,000
Interest During Construction	$25,884,000	$43,144,000
Construction Supervision & Admin	$10,800,000	$12,994,000
Preconstruction Engineering & Design	$17,965,000	$21,614,000
Contingency (23.4%)	$124,448,000	$149,730,000
Mitigation & Monitoring	$30,000,000	$30,000,000
Total	**$750,342,000**	**$906,912,000**
Incremental Maintenance Increase	$1,155,000	$1,390,000

6.2 With-Project Conditions Benefits

The projected future commodity tonnage and the projected future fleet are the same under without- and with-project conditions. The NED benefits generated by the project are the transportation cost reductions due to commodities with origins and destinations in the Port of Wilmington hinterland moving through alternative ports under without-project conditions and shifting to the Port of Wilmington under with-project conditions. Under existing conditions, the Asia cargo in question uses the Port of Wilmington. Under without-project conditions, including completion of the several channel deepening projects at USEC ports, the depth deficit at the Port of Wilmington will make it economically infeasible for the two USEC-Asia services to maintain the Port of Wilmington as a port-of-call (see Section 2: Without-Project Conditions). Under with-project conditions, channel deepening removes the depth deficit making the Port of Wilmington an economically rationale choice as a port-of-call, as it is under existing conditions (see section 4.5.1: Preliminary Alternative Plan Development).

6.2.1 Origin to Destination Transportation Cost Savings

The calculation of origin to destination transportation cost savings includes waterborne transportation costs and landside transportation costs. Total transportation cost savings are net of any increases in transportation costs, which may occur due to cargo traveling additional distances under with-project conditions. Savannah is the most likely alternative port for both the ZCP and EC2 services because Savannah comes before Charleston in the port rotation for both services and because carriers would reduce delivery times by offloading or picking up cargo at the first reasonable opportunity, which is a competitive advantage for carriers. Asia cargo with origins and destinations in the Port of Wilmington hinterland is projected to use Savannah under without-project conditions. Other potential alternatives ports, including Charleston, NC and

Norfolk, VA, are presented for reference, but all base-case benefit and net benefit calculations are based on comparisons between the Port of Wilmington and the most likely alternative port (Savannah).

6.2.1.1 Waterborne Transportation Cost Savings

Waterborne transportation costs are calculated for the Port of Wilmington hinterland cargo on the two USEC-Asia services (see Section 2.4 Commodity Projections). The cost calculations are performed without the Port of Wilmington in the port rotation (without-project condition) and with the Port of Wilmington in the port rotation (with-project condition). Waterborne transportation costs were calculated using the HarborSym model by the USACE Deep Draft Navigation Planning Center of Expertise.

The present value sum of waterborne transportation costs and the average annual equivalent values for without and with-project conditions are presented in Table 6-2. Note that transportation cost savings are negative because the cost of the additional distance traveled to the Port of Wilmington outweighs the savings afforded by more efficient vessel loading.

Table 6-2
Waterborne Transportation Cost Savings

	Without-Project	47-foot Plan	48-foot Plan
Present Value Total Cost	$3,085,752,000	$3,295,198,000	$3,286,635,000
AAEQ Total Cost	$117,098,000	$125,046,000	$124,722,000
AAEQ Savings		($7,948,000)	($7,624,000)

6.2.1.2 Landside Transportation Cost Savings

The same landside transportation costs calculations are performed for the without-project (Section 3.6 Without-Project Transportation Costs) and with-project conditions. Under without-project conditions, trucking costs are calculated for Port of Wilmington hinterland cargo using the Port of Savannah. Under with-project conditions, costs are calculated for Port of Wilmington hinterland cargo using the Port of Wilmington.

Port of Wilmington hinterland cargo includes some origins and destinations, which are closer to alternative ports, most often Charleston. This cargo has an increase in landside transportation costs under with-project conditions and is included in all landside transportation cost calculations. Table 6-3 presents weighted average landside transportation costs and distances to illustrate differences among the alternative ports.

Table 6-3
Alternative Port Distances and Costs

Evaluation Metric	Wilmington	Charleston	Savannah	Norfolk
Weighted Avg Round Trip Cost/TEU	$386.75	$602.26	$759.54	$690.70
Weighted Avg Round Trip Miles/Haul	296	508	663	595

Total truck haul miles per year (Table 6-4) are presented for selected years and for all alternative ports. Total landside transportation costs per year (Table 6-5) and associated savings are presented for selected years for the ports of Wilmington and Savannah to illustrate the source of transportation cost savings.

Table 6-4
Total Haul Miles (thousands)

Year	Wilmington	Charleston	Savannah	Norfolk
2025	14,146	24,274	31,666	28,431
2030	17,597	30,196	39,391	35,366
2035	19,909	34,164	44,567	40,014
2040	22,526	38,654	50,424	45,272
2045	25,486	43,733	57,050	51,221

Table 6-5
Landside Transportation Costs ($ thousands)

Year	Wilmington	Savannah	Savings
2025	$105,433	$207,063	$101,630
2030	$131,153	$257,576	$126,422
2035	$148,388	$291,423	$143,035
2040	$167,887	$329,719	$161,831
2045	$189,949	$373,047	$183,097

The present value sum of landside transportation costs and the average annual equivalent values under without-project conditions (alternate port = Savannah) and with-project conditions (Port of Wilmington) are presented in Table 6-6.

Table 6-6
Landside Transportation Cost Savings: With-project Conditions

	Wilmington	Savannah	Savings*
Present Value	$4,549,980,000	$8,935,830,000	$4,385,850,000
AAEQ	$172,660,000	$339,100,000	$166,440,000

*Note that these savings would accrue to all plans with project depths of -47 feet MLLW and deeper (See Section 4.5.2 Preliminary Alternative Plan Evaluation)

6.2.1.3 Total Transportation Cost Savings

Total transportation cost savings include the difference in without-project and with-project waterborne and landside costs (Table 6-7). Note that waterborne transportation costs increase marginally under with-project conditions, but in total there is a net reduction in transportation costs under with-project conditions.

Table 6-7
Total Transportation Savings (AAEQ)

	-46-foot Plan	-47-foot Plan	-48-foot Plan
Waterborne Savings	$0	($7,948,000)	($7,624,000)
Landside Savings	$0	$166,440,000	$166,440,000
Total Benefits	$0	$158,492,000	$158,816,000

6.3 Net Benefits of Alternative Plans

The net benefits of the final alternative (-47-foot plan) are presented in Table 6-8. The net benefits of the -48-foot plan are also presented to indicate that the -47-foot Plan is the NED Plan as identified in section 4.2.2 Preliminary Alternative Plan Evaluation.

Table 6-8
-47-foot Plan & -48-foot Plan AAEQ Benefits and Costs

	-47-foot Plan	-48-foot Plan
Annual Benefits	$158,492,000	$158,816,000
Annualized Project Costs	$28,470,000	$34,420,000
Annual Maintenance Costs	$1,160,000	$1,390,000
Total Annual Costs	$29,630,000	$35,810,000
Net Benefits	$128,862,000	$123,006,000
Benefit to Cost Ratio	5.4	4.4

AAEQ calculated over 50 years at the FY19 Federal discount rate of 2.875%

The -47-foot plan is the NED Plan. The incremental analysis performed during preliminary screening indicated that a lesser plan (-46 feet) would not induce the port shift for the two USEC-Asia services and therefore would generate very small benefits, which would not offset the costs of a -46-foot project. The incremental analysis also indicated that a greater plan (-48-foot plan), would generate only a small amount of waterborne transportation cost savings and no additional landside transportation cost savings. Note that the Benefit to Cost Ratio calculated at 7% is 2.6 to 1.

There are no additional increments to assess for the -47-foot Plan. The benefitting terminal is at the end of the improved section of the Federal navigation channel from the Atlantic Ocean to the Port of Wilmington and adjacent turning basin in the Lower Anchorage. Channel widening is included only as a requirement for safe navigation of the design vessel and is not a project element designed to improve vessel meeting conditions.

7 SENSITIVITY ANALYSIS

Sensitivity analyses were performed for alternative ports and for an alternative commodity forecast. In the base-case, the Port of Savannah is the alternative port for Asia cargo with origins or destinations in the Port of Wilmington's hinterland.

7.1 Alternative Port Sensitivity Analyses

The alternative port sensitivity analyses include a sensitivity analysis performed with the Port of Charleston as the alternative port (Tables 7-1 through 7-3) and a sensitivity analysis performed with 50% of the Port of Wilmington's hinterland cargo going to Savannah and 50% going to Charleston (Tables 7-4 through 7-6). Neither alternative scenario changes the NED Plan.

Table 7-1
Sensitivity Analysis 100% Charleston: Landside Transportation Cost Savings

	Wilmington	Charleston	Savings*
Present Value	$4,549,980,000	$7,085,450,000	$2,535,470,000
AAEQ	$172,660,000	$268,880,000	$96,220,000

*Note that these savings would accrue to all plans with project depths of -47 feet MLLW and deeper (See Section 4.5.2 Preliminary Alternative Plan Evaluation)

Table 7-2
Sensitivity Analysis 100% Charleston: Total Transportation Savings (AAEQ)

	-46-foot Plan	-47-foot Plan	-48-foot Plan
Waterborne Savings	$0	($7,948,000)	($7,624,000)
Landside Savings	$0	$96,220,000	$96,220,000
Total Benefits	$0	$88,272,000	$88,596,000

Table 7-3
Sensitivity Analysis 100% Charleston: -47-foot Plan & -48-foot Plan AAEQ Benefits and Costs

	-47-foot Plan	-48-foot Plan
Annual Benefits	$88,272,000	$88,596,000
Annualized Project Costs	$28,470,000	$34,420,000
Annual Maintenance Costs	$1,160,000	$1,390,000
Total Annual Costs	$29,630,000	$35,810,000
Net Benefits	$58,642,000	$52,786,000
Benefit to Cost Ratio	3.0	2.5

AAEQ calculated over 50 years at the FY19 Federal discount rate of 2.875%

Table 7-4
Sensitivity Analysis 50% Charleston/50% Savannah:
Landside Transportation Cost Savings

	Wilmington	50%SAV 50% CHL	Savings*
Present Value	$4,549,980,000	$8,010,636,000	$3,460,656,000
AAEQ	$172,660,000	$303,990,000	$131,330,000

*Note that these savings would accrue to all plans with project depths of -47 feet MLLW and deeper (See Section 4.5.2 Preliminary Alternative Plan Evaluation)

Table 7-5
Sensitivity Analysis 50% Charleston/50% Savannah:
Total Transportation Savings (AAEQ)

	-46-foot Plan	-47-foot Plan	-48-foot Plan
Waterborne Savings	$0	($7,948,000)	($7,624,000)
Landside Savings	$0	$131,330,000	$131,330,000
Total Benefits	$0	$123,382,000	$123,706,000

Table 7-6
Sensitivity Analysis 50% Charleston/50% Savannah:
-47-foot Plan & -48-foot Plan AAEQ Benefits and Costs

	-47-foot Plan	-48-foot Plan
Annual Benefits	$123,382,000	$123,706,000
Annualized Project Costs	$28,470,000	$34,420,000
Annual Maintenance Costs	$1,160,000	$1,390,000
Total Annual Costs	$29,630,000	$35,810,000
Net Benefits	$101,700,000	$95,520,000
Benefit to Cost Ratio	4.2	3.5

AAEQ calculated over 50 years at the FY19 Federal discount rate of 2.875%

7.2 Commodity Forecast Sensitivity Analyses

In the base-case, the commodity forecast is based on the most recent calendar year data (2018). Using the most recent year's data is consistent with the economic analysis that was performed for the Charleston Post-45 Study (USACE, 2015). An alternative approach would be to base the commodity forecast on an average of previous year's data, which would smooth out years with high and low commodity flows. This approach was applied to the Savannah Harbor Expansion Project Study because of the recessionary impacts to the most recent year's data at that time (USACE, 2012). For this sensitivity analysis, a five-year average (2014 – 2018) is calculated, which includes the effects of the Hanjin bankruptcy and pre-dates many of the terminal improvements constructed at the Port of Wilmington (Table 7-7). Using a five-year average as the baseline for the commodity forecast does not affect the selection of the NED Plan (Tables 7-8 through 7-10).

Table 7-7
Sensitivity Analysis Commodity Forecast Baseline:
Port of Wilmington Containerized Cargo Forecast (TEUs)

Region	Scenario	2025	2030	2035	2040	2045
Asia	Base Case	272,615	339,119	383,682	434,101	491,145
Asia	3-Year Average	237,828	295,846	334,723	378,708	428,473

Table 7-8
Sensitivity Analysis Commodity Forecast Baseline:
Landside Transportation Cost Savings

	Wilmington	Savannah	Savings*
Present Value	$3,969,380,000	$7,795,580,000	$3,826,200,000
AAEQ	$150,630,000	$295,830,000	$145,200,000

*Note that these savings would accrue to all plans with project depths of -47 feet MLLW and deeper (See Section 4.5.2 Preliminary Alternative Plan Evaluation)

Table 7-9
Sensitivity Analysis Commodity Forecast Baseline:
Total Transportation Savings (AAEQ)

	-46-foot Plan	-47-foot Plan	-48-foot Plan
Waterborne Savings	$0	($7,948,000)	($7,624,000)
Landside Savings	$0	$145,200,000	$145,200,000
Total Benefits	$0	$137,252,000	$137,576,000

Table 7-10
Sensitivity Analysis Commodity Forecast Baseline:
-47-foot Plan & -48-foot Plan AAEQ Benefits and Costs

	-47-foot Plan	-48-foot Plan
Annual Benefits	$137,252,000	$137,576,000
Annualized Project Costs	$28,470,000	$34,420,000
Annual Maintenance Costs	$1,160,000	$1,390,000
Total Annual Costs	$29,630,000	$35,810,000
Net Benefits	$115,570,000	$109,390,000
Benefit to Cost Ratio	4.6	3.8

AAEQ calculated over 50 years at the FY19 Federal discount rate of 2.875%

ATTACHMENT A: PIERS DATA ANALYSIS

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. Among the data provided by PIERS are the company name and company location (city and state), as well as the commodity being imported or exported, number of TEUs used for each shipment, vessel name, and vessel call date. Supplemental vessel manifest data and a listing of known company locations was provided by the Port for additional reference.

Geographic Distribution of Cargo

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 names and locations from the PIERS database can be grouped into four categories:

- Obfuscated;
- Third party logistics;
- Mappable; and
- Unmappable.

Obfuscated

Many records within the PIERS database use the company name “ORDER”, “TO ORDER”, or “NOT SPECIFIED”. Cargo using these company names were not mapped.

Third Party Logistics (3PL)

Many cargo shipments are managed by companies providing third party logistics, brokerage, supplier, or freight forwarding services. The location information pertaining to those shipments reflect national or regional coordinating office headquarters for these companies rather than the origin or destination of the referenced commodities. These companies were identified by reviewing company names and associated websites. The location associated with these shipments was deemed indeterminate and the cargo locations were excluded from geographic analysis.

For example, Contamar Shipping, headquartered in New York, NY exported over 660 TEUs of goods through the Port of Wilmington during 2017 and 2018. The actual domestic origin of these goods can not be determined through this dataset.

Mapped

Company locations in North Carolina, but not associated with an obfuscated 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. Since the city and state provided 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, 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 a was used.

For example, the furniture company Intercon, with location description of Salt Lake City, UT, imported over 54 TEUs through the Port in 2017; however, a review of the company website reveals that although corporate headquarters are in Salt Lake City, UT, a regional domestic warehouse is located in Lexington, NC. This revised location was used in subsequent analyses.

In contrast, 2H Manufacturing & Distribution Corp., manufacturers of absorbent pads for the healthcare industry, has facilities in China and an office in Irvine, CA. The company has imported a total of over 450 TEUs of product through the Port of Wilmington in 2017 and 2018. The PIERS database references the Irvine, CA office as the company location. Despite the incredulity of the domestic destination being in California, since no other facility, warehouse, distribution center, or business partner could be found, the Irvine, CA company location was used for mapping purposes.

Unmapped

Some companies and locations were unable to be identified mapped with the information provided in the PIERS database. Some locations were incomplete, containing typographical errors, or reference locations outside of the United States. These cargo locations were excluded from the geographic analysis.

For example, the company "HANGZHOU XINYI GARMENTS" imported a total of 22 TEUs containing "GENERAL CARGO, MISC". The city and state associated with these shipments is "HANGZHOU" and "ZZ", respectively. Internet resource searches were unable to determine a location for this company within the United States, and as such, it was unmapped.

Company Location Corrections

As shown in Table A-1, 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 unique companies, 591 were identified as obfuscated or 3PL and the associated 1,138 company locations were excluded from mapping. The PIERS data provided identified 2,001 companies with locations within North Carolina and 3,505 company locations outside of North Carolina.

Table A-1
Company Locations in the PIERS Database

	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 A-2). 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 A-2: PIERS Database Company Locations Outside North Carolina

	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%	

Table A-3 provides a summary of the number of PIERS database records and TEUs within each category.

Table A-3
Mapping Status of PIERS Database Records and TEUs

		2017		2018					
		Import	Export	Import	Export	Total	2017	2018	Total
Records	ORDER	6,014	847	9,236	1,185	17,282	18.3%	21.4%	20.0%
Records	3PL	846	3,503	1,181	3,095	8,625	11.6%	8.8%	10.0%
Records	Mapped	16,880	8,865	25,153	8,362	59,260	68.5%	68.9%	68.7%
Records	Unmapped	505	110	405	58	1,078	1.6%	1.0%	1.2%
TEUs	ORDER	24,723	11,862	36,799	12,550	85,935	20.4%	24.1%	22.4%
TEUs	3PL	1,453	19,012	2,171	15,531	38,166	11.4%	8.6%	9.9%
TEUs	Mapped	48,405	69,588	72,679	64,216	254,887	65.9%	66.8%	66.4%
TEUs	Unmapped	999	3,065	628	237	4,928	2.3%	0.4%	1.3%

Company Point Locations

Comparison of hinterland transportation distances from potentially competing ports required the determination of the latitude and longitude of the geographic point location for each city identified in the PIERS dataset. This process was accomplished by importing the data into geographic information system software (using ArcGIS 10.4.1) and geographically locating the listed location through the process of geocoding. A GIS database of the point locations for over 100,000 communities in the U.S. and Canada was used as the geocoding geographic reference data.

Port Locations

The location of the U.S. east coast deep-draft ports was determined manually with the use of aerial photography. Point locations at the container terminals for ports at Wilmington, NC, Norfolk, VA, Charleston, SC, and Savannah, GA were created in GIS.

Port-City Matrix

To facilitate the calculation of truck routing travel distances between each port and location in the PIERS data, a table was populated containing the port name, latitude, and longitude, as well as the city, latitude, and longitude for each port-city pairing – a total over 4,600 truck routes.

Routing

Routing of commodity flow via truck was conducted using the 2013 edition of StreetMap North America, as provided in Data & Maps for ArcGIS 10.2. This street network dataset represents streets, highways, freeways, motorways, major roads, secondary roads, local and connecting roads, back roads, roads with special characteristics, access ramps, and service roads within the United States and Canada. This dataset contains road network features such as functional road classifications, blocked passages, overpass and underpass (Z-level) information, toll roads, speeds, access restrictions, lane information, and direction of travel. Using the port-city matrix table, route paths were calculated from each of the comparison ports and the Port of Wilmington to the point location for each city. The route path calculated balanced the use of interstate roads and highway roads, as is typical for freight hauling.

Route calculation was processed using custom ArcObjects code written in Visual Basic for Applications by accessing the SMRouter object in ArcGIS 10.4.1 and using the `streets.rs` router dataset provided with StreetMap North America. The port latitude and longitude values were provided as the starting point and city latitude and longitude were provided as the ending point. A highway priority preference was chosen at 45 from a potential value domain of 0.0 to 100.0. The value of 45 was selected after iterating through various test values used to calculate a route between Wilmington and Charlotte and comparing the route selected by the algorithm to the route typically taken by trucks. Route optimization was set to preserve total travel time rather than total travel distance. Output values for travel distance, time, and geometry were generated. It is assumed that the return trip distance from the city to the port is the same as the distance traveled from the port to the city.

The one-way travel distance from the port to city for each deep-draft port and the Port of Wilmington was associated with each city, as well as the identification of the closest deep-draft port to each city. This table was imported into SQL Server for data integration and further analysis.

Routing Sensitivity Analysis

Since the actual path taken by trucking companies is unknown, the truck route path found by the routing algorithm may not represent the actual path traveled. The route optimization in the above analysis was configured to preserve total travel time; however, this may not represent the decisions made by a trucking company. To assess the sensitivity of the economic analysis to the routing algorithm, a second set of trucking routes were calculated using the route optimization of preserving total travel distance rather than time.

As an example, Figure A-1 depicts the different routes calculated for traveling from Wilmington to Greensboro. The time-optimized route (blue) portrays a driving distance of 211 miles and travel time of 3 hours and 27 minutes. In contrast, the distance-optimized route (red) depicts a driving distance of 181 miles and a travel time of 5 hours and 17 minutes.

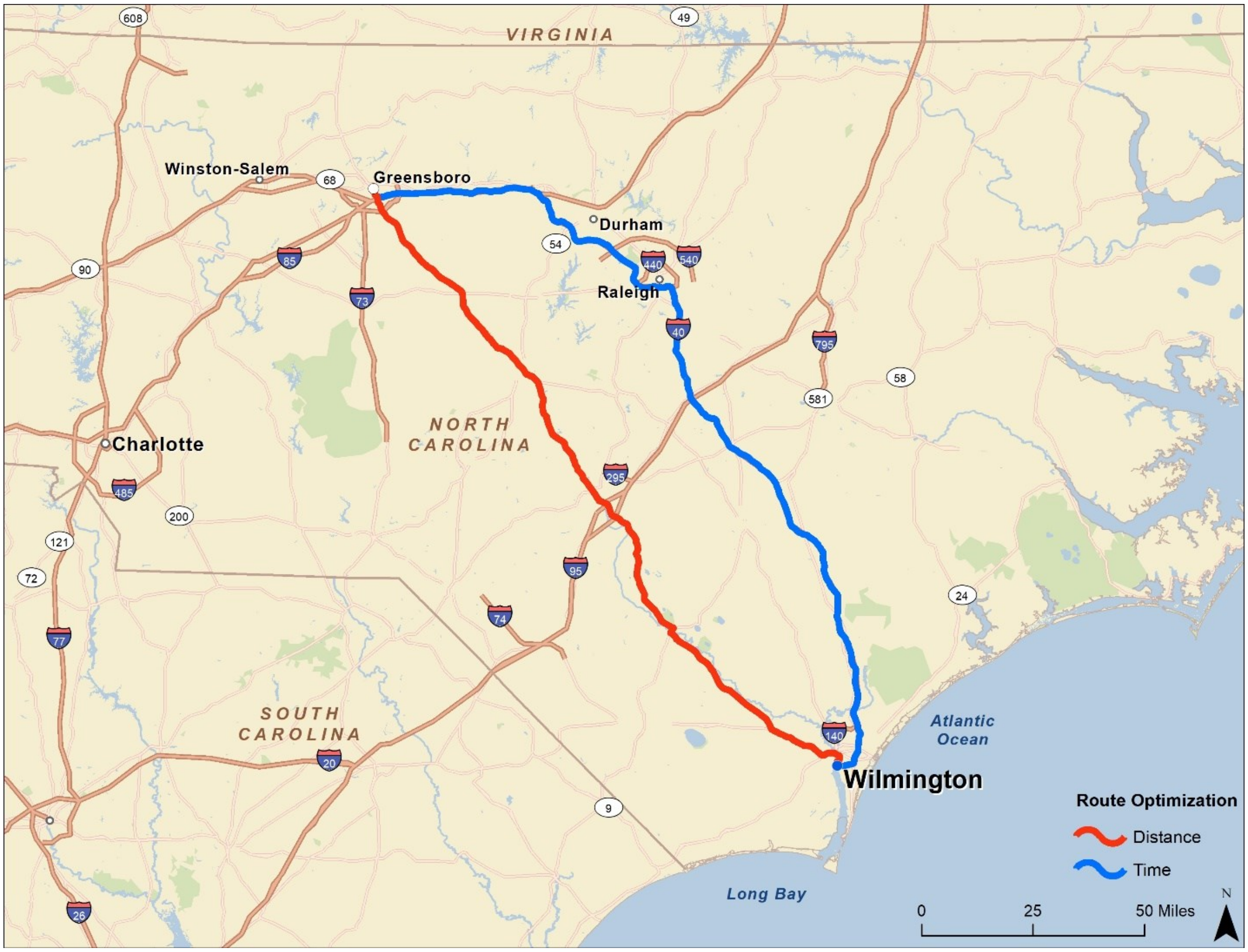

Figure A-1
Sensitivity Analysis Routes from Wilmington to Greensboro, North Carolina

Cargo Distribution

The landside geographic distribution of cargoes transiting through the Port of Wilmington was assessed by distributing all TEUs associated with mapped company locations. 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 (Fig. A-2). Table A-4 shows the geographic distribution of TEUs within these regions and those outside of North Carolina.

Table A-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%**

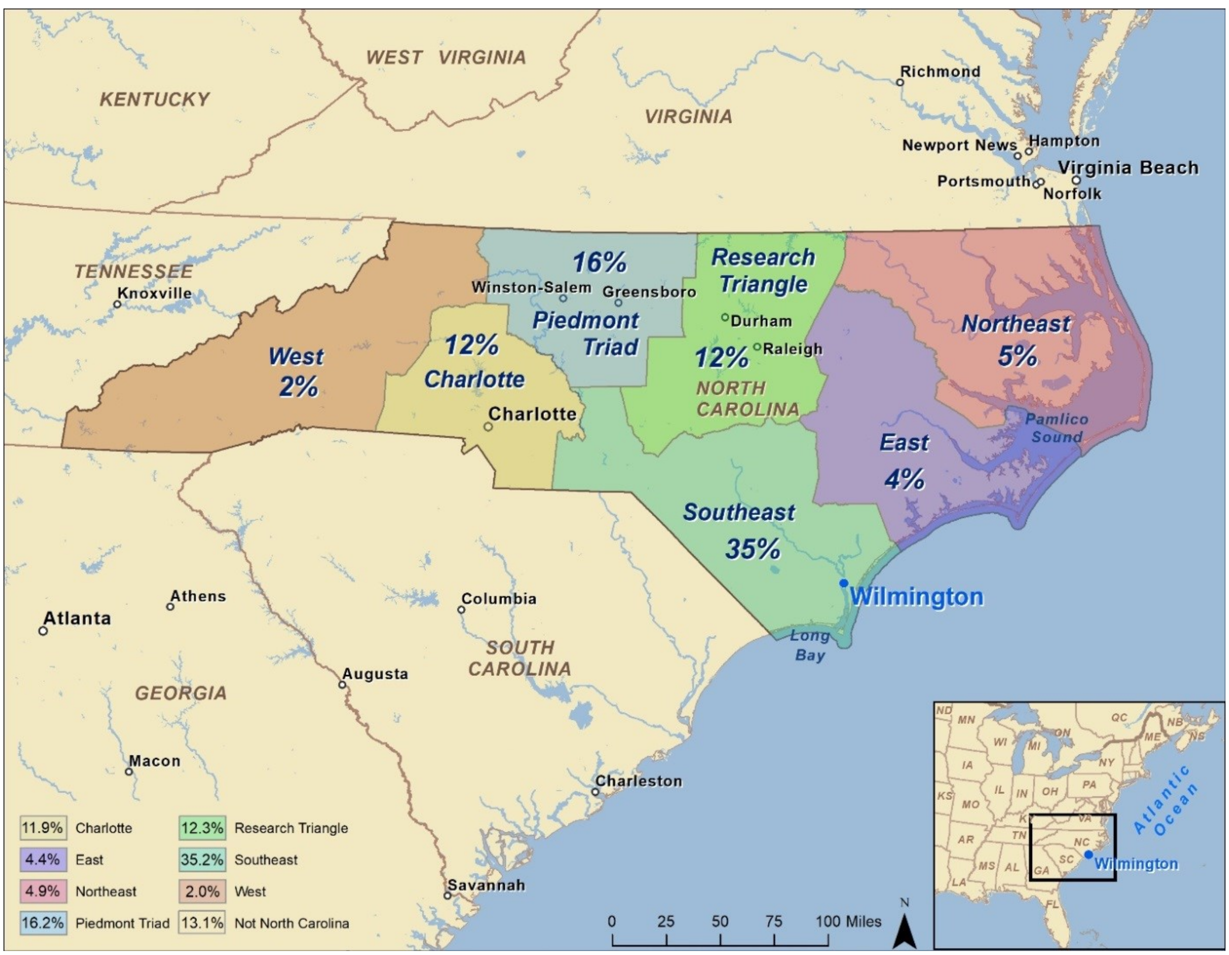

Figure A-2
Geographic Distribution of TEUs Transiting the Port of Wilmington

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 imported to or exported from North Carolina.

Given this geographic distribution of cargo, it is reasonable to assume that the remaining 129,029 unmapped TEUs (either obfuscated, 3PL, or unmappable) follow a similar pattern.

ATTACHMENT B: TRUCKING COST MODEL

Trucking Costs

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 Companies

Requests for trucking quotes were sent to six trucking companies providing services from the Port of Wilmington and other ports in the region. Four companies responded with quotes from each port to each of the destination cities and one company responded with quotes only from Wilmington to cities in North Carolina and South Carolina. Each trucking company also provided their fuel service charge, which is included in the total trucking cost. Table B-1 depicts which surveyed trucking companies provided quotes for the destination cities.

Table B-1
Surveyed Trucking Companies and Destination City Responses

City	XPO	A.R.C. Transit	W & B	Service Transfer	Robin Hood
Fayetteville, NC	X	X	X	X	X
Raleigh, NC	X	X	X	X	X
Columbia, SC	X	X	X	X	X
Charlotte, NC	X	X	X	X	X
Winston-Salem, NC	X	X	X	X	X
Greenville, SC	X	X	X	X	X
Nashville, TN	X	X		X	X
Cleveland, OH	X	X		X	X
Chicago, IL	X	X		X	X

Hinterland Transportation Analysis

The economic viability of a deeper channel and berths at the Port of Wilmington was determined by assessing the competitive advantage of land-side transportation of freight via truck to and from the hinterland of the United States through the Port of Wilmington and other deep-draft ports on the U.S. east coast including Norfolk, VA, Charleston, SC, and Savannah, GA.

Port Locations

The location of the U.S. east coast deep-draft ports was determined manually with the use of aerial photography. Point locations at the container terminals for ports at Wilmington, NC, Norfolk, VA, Charleston, SC, and Savannah, GA were created in GIS.

Port-City Matrix

To facilitate the calculation of truck routing travel distances between each port and each destination city, a table was populated containing the port name, latitude, and longitude, as well as the destination city name, latitude, and longitude for each port-city pairing – a total of 36 truck routes. The destination location within the city was determined using the population-weighted mean center of the city.

Routing

Routing of commodity flow via truck was conducted using the 2013 edition of StreetMap North America, as provided in Data & Maps for ArcGIS. This street network dataset represents streets, highways, freeways, motorways, major roads, secondary roads, local and connecting roads, back roads, roads with special characteristics, access ramps, and service roads within the United States and Canada. This dataset contains road network features such as functional road classifications, blocked passages, overpass and underpass (Z-level) information, toll roads, speeds, access restrictions, lane information, and direction of travel. Using the port-city matrix table, route paths were calculated from each of the ports to the point location for destination city. The route path calculated prioritized the use of interstate and highway roads, as is typical for freight hauling. Routing and costs are round- trip because the chassis must be returned to the port, whether it's carrying a box or not.

To establish a reasonably proper setting for the prioritization of interstate and highway use, the route paths between Wilmington, NC and Charlotte, NC were calculated using a variety of highway priority values and compared to the likely route to be taken, as informed by Port of Wilmington staff. Highway priority values of 50 or greater routed through Raleigh and Greensboro, whereas routes using highway priority values less than 40 used a more direct route utilizing local roads. A highway priority value of 45 was found to best represent the typical driving path. Figure B-1 depicts the calculated path between Wilmington and Charlotte, NC at varying highway priority values.

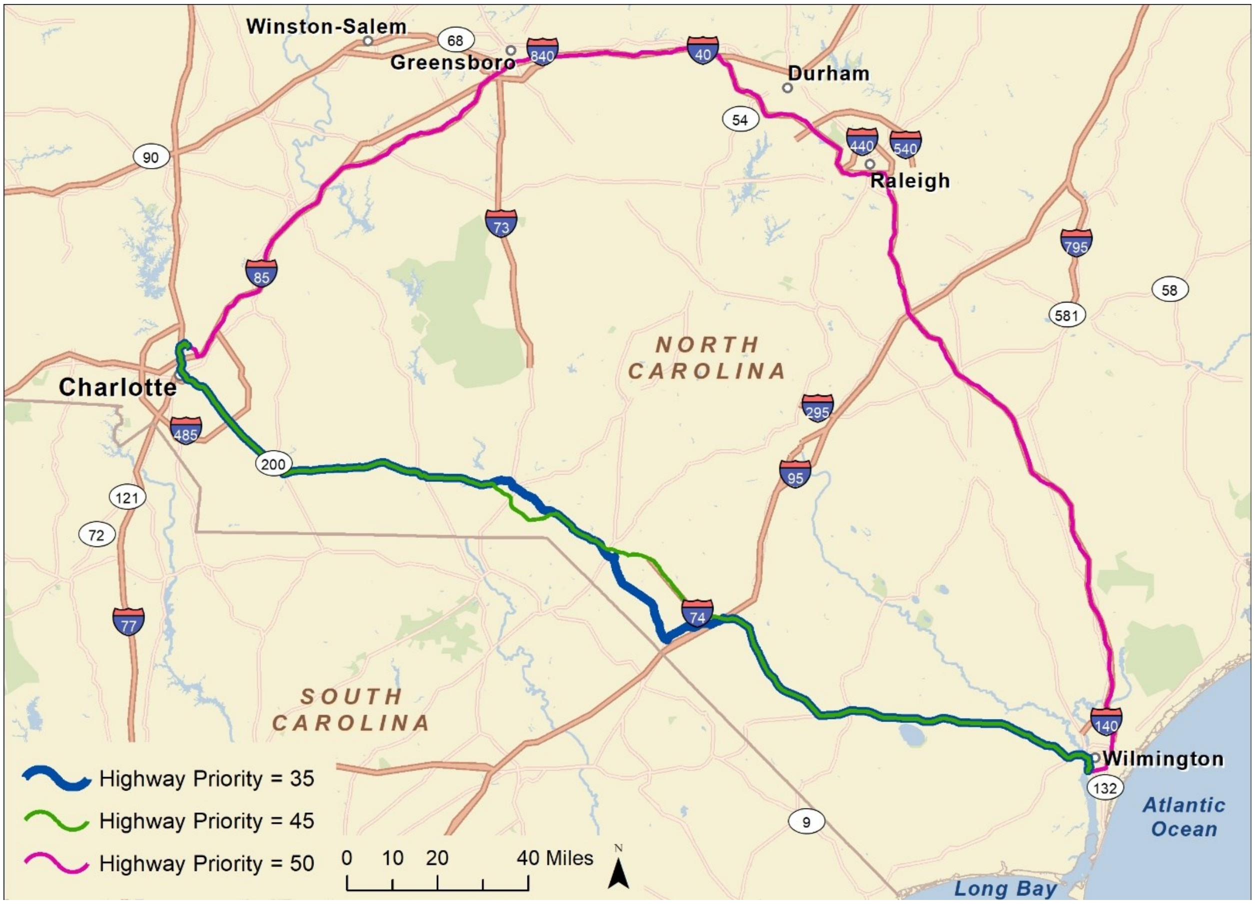

Figure B-1
Calculated Routing Paths Between Wilmington and Charlotte, NC

Route calculation was processed using custom ArcObjects code written in Visual Basic for Applications by accessing the SMRouter object in ArcGIS 10.4.1 and using the streets.rs router dataset provided with StreetMap North America. The port latitude and longitude values were provided as the starting point and city latitude and longitude were provided as the ending point. A highway priority preference was chosen at 45 from a potential value domain of 0.0 to 100.0. 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. Table B-2 shows the round trip distance between each sampled port and destination city, as calculated from the GIS routing calculation.

Table B-2
Round Trip Distances Between Ports and Cities

	Round Trip Port Distance (mi)			
City	**Wilmington**	**Norfolk**	**Charleston**	**Savannah**
Fayetteville, NC	196	454	432	524
Raleigh, NC	284	390	572	666
Columbia, SC	396	778	224	318
Charlotte, NC	416	648	428	520
Winston-Salem, NC	450	508	596	688
Greenville, SC	574	854	404	496
Nashville, TN	1278	1412	1108	974
Cleveland, OH	1376	1080	1412	1506
Chicago, IL	2008	1794	1842	1934

Data Analysis

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.

Graphical analysis of trucking quotes as depicted in Figures B-2 and B-3 reveals an initial cost of $70.13 to initiate a trip and an expected decrease in trip rate with increased distance traveled. Typical trucking costs were calculated using the linear interpolation depicted in Figure B-2 and are shown in Table B-3. Anticipated costs to any city in the hinterland could be similarly calculated.

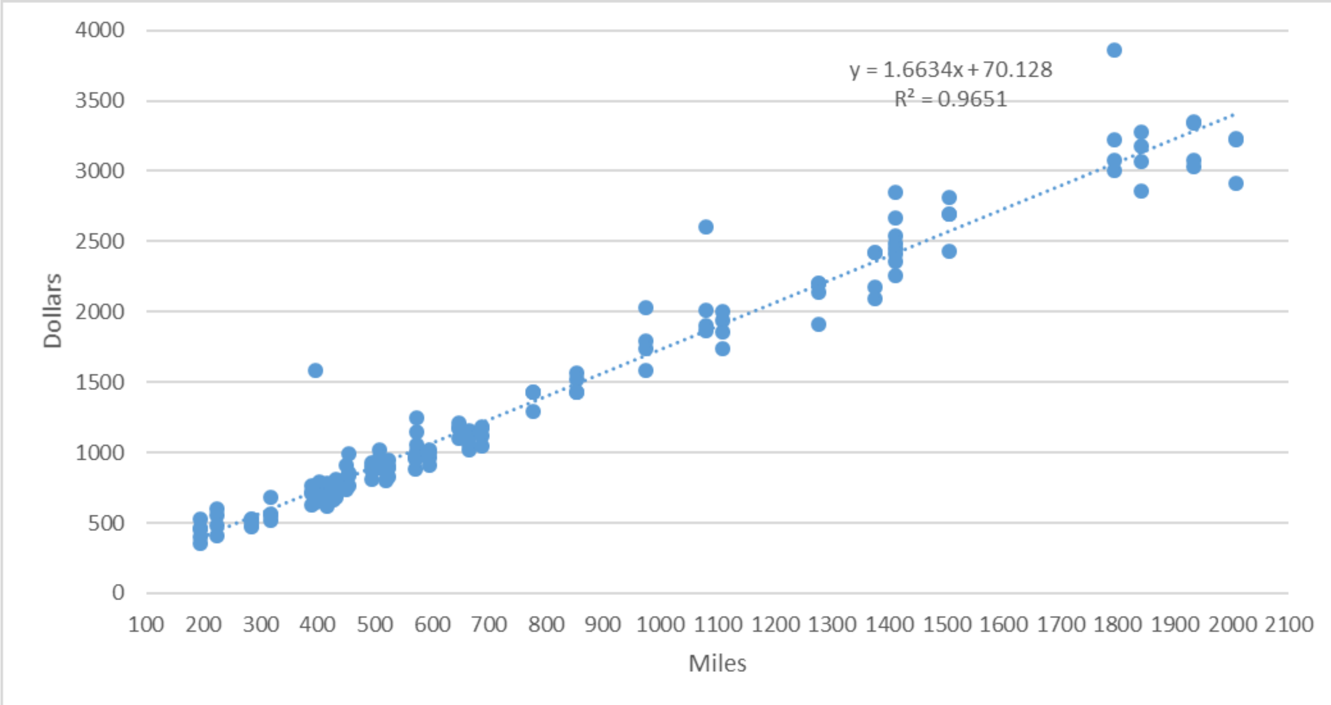

Figure B-2
Trucking Costs by Miles Driven

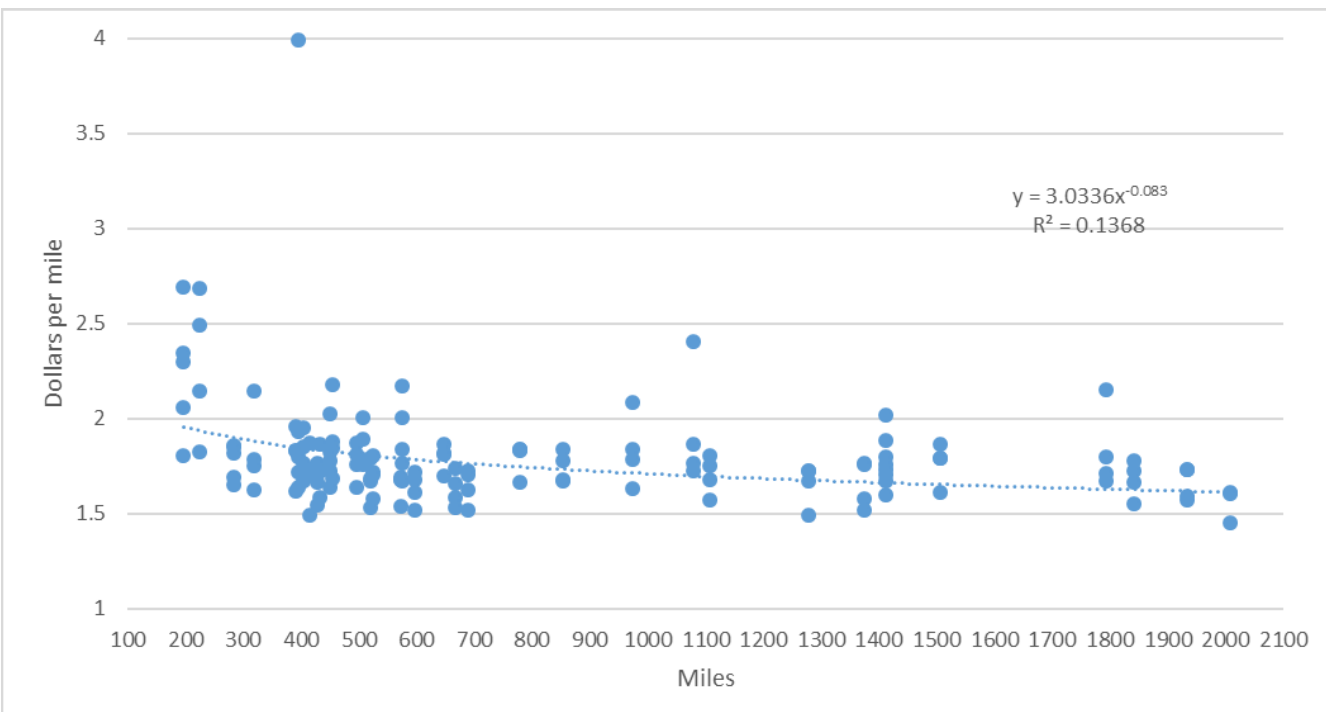

Figure B-3
Trucking Rates (dollars per mile) by Miles Driven

Table B-3
Trucking Costs Estimated by Linear Interpolation of Sampled Quotes

City	Linear Interpolated Costs (dollars)			
	Wilmington	Norfolk	Charleston	Savannah
Fayetteville, NC	396	825	789	942
Raleigh, NC	543	719	1022	1178
Columbia, SC	729	1364	443	599
Charlotte, NC	762	1148	782	935
Winston-Salem, NC	819	915	1062	1215
Greenville, SC	1025	1491	742	895
Nashville, TN	2196	2419	1913	1690
Cleveland, OH	2359	1867	2419	2575
Chicago, IL	3410	3054	3134	3287

Excel Workbook

Data in the workbook "TruckingCosts.xlsx" is organized such that trucking quotes from each company are provided in green tabs with each trucking company's name as the tab name, distances from ports to cities are provided in the white tab named Miles, and yellow summary tabs named Summary and Interpolation provide the analysis of those quotes and subsequent interpolated costs based on the analysis, respectively.

Apart from W & B Trucking, each trucking company provided the full array of port-to-city quotes (B2:E10). In addition, current fuel service costs (found in row 12) were provided. Some fuel service costs vary by port and all values were general estimates due to variability in market rates.

The Miles tab contains distances from port to the destination city as calculated through GIS routing, as described above.

The Summary tab contains the aggregation of all data sources and the calculations of total trip costs. Rows 1 through 11 contain references to relevant distances and quotes for each trucking company from each port to each destination city. Listed in column A are the various destination cities for which distances and quotes are referenced in columns B through AB. Columns B:H refer to distance and price quotes for Wilmington (white background), columns I:O provide references to distance and price quotes for Norfolk (yellow background), columns P:V provide references to distance and price quotes for Charleston (blue background), and columns W:AB provide references to distance and price quotes for Savannah (green background).

Calculations of total costs (cost + fuel service charge) and cost rate (dollars per mile) for each port-city combination are provided in rows 14 through 59, with colored headings representing the associated port. The fuel service cost is embedded in the formula as referenced by source data tab. Note that calculations from W & B are in grey for those destinations without quotes.

Rows 62 through 242 are used to format the calculations of total cost and dollars per mile for graphical display. Columns B, C and D contain references to the calculations in rows 14 through 59, including those from W&B that result in to no value. To accommodate sorting and filtering, these values are repeated (using copy/paste values) in columns E, F and G. These values are formatted as a table and filtered to remove empty values. Furthermore, the distance has been sorted in increasing distance.