NORTH CAROLINA PORTS

Wilmington Harbor, North Carolina
Navigation Improvement Project

Integrated
Section 203 Study
&
Environmental Report

APPENDIX C

ECONOMICS

February 2020

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1 INTRODUCTION

This Economics Appendix is a component of the Integrated Section 203 Feasibility and Environmental Study 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 the integrated report is economically justified, technically feasible, consistent with protecting the nation's environment, and is publicly acceptable. The Certification of Independent Review by Larry Prather (former Assistant Director of Civil Works (Legislation and Planning), USACE and Chief, Navigation Planning Branch, USACE) and letters supporting projected future without-project conditions from six carriers are appended to this document.

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. 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

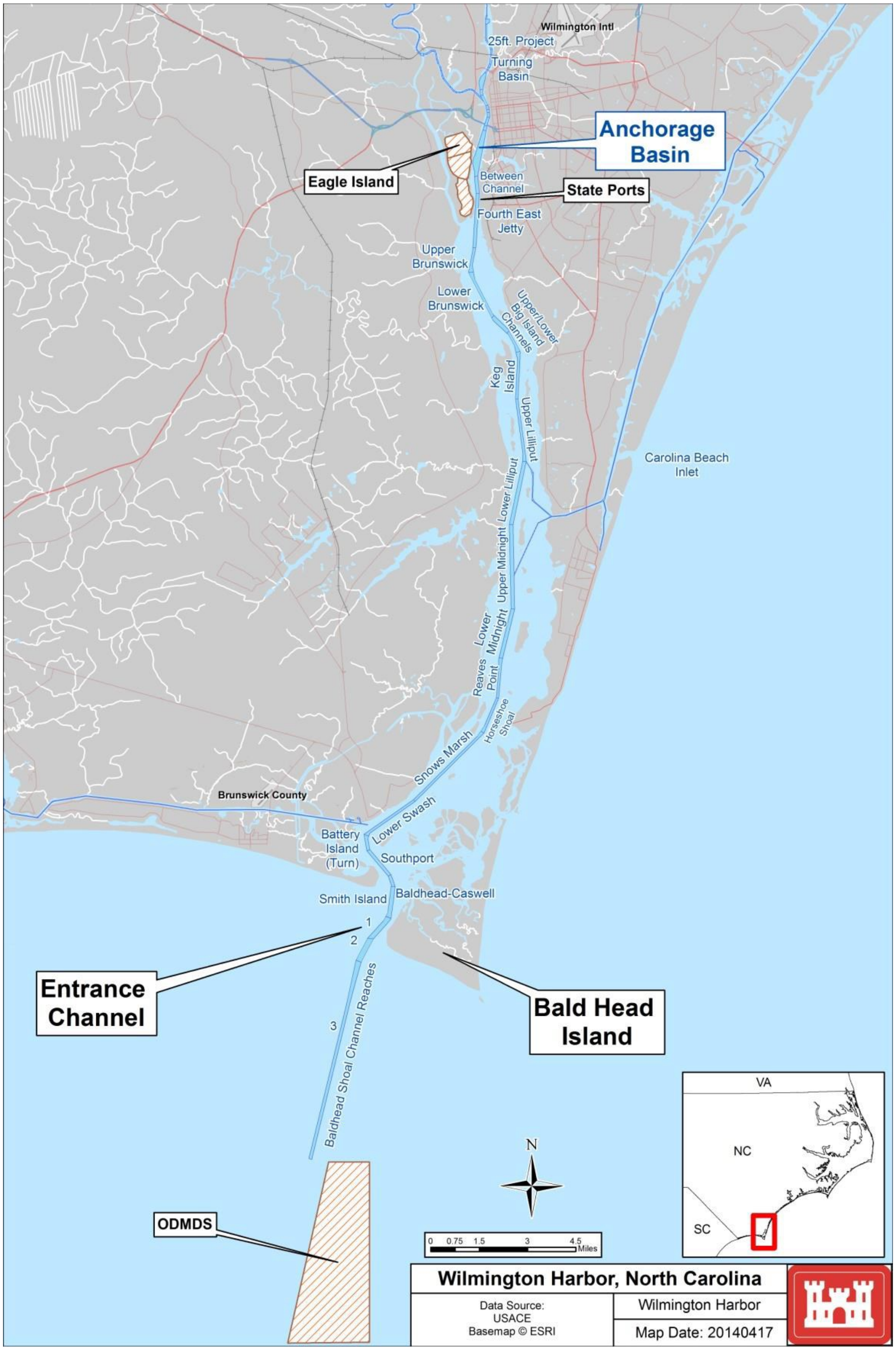

Figure 1-1
Wilmington Harbor Federal Navigation Project

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 2019 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.

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

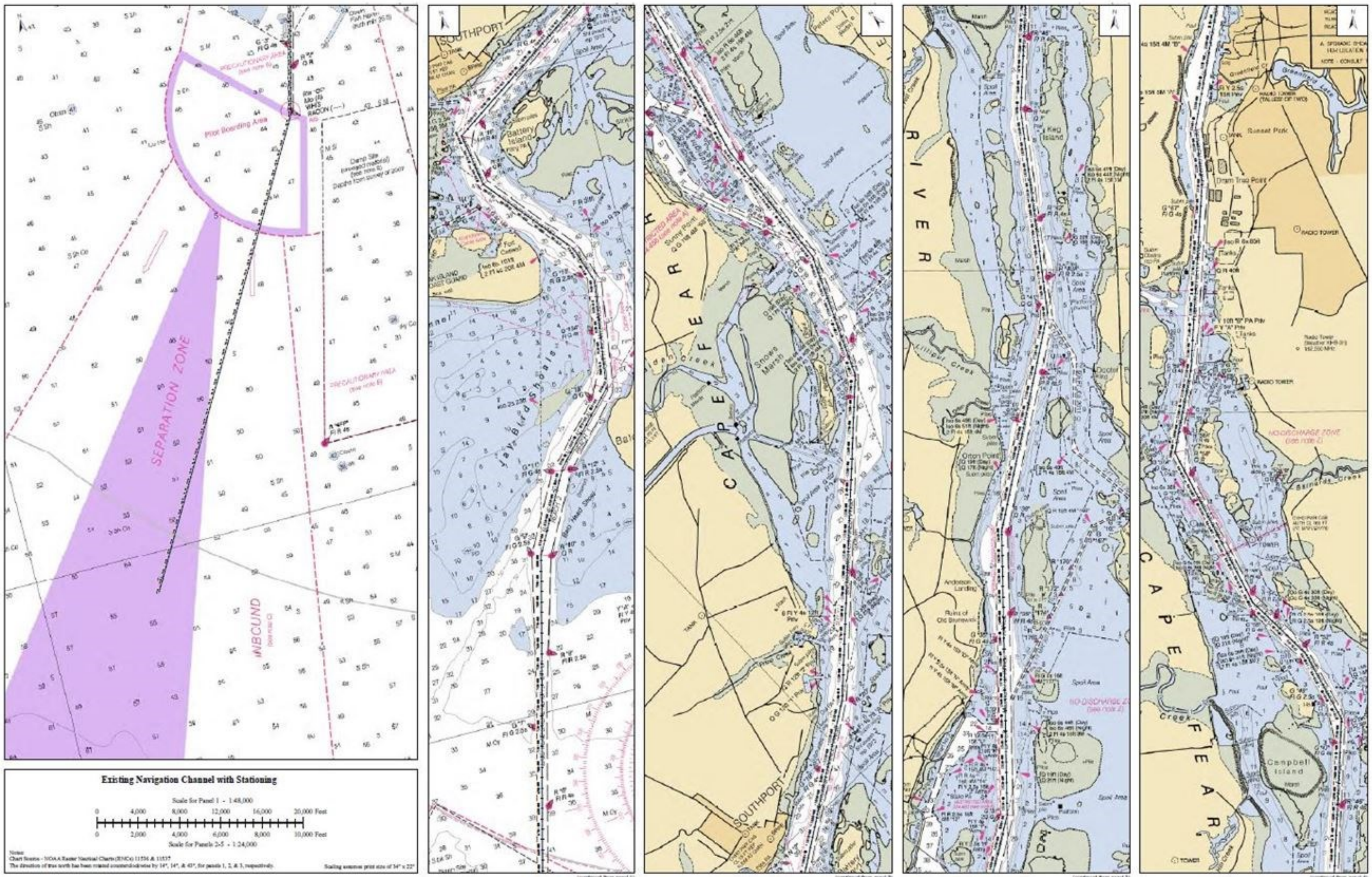

Figure 1-2
NOAA Nautical Chart number 11537

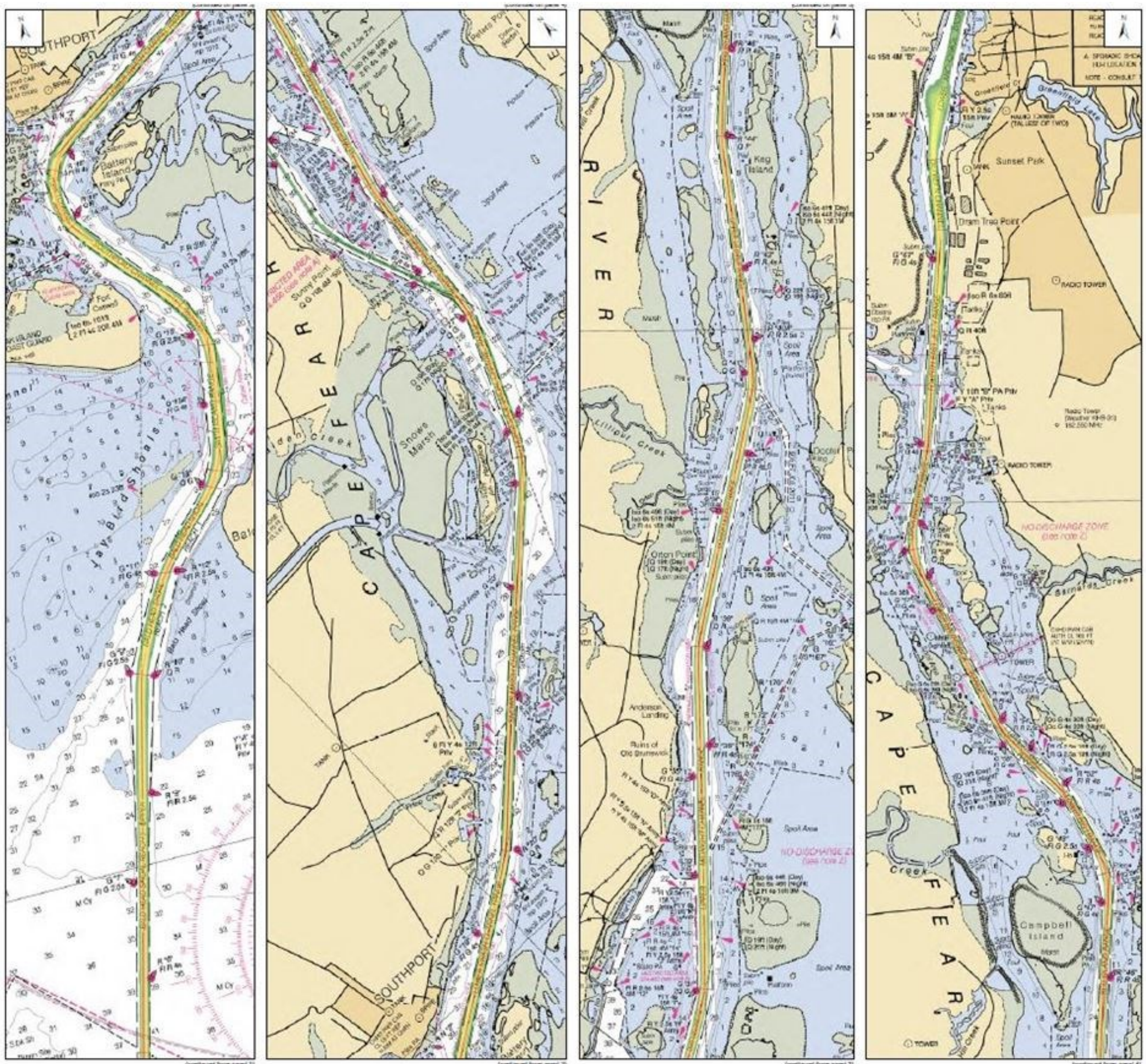

Figure 1-3
Continuation of NOAA Nautical Chart number 11537

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 210 feet above MHHW due to electric cable crossing.

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

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

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

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

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 permanently use Port of Wilmington Berth 1.

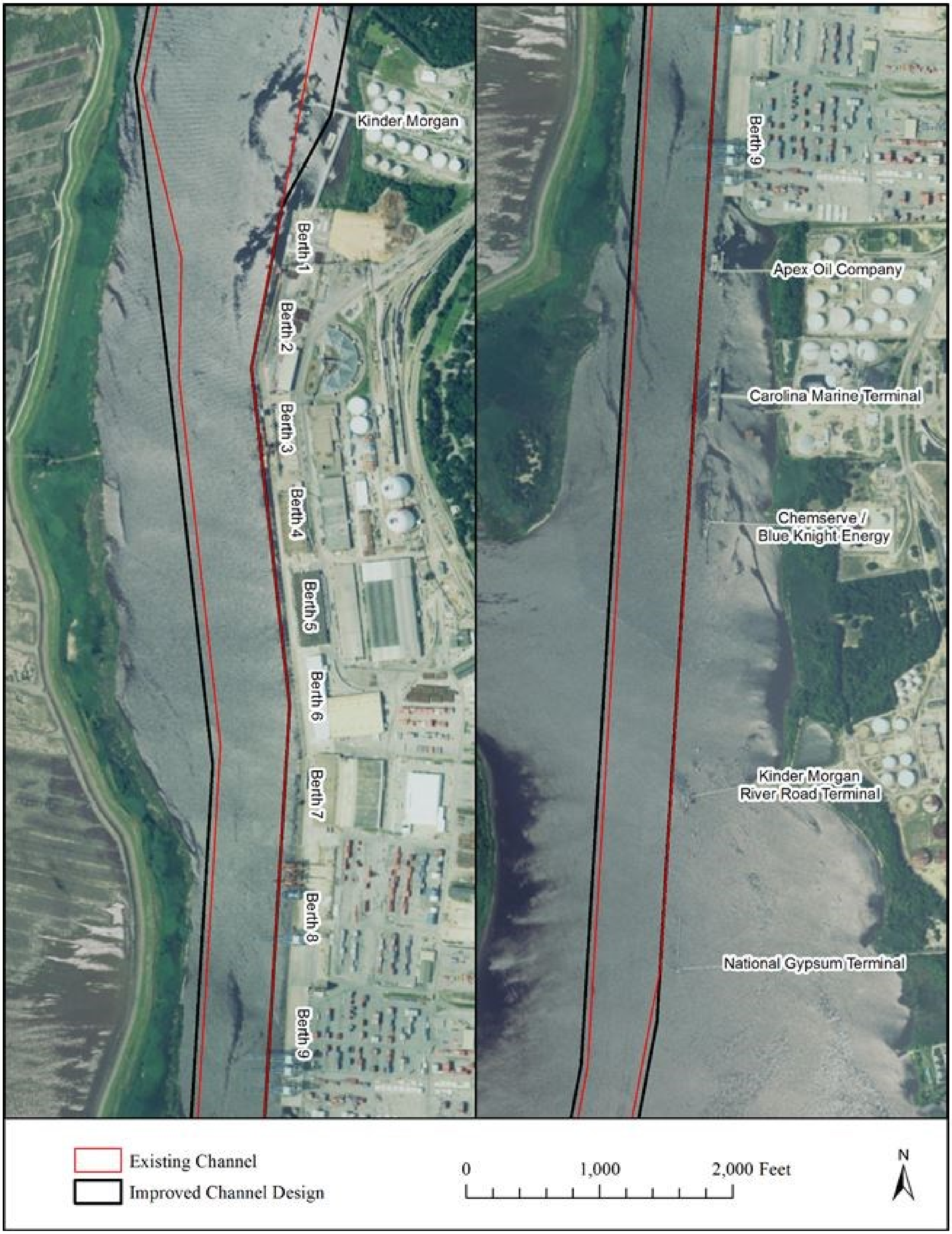

Figure 1-4
Identification of Terminals

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

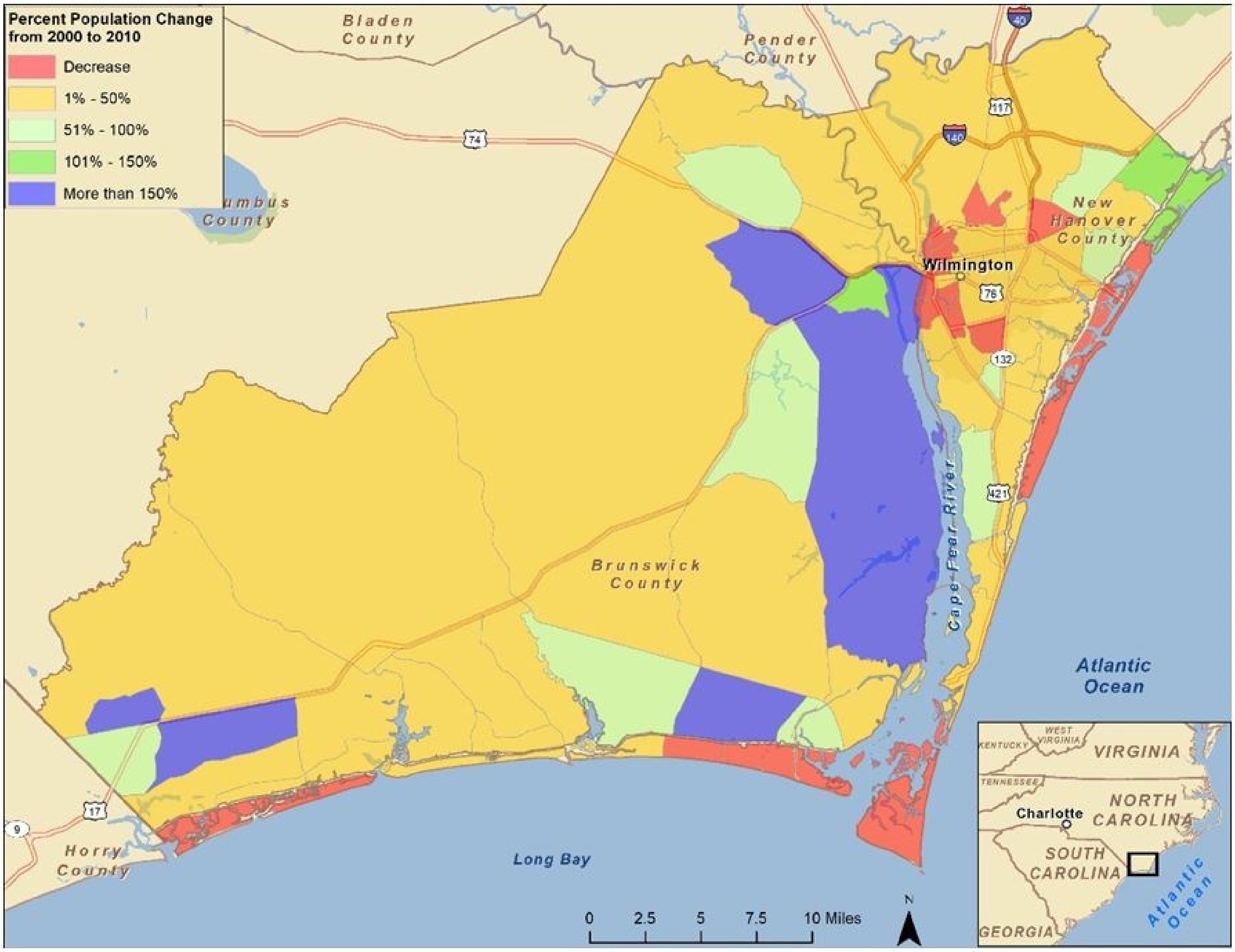

Figure 1-6
Percent Population Change from 2000 to 2010
in Brunswick and New Hanover Counties by Census Tract

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.

[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 associated 1,138 company locations were excluded from mapping. The PIERS data identified

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

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%**

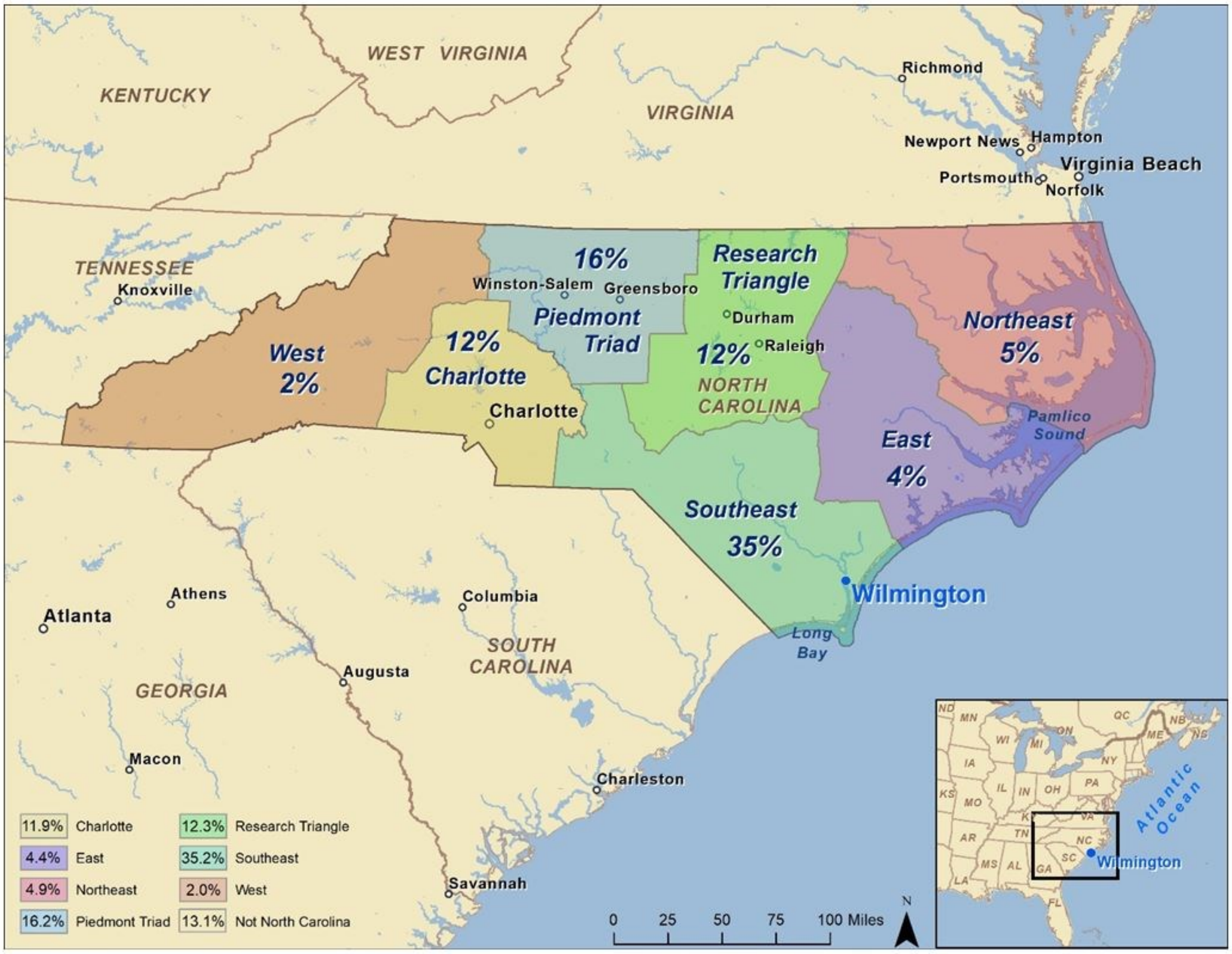

Figure 1-7
Geographic Distribution of TEUs Transiting the Port of Wilmington

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 are 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.

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.

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

Bulk and breakbulk cargo operations at the Port of Wilmington are not typically constrained by existing channel conditions as indicated by Table 1-9. Port of Wilmington bulk and breakbulk data (Tables 1-13 and 1-14) indicate no historic growth trend in tonnage observed in recent years, with the exception of wood pellets which are carried on vessels with design drafts in the 36 to 40-foot range (wood pellet fleet is not constrained under existing). It is also important to note that many bulk shipments are partial loads for which Wilmington channel depth does not constrain vessel loading. For example, the average size shipment (FY 2019) of UAN was19,962 short tons, of fertilizers was 9,696 short tons, of chemicals was 11,379 short tons, and cement was 8,063 short tons.

Table 1-13
Port of Wilmington Breakbulk Commodities NCSPA FY 2013 – 2019 Short Tons

Commodity	2013	2014	2015	2016	2017	2018	2019
Forest Products	40,189	22,427	31.238	35,559	1,902	5,911	8,076
Metal Products	92,021	75,427	102,260	136,100	200,518	73,020	67,690
Other/Military	23,084	22,819	17,846	12,632	8,462	24,252	25,025
Fertilizer (Bag)	1,764	8,415	3,323	3,193	1,911	567	2,324
Wood Pulp	167,114	142,606	124,657	136,472	151,903	95,896	69,408
Cement (Bag)	0	0	0	0	0	0	36,103
Breakbulk Total	**324,172**	**271,731**	**279,324**	**323,955**	**364,697**	**195,089**	**213,189**

Table 1-14
Port of Wilmington Bulk Commodities NCSPA FY 2013 – 2019 Short Tons

Commodity	2013	2014	2015	2016	2017	2018	2019
UAN	268,994	209,099	186,506	185,739	213,361	127,183	139,734
DRI & Ores	99,144	36,214	99,462	0	0	0	0
Fertilizers	173,223	184,360	150,628	89,015	77,148	93,527	155,134
Feed/Ag	1,539,392	602,822	218,751	656,961	327,110	217,932	0
Chemicals	505.263	429,831	565,014	470,286	528,010	621,340	523,418
Wood Fiber/Chips	323,346	214,373	496,930	315,458	227,898	293,799	47,521
Cement	37,759	0	0	0	0	22,533	8,063
Wood Pellets	0	0	0	0	269,452	941,213	843,746
Dolomite	0	0	118,837	0	60,395	91,025	93,196
Zircon Sand	0	0	12,890	7,121	0	0	0
Tire Chips	0	0	10,150	0	0	0	0
HBI	0	0	12,133	19,648	78,815	0	0
Bulk Total	**2,947,121**	**1,676,698**	**1,871,301**	**1,774,227**	**1,782,189**	**2,408,552**	**1,810,812**

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 1-15) due to the increased capacity of vessels calling at the port (see 1-24).

Table 1-15
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 1-16) used by the DDNPCX in the Norfolk Harbor Channel Deepening Study (USACE 2018). The Panamax reference used in the DDNPCX classification is the maximum vessel size of vessels accommodated by the old locks at the Panama Canal. The Post-Panamax designation refers to all vessels larger than Panamax vessels. The Panama Canal size 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 1-16
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 1-17) indicate that the larger vessels in the fleet are also the newest vessels. Note that the table includes 85% average TEU capacity to illustrate operation capacity for loaded containers accounting for empty containers, empty slots, and other non-cargo factors affecting total tonnage on the vessel. The progression of

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

increase in vessel size since 1995 (Table 1-18) 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 1-19). When these new build vessels are added to the world fleet (2 to 3 years), and assuming no scrapping of older vessels, the two largest vessel classes will account for 46% of the fleet's TEU capacity (Table 1-20). Currently, the average age of vessels in the PPX3Max and PPX4 classes are 6 year and 3 years, respectively.

Table 1-17
Existing World Container Ship Fleet Characteristics

Class	Number of Vessels	Average Year Built	Average Maximum Draft	Average TEU Capacity	85% Average TEU Capacity
PX	549	2007	42	4,466	3,796
PPX1	399	2005	45	6,041	5,135
PPX2	325	2008	46	7,938	6,747
PPX3	282	2013	47	9,362	7,958
PPX3Max	275	2013	50	12,725	10,817
PPX4	163	2016	51	17,400	14,790

Source: www.Lloydslistintelligence.com accessed 01Jan2019

Table 1-18
Average Vessel Characteristics by Year Built

Year Built	Average TEU Capacity	Average Maximum 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 1-19
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 1-20
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 1-21 through 1-23). 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 1-21
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 1-22
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 1-23
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 1-21 through 1-23.

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 1-21 through 1-23.

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 1-24). However, these larger vessels cannot operate to their full efficiency at Wilmington, due to existing channel constraints.

[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.

Table 1-24
Vessel Class Distribution for Container Ships Asia Services Calling at the Port of Wilmington

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

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

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

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

The result of the changes that began in 2018 can be seen in the vessel size distribution for the Port of Wilmington in 2020. The 2020 data is based on vessel schedules published on the Zim and ONE websites for vessel calls from January 2020 through April 2020. The schedules include vessels from members of the two alliances (THE and 2M). Vessels in the current schedule for the EC2 service range in TEU capacity from 9,978 TEUs to 10,100 TEUs, with an average capacity of 10,070 TEUs. Vessels on the current schedule for the ZCP service range in TEU capacity from 9,178 TEUs to 11,010 TEUS, with an average capacity of 10,286 TEUs. On January 1, 2020 the THE Alliance announced that it will transitions the EC2 service into vessels with 13,100 TEU capacity starting in April 2020. The ports-of-call for the two USEC-Asia services calling at the Port of Wilmington are presented in Table 1-25.

Table 1-25
Existing Conditions: Ports-of-Call for Asia Services Calling at the Port of Wilmington

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

2 WITHOUT-PROJECT CONDITIONS

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

- Without-project future conditions include completion of the ongoing navigation and marine transport improvements that are occurring at the Port of Wilmington (Sections 2.1 and 2.2);
- Without-project future conditions include completion of the ongoing navigation and marine transport improvements that are occurring at other USEC ports (Section 2.3);
- Continuing increases in the amount and proportion of fleet capacity in PPX3Max and PPX4 containership classes, the cascade effect of larger vessels displacing smaller vessels on the USEC-Asia services, and the efficiencies provided by larger vessels will further increase the size of vessels calling at USEC ports resulting in PPX3Max vessels being deployed on the ZCP and EC2 services(Section 2.4); and
- Under without-project condition channel depth constraints and draft restrictions at the Port of Wilmington, the resulting light loading of the design vessel for the ZCP and EC2 services will cause the two Asia services to drop Wilmington as a port-of-call (Section 2.5).

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

2.1 Wilmington Harbor Navigation Features

The without-project conditions at the Wilmington Harbor Federal navigation project include completion of 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 has applied 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. Construction began in 2019 and is projected to be completed in 2020. The Lower Anchorage Basin 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 (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.

The without-project future condition Federal navigation channel at Wilmington Harbor, exclusive of the turning basin expansion, was designed for a Panamax vessel with a length overall of 965 feet, a beam of 106 feet, and a maximum draft of 40 feet (USACE 1996), which is substantially smaller than the design vessel mentioned above. 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 under normal operating practices. Under without-project conditions the design vessel will not have 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.

These without-project condition terminal improvements enhance current terminal operations and efficiency independent of improvements to the federal channel. The NCSPA is currently realizing the benefits of larger and faster cranes, improved mooring facilities, and yard configuration. Planned future improvements will further increase the efficiency of cargo flow at the terminal under without-project conditions. The costs of these improvements are “sunk costs” that are currently providing benefits to the NCSPA. The costs of implementing the Port of Wilmington’s terminal master plan are not associated costs of the navigation improvement project.

Figure 2-1
Port of Wilmington Container Terminal Improvement Plan

2.3 Other 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 and/or are constructing deepening projects to allow the new generation of containerships to achieve operating drafts similar to major international trade partner ports. The majority of these projects will be completed over the next 5 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 and at a rate more rapid than predicted.

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 – under construction	2025
Wilmington, NC	**42 feet**	**42 feet – constructed**	**N/A**
Charleston*	45 feet	52 feet – under construction	2021
Savannah*	42 feet	47 feet – under construction	2020
Jacksonville*	40 feet	47 feet – under construction	2025
Port Everglades	42 feet	48 feet – in design	2024
Miami	50 feet	50 feet - constructed	Complete

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

At the present time, before the improvements shown in Table 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. 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 all of the other USEC container ports on the two USEC-Asia services. 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 (Table 2-2). After completion of the construction projects listed in Table 2-1, the two USEC-Asia 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 identified in Tables 1-19 and 1-20. This will place Wilmington at a further disadvantage since the vessels on the service will need to substantially light load to call at Wilmington, but not at the other service ports.

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

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

2.4 Without-project Condition Containership Fleet for EC2 and ZCP Services

The design vessel for this analysis, which is the same design vessel used for the Charleston Post-45 Study, represents the average characteristics of the PPX3Max vessel class (Tables 1-16 and 1-17). This vessel class is also known as the neo-Panamax class of containerships. The characteristics of a neo-Panamax vessel have been increasing slightly as the Panama Canal Authority gains more experience working the expanded lock system. The largest containership (*Triton*) to pass through the Panama Canal to date[15] has a beam of 168 feet and length overall of 1,211 feet, which exceeded the previous dimension restrictions enforced by the Panama Canal Authority for neo-Panamax vessels by 7 feet of beam 10 feet of length. The current maximum dimensions for vessels transiting the Panama Canal appear to characterize the full physical constraint of the locks. It is unlikely that vessels substantially larger than the *Triton* will be able to transit the Panama Canal in the future. Tables 1-19 and 1-20 show that carriers are increasing the neo-Panamax capacity of the world's fleet and Tables 1-21 through 1-23 show the dynamic transition from a nearly 100% Panamax fleet to an increasingly neo-Panamax fleet for vessels on USEC-Asia services.

The two alliances currently calling at Wilmington (2M alliance supporting the ZCP service and THE alliance supporting the EC2 service) have a combined fleet (existing, under construction, or on order) of 200 neo-Panamax vessels (94 for 2M and 106 for THE). Each USEC-Asia service requires 10 or 11 vessels, which indicates that each alliance has enough neo-Panamax vessels to deploy a fully neo-Panamax fleet on their respective USEC-Asia services, and still have nearly 90% of their neo-Panamax fleet available for deployment elsewhere. Note that the THE Alliance announced on January 1, 2020 that it will transition the EC2 service fleet into vessels with 13,100 TEU capacity.

The rationale for neo-Panamax vessel deployment in the without-project condition is the same rationale that historically resulted in the nearly 100% deployment of Panamax vessels identified

[15] Evergreen's *Triton* 15,313 TEUs https://www.maritime-executive.com/article/evergreen-container-ship-makes-record-transit-through-panama-canal accessed 11Nov19

in tables 1-21 through 1-23, namely economic efficiency. Note that existing channel depths and resulting draft restrictions identified in Table 2-2 have discouraged the use of neo-Panamax vessels on these two services under existing conditions, but under without-project conditions future channel depths will substantially relieve draft restrictions at the other USEC Ports of call – except at Wilmington.

Under without-project conditions, the PPX3Max neo-Panamax vessels will be able to achieve the economies of scale for which these vessels were designed. Table 2-3 presents the number of TEUs on board post-Panamax vessels at various vessel drafts. The number of TEUs on board was calculated using the weighted average import and export cargo tonnage at Wilmington for the EC2 and ZCP services and average vessel dimensions for each vessel class. The maximum number of TEUs on board was truncated at 85% of the vessel's nominal capacity to account for factors other than cargo affecting vessel immersion. Table 2-4 presents the operating costs per TEU per 1,000 miles for each vessel class at various vessel drafts. Costs were calculated based in USACE 2013 vessel operating costs adjusted to 2017 (most recent information available).

Table 2-3
TEUs on Board at Various Vessel Drafts

	40	42	44	46	48
PPX1	3,931	4,376	4,821	5,135	5,135
PPX2	5,039	5,577	6,115	6,653	6,747
PPX3	5,936	6,509	7,082	7,654	7,958
PPX3Max	7,337	8,012	8,687	9,361	10,036
PPX4	10,346	11,166	11,987	12,808	13,629

Table 2-4
Operating Costs per TEU per 1,000 miles at Various Vessel Drafts

	40	42	44	46	48
PPX1	$57.35	$51.52	$46.76	$43.91	$43.91
PPX2	$55.75	$50.37	$45.94	$42.23	$41.64
PPX3	$52.66	$48.03	$44.14	$40.84	$39.28
PPX3Max	$39.81	$36.46	$33.63	$31.20	$29.11
PPX4	$30.59	$28.34	$26.40	$24.71	$23.22

Table 2-5 uses the information in Tables 2-3 (number of TEUs on board the vessel) and 2-4 (transportation cost per TEU per 1,000 miles) to illustrate the efficiency gained by using a

PPX3Max vessel. This efficiency is part of the calculus used by carriers to deploy vessels on their services. Consider the efficiency of the PPX3Max as compared to a PPX3 vessel with each vessel loaded to a 46-foot draft (bottom two rows of Table 2-5). The two weekly services (ZCP and EC2) together make 104 calls per year to the USEC. If a PPX3 vessel were used instead of a PPX3Max vessel there would be 177,520 fewer TEUs carried one-way (1,707*104=177,520). Total annual transportation costs are higher for the services using PPX3 vessels due to the need for additional PPX3 vessel calls to carry the 177,520 TEUs left at the dock and due to the 31% increase in cost per TEU. The two alliances (2M and THE) have enough PPX3Max vessels in their respective fleets to deploy 100% PPX3Max vessels on these services (see preceding paragraphs). In addition, US west coast ports are preparing for PPX4-size vessels[16], which would displace the existing PPX3Max vessels currently servicing the US west coast further increasing the availability of PPX3Max vessels. It would defy economic rationality if these two alliances deployed vessels smaller than PPX3Max vessels on a regular basis, given the large efficiencies PPX3Max vessels provide and the with-out project condition channel depths at the other ports-of-call on these services (Table 2-2), which can support vessels of this size.

Table 2-5
Relative Efficiency of PPX3Max Vessels (all vessels at 46-foot draft)

	TEUs	TEU Deficit compared to PPX3Max	% TEU Deficit	$/TEU	Cost Increase	% Cost Increase
PPX1	5,135	-4,226	45.1%	$43.91	$12.70	40.7%
PPX2	6,653	-2,708	28.9%	$42.23	$11.02	35.3%
PPX3	7,654	-1,707	18.2%	$40.84	$9.63	30.9%
PPX3Max	9,361	0	0.0%	$31.20	$0.00	0.0%

2.5 Without-project Condition Status of Wilmington as a Port of Call on the EC2 and ZCP Services

Table 2-5 (above) presents an illustration of the relative efficiency of PPX3Max vessels. The following discussion presents an estimate of the loss of efficiency caused by calling at the Port of Wilmington under without-project conditions for the EC2 and ZCP service fleets consisting of the design vessel, which is an average size PPX3Max vessel (Table 1-17). The loss of efficiency, i.e., the additional cost, of maintaining the Port of Wilmington as a port-of-call on these services under without-project conditions indicates that the most likely without project future condition is that Wilmington will be by-passed by these two services and Wilmington's hinterland containerized Asia cargo will need to use alternative ports.

Vessel operating costs per TEU per 1,000 miles were calculated to display the inefficiency of Wilmington remaining a port of call on these two services under without-project conditions. Vessel operating costs per TEU per 1,000 miles were calculated based on:

- Historical weighted average tons/TEU for Port of Wilmington Asia import and export cargo;

[16] See recent and ongoing Feasibility Studies for Long Beach, Seattle, and Tacoma, each of which uses PPX4 vessels as the design vessel.

- weighted average TEUs per call based on 85% capacity and the vessel draft cumulative distribution functions developed for the design vessel for the Charleston Post-45 Feasibility Study (same design vessel as this analysis); and
- USACE 2017 Vessel Operating Costs.

Port data from 2017 and 2018 indicate that Asia imports account for 38.1% of TEUs with an average TEU cargo weight of 7.37 metric tons. Asia exports account for 61.9% of TEUs with an average cargo weight of 12.25 metric tons. The weighted average TEU cargo weight (weighted by the ratio of imports to exports) is 10.39 metric tons. The weight of a twenty-foot box is estimated at 2.0 metric tons.

Cumulative draft distribution functions for the Design Vessel were developed for the Charleston Post-45 Feasibility Study (Figure 2-2) for alternative channel depths of 45, 48, 50, and 52 feet. Table 2-6 presents the cumulative distributions for the 45 and 48-foot channel depths as presented in Figure 2-2 in tabular form and presents the 45-foot distribution function extrapolated to 42-feet (Wilmington without-project condition). Note that throughout this analysis the 45-foot distribution function (red curve) is used for channel depths from -44 to -46 feet and the 48-foot distribution function (blue curve) is used for channel depths of -47 and -48 feet.

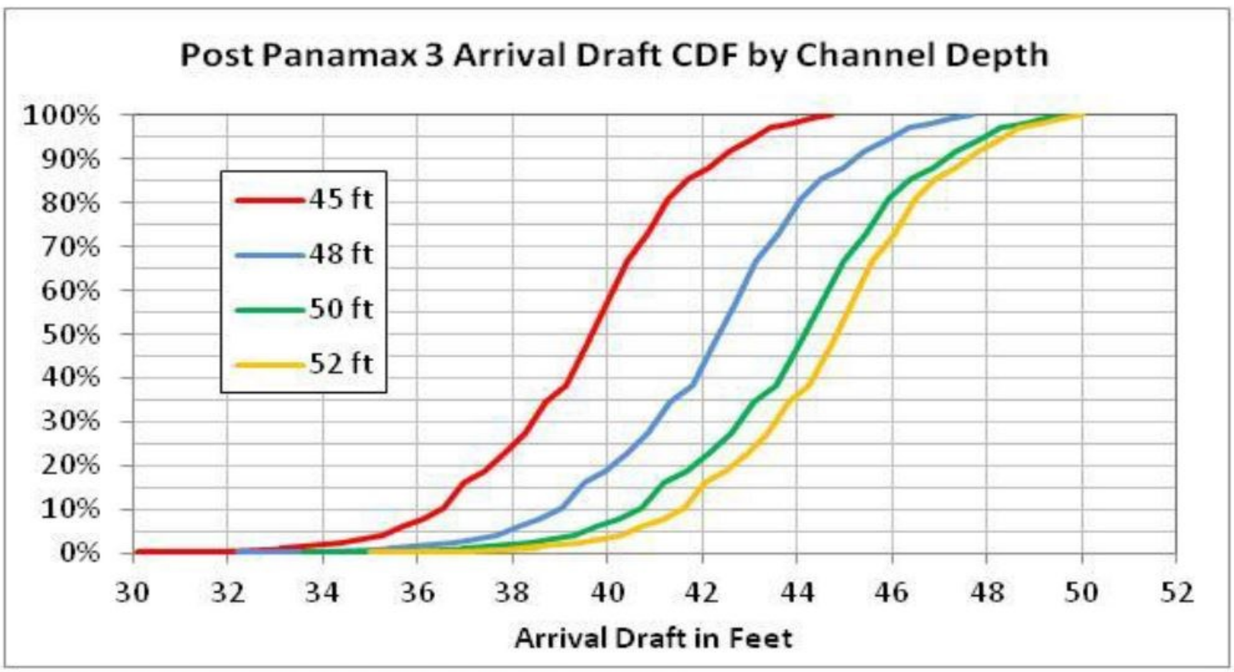

Figure 26: Post Panamax Gen III Arrival Draft by Channel Depth

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

Table 2-6
Existing and Future Without-Project Condition Channel Depths for USEC Ports on the Two USEC-Asia Services
(Feet below MLLW)

Vessel Draft	42-foot Channel* Percentage of Calls		45-foot Channel Percentage of Calls		48-foot Channel Percentage of Calls	
	Cumulative	Marginal	Cumulative	Marginal	Cumulative	Marginal
32	7.5	7.5	0	0	0	0
33	15	7.5	1	1	0	0
34	25	10	2.5	1.5	0	0
35	36	11	4	1.5	0	0
36	57	21	7.5	3.5	2	2
37	75	18	15	7.5	3	1
38	86	11	25	10	6	3
39	95	9	36	11	10	4
40	98	3	57	21	18	8
41	100	2	75	18	30	12
42			86	11	42	12
43			95	9	65	23
44			98	3	80	15
45			100	2	87	7
46					95	8
47					100	5

Source: Charleston Post-45 Economics Appendix Figure 26: Post-Panamax Gen III Arrival Draft by Channel Depth; *extrapolated from 45-foot data

The weighted average number of TEUs on board and the weighted average cost per TEU per 1,000 miles (Table 2-7) were calculated for the design vessel at future without-project condition vessel draft distributions at Wilmington and at the prior and next ports of call on the two Asia services as identified in Table 2-2. The weighted average cost per TEU is calculated as the sum of the proportional costs allocated to each vessel draft based on the cumulative draft distribution. For any of the ports in Table 2-7, the highest proportional costs are associated with the vessel drafts with the highest TEU allocation. Similarly, the fewer TEUs allocated to a vessel draft the lower the proportional cost.

Note that at a channel depth of -48 feet (Figure 2-2 and Table 2-6) the maximum operating draft for the design vessel is 47 feet. Although Savannah Harbor is being deepened to -47 feet, the substantial tidal advantage at Savannah allows vessel to regularly load to drafts equivalent to project depth. This regular use of tidal advantage at Savannah indicates that the cumulative distribution function developed for the 48-foot channel is appropriate for operations at Savannah with a -47-foot channel. Boston and Savannah are the prior and next ports on the EC2 Service. Jacksonville and Kingston, JM are the prior and next ports on the ZCP service. At Jacksonville, with a -47-foot channel and limited tidal advantage, the maximum operating draft of the design vessel is projected to be 46 feet. Weighted average costs for Kingston, JM were not developed because the 47-foot depth at Jacksonville restricts design vessel drafts to no more than 46 feet.

Table 2-7
Weighted Without-Project Condition TEUs and $/TEU for USEC Ports on the Two USEC-Asia Services
(Feet below MLLW)

Vessel Draft	Boston & Savannah Weighted Distribution		Jacksonville Weighted Distribution		Wilmington Weighted Distribution	
	TEUs on Board	$/TEU/ 1,000 miles	TEUs on Board	$/TEU/ 1,000 miles	TEUs on Board	$/TEU/ 1,000 miles
32	-	-	-	-	348	$4.46
33	-	-	-	-	373	$4.18
34	-	-	-	-	531	$5.25
35	-	-	113	$0.99	622	$5.45
36	120	$0.94	60	$0.47	1,257	$9.86
37	63	$0.45	190	$1.34	1,139	$8.03
38	200	$1.27	267	$1.70	733	$4.67
39	280	$1.62	560	$3.24	630	$3.65
40	587	$3.10	880	$4.65	220	$1.16
41	921	$4.46	921	$4.46	153	$0.74
42	961	$4.28	1,843	$8.21	-	-
43	1,920	$7.89	1,252	$5.15	-	-
44	1,303	$4.96	608	$2.31	-	-
45	632	$2.23	722	$2.55	-	-
46	749	$2.47	468	$1.54	-	-
47	485	$1.54	-	-	-	-
Weighted Averages	**8,221**	**$35.23**	**7,884**	**$36.62**	**6,006**	**$47.45**

Table 2-8 presents a summary of without-project condition channel depths, weighted average TEUs on board, and weighted average costs per TEU for the design vessel on the two USEC-Asia services.

Table 2-8
Summary Weighted Average TEUs and $/TEU for USEC Ports on the Two USEC-Asia Services

ZCP Service	TEUs	$/TEU /1,000 miles	EC2 Service	TEUs	$/TEU /1,000 miles
Jacksonville	7,884	$36.62	Boston	8,221	$35.23
Wilmington	6,006	$47.45	Wilmington	6,006	$47.45
Kingston*	7,884	$36.62	Savannah	8,221	$35.23
Difference	-1,887	$10.83	Difference	-2,215	$12.22
% Difference	-23.8%	29.6%	% Difference	-26.9%	34.7%

* Kingston TEUs and costs limited by Jacksonville's 47-foot depth as prior port

Under without-project conditions based on weighted average calculations and vessel TEU capacity truncated at 85% of nominal capacity, if the two services were to maintain Wilmington as a port-of-call using PPX3Max vessels:

- The ZCP service would leave 97,618 at the dock (1,887* 52 = 97,618) due to depth constraints at the port of Wilmington, which would require an additional 16 vessel calls (calculated a 6,006 TEUs per call); and
- The EC2 service would leave 115,159 at the dock (2,215 * 52 = 115,159) due to depth constraints at the port of Wilmington, which would require an additional 19 vessel calls (calculated a 6,006 TEUs per call).

The extraordinary cost burden of having to add 16 or 19 additional vessel calls at a cost increase of 29.6% or 34.7% makes it highly unlikely that either of the two alliances would continue to call at Wilmington under without-project conditions. The cost burden of calling at Wilmington would be economically unsustainable.

2.6 Bulk and Breakbulk Commodity and Fleet Forecasts

Bulk and breakbulk commodities include fuel and chemicals (liquid bulk), wood chips and potash (dry bulk), and lumber (break bulk). Historical tonnages (Tables 1-13 and 1-14) show no persistent growth trends and no projected future growth in bulk commodity tonnages were identified. Therefore, future without-project bulk commodity tonnages are projected to be consistent with recent historical tonnages. The transport of bulk commodities is not constrained by without-project channel dimensions and will not benefit from the proposed project. Therefore, bulk commodity transport has no effect on plan formulation or plan selection and is included in the detailed economic analysis only to account for the impact of bulk vessel transits on potential channel congestion.

The fleet forecast for bulk and break bulk commodities was developed using the HarborSym vessel loading tool. The number of vessel calls does not change from year to year under future without-project conditions (Table 2-9) because the commodity forecast is held constant.

Table 2-9
Bulk, Breakbulk, and Non-Asia Container Vessel Fleet Forecast
(Annual Vessel Calls)

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

2.7 Containerized Commodity Projections

Without-project commodity projections for the Federal navigation channel at Wilmington Harbor are focused on containerized cargo at the Port of Wilmington. The future without-project containerized commodity forecast is divided into two components:

- non-Asia containerized cargo that is projected to use the Port of Wilmington under without-project conditions; and
- containerized cargo on the two USEC-Asia services (EC2 and ZCP) 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 (as discussed in Section 2.5). 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 2-10). 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 2-10
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 (Tables 2-11 and 2-12). Note that only loaded containers are used in landside transportation cost calculations.

Table 2-11
Port of Wilmington Hinterland Containerized Cargo Forecast (loaded TEUs only)

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

Table 2-12
Port of Wilmington Hinterland Containerized Cargo Forecast
(loaded and empty 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

2.8 Containership 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.

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 2-13). 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 2-13
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 (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.

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 2-14) for the USEC-Asia without-project condition commodity forecast (Table 2-12) was developed using the HarborSym vessel loading tool.

Table 2-14
Wilmington Hinterland Containerized Asia Cargo
Without-project Containership Fleet Forecast

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

2.9 Without-project Transportation Costs

Without-project transportation costs are calculated for Wilmington's hinterland containerized Asia cargo, which is projected to use alternative ports and PPX3Max vessels under without-project conditions. Without-project transportation costs for Wilmington's hinterland containerized 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.

2.9.1 Without-project Waterborne Transportation Costs

Without-project waterborne transportation costs are based on the Port of Savannah as the alternative port for Wilmington's hinterland containerized Asia cargo identified in the commodity forecast (Tables 2-11 and 2-12). Savannah was selected as the most likely alternative port because Savannah's position in the without-project condition port rotation is ahead of Charleston (Table 2-15), which is reasonable considering that Savannah has the largest share of cargo on the vessel. Calling at Savannah before calling at Charleston, which is consistent with the existing condition (Table 1-25) creates a 2-day time advantage for Wilmington-hinterland cargo being offloaded at Savannah as compared to Charleston. Base-case without-project waterborne transportation costs are calculated for Wilmington's hinterland containerized Asia cargo using Savannah as the alternative port. The risk and uncertainty associated with this without-project condition assumption is addressed in a sensitivity analyses that uses Savannah as the alternative port for Wilmington's hinterland Asia imports (maintaining the time advantage) and using Charleston as the alternative port for Wilmington's hinterland Asia exports.

Table 2-15
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 2-16) were calculated by the USACE Deep Draft Navigation Planning Center of Expertise, using the HarborSym model. The average annual equivalent value waterborne transportation costs, under Base-case without-project conditions (Savannah as alternate port), are $119,361,000 calculated at the FY 2020 Federal discount rate (2.75%) over 50 years. Waterborne transportation costs are marginally lower for the sensitivity analysis because export cargo, which uses Charleston in the sensitivity analysis, has a 100-nautical mile shorter distance to travel to Asia.

Table 2-16
Wilmington Hinterland Containerized Asia Cargo Without-project Waterborne Transportation Costs: Alternate Ports for Selected Years (thousands $FY20)

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

2.9.2 Without-project Landside Transportation Costs

Without-project landside transportation costs are calculated based on:

- The number of truck hauls required to transport the cargo (Table 2-17) calculated at 1.85 TEUs per haul:
- the distance from the cargo's origin or destination in the Port of Wilmington's hinterland to the Port of Savannah, and
- the trucking costs associated with that haul distance.

Table 2-17
Port of Wilmington's Hinterland Containerized Asia Cargo
Loaded TEUs and Truck Hauls

	2025	2030	2035	2040	2045
Loaded TEUs	154,002	190,882	215,966	244,345	276,454
Truck Hauls	83,245	103,180	116,738	132,079	149,435

Haul miles were calculated by optimizing routes set to preserve total travel time rather than total travel distance (Table 2-18). Output values for travel distance, time, and route path GIS line geometry were generated in the route optimization. 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. 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. 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[17]. 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.

Table 2-18
Port of Wilmington's Hinterland Containerized Asia Cargo Total Haul Miles
(Thousands of Miles)

	2025	2030	2035	2040	2045
Savannah	50,068	62,058	70,213	79,440	89,879
Savannah/Charleston	43,067	53,380	60,395	68,331	77,311

[17] Additional detail concerning the trucking cost model is provided in an Attachment to this Appendix (Attachment B: Trucking Cost Model)

Graphical analysis of trucking quotes as depicted in Figures 2-3 and 2-4 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 in FY17 dollars were calculated using the linear regression depicted in Figure 2-3 and are shown in Table 2-19. Estimated costs to any city in the hinterland are similarly calculated. Note that trucking costs per TEU are calculated at 1.85 TEUs per truck haul, which is based on historical Port of Wilmington data. The FY 2017 costs are updated to current costs using the Producer Price Index for General Freight Trucking, Long-Distance Truckload generated the Federal Reserve Bank of St. Louis.[18] Attachment B: Trucking Cost Model provides additional detail on the trucking cost model development.

Rail is not considered as a lower cost alternative mode of transport compared to trucking because rail is not a lower cost alternative for the short haul distances between Wilmington's hinterland and the alternative ports. Rail service from Wilmington's hinterland to either Savannah or Charleston is inefficient and more expensive than truck service because there is limited cargo in any single area within the hinterland that would be used to make up trains, which means that cargo would need to be trucked to the rail yard (double handling) and the cargo would have to wait for a sufficient volume of cargo to arrive to build the train (time delay). The port of Wilmington currently has rail service that is under-utilized, even though it is subsidized with government funds, due to the transportation inefficiencies mentioned above. In calendar year 2019, approximately 2% (10,468) of TEUs handled at the Port of Wilmington were moved by rail. Rail is only an efficient alternative to trucking for cargo travelling the equivalent of multi-day truck distances, in which the inefficiencies of double handling and waiting for sufficient cargo to accumulate at the rail yard is more than offset by travelling 24 hours-a-day on a double-stacked train carrying 400 TEUs.

[18] Average PPI for FY17 (Oct16 through Sep17) = 124.6; Average PPI for FY19 (Oct18 through Sep19) = 138.2; Update factor = 1.10915

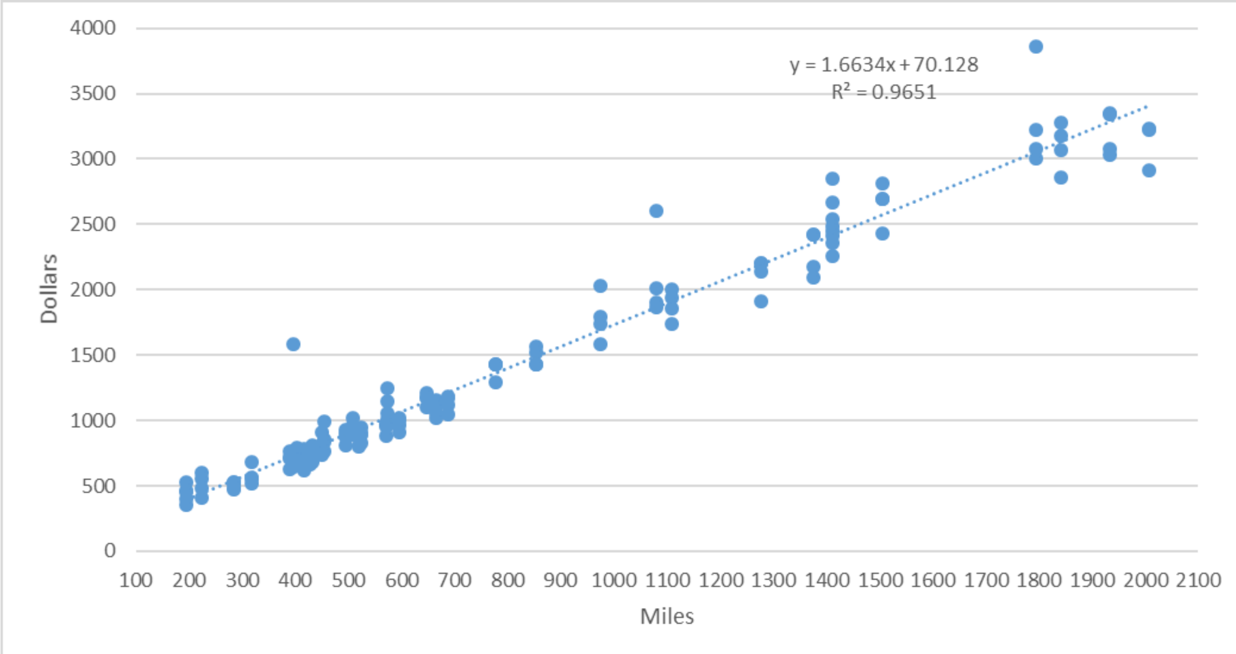

Figure 2-3
Trucking Costs by Miles Driven

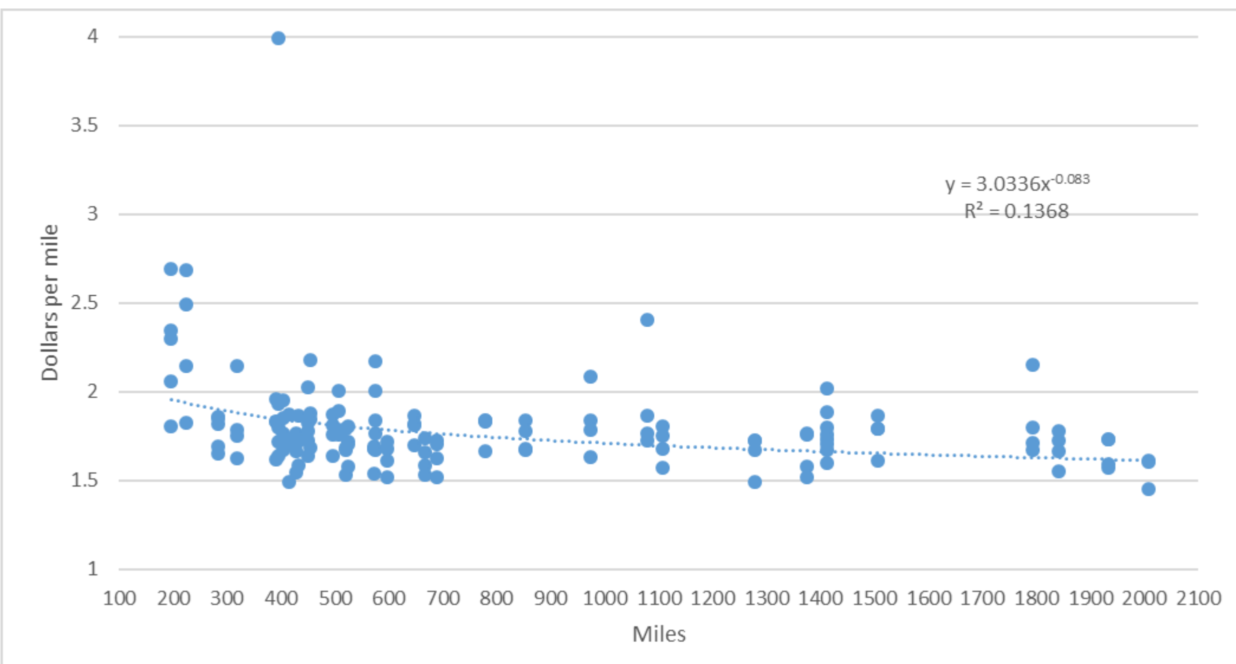

Figure 2-4
Trucking Rates (dollars per mile) by Miles Driven

Table 2-19
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 Wilmington's hinterland containerized Asia cargo are calculated for Savannah as the alternative port in the base-case. Calculation are also performed for a sensitivity analysis using Savannah as the alternative port for imports and Charleston as the alternative port for exports. Weighted average trucking costs per TEU and weighted average trucking costs per truck haul are presented in Table 2-20. The values in Table 2-20 are weighted by the number of TEUs and number of trips from each origin and destination for cargo in the Wilmington hinterland Asia containerized cargo forecast. Trucking costs are calculated for each year of the 50-year planning period and are held constant at 2045 levels from 2045 – 2076 because the commodity forecast is held constant during the same time period, although discounting continues for the full 50 years. Table 2-21 presents trucking costs for selected years.

Table 2-20
Round Trip Trucking Costs

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

Table 2-21
Port of Wilmington's Hinterland Containerized Asia Cargo Total Trucking Costs (Thousands of FY20 Dollars)

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

Total origin to destination transportation costs for Wilmington's hinterland containerized Asia cargo includes water borne costs (Table 2-16) and landside costs (Table 2-21). Total transportation costs are presented in Table 2-22 for the base-case (Savannah as alternate port for all cargo) and in Table 2-23 for the sensitivity analysis (Savannah as alternative port for imports and Charleston as the alternative port for exports).

Table 2-22
Port of Wilmington's Hinterland Containerized Asia Cargo Total Transportation Costs: Savannah as Alternate Port (Thousands of FY20 Dollars)

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

Table 2-23
Port of Wilmington's Hinterland Containerized Asia Cargo Total Transportation Costs: Savannah as Alternate Port for Imports and Charleston as Alternate Port for Exports (Thousands of FY20 Dollars)

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

3 Economic Evaluation of Measures

Problems, opportunities and constraints are developed in the Main Report. Similarly, the identification of objectives, planning measures, and the evaluation of measures are all discussed in the Main Report. This section of the Economics Appendix focusses on the use of economics in the evaluation of measures, which includes an economic evaluation of structural measures that was performed in the development of alternative plans. The structural measures that were advanced from preliminary screening include channel widening, channel deepening, and berth deepening that would be performed as a local service facility improvement.

Channel widening and channel deepening are evaluated individually and in combination (Table 3-1) in an intermediate screening based on potential transportation cost savings. Channel widening allows the design vessel (PPX3Max) to navigate the channel on a regular basis, which even without channel deepening, would allow more cargo to be carried on each vessel call thereby reducing the transportation cost per TEU. Channel deepening also reduces transportation costs per TEU by allowing vessels to load more deeply and carry more cargo per trip, but without channel widening vessel size is restricted to no larger than the existing fleet (PPX3). Note that in order to realize the transportation cost savings associated with channel deepening berths at the Port of Wilmington must also be deepened to the depth of the channel. The combination of channel widening and deepening, with the necessary berth deepening, allows the design vessel to regularly navigate the channel and allows the vessel to load more deeply.

Table 3-1 presents the economic evaluation of channel widening and channel deepening individually and in combination. The waterborne cost per TEU per $1,000 miles is weighted by the historical tonnage for imports and exports at the Port of Wilmington as was presented previously in Table 2-7. The combination of widening and deepening reduces transportation costs per TEU more than either widening or deepening reduces transportation costs individually. Therefore, the combination of widening and deepening is forwarded for more detailed evaluation.

Table 3-1
Weighted $/TEU/1,000 Miles for the Structural Measures at Wilmington Harbor

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

The following describes the information presented in Table 3-1:

- Row 1 presents the waterborne transportation cost per TEU per 1,000 miles for the largest vessel that could call at Wilmington under without-project conditions, which a

PPX3 vessel. Section 2.5 Without-project Condition Status of Wilmington as a Port of Call on the EC2 and ZCP Services (above), shows that the relative inefficiency associated the PPX3 size vessel would cause the two services to bypass Wilmington and Wilmington's hinterland Asia cargo would shift to Savannah as a lower cost alternative port.

- Row 2 shows that implementing the widening measure allows the PPX3Max vessel to call at Wilmington and cost per TEU is lower than without-project conditions, but the vessel would not be able to load any deeper than allowed by the without-project condition depth, thereby restricting any additional cost savings.
- Row 3 indicates that implementing the deepening measure allows additional efficiency for the PPX3 vessel but does not allow for an increase in vessel size. Berth deepening would also need to be implemented for this measure to be effective.
- Row 4 shows that implementing the widening and deepening measures in combination allow for the increase in vessel size and additional efficiency for each incremental increase in depth. Berth deepening would also need to be implemented for this measure to be effective. These structural measures, implemented in combination, provide the greatest potential for transportation costs savings and are forwarded for more detailed analysis.

4 ALTERNATIVE PLAN ECONOMIC EVALUATION

Alternative plan benefits are based on full origin to destination transportation cost savings as described in the Principles and Guidelines[19], the Planners Guidance Notebook[20], and the NED Manual for Deep Draft Navigation[21]. Without-project transportation costs are developed in Section 2: Without-Project Conditions and presented in Table 2-21. With-project transportation costs are similarly calculated for waterborne and landside costs. In addition, with-project transportation costs are calculated for each increment of channel depth from -44 feet to -48 feet. As presented in Section 3 Economic Evaluation of Measures, each alternative plan includes channel widening to allow the design vessel to navigate the channel on a regular basis and berth deepening.

4.1 Port of Wilmington Hinterland Asia Cargo Demand Analysis

Vessel unit operating costs, waterborne transportation costs per TEU per 1,000 miles, have been used to describe and support the carrier's deployment decisions in the existing and without-project conditions. Under with-project conditions, at incrementally increasing project depths, unit costs to carriers would be reduced as exhibited in Table 4-1, however, reductions in unit costs to the carriers do not fully explain the shift of TEUs from Savannah in the without-project condition to Wilmington under with-project conditions.

Table 4-1
Weighted Average Costs per TEU for Wilmington Harbor Channel Improvements (Widening and Deepening) and USEC Ports on the EC2 and ZCP Services

Port	Project Depth	$/TEU/1,000 miles
Boston	48	$35.23
Savannah	47	$35.23
Jacksonville	47	$36.62
Wilmington	44	$43.06
Wilmington	45	$41.10
Wilmington	46	$39.27
Wilmington	47	$36.62
Wilmington	48	$35.23

Note: All depths feet below MLLW

The port shift projected to occur under with-project conditions is based on the demand for transportation services at the Port of Wilmington. This demand is represented by a willingness-

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

to-pay schedule for the Port of Wilmington's hinterland Asia TEUs importers and exporters that use Savannah under without-project conditions. The willingness-to-pay (demand) schedule identifies the potential landside transportation cost savings for each Port of Wilmington's hinterland Asia import or export TEU that would have shifted to Savannah under without-project conditions. TEUs from each Port of Wilmington hinterland origin or destination were ranked by total potential savings from greatest savings to no savings (indifferent to using Wilmington or Savannah) and shifted from Savannah to Wilmington in order of potential savings. In this manner, TEUs with the highest potential savings (highest willingness-to-pay) were the first boxes to shift to Wilmington followed by boxes with the next highest potential savings and so on until the potential for savings had been exhausted.[22] The demand schedule was developed from PIERS data for Asia imports and exports for calendar years 2017 and 2018 (loaded TEUs only). The resulting demand schedule (Table 4-2 and Figure 4-1) identifies the incremental value of shifting to Wilmington for Wilmington's hinterland importers and exporters that necessarily use Savannah as an alternative port under without-project conditions.

Table 4-2
Demand Schedule for Asia Import and Export Cargo at the Port of Wilmington

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

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

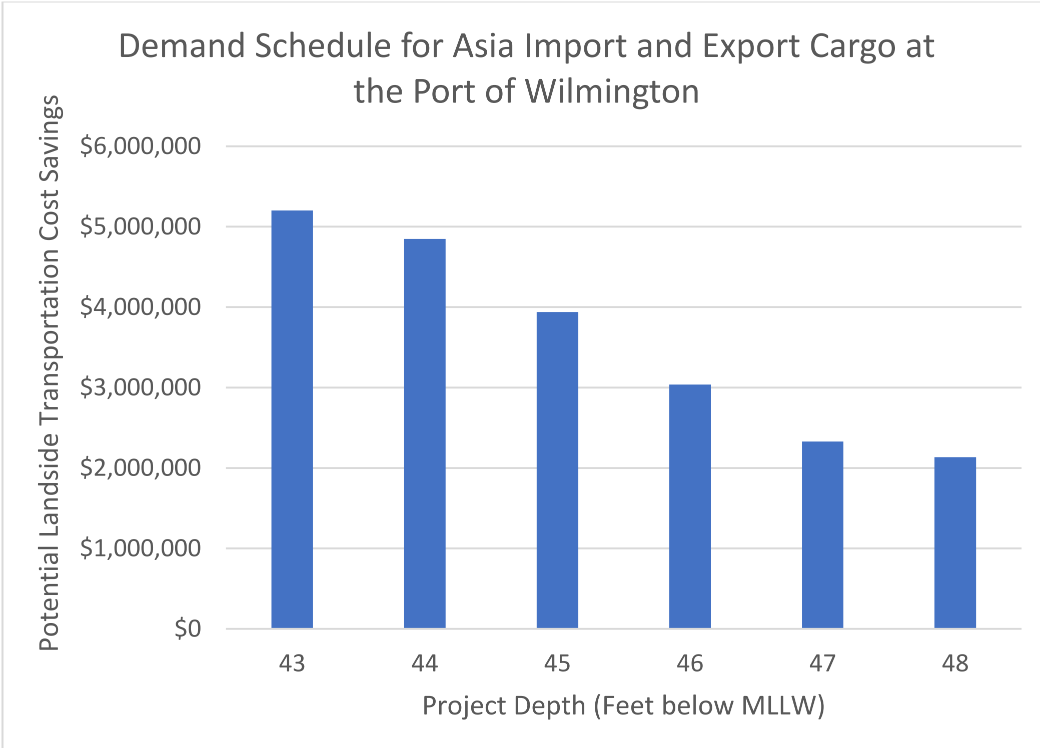

Figure 4-1
Demand Schedule for Asia Import and Export Cargo at the Port of Wilmington

The demand schedule presented in Table 4-2 and Figure 4-1 is a snapshot of potential willingness-to-pay based on historical data (2017 and 2018). The incremental increase in project depth is truncated at -48 feet because the depth constraints at the prior and next ports (-48 feet Boston, -47 feet Savannah and Jacksonville) indicate that there would be very limited cost savings at project depths deeper than -48 feet. Although the incremental increase in the number of TEUs is consistent from foot to foot, i.e., each incremental foot of project depth is capable of accommodating the same number of TEUs, there is a difference in the value (willingness-to-pay) for each incremental foot, with the first increment of depth being the most valuable and the last increment being the least valuable as indicated by the demand schedule. The boxes with the highest potential savings (potential consumer surplus) would be the first boxes to shift to the vessel capacity made available by the additional project depth, based on the standard economic assumption of resource allocation to the highest value.

4.2 Incremental Effects to Transportation Costs

The shift in cargo results in fewer truck hauls from the Port of Wilmington's hinterland to Savannah (Table 4-3), which results in fewer truck miles traveled (Table 4-4). Note that each truck haul carries 1.85 TEUs on average. Table 4-5 presents the number of truck-miles avoided for each increment of project depth. Table 4-6 presents the landside transportations costs allocated to cargo using Wilmington and cargo using Savannah for each increment of project depth. At each increment of project depth, the reduction in truck miles also reduces total landside transportation costs (Table 4-7) because at each depth increment more of the Port of

Wilmington's hinterland containerized Asia cargo is using the Port of Wilmington, which generates landside transportation cost savings.

Table 4-3
Port of Wilmington's Hinterland Containerized Asia Cargo Loaded TEUs: With-Project Conditions

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

Table 4-4
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Hauls: With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	0	0	0	0	0
-44	Wilmington	27,748	34,393	38,913	44,026	49,812
-45	Wilmington	41,622	51,590	58,369	66,039	74,717
-46	Wilmington	55,496	68,786	77,825	88,052	99,623
-47	Wilmington	69,370	85,983	97,282	110,065	124,529
-48	Wilmington	83,245	103,180	116,738	132,079	149,435
-42	Savannah	83,245	103,180	116,738	132,079	149,435
-44	Savannah	55,496	68,786	77,825	88,052	99,623
-45	Savannah	41,622	51,590	58,369	66,039	74,717
-46	Savannah	27,748	34,393	38,913	44,026	49,812
-47	Savannah	13,874	17,197	19,456	22,013	24,906
-48	Savannah	0	0	0	0	0

Table 4-5
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Miles: With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	0	0	0	0	0
-44	Wilmington	5,648,000	7,000,000	7,920,000	8,961,000	10,139,000
-45	Wilmington	8,472,000	10,500,000	11,880,000	13,442,000	15,208,000
-46	Wilmington	11,296,000	14,001,000	15,840,000	17,922,000	20,277,000
-47	Wilmington	14,120,000	17,501,000	19,801,000	22,403,000	25,346,000
-48	Wilmington	16,943,000	21,001,000	23,761,000	26,883,000	30,416,000
-42	Savannah	50,068,000	62,058,000	70,213,000	79,440,000	89,879,000
-44	Savannah	33,379,000	41,372,000	46,809,000	52,960,000	59,919,000
-45	Savannah	25,034,000	31,029,000	35,106,000	39,720,000	44,939,000
-46	Savannah	16,689,000	20,686,000	23,404,000	26,480,000	29,960,000
-47	Savannah	33,379,000	41,372,000	46,809,000	52,960,000	59,919,000
-48	Savannah	0	0	0	0	0
Total Miles						
-42	Savannah	50,068,000	62,058,000	70,213,000	79,440,000	89,879,000
-44	Sav & Wilm	39,027,000	48,372,000	54,729,000	61,921,000	70,058,000
-45	Sav & Wilm	33,506,000	41,529,000	46,986,000	53,162,000	60,147,000
-46	Sav & Wilm	27,985,000	34,687,000	39,244,000	44,402,000	50,237,000
-47	Sav & Wilm	22,465,000	27,844,000	31,503,000	35,643,000	40,326,000
-48	Wilmington	16,943,000	21,001,000	23,761,000	26,883,000	30,416,000

Table 4-6
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Miles Avoided: With-Project Conditions

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

Table 4-7
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Costs: With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	$0	$0	$0	$0	$0
-44	Wilmington	$20,676,000	$25,627,000	$28,995,000	$32,805,000	$37,116,000
-45	Wilmington	$28,779,000	$35,671,000	$40,358,000	$45,661,000	$51,662,000
-46	Wilmington	$35,028,000	$43,416,000	$49,121,000	$55,576,000	$62,879,000
-47	Wilmington	$39,819,000	$49,354,000	$55,840,000	$63,177,000	$71,479,000
-48	Wilmington	$44,210,000	$54,797,000	$61,998,000	$70,145,000	$79,362,000
-42	Savannah	$105,323,000	$130,546,000	$147,701,000	$167,110,000	$189,069,000
-44	Savannah	$70,216,000	$87,030,000	$98,467,000	$111,406,000	$126,046,000
-45	Savannah	$52,662,000	$65,273,000	$73,850,000	$83,555,000	$94,535,000
-46	Savannah	$35,108,000	$43,515,000	$49,234,000	$55,703,000	$63,023,000
-47	Savannah	$17,554,000	$21,758,000	$24,617,000	$27,852,000	$31,512,000
-48	Savannah	$0	$0	$0	$0	$0
Totals						
-42	Savannah	$105,323,000	$130,546,000	$147,701,000	$167,110,000	$189,069,000
-44	Sav & Wilm	$90,892,000	$112,657,000	$127,462,000	$144,211,000	$163,162,000
-45	Sav & Wilm	$81,441,000	$100,944,000	$114,208,000	$129,216,000	$146,197,000
-46	Sav & Wilm	$70,136,000	$86,931,000	$98,355,000	$111,279,000	$125,902,000
-47	Sav & Wilm	$57,373,000	$71,112,000	$80,457,000	$91,029,000	$102,991,000
-48	Wilmington	$44,210,000	$54,797,000	$61,998,000	$70,145,000	$79,362,000

Table 4-8
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Cost Savings: With-Project Conditions

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

Tables 4-3 through 4-8 present incremental TEU, mileage, and trucking cost information projected in 5-year increments from 2025 through 2045. Table 4-9 presents an annual average equivalent (AAEQ) summation of trucking costs at each depth increment using FY20 prices calculated over 50 years at the FY20 Federal discount rate of 2.75%. Average annual equivalent waterborne costs for the Port of Wilmington's hinterland containerized Asia cargo are calculated for each depth increment based on the amount of cargo using Wilmington and Savannah at each increment (Table 4-10). Waterborne transportation costs were calculated by the DDNPCX using the HarborSym model based data provided by the NCSPA. Note that waterborne transportation costs increase as more cargo shifts to Wilmington because there is a slight increase in the distance traveled by ships adding Wilmington to the port rotation as described in Section 2.9.1 Without-Project Condition Waterborne Transportation Costs. Figure 4-2 presents a summary of transportation costs at incremental project depths.

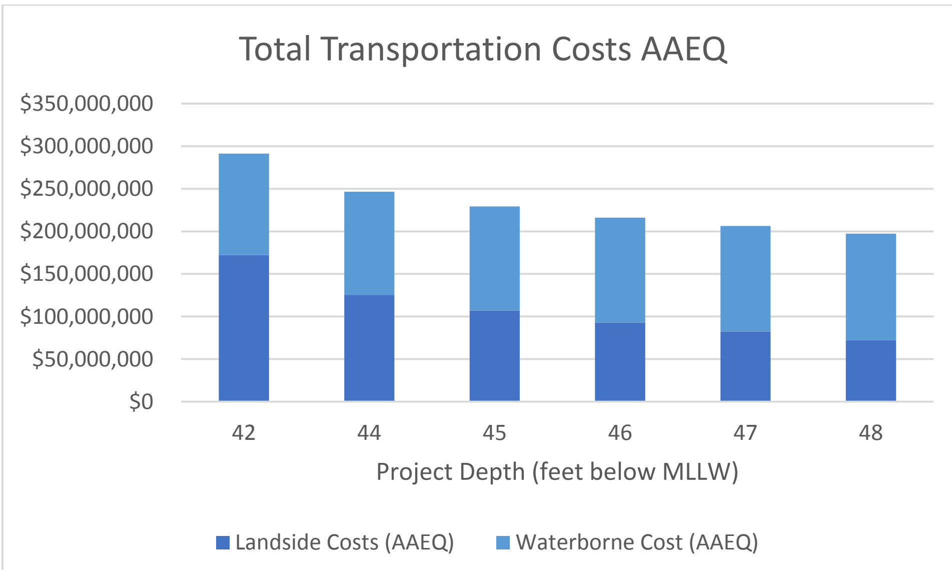

Figure 4-2
Total Transportation Costs at Incremental Project Depths

Table 4-9
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Cost AAEQ: With-Project Conditions

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

Table 4-10
Port of Wilmington's Hinterland Containerized Asia Cargo Waterborne Cost AAEQ: With-Project Conditions

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

4.3 Transportation Cost Savings at Incremental Project Depths

Table 4-11 summarizes Tables 4-9 and 4-10 to present the average annual equivalent total transportation costs and cost savings (project benefits) at each increment of project depth. Average annual equivalent project costs (developed in the Engineering Appendix) are presented in Table 4-12. Project costs are developed using FY20 prices. Incremental net benefits and benefit-to-cost ratios are presented in Table 4-13. Figure 4-3 presents a summary of project costs, benefits, and net benefits.

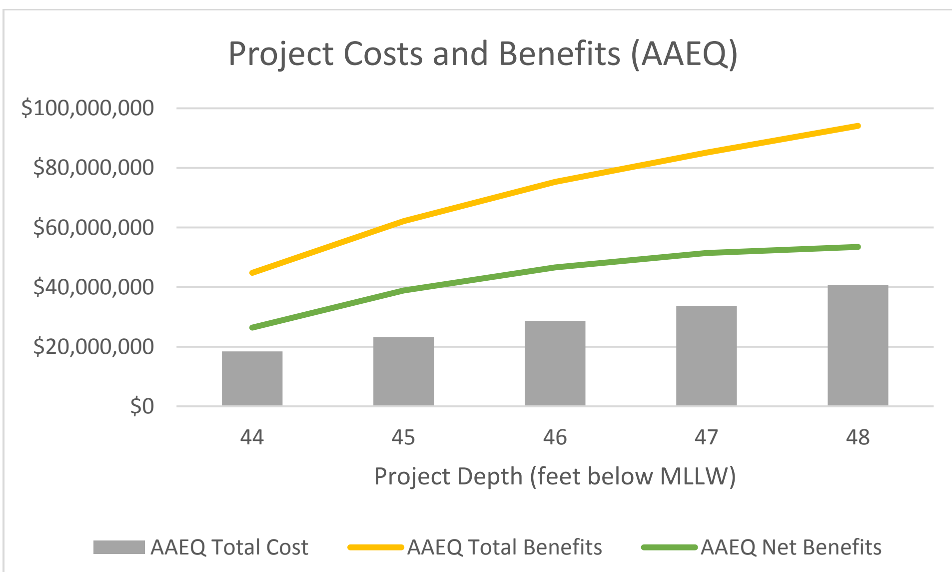

Figure 4-3
Project Costs, Benefits, and Net Benefits at Incremental Project Depths

Table 4-11
Port of Wilmington's Hinterland Containerized Asia Cargo Total Transportation Cost AAEQ: With-Project Conditions

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

Table 4-12
Project Costs

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

Table 4-13
Project Net Benefits

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

5 SENSITIVITY ANALYSIS ECONOMIC EVALUATION

Section 2.9.2 Without-project Landside Transportation Costs presents without-project landside transportation costs for a sensitivity analysis using Savannah as the alternative port for imports and Charleston as the alternative port for exports in the without-project condition (Tables 2-20 through 2-23). This section presents the incremental evaluation of project depths from -44 to -48 feet using Savannah as the alternative port for imports and Charleston as the alternative port for exports in the without-project condition.

Table 5-1
Port of Wilmington's Hinterland Containerized Asia Cargo Loaded TEUs: Sensitivity Analysis With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	0	0	0	0	0
-44	Wilmington	51,334	63,627	71,989	81,448	92,151
-45	Wilmington	77,001	95,441	107,983	122,173	138,227
-46	Wilmington	102,668	127,255	143,977	162,897	184,303
-47	Wilmington	128,335	159,068	179,971	203,621	230,379
-48	Wilmington	154,002	190,882	215,966	244,345	276,454
-42	Charleston	81,218	102,162	115,587	130,776	147,961
-44	Charleston	54,145	68,108	77,058	87,184	98,641
-45	Charleston	40,609	51,081	57,794	65,388	73,981
-46	Charleston	27,073	34,054	38,529	43,592	49,320
-47	Charleston	13,536	17,027	19,265	21,796	24,660
-48	Charleston	0	0	0	0	0
-42	Savannah	72,784	88,720	100,378	113,569	128,493
-44	Savannah	48,523	59,147	66,919	75,713	85,662
-45	Savannah	36,392	44,360	50,189	56,784	64,246
-46	Savannah	24,261	29,573	33,459	37,856	42,831
-47	Savannah	12,131	14,787	16,730	18,928	21,415
-48	Savannah	0	0	0	0	0

Table 5-2
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Hauls: Sensitivity Analysis With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	0	0	0	0	0
-44	Wilmington	27,748	34,393	38,913	44,026	49,812
-45	Wilmington	41,622	51,590	58,369	66,039	74,717
-46	Wilmington	55,496	68,786	77,825	88,052	99,623
-47	Wilmington	69,370	85,983	97,282	110,065	124,529
-48	Wilmington	83,245	103,180	116,738	132,079	149,435
-42	Charleston	43,902	55,223	62,480	70,690	79,979
-44	Charleston	29,268	36,815	41,653	47,127	53,319
-45	Charleston	21,951	27,611	31,240	35,345	39,990
-46	Charleston	14,634	18,408	20,827	23,563	26,660
-47	Charleston	7,317	9,204	10,413	11,782	13,330
-48	Charleston	0	0	0	0	0
-42	Savannah	39,343	47,957	54,259	61,389	69,456
-44	Savannah	26,229	31,971	36,172	40,926	46,304
-45	Savannah	19,671	23,978	27,129	30,694	34,728
-46	Savannah	13,114	15,986	18,086	20,463	23,152
-47	Savannah	6,557	7,993	9,043	10,231	11,576
-48	Savannah	0	0	0	0	0

Table 5-3
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Miles: Sensitivity Analysis With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	0	0	0	0	0
-44	Wilmington	5,648,000	7,000,000	7,920,000	8,961,000	10,139,000
-45	Wilmington	8,472,000	10,500,000	11,880,000	13,442,000	15,208,000
-46	Wilmington	11,296,000	14,001,000	15,840,000	17,922,000	20,277,000
-47	Wilmington	14,120,000	17,501,000	19,801,000	22,403,000	25,346,000
-48	Wilmington	16,943,000	21,001,000	23,761,000	26,883,000	30,416,000
-42	Chl/Sav	43,067,000	53,380,000	60,395,000	68,331,000	77,311,000
-44	Chl/Sav	28,711,000	35,587,000	40,263,000	45,554,000	51,541,000
-45	Chl/Sav	21,534,000	26,690,000	30,198,000	34,166,000	38,655,000
-46	Chl/Sav	14,356,000	17,793,000	20,132,000	22,777,000	25,770,000
-47	Chl/Sav	7,178,000	8,897,000	10,066,000	11,389,000	12,885,000
-48	Chl/Sav	0	0	0	0	0
Total Miles						
-42	Chl/Sav	43,067,000	53,380,000	60,395,000	68,331,000	77,311,000
-44	Chl/Sav& Wilm	34,359,000	42,587,000	48,183,000	54,515,000	61,680,000
-45	Chl/Sav& Wilm	30,006,000	37,190,000	42,078,000	47,608,000	53,863,000
-46	Chl/Sav& Wilm	25,652,000	31,794,000	35,972,000	40,699,000	46,047,000
-47	Chl/Sav& Wilm	21,298,000	26,398,000	29,867,000	33,792,000	38,231,000
-48	Wilmington	16,943,000	21,001,000	23,761,000	26,883,000	30,416,000

Table 5-4
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Miles Avoided: Sensitivity Analysis With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Chl/Sav	0	0	0	0	0
-44	Chl/Sav& Wilm	8,708,000	10,793,000	12,212,000	13,816,000	15,631,000
-45	Chl/Sav& Wilm	13,061,000	16,190,000	18,317,000	20,723,000	23,448,000
-46	Chl/Sav& Wilm	17,415,000	21,586,000	24,423,000	27,632,000	31,264,000
-47	Chl/Sav& Wilm	21,769,000	26,982,000	30,528,000	34,539,000	39,080,000
-48	Wilmington	26,124,000	32,379,000	36,634,000	41,448,000	46,895,000

Table 5-5
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Costs: Sensitivity Analysis: With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Wilmington	0	0	0	0	0
-44	Wilmington	$20,676,000	$25,627,000	$28,995,000	$32,805,000	$37,116,000
-45	Wilmington	$28,779,000	$35,671,000	$40,358,000	$45,661,000	$51,662,000
-46	Wilmington	$35,028,000	$43,416,000	$49,121,000	$55,576,000	$62,879,000
-47	Wilmington	$39,819,000	$49,354,000	$55,840,000	$63,177,000	$71,479,000
-48	Wilmington	$44,210,000	$54,797,000	$61,998,000	$70,145,000	$79,362,000
-42	Chl/Sav	$91,749,510	$113,471,368	$128,382,438	$145,252,945	$164,340,374
-44	Chl/Sav	$61,166,340	$75,647,579	$85,588,292	$96,835,296	$109,560,250
-45	Chl/Sav	$45,874,755	$56,735,684	$64,191,219	$72,626,472	$82,170,187
-46	Chl/Sav	$30,583,170	$37,823,789	$42,794,146	$48,417,648	$54,780,125
-47	Chl/Sav	$15,291,585	$18,911,895	$21,397,073	$24,208,824	$27,390,062
-48	Chl/Sav	0	0	0	0	0
Totals						
-42	Chl/Sav	$91,749,510	$113,471,368	$128,382,438	$145,252,945	$164,340,374
-44	Chl/Sav& Wilm	$81,842,340	$101,274,579	$114,583,292	$129,640,296	$146,676,250
-45	Chl/Sav& Wilm	$74,653,755	$92,406,684	$104,549,219	$118,287,472	$133,832,187
-46	Chl/Sav& Wilm	$65,611,170	$81,239,789	$91,915,146	$103,993,648	$117,659,125
-47	Chl/Sav& Wilm	$55,110,585	$68,265,895	$77,237,073	$87,385,824	$98,869,062
-48	Wilmington	$44,210,000	$54,797,000	$61,998,000	$70,145,000	$79,362,000

Table 5-6
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Cost Savings: Sensitivity Analysis With-Project Conditions

Depth	Port	2025	2030	2035	2040	2045
-42	Chl/Sav	0	0	0	0	0
-44	Chl/Sav& Wilm	$9,907,170	$12,196,789	$13,799,146	$15,612,648	$17,664,125
-45	Chl/Sav& Wilm	$17,095,755	$21,064,684	$23,833,219	$26,965,472	$30,508,187
-46	Chl/Sav& Wilm	$26,138,340	$32,231,579	$36,467,292	$41,259,296	$46,681,250
-47	Chl/Sav& Wilm	$36,638,925	$45,205,473	$51,145,365	$57,867,120	$65,471,312
-48	Wilmington	$47,539,510	$58,674,368	$66,384,438	$75,107,945	$84,978,374

Tables 5-1 through 5-6 present incremental TEU, mileage, and trucking cost information projected in 5-year increments from 2025 through 2045. Table 5-7 presents an annual average equivalent summation of trucking costs at each depth increment calculated over 50 years at the FY20 Federal discount rate of 2.75%. Average annual equivalent waterborne costs for the Port of Wilmington's hinterland containerized Asia cargo are calculated for each depth increment based on the amount of cargo using Wilmington and Savannah at each increment (Table 5-8). Note that waterborne transportation costs increase as more cargo shifts to Wilmington because there is a slight increase in the distance traveled by ships adding Wilmington to the port rotation as described in Section 2.9.1 Without-Project Condition Waterborne Transportation Costs. Additionally, note that there is no difference in waterborne costs for the bases-case (Table 4-8) and the sensitivity analysis (Table 5-7) because the port rotation is the same for both scenarios.

Table 5-7
Port of Wilmington's Hinterland Containerized Asia Cargo Truck Cost AAEQ: Sensitivity Analysis With-Project Conditions

Depth	Wilmington	CHL/SAV	Total
-42	$0	$155,260,000	$155,260,000
-44	$33,770,000	$82,650,000	$116,420,000
-45	$47,010,000	$54,190,000	$101,200,000
-46	$57,210,000	$32,250,000	$89,460,000
-47	$65,040,000	$15,420,000	$80,460,000
-48	$72,210,000	$0	$72,210,000

Table 5-8
Port of Wilmington's Hinterland Containerized Asia Cargo Waterborne Cost AAEQ: With-Project Conditions

Depth	Wilmington	CHL/SAV	Total
-42	$0	$119,360,000	$119,360,000
-44	$41,680,000	$79,570,000	$121,250,000
-45	$62,530,000	$59,680,000	$122,210,000
-46	$83,370,000	$39,790,000	$123,160,000
-47	$104,210,000	$19,890,000	$124,100,000
-48	$125,050,000	$0	$125,050,000

Table 5-9 summarizes Tables 5-7 and 5-8 to present the average annual equivalent total transportation costs and cost savings at each increment of project depth. Average annual equivalent project costs (developed in the Engineering Appendix) are presented in Table 5-10. Incremental net benefits and benefit-to-cost ratios are presented in Table 5-11.

Table 5-9
Port of Wilmington's Hinterland Containerized Asia Cargo Total Transportation Cost AAEQ: Sensitivity Analysis With-Project Conditions

Depth	Total	Savings (Benefits)	Incremental Savings
-42	$274,620,000	$0	$0
-44	$237,670,000	$36,950,000	$36,950,000
-45	$223,410,000	$51,210,000	$14,260,000
-46	$212,620,000	$62,000,000	$10,790,000
-47	$204,560,000	$70,060,000	$8,060,000
-48	$197,260,000	$77,360,000	$7,300,000

Table 5-10
Project Costs

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

Table 5-11
Sensitivity Analysis Project Net Benefits

Depth	AAEQ Total Cost	AAEQ Total Benefits	AAEQ Net Benefits	Benefit/Cost Ratio
-44	$18,434,000	$36,962,000	$18,516,000	2.0
-45	$23,426,000	$51,222,000	$27,844,000	2.2
-46	$28,838,000	$62,022,000	$33,232,000	2.2
-47	$33,890,000	$70,082,000	$36,240,000	2.1
-48	$41,512,000	$77,392,000	$35,918,000	1.9

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.

<u>Obfuscated</u>

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

<u>Third Party Logistics (3PL)</u>

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.

<u>Mapped</u>

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.

<u>Unmapped</u>

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%
	3PL	846	3,503	1,181	3,095	8,625	11.6%	8.8%	10.0%
	Mapped	16,880	8,865	25,153	8,362	59,260	68.5%	68.9%	68.7%
	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%
	3PL	1,453	19,012	2,171	15,531	38,166	11.4%	8.6%	9.9%
	Mapped	48,405	69,588	72,679	64,216	254,887	65.9%	66.8%	66.4%
	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.

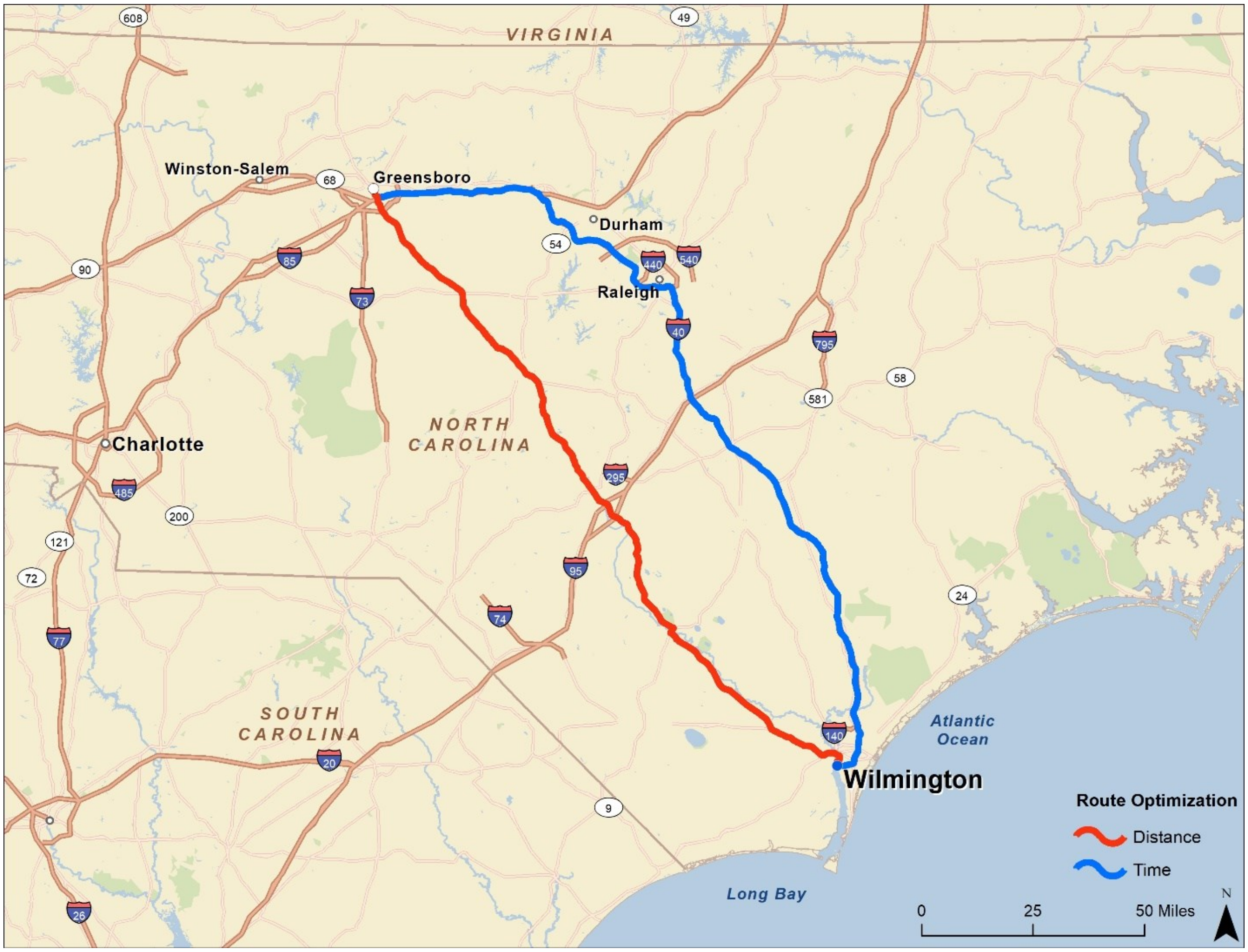

Figure A-1
Sensitivity Analysis Routes from Wilmington to Greensboro, North Carolina

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%**

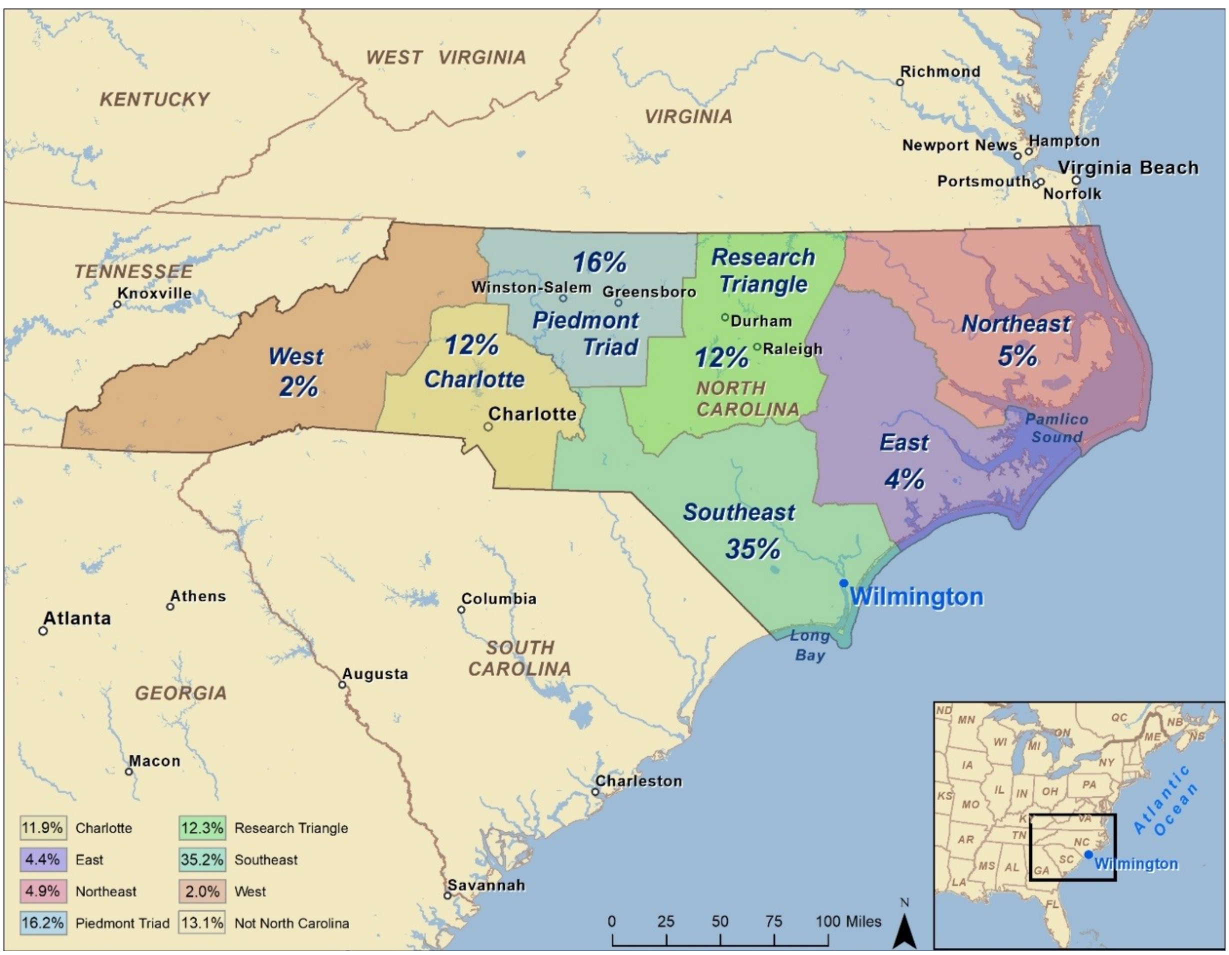

Figure A-2
Geographic Distribution of TEUs Transiting the Port of Wilmington

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.

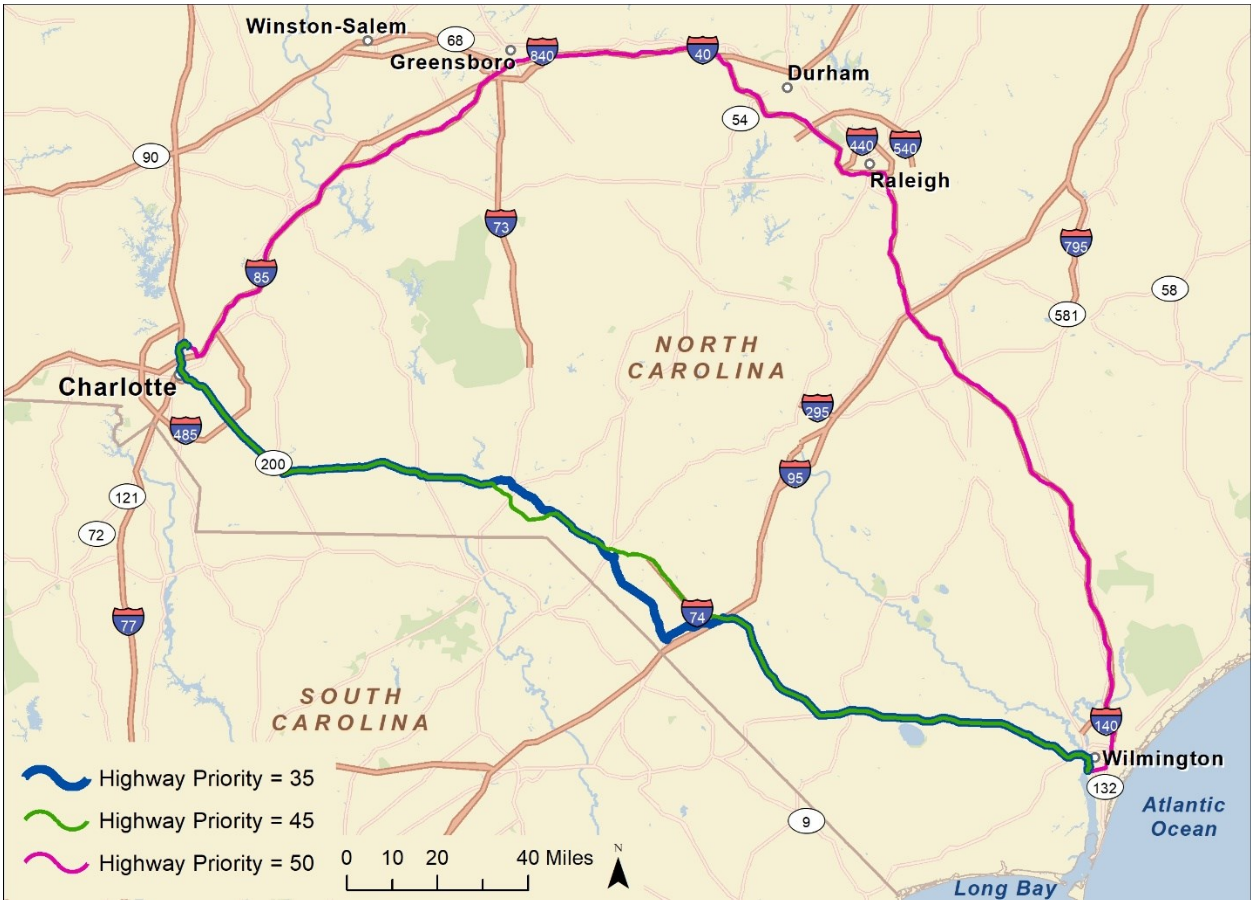

Figure B-1
Calculated Routing Paths Between Wilmington and Charlotte, NC

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.

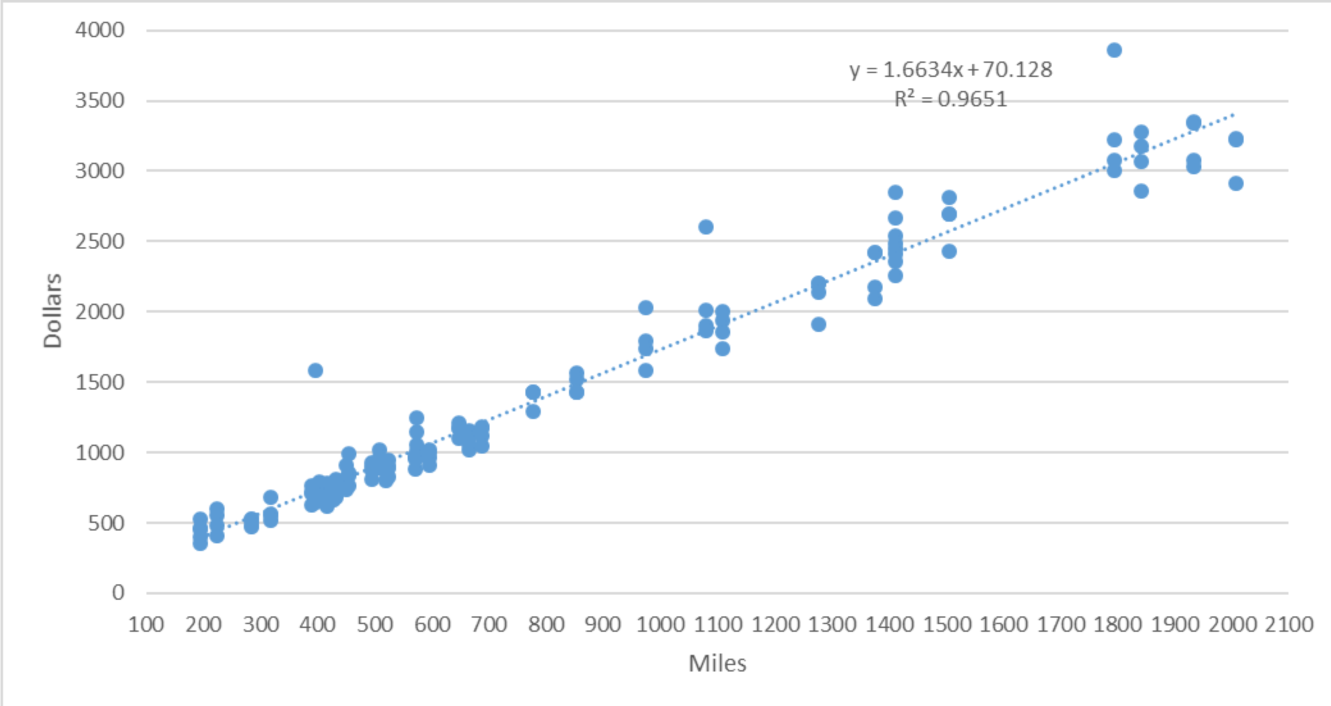

Figure B-2
Trucking Costs by Miles Driven

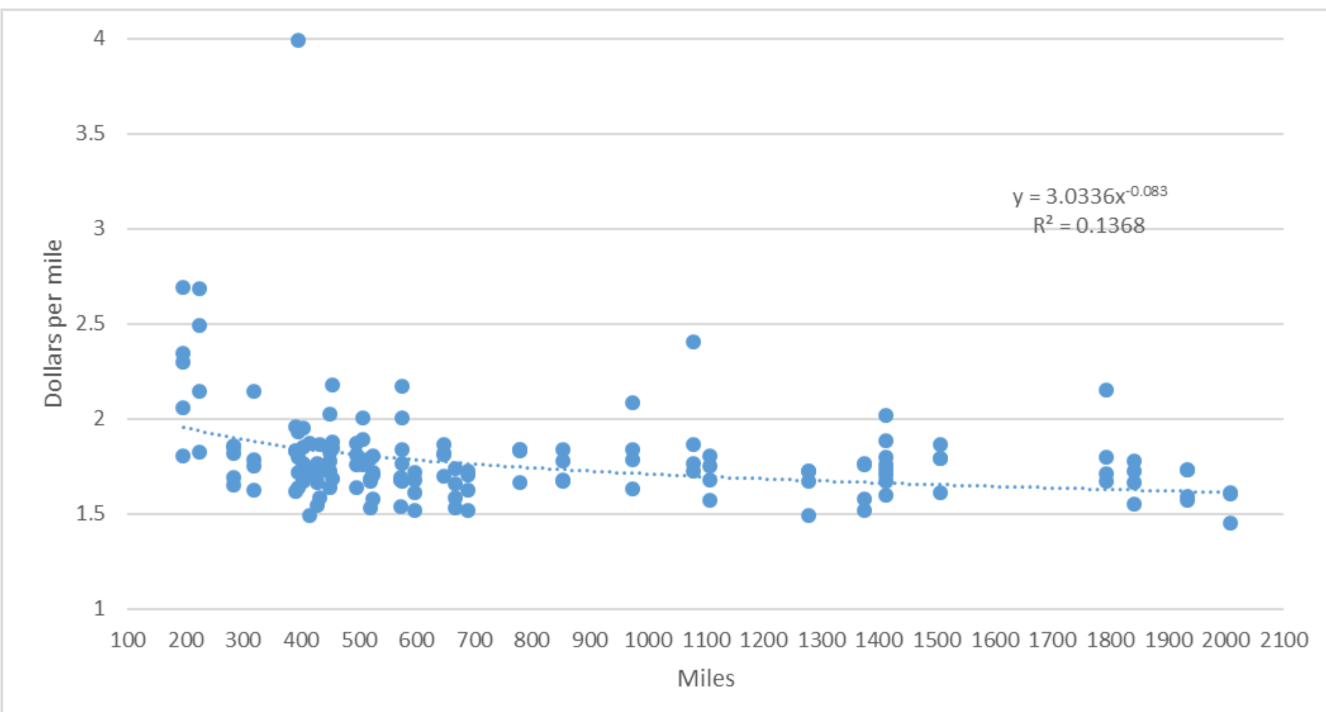

Figure B-3
Trucking Rates (dollars per mile) by Miles Driven

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.

INDEPENDENT REVIEW CERTIFICATION

Larry J. Prather
PO Box 1311
Middletown, Maryland 21769
larry.j.prather@gmail.com

Jerry Diamantides, Ph.D.
Senior Economist
David Miller & Associates
1637 Brookfield Road
Berlin, VT 05602

Dear Jerry,

I'm pleased to respond to your email copied below. I'm delighted that you found my recommendations useful. I have reviewed your responses and the modifications to the Economics Appendix.

Two aspects have been central to resolving uncertainties about the identification of the National Economic Development Plan. These were the without project condition assumption that Wilmington would be dropped from US East Cost-Asia containerized services and the consistency of with project benefit estimates with the ***Principles and Guidelines***.

Based on your responses and the Appendix modifications, I'm pleased to find that both key issues have been successfully resolved. This assures your defense of the NED plan identification. I can safely say that I could join you in defending this analysis. In addition, all minor or editorial concerns are resolved.

I commend your tenacity, diligence and outstanding analysis in complying with the Principles and Guidelines. The Port of Wilmington will be grateful for the rigor of your work in defending the Federal interest in their project. Good job!

Sincerely,

Larry J. Prather
Reviewer

Wilmington Harbor

Jerry Diamantides <jdiamantides@dma-us.com> Fri, Jan 31, 2020 at 9:11 AM
To: Larry Prather <larry.j.prather@gmail.com>

Larry,
Please see my responses to your comments and the revised Economics Appendix.
The parts of the Economics Appendix that have changed most importantly are 1.8.2.3 Existing Conditions Wilmington Fleet and section 4, which includes the revised benefits analysis based on the willingness to pay for transportation services.
I look forward to your insights. I believe I have performed the analysis you suggested.
Jerry

Jerry Diamantides, Ph.D.
Senior Economist
David Miller & Associates

CARRIERS LETTERS OF SUPPORT

HMM *Smart Shipping*

January 21, 2020

Mr. Paul Cozza
Executive Director
North Carolina State Ports Authority
2202 Burnett Blvd.
Wilmington, NC 28401

Re: Dredging at NC Ports

Dear Mr. Cozza,

As a customer of NC Ports, we are writing to you today to express support for the deepening of the federal channel of the Cape Fear River and the Port of Wilmington, NC.

HMM is a global integrated shipping company, in particular from the Wilmington Port area the transport of containerized cargo to destinations around the world.

We understand that you are currently working through a 203 study and we support your efforts. The port business is competitive, and we view the dredging to 47' or 48' to be essential to the viability of the port. Without the deepening of this waterway, we and other carriers will not be able to call your port.

Please keep us posted as to your developments.

Yours truly,

Kathleen D DePrizio, MBA
Marine & Terminal Operations / Director
Hyundai America Shipping Agency, Inc.
Office: 972-501-1378
Mobile: 480-273-1721
Email: kathleen.deprizio@hmm21.com

HYUNDAI AMERICA SHIPPING AGENCY, INC.
222 Las Colinas Blvd West, Suite 700 IRVING, TEXAS 75039 TEL: (972) 501-1100 FAX: (972) 501-1190

Captain Ronnie Newman
newman.ronnie@us.zim.com

January 16, 2020

Mr. Paul Cozza
Executive Director
North Carolina State Ports Authority
2202 Burnett Blvd.
Wilmington, NC 28401

Re: Dredging at NC Ports

Dear Mr. Cozza,

As a customer of NC Ports, we are writing to you today to express support for the deepening of the federal channel of the Cape Fear River and the Port of Wilmington, NC.

We understand that you are currently working through a 203 study and we support your efforts. The port business is competitive, and we view the dredging to 47' or 48' to be essential to the viability of the port. Without the deepening of this waterway, we and other carriers will not be able to call your port.

Please keep us posted as to your developments.

Yours truly,

Captain Ronnie Newman
Senior Vice President Operations

ZIM American Integrated Shipping Services Co. LLC **www.zim.com**

5801 Lake Wright Dr. Norfolk, VA 23502 Tel. 757 228-1468 Mobile 757 470-7458

YANG MING GROUP

January 16, 2020

Mr. Paul Cozza
Executive Director
North Carolina State Ports Authority
2202 Burnett Blvd.
Wilmington, NC 28401

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Please keep us posted as to your developments.

Yours truly,

W Lee

Wenjin Lee
Senior Executive Vice President
Yang Ming (America) Corp.

One Newark Center
1085 Raymond Boulevard, 9th Floor
Newark, NJ 07102

YANG MING (AMERICA) CORP.
1085 Raymond Blvd., 9th Floor, Newark, New Jersey 07102 TEL: 201-222-8899 FAX: 201-222-6699 http://www.yangming.com

ONE
OCEAN NETWORK EXPRESS

North America RHQs
8730 Stony Point Parkway
Suite 400
Richmond, Virginia 23235
www.one-line.com

February 4, 2020

Mr. Paul Cozza
Executive Director
North Carolina State Ports Authority
2202 Burnett Blvd.
Wilmington, NC 28401

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Please keep us posted as to your developments.

Yours truly,

Dave Daly
Vice President Marine, Rail, & Operations Planning

January 16, 2020

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Executive Director
North Carolina State Ports Authority
2202 Burnett Blvd.
Wilmington, NC 28401

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Please keep us posted as to your developments.

Yours truly,

Christopher J. Parvin
Executive Vice President
Mediterranean Shipping Company USA

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700 Watermark Blvd., Mount Pleasant, SC 29464 (USA)
T: +1 843.654.6064 E: info@msc.us

Hapag-Lloyd

January 16, 2020

Mr. Paul Cozza
Executive Director
North Carolina State Ports Authority
2202 Burnett Blvd.
Wilmington, NC 28401

Hapag-Lloyd (America) LLC
399 Hoes Lane
Piscataway, NJ 08854
Phone (732) 562-1800
Fax (732) 885-6132
www.hapag-lloyd.com

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Please keep us posted as to your developments.

Yours truly,

Thomas Engel
SVP Corporate Operation
Region North America